

2021

वार्षिक प्रतिवेदन
ANNUAL REPORT

Ranked No. 1
Amongst
Agricultural
Universities
in India

Serving the
Nation through

Innovative
Dairying



भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान

(मानद् विश्वविद्यालय) कर्नाल - 132 001 भारत

ICAR-NATIONAL DAIRY RESEARCH INSTITUTE

(Deemed University) Karnal - 132 001 India

VISION

Ensure availability of quality milk and milk products at affordable cost, livelihood security to the producer and profitability to the dairy sector through adoption of appropriate technologies and human resource development.



MISSION

Serve the cause of dairying by developing quality human resource and suitable technologies related to the production, processing and marketing of milk and milk products, and their dissemination for the benefit of dairy industry, farming community and the Nation.



GOAL

Provide R&D support towards generation and dissemination of knowledge towards improved national milk herd for milk production enhancement, greater productivity of dairy industry and management aspects of the dairy profession leading to the social, economic and environmental benefits to the Nation as well as contributing towards manpower development programmes

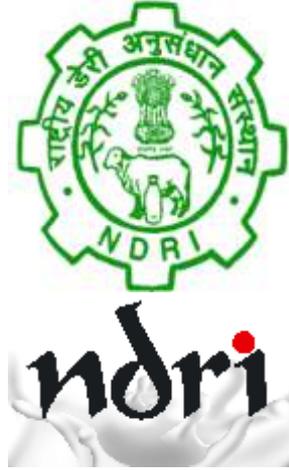


MANDATE

- Research in the Areas of Dairy Production, Processing and Marketing.
- Human Resource Development in Dairy Sector.
- Dissemination of Innovative Dairy Technologies.



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MILESTONES

1923	Established in Bangalore as Imperial Institute of Animal Husbandry and Dairying.		
1936	Renamed "Imperial Dairy Institute".		
1955	National Dairy Research Institute came into existence at Karnal, at the former Central Cattle Breeding Farm. Bangalore facilities became Southern Regional Station of the Institute.		
1957	B.Sc. Dairying commenced at NDRI, Karnal.		
1961	B.Sc. Dairying bifurcated into two branches, namely B.Sc. (Dairy Technology) and B.Sc. (Dairy Husbandry); M.Sc. Dairying courses commenced at Karnal.	2010	DST supported Technology Business Incubator (TBI) facility made functional. New Course Curricula for B.Tech in Dairy Technology and Masters and Doctoral Programmes introduced. Reforms in examination system, grading system and introduction of comprehensive exam. for Ph.D. programme introduced. A new extension programme "Dairy Education at Farmers' Door" started.
1962	Western Regional Station established at Bombay.		
1964	Eastern Regional Station established at Kalyani (W.B.).	2011	8 th Convocation of NDRI, Deemed University held in presence of Dr. A. P. J. Abdul Kalam, Former President of India.
1966	Institute brought under the aegis of ICAR.		
1975	Operational Research Project initiated.		
1976	Department of Human Nutrition and Dietetics established at NDRI, Karnal.	2011	M.Sc. in Forage Production Introduced at NDRI, Karnal. NDRI recognized as Centre of Advanced Faculty Training (CAFT) in the Disciplines of Dairy Production and Dairy Processing.
1979	M.Sc., Ph.D. Programme in Dairy Engineering commenced at Karnal.	2012	Sahiwal Calf "Holi" through Ovum Pick up (OPU-IVF) technique born on 7 th March, 2012. NRC on Milk Quality and Safety established at NDRI, Karnal.
1983	IDD (DH) started at Bangalore.		
1985	"Farm Advisory Bureau" and "Industrial Consultancy Cell" set up. The Institute recognised as Centre of Excellence in Animal Biotechnology.	2013	Business Planning and Development (BPD) Unit established at NDRI, Karnal. First female calf named 'Mahima' was born to a cloned buffalo on 25 th January 2013.
1987	Embryo Biotechnology Centre established.		
1989	The Institute granted "Deemed to be University" status. M.Sc. in Biotechnology started.	2013	A male cloned buffalo calf named 'Swarn' was born on 18 th March 2013. Donor somatic cell used was isolated from the seminal plasma of an elite bull. A Diploma in Dairy Technology started at Southern Regional Station, Bangalore.
1990	Birth of Pratham, first IVF buffalo calf of the world.	2013	
1991	20 bedded Hospital Complex set up and made functional.	2014	NDRI bagged the Sardar Patel Outstanding ICAR Institution Award presented by Hon'ble Prime Minister of India, Sh. Narendra Modi Ji. NDRI produced a clone of endangered wild buffalo of Chhattisgarh named "Deepasha" on 12 th December, 2014.
1994	The Institute got recognition as Centre of Advanced Studies in Dairy Technology and Dairy Cattle Breeding.		
1996	A two-year National Dairy Diploma (NDD) course introduced at Southern Regional Station of NDRI at Bangalore.	2014	A new extension education approach "Farmers' Farm School" was started at NDRI, Karnal. NDRI got ISO 9001: 2008 certification. NDRI implemented MIS/FMS to carryout administrative and financial activity of the Institute.
1993-94	The ICAR award for outstanding KVK conferred on the KVK located at NDRI.	2016	Two service centres established at Lalukheri, Muzzafarnagar (UP) and Piprakothi East Champaran (Bihar).
1997	A state-of-the-art Auditorium having seating capacity of 950 and 2 conference rooms and 2 meeting rooms made functional. A commercial Model Dairy Plant with a capacity of 60,000 lit./ day commissioned for providing practical training to the students of NDRI University and to serve as an interface between Institute and Industry.	2017	Additional KVK established at Eastern Campus, Kalyani.
1998	A Modern Cafeteria with a seating capacity of 150 constructed in front of the Institute Hostels.		
1999	Total no. of 9 NATP Projects with financial outlay of 266.25 lakhs initiated.		
2000	A Guest House with two suites named as "Kamdhenu" was constructed at SRS, Bangalore. Web-site of NDRI was created and launched by the Hon'ble Union Minister for Agriculture on 23 rd December 2000.	2018	ICAR - NDRI ranked first among all Agricultural Universities and four Deemed Universities of ICAR (2016-17, 2017-2018 & 2018-19). One month Foundation Course for newly admitted students of 2017-18 batch introduced. Automation of the 'Academic Management System' implemented. A mega world-bank funded Institutional Development Plan (IDP) of National Agricultural Higher Education Project initiated.
2001	Foundation stone of the Agricultural Technology Information Centre laid on 1 st August, 2001 under NATP project at NDRI, Karnal.		
2002	International Students' Hostel equipped with modern facilities and amenities constructed at NDRI, Karnal. Feed Quality Control Lab. set up to help keep-strict quality check on feeds being fed to bovine livestock.	2019	National Referral Center for Milk Quality and Safety (NRCMQS) granted accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL). Set up Atal Incubation Centre at Southern Campus of NDRI, Bengaluru under Section 8 of Companies Act, 2013.
2003	State-of-the-art milking parlour system introduced in cattle section.	2020	Three cloned calves produced using donor cells of an elite bulls. Twenty three Faculty members and fifty five students successfully completed their International training in 25 Overseas Universities located in 8 different Countries.
2004	First IVF goat kid born at NDRI. ATIC centre made functional at NDRI.		
2006	New Animal Biotechnology Centre commissioned.		
2007	Creation of Video Conferencing Lab and Mini Auditorium.		
2009	World First Cloned Buffalo Calf and second cloned calf "Garima" produced by hand-guided cloning technique at NDRI.		

प्रस्तावना

PREFACE



भाकृअनुप-राडेअनुसं के वर्ष 2021 का वार्षिक रिपोर्ट प्रस्तुत करते हुए मुझे असीम हर्ष हो रहा है। यह रिपोर्ट डेरी अनुसंधान, शिक्षा, विस्तार और वर्ष 2021 के दौरान किए गए कार्यक्रमों को मजबूत करने के लिए की गई संबंधित गतिविधियों के क्षेत्रों में संस्थान की महत्वपूर्ण उपलब्धियों का वर्णन करती है। इसमें व्याप्त सूचना को इस प्रकार से व्यवस्थित किया गया है कि यह देश के इस प्रमुख डेरी संस्थान और इसकी कार्यप्रणाली का संपूर्ण विहंगम दृश्य प्रस्तुत करती है।

यह गर्व का विषय है कि भाकृअनुप-राडेअनुसं ने 2016-17, 2017-18, 2018-19, 2019-20 और 2020-21 में लगातार पांच बार 4 मानद विश्वविद्यालयों सहित भारत के सभी कृषि विश्वविद्यालयों में पहला स्थान प्राप्त किया है। एनडीआरआई की अनुसंधान और विकास गतिविधियों को इसके अधिदेश-उन्मुख और अच्छी तरह से संरचित अनुसंधान कार्यक्रमों के माध्यम से और गति प्राप्त हुई है। इसमें 85 इन-हाउस और 68 बाहरी वित्त पोषित अनुसंधान परियोजनाएं हैं, जिसमें छह अंतर्राष्ट्रीय सहयोगी अनुसंधान परियोजनाएं भी शामिल हैं।

राडेअनुसं ने प्रौद्योगिकियों और डेरी से संबंधित जानकारियों का प्रसार करने और जमीनी स्तर पर हितधारकों के बीच उनको लागू करने के लिए ठोस प्रयास किए। भाकृअनुप-राडेअनुसं के कृषि विज्ञान केंद्र ने वर्ष 2021 के दौरान 59 ऑन-कैंपस और 69 ऑफ-कैंपस प्रशिक्षण कार्यक्रम आयोजित किए जिससे देश भर के 3356 किसान लाभान्वित हुए हैं। एनईएच के तहत, 2021 के दौरान भारत के पांच उत्तर पूर्वी राज्यों, अरुणाचल प्रदेश, नागालैंड, त्रिपुरा, असम और सिक्किम में कुल पांच पशुधन विकास शिविर आयोजित किए गए। पशुधन पशु, कुकूट के चिक्स, बतख तथा विभिन्न कृषि निवेश को किसानों में वितरित किया है। टीएसपी के तहत, पूर्वी और उत्तर-पूर्वी भारत के विभिन्न हिस्सों में 4 शिविर आयोजित किए गए और 4 कैंपस

It gives me immense pleasure to present before you the ICAR-NDRI Annual Report 2021. The report chronicles the significant achievements of the Institute in the areas of Dairy Research, Education, Extension and related activities undertaken to strengthen these programmes during the year 2021. The information has been so arranged that it provides a complete panoramic view of this premier dairy Institute of the country and its functioning.

To our pride, ICAR-NDRI secured first rank among all Agricultural Universities of India, including 4 Deemed Universities, consecutively for five times in the years 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21. The research and development activities of NDRI got further momentum through its mandate-oriented and well-structured research programmes comprising 85 in-house and 68 externally funded research projects, which also included six international collaborative research projects.

NDRI made concerted efforts to disseminate the technologies and dairying related information and translate them among the stakeholders at the grass root level. Krishi Vigyan Kendra of ICAR-NDRI conducted 59 on-campus and 69 off-campus training programs during the year 2021 benefitting 3356 farmers across the country. Under the NEH, a total of five livestock developmental camps were organized in five North Eastern states of India namely, Arunachal Pradesh, Nagaland, Tripura, Assam and Sikkim during 2021. Livestock animals, poultry chicks, ducks and different agri-inputs were distributed among farmers. Under TSP, 4 camps were organised in different parts of Eastern and North-Eastern India and 4 on-campus training programmes were organized. Seven extension

प्रशिक्षण कार्यक्रम आयोजित किए गए। 2021 के दौरान पूर्वी क्षेत्रीय स्टेशन (इ.आर.एस.), कल्याणी में एससीएसपी कार्यक्रम के तहत सात विस्तार कार्यक्रम आयोजित किए गए। इ.आर.एस. कल्याणी ने खरपतवार प्रबंधन, एकीकृत खेती, चारा उत्पादन, जल प्रबंधन, मृदा उर्वरता प्रबंधन, डेरी प्रबंधन, सुअर पालन प्रबंधन, रोग प्रबंधन, बकरी पालन आदि पर 46 प्रशिक्षण कार्यक्रम भी आयोजित किए जिससे कुल 1015 पुरुष और 896 महिला किसान लाभान्वित हुए।

पशु उत्पादन के क्षेत्र में, राडेअनुसं भैंस की क्लोनिंग पर मौलिक कार्य कर रहा है, जिसे स्वदेशी मवेशियों तक बढ़ाया जा रहा है। वर्ष 2021 के दौरान, कृत्रिम गर्भाधान के माध्यम से दो क्लोन बैलों के वीर्य का उपयोग कर बारह बछड़े पैदा किए गए। उच्च दूध देने वाली भैंस के सोमैटिक सेल का उपयोग कर उत्पादित एक क्लोन मादा भैंस बछड़ा 'कर्णिका' ने मानक 305 दिनों के दुग्ध काल में 4810 किलोग्राम दूध का उत्पादन किया। इसी प्रकार देशी गाय की नस्लों के लिए भी क्लोन भ्रूण तैयार किए गए। सीमन सेक्सिंग तकनीक को लक्षित करते हुए, सेक्सड सीमेन के उत्पादन में उनके संभावित अनुप्रयोग के लिए शुक्राणु की सतह के लिए उनके अंतर बंधन के आधार पर संभावित लिगेंड की पहचान की गई। इसके अलावा, डेरी मवेशियों में मादाओं के प्रति शुक्राणुओं के लिंग अनुपात को बढ़ाने के लिए ऐंटीबॉडी आधारित "लक्षित स्थिरीकरण प्रौद्योगिकी" विकसित की गई। प्रारंभिक गर्भावस्था का पता लगाने के लिए, एलिसा और एलएफआई को मवेशियों और भैंसों के गर्भावस्था से जुड़े ग्लाइकोप्रोटीन के विरुद्ध तैयार किया गया। डेरी गायों में ब्यानें की प्रक्रिया की दूरस्थ निगरानी के लिए, इंटर-वेजाइनल वायरलेस सेंसर का एक प्रोटोटाइप विकसित किया गया। दूध में एस्चेरिचिया कोलाई का त्वरित पता लगाने के लिए स्वर्ण नैनोकण आधारित एक दृश्य परीक्षण भी विकसित किया गया। भैंसों में इस्ट्रस की शुरुआत की पहचान करने के लिए मूत्र और लार फर्न पैटर्न विश्लेषण के साथ-साथ मूत्र माइक्रो आर.एन.ए. को आशाजनक साधन के रूप में पाया गया।

डेरी प्रसंस्करण के क्षेत्र में उत्पादों और प्रक्रियाओं को वितरित करने में संस्थान जीवंत उदाहरण रहा है। इस डोमेन में कुछ प्रमुख नवाचार हैं: कैल्सियम अवशोषण में सुधार के लिए स्टार्टर कल्चर या लैक्टोज ऑक्सीडेज एंजाइम का उपयोग कर लैक्टोबियोनिक एसिड का संवर्धन; महिला आबादी के समग्र स्वास्थ्य प्रबंधन के लिए दूध-अलसी आधारित प्रोबायोटिक खाद्य; गौ-दुग्ध निर्मित, उच्च एंटीऑक्सीडेंट और हाइपोकोलेस्टेरोलेमिक प्रभावी हल्दी प्रयुक्त घी और लस्सी; बढ़े हुए लौह तत्व की अधिक जैव अभिगम्यता एवं उच्च एंटीऑक्सीडेंट गुणों सहित किण्वित मट्ठा; विभिन्न स्वास्थ्य विशेषताओं के साथ फॉस्फोलिपिड समृद्ध देसी छाछ का इस्टेंट पाउडर; स्रे सुखाने की प्रक्रिया का उपयोग कर ग्लूटेन मुक्त मल्टीग्रेन सेंवई खीर और इसका इस्टेंट मिश्रण; दूध-बाजरा के पूरक आहार की वास्तविक गुणवत्ता स्थिति के ऑकलन के लिए ऑन-पैकेज वर्णमिति संकेतक लेबल; मक्खन के तेल से घी तैयार करने की एक नई ऊर्जा दक्ष विधि; दूध में

programmes were organized under SCSP programme during 2021 at Eastern Regional Station (ERS), Kalyani. ERS, Kalyani also organized 46 training programmes on Weed Management, Integrated Farming, Fodder Production, Water Management, Soil fertility management, Dairy Management, Piggery Management, Disease Management, Goat Farming, etc, which benefitted a total of 1015 male and 896 female farmers.

In the domain of animal production, NDRI has been crafting seminal work on buffalo cloning, which is being extended to indigenous cattle. During the year 2021, twelve buffalo calves were produced using semen of the two cloned bulls through artificial insemination. A cloned female buffalo calf 'KARNIKA' produced using somatic cell of high milk-producing buffalo yielded 4810 kg of milk in standard 305 days lactation. Likewise, cloned embryos were also produced for indigenous cow breeds. Targeting semen sexing technology, potential ligands were identified based on their differential binding to sperm surface for their potential application in the production of sexed semen. Further, antibodies based "Targeted immobilization technology" was developed to skew the sex ratio of spermatozoa towards females in dairy cattle. For early pregnancy detection, ELISA and LFIA were produced against pregnancy associated glycoproteins of cattle and buffaloes. For remote monitoring of calving process in dairy cows, a prototype of intra-vaginal wireless sensor was developed. A visual test nanoparticles was also developed based on gold for quick detection of *Escherichia coli* in milk. Urine and saliva fern pattern analysis as well as urinary miRNA were found as promising tools to identify the onset of the estrus in buffaloes.

The Institute has been vibrant in delivering products and processes in the sphere of dairy processing. Some of the key innovations in this domain are: enrichment of lactobionic acid by using starter culture or lactose oxidase enzyme to improve calcium absorption; Milk-flaxseed based probiotic food for overall health management of female population; Haldi ghee and lassi possessing higher anti-oxidant activity and hypocholesterolemic effect prepared from cow milk by fortification with turmeric; Fermented whey with enhanced bio-accessibility of iron content with higher antioxidant activity; Phospholipid rich instant powder from *desi chhaach* with different health attributes; Gluten free multigrain vermicelli *kheer* and its instant mix using spray drying process; On-package colorimetric indicator label for the assessment of real time quality status of milk-millet complementary food; A novel energy efficient method for ghee preparation from butter oil; A dye based method to detect sorbitol adulteration in milk; A color sensor based rapid method

सोर्बिटोल मिलावट का पता लगाने के लिए डाई आधारित विधि; घी में वनस्पति तेल की मिलावट का पता लगाने के लिए कलर सेंसर आधारित त्वरित विधि; घी में खनिज तेल और नारियल तेल की मिलावट का पता लगाने के लिए एटीआर-एफटीआईआर आधारित विधि विभिन्न तापमानों पर संदेश के भंडारण के आकलन के लिए ऑन-पैकेज वर्णमिति ताजगी संकेतक; गाजर जैव-अपशिष्ट से प्राकृतिक रंजक के रूप में इसके अंतिम उपयोग के लिए कैरोटेनॉयड्स के निष्कर्षण के लिए हरित निर्माण प्रौद्योगिकी और थर्मल दुरुपयोग और पनीर की गुणवत्ता की निगरानी के लिए जैविक स्मार्ट समय तापमान संकेतक। इसी तरह, सुविधा के उत्पादन के लिए दक्षिणी क्षेत्रीय स्टेशन (एस. आर.एस.), बैंगलोर में मूल्य वर्धित कार्यात्मक खाद्य पदार्थ विकसित किए गए। न्यूट्रीसीरियल्स में प्रोबायोटिक स्प्रेड और डिप्स प्राकृतिक मिठास के साथ कम चीनी की बर्फी, डीपीपी-IV निरोधात्मक पेप्टाइड्स फोर्टिफाइड स्नैक बार और विटामिनबी12 रिच न्यूट्रीमिक्स शामिल हैं। घी अवशेषों से फास्फोलिपिड्स के निष्कर्षण और स्प्रे शुष्कन द्वारा प्रोबायोटिक बैक्टीरिया के माइक्रो-एनकैप्सुलेशन के लिए एक विधि भी विकसित की गई है।

डेरी प्रबंधन के क्षेत्र में, किसानों की शुद्ध आय में 35% की वृद्धि, दूध के उत्पादन में 14% की वृद्धि और दुग्ध ज्वर की घटना को 21% से 2% तक कम कर आयनिक खनिज मिश्रण (एएमएम) पूरकता के प्रभाव को महसूस किया गया। एएमएम के प्रयोग से हरियाणा में प्रति वर्ष 873 करोड़ रुपये के आर्थिक नुकसान से बचाया जा सकता है। बरसात के मौसम के दौरान 28.34% पशुओं में क्लिनिकल थनैला की घटनाएं पाई गईं जिससे और अहमदनगर (महाराष्ट्र) में 14.19 करोड़ रुपये का नुकसान होने का अनुमान लगाया गया था। दुग्ध उत्पादक कंपनी (एमपीसी) का प्रभाव परिवर्तनीय लागत (8%) में कमी और गुजरात के सौराष्ट्र और कच्छ क्षेत्रों की आय में ₹.10000/घर/सालाना की वृद्धि स्पष्ट रूप से पायी गई। ओडिशा में ग्रामीण महिलाओं के लिए कौशल वृद्धि के प्रभाव का अध्ययन किया गया जिससे प्रेषण (54% तक) और सामाजिक अनुदान (52%) पर उनकी निर्भरता को कम किया जा सके।

डेरी शिक्षा के क्षेत्र में एनडीआरआई मानद विश्वविद्यालय भारत सरकार की नई शिक्षा नीति (एनईपी-2020) के साथ-साथ उच्च शिक्षा के वैश्विक संस्थानों के रुझानों से जोड़कर रखने के लिए नए सुधार लाने की दिशा में कदम बढ़ा रहा है। अकादमिक कार्यक्रमों को मजबूत करने, पूर्व के छात्रों के नेटवर्क का लाभ उठाने, छात्रों के सॉफ्ट स्किल्स का पोषण करने और संस्थागत विकास योजना (आईडीपी) के तहत इक्विटी एक्शन प्लान प्लस ग्रीन कैम्पस के लिए अनेक पहल किए गए हैं। आईडीपी-एनएएचईपी के तहत वर्ष 2021 के दौरान "खाद्य सुरक्षा", "खाद्य सुरक्षा और पोषण गुणवत्ता के लिए नवीन और उभरती हुई प्रौद्योगिकियाँ", "पार्श्व प्रवाह परख में डिजाइन और उभरते अनुप्रयोगों में हालिया प्रगति" और "वैज्ञानिक लेखन" पर चार कार्यशालाएं आयोजित की गईं। इसके अलावा, आईडीपी-नाहेप के तहत वर्चुअल मोड में चौबीस वेबिनार आयोजित किए गए जिसमें 39 अंतर्राष्ट्रीय वक्ताओं ने व्याख्यान दिए।

for detection of vegetable oil adulteration in ghee; ATR-FTIR based method for detection of mineral oil and coconut oil adulteration in ghee; On-package colorimetric freshness indicator for the assessment of storage of *Sandesh* at different temperatures; Green manufacturing technology for extraction of carotenoids from carrot bio-waste for its end use as natural colorant; and Biological smart time temperature indicator for monitoring thermal abuse and quality of *paneer*. Likewise, technologies were developed at Southern Regional Station (SRS), Bangalore for the production of convenience, value added functional foods viz. nutricereals incorporated probiotic spreads and dips, reduced sugar burfi with natural sweeteners, DPP-IV inhibitory peptides fortified Snack bar and Vit.B12 rich nutrimix. At SRS, Bangalore, a method was also developed for extraction of phospholipids from ghee residue and for micro-encapsulation of probiotic bacteria by spray drying.

In the area of dairy management, the impact of Anionic Mineral Mixture (AMM) supplementation was realized in terms of enhancing farmers' net income by 35%, improvements in milk yield by 14% and reduced milk fever incidence from 21% to 2%. AMM intervention has potential to save economic losses to the extent of Rs.873 crores per annum in Haryana. The incidence of clinical mastitis was found in 28.34% sample animals during the rainy season and projected loss was estimated to be Rs. 14.19 crores in Ahmednagar (Maharashtra). Impact of milk producer company (MPC) was found evident from reduction in variable cost (8%) and increase in income by Rs. 10000/ household/ annum in Saurashtra and Kutch region of Gujarat. Impact of Skill enhancement for rural women in Odisha was studied towards reducing their dependence on remittances (upto 54%) and social grants (52%).

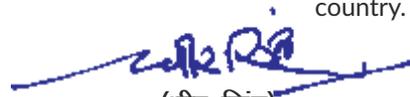
In the area of Dairy Education, NDRI Deemed University is marching ahead to bring in new reforms to keep its activities aligned to the new education policy (NEP-2020) of the Government of India as well as the trends in global institutions of higher learning. Various initiatives were taken for strengthening academic programmes, leveraging alumni network, nurturing soft skills of the students and equity action plan plus green campus under Institutional Development Plan (IDP). Four Workshops were conducted under IDP-NAHEP on "Food Safety", "Innovative and Emerging Technologies for Food Safety & Nutritional Quality", "Recent Advances in Design and Emerging Applications in Lateral Flow Assay" and "Scientific Writing" during the year 2021. Besides, twenty four webinars were conducted under IDP-NAHEP in virtual mode in which 39 International Speakers delivered lectures.

एनडीआरआई का अठारहवां दीक्षांत समारोह 22 अगस्त, 2021 को ऑनलाइन मोड में आयोजित किया गया। डॉ. त्रिलोचन महापात्र, सचिव, डेयर और महानिदेशक, आईसीएआर इस अवसर पर मुख्य अतिथि थे और उन्होंने दीक्षांत भाषण दिया। दीक्षांत समारोह से पहले, व्याख्यान पुरस्कारों की एक श्रृंखला आयोजित की गई। डॉ. ए.के. मिश्रा, अध्यक्ष, कृषि वैज्ञानिक चयन मण्डल को डॉ. डी सुन्दरेसन मेमोरेयल ओरेशन पुरस्कार, डॉ. के. के. अडिया ओरेशन पुरस्कार प्रोफेसर (डॉ.) वी.पी. कांबोज, अध्यक्ष भारतीय राष्ट्रीय विज्ञान अकादमी तथा पूर्व निदेशक, केंद्रीय औषधि संस्थान (सीडीआरआई) को और पद्मश्री प्रोफेसर जे.एस. राजपूत, पूर्व निदेशक, एनसीईआरटी और संस्थापक सदस्य, राष्ट्रीय अध्यापक शिक्षा परिषद (एनसीटीई), नई दिल्ली को डॉ. दस्तूर मेमोरियल ओरेशन अवार्ड प्रदान किया गया।

इसके अलावा, विभिन्न उद्योगों और शैक्षणिक संस्थानों के साथ संपर्क स्थापित किए गए। सात समझौता ज्ञापनों की जांच की गई और श्री वेंकटेश्वर पशु चिकित्सा विश्वविद्यालय, तिरुपति, पीएयू, लुधियाना, यूनिवर्सिटी ऑफ पेट्रोलियम एंड एनर्जी स्टडीज (यूपीईएस), देहरादून, उत्तराखंड, गुरुकुल कांगड़ी मानद विश्वविद्यालय, हरिद्वार, उत्तराखंड, जीएलए विश्वविद्यालय, मथुरा (यूपी), असम कृषि विश्वविद्यालय, खानापारा, गुवाहाटी और एग्रिनोवेट इंडिया लिमिटेड: श्रेडबर डायनामिक्स डेयरीज प्रा. लिमिटेड, मुंबई के साथ हस्ताक्षर किए गए। वर्ष 2021 के दौरान, सात पेटेंट प्राप्त हुए और ग्यारह पेटेंट दाखिल किए गए। संस्थान में विकसित छह प्रौद्योगिकियों को कृषि-नवोन्मेष के माध्यम से वाणिज्यिक घरानों को हस्तांतरित किया गया और 20 प्रौद्योगिकियों को व्यावसायीकरण के लिए अनुमोदित किया गया।

यह सब संस्थान द्वारा राडेअनुसं के बंधुओं के समर्पण, कठिन परिश्रम, सहयोग और समझ से प्राप्त किया जा सकता है। संस्थान डेरी अनुसंधान, शिक्षा और आउटरीच को बढ़ावा देने के लिए एक विश्व स्तरीय मॉडल परिसर बनने के लिए प्रतिबद्ध है क्योंकि डेरी क्षेत्र लाखों किसानों के सामाजिक-आर्थिक जीवन को बदलने के लिए एक प्रमुख गेम चेंजर के रूप में उभर रहा है।

मुझे पूरी उम्मीद है कि राडेअनुसं की वर्ष 2021 की वार्षिक रिपोर्ट देश के अन्य उच्च शिक्षण संस्थानों और डेरी विकास संगठनों के पेशेवरों के लिए सूचना के एक मूल्यवान स्रोत का कार्य करेगी।


(धीर सिंह)

निदेशक, भाकूअनुप-राडेअनुसं

Eighteenth Convocation of NDRI was organized on August 22, 2021 in an on-line mode, Hon'ble Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR was the Chief Guest on the occasion and delivered the Convocation Address. Prior to the Convocation, a series of oration Awards were conferred such as Dr. D. Sundaresan Memorial Oration Award on Dr. A.K. Mishra, Chairman Agricultural Scientists Recruitment Board, Dr. K.K. Iya Oration Award on Prof. (Dr.) V.P. Kamboj, President of the National Science Academy of India and Ex Director, Central Drug Institute (CDRI) and Dr. N.N. Dastur Memorial Oration Award on Padamshri Professor J.S. Rajput, Former Director, NCERT and Founder Member, National Council for Teacher Education (NCTE), New Delhi.

Furthermore, linkages were established with different industries and academic institutions. Seven MoUs were screened and signed with Sh. Venkateswara Veterinary University, Tirupati; PAU, Ludhiana; University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand; Gurukula Kangri Deemed to be University, Haridwar, Uttarakhand; GLA University, Mathura (UP); Assam Agricultural University, Khanapara, Guwahati; and Agrinnovate India Limited: Schreiber Dynamix Dairies Pvt. Limited, Mumbai. During the year 2021, seven patents were granted and eleven patents filed. Six technologies developed at the Institute were transferred to the commercial houses through Agri-innovate and 20 technologies were approved for commercialization.

All this could be achieved by the Institute with the dedication, hard work, cooperation and understanding of the NDRI fraternity. The Institute is committed to become a world-class model campus for promoting dairy research, education and outreach as dairying is emerging as a major game changer for transforming socio-economic lives of millions of farmers.

I sincerely hope that NDRI Annual Report 2021 would serve as a valuable source of information to the professionals of the other Institutions of Higher Learning and Dairy Development Organizations in the country.


(Dheer Singh)
Director, ICAR-NDRI

कार्यकारी सारांश

EXECUTIVE SUMMARY

भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल डेरी विकास कार्यक्रमों के लिए अनुसंधान और विकास (अनुसंधान एवं विकास) और मानव संसाधन विकास (एचआरडी) सहायता प्रदान करने के लिए समर्पित देश का एक प्रमुख अनुसंधान संगठन है। सन् 1923 में बंगलुरु में स्थापित, संस्थान के मुख्यालय को सन् 1955 में करनाल में वर्तमान स्थान पर स्थानांतरित कर दिया गया था। इसके दो क्षेत्रीय केन्द्र हैं, एक बंगलुरु में और दूसरा कल्याणी में। उनके क्षेत्र में कृषि-जलवायु परिस्थितियों के अनुकूल क्षेत्र-विशिष्ट सहायता प्रदान करते हैं। भाकृअनुप-राडेअनुसं को 1989 से अपने शैक्षणिक कार्यक्रमों को लागू करने के लिए एक मानद विश्वविद्यालय होने का गौरव प्राप्त है। वर्ष 2016-17, 2017-18, 2018-19, 2019-20 एवं 2020-21 में लगातार पांच बार संस्थान को 4 मानद विश्वविद्यालयों सहित भारत के सभी कृषि विश्वविद्यालयों में प्रथम स्थान दिया गया है।

संगठनात्मक संरचना

भाकृअनुप की मानद विश्वविद्यालय प्रणाली के प्रशासनिक स्वरूप के अनुरूप, विभिन्न नीति/निर्णय लेने वाले निकायों अर्थात् प्रबंधक मंडल, अनुसंधान सलाहकार समिति, अकादमिक परिषद, कार्यकारी परिषद और विस्तार परिषद के माध्यम से संस्थान का प्रबंधन होता है। निदेशक मुख्य कार्यकारी अधिकारी होते हैं, जिन्हें संयुक्त निदेशकों के द्वारा अनुसंधान, अकादमिक और विस्तार कार्यों के प्रबंधन के लिए सहायता प्रदान की जाती है। संस्थान में अनुसंधान एवं विकास गतिविधियों के तीन प्रमुख क्षेत्र अर्थात् i) डेरी उत्पादन, ii) डेरी प्रसंस्करण और iii) डेरी विस्तार/प्रबंधन हैं। सभी अनुसंधान एवं विकास गतिविधियों का तेरह अनुसंधान प्रभागों/अनुभागों के माध्यम से प्रबंधन किया जाता है, यथा पशु आनुवंशिकी एवं प्रजनन, पशुधन उत्पादन एवं प्रबंधन, पशु पोषण, चारा अनुसंधान एवं प्रबंधन, पशु शरीरक्रिया विज्ञान, पशु जैवसायन, पशु जैव प्रौद्योगिकी, डेरी प्रौद्योगिकी, डेरी अभियांत्रिकी, डेरी रसायन, डेरी सूक्ष्म जीवाणु, डेरी विस्तार एवं डेरी अर्थशास्त्र, सांख्यिकी एवं प्रबंधन। संस्थान में कृषि प्रौद्योगिकी सूचना केन्द्र (एटिक), कृषि विज्ञान केन्द्र और डेरी प्रशिक्षण केन्द्र, कृत्रिम प्रजनन अनुसंधान केन्द्र, के.वी.के., पिपराकोठी, पूर्वी चंपारण, मोतिहारी, बिहार में कृषि व डेरी विकास केंद्र एवं मॉडल डेरी केन्द्र मुजफ्फर नगर, उत्तर प्रदेश के लालुखेड़ी में है। संस्थान में केंद्रीय सुविधाओं से युक्त बुनियादी ढांचा जैसे पशुधन अनुसंधान केंद्र, चारा अनुसंधान और प्रबंधन केंद्र, पशु स्वास्थ्य परिसर, मॉडल डेरी प्लांट, प्रौद्योगिकी व्यवसाय इनक्यूबेटर, व्यवसाय योजना व विकास इकाई, दूध की गुणवत्ता और सुरक्षा के लिए राष्ट्रीय रेफरल प्रयोगशाला, प्रयोगात्मक डेरी संयंत्र, परामर्श इकाई, पुस्तकालय और राष्ट्रीय जैवसूचना केंद्र, कंप्यूटर केंद्र, संपदा अनुभाग और अनुरक्षण अभियंता अनुभाग है। प्रशासनिक कार्य जैसे खरीद, भण्डार और सुरक्षा संयुक्त निदेशक (प्रशासन) और कुलसचिव के प्रशासनिक नियंत्रण में हैं जबकि वित्त विभाग नियंत्रक(वित्त) के प्रशासनिक नियंत्रण में है। संस्थान में वर्तमान में 138 वैज्ञानिक, 168 तकनीशियन, 130 प्रशासनिक कर्मचारी और 268 कुशल सहायक कर्मचारी हैं।

बजट परिव्यय

वर्ष 2021-22 के दौरान वास्तविक व्यय के रूप में संस्थान का वित्तीय परिव्यय 23444.33 लाख रु. था एवं वर्ष 2021-22 के लिए स्वीकृत बजट 23449.96 लाख रु. था। इन आंकड़ों में क्षेत्रीय परिसरों के सुदृढीकरण के लिए वित्तीय परिव्यय भी शामिल है। 2021-22 के दौरान क्षेत्रीय परिसरों सहित संस्थान की राजस्व प्राप्तियां 1033.17 लाख रु. थीं।

ICAR-National Dairy Research Institute, Karnal is a premier research organization dedicated to provide Research and Development (R&D) and Human Resource Development (HRD) support towards dairy development programmes in the country. Established in 1923 at Bangalore, the headquarters of the Institute was moved to the present location at Karnal in 1955. It has two regional stations, one at Bengaluru and the other at Kalyani for providing region-specific support suited to their agro-climatic conditions. ICAR-NDRI has the distinction of being a Deemed University for implementing its academic programmes since 1989. The Institute has been ranked first among all Agricultural Universities of India including 4 Deemed Universities of ICAR consecutively for the five times in the year 2016-17, 2017-18, 2018-19, 2019-20 and 2021-21.

ORGANISATIONAL STRUCTURE

In consonance with the administrative pattern of the Deemed University System of the ICAR, the Institute is managed through various policy/ decision making bodies, viz. Board of Management, Research Advisory Committee, Academic Council, Executive Council and Extension Council. The Director is the Chief Executive Officer assisted by the Joint Directors for managing research, academic and extension functions. The Institute has three major areas of R & D activities viz. i) Dairy Production, ii) Dairy Processing and iii) Dairy Extension/ Management. All the R & D activities are managed through thirteen Research Divisions/ Sections, namely, Animal Genetics & Breeding, Livestock Production and Management, Animal Nutrition, Forage Research and Management, Animal Physiology, Animal Biochemistry, Animal Biotechnology, Dairy Technology, Dairy Engineering, Dairy Chemistry, Dairy Microbiology, Dairy Extension and Dairy Economics, Statistics and Management. The Institute also has an Agricultural Technology Information Centre (ATIC), Krishi Vigyan Kendra and Dairy Training Centre, Artificial Breeding Research Centre, Krishi and Dairy Vikas Kendra at KVK, PipraKothi, East Champaran, Motihari, Bihar and Model Dairy Centre at Lalukheri in Muzaffarnagar, U.P. The Institute has infrastructure consisting of central facilities such as Livestock Research Centre, Farm Section, Animal Health Complex, Small Animal House, Model Dairy Plant, Technology Business Incubator, Business Planning and Development Unit, National Referral Laboratory for Milk Quality and Safety, Experimental Dairy Plant, Consultancy Unit, Library and National Bio-informatic Centre, Computer Centre, Estate Section and Maintenance Engineering Section. The administrative functions viz. purchase, stores and security are under the administrative control of the Joint Director (Admn.) and Registrar, whereas finance division is under the administrative control of Comptroller (Finance). The Institute presently has strength of 138 scientists, 168

अनुसंधान

डेरी उत्पादन

- कृत्रिम निशेचन विधि का उपयोग करते हुए दो क्लोन्ड सांडों के वीर्य से भैंस के कुल बारह नवजात कटड़े पैदा किए गए।
- शुक्राणुजनन, उर्वरता तथा प्रारंभिक भ्रूण विकास को नियंत्रित करने वाले अणुओं का निर्धारण करने के लिए क्लोन किए गए सांडों और उनके कायिक कोशिका प्रदाता सांडों के शुक्राणुजनन का ग्लोबल ट्रांसक्रिप्टोम किया गया।
- अधिक दूध देने वाली भैंस जो कि 305 दिनों की दुग्धस्रवण अवधि में कुल 4810 किलोग्राम दूध देती है, की कायिक कोशिका का उपयोग करते हुए क्लोन मादा भैंस कटड़ी 'कर्निका (KARNIKA)' उत्पन्न की गई।
- स्वदेशी गायों के क्लोन भ्रूण उत्पन्न किए गए।
- तकनीक का उपयोग करते हुए भैंस की स्तन उपकला कोशिकाओं में बी. लैक्टोग्लोबुलिन जीन को सम्पादित किया गया।
- गोपशु अथवा मवेशी के सब क्लीनिकल थनैला एवं गर्भाशयपेशी शोध की रोकथाम के लिए एक पुनर्योजी चिकित्सा के तौर पर मिसेनकाइमल स्टेम कोशिकाओं का उपयोग किया गया।
- CRISPR/ Cas9 तकनीक का उपयोग करते हुए बकरी की स्तन उपकला कोशिकाओं को नॉक करके मानव इरिथ्रोप्रोटीन का अलग से प्रकटन हासिल किया गया।
- उर्वरता से सम्बद्ध सिग्नेचर्स के वाहक सेमीनल EVs को शुक्राणु कार्यों का नियंत्रण करने हेतु उत्तरदायी पाया गया।
- फलों साइटोमीट्रि का उपयोग करते हुए लवण एवं एंजाइम उपचारों के साथ शुक्राणु की सतह पर ग्लाइकन की गतिशीलता का मूल्यांकन किया गया।
- एशेरिकिया कोलाई एवं एस. ऑरियस के विरुद्ध कुछ सूक्ष्मजीव-रोधी पेप्टाइड्स का प्रमाणन किया गया।
- भैंस तथा गोपशु के लिए सीरम PAGs के विरुद्ध सैण्डविच एंजाइम लिंक्ड इम्यूनो सॉर्बेंट एसे (ELISA) तथा लैटरल फ्लो इम्यूनो एसे (LFIA) विकसित किए गए।
- नॉक आउट भैंस की स्तन उपकला कोशिकाओं (BuMEC) के मात्रात्मक प्रोटियोमिक्स से विभिन्न जैविक प्रक्रियाओं और प्रतिरक्षा प्रणाली में MFGE8 की भूमिका का पता चला।
- गोजातीय प्रजातियों में कॉन्सेप्टस एंडोमेट्रियल संवाद में शामिल जीनों अथवा प्रोटीनों के कार्यात्मक लक्षणवर्णन के लिए भैंस की एंडोमेट्रियल उपकला कोशिकाओं को संवर्धित किया गया।
- रतिक्रिया हेतु क्षमताशील वीर्य के उत्पादन में इनके क्षमताशील प्रयोग के लिए शुक्राणु सतह में इनकी भिन्नात्मक बाइन्डिंग के आधार पर क्षमताशील लिगेन्ड्स/ औषधि की पहचान की गई।
- भारतीय पशमीना बकरी में रेशा विकास के लिए उत्तरदायी कारकों के बारे में पता लगाने के लिए पशमीना रेशा प्रोटियोम का खुलासा किया गया।
- दूध में एशेरिकिया कोलाई का तेजी से पता लगाने के लिए गोल्ड नैनो पार्टिकल्स के आधार पर एक विज्युल जांच विकसित की गई।
- थनैला रोग के कारक मेषीसिलिन प्रतिरोधी स्टेफाइलोकोकस ऑरियस (MRSA) के जीवाण्विक जीनोम में उग्र जीनों का अध्ययन किया गया।
- PU.1 ट्रांसक्रिप्शन कारकों से फाइब्रोब्लास्ट कोशिकाओं में वायरल DNA तथा RNA सेंसर के प्रकटन में बढ़ोतरी हुई।
- भैंस के फाइब्रोब्लास्ट की कोशिका संवर्धन प्रणाली में, पॉली (1:1):C,

technicians, 130 administrative staff and 268 skilled supporting staff.

BUDGET OUTLAY

The financial outlays of the Institute in terms of actual expenditure during the year 2021-22 was Rs. 23444.33 lakhs and budget sanctioned for the year 2021-22 was Rs. 23449.96 lakhs. These figures also include the financial outlays for the strengthening of Regional Campuses. The revenue receipts of the Institute including regional campuses were Rs. 1033.17 lakhs during 2021-22.

RESEARCH

Dairy Production

- Twelve buffalo calves produced using semen of the two cloned bulls through artificial insemination.
- Global transcriptome of spermatozoa of cloned bulls and their somatic cell donor bulls was performed to determine the molecules regulating spermatogenesis, fertility and early embryonic development.
- Cloned female buffalo calf 'KARNIKA' produced using somatic cell of high milk-producing buffalo that yielded 4810 kg of milk in standard 305 days lactation.
- Cloned embryos of indigenous cows produced.
- β -lactoglobulin gene edited in buffalo mammary epithelial cells by using CRISPR/ Cas9 technique.
- Mesenchymal stem cells used as a regenerative therapy for the prevention of sub-clinical mastitis and metritis of cattle.
- Secreted expression of human erythropoietin achieved by knocking the gene in goat mammary epithelial cells by using the CRISPR/ Cas9 technique.
- Seminal EVs carrying fertility associated signatures were found responsible for regulating sperm functions.
- Glycan dynamics on sperm surface were assessed with salt and enzymes treatments using Flow cytometry.
- Few antimicrobial peptides were validated against *Escherichia coli* and *S. aureus*.
- Sandwich Enzyme Linked Immuno-sorbent Assay (ELISA) and Lateral Flow Immuno-Assay (LFIA) against serum PAGs were developed for buffalo and cattle.
- Quantitative proteomics of MFGE8 knock-out Buffalo mammary epithelial cells (BuMEC) revealed role of MFGE8 in various biological processes and immune system.
- Buffalo endometrial epithelial cells cultured for functional characterization of genes/ proteins involved in the conceptus-endometrial dialogue in the bovine species.
- Potential ligands/ drugs identified based on their differential binding to sperm surface for their potential application in the production of sexed semen.
- The pashmina fibre proteome was deciphered to understand the factors responsible for fibre development in the Indian pashmina goat.
- A visual test based on gold nanoparticles was developed for quick detection of *Escherichia coli* in milk.

- एक वायरल dsRNA। एनालॉग से डीएनए सेन्सिंग पाथवे को बढ़ावा मिलता है।
- साहीवाल गोपशु में जीनोमिक विविधता को संतुलित ($H_o=0.33\pm 0.19$) पाया गया। ROH विश्लेषण से हालिया अंतः प्रजनन घटना का पता चला।
 - गुणसूत्र 1 में सबसे लंबा आरओएच (66.92 Mb, 1241 SNPs) था जिसमें 6.68 प्रतिशत गुणसूत्र शामिल थे; जबकि गुणसूत्र 5 में आरओएच विखण्डन ($n=377$) की सबसे अधिक संख्या थी।
 - अध्ययन से पता चला कि साहीवाल गोपशु का चयन उत्पादन गुणों के साथ सकारात्मक आनुवंशिक सह-संबंध रखने वाले रेखीय टाइप गुणों (संरचना, शरीर की लंबाई, वक्ष की परिधि) के आधार पर किया जाए।
 - दस से अधिक वर्तमान पीढ़ियों (GPopSim tool) में यौनक्रिया को सीमित करने वाले गुणों के लिए गोपशु जीनोम पर डाटा का अनुकरण किया गया।
 - GEBV पूर्वानुमान पूर्वाग्रह पर विकासपरक बलों का प्रभाव भी सिमुलेटिड था। अध्ययनों से पता चला कि चयन + उच्च उत्परिवर्तन एवं रिकॉम्बिनेशन मॉडलों से पीढ़ियों में कहीं तेजी से अंतःप्रजनन संचित हुआ।
 - एक miRNA आधारित अध्ययन में थारपरकर तथा करन फ्राइज गोपशुओं के मध्य ताप दबाव में सतही तापमान और श्वसन दर में मौजूद नस्ल वार भिन्नता मौजूद थी।
 - CUX1 जीन में जीनोटाइपिंग rs43722771 (ENSBTAT0 00000 14098.6:c.1050 + 4197C > T) के लिए टेट्रा प्राइमर ARMS-PCR प्रोटोकॉल विकसित किए गए और करन फ्राइज में सभी तीनों जीनप्ररूपों की पहचान की गई लेकिन थारपरकर पशुओं में सीसी जीनप्ररूप के साथ एकलरूपीय पैटर्न प्रदर्शित हुआ।
 - डेरी पशुओं में मादाओं के प्रति लिंग अनुपात को कम करने की दिशा में एण्टीबीबीजी आधारित 'लक्षित स्थिरीकरण प्रौद्योगिकी (Targeted immobilization technology)*' विकसित की गई। स्वः पात्रे परीक्षणों में इस विकसित की गई तकनीक का उपयोग करते हुए मादाओं के प्रति लिंग अनुपात को 1:1 से घटाकर 3.16:1 किया गया।
 - डेरी गायों में जननप्रक्रिया की रिमोट निगरानी करने के लिए योनि के अंदर ताररहित सेंसर वाला एक प्रोटोटाइप विकसित किया गया।
 - मलनाड गिद्धा के जीनोम अनुक्रमण, डि नोवो एसेम्बली तथा प्रोटियोजीनोमिक व्याख्या के साथ एकीकरण ने एक नए जीन की पहचान करने में मदद की जो अभी तक सार्वजनिक रिपॉजिट्री में किसी भी गोपशु नस्ल डाटा में सूचित नहीं किया गया है।
 - भविष्य में डेरी बकरी प्रजनन के लिए एल्पाइन x बीटल तथा सानेन x बीटल बकरियों का आनुवंशिक मूल्यांकन प्रारंभ किया गया था और इस संबंध में सानेन x बीटल के कुल 1200 मेमनों पर डाटा को दर्ज किया गया।
 - सानेन x बीटल बकरियों का प्रदर्शन इस प्रकार पाया गया % टीएमवाई % 379.81 (47.2) किलोग्राम (डीएमवाई 150 %234.34 (4.7) किलोग्राम; नम औसत %1-4 किलोग्राम) झुण्ड औसत %1-21 किलोग्राम तथा दुग्धस्रवण दिवस : 238 दिन।
 - सानेन x बीटल बकरियों में प्रसव प्रचुरता का भी अध्ययन किया गया। कुल 1202 किडिंग्स में से 1814 मेमनों ने जीवित अवस्था में जन्म लिया; लिटर आकार (सीमा 1-3)। जन्म के समय भार औसत (किलोग्राम) % एकल %3.3 ± 0.63; जुड़वां : 3.0 ± 0.54; एकसाथ तीन 2.70 ± 0.57, लिटर भार : 4.81 (सीमा 1 से 10.6)।
 - उत्तराखण्ड के अनुसूचित जाति, अनुसूचित जनजाति एवं अन्य
 - The virulence genes in the bacterial genome of Mastitis-causing Methicillin-resistant *Staphylococcus aureus* (MRSA) were studied.
 - The PU.1 transcription factors increased the expression of viral DNA and RNA sensors in fibroblast cells.
 - In a cell culture system of buffalo fibroblasts, Poly (I:C), a viral dsRNA analogue, promotes DNA sensing pathways.
 - Genomic diversity in Sahiwal cattle of NDRI herd found to be moderate ($H_o = 0.33 \pm 0.19$). ROH analysis indicated a recent inbreeding event.
 - Chromosome 1 had longest ROH (66.92 Mb, 1241 SNPs), covering 6.68% of chromosome; while Chromosome 5 had highest number of ROH segments ($n = 377$).
 - Studies revealed that Sahiwal cows may be selected on the basis of these linear type traits (stature, body length, chest girth) having positive genetic correlation with production traits.
 - The data on cattle genome were simulated for sex limited traits over 10 current generations (GPopSim tool). Impact of evolutionary forces on GEBV prediction bias was also simulated. The studies indicated that Selection + High mutation and Recombination models rapidly accumulated inbreeding over generations.
 - In a miRNA based study, breed wise variation existed in Surface Temperature and Respiration Rate in heat stress between Tharparkar and Karan Fries cattle.
 - Tetra-primer ARMS-PCR protocols were developed for genotyping rs43722771 (ENSBTAT0000001 4098.6:c.1050+4197C>T) in CUX1 gene and all the three genotypes identified in Karan Fries. But Tharparkar animals showed monomorphic pattern with CC genotype.
 - Antibodies based "Targeted immobilization technology" was developed to skew the sex ratio towards females in dairy cattle. The sex ratio was skewed towards females from 1:1 to 3.16:1 using the developed technology in *in-vitro* trials.
 - A prototype of intravaginal wireless sensor was developed device for remote monitoring of calving process in dairy cows.
 - Sequencing, *de-novo* assembly and integrating with proteogenomic annotation of the genome of Malnad Gidda identified a novel gene which is not yet reported in any of the cattle breed data in the public repositories.
 - Genetic evaluation of Alpine x Beetal and Saanen x Beetal goats for prospective dairy goat breeding was initiated and data on 1200 kids of Saanen x Beetal were recorded.
 - Performance of Saanen x Beetal goats was found to be: TMY: 379.81 (47.2) kg; DMV150: 234.34 (4.7) kg; Wet average: 1.4 kg; Herd average: 1.21 kg and Days in milk: 238 days
 - Prolificacy in SxB goats was also studied. Out of 1202 kiddings, 1814 kids born: 1.51 litter size (range 1-3).

समुदाय द्वारा संरक्षित पर्वतीन गोपशु (बद्री) में उत्पादकता को बढ़ाने के लिए परिवार का आकार, फसल पैटर्न, भूमि पैटर्न, झुण्ड का आकार, उत्पादन पैरामीटरों, फीडिंग, उपचार, रोगों के विरुद्ध टीकाकरण, रूग्णता एवं मृत्युदर के संबंध कुल 71 प्रतिवादियों से आधारीय डाटा संकलित किया गया।

- अनुसूचित जाति समुदाय में बद्री नस्ल के पशुपालकों की सूची तैयार की गई और उन्हें एंजाइम पाउडर (5 किलोग्राम), खनिज मिश्रण (2.5 किलोग्राम), डिवाॅर्मर (1 पैकेट), घाव को उपचारित करने वाला स्प्रे, इकबॉलिक (500 मिलि.), लिवर बूस्टर (500 मिलि.) तथा ब्लॉट गॉर्ड को शामिल करते हुए कुल 120 थैले उपलब्ध कराए गए।
- स्वदेशी गोपशु परियोजना की अखिल भारतीय समन्वित अनुसंधान परियोजना के अंतर्गत साहीवाल गोपशु के पैरामीटर इस प्रकार थे : वर्ष 2021 में औसत एएफसी (1290.65 ± 45.22 दिन), एएलएमवाई (1596.71 ± 79.23 किलोग्राम), टीएलएमवाई (1961.07 ± 77.0 किलोग्राम), पीवाई (10.37 ± 0.31 किलोग्राम), एलएल (320.97 ± 3.47 दिन), डीपी (103.32 ± 0.31 दिन), सीआई (432.64 ± 7.64 दिन), एसपी (160.27 ± 23.06 दिन), डब्ल्यूए (7.6 किलोग्राम) एवं डीए (4.5 किलोग्राम)।
- चयनित नरों का ईपीडी 4.66 प्रतिशत था और मादा का सर्वश्रेष्ठ दुग्ध उत्पादन 3967 किलोग्राम दर्ज किया गया जबकि इसके मुकाबले में झुण्ड में औसत दुग्ध उत्पादन 2128 किलोग्राम ही दर्ज किया जा सका।
- साहीवाल नस्ल की कुल 196 मादाओं में से 47 की पहचान श्रेष्ठ गायों के तौर पर की गई। श्रेष्ठ साहीवाल गायों में प्रथम 305 – दुग्धस्रवण उपज, सर्वश्रेष्ठ दुग्धस्रवण दुग्ध उपज तथा सर्वश्रेष्ठ ईपीए को क्रमशः 4012 किलोग्राम, 4424 किलोग्राम एवं 2486 किलोग्राम दर्ज किया गया जबकि इसकी तुलना में झुण्ड का औसत 2118 किलोग्राम ही पाया गया।
- भैंस सुधार – संस्थान इकाई पर नेटवर्क परियोजना के अंतर्गत विभिन्न उत्पादन गुणों के लिए मुर्राह (राष्ट्रीय डेरी अनुसंधान संस्थान) में वास्तविक समलक्षणी एवं जीनप्ररूपी वृद्धि का अनुमान लगाया गया जैसे MY (किलोग्राम) (10.98 ± 2.345; 0.39 ± 0.352); TLMY (किलोग्राम), 11.05 ± 2.892, 0.575 ± 0.458); (AFC (माह) (0.009 ± 0.027; -0.008 ± 0.004); LL (दिवस) (-0.12 ± 0.307; 0.008 ± 0.023); WA (ग्राम), 320 ± 0.7, 20.0 ± 0.001)।
- गुणों को क्रमशः 48 प्रतिशत, 30 प्रतिशत, 1 प्रतिशत, 1 प्रतिशत एवं 20 प्रतिशत की भारिता देते हुए क्रमशः औसत दैनिक दुग्ध उपज, पीवाई, एसपी, एएफसी तथा मादा उर्वरता के आधार पर मुर्राह भैंस में एक चयन सूचकांक का विकास किया।
- सूचकांक मान = 56.733 (ADMY) + 35.588 (PY) - 1.473 (SP) - 1.341 (AFC) - 23.407 (FF) A विभिन्न जांच दिवसों को आबंटित भारिता के साथ मॉडल विकसित किया गया जहां टीडी 90, टीडी 106 तथा टीडी 150 का उपयोग अंतर्राष्ट्रीय सीएआर विधि के साथ 90 प्रतिशत सह-संबंध के साथ दुग्ध उपज का पूर्वानुमान करने में किया जा सकता है।
- भैंस सुधार – खेत इकाई पर नेटवर्क परियोजना के अंतर्गत अंगीकृत किए गए गांवों में 46.74 के सीआर के साथ 4,281 एआई को अपनाया गया। औसत एएफसी को 48.56 माह तथा टीडीवाई को 8.07 किलोग्राम दर्ज किया गया।
- भारत की भेड़ नस्लों में ओवार – एमएचसी विभिन्नता का खुलासा किया गया तथा बहुरूपिता अध्ययन के लिए पीसीआर – एसबीटी का उपयोग कर तीन हाइपर भिन्न जीनों खडीआरबी 1 (301bp), डीक्यूए 1 (269bp) तथा डीक्यूए 2 (242bp), के विखण्डनों को लक्षित किया गया

Birth weight average (kg): Single: 3.3 ± 0.63; Twin: 3.0 ± 0.54; Triplet: 2.70 ± 0.57 Litter weight: 4.81 (range 1 to 10.6)

- For the productivity enhancement in Hill Cattle (Badri) conserved by SC, ST and other communities of Uttarakhand, baseline data were collected from the respondents (71) regarding Family Size, Crop Pattern, Land size, Herd Size, Production Parameters, Feeding, Treatment, Vaccination against diseases, Morbidity and Mortality.
- List of Badri keepers from SC community was prepared and 120 bags comprised of Enzyme powder (5kg), Mineral Mixture (2.5 kg), Dewormer (1 pkt), Wound healing Spray, Ekbovic (500ml), Liver booster (500ml) and Bloat guard were given as critical inputs.
- Under the AICRP of Indigenous Cattle project, the performance parameters of Sahiwal cattle were: the average AFC (1290.65 ± 45.22 days), FLMY (1596.71 ± 79.23 kg), TLMY (1961.07 ± 77.0 kg), PY (10.37 ± 0.31 kg), LL (320.97 ± 3.47 days), DP (103.32 ± 0.31 days), CI (432.64 ± 7.64 days), SP (160.27 ± 23.06 days); WA (7.6 kg) and DA (4.5 kg) in the year 2021.
- EPD% of the selected males was 4.66% and average of Dam's best lactation yield was 3967 kg against herd average of 2128 kg.
- Out of 196 Sahiwal females, 47 were identified as elite cows. Among the elite Sahiwal cattle, the first 305-LY, best lactation milk yield, and best EPA were 4012 kg., 4424 kg, and 2486 kg against herd average of 2118 kg.
- Under the Network project on buffalo improvement-Institute Unit, Actual phenotype and Genotype gain were estimated in Murrah (NDRI) for various production traits; viz. 305 MY (kg) (10.98 ± 2.345; 0.39 ± 0.352); TLMY (kg) (11.05 ± 2.892, 0.575 ± 0.458); (AFC (month) (0.009 ± 0.027; -0.008 ± 0.004); LL (days) (-0.12 ± 0.307; 0.008 ± 0.023); WA (gm) (320 ± 0.7, 20.0 ± 0.001)
- A Selection Index in Murrah buffalo was developed based on average. Daily Milk Yield, PY, SP, AFC and Female Fertility giving 48%, 30%, 1%, 1% and 20% weightage to the traits, respectively as: Index Value = 56.733 (ADMY) + 35.588 (PY) - 1.473 (SP) - 1.341 (AFC) - 23.407 (FF), The developed model with assigned weights to different test days, where TD90, TD106, and TD150 can be used to predict lactation yield with 90% correlation with the Intl. CAR method.
- Under the Network project on buffalo improvement - Field Unit, 4, 281 AI with CR of 46.74% were performed in 16 adopted villages. Average AFC was recorded 48.56 months and TDY was 8.07 kg.
- Deciphering the Ovar-MHC Variability in sheep breeds of India, segments of three hyper variable genes [DRB1 (301bp), DQA1 (269bp) and DQA2 (242bp)] were targeted using PCR-SBT for polymorphism study and a large polymorphism was identified in DRB1 (29 old/ 10 new alleles; 115 sequences), DQA1 (13 old/ 5 new

- और डीआरबी 1 (29 पुराने/10 नए युग्मविकल्पी; 115 अनुक्रम), डीक्यूए 1 (13 पुराने/5 नए युग्मविकल्पी; 133 अनुक्रम); डीक्यूए 2 (18 पुराने/4 नए युग्मविकल्पी; 143 अनुक्रम) में दीर्घ बहुरुपिता की पहचान की गई और इसे एनसीबीआई में प्रस्तुत किया गया।
- ताप निरपेक्ष तथा शीत दबाव के दौरान चिन्हित बकरी के दूध में उपापचय का उपयोग दूध देने वाली बकरियों में तापीय दबाव को मापने के लिए क्षमताशील जैव मार्करों के तौर पर किया जा सकता है।
 - एपिटोप विशिष्ट एंटीबॉडीज का उपयोग करते हुए bAMH (गोजातीय मुलेरियन-रोधी हार्मोन) के विरुद्ध एक नवीन अत्यधिक संवेदनशील और सटीक एलाइजा का विकास किया गया। साहीवाल और थारपरकर नस्लों में पहली बार bAMH (गोजातीय मुलेरियन-रोधी हार्मोन) का आयु विशिष्ट लक्षणवर्णन किया गया।
 - गर्भवती गायों में सूक्ष्म पोषक तत्वों की आपूर्ति करने पर कोलोस्ट्रम (खीस अथवा पीयूश) उपज, जीवनक्षमता तथा प्रतिशत मैक्रोफेज में उल्लेखनीय ($P < 0.05$) रूप से बढ़ोतरी दर्ज की गई और साथ ही इनमें कोलोस्ट्रम (खीस अथवा पीयूश) में प्लाज्मा कॉर्टिसोल स्तर में उल्लेखनीय रूप से कमी देखने को मिली।
 - साहीवाल नस्ल में नवजात के जन्म से लेकर पांच दिनों की अवधि के दौरान माता के साथ पूरी तरह सम्पर्क बनाने, स्वैच्छिक तौर पर खीस को चूसने और तदुपरान्त माता के साथ चारदीवारी सम्पर्क बनाने पर 21 दिनों की अवधि तक दूध फीडिंग (शरीर भार का 15 प्रतिशत) में और चूसने की आवृत्ति (एक दिन में तीन बार) में बढ़ोतरी देखने को मिली जिससे साहीवाल नवजात के वृद्धि, स्वास्थ्य और कल्याण में उल्लेखनीय सुधार देखने को मिला।
 - चारदीवारी लाइन में रखे गए नवजात बछड़ों/बछड़ियों के साथ रखी गई प्रसवोत्तर साहीवाल गायों के मदकाल व्यवहार, मदकाल सघनता और प्रजनन प्रदर्शन के प्रकटन में चारदीवारी लाइन सांड सम्पर्क का अवसर प्रदान कर जैव अनुकरण द्वारा उल्लेखनीय सुधार देखने को मिला।
 - एपिटोप आधारित पेप्टाइड निर्देशित एंटीबॉडीज का उपयोग करके VMO1 प्रोटीन के लिए एक अप्रत्यक्ष एलाइजा ELISA (iELISA) का विकास किया गया और भैंस में मदकाल/मौन मदकाल की सटीक तरीके से पहचान करने के लिए ऑन-स्पॉट टूल का विकास करने हेतु गर्भधारण का साक्ष्य विकसित किया गया।
 - भैंस में मदकाल प्रारंभ होने का सटीक तरीके से पता लगाने के लिए मूत्र फर्न पैटर्न विश्लेषण को एक आशाजनक टूल के रूप में पाया गया।
 - सांडों पर किए गए अध्ययनों में पता चला कि उनकी वीर्य गुणवत्ता प्रभावित नहीं हुई जबकि सात सांडों की वीर्य गुणवत्ता पर विशाषकर गर्म-शुष्क तथा गर्म-आर्द्र मौसम का प्रभाव देखने को मिला। आमतौर पर, सांडों की वीर्य गुणवत्ता वसंत के मौसम में सबसे अच्छी बनी रही जबकि तदुपरान्त क्रमशः सर्दी, गर्म-शुष्क तथा गर्म-आर्द्र मौसम में पाई गई। गरमी मौसम (गर्म-शुष्क तथा गर्म-आर्द्र) की तुलना में शीत तथा वसंत मौसम में, कहीं अधिक संख्या में सांडों द्वारा गुणवत्तायुक्त वीर्य उत्पन्न किया गया।
 - उच्च तथा कम उर्वर सांड और कम मात्रा में परिरक्षण के लिए उच्च उर्वर स्खलन का मूल्यांकन करने के लिए तकनीक विकसित की गई। गोपशुओं और भैंस की विभिन्न नस्लों के लिए कम मात्रा परिरक्षण (5×10^6) हेतु तनुकारक और परिरक्षण प्रोटोकॉल विकसित किए गए। खेत परिस्थितियों में 8 मिलियन शक्राणु मात्रा तक सफल उर्वरता प्रमाणन किया गया।
 - वीर्य की विशेषताओं और स्वः पात्रे शक्राणु उर्वरता मूल्यांकन के लिए उच्च उर्वर साहीवाल तथा मुर्ह सांडों में मौसम और खुरपका एवं alleles; 133 sequences); DQA2 (18 old/ 4 new alleles; 143 sequences) submitted to NCBI.
 - Metabolites in goat milk identified during thermoneutral and cold stress can be used as potential biomarkers for measuring thermal stress in lactating goats.
 - A novel highly sensitive and precise ELISA was developed against bAMH (bovine antimullerian hormone) using epitope specific antibodies. Age specific characterization of bAMH was done for the first time in Sahiwal and Tharparkar breeds.
 - Supplementation of micronutrients to pregnant cows significantly ($P < 0.05$) increased the colostrum yield, viability and percentage macrophages and decreased plasma cortisol levels in the colostrum of supplemented cows.
 - Full mother contact, voluntary colostrum suckling during birth to five days followed by fence-line mother contact, enhanced milk feeding (15% of body weight), and increased suckling frequency (3 times a day) up to 21 days remarkably improved the growth, health and welfare of Sahiwal calves.
 - The expression of estrus behaviour, estrus intensity and the reproductive performance of postpartum Sahiwal cows housed in fenceline calf contact were remarkably improved by bio-stimulation through exposure to a fence-line bull contact.
 - An indirect ELISA (iELISA) for VMO1 protein was developed using epitope-based peptide-directed antibodies and a proof of concept was developed for development of on-spot tool for accurate identification of estrus/ silent estrus in buffaloes.
 - Urine fern pattern analysis was found as a promising tool to accurately identify onset of the estrus in buffaloes.
 - Semen quality was superior in spring season followed by winter, hot-dry and hot-humid seasons. In winter and spring seasons, more number of bulls produced quality semen compared to summer season (hot-dry and hot-humid).
 - Technology was developed to assess high and low fertile bull and high fertile ejaculates for low dose preservation. Dilutors and preservation protocol for low dose preservation (5×10^6) were developed for different breeds of cattle and buffaloes. Successful fertility validation was done up to 8 million sperm dose in field conditions.
 - Effect of season and FMD vaccination was studied in high fertile and low fertile Sahiwal and Murrah bulls for semen characteristics and *in vitro* sperm fertility evaluation. Expression of selected sperm fertility related genes (CRISP2, PRM1, CCT5 and CCT8) was affected maximum after 15 days of vaccination and was returned back to pre vaccination range after 45 to 60 days of vaccination.
 - Infra Red Thermography (IRT) can be used as a

मुंहपका रोग टीकाकरण के प्रभाव का पता लगाने के लिए अध्ययन किया गया। टीकाकरण के 15 दिनों बाद चयनित शक्राणु उर्वरता संबंधी जीनों (CRISP2, PRM1, CCT5 तथा CCT8) का प्रकटन सर्वाधिक प्रभावित था जो कि टीकाकरण के 45 से 60 दिनों के उपरान्त टीकाकरण करने से पूर्व की स्थिति में पाया गया।

- मदकाल के दौरान साहीवाल गायों में बिना प्रसव वाली बछिया तथा प्रसव कर चुकी गायों दोनों में योनि तापमान में हो रही बढ़ोतरी की निगरानी करने के लिए इन्फ्रा रेड थर्मोग्राफी (IRT) का उपयोग एक सहायी टूल के तौर पर किया जा सकता है। आईआरटी तकनीक का उपयोग करते हुए साहीवाल नस्ल की गायों में औसत ± 0.5 SD के योनि तापमान की सीमा पर 70 प्रतिशत पॉजीटिव मदकाल घटनाओं और औसत ± 1.0 SD के योनि तापमान की सीमा में 60 प्रतिशत पॉजीटिव मदकाल घटनाओं की पहचान की जा सकती है।
- आईआरटी तकनीक का उपयोग साहीवाल गायों और मुराह भैंस में उप-क्लीनिकल थनैला रोग की पहचान करने हेतु एक सहायी टूल के तौर पर किया जा सकता है।
- दूध देने वाली मुराह भैंस में जैव प्रबलित गेहूँ पुआल को आहार के रूप में खिलाने पर पोषक तत्व उपयोगिता, दूध उपज तथा इसकी गुणवत्ता में गैर उल्लेखनीय भिन्नता देखने को मिली।
- आहार में 12 प्रतिशत सान्द्र की दर पर एम. ऑलिफेरा पत्ती भोजन और हर्बल गैलेक्टोगोगस मिश्रण (प्रति गाय प्रतिदिन 60 ग्राम की दर पर 1:1:1 के अनुपात में शतावरी, मेथी तथा जिवांती) को अकेले अथवा संयोजन में शामिल करने पर साहीवाल गायों के उत्पादन एवं प्रजनन प्रदर्शन में सुधार देखने को मिला। मोरिंगा ऑलिफेरा तथा हर्बल गैलेक्टोगोगस को शामिल करने से गोपशुओं में न केवल प्रतिरक्षा बढ़ोतरी हुई वरन् रोग प्रकोप में भी कमी देखने को मिली।
- बारबरी बकरियों के आहार में एम. ऑलिफेरा पत्ती आहार के साथ 50 प्रतिशत सान्द्र मिश्रण का प्रतिस्थापन करने पर जहां एक ओर बकरियों में पोषक तत्व उपयोगिता, रूधिरविज्ञान पैरामीटरों में सुधार देखने को मिला वरन् डेरी आधारित पालन प्रणाली के तहत अच्छे आर्थिक लाभ के साथ उत्पादन प्रदर्शन में भी सुधार आया।
- डेरी आधारित एकीकृत खेती प्रणाली से रिपोर्टेड अवधि के दौरान रुपये 3,63,595/- का शुद्ध लाभ अर्जित किया गया। इसमें डेरी उद्यम का योगदान शुद्ध आय में 54.63 प्रतिशत था जबकि खाद्य फसलों, चारा फसलों तथा सहायी उद्यमों का योगदान क्रमशः 15.32, 17.35 एवं 12.70 प्रतिशत था। परिणामों से यह सुझाव मिलता है कि डेरी आधारित एकीकृत खेती प्रणाली मॉडल से न केवल उत्पादन और लाभप्रदता में ही बढ़ोतरी होती है वरन् इससे दूध और अण्डों की नियमित आपूर्ति के माध्यम से खाद्य एवं पौषणिक सुरक्षा भी सुनिश्चित होती है, कृषक परिवारों को वर्षभर रोजगार मिलता है और साथ ही इसमें उत्पादन प्रणाली की संसाधन उपयोग प्रभावशीलता एवं अनुकूलनता को बढ़ाने की क्षमता भी है।
- प्रत्येक पशु में प्रतिदिन 50 ग्राम की दर पर खनिज मिश्रण की आपूर्ति करने पर खेत परिस्थितियों के तहत गायों व भैंस के उत्पादन प्रदर्शन में सुधार देखने को मिला।
- वर्ष 2021 के दौरान संस्थान के एलपीएम प्रभाग के एबीआरसी द्वारा तरल एवं हिमीकृत वीर्य की बिक्री करके रुपये 26,08,530/- का राजस्व अर्जित किया गया। इसी प्रकार प्रजनक सांडों की बिक्री करके भी कुल रुपये 9,33,616/- का राजस्व अर्जित किया गया।
- आधारीय स्तर से ऊपर विशिष्ट ट्रेस खनिजों (जिंक, कॉपर, मैंगनीज तथा क्रोमियम) की आपूर्ति करने पर कहीं बेहतर प्रति-ऑक्सीकारक स्थिति, प्रतिरक्षा तथा वृद्धिशील नर बछड़ों का समग्र स्वास्थ्य

supportive tool to monitor increase in vulva temperature in both cyclic heifers and cyclic multiparous animals of Sahiwal cows during estrus. 70 % of true positive estrus events can be identified at threshold of vulval temperature of Mean \pm 0.5 SD and 60 % of true positive can be identified at threshold of vulval temperature of Mean \pm 1.0 SD in Sahiwal cows using IRT.

- IRT can be used as a supportive tool for identification of Sub-clinical mastitis in Sahiwal cows and Murrah buffaloes.
- Non-significant difference was observed in nutrient utilization, milk yield and its quality by feeding of biofortified wheat straw to lactating Murrah buffaloes.
- The dietary inclusion of *Moringa* leaf meal @12% of concentrate and herbal galactogogues mixture (Shatavari, Fenugreek and Jivanti in the ratio of 1:1:1 @60g/ day/ cow) alone or in combination improved production and reproduction performance of Sahiwal cows. Inclusion of *Moringa oleifera* and herbal galactogogues not only enhanced immunity but also reduced disease incidence.
- Replacement of 50% of concentrate mixture with *M. oleifera* leaf meal in the ration of Barbari goats improved the nutrient utilization, hematological parameters and increased the production performance with good economic returns under dairy based farming system.
- The net return of Rs. 3,63,595/- was obtained during the period under report from the dairy based IFS. The contribution of dairy enterprise was 54.63 %, whereas food crops, fodder crops and subsidiary enterprises contributed 15.32, 17.35 and 12.70 %, respectively to the net income. The results suggest that dairy based IFS model not only increases the production and profitability but also ensures the food and nutritional security through regular supply of milk and eggs, provides round the year employment to the farm families, and has potential to increase resource use efficiency and resilience of the production system.
- Mineral mixture supplementation @50g/ day/ animals improved the production performance of cows and buffaloes under field conditions.
- Animal Breeding Research Center (ABRC) generated Rs. 26,08,530/- as revenue through the sale of liquid and frozen semen and of Rs. 9,33,616/- through the sale of breeding bulls during 2021.
- Supplementation of specific trace minerals (zinc, copper, manganese and chromium) above the basal level proved better anti oxidant status, immunity, and overall health of the growing male calves without altering digestibility of nutrients and growth performance.
- The paddy straw may be used efficiently for silage production and prevent the environmental pollution. Paddy straw was ensiled with brewer's grains and peapods (pea canning waste); in the ratio of 35:50:15 for 30, 40, and 50 days duration. Exogenous fibrolytic enzyme, homofermentor bacteria (*Lactobacillus*

हासिल किया गया और साथ ही इसमें पोषक तत्वों की पाचनीयता एवं वृद्धि प्रदर्शन पर भी किसी प्रकार का बदलाव देखने को नहीं मिला।

- सिलेज उत्पादन के लिए धान पुआल का उपयोग प्रभावी रूप में किया जाए और साथ ही पर्यावरणीय प्रदूषण को रोका जाए। धान पुआल को शराब तैयार करने वाले अनाज दानों और मटर की फलियों (मटर कैनिंग अपशिष्ट) के साथ 30, 40 तथा 50 दिनों की अवधि के लिए 35:50:15 के अनुपात में मिलाया जाता था। स्ट्रालेज सामग्री में बहिर्जात फाइब्रोलाइटिक एंजाइम, होमोफर्मन्टर जीवाणु (लैक्टोबैसिलस प्लाण्टेरम एनसीडीसी 221) तथा हिटेरोफर्मन्टर जीवाणु (लैक्टोबैसिलस फर्मन्टम एनसीडीसी 412) को शामिल किया गया। मिलाने के 50वें दिन पर सबसे अच्छी गुणवत्ता वाली स्ट्रालेज तैयार हुई। बॉस इण्डिकस नवजात बछड़ों/कटड़ों में से कुल 11 लिगिलैक्टो बैसिलस सैलीवेरियस स्ट्रेन को अलग किया गया और स्व: पात्रे विशेषताओं के आधार पर प्रोबायोटिक क्षमता के लिए इनका लक्षणवर्णन किया गया।
- इलेक्ट्रोहाइड्रो गतिशील संपुटित प्रोबायोटिक्स, लैक्टोप्लाण्टी बैसिलस प्लाण्टेरम सीआरडी 7 तथा लैक्टोकैसीबैसिलस रैमोसस सीआरडी 11 को खाद्य प्रयोग के लिए और साथ ही बछड़ों/बछड़ियों में योज्य के रूप में प्रयोग करने के लिए उत्पन्न किया गया।
- करन फ्राइज नस्ल के नवजात पशुओं के आहार में 10 पीपीएम के स्तर पर निकल की अनुपूर्ति करने का पोषक तत्व की उपयोगिता और खाद्य रूपांतरण दर पर कोई प्रभाव नहीं पड़ा।
- सोडियम सल्फेट की 0.30 प्रतिशत स्तर पर अनुपूर्ति करने पर औसत दैनिक वृद्धि, खाद्य रूपांतरण दर तथा डीएम, सीपी एवं एनडीएफ की पाचनीयता में सुधार देखने को मिला जबकि अन्य समूहों की तुलना में मीथेन उत्सर्जन में 14.7 प्रतिशत तक की कमी देखने को मिली।
- गर्म तथा आर्द्र परिस्थितियों के अंतर्गत रक्त के जैव रासायनिक तथा शरीरक्रिया विज्ञान पैरामीटरों को प्रभावित किए बिना ही बकरों में खाने योग्य कांटारहित कैक्टस द्वारा मक्का चारे को पूरी तरह से प्रतिस्थापित किया जा सका।
- डेरी गायों में कुशल प्रजनन प्रबंधन के लिए यौवन प्रारंभ होने तथा प्रसवोत्तर चक्रीयता पर बायपास वसा के प्रभाव की संभावना का पता लगाया गया।
- कैप्राइन प्रजातियों में फॉलीकुलर गतिशीलता पर बहिर्जात किसपेप्टिन के प्रभाव का पता लगाया गया।
- कैप्राइन प्रजातियों में प्रजनन को नियंत्रित करने वाले जीनों की पहचान की गई और प्राथमिकता दी गई।
- संकर नस्ल की गायों में प्रजनन चक्र के दौरान फॉलीकुलर तरंगों और SMIM20, GPR173 जीनों के ट्रांसक्रिप्टस की प्रचुरता से PNX-FSH पीक के आविर्भाव को सम्बद्ध किया गया।
- संवर्धन मीडिया में वृद्धि कारकों के साथ सम्पूरित अपरिपक्व गोपशु अंडाणुओं की विकास क्षमता में वृद्धि की गई।
- भारत के पूर्वी क्षेत्र में उत्पादकता के संवर्धन हेतु ब्लैक बंगाल बकरियों में सुधार किया गया।
- नवजात बछड़ों में दस्त के कारक रोगजनक ई. कोलाई के विरुद्ध रसोई में उपलब्ध जड़ी बूटियों का रोग निरोधी उपयोग किया गया।
- पशुधन आधारित एकीकृत खेती प्रणाली के माध्यम से सुन्दरबन क्षेत्र में प्रतिकूल मौसमी घटनाओं के लिए रणनीतियां तैयार करना।
- अध्ययनों में भैंस में मदकाल की पहचान के लिए मूत्र में एक क्षमताशील जैव मार्कर miR-99a-5p की उपस्थिति का पता चला।

plantarum NCDC 221), and heterofermentor bacteria (*Lactobacillus fermentum* NCDC 412) were added to the strawlage materials. Best quality strawlage was formed at day 50 of ensiling. Eleven *ligilactobacillus salivarius* strains were isolated from *Bos indicus* calves and characterized for probiotic potential based on in vitro attributes.

- Electrohydrodynamic encapsulated probiotics, *Lactiplantibacillus plantarum* CRD7 and *Lactocaseibacillus rhamnosus* CRD11 were produced for food application as well as for application as additives in calves. Nickel supplementation at 10 ppm level in the diet of Karan Fries male calves did not influence nutrient utilisation and feed conversion ratio.
- Supplementation with sodium sulphate at 0.30% level improved average daily gain, feed conversion ratio, digestibility of DM, CP and NDF while enteric methane emission was found to be lower to the extent of 14.7% as compared to other groups.
- Edible spineless cactus could replace maize fodder fully in male goats without affecting blood biochemical and physiological parameters under hot and humid conditions.
- Effect of bypass fat on onset of puberty and postpartum cyclicity was explored for efficient reproductive management in dairy cows.
- Effect of Exogenous Kisspeptin on Follicular Dynamics in Caprine Species was explored.
- Identified and Prioritized the Genes Regulating Reproduction in Caprine Species.
- Associated the emergence of PNX-FSH peaks to follicular waves and abundance of transcripts of the SMIM20 and GPR173 genes during reproductive cyclicity in crossbred cows.
- Developmental competence enhancement of immature cattle oocytes supplemented with growth factors in culture media.
- Improvement of Black Bengal goats for enhancement of productivity in eastern region of India.
- Effect of dietary chromium supplementation on nutrient utilization and growth performance in Black Bengal goats.
- Prophylactic use of kitchen herbs against pathogenic *E coli* causing calf diarrhoea.
- Formulating coping up strategies for extreme weather events in Sundarbans region through livestock based Integrated Farming System.
- Studies revealed miR-99a-5p in the urine as a potential biomarker for estrus identification in buffalo.
- Salivary ferning based estrus identification method was validated in a large population of buffaloes in the field conditions.
- Organochlorine pesticide dieldrin increases estrogen production by up-regulating proximal promoter (Pll) driven CYP19A1 gene expression in granulosa cells.

- खेत परिस्थितियों में भैंस की एक बड़ी संख्या में सैलीवरी फर्निंग आधारित मदकाल पहचान विधि का प्रमाणन किया गया।
- ऑर्गनोक्लोरीन कीटनाशक डाइलड्रिन द्वारा ग्रेनुलोजा कोशिकाओं में समीपस्थ प्रोमोटर (PII) संचालित VYP 19 A 1 जीन प्रकटन को विनियमित करके एस्ट्रोजन उत्पादन बढ़ाया जाता है।
- बी. कैजीन से उत्पन्न पेप्टाइड C द्वारा ऑस्टियोजेनिक पोस्ट ट्रांसक्रिप्शनल नियामक, microRNA-592(miR592) के प्रकटन को अधो निगमित किया गया जो BMP7/ सिग्नलिंग कैस्केड को लक्षित करते हुए अस्थिजनन को रोकता है।
- मूसक मॉडल में कैजीन प्रोटीन की तुलना में छाछ अथवा मट्टा प्रोटीन की मोटापा-रोधी तथा मधुमेह रोधी विशेषता पाई गई। प्रोबायोटिक्स का उपयोग करके निश्चित किए गए छाछ अथवा मट्टा प्रोटीन और सोया प्रोटीन अपनी मोटापा रोधी और मधुमेह रोधी विशेषताओं के संबंध में तुलनीय पाए गए।
- लैक्टोबैसिलस फर्मन्टम (MTCC 5898) आधारित तैयारी ने कठोर अथवा तंग जंकशन, मैट्रिक्स स्थिरीकरण और त्वचा उपकला कोशिकाओं के प्रति-ऑक्सीकारक जीनों के ट्रांसक्रिप्शनल प्रकटन में उल्लेखनीय बदलाव प्रदर्शित किए।
- कोलोस्ट्रम अथवा खीस या पीयूष के उत्पादन के लिए प्रसव पूर्व गायों में किए गए हस्तक्षेप के बावजूद प्रतिरक्षा दमन वाले चूहों को गोजातीय का कोलोस्ट्रम अथवा खीस या पीयूष खिलाने से प्रतिरक्षा में सुधार देखने को मिला।
- कैजीन तथा छाछ प्रोटीन हाइड्रोलेट्स (P, T, C, PT, PC, TC & PTC) में पैन्क्रियाटिक लिपेज एंजाइम का निरोध करके मोटापा-रोधी क्षमता प्रदर्शित हुई।
- भैंस में न्यूक्लियर जीनोम और माइटोकॉण्ड्रियल tRNAs से माइटोकॉण्ड्रियल प्रोटीन कोडिंग जीनों के प्रकटन पर ऊतक विशिष्ट प्रभाव पाए गए।
- भैंस के विभिन्न ऊतकों में माइटोकॉण्ड्रिया सम्बद्ध miRNAs की पहचान की गई।
- अध्ययनों से यह साबित हुआ कि माइटोकॉण्ड्रियल डीएनए हैप्लोटाइप्स से भैंस की प्रजनन प्रभावशीलता प्रभावित होती है।

डेरी प्रसंस्करण

- जैव सक्रिय प्रोटीनों और पेप्टाइड्स से तैयार किए गए फार्मुलेशन में वीनिंग मूसक मॉडल में उपचार पूर्व तथा उपचार उपरांत दोनों में ई. कोलाई MTCC 723 के विरुद्ध दस्त रोधी गतिविधि प्रदर्शित हुई।
- लैक्टिक संवर्धन (1 प्रतिशत) एवं खमीर अथवा यीस्ट संवर्धन (3 प्रतिशत) के संयोजन के साथ जैव कार्यात्मक लैक्टिक-खमीर अथवा खमीर किण्वित दूध तैयार किया गया।
- जैव कार्यात्मक लैक्टिक-खमीर अथवा यीस्ट किण्वित दूध में प्रति-ऑक्सीकारक, प्रति-सूक्ष्मरोधी और एसीई-निरोधक गतिविधि थीं।
- सूक्ष्मजीव किण्वन द्वारा कोलोस्ट्रम अथवा खीस या पीयूष छाछ प्रोटीनों से उत्पन्न जैव सक्रिय पेप्टाइड में सूक्ष्मजीव रोधी, प्रतिरक्षा तथा प्रति-ऑक्सीकारक गतिविधि थीं।
- गैर किण्वित छाछ में 1-305 µg/ उस की पेप्टाइड मात्रा के मुकाबले में 48 घंटे के उपरान्त किण्वित छाछ में पेप्टाइड की मात्रा में 16-314 µg/mL तक की बढ़ोतरी देखने को मिली।
- बी. सेरियस ATCC 13061 (24.33mm), ई. कोलाई ATCC 2592 (20.66 mm), ई. फेकैलिस ATCC 27736 (19.66 mm) तथा एस. ऑरियस (18.66mm) के विरुद्ध <10 kDa पेप्टाइड खण्ड का अधिकतम निरोधक जोन था।
- β-casein derived Peptide C down-regulated the expression of anti-osteogenic post transcriptional regulator, microRNA-592 (miR592), which suppresses osteogenesis by targeting BMP7/ Smad signalling cascade.
- The anti-obesity and anti-diabetic property of whey protein was found to be better than casein protein in rat model. Whey protein and soy protein extracted using probiotics were comparable in terms of their anti-obesity and anti-diabetic properties.
- *Lactobacillus fermentum* (MTCC 5898) based preparations showed significant modulations in transcriptional expression of tight-junction, matrix stabilizing, and anti-oxidative genes of skin epithelial cells.
- Feeding of bovine colostrum to immune-suppressed mice improved the immunity irrespective of the type of intervention made in parturient cows for colostrum production.
- Casein and whey protein hydrolysates (P, T, C, PT, PC, TC & PTC) exhibited anti-obesity potential by inhibition of pancreatic lipase enzyme. Tissue-specific effects were observed on the expression of mitochondrial protein coding genes from the nuclear genome and mitochondrial tRNAs in buffalo.
- Mitochondria-associated miRNAs were identified in different tissues of buffalo.
- Studies proved that mitochondrial DNA haplotypes influence the reproductive efficiency of buffaloes.

Dairy Processing

- Formulation prepared with bioactive proteins and peptides showed anti-diarrhoeagenic activity against *E. coli* MTCC 723 in both pre-treatment and post-treatment in weaning mice model.
- Biofunctional lactic-yeast fermented milk was prepared with a combination of lactic cultures (1%) and yeast cultures (3%).
- Biofunctional lactic-yeast fermented milk possessed antioxidant, antimicrobial and ACE-inhibitory activity.
- Bioactive peptides derived from colostrum whey proteins by microbial fermentation were having antimicrobial, immunomodulatory and antioxidant activity.
- The peptide content in fermentation increased up to 16.314 µg/ ml after 48 hours compared to 1.305 µg/ ml of unfermented whey.
- The highest inhibitory zone of <10 kDa peptide fraction was against *B. cereus* ATCC 13061 (24.33mm), *E. coli* ATCC 2592 (20.66mm), *E. faecalis* ATCC 27736 (19.66mm), *S. aureus* (18.66mm).
- Isolated AMPs (<10kDa) exhibited the highest antimicrobial activity against clinical isolate of antibiotic-resistant *E. coli* (ESBL) (Extended-spectrum beta-lactamases) (16.6mm), and *Acinetobacter* 1379 (7.4mm) and not against MRSA.

- अलग किए गए एएमपी (<10kDa) में प्रति जैविक प्रतिरोधी ई. कोलाई (ESBL) (विस्तारित स्पेक्ट्रम बीटा लैक्टामैसिस) (16.6 मिमी) तथा एसिनियोटोबैक्टर 1379 (7.4 मिमी.) के क्लिनिकल पृथक के विरुद्ध सबसे अधिक सूक्ष्मजीव रोधी गतिविधि देखने को मिली जबकि MRSA के विरुद्ध इस प्रकार की गतिविधि देखने को नहीं मिली।
- ऊंटनी के दूध से लैक्टिक अम्ल जीवाणु के कुल 188 स्ट्रेन अलग किए गए। केवल 23 में ही अच्छी प्रोटियोलाइटिक गतिविधि पाई गई।
- तीन पृथक् RL 4, RZ 18, LG 12 rFkk NCDC 24 स्ट्रेन पर्याप्त अम्ल विकास (1.224 प्रतिशत तक) के साथ ऊंटनी के दूध के किण्वन हेतु उपयुक्त थे।
- कलाइवेरोमायसीज मार्सीयेनस MTCC 1389 को वाईपीएल शोरबा में 110 दिनों में 12 प्रतिशत इथानॉल तक अनुकूलित किया गया।
- डेरी उत्पादों के जैव परिरक्षण के लिए सूक्ष्मजीव रोधी प्रोटीनों तथा पेप्टाइड फार्मुलेशन यथा 5.4 मिग्रा./मिलि. वहिजय 50 kDa तथा 0.5 मिग्रा./मिलि. वसिजय 10kDa को तैयार किया गया।
- पनीर और खोया में सूक्ष्मजीव रोधी प्रोटीनों और पेप्टाइड फार्मुलेशन को शामिल करने पर 7°C तापमान पर 6 से 7 दिनों तक उत्पादों की निधानी आयु अथवा जीवनकाल बढ़ा।
- मीठे मांस का परिरक्षण करने के लिए सूक्ष्मजीव रोधी प्रोटीनों और पेप्टाइड फार्मुलेशन द्वारा सूक्ष्मजीव रोधी पैकेजिंग तैयार की गई।
- कोलोस्ट्रम अथवा खीस या पीयूष वाली छाछ से उत्पन्न पेप्टाइड्स का उपयोग जैव कार्यात्मक फ्लेवर्ड दूध को तैयार करने में संघटकों के तौर पर किया गया।
- रिवर्स ट्रांसक्रिप्शन लूप मीडिएटेड आइसोथर्मल एम्पलीफिकेशन (RT-LAMP) एसें अथवा आमाप को SARS-CoV-2 के लिए प्वाइंट ऑफ केयर नैदानिकी के तौर पर विकसित किया गया।
- लैक्टोकोक्सि, स्ट्रेप्टोकोक्सि तथा लैक्टोबैसिलार्ई एवं ल्यूकोनोस्टॉक (~35:20:20:5) की पहचान पारम्परिक दही नमूनों में 80 से 90 प्रतिशत की कुल प्रचुरता के साथ एलएबी के प्रमुख वंश के तौर पर की गई।
- प्रत्यक्ष वेट सेट तैयारी के लिए प्रोबायोटिक बायोमास हासिल करने के लिए छाछ आधारित सस्ता अथवा लागत प्रभावी मीडिया तैयार किया गया।
- फ्रीज शुश्कन के दौरान इनकी उत्तरजीविता में संवृद्धि करने के लिए प्रोबायोटिक लैक्टोबैसिलार्ई संवर्धन हेतु संवर्धन वृद्धि परिस्थितियों को अनुकूल बनाया गया।
- PANI-PEC पेपर स्ट्रिप का मूल्यांकन एवं प्रमाणन करने से पता चला कि कच्चे दूध, पाश्चुरीकृत दूध, आइसक्रीम, मक्खन तथा पाउडर में कुल प्लेट गणना का निर्धारण करने के लिए पेपर स्ट्रिप एक सटीक, त्वरित तथा एक वैकल्पिक स्रोत था।
- अध्ययनों से यह भी पता चला कि PANI-PEC पेपर स्ट्रिप सेंसर द्वारा प्रति जैविकों, रासायनिक एजेन्टों जैसे कि यूरिया की मौजूदगी में भी कार्य किया जाता है और बीजाणु निर्माताओं को छोड़कर दूध में किसी भी अन्य जीवाणु द्वारा यह प्रभावित नहीं होता।
- PANI-PEC पेपर स्ट्रिप MBRT के लिए भी एक वैकल्पिक जांच पाया गया। PANI-PEC पेपर स्ट्रिप का उपयोग कच्चे दूध की गुणवत्ता, आइसक्रीम, पाश्चुरीकृत दूध, पाउडर तथा मक्खन के अंतिम उत्पाद की गुणवत्ता की जांच करने के लिए रिसेप्शन डॉक पर भी किया गया।
- विस्तारित स्पेक्ट्रम बीटा लैक्टामैसिस (ESBL) पॉजीटिव एशेरिकिया
- A total of 188 strains of lactic acid bacteria were isolated from camel milk. Only 23 were having good proteolytic activity.
- Three isolates RL4, RZ18, LG12 and NCDC24 strains were suitable for camel milk fermentation with sufficient acid development (upto 1.224%).
- Kluyveromyces marxianus MTCC1389 was adapted up to 12% of ethanol in 110 days in YPL broth.
- Antimicrobial proteins and peptides formulation i.e. 5.4 mg/ ml of & gt; 50 kDa and 0.5 mg/ ml of & lt; 10kDa was prepared for biopreservation of dairy products.
- Incorporation of antimicrobial proteins and peptides formulation in paneer and khoa enhanced the shelf life of the products up to 6-7 days at 7°C.
- Antimicrobial packaging was prepared by the Antimicrobial proteins and peptides formulation for preservation of sweetmeats.
- Colostrum whey derived peptides were used as ingredients for preparation of biofunctional flavoured milk. The beverage exhibited higher antimicrobial, antihypertensive and antioxidative properties.
- Reverse Transcription Loop-Mediated Isothermal Amplification (RT-LAMP) assay was developed as point-of-care diagnostic for SARS-CoV-2
- *Lactococci*, *Streptococci* and *Lactobacilli* and *Leuconostoc* (~35:20:20:5) were identified as major genera of LAB with total abundance of 80-90% in traditional dahi samples.
- Cost effective whey based media was developed for harvesting of Probiotic biomass for direct vat set preparation.
- Cultural growth conditions were optimized for Probiotic *lactobacilli* cultivation to enhance their survivability during freeze drying.
- Evaluation and validation of PANI-PEC paper strip revealed that paper strip was accurate, rapid, and an alternative source for determination of the total plate count in raw milk, pasteurized milk, ice cream, butter, and powder.
- Studies also revealed that PANI-PEC paper strip sensor also works in the presence of antibiotics, urea like chemical agents, and not affected by any bacteria present in the milk except spore formers.
- The PANI-PEC paper strip also found to be an alternative test for MBRT. PANI-PEC paper strip was also used at the Reception dock for checking the raw milk quality, final product quality of the ice cream, pasteurized milk, powder, and butter.
- The whole genome sequencing of Extended spectrum beta-lactamases (ESBL) positive *Escherichia coli* revealed the potentiality of antibiotic inactivation mechanism harboring ampC type Beta-lactamases (Cephalosporin, penem); NmcA Beta-lactamases (Carbapenem, Cephalosporin, Penem, Cephamycin) (NmcR) genes in their respective genome.

- कोलाई के सम्पूर्ण जीनोम अनुक्रमण से अपने संबंधित जीनोम में ampC टाइप बीटा लैक्टामेसिस (सिफैलोस्पोरिन, पेनेम); NmcA बीटा लैक्टामेसिस (कार्बापेनेम, सिफैलोस्पोरिन, पेनेम, सिफैमाइसिन) (NmcR) जीनों को आश्रय देने वाली जैविक रोधी निष्क्रियता क्रियाविधि की क्षमता का पता चला।
- ईएसबीएल के लिए पॉजीटिव एक अन्य एशेरिकिया कोलाई में भी अपने संबंधित जीनोम में CTX-M बीटा लैक्टामेज (CTX-M-15), TEM बीटा – लैक्टामेज (TEM-1), तथा बीटा – लैक्टामेज (NmcR) जीनों को आश्रय देने वाली निष्क्रियता क्रियाविधि का पता चला।
 - स्टेफाइलोकोकस ऑरियस में अपने संबंधित जीनोम में mecR1, mecl (मेथीसिलिन प्रतिरोधी PBP2), तथा mecA (मेथीसिलिन प्रतिरोधी PBP2-कार्बापेनेम; सिफैलोस्पोरिन; सिफैमाइसिन; मोनोबैक्टम; पेनम) जीनों के साथ साथ जैविक रोधी लक्ष्य प्रतिस्थापन क्रियाविधियां प्रदर्शित हुईं।
 - एण्टेरोकोकस फीकियम में अपने संबंधित जीनोम में ग्लाइकोपेप्टाइड प्रतिरोधित जीन कलस्टर; vanH (vanHD), van ligase (D-Ala-D-Ala), ग्लाइकोपेप्टाइड प्रतिरोधिता जीन कलस्टर; vanY (vanYF), vanR (vanRM), vanRF (vanR), vanSF (vanS), vanHO (vanH) जीनों के साथ साथ जैविक रोधी लक्ष्य विकल्प प्रदर्शित हुआ।
 - के. लैक्टिस से उत्पन्न बी. गैलेक्टोसीडेज का उपयोग करके एक किण्वन प्रक्रिया का मानकीकरण गैलेक्टो ऑलिगोसैकराइड के निर्माण हेतु किया गया।
 - छाछ प्रोटीन पॉलीफिनोल संयुग्म तैयार किए गए जिनका उपयोग कार्यात्मक खाद्य उत्पादों में खाद्य योज्य के तौर पर किया जा सकता है।
 - विभिन्न व्युत्पन्न अभिकर्मकों का उपयोग करते हुए दूध उपापचयों की पहचान करने के लिए एक जीसी-एमएस विधि का मानकीकरण किया गया।
 - सिमिलेटिड जठरांत्र पाचन के उपरांत ताप प्रसंस्कृत गाय दूध से कैसोमॉर्फिन-7 (BCM-7) के परिमाणन के लिए एक आरपी – एलपीएलसी विधि का मानकीकरण किया गया।
 - दूध में सॉर्बिटोल मिलावट का पता लगाने के लिए एक रंग आधारित विधि तैयार की गई।
 - घी में वनस्पति तेल की मिलावट का पता लगाने के लिए एक रंग संसर आधारित त्वरित विधि विकसित की गई।
 - घी में खनिज तेल तथा नारियल तेल की मिलावट का पता लगाने के लिए एटीआर – एफटीआईआर आधारित विधि विकसित की गई।
 - दही में कम सघनता वाली पॉलीइथीलिन (LDPE) पैकेजिंग सामग्री से रासायनिक प्रवासियों की पहचान की गई।
 - हरियाणा राज्य की गोपशु नस्ल के दूध की प्रोटीन प्रोफाइलिंग की गई।
 - गाय दूध प्रणाली से तीस दिनों के विस्तारित जीवनकाल के साथ रिकोटा चीज़ की प्रौद्योगिकी में चेंडर चीज़ छाछ का उपयोग किया गया जिसके परिणामस्वरूप अधिकतम दूध ठोस वसूली हासिल की गई, उपज, उत्कृष्ट संरचना तथा संसरी विशेषताओं में सुधार आया।
 - जल और सुखाने की छिड़काव प्रक्रिया द्वारा तैयार किए गए पाउडर के साथ मिलाकर स्थिर फ़ैलाव तैयार करके घी अपशिष्ट में मूल्यवृद्धि की गई।
 - कैल्सियम अवशोषण में सुधार करने हेतु स्टार्टर संवर्धन अथवा लैक्टोज ऑक्सीडेज एंजाइम का उपयोग करके लैक्टोबायोनिक अम्ल संवर्धित योगार्ट तैयार किया गया।
 - In another *Escherichia coli* having positive for ESBL also revealed the inactivation mechanism harboring CTX-M beta-lactamase (CTX-M-15), TEM beta-lactamase (TEM-1), and beta-lactamase (NmcR) genes in their respective genome.
 - Staphylococcus aureus* showed antibiotic target replacement mechanisms along with mecR1, mecl (methicillin resistant PBP2), and mecA (methicillin resistant PBP2 - carbapenem; cephalosporin; cephamycin; monobactam; penam) genes in their respective genome.
 - Enterococcus faecium* showed antibiotic target alteration along with Glycopeptide resistance gene cluster; vanH (vanHD), van ligase (D-Ala-D-Ala), glycopeptide resistance gene cluster; vanY (vanYF), vanR (vanRM), vanRF (vanR), vanSF (vanS), vanHO (vanH) genes in their respective genome.
 - An enzymatic process using β -galactosidase derived from *K. lactis* was standardized for the formation of galacto-oligosaccharide.
 - Whey protein-polyphenol conjugates were prepared which can be used as food additives in functional food products.
 - A GC-MS method was standardized for identification of milk metabolites using different derivatizing reagents.
 - A RP-HPLC method was standardized for Quantification of -Casomorphin-7 (BCM 7) from heat processed cow milk after simulated gastrointestinal digestion.
 - A dye based method was developed to detect sorbitol adulteration in milk.
 - A colour sensor based rapid method was developed for detection of vegetable oils adulteration in ghee.
 - ATR-FTIR based method was developed for detection of mineral oil and coconut oil adulteration in ghee.
 - Chemical migrants from low density polyethylene (LDPE) packaging material into Dahi were identified.
 - Protein profiling of milk from Haryana Cattle Breed was done.
 - Technology of Ricotta cheese with extended shelf life of 30 days from cow milk system utilized cheddar cheese whey and resulted in maximum milk solids recovery, improved yield, excellent textural and sensory properties
 - Valorization of ghee residue was performed by preparing stable dispersion by mixing with water and the resultant powder preparation by spray drying process.
 - Lactobionic acid enriched yoghurt was manufactured using starter culture or lactose oxidase enzyme to improve calcium absorption.
 - Milk-flaxseed based probiotic food was developed for overall health management of female population.
 - Haldi ghee and lassi were prepared from cow milk by fortification with turmeric which possess higher anti-oxidant activity and hypocholesterolemic effect.

- दूध-अलसी बीज आधारित प्रोबायोटिक खाद्य को मादा जनसंख्या के समग्र स्वास्थ्य प्रबंधन के लिए तैयार किया गया।
- गाय के दूध से हल्दी – घी और लस्सी तैयार की गई और इस कार्य में हल्दी के साथ प्रबलीकरण किया गया। इस उत्पाद में कहीं उच्चतर प्रति ऑक्सीकारक गतिविधि और हाइपो कॉलेस्ट्रॉलेमिक प्रभाव पाया जाता है।
- स्वास्थ्य के प्रति विभिन्न लाभकारी विशेषताओं के साथ मोरिंगा ऑलिफेरा से समृद्ध चीज़ स्प्रेड प्रसंस्कृत किया गया।
- किण्वित छाछ को आयरन की बढ़ी हुई जैव उपलब्धता के साथ तैयार किया गया जिसमें कहीं उच्चतर प्रति-ऑक्सीकारक गतिविधि अथवा सक्रियता थी।
- बटर ऑयल से घी तैयार करने की एक नवीन ऊर्जा प्रभावी विधि विकसित की गई।
- गिर नस्ल की गायों के दूध से अलग किए गए DPP-IV निरोधक पेप्टाइड्स का सम्पुटीकरण किया गया और इस कार्य में दोहरी इमल्सीफिकेशन तकनीक का उपयोग किया गया। इसमें बढ़ी हुई प्रति-ऑक्सीकारक सक्रियता के साथ मधुमेह रोधी विशेषता पाई जाती है।
- देशी छाछ से विभिन्न स्वास्थ्य गुणों के साथ फॉस्फोलिपिड से भरपूर इन्सटेंट पाउडर तैयार किया गया।
- अण्डों के स्थान पर दूध प्रोटीन का उपयोग करके अण्डारहित मफिन तैयार किए गए।
- वांछनीय बनावट तथा सेंसरी गुणों के साथ ऊंटनी के दूध से पकी हुई चीज़ को तैयार किया गया।
- ग्लूटेन रहित मल्टी अनाज वर्मीसेली खीर और इसका इन्सटेंट मिश्रण तैयार किया गया और इस कार्य में छिड़काव शुष्कन प्रक्रिया का उपयोग किया गया।
- दूध-कदन्न अनुपूरक खाद्य (न्यूट्रामिक्स) की यथार्थ समय में गुणवत्ता स्थिति का मूल्यांकन करने के लिए ऑन पैकेज कैलोरीमीटर संकेतक लेबल विकसित किया गया।
- विभिन्न तापमानों पर संदेश मिठाई के भण्डारण का मूल्यांकन करने के लिए ऑन पैकेज कैलोरीमीट्रिक ताजापन संकेतक का विकास किया गया।
- प्राकृतिक रंग के रूप में इसका प्रयोग करने के लिए गाजर से अपशिष्ट से कैरोटिनॉइड्स का निष्कर्षण करने के लिए ग्रीन मैन्युफैक्चरिंग तकनीक विकसित की गई।
- टिनोस्पोरा कॉर्डिफ्लोरा के साथ बकरी दूध से प्रति-ऑक्सीकारक तथा प्रतिरक्षा क्षमता वाला कार्यात्मक पेय तैयार किया गया।
- पनीर के तापीय अपघटन और गुणवत्ता की निगरानी करने के लिए जैविक स्मार्ट समय तापमान संकेतक विकसित किया गया।
- दक्षिणी क्षेत्रीय स्टेशन (SRS) बेंगलुरु में सुविधाजनक, मूल्यवर्धित कार्यात्मक खाद्य यथा न्यूट्रिसीरियल्स को शामिल करके प्रोबायोटिक स्प्रेड तथा डिप्स, प्राकृतिक स्वीटनर्स के साथ कम मीठे वाली बर्फी, क्वच्ट निरोधक पेप्टाइड संवर्धित स्नैक बार तथा विटामिन बी 12 से भरपूर न्यूट्रिमिस्क का उत्पादन करने के लिए प्रौद्योगिकियां विकसित की गईं।
- दक्षिणी क्षेत्रीय स्टेशन (SRS) बेंगलुरु में घी अपशिष्ट से फॉस्फोलिपिड्स का निष्कर्षण करने के लिए और स्प्रे शुष्कन द्वारा प्रोबायोटिक जीवाणु के सूक्ष्म सम्पुटीकरण के लिए एक विधि तैयार की गई।
- दक्षिणी क्षेत्रीय स्टेशन (SRS), बेंगलुरु में फ्रोजन मक्खन ब्लॉक को
- Processed cheese spread enriched with *Moringa Oleifera* was developed with various health beneficial properties.
- Fermented whey with enhanced bioaccessibility of iron content was manufactured with higher antioxidant activity.
- A novel energy efficient method for ghee preparation from butteroil was developed.
- Encapsulation of DPP-IV inhibitory peptides isolated from milk of Gir cows was done through double emulsification technique and was reported to be antidiabetic with enhanced antioxidant activity.
- Phospholipid rich instant powder was prepared from *desi chhaach* with different health attributes.
- Eggles muffins were prepared with replacement of eggs with milk proteins.
- Ripened cheese from camel milk was prepared with desirable textural and sensory attributes.
- Gluten free multigrain vermicelli *kheer* and its instant mix were developed using spray drying process.
- On-package colorimetric indicator label was developed for the assessment of real time quality status of milk-millet complementary food (Nutrimix).
- On-package colorimetric freshness indicator was developed for the assessment of storage of *Sandesh* at different temperatures.
- Green manufacturing technology was developed for extraction of carotenoids from carrot bio-waste for its end use as natural colorant.
- Goat milk based functional beverage incorporated with *Tinospora cordifolia* was prepared with antioxidative and immunomodulatory potential.
- Biological smart time temperature indicator was developed for monitoring thermal abuse and quality of *paneer*
- Technologies were developed at Southern Regional Station (SRS), Bangalore for the production of convenience, value added functional foods viz. Nutricereals incorporated probiotic spreads and dips, reduced sugar burfi with natural sweeteners, DPP-IV inhibitory peptides fortified Snack bar and Vit.B12 rich nutrimix.
- A method was developed at SRS, Bangalore for extraction of phospholipids from ghee residue and for microencapsulation of probiotic bacteria by spray drying.
- A prototype was developed at SRS, Bangalore for cutting of frozen butter block.
- Scraped Surface Heat Exchanger (SSHE) based low cost milk heating system was designed, developed and evaluated for continuous milk cooling for small scale application.
- Simulation model for bioreactor prototype for cattle waste management was developed based on different functions of total solids, viscosity, temperature, shear rate and consistency coefficient of cow manure slurry.

काटने के लिए एक प्रोटोटाइप तैयार किया गया।

- लघु स्तरीय प्रयोग के लिए दूध को लगातार ठंडा बनाये रखने के लिए स्कैण्ड सरफेस हीट एक्सचेंजर (SSHE) आधारित दूध को गरम करने वाली सस्ती प्रणाली की डिजाइन तैयार की गई, उसका विकास करके मूल्यांकन किया गया।
- कुल ठोस, श्यानता, तापमान, शीयर दर तथा गाय खाद स्लरी के सतत गुणांक के विभिन्न कार्यों के आधार पर गोपशु अपशिष्ट प्रबंधन हेतु बायो रियेक्टर प्रोटोटाइप के लिए अनुकरण मॉडल तैयार किया गया।

डेरी प्रबंधन

- एनियोनिक खनिज मिश्रण (AMM) की आपूर्ति करने पर किसानों की आमदनी में 35 प्रतिशत तक बढ़ोतरी करने, दूध उपज में 14 प्रतिशत तक सुधार करने और साथ ही दूध उपज अवधि के दौरान बुखार की घटनाओं में 21 प्रतिशत से 2 प्रतिशत तक कमी देखने को मिली। एनियोनिक खनिज मिश्रण का उपयोग करने पर हरियाणा राज्य में प्रति वर्ष रूपये 873 करोड़ तक के आर्थिक नुकसान से बचने की क्षमता देखने को मिली।
- वर्ष 1990-91 से 2015-16 की अवधि के दौरान प्रतिवर्ष 3.9 प्रतिशत की दर पर पशुधन सेक्टर की कुल कारक उत्पादकता (TFP) बढ़ोतरी हुई। निवेश उपयोग के मौजूदा स्तरों के साथ अतिरिक्त 30 प्रतिशत आउटपुट हासिल करने के लिए पशुधन के अनुसंधान एवं विकास में कहीं अधिक निवेश करने की जरूरत है।
- डेयरी अपस्ट्रीम कार्मिकों के साथ बेहतर सम्पर्क बनाये रखने के परिणामस्वरूप जहां एक ओर कहीं बेहतर समग्र खाद्य सुरक्षा सूचकांक मान (0.66) और साथ ही उच्चतर लाभप्रदता के साथ सम्बद्धता को हासिल करने में मदद मिली।
- हरियाणा राज्य में दूध उत्पादन की लागत में प्रति लिटर रु. 29/- (संकर नस्ल की गाय) से लेकर प्रति लिटर रूपये 40.35 (भैंस) की भिन्नता देखने को मिली जबकि संकर नस्ल की गायों के लिए शुद्ध लाभ सबसे अधिक (प्रति लिटर रूपये 3.29) और तदुपरान्त भैंस (प्रति लिटर रूपये 3.12) के लिए पाया जबकि इसे सबसे कम देशी गाय (प्रति लिटर रूपये 1.28) में पाया गया।
- भाकृअनुप - राष्ट्रीय डेरी अनुसंधान संस्थान द्वारा वीर्य की प्रत्येक खुराक को रूपये 24.50 की अनुमानित लागत पर उत्पन्न किया जबकि इसे प्रति खुराक रु.20/- की दर पर बेचा जिसमें लाभान्वित किसानों को प्रति खुराक रूपये 4.50 की सीमा तक रियायत प्रदान की गई।
- ओडिशा राज्य में ग्रामीण महिलाओं के लिए कौशल संवर्धन कार्यक्रम वित्त (54 प्रतिशत तक) तथा सामाजिक अनुदान (52 प्रतिशत) पर उनकी निर्भरता को कम करने की दिशा में उठाया गया प्रयास है।
- वर्षाकाल के दौरान नमूना लिए गए 28.34 प्रतिशत पशुओं में क्लीनिकल थनैला रोग का प्रकोप देखने को मिला और अहमदनगर (महाराष्ट्र) में इसका अनुमानित नुकसान 14.19 करोड़ रूपये लगाया गया।
- गुजरात के सौराष्ट्र एवं कच्छ क्षेत्र में दुग्ध उत्पादक कम्पनी (डच्) का प्रभाव प्रति वर्ष प्रति परिवार में रु.10000/- तक आय में बढ़ोतरी करने में और परिवर्तनीय लागत में कमी (8 प्रतिशत) करने में देखने को मिला।

शिक्षा

- एनडीआरआई का 18वां दीक्षांत समारोह 22 अगस्त, 2021 को ऑनलाइन मोड में आयोजित किया गया था। माननीय डॉ. त्रिलोचन महापात्र, सचिव, डेयर और महानिदेशक, आईसीएआर ने दीक्षांत समारोह की अध्यक्षता की और भाषण दिया।

Dairy Management

- The impact of Anionic Mineral Mixture (AMM) supplementation was assessed in terms of enhancing farmers' net income by 35%, improvements in milk yield by 14% and reduced milk fever incidence from 21% to 2%. AMM intervention has potential to save economic losses to the extent of Rs.873 crores per annum in Haryana.
- The Total Factor Productivity (TFP) of livestock sector has grown @ 3.9% annually during 1990-91 to 2015-16. Higher level of investment in livestock R&D is required to tap the additional 30% output with existing levels of input-use.
- Better linkages with dairy upstream actors resulted in better overall Food Safety Index value (0.66) and also associated with higher profitability.
- The cost of milk production varied from Rs. 29/l (crossbred cow) to Rs. 40.35/l (buffalo), while the net returns were highest for crossbred cows (Rs. 3.29/ litre) followed by buffalo (Rs.3.12/ litre) and lowest in indigenous cow (Rs. 1.28/l) in Haryana.
- ICAR-NDRI produced semen at an estimated cost of Rs. 24.50/ dose, while sold at price of Rs. 20/ dose-extending implicit subsidiary support to the tune of Rs. 4.50/ dose to the beneficiary farmers.
- Skill enhancement for rural woman in Odisha-is a step towards reducing their dependence on remittances (upto 54%) and social grants (52%).
- The incidence of clinical mastitis was found in 28.34% sampled animals during the rainy season and projected loss was estimated to be Rs. 14.19 crores in Ahmednagar (Maharashtra).
- Impact of milk producer company (MPC) is evident from reduction in variable cost (8%) and increase in income by Rs. 10000/ household/ annum in Saurashtra and Kutch region of Gujarat.

EDUCATION

- 18th Convocation of NDRI was held on August 22, 2021 in an on-line mode. Hon'ble Dr. Trilochan Mohapatra, Secretary DARE and Director General, ICAR presided over and delivered the Convocation Address.
- Prior to Convocation, a series of oration Awards were conferred such as Dr. D.Sundaresan Memorial Oration Award on Dr. A.K. Mishra, Chairman Agricultural Scientists Recruitment Board, Dr. K.K. Iya Oration Award on Prof. (Dr.) V.P. Kamboj, President of the National Science Academy of India and Ex Director, Central Drug Institute (CDRI) and Dr. N.N. Dastur Memorial Oration Award on Padamshri Professor J.S. Rajput, Former Director, NCETY and Founder Member, National Council for Teacher Education, NCERT, New Delhi.
- Best Division Award for Academic Achievement and Innovations in Teaching was presented to Animal Biochemistry Division. Besides Best Thesis Awards for Master's Thesis as well as Doctoral Thesis (one each in Production, Processing and Management Groups) were conferred on students after thorough evaluation by the Award Committee.

- दीक्षांत समारोह से पूर्व, व्याख्यान पुरस्कारों की एक श्रृंखला के अंतर्गत डॉ. ए.के. मिश्रा, अध्यक्ष कृषि वैज्ञानिक भर्ती बोर्ड द्वारा डॉ. डी सुन्दरसन मेमोरियल ओरेशन अवार्ड, डॉ. वी.पी. कांबोज, भारतीय राष्ट्रीय विज्ञान अकादमी के अध्यक्ष और पूर्व निदेशक, केंद्रीय औषधि संस्थान (सीडीआरआई) द्वारा डॉ. के के अज्ञा ओरेशन अवार्ड और पद्मश्री प्रोफेसर जे.एस. राजपूत, पूर्व निदेशक, एनसीईटीवाई और संस्थापक सदस्य, राष्ट्रीय अध्यापक शिक्षा परिषद (एनसीटीई), नई दिल्ली द्वारा डा एन एन दस्तूर मेमोरियल ओरेशन अवार्ड प्रस्तुत किया गया।
- शैक्षिक उपलब्धि और शिक्षण में नवाचार के लिए सर्वश्रेष्ठ प्रभाग पुरस्कार पशु जैव रसायन प्रभाग को प्रदान किया गया। स्नातकोत्तर थीसिस के लिए सर्वश्रेष्ठ थीसिस पुरस्कार के साथ-साथ डॉक्टरेट थीसिस (उत्पादन, प्रसंस्करण और प्रबंधन समूहों में से प्रत्येक में एक) को पुरस्कार समिति द्वारा गहन मूल्यांकन के बाद छात्रों को प्रदान किया गया।
- दीक्षांत समारोह के दौरान वर्ष 2020 और 2021 के लिए चयनित संकाय को उत्कृष्ट युवा शोधार्थियों को शिक्षण में उत्कृष्टता के लिए सर्वश्रेष्ठ शिक्षक पुरस्कार और डॉ. एस.के. सिरौही मेमोरियल अवार्ड भी प्रदान किया गया।
- वर्ष 2021 के दौरान आईडीपी-नाहेप के तहत "खाद्य सुरक्षा", "खाद्य सुरक्षा और पोषण गुणवत्ता के लिए नवीन और उभरती हुई प्रौद्योगिकियां", "लेटरल प्रवाह परख में डिजाइन और उभरते अनुप्रयोगों में हालिया प्रगति" और "वैज्ञानिक लेखन" पर चार कार्यशालाएं आयोजित की गईं।
- आईडीपी-एनएएचईपी के तहत वर्ष 2021 के दौरान चौबीस वेबिनार वर्चुअल मोड में आयोजित किए गए जिनमें 39 अंतर्राष्ट्रीय वक्ताओं ने व्याख्यान दिए।
- बी.टेक. (डैरी प्रौद्योगिकी) छात्रों और संस्थान के संकाय ने राष्ट्रीय कृषि उच्च शिक्षा परियोजना के तहत संस्थागत विकास योजना के तहत विदेशी विश्वविद्यालयों में प्रशिक्षण प्राप्त किया। कार्यक्रम का उद्देश्य बी.टेक (डैरी प्रौद्योगिकी) कार्यक्रम और छात्र और संकाय सुधार के लिए कई मॉड्यूल शामिल हैं को प्रोत्साहित करना है।

विस्तार

- वर्ष 2020-21 के दौरान, केवीके द्वारा 59 ऑन-कैंपस प्रशिक्षण कार्यक्रम आयोजित किए गए, जिसमें देश के विभिन्न राज्यों के 1874 प्रतिभागियों ने भाग लिया, जबकि केवीके द्वारा 1482 किसानों के लिए 69 ऑफ-कैंपस प्रशिक्षण कार्यक्रम आयोजित किए गए।
- 2020-21 के रबी सीजन दौरान, करनाल जिले के विभिन्न गांवों में सिंचित परिस्थितियों में 20.0 हेक्टेयर क्षेत्र में ग्राम (एचसी-5) पर कुल 54 एफएलडी (फ्रंट लाइन प्रदर्शन) बिछाए गए। प्रदर्शन प्लाटों में किस्म का औसत उत्पादन 12.30 क्विंटल प्रति हेक्टेयर पाया गया। रबी सीजन 2020-21 के दौरान 50.0 हेक्टेयर क्षेत्र में सरसों, सीएस-58 किस्म का फ्रंट लाइन प्रदर्शन किया गया। प्रदर्शित किस्म का औसत उत्पादन 18 क्विंटल प्रति हेक्टेयर था।
- ग्रीष्म ऋतु 2021 के दौरान मूंग (आईपीएम-205-07 (विराट)) पर कुल 50 एफएलडी सिंचित परिस्थितियों में 20.0 हेक्टेयर क्षेत्र में बिछाई गई। प्रदर्शन प्लाटों में किस्म का औसत उत्पादन 8.1 क्विंटल प्रति हेक्टेयर पाया गया।
- केवीके ने 23,75,508 रु. विभिन्न गतिविधियों के माध्यम से परिक्रामी निधिसे संस्थान के लिए अर्जित किए।
- केवीके ने करनाल जिले के दो अंगीकृत गांवों, नबीपुर (78 एकड़) और फुरलक (81 एकड़) में फसल अवशेषों (धान के पुआल) के यथास्थान प्रबंधन का प्रदर्शन किया।
- Best Teacher Award for Excellence in Teaching and Dr. S.K. Sirohi Memorial Award to the outstanding Young Researchers were also conferred for the year 2020 and 2021 on the selected faculty during the Convocation.
- Four Workshops were conducted under IDP-NAHEP on "Food Safety", "Innovative and Emerging Technologies for Food Safety & Nutritional Quality", "Recent Advances in Design and Emerging Applications in Lateral Flow Assay" and "Scientific Writing" during the year 2021.
- Twenty four webinars were conducted during the year 2021 under IDP-NAHEP in virtual mode in which 39 International Speakers delivered lectures.
- B.Tech. (Dairy Technology) students and Institute faculty received training in foreign universities under the Institutional Development Plan under the National Agriculture Higher Education Project. The programme aims to incentivize the B.Tech. (Dairy Technology) programmes, and comprises of several modules for student and faculty improvement.

EXTENSION

- During the year 2021, 59 on-campus training programs were conducted by KVK in which 1874 participants from different states of the country took part, whereas 69 off-campus training programmes for 1482 farmers were conducted by KVK.
- During the Rabi season 2021 a total of 54 FLDs (Front line demonstration) on Gram (HC-5) were laid in 20.0 hectare area under irrigated conditions in different villages of Karnal district. In the demonstration plots, an average production of variety was observed to be 12.30 quintal per hectare. Front Line Demonstrations on Mustard, CS-58 variety was conducted in 50.0 hectare area during Rabi season 2021. An average production of the demonstrated variety was 18 quintal per hectare.
- During the summer season 2021, total 50 FLDs on Moong (IPM-205-07 (Virat)) were laid in 20.0 hectare area under irrigated conditions. In the demonstration plots, an average production of variety was observed to be 8.1 quintal per hectare.
- KVK generated Rs. 23,75,508/- for the Institute and revolving fund through various activities.
- KVK demonstrated *in-situ* management of crop residues (paddy straw) at two adopted villages, Nabipur (78 Acre) and Phurlak (81 Acre) of Karnal district.
- A total of 1438 services related to dissemination of dairy related information (exposure visits, attending toll free calls, attending farmers, lectures in trainings etc.) were provided to 3841 farmers, students, visitors who visited ATIC during 2021.
- A revenue of Rs. 21,37,655/- was collected by selling seed of paddy (varieties PR-114, PB-1718, PB-1509 and PB-1692) and wheat (varieties, HD-3226 and DBW-187).
- In compliance of an Memorandum of Understanding signed in 2020 between the ICAR-NDRI, Karnal and the

- 2021 के दौरान एटीआईसी का दौरा करने वाले 3841 किसानों, छात्रों, आगंतुकों को डेरी से संबंधित जानकारी के प्रसार से संबंधित कुल 1438 सेवाएं (एक्सपोजर विजिट, टोल फ्री कॉल में भाग लेना, किसानों में भाग लेना, प्रशिक्षण में व्याख्यान आदि) प्रदान की गईं।
- धान के बीज (किस्में पीआर.114, पीबी-1718, पीबी-1509 और पीबी-1692) और गेहूँ (किस्में, एचडी-3226 और डीबीडब्ल्यू-187) को बेचकर 21,37,655 /- रुपये का राजस्व एकत्र किए गए।
- आईसीएआर-एनडीआरआई, करनाल और पंजाब कृषि विश्वविद्यालय (पीएयू), लुधियाना के बीच 2020 में हस्ताक्षरित एक समझौता ज्ञापन के अनुपालन में, पीएयू, लुधियाना ने धान के बीज (किस्में पीआर-114, पीआर-124) और गेहूँ के बीज किस्मों (पीबी-343, पीबी-550) करनाल जिले और आसपास के क्षेत्रों के किसानों को लाभान्वित करने के लिए एटिक के बीज काउंटर पर बेचे।
- हरियाणा और हिमाचल प्रदेश से अनुसूचित जाति समुदायों के चौदह युवाओं की पहचान की गई और उन्हें कृत्रिम गर्भाधान पर 02.08.2021 से 15.09.2021 तक राष्ट्रीय डेयरी विकास बोर्ड, जालंधर, पंजाब के क्षेत्रीय केंद्र में 45 दिनों के लिए प्रशिक्षित किया गया। बाद में, उन्हें प्रशिक्षित पशु चिकित्सकों के तहत अपने संबंधित मूल स्थानों पर 75 दिनों के क्षेत्र प्रशिक्षण से गुजरने की सुविधा प्रदान की गई। इस क्षमता निर्माण का मुख्य उद्देश्य ग्रामीण क्षेत्रों में शिक्षित बेरोजगार युवाओं के लिए स्वरोजगार मॉडल तैयार करना था।
- एमओएफपीआई, भारत सरकार की मध्यम और लघु उद्यम (पीएम-एफएमई) योजना प्रधानमंत्री के तत्वावधान में डेरी प्रसंस्करण पर मास्टर प्रशिक्षकों के लिए एक ऑनलाइन प्रशिक्षण का आयोजन किया गया और भारतीय खाद्य प्रसंस्करण प्रौद्योगिकी संस्थान (IIFPT), तंजावुर द्वारा प्रायोजित।
- करनाल, पानीपत, सोनीपत जिले की संभावित महिला उद्यमियों को दूध और दुग्ध उत्पाद प्रसंस्करण (दही, पनीर, घी आदि) पर एक डीएसटी-वित्त पोषित परियोजना के तहत प्रशिक्षण दिया गया।
- विस्तार शिक्षा संस्थान (दक्षिणी क्षेत्र), कृषि और सहकारिता और किसान कल्याण विभाग, PJTSAU कैंपस, राजेंद्रनगर, हैदराबाद में हितधारकों के लिए मूल्यवर्धन और डेरी उत्पाद और समग्र डेरी फूड्स प्रसंस्करण के क्षेत्र में नवीनतम विकास पर आयोजित आभासी प्रशिक्षण कार्यक्रमों के लिए फैंकल्टी ने संसाधन व्यक्तियों के रूप में कार्य किया।
- एनईएच के तहत 2021 के दौरान भारत के पांच पूर्वोत्तर राज्यों, अरुणाचल प्रदेश, नागालैंड, त्रिपुरा, असम और सिक्किम में कुल पांच पशुधन विकास शिविर आयोजित किए गए। पशुधन पशु, कुकुट, बतख तथा विभिन्न कृषि निवेश किसानों में वितरित किए गए।
- टीएसपी के तहत, पूर्वी और उत्तर-पूर्वी भारत के विभिन्न हिस्सों में 4 शिविर आयोजित किए गए और 4 ऑन-कैंपस प्रशिक्षण कार्यक्रम आयोजित किए गए।
- पूक्षेके, कल्याणी में जनवरी 2021 से दिसंबर 2021 के दौरान एससीएसपी कार्यक्रम के तहत सात विस्तार कार्यक्रम आयोजित किए गए।
- पूक्षेके, कल्याणी में खरपतवार प्रबंधन, एकीकृत खेती, चारा उत्पादन, जल प्रबंधन, मृदा उर्वरता प्रबंधन, डेरी प्रबंधन, सूअर पालन प्रबंधन, रोग प्रबंधन, बकरी पालन आदि जैसे विभिन्न विषयों पर कुल 46 प्रशिक्षण कार्यक्रम आयोजित किए गए। इन प्रशिक्षणों के माध्यम से कार्यक्रमों, कुल 1015 पुरुष प्रतिभागियों और 896 महिला प्रतिभागियों को लाभान्वित किया गया।
- Punjab Agricultural University (PAU), Ludhiana, the PAU, Ludhiana sold paddy seed (varieties PR-114, PR-124) and wheat seed (varieties PBW-343, PBW-550) themselves at seed counter of ATIC to benefit farmers of Karnal district and adjoining regions.
- Fourteen youth belonging to scheduled caste communities were identified from Haryana and Himachal Pradesh and trained for 45 days at Regional Centre of National Dairy Development Board, Jalandhar, Punjab from 02.08.2021 to 15.09.2021 on Artificial Insemination. Later, they were facilitated to undergo 75 days field training at their respective native places under the trained veterinarians. The prime objective of this capacity building was to generate self-employment models for the educated unemployed youth in rural areas.
- An online Training for Master Trainers on Dairy Processing under the aegis of Prime Minister's-Formulation of Medium and Small Enterprises (PM-FME) Scheme of MOFPI, Govt. of India and sponsored by Indian Institute of Food Processing Technology (IIFPT), Thanjavur.
- Training was imparted to potential women entrepreneurs from Karnal, Panipat, Sonapat district on milk and milk products processing (*dahi, paneer, ghee etc.*) under a DST-funded project.
- Faculty served as resource persons for Virtual Training Programs conducted for stakeholders at the Extension Education Institute (Southern Region), Department of Agriculture & Cooperation & Farmer's Welfare, PJTSAU Campus, Rajendranagar, Hyderabad on latest developments in the area of Value Addition and Processing of Dairy Products and Composite Dairy Foods.
- Under the NEH a total of five livestock developmental camps were organized in five North Eastern states of India namely, Arunachal Pradesh, Nagaland, Tripura, Assam and Sikkim during 2021. Livestock animals, poultry chicks, ducks and different agri-inputs were distributed among farmers.
- Under TSP, 4 camps were organised in different parts of Eastern and North- Eastern India and 4 on-campus training programmes were organized.
- Seven extension programmes were organized under SCSP programme during January 2021 to December 2021 at ERS, Kalyani.
- A total of 46 training programmes were conducted at ERS, Kalyani on different topic like Weed Management, Integrated Farming, Fodder Production, Water Management, Soil fertility management, Dairy Management, Piggery Management, Disease Management, Goat Farming, etc. Through these training programmes, a total of 1015 male participants and 896 female participants were benefited.

आधारभूत संरचना

- बिजली की सुरक्षा के लिए शेड का पी एंड एफ सब-स्टेशन पर जेन सेट और एम.एस. भाकृअनुप-राडेअनुसं में कृष्णा छात्रावास के छात्रों के कमरे में तार की जाली के शटर।
- भाकृअनुप-राडेअनुसं, करनाल में प्रशासन में तीन कमरों का नवीनीकरण, ऑडिट अनुभाग, क्रय अनुभाग और ई-II/ई-III कमरा एल्यूमीनियम खिड़की, फाल्स सीलिंग और पूर्ण सफेदी प्रदान किया गया।
- भाकृअनुप-राडेअनुसं, करनाल में स्प्रिंकलर सिस्टम के लिए पानी के कनेक्शन सहित आरसीसी पानी की टंकी उपलब्ध कराई गयी।
- भाकृअनुप-राडेअनुसं, करनाल में परिसर में सीवेज लाईन मैनहोल का आर एंड आर सतलुज छात्रावास का एक पानी का टैंक और एमई अनुभाग का पार्किंग शेड।
- भाकृअनुप-राडेअनुसं, करनाल में निक्का भवन और संरचनाओं की मरम्मत और नवीनीकरण।
- भाकृअनुप-राडेअनुसं, करनाल के पुस्तकालय में महिलाओं और पुरुषों के शौचालयों और बाहरी सीढ़ियों का निर्माण।
- भाकृअनुप-राडेअनुसं, करनाल के संयुक्त निदेशक (अनुसंधान) कार्यालय और पीएमई सेल की मरम्मत और नवीनीकरण।

INFRASTRUCTURE

- P&F of Shed for protection of Elect. Gen Set at Sub-station and M.S. wire mesh shutters to the Students' Room of Krishna Hostel at ICAR-NDRI.
- Renovation of three rooms in Admn. Block i.e. Audit Section, Purchase Section and E-II/ E-III room by providing aluminium window, false ceiling & complete white washing at ICAR-NDRI, Karnal.
- Provided RCC water tank including water connection for sprinklersystem at ICAR-NDRI, Karnal.
- R&R of Sewage Line manholes in the campus, one water tank of Satluj Hostel and Parking Shed of ME Section at ICAR-NDRI, Karnal.
- Repair and Renovation of NICRA Building and Structures at ICAR-NDRI, Karnal.
- Construction of Ladies and Gents Toilets and outside staircase in Library of ICAR-NDRI, Karnal.
- Repair and Renovation of Joint Director (Research) Office and PME Cell of ICAR-NDRI, Karnal.



1. INTRODUCTION

ICAR-National Dairy Research Institute (NDRI) at Karnal, Haryana is one of the premier Institutes in dairy sector. The Institute has contributed tremendously in the growth of the Indian dairy industry and played a crucial role in India's development in milk production with its continuous research. Over ninety year old, NDRI's lineage goes back to the Imperial Institute for Animal Husbandry & Dairying, which was set up in Bangalore in 1923 as a center for dairy education. It was shifted to its present site in Karnal in 1955 and renamed as National Dairy Research Institute. The infrastructure of Imperial institute was retained as Southern Regional Station of NDRI and later in 1964 Eastern Regional Station was set up at Kalyani in West Bengal. NDRI was brought under Indian Council of Agricultural Research in 1970. The Institute has been granted a Deemed University status for implementing its academic programmes since 1989. NDRI has the unique distinction of having been ranked first among all Agricultural Universities and Deemed Universities consecutively five times in the years 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21. The Institute has been accredited by National Agricultural Education Accreditation Board, ICAR up to 2021. The Institute also finds a place in the Special Mention Category of Institutions by National Institute Ranking Framework (NIRF), Ministry of Human Resources Development, Ranking (2018). The Institute is also ISO 9001: 2015 certified. The primary goal of the Institute is to provide R&D support towards generation and dissemination of knowledge for development of national milch herd, milk production enhancement; greater productivity of the dairy industry and upliftment of the dairy profession, leading to socio-economic and environmental benefits to the nation as well as contribution towards manpower development programme. This is a unique campus, which alongside Deemed University and residential buildings, has various well equipped research laboratories as well as green spaces with perennial plants and gardens. Well equipped sports facilities and attractive leisure time opportunities are offered to the students and employees of the Institute.

Southern Campus, Bengaluru

The foundation stone of the edifice of NDRI was laid at Bengaluru on July 1, 1923. It was the forerunner institution in starting dairy education programmes to meet the manpower requirements of the Nation's dairy industry. Upon shifting of the Institute Head Quarters to Karnal in 1955, the establishment at Bengaluru continued as the Southern Regional Station of NDRI. The station has been catering to the research, training and extension needs of the dairy farmers and dairy industry of the southern region of the Nation. This centre was the first to initiate training in artificial insemination in cattle in the country.

Eastern Campus, Kalyani

The Eastern Regional Station of the Institute was established at the Central Dairy in Kolkata in 1964 and was shifted in 1966 to Kalyani (Nadia district), about 50 km north of Kolkata. The main objective of establishing the Eastern Regional Station was to identify the major constraints of dairy production in eastern and north eastern India and to offer solutions through research and extension activities to these problems.

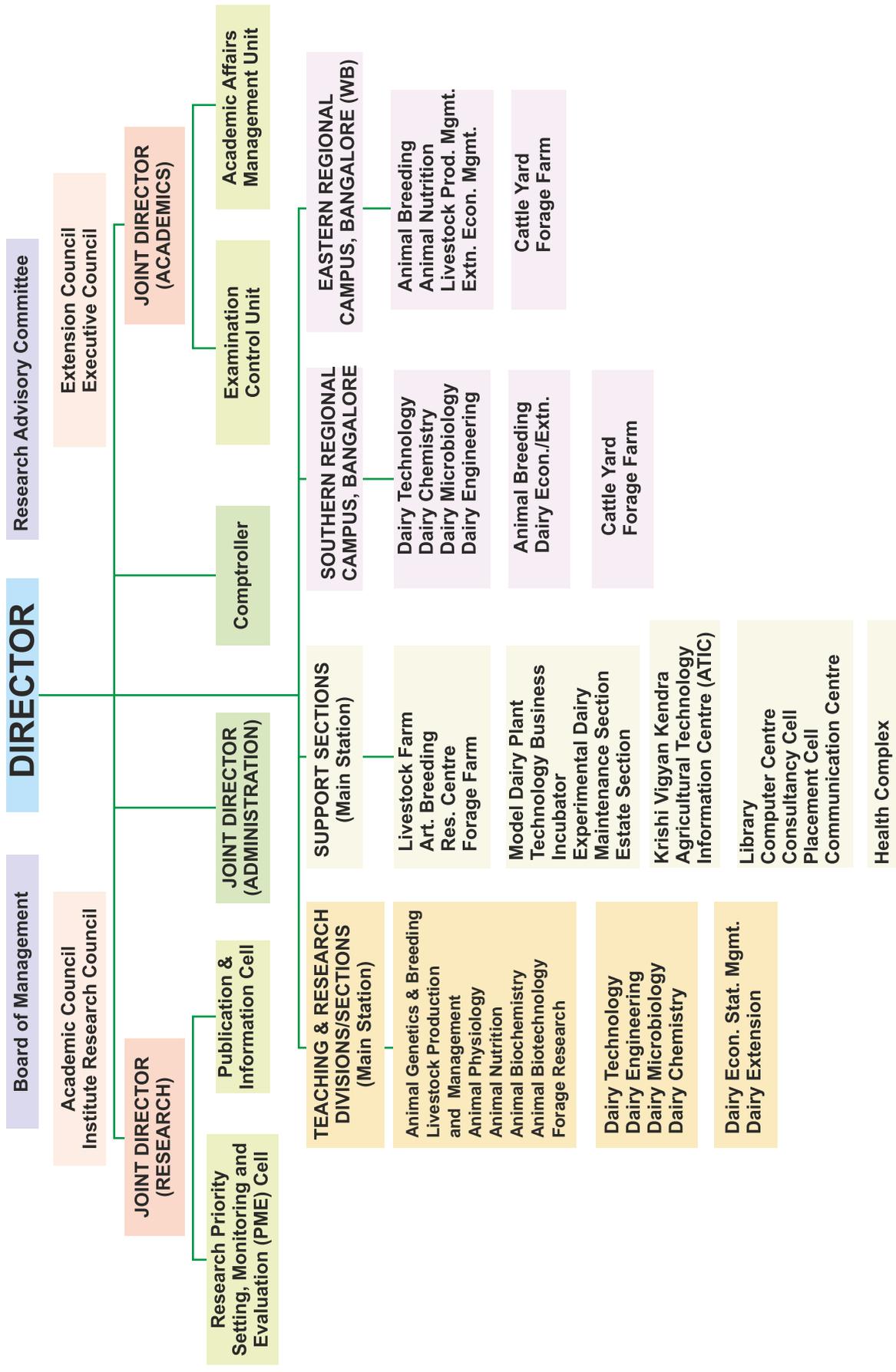
Krishi and Dairy Vikas Kendra, Piprakothi-Motihari

ICAR-NDRI established Krishi and Dairy Vikas Kendra (KDVK) at KVK, Piprakothi, East Charparan (Bihar) in the premises of Dr. Rajendra Prasad Central Agriculture University, Pusa. The Centre was inaugurated by Hon'ble Union Agriculture and Farmers Welfare Minister, Sh. Radha Mohan Singh on July 10, 2016.

Model Dairy Centre, Lalukheri - Muzzafarnagar

The centre was initiated at Lalukheri in Muzzafarnagar, Uttar Pradesh under the project approved by ICAR, New Delhi vide letter No. 2-2/02-ASR-III dated 25.09.2002. The basic facilities have been created for empowering youth and women involved in dairy sector.

Organizational Structure of NDRI



2. ORGANISATIONAL SETUP

The organizational structure of NDRI follows the Deemed University pattern of the ICAR. The policy making functions pertaining to research, education and extension activities are managed through six main bodies.

- Board of Management
- Research Advisory Committee
- Academic Council
- Institute Research Council
- Extension Council
- Executive Council

The highest policy making body is the Board of Management (BOM). The Director, NDRI, is the Chairman of this Board. The Research Advisory Committee (RAC) is responsible for the all-round progress in research at the Institute and its application. The Academic Council is responsible for all issues relating to the education and training. The Academic Council, in turn, is supported by (i) Standing Committees, (ii) the Post Graduate Faculty, and (iii) the Board of Studies in the respective disciplines. The Extension Council is responsible for guiding extension programs. Institute Research Committee (IRC) is responsible for prioritization, monitoring and evaluation of research conducted in the Institute. The Executive Council is the main task-implementing body on Administrative matters and the powers and the function of this Council shall be those as may be delegated by the BOM. The research, education and extension activities of the Institute are managed by the Director and the Joint Directors through scientific, technical, administrative and supporting staff. The Director is the overall Administrative Head of the Institute and its Regional Stations. The Joint Directors in addition to extending support to the Director in the area of research, academics and administration are responsible to co-ordinate research and educational activities of various Divisions and Regional Stations, respectively. Each of the Regional Stations is administered through the Head located at the station. The scientific and teaching work at the main campus and its regional campuses is conducted in 15 subject-matter disciplines.

BOARD OF MANAGEMENT

Chairman	Dr. M.S. Chauhan, Director, ICAR-NDRI, Karnal
Member Secretary	Joint Director (Administration) & Registrar, ICAR-NDRI, Karnal
Members	
Dr. Dheer Singh, Joint Director (Research), ICAR-NDRI	Dr. R.R.B. Singh, Joint Director (Academic), ICAR-NDRI
Dr. N.C. Gautam, Vice-Chancellor, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalaya, Chitrakoot, Satna (MP)	Sh. K.S. Ponnuru, Secretary, Agriculture, Dept. of Agriculture, Punjab, 5th Floor, Mini Secretariat Punjab, Sec-9, Chandigarh
Dr. S.M. Deb, Head, ERS, Kalyani, Dist. NADIA (WB)	Dr. P. Barnwal, Head, Dairy Engineering Division, NDRI
Dr. Sumit Arora, PS, Dairy Chemistry Division, NDRI	Dr. T.K. Datta, Director, ICAR-CIRB, Hisar (Haryana)
Dr. Naresh Kumar, PS, Dairy Microbiology Division, NDRI	Dr. T.K. Mohanty, PS, ABRC, NDRI
Dr. S.K. Jha, PS, ICAR-IIS & WC, Chandigarh	Dr. Rakesh Kumar, PS, ABRC, NDRI
Dr. G.K. Singh, Vice-chancellor, UP Pt. Deen Dayal Upadhyay Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan, Mathura (UP)	Dr. B.N. Tripathi, Deputy Director General (AS), Indian Council of Agricultural Research, Krishi Bhavan, New Delhi-110001
Dr. Triveni Dutt, Director, Indian Veterinary Research Institute, Izatnagar (UP)	Sh. Jagdev Singh Padha, Kothi No. 1920, Sector-13, Urban Estate, Karnal-132001 (Haryana)
Sh. S. Ravinder Singh Dhillon, 6-F, Model Town, Patiala-147001, Punjab	Sh. Manish Wadhwa, Sr. F&AO, Krishi Bhawan, New Delhi

ACADEMIC COUNCIL

Chairman	Dr. M.S. Chauhan, Director, ICAR-NDRI, Karnal
Vice-Chairman	Dr. R.R.B. Singh, Joint Director (Academic), ICAR-NDRI
Member	Dr. Dheer Singh, Joint Director (Research), NDRI, Karnal
Members	
Dr. S. Majumdar, Director, National Institute of Animal Biotechnology (Deemed University), Hyderabad	Dr. S.S. Tomar, Dean, College of Veterinary Sciences Kuthulia, Rewa-486001 (MP)
Dr. A.K. Rawat, Advisor, Department of Biotechnology, New Delhi	Dr. Triveni Dutt, Joint Director (Academics), IVRI, Izatnagar-243122 (UP)
Dr. Gautam Kaul, Head, ABC Division	Dr. A.K. Singh, Head, DT Division
Dr. Raman Seth, Head, DC Division	Dr. K.S. Kadian, Head, Dairy Extension Division
Dr. A.K. Dang, Head, AP Division	Dr. P. Barnwal, Head, DE Division
Dr. B.S. Chandel, Head, DES&M Division	Dr. Raman Malik, Head, AN Division
Dr. A.K. Puniya, Head, DM Division	Dr. Archana Verma, Head, AG&B Division
Dr. S. De, In-charge ABTC	Dr. A.K. Mishra, In-charge LPM
Dr. Rakesh Kumar, In-charge FR&MC	Dr. K.P. Ramesha, Head, SRS, Bengaluru (Karnataka)
Dr. S.M. Deb, Head, ERS, Kalyani, Nadia (WB)	Dr. Nitin Tyagi, Academic Coordinator
Dr. R. Malhotra, Controller of Examination	Dr. Sumit Arora, PS, DC Division
Dr. Vikas Vohra, PS, AG&B Division	Representative, UGC
DDG Education, ICAR, New Delhi/ his Nominee	Ms. Kanika Bhakuni, M.Sc., 2nd Year Topper, Agronomy
Ms. Navkiran Kaur, Ph.D. 2nd Year Topper, ABTC	Joint Director (Administration) & Registrar, NDRI, Member Secretary

RESEARCH ADVISORY COMMITTEE

Chairman	Dr. S. L. Goswami, Ex-Vice-Chancellor, Banda University of Agriculture & Tech., ZC-590, CHD City, Karnal-132001
Member Secretary	Dr. Dheer Singh, Joint Director (Research), NDRI
Members	
Deputy Director General (Animal Science), ICAR, New Delhi	Dr. M.S. Chauhan, Director, ICAR-NDRI, Karnal
Dr. D. Kathiresan, Ex-Dean, College of Veterinary Science and Animal Husbandry (CVSc & AH), Aizawl, Director, TVCC, Apollo College of Veterinary Medicine, Jaipur (Rajasthan)	Dr. R. K. Sethi, Former Director, Central Institute for Research on Buffaloes, Hissar
Dr. V.P. Reddy, Dean, Dairy Science, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh	Dr. Seema Bathla, Professor (Agriculture Economics), Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi

EXTENSION COUNCIL

Joint Director (Extension)	Vice-Chairman
Dr. Dheer Singh, Joint Director (Research)	Member
Dr. R.R.B. Singh, Joint Director (Academic)	-do-
DDG (Extn. Education), ICAR, New Delhi or his Nominee	-do-
Three Scientists in Management position of the Institute	-do-
	<ul style="list-style-type: none"> i) Dr. Pawan Singh, I/C, LPM ii) Dr. S.M. Deb, Head, AG&B iii) Dr. B.S. Chandel, PS, DESM

Five Scientists of the Institute (to be nominated by the Board of Management on a two year tenure basis)	Member	i) Dr. Gautam Kaul, PS, ABC ii) Dr. T.K. Mohanty, I/C, ABRC iii) Dr. A.K Misra, I/C, ATIC iv) Dr. Madhu Mohini, Head, Animal Nutrition v) Dr. A.K. Singh, I/C, BPD Unit
One Scientist from Regional Station to be nominated by the Board of Management on a two year tenure basis)	-do-	Head, SRS of NDRI, Bengaluru
One representative of the Department of Agriculture, Ministry of Agriculture (to be nominated by the Agriculture Commissioner, Govt. of India)	-do-	Agriculture Commissioner, Govt. of India, Ministry of Agriculture, Department of Agriculture & Cooperation, Krishi Bhawan, New Delhi or his Nominee
One Extension Scientist representing Livestock Development and/ or Dairy Development (to be nominated by the Board of Management on a two year tenure basis)	-do-	Director General, Department of Animal Husbandry & Dairying, Govt. of Haryana, Pashudhan Bhawan, Sector- 2, Panchkula or his Nominee
Director (Farm Information), Directorate of Extension, Govt. of India, New Delhi	-do-	Director (Farm Information), Directorate of Extension, Govt. of India, New Delhi or his Nominee
Head, Division of Dairy Extension	Member Secretary	Dr. K. S. Kadian, Head, Dairy Extension Division

3. RESEARCH ACHIEVEMENTS

BIOTECHNOLOGICAL INTERVENTIONS FOR HIGHER PRODUCTIVITY

Buffalo Calves Produced Using Semen of the Cloned Bulls

For the faster multiplication of elite germplasm, NDRI has developed a simple, economical, and efficient animal cloning technology, called hand-guided cloning, that used to produce over 25 cloned buffaloes in the country. To upgrade the genetic potential of low milk producers and non-descript buffaloes; Indian government has proposed increasing the coverage of artificial insemination (AI) from the current 30% to 80-90% by the end of 2025. Buffalo cloning is an advanced technology that offers to make genetic copies of the elite bulls in the shortest possible time. ICAR-NDRI produced several cloned breeding bulls, of which two breeding bulls (named Swarn and Rajat) were used to demonstrate the fertility of cloned bulls. In the study, found that the physical semen parameters



such as volume, sperm concentration, and post-thaw motility are similar to non-cloned bulls. Also, at the molecular level, sperm transcripts and miRNA regulating spermatogenesis, fertility, and early embryonic development are similar between the clones and their parents. To determine the fertility of cloned bulls, 20 female buffaloes were inseminated with the semen of two above mentioned cloned bulls. Following insemination in female buffaloes, a 65% conception rate was achieved which is normal in buffaloes. Twelve healthy calves (six females and six males) were produced and further attempts are ongoing to produce more calves. These calves are physiologically normal, growing well and healthy (NASF Project on Buffalo Cloning).

Sperm Transcriptome of Cloned Buffalo Bulls and their Respective Somatic Cell Donor Bulls

Global transcriptome and miRNA profile of spermatozoa of cloned bulls and their respective somatic cell donor bulls against *Bos taurus* reference genome, UMD 3.1.1 showed alignment of 76.76% to 88.25% for transcriptome and between 90.32% to 94.14% for miRNA. Total number of transcripts evaluated were 27,481 out of which 18,703 transcripts were expressed commonly in both cloned and somatic cell donor bulls spermatozoa, 4120 transcripts were unique to cloned bulls spermatozoa and 4658 transcripts were unique to somatic cell donor bulls spermatozoa. 51 transcripts were found to express differentially ($FC \geq 10$; $P < 0.05$) in cloned bulls spermatozoa relative to parent bulls spermatozoa. A total of 278 miRNAs in the spermatozoa of cloned and parent bulls out of which 239 miRNAs were common in both the groups, 28 miRNAs were unique to cloned bulls spermatozoa and 11 miRNAs were unique to parent bulls spermatozoa. Upon differential expression analysis (at $FC \geq 2$ and $P < 0.05$), 62 miRNAs were found to express differentially between the two groups, out of which 31 miRNAs were up-regulated and 31 miRNAs were down-regulated in cloned bulls spermatozoa relative to parent bulls spermatozoa. But the expression pattern of transcripts and miRNAs associated with spermatogenesis, bull fertility and early embryonic development were apparently similar in cloned bulls spermatozoa and parent bulls spermatozoa. Also, there was no difference was observed in the fresh semen parameters of cloned bulls and non-cloned bulls. With this limited study, we can say that semen from cloned bulls may be used in various assisted reproductive technologies (ART).

Production of Double-Muscle Mass Farm Animals Using CRISPR

To characterize the MSTN gene, the genomic DNA from 4 individuals of three species (Buffalo, Goat, sheep) was isolated. And, all three exons of the MSTN gene were amplified using PCR and cloned PCR products into sequencing vectors. The sequencing data were analyzed to characterize the MSTN gene. Then, the sequence of Exon 1 was used to design guides using CHOP-CHOP/ CRISPOR algorithms. A total of six sgRNAs have been designed for RNP complexes and three sgRNAs for CRISPR Vectors (PX-458/ 459). Designed sgRNAs for

vectors were cloned into vectors and confirmed their ligation and alignment using the Sanger sequencing. These sgRNAs were shared with partners' institutions (CIRB, CIRG, and SKUAST-K). Somatic cells from 4-selected animals were established for editing experiments and now initiated electroporation experiments to optimize the editing conditions (NASF project).

Optimization of Method to Produce Cloned Embryos of Indigenous Cows

To initiate the cloning of indigenous cows, somatic cells from elite cows that belong to Gir, Sahiwal, Red-Sindhi have been established and their cells were cryopreserved using a slow freezing method. For SCNT, healthy animals, with normal reproduction, available at the NDRI animal farm/ULDB farm were used to collect oocytes according to the OPU methods. Both stimulation and non-stimulation protocols were used to harvest the maximum number of oocytes. OPU derived oocytes were subjected to in vitro maturation, followed by handmade cloning procedures such as enucleation and electrofusion. Factors affecting the efficiency of maturation, protrusion cone appearance, electrofusion of enucleated eggs, and donors of nuclei have been examined. The generated HMC embryos were cultured to develop them to the pre-implantation transferable stage embryos (morula or blastocyst). During the reporting period, a total of seven OPU experiments were performed for the development of HMC protocol in cows. For HMC experiments, Donor cells were used from Sahiwal, Gir, Red-Shindi. We produced 71 embryos of indigenous cows using enucleated oocytes of Sahiwal/ Red-Shindi, of which 5 blastocysts were developed. In the case of cross-bred cows' oocytes, a total of 8 embryos were produced, of two blastocysts were produced. Further attempts were continued to improve blastocyst production rate, and produced blastocysts will be transferred to recipient animals for the production of cloned cows.

Regenerative Therapy for the Prevention of Sub-Clinical Mastitis of Cattle Using Mesenchymal Stem Cells

Mastitis is the inflammation of the mammary gland caused by the bacteria which drastically decreases milk production causing a huge economic loss to the farmers in India. Antibiotics are generally used to cure mastitis which are unable to regenerate the mammary glandular tissue and gradually increase the antibiotic resistance in milking cows. The antibiotics residues also percolate down in to the milk causing harm to the consumers. Mesenchymal stem cells are anti-inflammatory, immunomodulatory, and help in regenerating the damaged tissue of the mammary gland. In the present study, umbilical cord blood-derived mesenchymal stem cells (UCB-MSCs) were used for the prevention of sub-clinical mastitis of cows. UCB-MSCs were isolated, in vitro cultured, and characterized by Alkaline phosphatase staining, RT-PCR, Immunostaining, and directed differentiation into adipogenic, osteogenic, and chondrogenic lineages. The MSCs were further cryopreserved into liquid nitrogen and used for the treatment of sub-clinical mastitis. Sub-clinical mastitis cows were allotted in groups (Each group of 10 cows) for local and IV injections of the antibiotic (control), fresh MSCs, cryopreserved MSCs, and the Extracellular Vesicles (EV) on days 0 and 7. Total RNA was isolated for the gene expression study on days 0, 1, 7, and 15 blood samples. Somatic Cell Count (SCC) was significantly ($P < 0.05$) decreased in all MSCs and EV treatment groups compared to the control group in mastitis suffering cows. Anti-inflammatory cytokine (IL-10), Cathelicidin, Cystatin, Lipocalin 2, angiopoietin were increased and the Pro-



Fig.: California mastitis test (CMT) of Antibiotic, Cryo-MSCs, fresh MSCs and EV groups were compared after 15 days of treatment and observed drastically reduced bacterial load after MSCs treated groups.

inflammatory cytokine (IL-6) genes were significantly ($P < 0.05$) decreased in the treatment groups compared to the control group cow. It may be concluded that MSCs therapy significantly decreased the SCC in mastitis milk of cows and gene expression increased than the control group cows. MSCs may be injected as an alternative regenerative therapy for the prevention of sub-clinical mastitis in cattle as all MSCs treated cows were cured within a month.

Production of Human Erythropoietin Protein into Goat Mammary Epithelial Cells Using CRISPR/ Cas9 Technique

CRISPR is an RNA-guided DNA endonuclease Cas9 can be easily programmed to target sites of interest in the host genome. Human Erythropoietin (hEPO) is a therapeutically important glycoprotein hormone that is responsible for erythropoiesis in mammals and is effective in treating the anemic patients because of chemotherapy, renal diseases, HIV and cancer etc. In the present study, we used the CRISPR/Cas9 system to knockin the human erythropoietin gene into goat mammary epithelial cells. The guide RNAs were designed and customized using chop chop CRISPR software, and cloned into CRISPR vectors. Co-transfection of guide RNA and pAc-csn2-EPO-GFP-n1 vector was carried out using lipofectamine 3000 into goat mammary epithelial cells. Transgenic GFP-positive cells were selected using puromycin antibiotics. Genotypic PCR analysis was done to determine gene knockin efficiency. The goat mammary epithelial cells and fetal fibroblast cells were cultured and propagated in vitro using DMEM/F12 and growth factors. The pAc-csn2-EPO-GFP-n1 vector was prepared by cloning of beta-casein (csn2) promoter and hEPO gene. The cloning of beta-casein (csn2) promoter and hEPO gene in the pAcGFP-n1 vector backbone were validated by Sanger sequencing. The knockin efficiency of the gene construct was estimated through the genotypic PCR and Sanger sequencing analysis. There was no phenotypic difference between the transgenic and non-transgenic cells. Human erythropoietin protein was secreted into cell culture medium DMEM/F12 medium, and detected by Western blotting method.

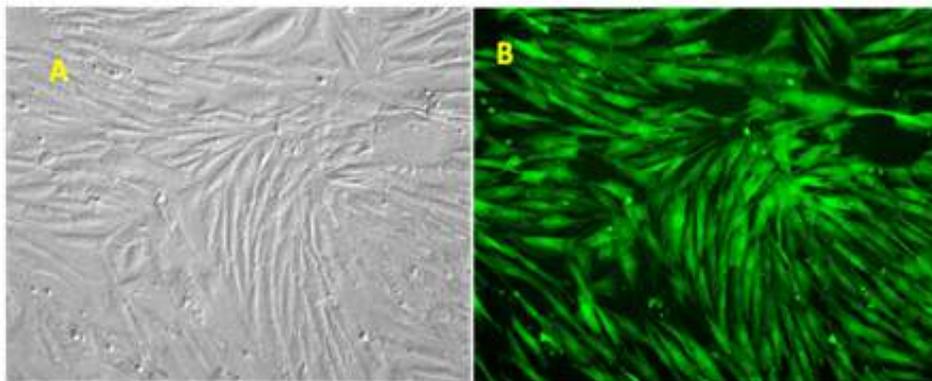


Fig.: Clonal expansion of Human Erythropoietin gene transgenic goat foetal fibroblast cells expressing GFP. Bright field images (A); Blue light filter (B) (100X; Scale: 100 μ m)

CRISPR/ Cas9 Mediated Knockout of COX-2, PTGES, PTGFS and AKR1B5 Genes for Determining their Role in the Fertility of Mouse

Transfection of gene-specific CRISPR-Cas9 mix was injected in mouse zygotes through microinjection. The zygotic stage embryos were recovered from the mice's oviducts. The microinjection mix containing COX2-targeted sgRNA-CAS9 in the buffer was prepared at a concentration of 5ng/ μ l and injected near the pronucleus of the zygotes. The zygotes which developed to the 2-cell stage were considered to be the ones that survived the microinjection regime. In the present study, more than 60% of the embryos developed into 2-cell stage embryos. Embryos were in-vitro cultured after 12-24 hrs when developed to 2-cell stages. A total of 36 embryos were transferred surgically in oviducts of 4 surrogate mice. The embryos were also cultured further to assess their growth potential up to the blastocyst stage. It has been observed that 80% of the surviving embryos reached the blastocyst stage. The samples of the embryos have been collected and stored to assess the mono-allelic or bi-allelic deletions.

Production of CRISPR-Cas9 Mediated β -lactoglobulin Gene Edited Buffalo Embryos

β -lactoglobulin (β -LG) is a milk whey protein, which causes the allergic reactions in infants and children. The full coding region of buffalo milk protein genes viz. beta lactoglobulin (β -LG), alpha lactalbumin (LALBA), beta casein (CSN2), kappa casein (CSN3), and alpha S1 casein (CSN1S1) were characterized. Several allelic variations were

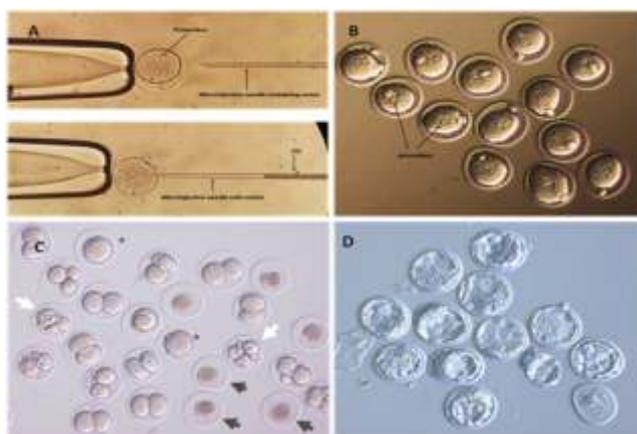


Fig.: Development of blastocysts of microinjected mouse zygotes: Microinjection of sgRNA-CAS9 against COX2 gene in zygotes (A). Zygotic stage of mouse embryos used for microinjection of sgRNA-Cas9 mix. Pronuclei are clearly visible (B). Embryos were further in vitro cultured after 12-24 hrs when developed to 2-cell stage (C). It has been observed that 80% of the survived embryos reached to blastocyst stage (D). White arrowheads represent degenerated embryos. Black arrowheads show the lysed embryos and the asterix represents the unfertilized or failed to cleave embryos.

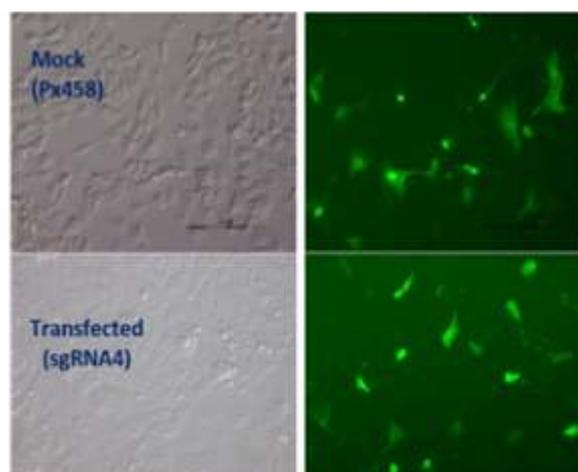


Fig.: Transfection of the buffalo mammary epithelial cells with gene construct (PX458_GFP_sgRNA4).

found in these milk protein genes. Physicochemical properties of buffalo β -LG and LALBA protein was analyzed by bio-informatics tools. CRISPR/ Cas9 was used to knockout the β -LG gene in buffalo mammary epithelial cells. For this purpose, four different sets of CRISPR guide RNA viz. sgRNA1, sgRNA2, sgRNA4, sgRNA7 were designed. Finally, three GFP carrying CRISPR gene constructs (i.e. sgRNA2, sgRNA4 and sgRNA7) and two puromycin carrying CRISPR gene constructs (i.e. sgRNA2 and sgRNA4) were prepared. GFP carrying CRISPR gene constructs were transfected in buffalo mammary epithelial cells. These epithelial cells showed the green fluorescence and were cultured till 7 days. An editing event (8 base pair deletion) was confirmed in transfected buffalo mammary epithelial cells by T7 E1 assay and sequencing. Expression of the milk protein genes (β -LG, LALBA, CSN2, CSN3, CSN1S1, CSN1S2 and Lactoferrin) were analyzed in edited epithelial cells by qRT-PCR. Results showed that the expression of β LG gene transcript was significantly reduced in edited cells. Similarly, puromycin carrying CRISPR gene constructs (sgRNA2 and sgRNA4) were transfected in buffalo mammary epithelial cells. After a week, second transfection was performed for their enrichment. After 21-25 days, the epithelial cells were analyzed by T7 E1 assay and sequencing. Three base pair deletion was found in exon-1 of β LG gene of epithelial cells. Results showed that the expression of the β LG gene transcript was significantly reduced in edited epithelial cells.

Extracellular Vesicles (EVs) in Seminal Plasma of Sahiwal Bull Contain Fertility Associated Proteins and EVs Deliver the Fertility Factors to Spermatozoa

Male reproductive tract of bulls carries millions of EVs in seminal plasma and these EVs possess unique molecular signatures having potential of regulating sperm functions. Presence of fertility associated proteins viz., SP-10, SPAM-1 & ADAM-7 was assessed in the seminal EVs of Sahiwal bulls. Four high (HF) and low fertile (LF) in each group were selected on the basis of their conception rate in the study. Size of seminal EVs was in the range from 98 to 198 nm by the Zetasizer and <200 nm by the NTA approach and transmission electron microscopy (TEM) images further supported the presence and morphology of EVs in seminal plasma. Assessment of differential abundance SP-10, SPAM-1 and ADAM-7 in seminal EVs of HF and LF bulls revealed that expression of candidate proteins differ significantly in high and low fertile Sahiwal bulls. The expression pattern of SP-10 and SPAM-1 was significantly high in HF bulls whereas expression of ADAM-7 was consistently high in LF bulls. The protein cargo was successfully transferred into spermatozoa suggesting that EVs worked as a delivery vehicle for transferring the fertility factors to spermatozoa, thus EVs consisting of protein signatures can be utilized for improving sperm functional traits.

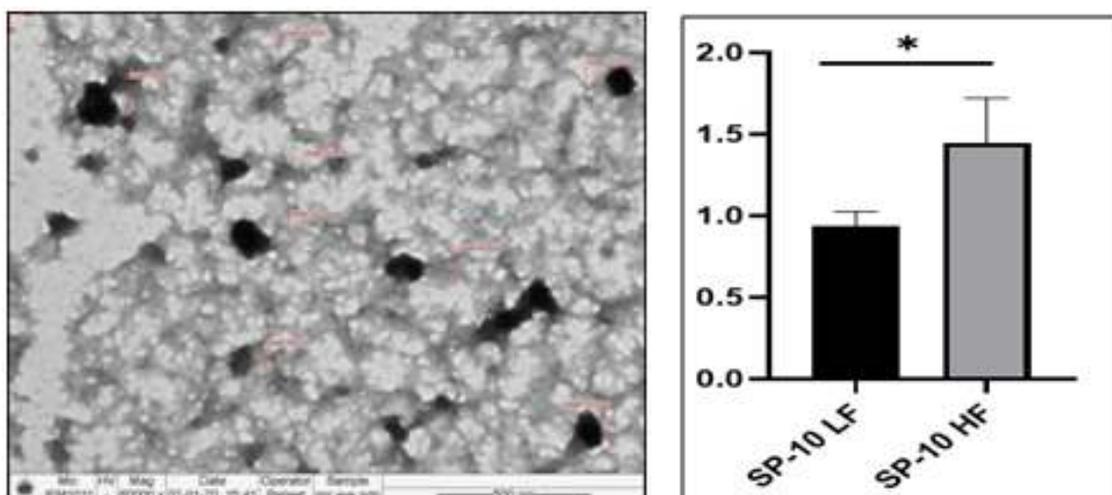


Fig.: Confirmation of EVs by TEM in seminal plasma of Sahiwal Bulls and abundance of SP-10 in Low and High fertile seminal EVs

Flow Cytometry Assessment of Dynamic Pattern of Glycosylated Proteins on Buffalo Sperm Surface Based on Elevated Salt and PI-PLC Treatments

Glycan moieties associated with coat protein of sperm surface provide unique topology and strong immunoprotection to spermatozoa while traversing through the female reproductive tract. An assessment of glycan moieties on sperm surface was performed based on DPBS and PI-PLC treatments followed by flow cytometry. Both the treatments removed distinct sets of immune related glycoproteins from the surface of buffalo spermatozoa. The unstained spermatozoa were excluded from the analysis by gating, and the singlets were chosen and the analyses were performed on single, stained spermatozoon. The analyses revealed a reduction in O-linked as well as N-linked glycans after elevated salt and PI-PLC treatments as illustrated by the reduction in the MFI from the FITC-bound lectin binding on the buffalo sperm-surface. A panel of five O-linked glycans specific lectins viz. ABL, JAC, MAL-II, LCA and PNA and one N-linked glycan specific lectin, LEL was used. Overall, both the treatments reduced the availability of respective cognate glycans thus bringing a reduction the mean fluorescence index (MFI) of most lectins except the PNA wherein the MFI contrarily increased. Furthermore, both the treatments were significantly different from each other vis-à-vis the MFI produced upon lectin binding on sperm-surface, indicating that diverse niche of glycans exposed on sperm surface due to DPBS and PI-PLC treatments. This finding advances our understanding of sperm membrane modulation and glycan dynamics due to change in the environment milieu as simulated in this study.

Proteomic Analysis Revealed Subdued Follicle Regeneration and Fibre Growth Pathways in Low Yielding Pashmina Goat during Anagen Phase of the Fibre Development

India contributes less than one percent to the total pashmina production. On an average, the pashmina fibre annual yield is around 240 gm/animal (Shakyawar et al., 2013). There is a significant difference in the yield of animals. High yielder can produce more than 600gm/ year, while low yielder animals could produce less than 100gm/ year. Our transcriptomic study revealed that the expression of key proteins responsible for the entry of pashmina fibre into the anagen phase significantly differed between the high yielding (HY) and the low yielding (LY) groups. Decreased expression level of proteins in the active growth stage (anagen) should render the follicles lesser active and productivity might suffer resulting in a lower yield. Expression profile of metabolic proteins in HY vs LY was found to be more or less similar with significant variations at some specific time points, such as MDH2 and ACLY showed differential expression in May, while LDHB in March. On the other hand, some other proteins showed significant difference in expression level throughout the growth phases between HY and LY. Proteins which are responsible for the active growth of fibres showed higher expression in anagen phase as compared to catagen phase. On the other hand, proteins responsible for the regression of fibres showed higher expression in catagen phase as compared to anagen phase. The results showed that the dysregulated proteins in HY and LY could be responsible for the regulation of important biological processes like keratinisation, cornification, hair follicle growth and regeneration, hair follicle morphogenesis, apoptosis, and metabolic pathways.

Quantitative Proteomics of MFGE8 Knock-out Buffalo Mammary Epithelial Cells

MFGE8 gene is differentially expressed in the Mammary epithelial Cells of the high and low lactating cows and its potential role in milk yield and lactation persistency has been projected. Therefore, MFGE8 knockout cells were generated via CRISPR/ Cas technology to understand its role of in lactation in bovine. Quantitative proteomics data revealed significant reduction in MFGE8 protein expression in MFGE8 knock-out buffalo mammary epithelial cells (BuMEC) as compared to control. It was found that 82 proteins were down regulated (fold change- ≤ 0.5) and 101 up regulated (fold change- ≥ 0.5) in MFGE8 knock-out BuMEC when compared to control BuMEC. Pathway analysis and gene ontology study revealed enrichment of various biological processes and immune system processes associated with the down regulation of MFGE8 gene in our study. In line with the findings, previous studies have reported role of MFGE8 in antitumor immune response in association with Interferon alpha ($IFN\beta$). MFGE8 has also been associated with regulation of several genes involved in lactation biology pathways e.g. VLDLR protein expression has been found to be up regulated by 1.5 fold and FABP3 protein expression has been found to be down regulated by 0.5 folds, which validates its role in lactation.

Isolation, Culture and Characterization of Buffalo Endometrial Epithelial cells

Ruminants undergo a relatively noninvasive placentation process that gives rise to a synepitheliochorial placenta. In bovine's establishment and maintenance of successful pregnancy, requires interaction from both conceptus and maternal system and in that case particularly with first respondent i.e., endometrial epithelial cells (EECs). Thus, the current study is intended to provide a platform to investigate biology and functionality of pregnancy by establishing a stable invitro culture system. Buffalo uteruses were collected from local slaughter house in saline solution supplemented with antibiotics. Primary buffalo EECs were isolated and cultured as previously described (Xiawei et al. 2016) with some modifications. Briefly, uteruses were quickly brought to the laboratory after retrieval, washed three times with saline and the horns ipsilateral to corpus luteum were dissected out and used for EECs isolation and culture. Cells were isolated via enzymatic digestion after washing horns thoroughly from inside and outside with sterile Dulbecco's phosphate buffered saline (DPBS) supplemented with broad spectrum antibiotics. A 20ml sterile injector was used to fill the lumen with 30-40ml of an enzyme solution composed of 0.5% Collagenase I in sterile DPBS and incubated for 2 h with gentle shaking at 37°C. The cell suspension obtained after this digestion was filtered by cell strainer (40 μ m) and the cell strainer was again backwashed with DPBS. Cells obtained from both filtrate and backwashing were centrifuged (5min at 500g) and the pellet was resuspended in culture medium [DMEM/Ham' F12; 1:1] (Sigma) supplemented with 10% FBS and human epidermal growth factor (5ng/ μ l) and seeded separately in 6 well plates to allow the cells to attach and grow in standard conditions. The cell culture medium was changed when the cells were attached and after that point medium was changed every 48 hrs. To purify EECs cells from other cells like stromal fibroblasts selective trypsinization was done during successive passages. Typical cobblestone shaped epithelial cells were obtained and it was aimed to immortalize them by chemical carcinogens. During the process we were able to maintain this primary culture upto seven passages without noticing changes in cell morphology. Additionally, the EECs, thus, obtained were also characterized by using gene specific primers like cytokeratin 18 (KRT18) and bovine uterine epithelial markers such as Progesterone receptor (PGR) and Estrogen receptor 1 (ESR1). EECs culture system offers an in vitro model to elucidate molecular mechanism associated with proper conceptus-endometrial dialogue in the bovine species.

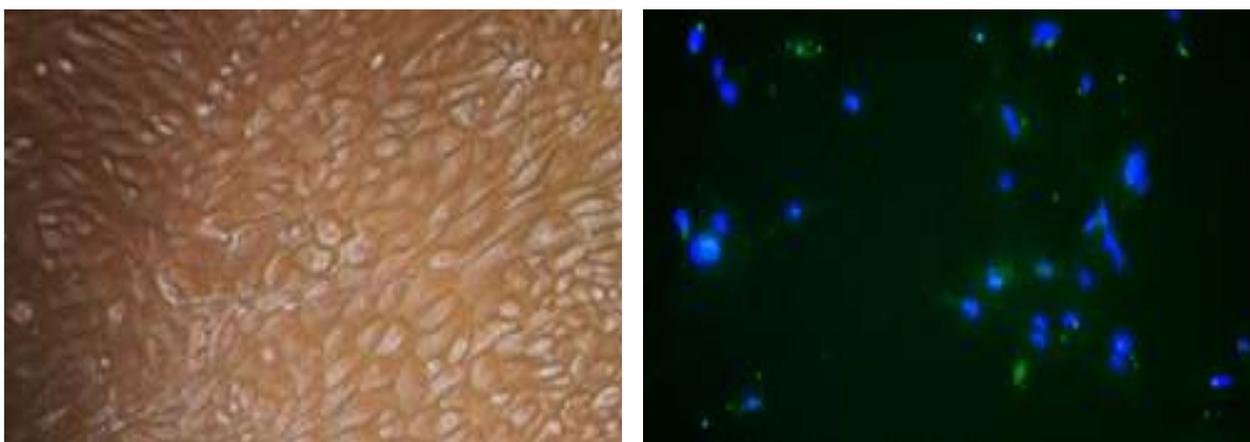


Fig.: Cobble stone epithelial cells (left handed panel), and immunofluorescence characterization of EECs shown on right hand side.

Development of an Enzyme Linked Immuno-sorbent Assay (ELISA) and Lateral Flow Immuno-Assay (LFIA) against serum PAG2

A sandwich ELISA was developed and optimized against serum PAG2 of cattle and buffaloes. Various conditions at various steps of ELISA assay were optimized like antigen antibody concentration, blocking buffer and time of incubations. The HRP substrate TMB was used (100 μ L) and 100 μ L of 2M H_2SO_4 was used for the stopping of reaction. The OD was taken at 450 nm and the regression analysis was performed. A sandwich Lateral Flow Immuno-Assay (LFIA) was developed and optimized against serum PAG2 of cattle and buffaloes. This developed LFIA assay accurately detected confirmed pregnant and non-pregnant serum samples. Although these results would be tested on large number of samples for further establishment of this anti-PAG2 antibody based LFIA test.

Urinary Peptidome Profiling Reveals Anti-Microbial Peptide(S) against Dairy Mastitis Causing Pathogens

The genito-urinary tract has to bear substantial burdens as it has a constant job of accommodating and voiding urine and at the same time maintaining a sterile environment. Urine is a biological fluid that contains a variety of proteins and peptides which have local as well as systemic origin. Blood circulating in various part of the body get filtered in the kidney making it obvious that urine might be capable of providing information in terms of physiology and pathology of the animal. While most of the protein and peptide are present at the basal level, fluctuation or novel expression can be seen because of variation in physiology and clinical status of animal, a urinary peptidome might be helpful in clinically related biomarker discovery. Urinary peptides were captured from three different physiology of Sahiwal cow in hope to identify sequences with antimicrobial properties against pathogenic strains of *S. aureus* and *E. coli* which are major culprit in frequent occurrences of mastitis in dairy cattle. The nLC-MS/MS experiments revealed 5239, 4774, and 5466 peptides in the heifer (n=10), pregnant (n=10) and lactating (n=10) animals respectively. Similarly, we extracted urinary peptides from Murrah Buffalo (n=10) and identified 8165 peptides. The crude urinary peptides mixtures from different animals were subjected to disc diffusion assay to ascertain the antimicrobial activity. The presence of peptides in the extracted samples was confirmed by tricine-SDS-PAGE. The sequence retrieved from nLC-MS/MS were used for the prediction of antimicrobial peptide sequences using CAMPR3 prediction platforms. The high scoring candidate peptides (n=7) were synthesized and were evaluated for antimicrobial activity. Out of seven peptides, four peptides showed activity against *S. aureus* and five peptides exhibited antimicrobial activity against *E. coli*. The results were also validated by fluorescence and confocal microscopy which showed the interaction of the FITC tagged peptides with bacterial membrane. Intracellular presence of peptides was validated by confocal microscopy, where z-stacks images confirmed the presence of peptides on membrane as well as in cytosol. iTRAQ based quantitative proteomics of peptide treated *E. coli* showed enhanced expression of proteins related to oxidative damage. This suggests that peptide utilizes membrane damage and oxidative damage to show its lethal activity against bacteria.

Screening of Potential Ligands for Sperm Surface Proteins and Validation of their Interaction with Selected Target Proteins in Cattle

The milk and milk based industries largely depend on the female cattle and heifers to meet the ever increasing demand for milk. This makes gender pre-selection an important aspect of animal farming. The use of sexed semen has revolutionized the dairy industries. One of the approach that has been widely used these days is the biomarker based approach involving the use of differentially or uniquely expressed X and Y sperm specific surface proteins. Using bioinformatics analysis, we have shortlisted some proteins viz. Toll like receptor-7 (TLR7), GABA Receptor subunit epsilon (GABAE), Gastrin releasing peptide receptor (GRPR) and Angiotensin Converting Enzyme 2 (ACE2), as the potential candidates that can be used as a unique sperm surface biomarker. For each protein, a separate ligand (TLR7 receptor- Resiquimod (R848); GABAE receptor- Clonazepam and ACE2- Captopril) was identified; homology modeling and molecular simulations were done using YASARA. Molecular docking studies using AutoDock, PyRx, revealed the binding interaction between the selected proteins and their respective ligands. Further, the effect of these ligands and their interaction with the selected receptors was evaluated by treating semen sample with their varying concentration and resulting X and Y sperm specific enrichment was analyzed by real-time PCR. Semen sample from KF breed, treated with captopril concentrations of ranging from 1nM to 6nM between 60 and 120 minutes (Incubation at 37°C, 5% CO_2), resulted in enrichment of the upper portion of semen sample with X sperms. In contrast, the lower portion showed a mixed semen population. Five concentrations of Resiquimod drug were evaluated in Sahiwal semen samples and 0.045 μ M showed the most promising results. In addition to this, 0.03 μ M and 0.06 μ M of R848 also showed significant X and Y sperm specific enrichment in lower and upper

layers from the treated sample. During Clonazepam treatments, 8 different concentrations were evaluated in Sahiwal semen samples, however only 3 concentrations including 1.5 μ M, 6 μ M and 10 μ M showed differences in X and Y sperm specific enrichment in different fractions. Thus, the above results conclude that this approach may have a potential application in production of sexed semen.

Gold-Nanoparticle Based Visual Assay for Rapid Detection of *Escherichia Coli* Specific DNA in Milk

A rapid, sensitive, and precise approach to identify microbial DNA from veterinary clinical samples, such as milk from cows with mastitis, is exciting for early infection identification. An amplification-free visual assay was developed for rapid and sensitive detection of specific DNA from *Escherichia coli*, based on uidA gene encoding for beta-glucuronidase. Based on multiple gold nanoparticles (AuNPs) captured on a magnetic microbead surface, leading to plasmonic signal enhancement, thereby improving overall sensitivity of the assay. This test can be performed in 1–1.5 h after post template DNA preparation and can be visualized with naked eyes without the use of any expensive equipment. The visual assay detects a minimum microbial load of 10² CFU/ l and can identify bacterial DNA as low as 1 pg. This test provides a precise detection tool for *E coli* in clinical samples, such as milk of cows affected with mastitis, as a quick and user-friendly molecular detection approach. The proposed gold nanoparticle-based amplification-free assay was shown to be a promising alternative molecular technique for detecting *E coli* specific DNA in milk samples of cow affected with mastitis in a quick and easy manner. Visual examination of microbial DNA up to 1 pg level is possible with this test, which is equivalent to or even more sensitive than PCR. Thus, this preliminary assay could be a useful rapid detection tool for screening of *E coli* in clinical mastitis milk samples.

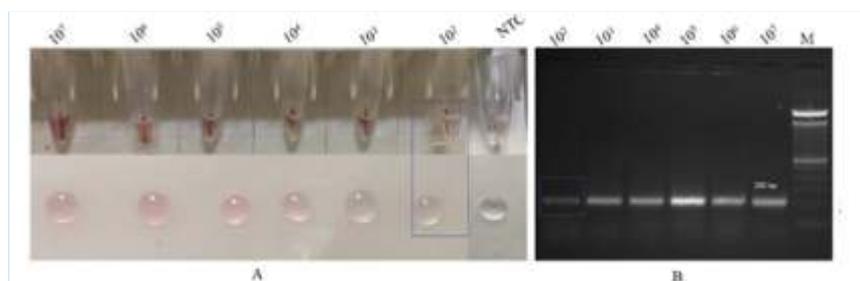


Fig.: Sensitivity assessment of the assay in serially diluted *E coli* bacterial culture with different colony forming units (CFU/ l). A. Visual assay (both under magnetic field and in paraffin film); B. PCR-based assay; M: Molecular marker; NTC: No template control.

Methicillin-resistant *Staphylococcus aureus* Isolates from Bovine Mastitis

Methicillin-resistant *Staphylococcus aureus* (MRSA) among bovine mastitis is matter of concern for animal health and dairy industry. The present study was conducted to detect the distribution of virulence and enterotoxin genes among MRSA isolates from bovine mastitis. Out of 500 milk samples, 126 isolates were identified as *Staphylococcus* and from these only 56 were *S. aureus*. *S. aureus* were resistant to ceftazidime (75%), ceftazidime (75%), amoxicillin (71.4%), cefodaxime (67.8%), cefepime (66.1%), oxacillin (64.3%), norfloxacin (60.7%) and gentamicin (58.9%). Only 42 isolates were identified as MRSA strains among staphylococci isolates. MRSA were harbouring virulence genes; *mecA* (100%), *coa* (100%) and *nuc* (100%). The other virulence factors such as *hlg* (80.9%, 34/42), *pvl* (47.6%, 20/42) and *spa* (92.8%, 39/42) were also reported. Molecular characterisation of enterotoxin genes revealed that out of 42 tested isolates 11 were found negative (26%) for any enterotoxin gene whereas 7 (16.6%), 6 (14.3%), 18 (42.8%), 1 (2.3%), 26 (61.9%), 27 (64.2%), 3 (7.1%) were found positive for *sea*, *seb*, *sec*, *sed*, *seg*, *sei*, and *seq* enterotoxin respectively. This research approach would pave the way for creating an effective mastitis management strategy by screening a large number of mastitis milk samples for MRSA isolates, virulence and enterotoxin gene characterization, and antibiotic resistance profiles.

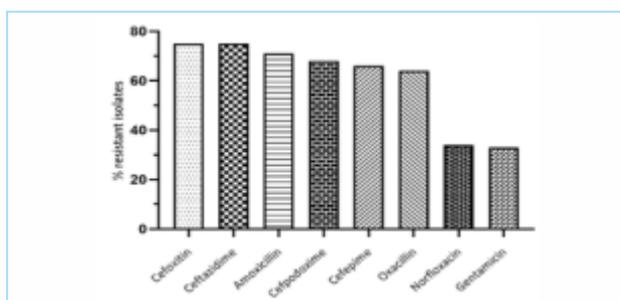


Fig.: Antimicrobial resistance pattern (%) of *S. aureus* (n = 56) obtained from Mastitis milk samples.

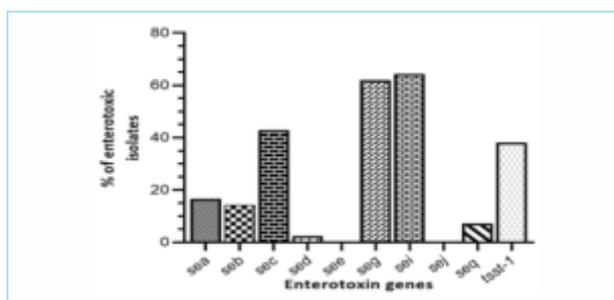


Fig.: Enterotoxin gene (%) of MRSA (n = 42) from mastitis milk samples.

PU.1 Robustly Up-regulates the Transcription of Viral RNA and DNA Sensors in Buffalo Fibroblasts

Specific transcription factors can be used to modulate innate immune response in non immune cell. PU.1, CEBPA and CEBPB are Lineage Determining Transcription Factors (LDTFs) that play roles in biological processes such as cell differentiation and the immune system regulation including the innate immune pathways. The role of LDTFs in immune pathway gene regulation has not been much explored. As recently reported that in buffalo fibroblasts, PU.1 causes the mRNA up-regulation of the viral RNA and viral DNA sensors such as RIG-I, MDA5, IFI16-L and cGAS while CEBPA does the same but to a lesser extent. CEBPB does not appear to have a role in the up-regulation of these genes. PU.1 expression also primes the cells to develop a strong immune response against the dsRNA virus mimic polyinosinic: polycytidylic acid (poly I:C) by significantly up-regulating Interferon- β . CEBPA up-regulates Interferon- β to a lower level than PU.1 whereas CEBPB exhibits non-significant up-regulation. As PU.1 robustly up-regulates the nucleic acid sensing pathways, it can prove to be useful in improving the defence against viruses that can cause losses to animal husbandry especially, the highly infectious RNA viruses.

Poly (I:C), a Viral dsRNA Analog Stimulates the DNA Sensing Pathways in Buffalo Fibroblasts

Polyinosinic:polycytidylic acid or poly (I:C) is a double stranded RNA analog that is known for stimulating RNA sensing pathways in a variety of cell culture and animal models. Activation of nucleic acid sensing pathways lead to the up-regulation of Interferon- β which ultimately creates an antiviral state in the host. The involvement of intracellular DNA sensors in poly (I:C) mediated immune response has not been extensively explored. Poly (I:C) stimulates the intracellular DNA sensing in addition to RNA sensing pathways in buffalo fibroblasts. Genomic DNA leak into the cytosol due to poly (I:C) is likely to stimulate the intracellular DNA sensing pathways. The mRNA expression of DNA sensors cGAS, IFI16-L and DAI are elevated while DDX41 and STING are down-regulated in poly (I:C) treated cells. However, STING activation is evident in poly (I:C) treated cells through the formation of aggregates around the nucleus. IFI16-L also aggregates like STING and translocates from the nucleus to the cytoplasm in response to poly (I:C). The activation of DNA sensors by a dsRNA mimic indicates that mammalian cells can use their own molecules for defending themselves against pathogenic RNA viruses. This provides an opportunity to search for novel therapeutic targets against RNA viruses that evade detection by canonical pattern recognition receptors.

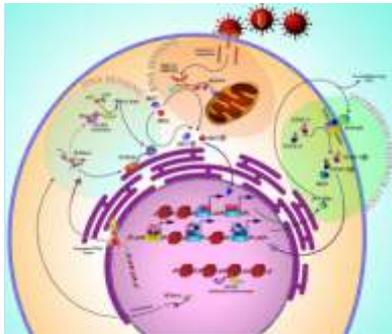


Fig.: The stimulation of RNA and DNA sensing pathways in fibroblast cells after detecting poly (I:C)/ viral RNA. Viral RNA or poly (I:C) is recognized by RNA sensors that lead to the downstream signaling which phosphorylates transcription factors IRF3 and IRF7. These transcription factors form complexes and bind ISRE (Interferon-Stimulated Response Element) regions on genomic DNA which leads to the expression of Interferons and ISGs. Type I Interferons then bind to IFNAR (Interferon-alpha/beta receptor) on plasma membrane and cause phosphorylation of STAT-1 and STAT-2 (Signal Transducer and Activator of Transcription). These STAT proteins along with IRF9 form complexes to bind GAS (Gamma interferon activation site) and ISRE on genomic

DNA which creates a positive Interferon feedback loop that leads to further up-regulation of Interferons and ISGs. Due to cytotoxic effects of poly (I:C)/viral RNA, the nuclear (and/or mitochondrial as reported previously) membrane disintegrates leading to leakage of DNA into the cytoplasm. The DNA ultimately gets sensed by DNA sensors IFI16-L and/or cGAS which interact with STING to further increase the phosphorylation of IRF3 and IRF7 thus, adding to the feedback loop of Interferon and ISG regulation. The cGAS in the nucleus is tightly tethered to the nucleosomes because of which, it remains inactive however, cGAS already present in the cytosol may detect host nuclear or mitochondrial DNA to elicit immune response as observed in various diseases and viral infections. IFI16-L moves from the nucleus to the cytoplasm in response to poly (I:C) to interact with STING for eliciting immune response.

Organochlorine Pesticide Dieldrin Increases Estrogen Production by Upregulating Proximal Promoter (PII) Driven CYP19A1 Gene Expression in Granulosa Cells

Pesticides are one of the common environmental pollutants, including in milk. Particularly, the organochlorine pesticides such as dieldrin act through estrogen receptor and can influence the estrogen biosynthesis. However, its exact mechanism by which estrogen biosynthesis is affected is not known. Therefore, a study was conducted on buffalo granulosa cell culture system not only to identify the mechanism but also to utilize the cell culture system for biosensor development in the future. Treatment of cultured buffalo granulosa cells with dieldrin in a dose (100,150 and 200 ng/mL) and time (6, 12, and 24 h) dependent manner showed significantly increased expression of the aromatase (CYP19A1) gene after 6 and 12 h. Promoters' specific CYP19A1

transcript analysis and chromatin immunoprecipitation assay (ChIP) confirmed that the upregulation of CYP19A1 was because of the active transcription driven by the proximal promoter but not the distal promoter. Interestingly, estradiol-17 level was also increased by dieldrin. Taken together, present study demonstrated that dieldrin increased the estradiol production by upregulating proximal promoter (PII) driven CYP19A1 gene expression in granulosa cells. Further, the upregulation of the CYP19A1 gene can be used for a biosensor development for dieldrin toxicity on reproductive cells.

Salivary Ferning based Estrus Identification Method Validated in a Large Population of Buffaloes in the Field Conditions

Saliva at the estrus stage of buffaloes has been observed to show typical fern-leaf like crystallization patterns after drying on a glass slide, indicating that this observation can be used as a method of estrus identification. To implement this method in the field conditions, the method has been validated in the scenario of organized herd, artificial insemination centers, induced estrus condition, and at the farmers' door step. In an organized herd, 10 buffaloes were monitored every day for a year and collected saliva samples from 149 potential estrus events (S1). From an AI center, saliva samples were collected from 114 buffaloes brought for AI (S2). Similarly, saliva samples were collected from 44 buffaloes in which estrus were induced by hormonal treatment (S3). Finally, saliva samples were collected from 275 random buffaloes with unknown reproductive history and no estrous signs at farmers' doorsteps (S4). Taken together, a total of 582 saliva samples were collected from 443 buffaloes. The saliva samples were either centrifuged at 3000 g for 5 minutes or kept standstill in the collection tube for 15 minutes to settle down the feed particles. From each saliva sample, just 20 µl of saliva (4 matchstick head drops were taken in the field conditions where micropipette is not available) was smeared on a glass slide. The dried smears were observed under a simple microscope and a paper based microscope called Foldscope. The Foldscope was exclusively used at the farmers' doorsteps. The proportion of the estrus confirmation by this saliva based estrus identification was 0.74, 0.52, 0.16 and 0.08 in the S1, S2, S3 and S4 population samples, respectively, in which the expected proportion estrus identification was 0.5, 1, 0.8 and 0, respectively. Therefore, the proportion of estrus identification was significantly higher in the S1 (0.74, $P < 0.0001$) and S4 ($P < 0.05$), which are the real field scenarios of the organized herds and farmers doors that require an accurate estrus prediction method. Particularly, the random buffaloes predicted to be at late proestrus or early estrus by the typical fern like patterns of the saliva were advised to take for AI center after a day. Interestingly, 91% of those animals were confirmed at estrus, indicating that saliva fern like patterns based estrus identification is 91% confirmatory. Therefore, salivary ferning is a useful technique to identify early estrus in buffaloes in the field conditions at farmers' doorsteps by using Foldscope or any simple microscope.



Fig.: Estrus identification in buffaloes with typical salivary fern patterns

Tissue-specific Differences in Expression of Mitochondrial Protein Coding Genes from the Nuclear Genome and Mitochondrial Trnas in Buffalo

The mitochondrial proteins (MP) from both the nuclear (NuMP) and mitochondrial (MtMP) genomes are involved in the energy metabolism in mitochondria. Our previously published work showed tissue-specific differences in mitochondrial biogenesis and expression of MtMP genes. Taken together, we were motivated to identify the differential expression of MP genes encoded by the nuclear genome and comprehensive analysis of mitochondrial tRNAs (mt-tRNAs) and rRNA expression across different tissues of adult buffalo. We

investigated differentially expressed genes (DEGs) in adult buffalo kidney, brain, ovary, and heart tissues using RNAseq. The whole transcriptome results revealed that there were 12394, 17653, 11051, and 17653 genes expressed in the kidney, brain, ovary, and heart tissues, respectively. In all tissue NuMP genome comparisons, the kidney vs. brain, heart vs. brain, and brain vs. ovary groups have the largest number of DEGs, with 956 in each group (consisting of 512 up- and 444 down-regulated genes, 466 up- and 490 down-regulated genes, and 601 up- and 355 down-regulated genes, respectively), whereas the number of DE NuMP genes between heart and ovary was the least (873, consisting of 520 up- and 353 down-regulated genes). Further, the heart and brain exhibited the highest levels of mt-tRNAs, while the kidney and ovary displayed markedly lower levels. These findings provide new insight of mt-tRNAs tissue-specific effects on oxidative phosphorylation. Similarly, higher levels of rRNAs were observed in the brain and heart, respectively, as compared to the kidney and ovary. Among the observed patterns of differential expression of different genes within the tissue, the MP genes were over-expressed in tissues with high metabolic demand, such as the kidney, heart, and brain. Thus, it is plausible that energy demand in tissues is the basis of increased transcription rates of MP genes.

Mitochondria-associated miRNAs Expression Profiles in Buffalo

Apart from the cytosol, small non-coding microRNAs (miRNAs) have been identified in other cellular compartments and organelles, including the mitochondria. There is nothing known about mitochondria-associated miRNA expression in different tissues of buffalo. We were thus motivated to design a study to determine mitochondria-associated miRNA expression signatures in different tissues of buffalo. The RNAs isolated from purified mitochondria of different tissues were used for small RNA library construction and sequencing. A total of 505 known miRNAs were identified in liver, kidney, and brain tissues, whereas in the ovary, that was down to 455. A total number of 184 novel miRNAs could be identified in liver, kidney, and brain tissues, whereas, in the ovary, it was 175. In all tissue known miRNA comparisons, the brain vs. kidney group had the largest number of differentially expressed (DE) miRNAs (219, consisting of 155 up- and 64 down-regulated miRNAs), whereas the number of DE miRNAs between kidney and liver (165, consisting of 55 up- and 110 down-regulated miRNAs), and ovary and liver were the least (163, consisting of 53 up- and 110 down-regulated miRNAs). In all tissue novel miRNA comparisons, the ovary vs. brain group had the largest number of DE miRNAs (105, consisting of 19 up- and 86 down-regulated miRNAs), whereas the number of DE miRNAs between ovary and liver was the least (63, consisting of 27 up- and 36 down-regulated miRNAs). Further, the identified known and novel miRNAs among different tissues indicates that there is a tissue-specific presence of mitochondria-associated miRNAs in buffaloes. In addition, these miRNAs from mitochondrial extract may be either mitochondrial genome encoded or nuclear-encoded and may regulate mitochondrial metabolism and function in a tissue-specific manner.

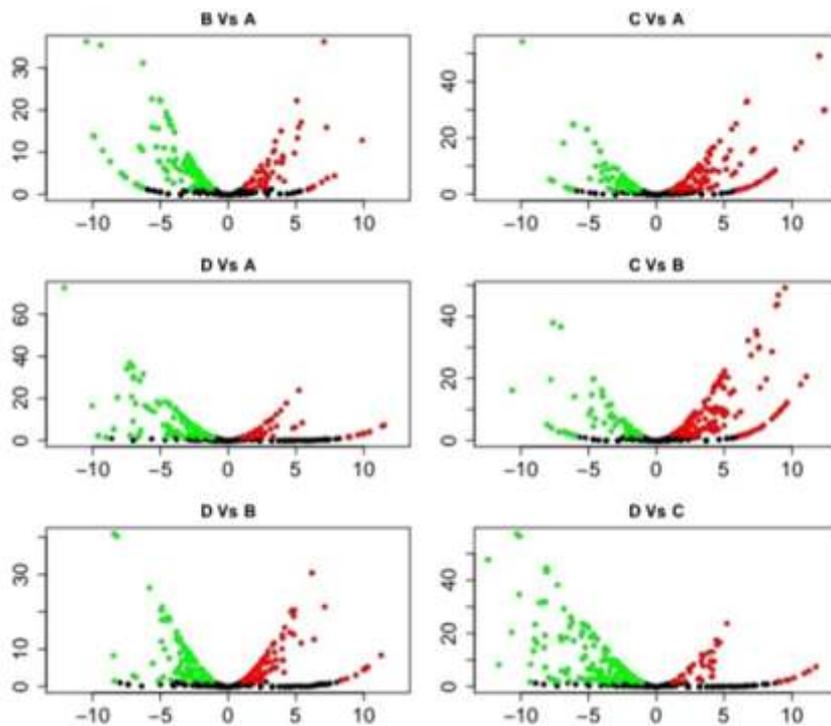


Fig. 6: Volcano plot of differentially expressed known miRNAs among different tissues. $\log_2FC > 1$ and $padj < 0.05 \Rightarrow$ green; $padj < 0.05 \Rightarrow$ red; $|\log_2FC| > 1$ and $padj > 0.05 \Rightarrow$ orange; $|\log_2FC| < 1$ and $padj > 0.05 \Rightarrow$ black. A-Liver; B-Kidney; C-Brain; D-Ovary

Mitochondrial DNA haplotypes Influence the Reproductive Efficiency of Buffaloes

The mitochondrial genome (mtDNA) is maternally inherited and contains essential genes for cellular energy production, cell signalling and growth, and development. Our previously published work showed that there are diverse mtDNA haplotypes in domestic buffaloes and that there are mtDNA haplotype-specific mtDNA copy numbers, enzyme activities, and gene expression. To investigate the relationship between mtDNA haplotype and reproductive efficiency in buffaloes, blood samples of about 88 buffaloes were collected along with certain recorded reproductive traits such as calving interval, gestation length, and services per conception from an organised buffalo farm in Hyderabad. Based on their reproductive trait data, the animals were categorised into the group of good reproductive traits (Group I) and poor reproductive traits (Group II). The mitochondrial D-loop amplified PCR products from both groups were sent for Sanger sequencing. Analysis revealed that there was a specific SNP at nucleotide position "101" in the D-loop region of the mitochondrial genome in 25 animals from group I, whereas this particular SNP was not present in group II animals. Also, results revealed that the calving intervals and services per conception relative to mtDNA haplotype were significantly different. The differences in reproductive capacities between these two groups may be attributed to their mtDNA haplotypes, as efficient energy metabolism of food is essential for survival and reproduction. Overall, our results provide evidence that mtDNA polymorphisms in the D-loop regions are significantly associated with buffalo fertility. Nevertheless, our findings on the relationship between mtDNA markers and reproductive efficiency must be extrapolated to and validated in a large group of buffaloes in the future with calving intervals and service per conception rates.

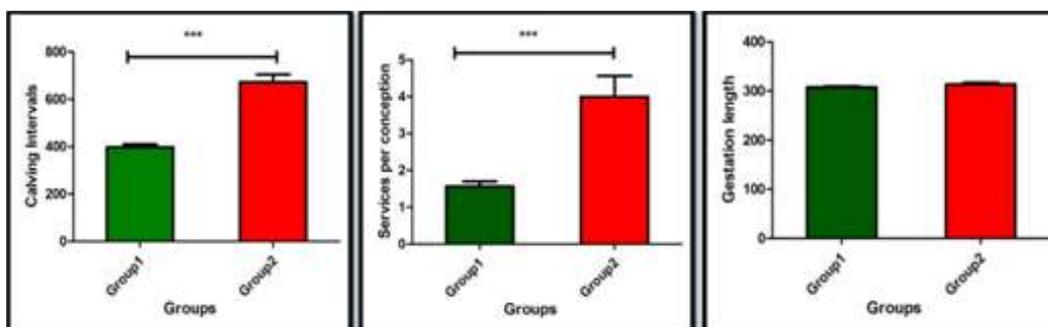


Fig.: Assessment of reproductive traits relative to mtDNA haplotype groups for all animals investigated. The results are presented as mean ± SEM (**P < 0.0001)

miR-99a-5p in the Urine as a Potential Biomarker for Estrus Identification in Buffalo

Discovery of biomarkers in non-invasive fluids is very helpful to identify the pathophysiological status of farm animals. Considering the difficulty in identifying heat or estrus stage in buffaloes, the non-invasive fluid urine was targeted to identify the potential miRNA biomarkers for estrus. In particular, the levels of 10 hormone-responsive miRNAs were analyzed in the urine buffaloes (n = 3) at proestrus (PE), estrus (E), and diestrus (DE) phases. Among 10 targeted miRNAs, the abundance of six miRNAs, including bta-mir-99a-5p (E/PE 0.5-fold, P < 0.05; DE/PE 1.9-fold), bta-miR-125b (E/PE 0.5-fold; DE/PE 0.7-fold), bta-mir-145 (E/PE 1.5-fold; DE/PE 0.7-fold), bta-mir-210 (E/PE 1.2-fold, DE/PE 0.7-fold), mir-21 (E/PE 1.5-fold, DE/PE 2-fold), and bta-mir-191 (E/PE 1.3-fold; DE/PE 0.8-fold) were found altered during different estrous cycle phases. However, the abundance of the remaining 4 miRNAs, bta-mir-126-3p, bta-let-7f, bta-mir-16b, and bta-mir-378, were undetected in buffalo urine. The validation study on 25 animals also reinforced the lower abundance of bta-mir-99a-5p at the estrus stage than the diestrus stage (3.92-fold at DE; P < 0.0001). This observation was further validated by Receiver operating characteristic curve analyses, which revealed the ability of urinary miR-99a-5p in distinguishing the E from the DE phase (area under the curve of 0.6464; P < 0.08). Bioinformatics analysis also showed

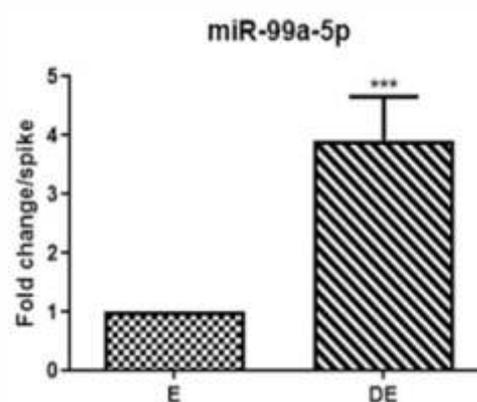


Fig.: Significantly (**P < 0.0001) lower abundance of miR-99a-5p in buffalo urine at the estrus stage than the diestrus stage

that miR-99a-5p putative targets played important roles in various ovarian signaling pathways, including androgen/estrogen/progesterone biosynthesis and apoptosis signaling. Therefore, significantly lower levels of bta-mir-99a-5p in urine at the E phase than the DE phase indicate its biomarker potential for the estrus stage in buffaloes. However, further validation in a large population of buffaloes will help to use this miRNA as an estrus biomarker in the buffalo.

CRISPR/CAS9 Guided Functional Analysis of Genes Regulating Early Embryonic Survival in Buffalo

CRISPR/Cas9 genome editing tool was applied for COX-2 gene towards unravelling relevant associated pathways governing early embryonic survival in buffaloes. Molecular cloning and characterization of COX-2 gene was carried out in buffalo endometrial epithelial cells and cloning was performed using SgRNA1; SgRNA2; SgRNA3 and SgRNA4. The presence of the SgRNAs in the plasmid was confirmed by PCR using U6 primers. The sequence data was analyzed by using CLUSTAL W, multiple alignment tool confirmed the presence of SgRNA3 and 4. Confluent endometrial epithelial cells were transfected with COX-2, SgRNA 3 and 4 CRISPR constructs. There was significant decrease ($P < 0.05$) in PGF2 and PGE2 concentrations following CRISPR/Cas9 based editing of COX-2 gene. Real time PCR showed a significant decrease ($P < 0.05$) in COX-2 sgRNA3 and 4. The concentration of PGF2 in CRISPR edited cells were quantified by using ELISA kit and found that there was significant decline in PGF2 and PGE2 concentration in transfected (edited) buffalo endometrial cells as compared to the control. Validation of CRISPR/Cas9 mediated editing of COX-2 gene was carried out. The genomic DNA was isolated and after puromycin selection of transfected buffalo endometrial cells using CRISPR/Cas9 sgRNA1 construct, the genomic DNA was extracted and subjected to PCR amplification with COX-2 gene specific screening primers. The PCR amplified products of 500 bp were purified by gel extraction kit and sent for sequencing with M13 forward primer. Analysis of sequenced data and chromatographic image revealed that one clone out of eighteen clones was successfully exhibited an indel within the sgRNA1 "2" nt ("AC") insertion within sgRNA1 specific target sequence.

Sequencing, de-novo Assembly and Integrated Proteogenomic Annotation of the Genomes of Malnad Gidda, Deoni and Hallikar Breeds

Aimed to identify the genetic diversity among Malnad Gidda, Deoni, and Hallikar breeds of cattle, we assembled their whole genome and attempted to discover sequence variations with reference to the genome of *Bos taurus*. The short paired-end and mate-pair reads were used for genome analysis. The comparison of Illumina paired-end sequenced data for protein-coding region variations revealed a total of 24,645; 24,109 and 23,772 variations specific to Malnad Gidda, Deoni and Hallikar breeds, respectively. A total of 69,868 coding region SNPs were common to all three breeds while 16,267 were shared between Deoni and Hallikar, 15,061 were shared between Hallikar and Malnad Gidda and 14,793 were shared between Deoni and Malnad Gidda breeds.

Quantitative Trait loci (QTL)/Sequence Variant analysis of Milk Production, Health, Reproduction and Production Traits Across Malnad Gidda, Deoni and Hallikar Genomes

SNVs identified in the current study were mapped to the QTL/SNVs associated with phenotype. All three breeds had a comparable number of QTL/SNV associations for each trait. A higher number of SNVs associated with milk-related traits was found in chromosomes 6, 14 and 24. Chromosome X had a high number of SNVs associated with reproduction. A total of 1,928 and 1,804 SNVs associated with milk production were found to be common in all the three breeds in chromosomes 6 and 14, respectively. The SNVs associated with milk production from chromosome 6 were clustered based on their presence across the three breeds. Four sub-traits i.e., milk kappa-casein content, milk fat percentage, milk yield and milk protein percentage were found to be predominant compared to other sub-traits. Similarly, SNV associations for milk fat percentage, milk yield, and milk protein percentage sub-traits were observed in chromosome 14.

Proteogenomics Based Genome Annotation and Identification of Novel Gene

The proteogenomic analysis has resulted in the identification of 10,728 non-redundant Gene-Specific Substitution Profiles (GSSPs). Here, 714; 3,178 and 6,836 non-redundant GSSPs were identified from milk, seminal plasma and spermatozoa proteomic datasets, respectively. A total of 5,501 GSSPs remained unmapped to the assembled genome of Malnad Gidda and were categorized as genome gaps. In the proteogenomic analysis, 4,744 GSSPs (only for novel protein-coding gene) were identified and this aided in the identification of 1,910 novel regions with peptide level evidence including a novel protein-coding gene, which code-named as SRS_MG_001. Orthologue evidence from the mammalian *Monodon monoceros* (XP_029086768.1), *Vicugna pacos* (XP_031540076.1) & *Camelus ferus* (XP_032350067.1) species strongly support the existence of this novel protein-coding gene in Malnad Gidda. Our analysis derived the first evidence for this protein-coding gene and its model in a bovine species.

Whole-Genome Sequencing of Amritmahal Cattle

The genome assembly was based on Illumina reads using the de novo fly polca assembler and polished genome was performed by generating a long-read assembly using flye assembler followed by polishing using Illumina short reads. The predicted genes of Amritmahal cattle were analysed to UniProt database using BLASTX program with E-value cut-off of 10^{-3} . The number of predicted genes was 68,080 with significance of E-value $< 1e^{-3}$ and similarity score $\geq 40\%$. The E-value distribution of the BLAST hit in the UniProt protein database showed that 33.09 of the mapped sequences have strong homology (smaller than $1.0e^{-50}$), while the other 67.01 of the homologous sequences ranged between $1.0e^{-5}$ to $1.0e^{-50}$ (Figure 3a). The similarity distribution showed 59.18% of the query sequences have similarities higher than 80, while 40.82% of the hits have a similarity ranging from 40% to 80%.

Whole Exome Sequencing of Malnad Gidda and Deoni Cattle

Whole-exome sequencing for *Bos indicus* breeds viz., Malnad Gidda and Deoni cows with either high or low milk yield was carried out using the Illumina NovoSeq6000 platform to identify Single Nucleotide Polymorphism (SNPs) specific to high and low milk yielders. The study revealed that any alteration in ABC transporter pathway and Glutathione metabolism could be the possible reasons for low milk yield in Malnad Gidda and Deoni cows. Variations observed in ABCG2, LPIN1, GSTM2 and PLCG2 genes were associated with milk yield trait and it could serve as potential candidate genes for identifying low milk yielders in indigenous cattle. We identified functional genes that may be useful for estimating the production traits attribute. Out of total 3797 QTLs only 188 QTL were mapped in Malnad Gidda group which corresponded to 738 variations in 150 genes. Similarly, for Deoni only 659 QTLs were mapped with QTL database for milk yield traits which corresponded to 1183 variation among 231 genes. The functional interpretation of genes was performed using network interaction tool ClueGo. QTL associated genes significant in Malnad Gidda group were associated with aminoglycan metabolic process, regulation of striated muscle cell differentiation, dendrite extension, neuromuscular process controlling balance and inner ear morphogenesis.

Cow Dung Processing and its Conversion to Bio-fortified Fertilizer

The efficient isolates of *Azotobacter* sp. (N fixer), *Pseudomonas* sp. (P solubilizer), and *Bacillus* sp. (K solubilizer) were mixed with the dewatered cow dung slurry for the preparation of the bio-fortified fertilizer. The effect of bio-fortified fertilizer on the growth and development of chilli and brinjal crops was evaluated. Based on the results indicated that the beneficial isolates effectively increased the growth parameters viz.



Fig : Containerised Cow Dung Digester for bio-fortified fertilizer & green energy production Pellet produced from. Dewatered cow dung slurry inoculated with the efficient microbial isolates

plant height, number of leaves, chlorophyll content of chilli and brinjal plant, and yield parameters viz, number of chilli fruit, chilli fruit length, chilli fruit yield of chilli crops. Shelf-life studies of the bio-fortified fertilizer indicated that the cow dung-based bio-fortified fertilizers can be stored up to 45 days after inoculation under room temperature in all three formulations viz. cow dung pellets, cow dung briquettes and cow dung powder. The bio-fortified fertilizer developed using the beneficial microbial isolates sourced from the rhizosphere soils of fodder crops has improved the plant growth and yield parameters of chilli and brinjal crops under the pot culture conditions.

Whole Metagenomic Analysis of Bovine Dung

Whole metagenomic analysis of dung of Malnad Gidda and Deoni *Bos indicus* cattle, HF Crossbreds and Murrah buffalo revealed Firmicutes followed by Bacteroidetes which were predominant phyla in all the bovine samples. Among all the cattle breeds, the maximum per cent of Firmicutes were found in the Malnad Gidda cattle. In the indigenous Malnad Gidda and Deoni cow dung, maximum percent of Firmicutes observed, which are the efficient degraders of complex plant organic matter (ex. Cellulose, lignin etc.). Firmicutes are very less in HF Crossbred cow dung. As indigenous cows are mostly reared on grazing system and they are fed with paddy/ragi straw, the presence of highest percent of Firmicutes indicates degradation of complex plant organic matter like Cellulose, lignin etc by them. Spirochaetes which are mostly mammalian pathogens were found highest in Holstein Friesian cattle dung and least in Malnad Gidda cattle dung. The organisms belong to the order Bacteroidales was more in indigenous Malnad Gidda cow dung which helps in carbohydrate fermentation by producing a pool of volatile fatty acids that are reabsorbed through the large intestine. In the indigenous cow-dung, the microbes belonging to the family Bacteroidiace, Rikenellaceae, Ruminococcaceae are more as compared to the buffalo and HF cow dung. The presence of microbes belonging to the family Ruminococcaceae is very essential for the free grazing animals as the organisms belonging to the Ruminococcaceae family plays major role in degradation of hemicelluloses and xylan which is an abundant biopolymer present in the cell walls of most of the plants especially dicot plants and cell wall of grasses.

Whole Exome Sequencing in Hallikar Bulls

Effective fertility of bulls is dependent on semen quality, often determined based on standard semen evaluation tests. Whole Exome Sequencing (WES) of 12 bulls from two breeds Holstien Friesian and Hallikar selected based on Ejaculate Rejection Rate (ERR). We explored the possibility of identifying genetic variants from the conserved protein coding regions of genome. A total of 10,510 SNPs and 10,236 INDELS were identified post alignment against reference genome (ARS-UCD 1.2) and were annotated using SnpEff. The number of variants with high and modifier functional impact detected were 145 and 19,122, respectively. Genetic variants common to both high and low ERR group bulls among Holstein Friesian were 08 and in Hallikar the common variants were 51. Prominent genes viz. UCP2, PANK2, GPD2, PTPRG, LARP7, EZH1, DENND1B and TDRD9 with a role in determining the semen quality were observed to be carriers of the genetic variant.

Differential Proteomics Revealed the Impact of Heat Stress on Milk Whey Proteins in Cattle

The mechanisms at a molecular level associated with heat tolerance among cattle are ill-understood till date. High-throughput milk whey proteomics was performed to identify the subtle changes occurring at protein level between normal and heat conditions in indigenous and crossbred cows. A total of 412 proteins were identified in the milk whey samples by LC-MS/MS technique coupled with bioinformatics analysis (Figure 6). Differential milk whey proteomics revealed that 27 and 53 proteins were up-regulated (fold>1.5), whereas, 10 and 8 proteins were down-regulated (fold<0.6) during heat stress (THI=82.2) as compared to normal (THI=66.6) condition in indigenous and crossbred cows, respectively. Gene Ontology analysis showed 38.09 and 48.15 percent of the enriched biological processes were related to the defense mechanism in indigenous and crossbred cows, respectively. ELISA followed by statistical analysis revealed that the expression of haptoglobin protein was highly significant in both the breeds during heat stress condition, thus, could act as a potential biomarker associated with thermo-tolerance ability of the animal.

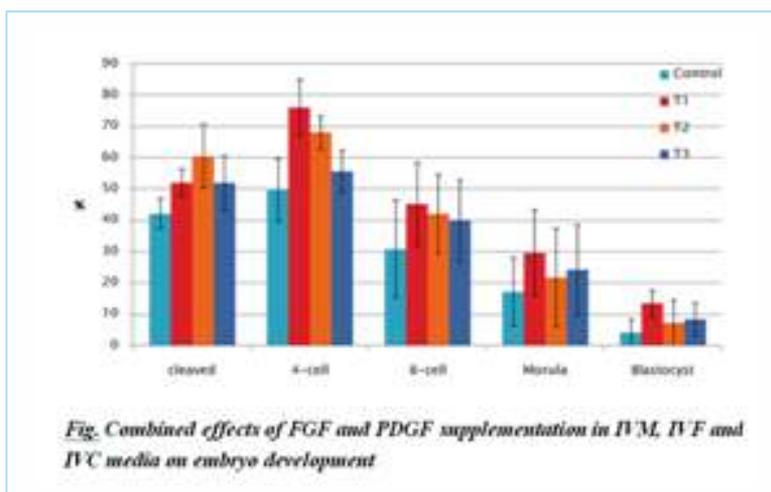
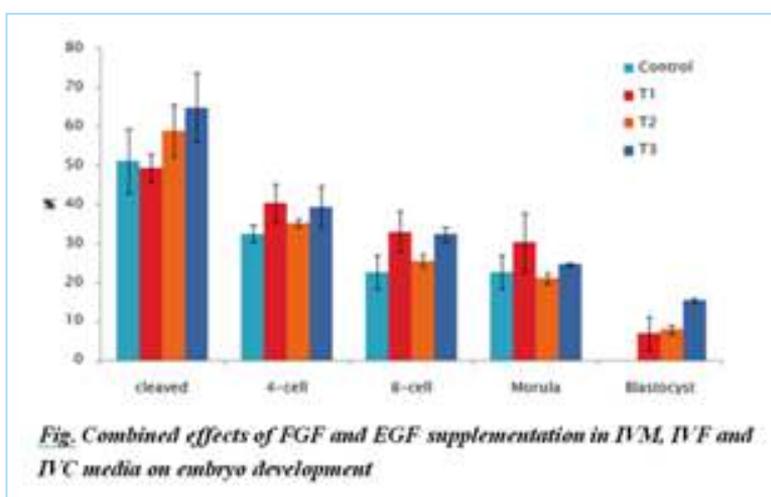
Proteomic Profiling of Semen of Hallikar Bulls

Profiling of the proteome of spermatozoa and seminal plasma of Hallikar Bulls was carried out to identify the differentially expressed proteins in bulls with varying Ejaculate Rejection Rate (ERR). A total of 2409 proteins were identified in LC-MS/MS analysis in which 828 proteins were common to both spermatozoa and seminal plasma. The number of unique proteins identified in seminal plasma and spermatozoa are 378 and 375 respectively. Differential proteomic analysis (± 1.3 -fold change, p-value ≤ 0.05) compared between Low and High ERR bulls revealed that 35 proteins were upregulated and 41 proteins were down-regulated in spermatozoa of Low ERR bulls whereas, 27 proteins were up-regulated and 15 proteins were downregulated in

seminal plasma of Low ERR bulls. Pathway analysis revealed that glutathione metabolism, glycolysis, SLC-mediated transmembrane transport pathways are enriched in Low ERR group. Spermatozoal proteins like Tektin 5, Testis specific gene 10, Glyceraldehyde 3-phosphate, Angiotensin Converting Enzyme, A kinase anchor protein 3 which regulate the motility are found to be upregulated in Low ERR group. Fertility associated seminal plasma proteins like Spermadhesin Z13 and metalloproteinase inhibitor 2 are found to be upregulated in Low ERR group. The study identified differentially expressed proteins in the semen of Hallikar bulls with High and Low Ejaculate Rejection Rate.

Developmental Competence Enhancement of Immature Cattle Oocytes Supplemented with Growth Factors in Culture Media

The aim of the present study was to improve the developmental competence of immature cattle oocytes using growth factors as media supplement. Cattle ovaries were collected from local abattoir in 0.9% saline (30-35°C) supplemented with antibiotics. Cumulus oocyte complexes were aspirated using aspiration media (TCM-199 + DPBS + 0.3% BSA + 50 µg/ml gentamicin sulphate), washed 5-6 times with washing media and placed in maturation media supplemented with growth factors and cultured in 5% CO₂ incubator at 38.5 °C with maximum humidity. After every 48 h ~50% of the medium used to replace with fresh medium. At the end of 15-18 h of sperm-oocyte co-incubation, the presumptive zygotes were separated from the drop and cumulus cells were washed off from the oocytes by repeated gentle pipetting in washing medium. The zygotes were then washed 1-2 times with modified Charles Rosenkrans 2 amino acid (mCR2aa) medium and cultured in 100 µl of mCR2aa medium. After 48 h cleaved oocytes/embryos were shifted to 100 µl droplets of mCR2aa blastocyst medium and co-incubated with vibrant oviductal cells for 8 days. Cleavage was observed after 40-42 h and embryos were co-cultured with oviductal cells for 7-9 days. The cleavage and blastocyst formation rate (%) in FGF & EGF combinedly @ 10 & 20 ng/ml were 64.91±8.83 and 15.31±0.7 respectively. The cleavage and blastocyst formation rate (%) in FGF & PDGF @ 1 & 1 ng/ml concentration 60.65 ± 10.2 and 13.51±4.31 respectively.



GENETIC IMPROVEMENT OF DAIRY ANIMALS

Genetic Improvement of Indigenous Cattle: AICRP on Sahiwal Cattle

The Sahiwal herd strength was 410 including 140 breedable females as on December 31, 2021. A total of 71 growing males and breeding bulls were available at the Germplasm Unit. During the year 2021 there were a total of 105 normal calving out of which 53 males and 52 females were born.

The average age at first calving was (1296.42±42.95days), FLMY (1596.71±79.23kg), Total Lactation milk yield (2172.18±88.83 kg) peak yield (9.19±0.65 kg) lactation length (268.33±8.10 days) dry period (130.56±15.36days) and calving interval (388.84±26.72 days) and service period (160.27±23.06 days) was observed with wet average (6.87 kg) and dry average (4.34 kg) in the year 2021.



Males were initially selected on the basis of EPD, dam's best 305 days lactation yield, breed characteristics and physical conformity for selection of young male calves for future breeding. 10 out of 47 males were selected in Bull screening meeting. EPD % of the selected males was 4.66% and average of Dam's best Lactation Yield was 43967 kg against herd average of 2128 kg.

Based on May, 2020 EPA, a total of 30 out of 196 Sahiwal females were identified as elite cows (Either 305-FLY equal to greater than 2500 kg or Best 305-LY equal to or greater than 3000 kg). The first 305-LY, Best lactation milk yield, average LY and average EPA were 4012 kg., 4424 kg, 2834kg and 2486 kg against herd average of 2118 kg and average EPA of 1878 kg.

During the period 82414 doses of frozen semen from 10 bulls of Set-IV were produced. Semen doses were supplied to DRU units at GADVASU, Ludhiana, GBPUA&T, Pantnagar and LUVAS, Hissar for AI at those centres. During the period, around 26575 doses of bulls of high genetic merit under Set I, II and III were supplied to farmers/ developmental agencies through sale in addition to supply of semen for Institute extension/other activities.

Table: Sahiwal Cattle: Production and reproduction performance during the year 2021

Traits	No.	Maximum	Minimum	Mean±SE
Age at First Calving (days)	33	1918	975	1290.65±45.22
First lactation total milk yield (kg)	29	3747	635	1925.80±183.47
First lactation 305-days or less milk yield (kg)	29	3571	635	1847.39±163.21
First Lactation length (days)	29	441	305	327.17±7.24
First Peak yield (FPY in kg)	30	17	4	9.20±0.61
First Dry Period (FDP in days)	8	149	69	98.25±12.12
First Service period (FSP in days)	8	174	76	128.88±11.45
First calving Interval (FCI in days)	8	521	374	453.88±17.31
All lactation total milk yield (kg)	110	3917	533.5	1961.07±77.00
All lactation 305-days or less milk yield (kg)	110	3571	533.5	1905.00±69.84
All Lactation length (FLL in days)	110	475	220	320.97±3.47
All lactation peak yield (FPY in kg)	110	17.5	4	10.37±0.31
All lactation dry Period (FDP in days)	25	179	66	103.32±7.07
All lactation service period (FSP in days)	25	174	60	120.84±6.17
All lactation calving Interval (FCI in days)	25	521	374	432.64±7.64
All lactation wet average (kg)				7.6
All lactation dry average (kg)				4.5

Trait	Phenotypic Gain (ΔP) NDRI	Genetic Gain (ΔG) NDRI
305 MY (kg)	10.98**±2.345	0.39±0.352
TLMY (kg)	11.05**±2.892	0.575±0.458
Wet Av. (gm)	320**±0.700	20.0*±0.001
LL (days)	-0.12±0.307	0.008±0.023
AFC (month)	0.009±0.027	-0.008*±0.004

Genetic Improvement of Murrah Buffaloes

Under Network Project on Buffalo improvement-Institute Herd

Actual phenotype and Genotype gain was estimated in Murrah (NDRI) as given below:

Selection Index in Murrah buffalo was developed using production, reproduction and health traits. Selection Index based on Av. Daily Milk Yield, PY, SP, AFC and Female Fertility giving 48%, 30%, 1%, 1% and 20% weightage to the traits, respectively:

$$\text{INDEX VALUE} = 56.733(\text{ADMY}) + 35.588(\text{PY}) - 1.473(\text{SP}) - 1.341(\text{AFC}) - 23.407(\text{FF})$$

Network project on Buffalo improvement: Field Progeny Testing Programme

- During the period 4,281 AIs with overall conception rate of 46.74% were obtained. Semen of 15 Bulls of 18th set were used. 1,542 calving out of which 665 (43.12%) females born from 19th set bulls.
- During this period 72 progenies, in milk, were recorded. The average lactation yield in the field was recorded as 2551.66 ± 52.22 kg. The average age at first calving was recorded 48.56 months and average milk yield 8.07 kg/day was recorded.
- The physical identification using ear tagging has regularly been done in all female progenies born in the field. The developed model with assigned weights to different test days, where TD90, TD106, and TD150 can be used to predict lactation yield with 90% correlation with the Intl. CAR method
- SCSP funds of NPBI - Calcium supplement, de-wormers and Ticks and Minerals were distributed to 362 dairy farmers of SC community in 6 villages (Bibipur, Biana, Sheikhpura, Darar, Kurali, Sohna)

Genetic polymorphism in LAP3, MASP2 and SIRT1 genes and their association with milk yield, composition traits and clinical mastitis in Sahiwal and Karan Fries cattle

Genetic polymorphism in LAP3, MASP2 and SIRT1 genes and their association with milk yield, composition traits and clinical mastitis in 140 Sahiwal and 145 Karan Fries cows were carried out. A total of 11 SNPs in the promoter and partial exon 1; 9 SNPs in intron 12 and 5 SNPs in exon 13 region of LAP3 gene; 6 SNPs in exon 2 and 3 region of MASP2 gene and 3 SNPs in promoter region of SIRT1 gene were identified. Association analysis using estimated breeding values (EBVs) was performed to test the effect of SNPs on 305d Milk Yield (305dMY), Total Lactation Milk Yield (TLMY), 305d Fat Yield (305dFY), 305d Solid Not Fat Yield (305dSNFY), Lactation Length (LL) and incidence of clinical mastitis in Sahiwal and Karan Fries cows. In LAP3 gene, the SNP g.-229A>G and g.25406C>T were associated with all milk yield traits, the SNP g.-239T>C, g.-71G>A and g.16C>T were associated with 305d MY, LMY and LL in Sahiwal cows. In MASP2 gene, the SNPs g.499C>T and g.609T>C were significantly associated with all milk yield traits in Sahiwal cows. Significant effect of SNP g.-306T>C of SIRT1 gene on all milk production traits in Sahiwal cows was also identified. For Karan Fries cows, SNPs g.-267C>G, g.-239T>C, g.-229A>G, g.-71G>A and g.51T>G, g.24555A>G and g.24794C>T in LAP3 gene were significantly associated with 305d MY, while SNPs (g.-267C>G and g.51T>G) also significantly influenced LMY. With a logistic regression model, significant association of the SNPs g.25406C>T (Sahiwal) and g.-239T>C (Karan Fries) with incidence of clinical mastitis was determined.

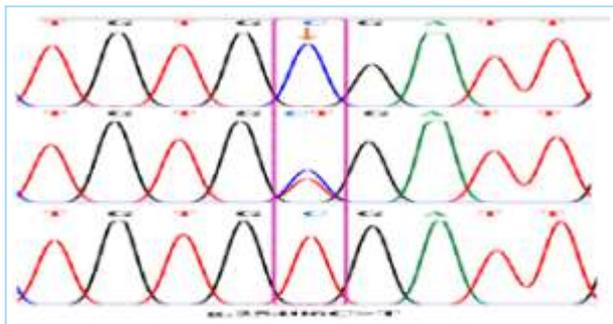


Fig : Chromatograph showing the SNP 25406C>T locus in LAP3 gene in Sahiwal and Karan Fries cattle

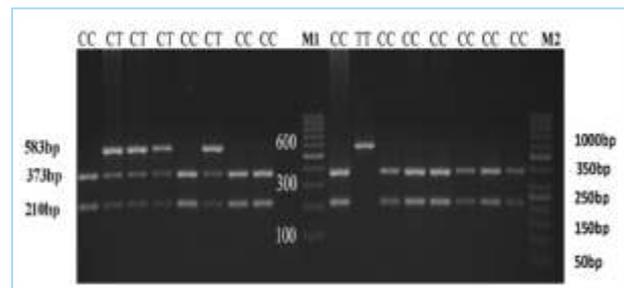


Fig: PCR-RFLP patterns of SNP g.499C>T locus in MASP2 gene in Sahiwal cattle by BstUI restriction enzyme CC: 373 and 210 bp CT: 583, 373 and 210 bp TT: 583 bp

Deciphering the Modifications in miRNA Binding Region of DNA Repair Genes in Concurrence with Thermal Stress in Tharparkar and Karan Fries Cattle

In the present study, an attempt was made to identify the miRSNPs in DNA repair genes and their association with heat stress response. A total of 60 blood samples were collected from Tharparkar and Karan Fries animals from LRC, ICAR-NDRI, Karnal and genomic DNA was isolated. Physiological (respiration rate, skin temperature and heart rate) and haematological parameters of all animals were measured. PCR conditions were standardised and SNPs were screened in the Tharparkar and Karan Fries population for SNPs ENSBTAT00000014098.6: c.1050+4197C>T in CUX1, ENSBTAT00000008174.5:c.*653C>T in RPA2 and ENSBTAT000000034186.4:c.*230del in H3F3A genes using PCR-RFLP. Further, tetra-primer ARMS-PCR protocol was developed for genotyping ENSBTAT00000014098.6: c.1050+4197C>T in CUX1 gene. Among the screened SNPs, only two SNPs were polymorphic with respect to Karan Fries population, where as none of the SNPs were polymorphic with in Tharparkar population. Association analysis including breed and genotype as fixed factor indicated significant association between the mutation ENSBTAT00000014098.6: c.1050+4197C>T in CUX1 gene and physiological parameters such as heart rate and respiration rate. The mutation ENSBTAT00000008174.5:c.*653C>T in RPA2 was not associated with any of the physiological and hematological parameters.

Genome Wide Association of Clinical Mastitis in Murrah Buffaloes

Genome-wide SNPs were identified for association with incidence of clinical mastitis in 96 Murrah buffaloes using the ddRAD approach. A total of 246 million quality reads were obtained with an average alignment rate of 99.01% and 812,823 SNPs were obtained at a read depth of 10 which got reduced to 18,056 SNPs after quality control filtration. A total of 11 genes viz. NCBP1, FOXN3, TPK1, ZBTB7C, XYLT2, CPXM2, HERC1, OPCML, PRTFDC1, PCDH9 and COBL were identified, including significant as well as suggestive thresholds. Majority of

the genes identified were having tumor suppressing action and having relation with glycolytic and energy production pathways. The gene enrichment analysis was carried out for molecular functions, biological processes and gene pathways. Molecular functions including binding (NCBP1, ZBTB7C, COBL), catalytic activity (XYLT2, TPK1, CPXM2) and molecular function regulator (ZBTB7C) and three biological processes namely biological regulation (NCBP1, ZBTB7C), cellular process (NCBP1, ZBTB7C, XYLT2, COBL, TPK1, CPXM2) and molecular process (NCBP1, ZBTB7C, TPK1, XYLT2, CPXM2) while eight different pathways were identified corresponding to these genes.

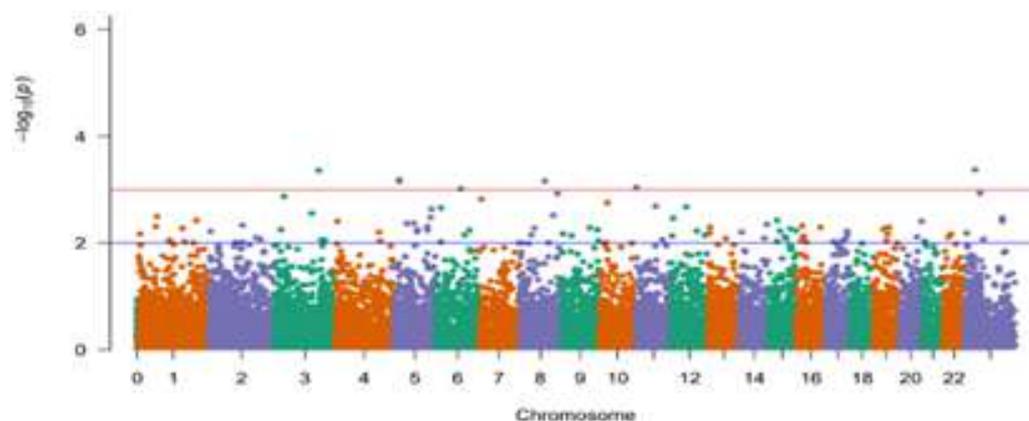


Fig: Manhattan plot for incidence of clinical mastitis in Murrah Buffalo

Top Gene and their Genomic Markers Identified for Lactation and its Persistency in Murrah Buffalo

Murrah breed of buffalo is excellent dairy germplasm known for its superior milk quality in terms of milk fat and solid not fat (SNF), however, it is often reported that Indian buffaloes had lower lactation and fertility potential compared to non-native cattle of the country. Recent techniques particularly the Genome-wide association studies to identify genomic variations associated with lactation and fertility traits offer prospects for systematic improvement of buffalo. DNA samples were sequenced using double digestion RAD tag genotyping-by-sequencing. Bioinformatics pipeline was standardized to call the variants and SNPs qualifying the stringent quality check measures were retained for GWAS. Over 38,000 SNPs were used to perform GWAS on the first two principal components of test day records of milk yields, fat percentages, and SNF percentages, separately. GWAS was also performed on 305 days milk yield, lactation persistency estimated through rate of decline after attaining the peak yield method, along with other three standard methods, and breeding efficiency, post-partum breeding interval, and age at sexual maturity were considered as fertility traits. Significant association of SNPs was observed for the first principal component explaining the maximum proportion of variation in milk yield. Gene ontology analysis with ± 20 Kb around significant SNPs revealed *GRIA3* and *ZNF292* to be associated with milk yield. Other potential genomic regions identified to have important role in regulating milk yield and milk composition were *GRIA1*, *GRIA2*, *GRIA4*, *GRIK1*, *ANKRD44*, *DAPK2*, *HNF4G*, *SYBU*, *MYNN*, *LRRC34*, *CAMTA1*, *TIGD2* and *ACTRT3*. Potential genes involved in regulating fertility in Murrah were *APC*, *PDP1*, *SLAMF6*, *GRID2*, *PDE11A*, *EDIL3*, *ERICH2*, and *EIF5A2*. Thus, these identified genomic regions shall help in carrying out an early selection of high-yielding persistent Murrah buffaloes, and in the long run, would be helpful in shaping their future genetic improvement programs.

Genome-wide Scan for Autozygosity, Selection Signature and Genomic Inbreeding in Karan Fries and Sahiwal Cows

The SNP genotypic data generated on 48 elite Sahiwal cows was subjected to quality control with standard attributes using Plink software. During the quality control the unmapped SNPs and those present on sex chromosomes were excluded.

Runs of Homozygosity

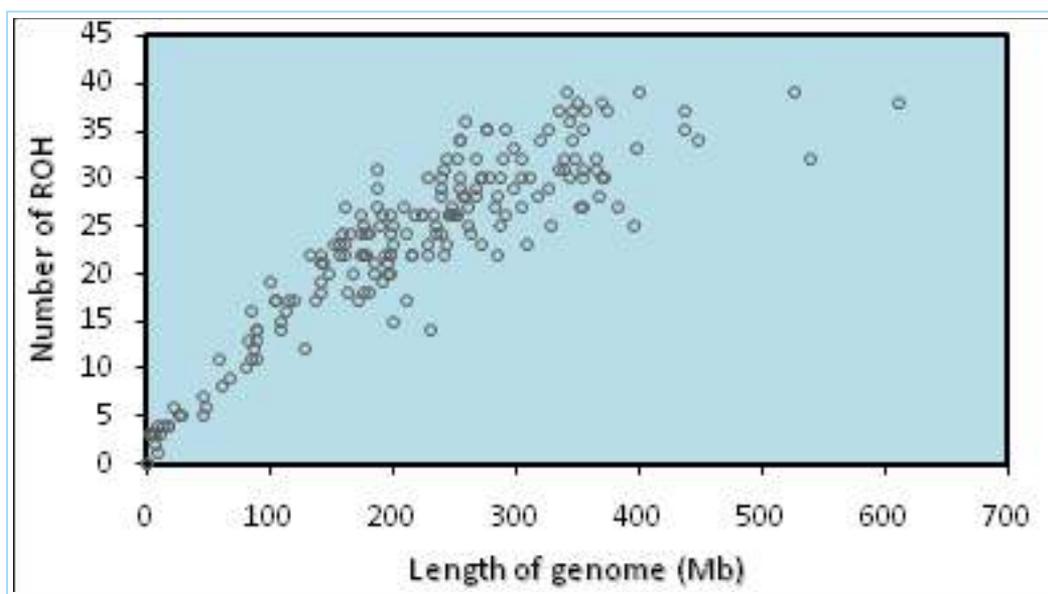
Runs of homozygosity (ROH) are contiguous homozygous stretches of genotypes/segments/ haplotypes in an individual inherited from both of its parents. The final data set consist of 724370 SNPs that were subject to

ROH analysis with predefined parameters consists of sliding window of 10 SNPs, number of SNP, minimum length of ROH as 0.5Mb, 250kb SNP gap and density of 1/120 and 1 heterozygote in a ROH. The ROH are categorized into five classes such as 0-2 Mb, 2-4 Mb, 4-8 Mb, 8-16 Mb and >16 Mb based on the ROH length.

Table : Parameters for ROH analysis using HD Bovine SNP array in Sahiwal population.

Parameter	Genome coverage%	Number of segments	Average length
Maximum gap 250Kb	4.34	9.29	108.94
Density 120SNP	8.065	14.16	202.48
50KB	4.66	12.84	116.98
10SNP sliding window	4.25	8.22	106.62
0.05	4.25	8.22	106.62

A total of 4464 ROH segments were observed with number of segments ranged from 1 to 39 and mean number per individual as 23.13 ± 9.52 in the Sahiwal herd. The average size of these segments ranged from 0.75 to 16.85 Mb and mean ROH length of 8.73 Mb per individual was found. The individual with largest ROH segment in the study was 611.23 Mb covering 24.34 percent of total autosome length. Likewise, the length of ROH in the low inbred individuals was 2.25 Mb having 3 segments accounted for 0.08 percent of the total autosomal genome (Fig.). On an average proportion of genome homozygous due to ROH was 3.44% of total genome (85.35 Mb).



Number of ROH per individual and genome length covered by ROH

Majority of the ROH segments were comprised of medium size segments (4-8 Mb) and the corresponding length was 28.64 percent. The genome coverage by shorter and longer ROH segments in the Sahiwal genome were within the range of 0.07 and 4.23 per cent, respectively. The distribution of longer ROH segments was less abundant comprising all the chromosomes, while more than half was occupied by medium sized segments in the Sahiwal genome. However, the genome coverage (percent) due to longer ROH segments were double, compared to the medium-sized ROH segments.

The chromosome 4 harbored the longest ROH segment with a length of 89.08 Mb, comprising 1790 SNPs. The chromosome 5 possessed the highest number of ROH segments ($n = 284$), followed by chromosome 7 ($n = 260$), and chromosome 1 ($n = 252$), respectively. It indicated that the genomes on these chromosomes were under the process of selection. Similarly, major portion of chromosome under ROH (6.41%) was noticed on BTA1 (Fig.). Greater number of shorter segments (<2 Mb) were found on BTA5, followed by BTA6 and BTA20, respectively. Similarly, maximum numbers of longer segments were located on BTA3, followed by BTA1 and BTA4, respectively.

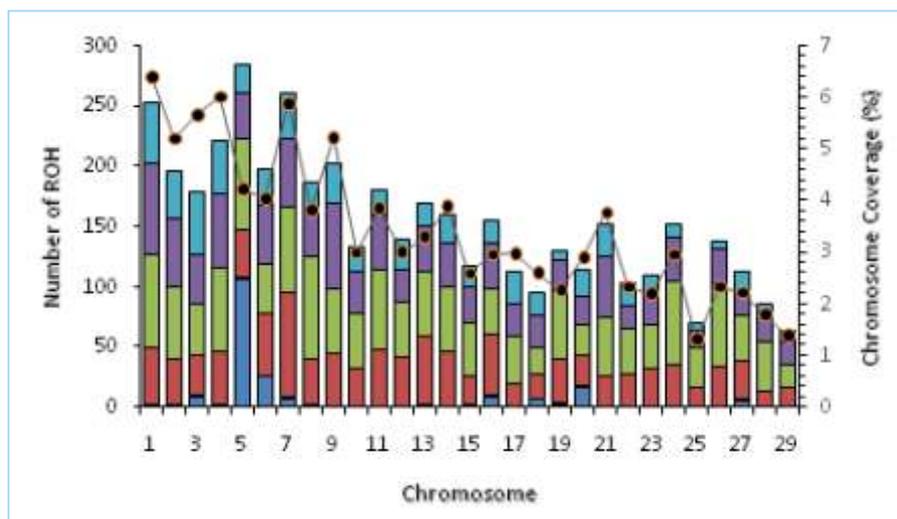


Fig: Runs of homozygosity distribution and coverage for each autosome in the Sahiwal cattle

Genomic Inbreeding

Analysis of ROH provides insights on genome wide autozygosity as well as genomic inbreeding of individuals in the population using SNP genotype data. The details of pedigree based inbreeding and genomic inbreeding of Sahiwal cattle were presented in Table below.

Table: Pedigree-based inbreeding coefficient (FPED), Genomic inbreeding coefficients based on runs of homozygosity (FROH) for different lengths of ROH and FHOM

Inbreeding Coefficient	Mean	Median	Minimum	Maximum	Coefficient of Variation (%)	N
FPED	0.009	0.000	0.000	0.062	12.19	187
FROH0-2Mb	0.0006	0.0004	0.000	0.003	85.75	135
FROH2-4Mb	0.006	0.006	0.000	0.015	54.73	186
FROH4-8Mb	0.018	0.018	0.001	0.038	43.82	179
FROH8-16Mb	0.026	0.025	0.003	0.057	52.61	179
FROH>16Mb	0.042	0.036	0.006	0.171	71.65	169
FHOM	0.039	0.032	0.000	0.172	84.93	54
FGRM	0.009	0.025	0.000	0.062	2.63	77

Coefficient of variation (CV) from different categories of F_{ROH} ranged from 43.82% to 85.75%. The average F_{PED} and other genomic inbreeding estimates (F_{ROH} , F_{HOM} and F_{GRM}) were 0.009, 0.107, 0.039 and 0.009, respectively. Trends of evolution of inbreeding measures in the population are presented in Fig.

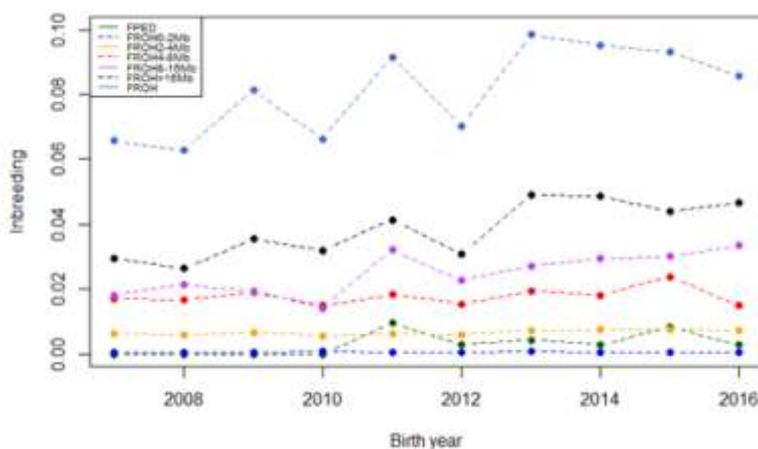
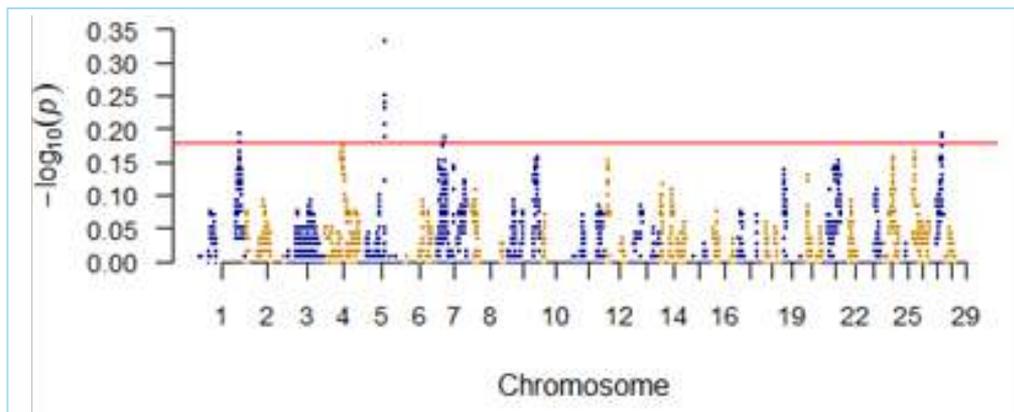


Fig.: Trends of evolution patterns of various inbreeding measures in the Sahiwal population

The trendline was showing lesser values during initial years, while showing higher trends during later years for all the genomic inbreeding measures over the years. Increasing magnitude in the inbreeding level over the years might be due to greater number of longer and medium ROH segments than shorter categories. The trend line of F_{PED} was similar to that of F_{ROH} , however, the magnitude was low. During the initial period inbreeding explained by pedigree was not evident, whereas, the estimates of genomic inbreeding were showing a higher trend.

ROH islands

The genomic regions with high frequency of homozygosity and shared by minimum two individuals are considered as ROH islands. The most common ROH islands detected were located on chromosome 9 and 1, sharing among 18 percent of the samples.



Manhattan plot of the distribution of runs of homozygosity (ROH) islands in the Sahiwal

A total of 179 genes were found in the ROH islands related with milk production, fertility, body conformation, stress tolerance and host immunity. To understand the functional aspects of identified genes, several GO terms were recognized including four biological processes, four cellular components and three molecular functions along with four KEGG pathways (Table 3). The network analyses performed indicate a total of 179 nodes with average node degree and local clustering coefficient as 2.51 and 0.417, respectively (Fig.) with p-values for expected number of edges and Protein-Protein interaction enrichment were found to be 139 and $1.05e-11$, respectively.

Gene interaction networks for genes in the ROH islands of Sahiwal cattle

In the network seven significant clusters were visualized with top hub gene WD repeat (WDR) was closely associated with the QTL that control udder depth, milk related traits and susceptibility to bovine respiratory disease.

Assessing Genetic Relationship among Production, Functional and Linear Type Traits for Selection of Indigenous and Crossbred Dairy Cattle

- Least square means of objective linear type traits viz., stature was 125.97 ± 0.68 cm, body length 136.58 ± 1.01 cm, chest girth 173.04 ± 1.14 cm, body depth 203.40 ± 1.39 cm, rump angle 14.50 ± 0.39 cm, rump width 20.62 ± 0.28 cm, udder depth 20.87 ± 0.41 cm, rear udder height 18.38 ± 0.33 cm, and teat length 6.16 ± 0.24 cm.
- On the other hand, least square mean scores of subjective linear type traits (1-9 scale) viz. fore teat placement was 6.32 ± 0.46 , rear teat placement was 7.27 ± 0.35 , rear leg side view was 6.26 ± 0.26 , rear leg rear view was 6.28 ± 0.27 score, foot angle 6.86 ± 0.27 , angularity 34.97 ± 0.50 -degree, central ligament 6.55 ± 0.39 , fore udder attachment 5.91 ± 0.32 , fore teat placement 6.32 ± 0.46 , and rear teat placement was 7.27 ± 0.35 .
- Parity had a significant ($p < 0.01$) effect on fore udder attachment and central ligament and teat length in Sahiwal cattle. Season of calving has the significant ($p < 0.01$) effect, observed in case of udder depth in Sahiwal cattle. Period of calving has a significant ($p < 0.05$) effect on rump angle, udder depth, teat length, angularity and central ligament in Sahiwal cattle.

- Most of the linear type traits, milking temperament and milking speed were found to be low to highly heritable (ranging 0.14 ± 0.01 to 0.69 ± 0.01); while days open was having low heritability (0.19 ± 0.02).
- Among linear type traits, stature, body length and chest girth were having high positive genetic correlation (ranging from 0.24 ± 0.06 to 0.31 ± 0.09) with total milk yield.
- Milking temperament was having negative phenotypic correlation with 305 days milk yield (-0.28 ± 0.03) and total milk yield (-0.37 ± 0.01). This indicated docile cows may produce more milk.
- It was observed that most of the high producing milking animal, were docile and got a temperament score of 1 to 2 and they were on higher parity (above 4), while first and second lactation cows were aggressive and nervous, were difficult to handle and were kicking more frequently during milking. High parity animals were docile and more friendly to environment of milking parlor.
- Total milk yield, 305 days milk yield, first lactation total milk yield and first lactation 305 days milk yield, were the production traits considered in present study. Heritability of Total milk yield, 305 days milk yield, first lactation total milk yield and first lactation 305 days milk yield were 0.38 ± 0.08 , 0.30 ± 0.08 , 0.21 ± 0.09 and 0.23 ± 0.09 respectively by using LSMLMW method. On the other hand, the estimates of heritability of these traits by Bayesian approach were, 0.38 ± 0.02 , 0.30 ± 0.02 , 0.27 ± 0.11 and 0.28 ± 0.12 respectively.
- Estimates of heritability in present study using animal model (BLUPF90), were higher than that of sire model (LSMLMW).
- The standard error (MCE) estimates, obtained by Bayesian approach were low indicating that the estimates were more precise by this method.
- Milking temperament was found to have high negative genetic and phenotypic correlation with 305 days milk yield and total milk yield in Sahiwal cattle; which indicated docile cows may produce more milk. It was observed that most of the high producing milking animal, were docile and got a temperament score of 1 to 2 and they were on higher parity (above 4), while first and second lactation cows were aggressive and nervous, were difficult to handle and were kicking more frequently during milking. High parity animals were docile and more friendly to environment of milking parlor.
- Milking speed (kg/min) was more in high producing animals with a least square mean of 0.707 ± 0.10 , which may be due to high milk lodgment in udder alveoli. High milking speed was also indicator of loose teat sphincter muscles of udder, so there must be a balance in tone of teat sphincter muscles. Milking speed was having positive genetic and phenotypic correlation with total milk yield that can be utilized in direct selection.
- Among linear type traits, stature, chest girth and body length and front teat placement have high positive genetic correlation with total milk yield in Sahiwal cattle. Stature has also a high positive genetic correlation among other linear type traits, viz., body length, chest girth, body depth, rump width and rear udder height; that can be utilized by direct selection for a correlated response to selection.
- Based on the heritability estimates using animal model in Bayesian approach, it was observed that angularity, rump width, body length, rear udder height, rear teat placement and stature have high heritability in Sahiwal cattle that can be utilized in selection and genetic improvement program. It may provide a lot of scope and genetic improvement in breeding procedures.
- However, for better estimates of genetic parameters of various traits under this study, more data is being collected and further research work was in progress.

Strategic Modelling of Reference Population for Effective Implementation of Advanced Selection Strategies

The data on cattle genome is simulated for sex limited trait over 10 current generation. Effective number of chromosome segments (M_e) were found to reduce with selection that increased average relatedness. Increasing 1 crossover per Morgan increased M_e significantly. Decline in the mutation rate increased M_e . M_e is inversely proportional to % inbreeding. Selection increased bias of genomic estimated breeding values prediction for higher recombination models. The higher mutation rate model had higher additive variance. Correlation between EBV and TBV (accuracy) was high for high mutation model. Decline in accuracy was

observed over the generations due to LD decay. Recent responses to selection might have inbuilt problems of evolutionary response. Selection and high mutation with Recombination model rapidly accumulated inbreeding.

Genetic evaluation of AlpinexBeetal and SaanenxBeetal Goat for Prospective Dairy Goat Breeding

Data on 1200 kids of Saanen x Beetal has been recorded till now. Data on Alpine x Beetal is being recorded. Preliminary analysis is done for traits of economic importance. The estimate for 150 days milk yield was 234.34 ± 4.7 kg, with wet average: 1.4 kg and herd average: 1.21 kg. Prolificacy in goats was recorded. 1202 kidding recorded. In total 1814 kids born with 1.51 litter size. The birth weight averages type of birth were, single: 3.3 ± 0.63 , Twin: 3.0 ± 0.54 and Triplet: 2.70 ± 0.57 . The average litter weight was 4.81 with range 1 to 10.6. Per cent.

Fitness Black Box: Deciphering the Ovar-MHC Variability in sheep breeds of India

Huge polymorphism across the three loci in MHC region of sheep breeds across India was observed. For DRB1, 29 old and 10 new alleles were obtained. 115 sequences submitted NCBI (MW790614 to 671; MW821667 to 710; OK169377 to 389). For DQA1, 13 old and 5 new alleles were obtained and 133 sequences submitted NCBI (MW790672 to 741; MW790855 to 898; OK169420 to 438). For DQA2, 18 old and 4 new alleles were obtained and 143 sequences submitted to NCBI (MW790742 to 854; OK169390 to 419). MHC database for sheep, goat and camels at the NDRI web platform were created. The name of the database is "www.mhcdbms.in". The SNP variation data, clean sequence data from PCR or cloned DNA sequencing will be separately posted. Evidence of balancing selection across breeds for MHC is observed.

Genetic Evaluation of Functional Traits and their Effect on Production and Reproductive Traits of Crossbred Cattle

Data on calving traits like Dystocia (DYS), Stillbirth (SB), Abortion (AB), Premature birth (PMB) and Retention of Placenta (ROP) of Jersey crossbred animals, maintained at the ERS-NDRI, Kalyani over a period of 40 years (1980-2019) were used to estimate the genetic parameters of this traits. Initially, least-squares analysis were applied to identify the significant non-genetic factors to be included in the animal model analysis. Estimates of variance components and genetic parameters for DYS and SB were carried out by Restricted Maximum Likelihood Method (REML) using WOMBAT program. Period of calving significantly ($P < 0.05$) affected the occurrence of DYS and SB of animals. Season of calving significantly ($P < 0.05$) influence the prevalence of AB and PMB in crossbred cattle. Parity of animal had highly significant ($P < 0.01$) influence on occurrence of PMB in Jersey crossbred cattle. The incidence of DYS and ROP of cows were significantly affected by birth weight groups of calves in this study. Cows having calves of higher birth weight groups had significantly higher risk of dystocia as compared to cows having lower birth weights. On the other hand, cows having fetal birth weight of 15 kg or less had the highest incidence of retained fetal membrane than cows of higher fetal birth weight. Estimates of direct heritability (h^2) for traits under consideration were low, which ranged from 0.02-0.04 in this study. Low maternal heritability (0.08) was observed for DYS and SB in this study.

INNOVATIVE APPROACHES IN MANAGEMENT OF DAIRY ANIMALS

Role of Ramie (*Boehmeria nivea*) Fodder Feeding for Improving Reproductive Performance of Sahiwal Heifers

Introduction of new package of practices along with flute music (8 hours) proved to be very effective in attaining higher daily weight gain and early age at insemination to establish pregnancy in indigenous breed of cattle (Sahiwal). The experiment was conducted in Sahiwal heifers (n=18) by providing regular feeding based on ICAR 2013 feeding standards. In addition to regular feeding practices, the experimental heifers were also fed green Ramie (*Boehmeria nivea*) fodder @ 2% of their body weight from the age of 12 months onwards. The animals were also allowed on *kacha* floor in an open paddock for 3 hours daily during the morning hours from 7.00 to 10.00 am in all seasons and also received sufficient sun light in open paddock. The average daily weight gain of these Sahiwal heifers was recorded 343.5 ± 8.26 g/day since birth till the age at first AI and maximum daily weight gain (g/day) of 570 ± 16.62 g (350-910 g/day) was recorded in these heifers between the age of 12-18 months. Age at the first service of experimental heifers was found to be significantly lower.

Table: Growth and reproductive performance of Sahiwal heifers

Sahiwal heifers	Av. Daily weight gain since birth (Grams/Day)	Peak daily weight gain (Grams/Day)	Av. age at puberty (in days)	Av. age at first Service (in days)
Average Performance n=14	343.5 ± 8.26 (303-424)	570.0 ± 16.62 g (350-910)	673.66	759.6 (598-873)
Group Performance		7 heifers-450-550 gms./ day 6 heifers-550-650 gms./ day 1 heifer-650-750 gms./ day		6 heifers-803-873 days 4 heifers-721-792 days 4 heifers-598-699 days



Sahiwal heifers at NICRA complex

Physiological Relevance of Metabolomics as Biomarker of Thermal Stress in Lactating Goats

A study on ten goats (*capra hircus*) was taken to identify metabolites in milk during thermal stress. Milk and blood samples were collected from the animals at ten day's interval. Environmental parameters were recorded on the day of sampling, to calculate Temperature Humidity Index (THI). More than 50 metabolites varied significantly ($p < 0.05$) in goat milk during different seasons, among which 15 metabolites can be used as

potential biomarkers of thermal stress. Metabolites like L-Valine, Palmitic acid, Pentadecanoic acid, Hexanoic acid, Eicosanoic acid, 2,5 Dimethoxy-mandelic acid and Glycerol increased significantly ($p < 0.05$) in cold stress compared to heat stress. Metabolites like Myristic acid, Heptadecanoic acid and 1, 3 propanediol increased significantly ($p < 0.05$) in heat stress compared to cold stress. Metabolites like 3 alpha mannopyranose, Maltose, D-Allofuranose, Ethanedioic acid, and 4-tert butoxy butanol were significantly ($p < 0.05$) higher in thermoneutral condition compared to heat and cold stress. A significant ($p < 0.05$) increase in respiration rate, heart rate and skin temperature between heat and cold stress with highest values were observed during heat stress and insignificant in rectal temperature between heat stress, thermoneutral condition and cold stress. Highest PCV, Hb and TEC were observed during thermoneutral conditions. A significant ($p < 0.05$) decrease in Hb, PCV and TEC were observed in heat stress compared to cold stress. Plasma cortisol concentration increased significantly ($p < 0.05$) in heat and cold stress compared to thermoneutral condition. Plasma thyroxine concentration increased significantly ($p < 0.05$) in cold stress compared to heat stress and thermoneutral condition. Milk yield and fat, protein, lactose and SNF percentage were significantly ($p < 0.05$) low in heat stress compared to cold stress and thermoneutral condition.

Effect of Replacement of Concentrate with *Moringa Oleifera* on Physio-Biochemical Attributes of Barbari Goats during Different Seasons

Replacement of 50% of concentrate with *Moringa oleifera* in Barbari goats during different season showed significantly ($P < 0.05$) lower physiological response (RT and RR) in treatment group compared to control group. The overall mean values of hematological parameters (Hb, RBC, PCV) were significantly ($P < 0.05$) higher in treatment group compared to control. The thyroid hormone (T3 and T4) were significantly ($P < 0.05$) and overall mean values of plasma cortisol were significantly ($P < 0.05$) lower in treatment group. Mean values of plasma catalase enzyme were significantly ($P < 0.05$) higher in treatment group than the control group. The mean values of plasma catalase was significantly ($P < 0.05$) higher during hot dry season compared to other seasons. IL2 concentration in blood plasma was significantly ($P < 0.05$) lower, whereas IL10 concentration was significantly ($P < 0.05$) higher in treatment group than control group. Body weight and dry matter intake was also significantly ($P < 0.05$) higher in treatment group compared to control group.. The results of the present study clearly indicated that, 50% replacement of concentrate with *Moringa oleifera* is beneficial for amelioration of the adverse effect of thermal stress, reducing the stress markers, enhancing the metabolic hormones, immunity and growth performance of Barbari goats.

Effect of Calf-mother Contact and Enhanced Milk Feeding on the Performance, Behaviour and Welfare of Sahiwal Calves

Cow-calf separation imposes many physical, psychological and nutritional stresses on calves affecting their growth, health and welfare. Positive effects of limited cow-calf contact at milking time or unrestricted contact through a fence-line have been demonstrated earlier in cattle and buffaloes. This study was aimed at investigating the effect of full mother-calf contact and free choice colostrum suckling from birth to 5 days and thereafter fence-line mother contact and enhanced milk suckling on growth, health and welfare of Sahiwal calves. For this 24 calf-mother pairs of Sahiwal calves were selected at parturition and blocked randomly into 3 groups of 8 each (T0, T1 and T2) for a period of three months. In T0, calves were separated from mother at birth and bottle fed twice daily (weaned and bottle fed); in T1, the calves were separated from their mother through fence-line barrier and



allowed mother suckling twice daily at milking time (fence-line contact and restricted suckling) and in T2 the calves were kept in full mother contact from birth to 5 days and then in fence-line contact with mother including milk feeding thrice daily upto 21 days and twice daily after that (fence line contact and enhanced suckling). The T0 and T1 calves were fed @ 10% of body weight upto 6 week with 1% weekly reduction afterwards till 90 days, whereas the T2 calves were offered ad lib. colostrum upto 5 days and then milk fed @ 15% body weight upto 3 weeks and 10% body weight upto 6 weeks with 1% weekly reduction afterwards.

Table : Growth, immunity and stress levels of calves in three calf-cow contact systems

Parameter	Weaned and bottle-fed milk(T0)	Fence-line cow contact and restricted suckling(T1)	Fence-line cow contact and enhanced suckling (T2)
Birth weight (kg)	20.82±0.67	21.45±0.64	22.77±0.55
Body weight at 12 weeks of age (kg)	51.70a±1.47	59.90b±1.39	70.00c±2.39
Average daily gain over 12 weeks (kg)	0.367a±0.010	0.457b±0.01	0.562c±0.01
IgG concentration at 30 days (mg/ml)	14.13a±0.40	20.04b±0.28	24.77c±0.50
Cortisol concentration over 90 days (ng/ml)	14.13a±0.40	20.04b±0.28	24.77c±0.50

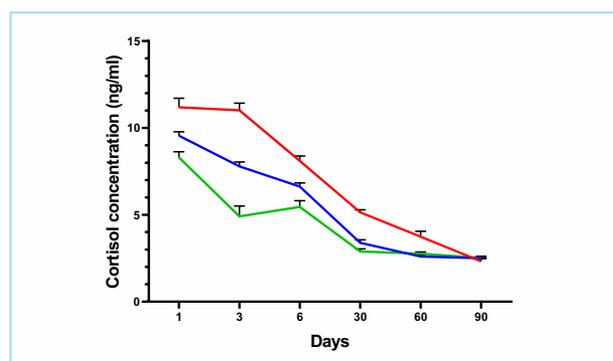
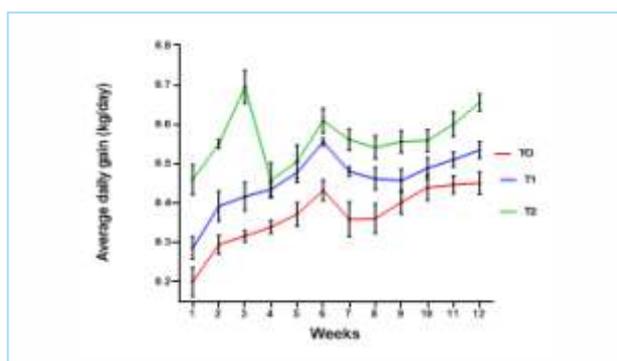


Fig.:Average daily body weight gain and blood cortisol concentrations of three groups of calves

It was concluded that full mother contact and voluntary colostrums suckling during birth to five days followed by fence-line mother contact and enhanced milk feeding (15% of body weight) and increased sucking frequency (3 times a day) up to 21 days remarkably improved the growth, health and welfare of Sahiwal calves in comparison to those calves which were allowed fence-line mother contact and restricted suckling or which were weaned at birth from mother and bottle fed restricted colostrum and milk.

Effect of Calf-mother Contact on the Performance, Behaviour and Welfare of Sahiwal Cows

The aim of present study was to investigate the effect of fence-line and restricted cow-calf contact on production performance and behaviour of Sahiwal cows. For this purpose, 20 cow-calf pairs were selected at parturition and assigned into 2 groups (T0 and T1) of 10 cow-calves pair each for a period of 6 months. In T0, restricted calf contact group, calves were separated from mother at birth and allowed limited contact for 10-15 min each at morning and evening milking. Calves in T1, fence-line calf contact group were separated from their mother through fenceline barrier and allowed mother suckling twice daily at milking.



Sahiwal cows with restricted calf contact



Sahiwal cows with fence-line calf contact

The overall means of daily milk yield and milk flow rate was higher ($p<0.01$) in T1 (7.61 ± 0.13 kg/day, 1.059 ± 0.02 kg/min) than in T0 (6.82 ± 0.19 kg/day, 0.969 ± 0.01 kg/min) respectively. The overall means of milk let-down time was higher ($p<0.01$) in T0 (71.00 ± 1.88 sec) than in T1 (51.30 ± 1.34 sec). The overall means of milking time was higher ($p<0.05$) in T1 (6.29 ± 0.09 min) than in T0 (5.82 ± 0.16 min). The mean difference in milking temperament score was significant up to 13 weeks of calving in two groups. The means of plasma cortisol levels were significantly higher ($p<0.01$) in T0 than T1 cows.

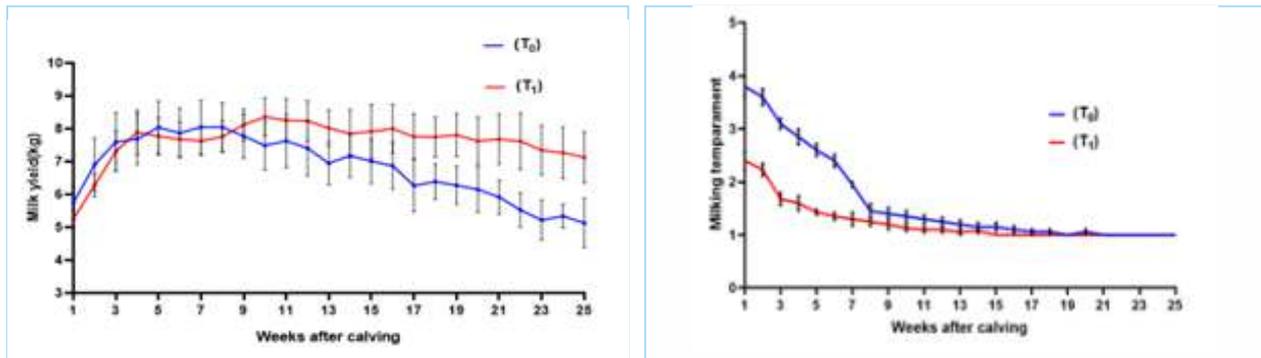


Fig. Average daily milk yield (kg) and milking temperament score of two groups of cows

It was concluded that natural calf suckling along-with fence-line calf contact improved the milking performance, milking behaviour and reduced the stress levels of Sahiwal cows

Effect of Calf-mother-bull Contact on the Reproductive Performance and Estrus Behaviour of Sahiwal Cows

The aim of present study was to investigate the effect of fence-line and restricted cow-calf contact and bio-stimulation on reproduction performance and behaviour of Sahiwal cows. For this purpose, 20 cow-calf pairs were selected at parturition and assigned into 2 groups (T0 and T1) of 10 cow-calf pair each for a period of 6 months. In T0, restricted calf contact group, calves were separated from mother at birth and allowed limited contact for 10-15 min each at morning and evening milking and cows were not exposed to bull. Calves in T1, fence-line calf contact group were separated from their mother through fence line barrier and allowed mother suckling twice daily at milking and cows were also exposed to fence line contact of bull.



Sniffing/licking by estrus cow to bull across the fence



Sniffing/licking by bull to cow across the fence

The average days to first estrus and first service were lower ($p<0.05$) in T1 (80.20 ± 6.19 , 93.30 ± 8.01) than in T0 (99.90 ± 6.57 , 127.20 ± 13.79) respectively. The average days to first estrus and first service were lower ($p<0.05$) in T1 (80.20 ± 6.19 , 93.30 ± 8.01) than in T0 (99.90 ± 6.57 , 127.20 ± 13.79) respectively.

In case of first and second estrus the mean frequencies of estrus behaviours including sniffing/licking, tail raising, micturition, chin resting, flehmen response, mounting on others, allowing mounting attempts, and agonistic interactions of cows and bull were significantly ($P<0.01$) higher in T1 than T0 from d -1 to d 0 of estrus and then declined from d +1 onwards. These frequencies of estrus behavior increased in second estrus as compared to first estrus in both groups.

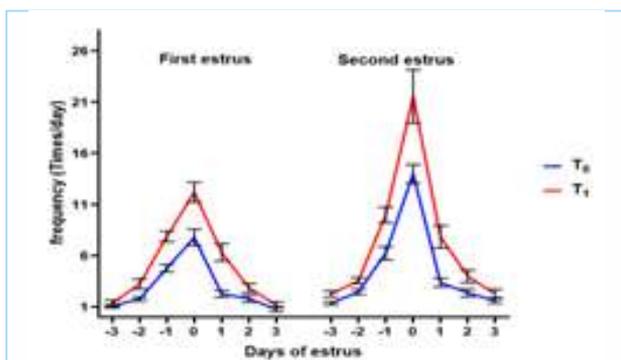


Fig: Frequencies of sniffing/licking to pen mates

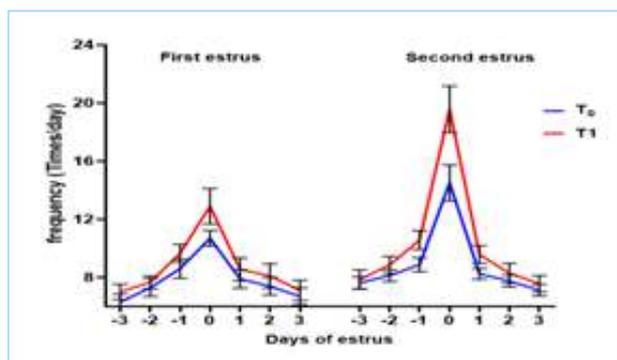


Fig: Frequencies of micturition

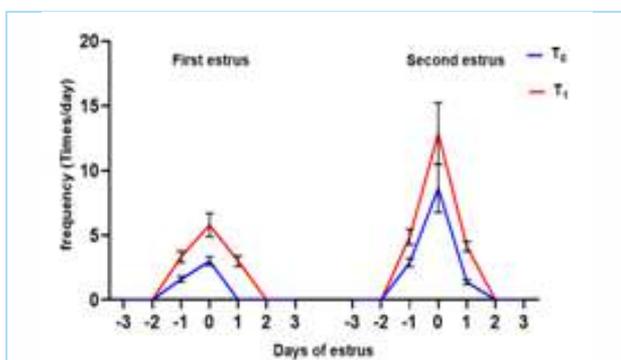


Fig: Mounting attempts on pen mates

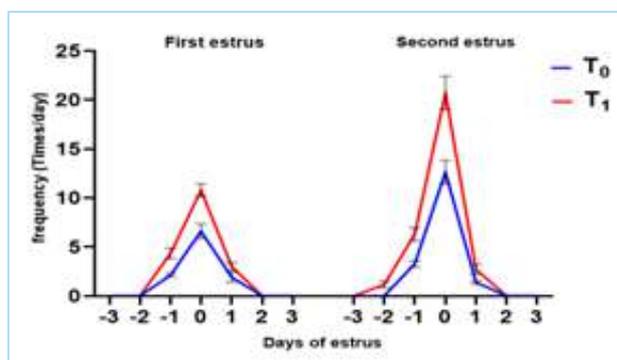


Fig: Standing to be mounted by pen mates

Mean daily time spent during first estrus on eating in T₀ and T₁ (6.70 ± 0.40 , and 5.44 ± 0.38 h), rumination (7.70 ± 0.30 and 6.66 ± 0.37 h) and resting (8.12 ± 0.28 and 7.55 ± 0.44 h) on the day of estrus, were significantly ($P < 0.01$) lower in T₁ than in T₀. Mean daily time spent during second estrus on eating in T₀ and T₁ (5.75 ± 0.37 and 4.29 h), rumination (6.88 ± 0.35 and 5.14 ± 0.34 h) and resting (7.50 ± 0.38 and 6.00 ± 0.44 h) on the day of estrus, were lower in T₁ than in T₀.

Overall mean intensity of estrus during first estrus in T₀ was largely weak (93.75%) and in T₁ weak to moderate (79.30 & 20.70 %) respectively. The per cent mean intensity of estrus in second estrus was weak to moderate (50.68 & 49.31) in T₀ whereas, percentage of weak, moderate and intense estrus (23.01, 66.26 and 14.28) in T₁, respectively.

In conclusion, the expression of estrus behaviour, estrus intensity and the reproductive performance of postpartum Sahiwal cows in calf contact were remarkably improved by biostimulation through exposure to a fence-line bull contact.

Exploring Molecular Basis of Seasonal Variation of Seminal Attributes and Identification of Potential Biomarkers for Selection of Buffalo Bulls with Quality Semen

The project is to explore the molecular basis of seasonal variation in semen quality of buffalo bulls and identification of possible biomarkers for selection of bulls which are least affected with seasonal effect. This project was sanctioned in the month of September 2020; there are three partner institutions in this project- ICAR- NDRI, ICAR-NBAGR, Karnal and ICAR-CIRB, Hisar. It is being implemented by taking physiological observations, testicular parameters, and blood and semen samples of the buffalo bulls kept at ABRC. Seasonal effect on bulls' physiological responses, hormonal profile and semen quality was assessed during whole one year 2020-21. During the year THI was > 80 in summer and < 60 in winter months, it shows that bulls were under cold stress during extreme winter and extreme summer; physiological responses of bulls in terms of respiration rates and rectal temperature of 28 bulls was recorded. Morning-evening respiration and rectal temperature was found to be higher in summer followed by spring and winter season. Hormonal profile in terms of T₃, T₄ and TSH was assessed, it was found that level of these hormones was higher during cooler

months and lower during summer months. Cortisol level was found to be higher during extreme winter and extreme hot-dry season compared to spring and hot-humid, whereas, testosterone concentration was found to be higher in hot-dry and hot-humid compared to spring and winter seasons. Seminal profile- data on semen quality attributes viz. percent individual motility, sperm abnormality, HOST, ROS positive cells, apoptosis, MDA etc across the seasons were considered to group the bulls into affected and non-affected by the season; for this, semen ejaculates of 28 bulls were assessed. Accordingly, semen quality of five bulls was not affected while seven bulls semen quality was affected by season particularly in hot-dry and hot-humid season. In general semen quality was superior in spring season followed by winter, hot-dry and hot-humid seasons. In winter and spring seasons more number of bulls produced quality semen compared to summer season (hot-dry and hot-humid).

Semen Sexing in Cattle

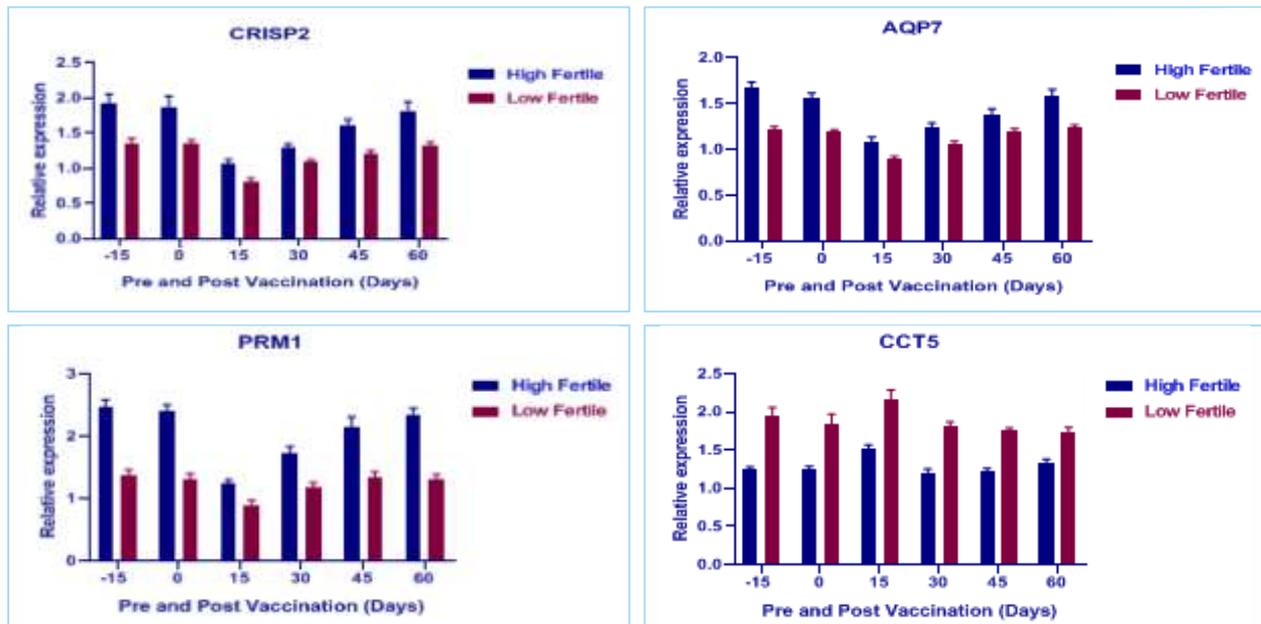
Two experiments aimed to determine the effect of trehalose and glycerol as vitrification diluents on the quality of bull semen at a low dose as well as on poor freezable samples. Also, conventional freezing was compared with vitrification to compare the detrimental effects of traditional freezing on bull sperm. The present study was undertaken with objectives (i) to study the effect of trehalose and glycerol as the combination of cryoprotectant for sperm vitrification in TEYC diluents (ii) Evaluation of vitrification diluents in low sperm dose and poor freezable ejaculates preservation. Semen was collected from 4 bulls (n=6) of the Sahiwal breed using an artificial vagina. Semen was collected from each animal twice a week, obtaining 24 ejaculates. Split samples were used, and control was subjected to conventional freezing and in other splits containing trehalose + glycerol was used for vitrification. For low dose 4 Sahiwal bulls (n=6) and poor freezable ejaculates, 3 Sahiwal bulls (n=18) were selected to carry out sperm vitrification. Fresh, pre-freeze and post-thaw seminal attributes of semen were analyzed. The results indicated that there was a significant increase ($p < 0.05$) in sperm quality parameters such as progressive motility%, viability%, HOS response% and acrosome integrity%, sperm kinetic parameters (CASA) in the post-thaw stage of cryopreservation in the treatment group than the control. In low-dose semen, up to 10 million dilutions, all these parameters showed similar post-thaw semen quality. Also, in poor freezable ejaculates, values for sperm parameters were significantly higher ($p < 0.05$) in the treatment group than in the control group. MDA concentration (nM MDA/100 million sperms) was significantly lower ($p < 0.05$) in the treatment group than in control and was no difference up to 10 million dilutions. Also, in poor freezable ejaculates, MDA concentration (nM MDA/100 million sperms) was significantly lower ($p < 0.05$) in the treatment group than in control. Hence, it can be concluded that sperm vitrification with trehalose and glycerol in combination helped improve the post-thaw sperm parameters in low doses and poor freezable ejaculates in our study.

Studies on Combination of Semen Additives for Low Dose Sperm Cryopreservation in Murrah Buffalo Bull

The two experiments aimed to determine the effect of the combination of semen additives on the quality of Murrah buffalo bull semen for low-dose cryopreservation. Various combinations of additives were compared with each other at normal concentrations and also at low doses. The present study was undertaken with objectives (i) Assessment of combination of additives with free radical scavenging/inhibition, prevention of lipid peroxidation and membrane stabilization activity on Murrah buffalo bull semen cryopreservation (ii) Study of a suitable combination of additives in Tris egg yolk citrate diluents for low dose semen preservation. The results indicated that there was a significant increase ($p < 0.05$) in sperm quality parameters such as progressive motility%, viability%, HOS response% and acrosome integrity%, sperm kinetic parameters (CASA) in the post-thaw stage of cryopreservation in the treatment group (CLC+resveratrol+cysteine and Anandamide+Mitoquinone+Trehalose) than other treatments and control. In low dose semen, treatment 1 containing cholesterol-loaded cyclodextrins+resveratrol+cysteine gave acceptable results up to 10 million dilutions. It gave significant results ($p < 0.05$) in 5 million in comparison to control. Live acrosome intact spermatozoa (%), non-capacitated spermatozoa (%), plasma membrane intact spermatozoa (%) and protamine deficient spermatozoa (%) were significantly higher ($p < 0.05$) in treatment 1. MDA concentration (nM MDA/100 million sperms) was significantly lower ($p < 0.05$) in the treatment group 1 upto 5 million. Hence, it can be concluded that the combination of cholesterol-loaded cyclodextrins+ resveratrol+ cysteine HCl helped to improve the post-thaw sperm parameters in normal concentrations as well as in low doses in our study.

Studies on Sperm Function Tests and Abundance of Fertility Related Transcripts (CRISP2, PRM1, CCT5 And CCT8) in Spermatozoa of Sahiwal and Murrah Bulls

To study the abundance of fertility related candidate transcripts (CRISP2, PRM1, CCT5 and CCT8) in spermatozoa of dairy bulls in relation to fertility, season and vaccination effect. Vaccination and seasonal variation of basic seminal parameters and advance sperm function tests are significantly affected in both high and low fertile bulls. Normal semen picture and candidate transcripts recovered to normal level around 45 to 60 days after FMD vaccination.



Effect of Vitamin E and Selenium Supplementation on Performance of Crossbred Bulls Under Induced Heat Stress Condition

Eight crossbred bulls were selected to evaluate effect of supplementation of vitamin E and Se on their performance during induced heat stress. There was feeding of vitamin-E @ 1000 IU and selenium @ 0.3ppm per kg DMI per bull per day. There was a pre-heat stress exposure condition where two groups of bulls were fed control and supplemented diet, respectively, for two months. There was assessment of physiological, biochemical and seminal parameters. Then two groups of bulls were shifted to the psychrometric chamber where they were exposed to a temperature of 37°C and relative humidity of 50 % for 8 hours per day for 14 days. Assessment of different parameters was continued up to two months after exposure to heat stress. Results indicated adverse effects of heat stress in both groups of bulls. However, these negative effects were less in the supplemented group of bulls. Physiological parameters i.e. respiratory rate, rectal temperature and skin temperature was significantly ($p < 0.05$) reduced in supplemented group as compared to control. Significantly ($p < 0.05$) higher mass activity, progressive motility and livability of spermatozoa was observed in supplemented group compared to control. There were significant ($p < 0.05$) differences in the serum cortisol, serum testosterone concentration and seminal plasma SOD and GPx activities between both groups. It can be concluded that supplementation of vitamin E and selenium in crossbred bulls has been found effective in ameliorating the adverse effects of heat stress.

Influence of Certain Antioxidants Supplementation on Physiological and Seminal Attributes of Cross Bred Bucks under Induced Heat Stress Condition

Effect of certain antioxidant [betaine and micronutrient mixture (Zinc and Chromium)] supplementation on physiological and seminal attributes in cross bred bucks during induced heat stress was investigated. For this study, 16 crossbred bucks were selected and classified into four groups as control, heat stressed, micronutrient mixture (zinc and chromium) supplemented and betaine supplemented groups on the basis of body weight and age. Heat stress was induced by placing the animals in a psychrometric chamber. All treatment groups were exposed to a temperature and relative humidity of $42 \pm 2^\circ\text{C}$ and $30 \pm 2\%$ respectively for 8 hours (9 am to 5 pm) per day for 15 days. The control group was placed in thermo-neutral zone temperature of 25° to 28°C and

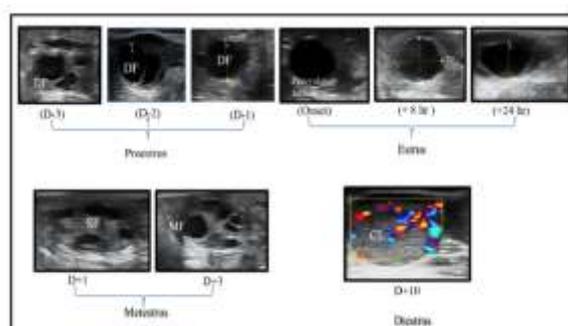
relative humidity $30\pm 2\%$ respectively. Semen was collected twice a week. The results indicated that sperm motility, viability, concentration, membrane integrity, acrosomal integrity and sperm morphology were significantly ($p < 0.05$) reduced in heat stressed groups, but significantly ($p < 0.05$) higher in micronutrient (zinc and Chromium) and betaine supplemented groups compared to control. There was significantly ($p < 0.05$) higher values of serum cortisol, total antioxidant capacity, zinc and chromium level were observed in supplemented groups. Significantly ($p < 0.05$) reduced values of heart rate, respiratory rate, rectal temperature, scrotal surface temperature and skin surface temperature were observed in treatment groups compared to control. It can be concluded that heat stress deteriorates semen quality and these changes can be partly modulated by addition of micronutrient mixture (zinc and chromium) and betaine in the feed. The provision of nutritional supplements like Betaine, Zinc and Chromium to ameliorate the adverse impact of heat stress in animals could be a beneficial and novel approach particularly for animals in heat stress.

Identification of Estrus Biomarker for Accurate Detection of Estrus/ Silent Estrus and Right Time Insemination in Buffaloes

Accurate and efficient identification of estrus is essential for successful conception and efficient reproduction management of farm animals. However, estrus detection is difficult in buffaloes because of its non-manifestation of overt signs of estrus and higher incidences of silent estrus, especially during the summer season. The present study was carried out to identify candidate proteins for buffalo estrus in easily accessible body-fluid like saliva by employing label-free (LFQ) and labeled (TMT) quantitation coupled to high resolution mass spectrometry (LC-MS/MS). Onset of estrus was detected in buffaloes ($n = 15$ heifers and 15 pluriparous buffaloes) based on behavioural signs, progesterone hormone, USG of ovaries, and reproductive tract examination. Saliva proteome profiles were generated during the proestrus (PE), estrus (E), metestrus (ME), and diestrus (DE) stages. A total of 520 proteins were identified as DEPs and among these, 59 and 04 proteins were upregulated ($FC \geq 1.5$) and downregulated ($FC \leq 0.5$) during E vs. PE, ME, and DE comparisons, respectively. Comparisons of proteins abundance and functional analysis revealed presence of one important candidate protein i.e. VMO1 as a DEP upregulated protein and its expression was confirmed by western blot. A novel peptide sequence of VMO1 identified through in silico epitope design using bioinformatics analysis and peptide was synthesized, characterized and polyclonal-antibodies (anti-VMO1) were raised the peptide in the rabbit. The affinity of the raised antibodies towards peptide was established by dot blot and western blot. An indirect ELISA was standardized and developed for detection and quantification of VMO1 protein in saliva of buffaloes during the estrous cycle. The concentration of protein VMO1 in buffalo saliva was found to be highest (49 ± 5.5 pg/mL) at estrus as compared to other phases ($P = 27.8 \pm 4.5$ pg/mL; $ME = 23.1 \pm 4.4$ pg/mL; $DE = 24.2 \pm 4.9$ pg/mL) of the estrous cycle. Receiver operating characteristics (ROC) analysis identified ability of iELISA to differentiate estrus from non-estrus stages is 86% at cut-off of 30.28 ng/mL ($P < 0.0001$). In conclusion, a potential candidate protein for estrus was identified in buffalo saliva and a proof of concept was developed for development of on-spot tool for accurate identification of estrus/ silent estrus in buffaloes.

Urine fern/crystallization pattern analysis as a easy, non-invasive tool to identify estrus in buffaloes

Fern pattern analysis of buffalo urine collected at different stages of estrous cycle was carried out to find an easy, reliable method for accurate determination of estrus in buffaloes. Urine fern pattern analysis revealed 8 distinct fern patterns during different stages of estrous cycle in buffaloes such as Fir type, branched type, fern type, fir-fern type, and atypical type, small typical fern leaf like, dotted typical fern and typical fern leaf like. Using an arbitrary scale ranging from 0 to 5 for scoring of urine fern patterns indicated overall score of urine



fern pattern varied from 1.8 ± 0.2 , 2.0 ± 0.2 on D-3, D-2 and highest ($P < 0.05$) score was observed on D-1 (3.4 ± 0.3) and at estrus (3.9 ± 0.2) followed by decrease towards +8h (1.8 ± 0.3), +24h (1.4 ± 0.2) after estrus and lowest score was obtained on day +1 (1.1 ± 0.2), +3 (1.0 ± 0.2) and +10 (0.9 ± 0.2) of the estrous cycle in buffaloes. The incidence of typical fern crystallization in urine significantly increases on D-1 and during onset of the estrus. The sensitivity and specificity of urine fern pattern score to determine estrus in buffaloes was high i.e. 93.33% and 83.33%, respectively.

Harnessing Geothermal Energy for Cooling and Heating of Animal Shed

The objective of the study was to develop a animal shed cooling and heating system using geothermal energy. Before making a full system, a pilot study was conducted to decide the depth of the underground pipes. A bore-well of 150 mm diameter and 12 m depth was drilled in the cattle yard of institute. Six numbers of temperature sensing probes (PT-100) were fixed at different depths at 2m, 4m, 6m, 8m, 10m and 12m with the help of a PVC pipe in the bore-well. The sensors were protruding out from the pipe wall and in touch with earth while the connecting wires were being safely contained inside the pipe. These six probes along with two other probes for measuring temperature of earth surface and



Geothermal system installed in animal shed

ambient/open air were connected with the 8-channel digital temperature scanner placed on surface adjacent to bore-well. One other U-shape tube was set with one leg of galvanized iron pipe 35 mm bore and 12 m length for air inlet and other leg of PVC pipe 25 mm bore and 12 m length for air outlet was also lowered down in the bore-well to work as a heat exchanger. It was set to record hourly readings of temperature of all the points in an Excel file in a pen-drive through USB output. The temperature data of every month were recorded and stored in computer on the last day of month. Diurnal variation of UG temperature was found to be negligible 4 m depth and beyond that throughout the year (January- October). Temperature difference between open air/ambient temp and at 4m depth was 9.5°C ($5\text{-}15^{\circ}\text{C}$) during June and 14.4°C ($6\text{-}16^{\circ}\text{C}$) during January month. Therefore, geothermal heat exchanger/pipes were decided to be placed at 3 m depth UG. On the basis of the above results of the pilot study, a trench of ~ 100 feet length, 5 feet width and 10 feet depth was made, the cast iron pipes (10" dia) were buried underground and filled with soil. A small room like structure was also constructed for air collection and for air blower which throw air into the animal shed through a tin pipe channel; the air blower speed was regulated as per need with VFD. Animal shed was also modified for conducting the trial on animals. The air temperature during summer season, after it passed through the system, got reduced by 9.1, 10.98, 9.19 and 8.93°C in April, May, June and July month, respectively. To observe the effectiveness of the system, six buffalo heifers of ~ six months of age in each of experimental (where system air was provided) and control shed (without system's air) was kept. Physiological responses of these heifers were recorded during the trial. It was found that the temperature was lowered by 1.13, 2.52, 2.87 and 0.76°C in April, May, June and July, respectively in the experimental animal shed compared to the control. The results showed that the effect of system's air was significant on reducing the ambient temperature (by $\sim 10^{\circ}\text{C}$) at the outlet of the tin pipe inside the shed. Whereas the effect of that (change of ambient air temperature after air passed through the system) could not be reflected in experimental shed's temperature. That's why the physiological parameters of the buffalo heifers did not show any significant change. The reason behind this was that the curtains which were used to check the temperature loss were not effective. Then the modified curtains were fixed to see the effect on reducing the loss of system's air temperature in the shed.

Faster multiplication of Sahiwal Germplasm through OPU-IVF -Assisted Reproductive Technology

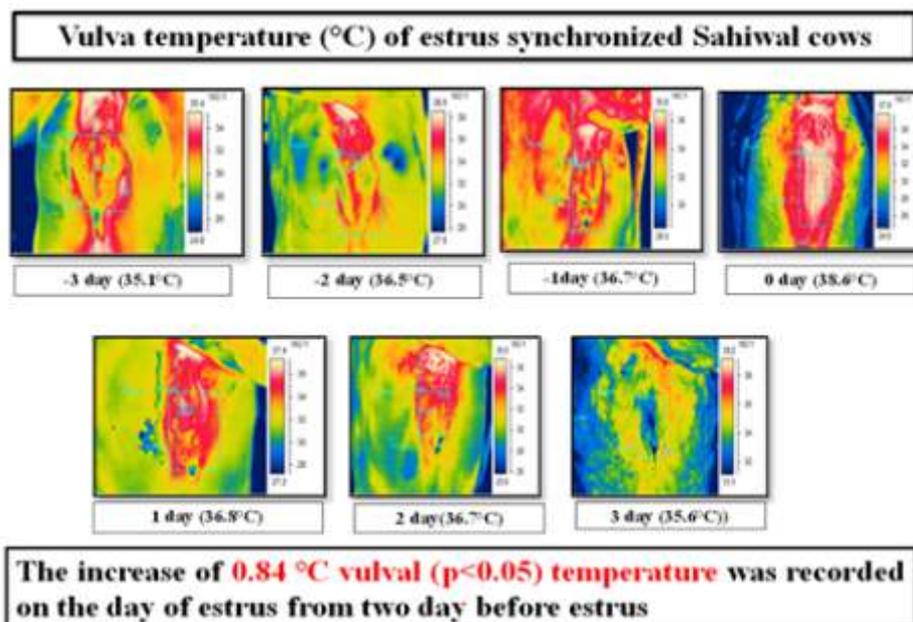
Ten infertile Sahiwal cows with lactation yield of $>3000\text{kg}$ were selected and dewormed and supplemented with vitamins to increase the follicular turn over. Out of these, only 9 animals were used for regular OPU. Initially different size, length and make of needle for follicle puncture was done and found that 18G needle was suitable for better recovery of oocytes. A total of 10 OPU sessions were practiced for oocyte retrieval and

embryo production. A total of 215 oocytes were retrieved. Two protocols followed for oocyte retrieval: with FSH stimulation and without stimulation. Using FSH stimulation, a total of 80 oocytes retrieved per 3 session with average of 27/ animal/ session. Using without FSH stimulation, a total of 112 oocytes retrieved per 10 session with average of 3.3 oocytes/ animal/ OPU session. A total of 40 blastocysts were produced and out of these 18 were transferred and 08 were cryopreserved and one pregnancy has been established.

Monitoring Various Physiopathological Conditions By Infra Red Thermography (IRT) in Dairy Animals for Efficient Management Decision

Estrus Identification in dairy animals using Infrared Thermography

The study was planned to understand the application of Infrared thermography (IRT) for identification of estrus in Sahiwal cows. In the experiment 14 cyclic multiparous animals and 8 cyclic heifers were synchronized by PGF2 protocol and temperature of muzzle, eye, ear, and vulva was monitored by IRT from the day of synchronization to seven days. Estrus was confirmed by ultrasonography, progesterone hormone concentration, cervical mucus fern pattern, and spinbarkeit value. Maximum muzzle, eye, ear and vulva temperature was recorded on the day of estrus. Muzzle and ear temperature showed increase on the day of estrus, followed by decrease after two days of estrus to normal in the estrus synchronized Sahiwal cows. Eye and vulva temperature showed increasing trend two days before estrus, then reached peak on day of estrus followed by decrease to normal after two days of estrus in the estrus synchronized Sahiwal cows. Significant ($p < 0.05$) increase of 0.84°C vulva, 0.35°C ear, 0.56°C eye and 0.62°C muzzle temperature was recorded on the

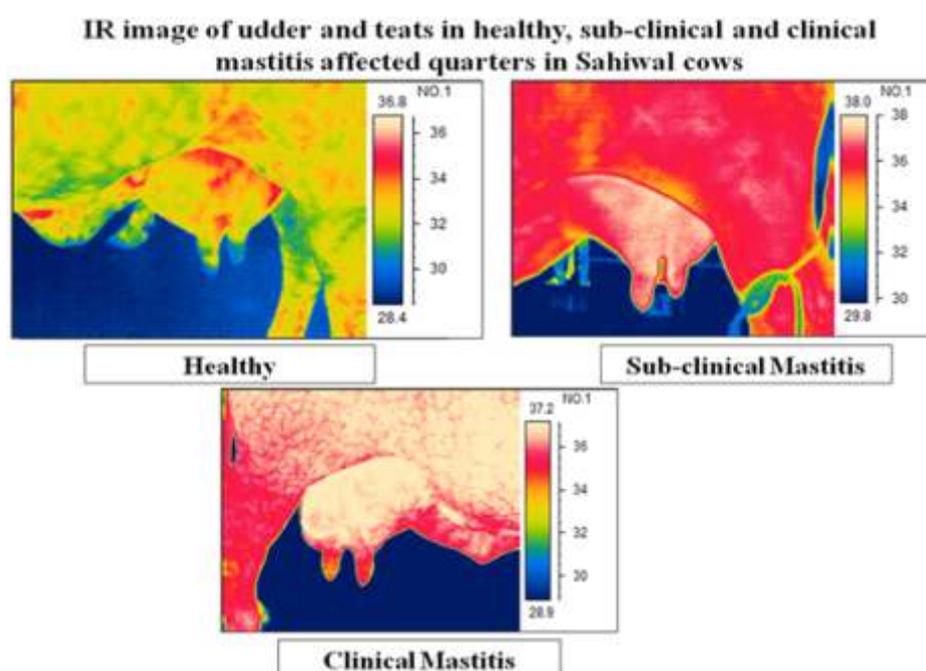


day of estrus from two day before estrus in Sahiwal cows. 70 % and 60% of true positive cases could be identified in estrus with the positive predictive value of 100%, when vulva temperature of $\text{Mean} \pm 0.5\text{SD}$ (36.9°C) and $\text{Mean} \pm 1.0\text{SD}$ (37.47°C), respectively was taken as a threshold. Estrus was confirmed by presence of dominant follicle (13.13 ± 0.39 mm), Fern pattern (54.54% typical fern pattern and 36.36% atypical fern pattern), progesterone concentration (0.31 ± 0.01 ng/ml) and spinbarkeit value (23.50 ± 0.76 cm) on the day of estrus. Therefore, it can be concluded that IRT can be used to monitor increase in vulva temperature during estrus in both cyclic heifers and cyclic multiparous animals with 70 % of true positive estrus events can be identified at threshold of vulva temperature of $\text{Mean} \pm 0.5\text{SD}$ and 60 % of true positive can be identified at threshold of vulva temperature of $\text{Mean} \pm 1.0\text{SD}$ in Sahiwal cows.

Mastitis and Sub-Clinical Mastitis Identification in Dairy Animals using Infrared Thermography

The clinical mastitis can be detected by observing the signs and symptoms visibly but the detection of sub-clinical mastitis is a real challenge when signs and symptoms are not visible and only confirmed by laboratory test. Therefore, the study was planned with an aim to detect the subclinical and clinical mastitis in 120 quarters

in each of lactating Sahiwal cows and Murrah buffaloes using non-invasive Infrared Thermography (IRT). The thermal images of teat and udder were taken during morning and evening hours by using handheld digital infrared thermal camera (DarviDTL007) and the images were analyzed using Darvi TI analysis software provided with the camera. Milk samples were collected after thermal imaging of udder for confirmation of healthy, sub-clinical (SCM) and clinical mastitis (CM) based on somatic cell count (SCC). The samples were further estimated for milk composition (Lactoscan milk analyzer) and macro minerals profiles (atomic absorption spectrophotometer) in Sahiwal cows and Murrah buffaloes. The teat and udder skin surface temperature of lactating Sahiwal cows were significantly higher in SCM and CM affected quarters as compared to healthy quarters, whereas teat skin surface temperature of lactating Murrah buffaloes were significantly higher. The difference in udder surface temperature “between healthy and sub-clinical” and “between healthy and clinical” quarter was 1.00 and 1.23°C in Sahiwal cows, and in teat surface temperature was 1.38 and 1.86°C in Murrah buffaloes. Milk composition such as fat percentage, SNF and lactose in both the breed were significantly decreased and protein, electrical conductivity and pH was significantly increased in clinically affected quarter followed subclinical and lowest in healthy quarters. There was a significant increase of sodium and a significant decrease of potassium, magnesium and calcium level of mastitic milk of Sahiwal cows and Murrah buffaloes. In view of the above results, Infrared thermography can be used for identification of sub-clinical mastitis in Sahiwal cows and Murrah buffaloes.



Strengthening Dairy Based Integrated Farming System for Optimal Resource Utilization

The dairy production tends to be more complex than crop production due to the immense role is animals in the overall farming system. Any constraint imposed on animal may also restrict the system as a whole. In general, the aims of dairy production in integrated farming systems are to (i) raise productivity through better utilization of available resources (ii) recycling and reuse of farm waste within the system, and (iv) optimize the allocation of resources through rational management. Keeping these facts in view, the project on dairy based integrated farming system was laid on an area of 1.00 ha with different sub-components viz., crop production (0.4 ha), fodder production (0.4 ha), dairy production (cattle-3; buffalo-3, goats-20), poultry farming (20 birds), fish pond and vermin-compost pits (0.1ha). The potentially important technologies that could make a significant increase in productivity in IFS are implemented. Since the supply of green fodder throughout the year was a major challenge, hence emphasis was given on production of quality greed fodder and feeding strategies for dairy animals.

In 0.4 ha area Hybrid Napier- Moringa intercrop-based fodder production systems being developed for round the year fodder availability. About 30 percent of the allocated area is covered under perennial fodder crops (Hybrid Napier and Moringa) and rest of the area (70%) under annual fodder crops like maize+cow pea in summer, cowpea in rainy season and berseem will be shown during winter season as intercrop between moringa and napier rows. The mean green fodder yield of 671.18 q/ha with dry matter yield of 140.05 q/ha was recorded from the system.

Table : Average yield and production of food and fodder crops

Enterprises	Crops	Season	Area (ha)	Yield (kg)			
				Grain	Straw	Green fodder	Dry fodder
Food	Wheat	Rabi	0.40	2115.00	2527.50	-	-
	Paddy	Kharif	0.40	1872.50	2688.50	-	-
Fodder	Berseem+ Mustard	Rabi	0.15	-	-	11392.50	2171.41
	Maize+ Cowpea	Summer	0.25	-	-	12362.50	2899.01
	Oat	Rabi	0.10	-	-	6634.00	1857.52
	Napier	Perennial	0.15	-	-	27585.00	5315.63
	Moringa	Perennial	0.10	-	-	9144.00	1762.05
Total		0.90	3987.50	5216.00	67118.00	14005.61	

The animals (three Sahiwal cattle, three Murrah buffaloes and 20 Barbari goats) are maintained on fodder available from the system under cut and carry system. The total milk yield of 5620 liters from cattle, 6120 liters from buffaloes and 117 liters from goats is recorded with C: B Ratio of 1.31, 1.46 and 1.43, respectively.

Table . Total and average milk yield of dairy animals

Details	Cattle (n=3)	Buffalo (n=3)	Goat (n=10)
Total Milk yield (kg)	5620.0	6120.0	1156.9
Average milk/day/animals	6.24kg	6.80kg	0.77kg

Table : System productivity, profitability and employment generation of dairy-based IFS at on-station

Enterprises	Cost of cultivation (Rs.)	Gross Return (Rs.)	Net Return (Rs.)	% share in Net Return	B:C ratio	Employment (Mandays)
Food	46128.10	101844.75	55716.50	15.32	2.20	40.00
Fodder	66154.28	129233.25	63078.97	17.35	1.95	84.00
Dairy	495787.50	694412.85	198625.35	54.63	1.40	310.00
Subsidiary	33396.00	79570.00	46174.00	12.70	2.38	40.00
Total	641465.88	1005060.85	363594.82	100.00	1.57	474.00

The net return of Rs. 3,63,595/- was generated during the period under report from the dairy based IFS. The contribution of dairy enterprise was 54.63 %, whereas food crops, fodder crops and subsidiary enterprises contributed 15.32, 17.35 and 12.70 %, respectively to the net income. The results suggest that dairy based IFS model not only increased the production and profitability but also ensured the food and nutritional security through regular supply of milk and eggs round the year and also provided employment to the farm families, and has potential to increase resource use efficiency and overall resilience of the production system.



Napier grass+ Cowpea and Moringa



Napier grass+ Berseem



Harvesting of fish



Natural scavenging by birds



Wallowing of buffaloes



Sahiwal cows

Effect of Supplementation of *Moringa Oleifera* Leaf Meal and Herbal Galactogogues on Production, Reproduction and Immunity of Sahiwal Cows

The present study was carried out to assess the effect of supplementation of *Moringa oleifera* leaf meal and herbal galactogogues on production, reproduction and immunity of Sahiwal cows. Twenty-four lactating Sahiwal cows were selected from LRC for the study for a period of 150 days post-partum in each cow. Experimental cows were randomly divided in four treatments consisting of six cows each. T_c considered as control (without any supplementation), T_M supplemented with *Moringa oleifera* leaf meal (MOLM) @12% of concentrate, T_{HG} supplemented with @60g/day/cow herbal galactogogues mixture containing shatavari, fenugreek and jivanti in the ratio of 1:1:1 and T_{MIX} supplemented combination of herbal galactogogues @60g/day/cow and MOLM @12% of concentrate. The results revealed adequate amounts of crude protein (22.69%) in *Moringa oleifera* leaf meal. Moreover, shatavari, fenugreek and jivanti had 6.55, 22.66, 16.58 % CP. Besides, significant ($P \leq 0.05$) improvements were recorded on nutrients utilization in T_M , T_{HG} , T_{MIX} than T_c . Whereas, DM intake, body weight and metabolic body weight of experimental animals were not affected following supplementation. Significant ($P \leq 0.05$) improvements were also noted on daily milk yield, total solids, fat per cent, 4% FCM and ECM yield in T_M , T_{HG} , T_{MIX} than T_c . Furthermore, milk SCC reduced significantly ($P \leq 0.05$) in T_M than T_c . As well as, SFA's in milk were significantly ($P \leq 0.05$) reduced while UFA's were significantly ($P \leq 0.05$) improved in T_{MIX} and T_M than T_c . Blood plasma profile including total plasma immunoglobulins, albumin, glucose were improved significantly ($P \leq 0.05$) in T_M , T_{HG} , T_{MIX} than T_c . Besides, reproductive parameters were significantly ($P \leq 0.05$) better in T_M , T_{HG} , T_{MIX} than T_c . In addition reproductive disease incidence reduced better in T_M , T_{HG} , T_{MIX} than T_c . At last, higher net return (₹) was noted in T_M (301.18), T_{MIX} (268.70), T_{HG} (231.04) than T_c (213.06). The benefit: cost ratio was also higher in T_M (3.31), and T_{MIX} (2.87) than T_c (2.81). Reproductive efficiency was improved as a result of percent reduction in total cost per cow per successful service by 15.77, 0.33 and 2.97, respectively in T_M , T_{HG} , T_{MIX} than T_c . It can be concluded that dietary inclusion of *M. oleifera* and herbal galactogogue alone and combination improved production and reproduction performance of Sahiwal cows. Inclusion of *Moringa oleifera* and herbal galactogogues not only enhanced immunity but also reduces disease incidence. These results suggest that dietary incorporation of *M. oleifera* leaf meal improves the performance of Sahiwal cows, and is economically feasible, hence, can be recommended to dairy farmers to generate maximum income.

Effect of Supplementation of *Moringa Oleifera* Leaf Meal on Nutrient Utilization, Immunity and Production Performance of Barbari Goats

Goat rearing is proved to be a very fast growing, high demanding emerging business. To sustain the consumers' demand and need, the production need to be increased both in quantity and quality. Low quality fodder/hay used by the farmers couldn't meet the nutrients requirement which eventually leads to low digestibility and performance. Tree foliage, usually has high nitrogen and minerals content, and can serve as a supplement, increasing dietary protein levels, improving the intake and digestibility of the food ingested. Keeping this in view, the present study was conducted on Barbari goats. The goats were supplemented with *Moringa oleifera* for a period of 180 days to study the effect of supplementation on nutrient utilisation, blood parameters, production performances and economics. The goats were divided into two groups of five animals in each, namely control and treatment. The control group was fed with concentrate mixture and hybrid napier (CO₃) as per ICAR requirements and the treatment group was supplied with 50% of concentrate mixture replaced by *M. oleifera* leaf meal on dry matter basis with hybrid napier. DM, OM, CP and NDF digestibility coefficients were increased significantly ($P < 0.05$) in treatment group (64.66, 71.62, 70.61 and 58.47, respectively). But there were no changes in EE and ADF digestibility between the two groups. Nitrogen balance (g/d) was found to be significantly higher ($P < 0.05$) in treatment group compared to control group. All the hematological parameters (Hb%, PCV, RBCs) showed significant improvement in treatment group compared to control except WBCs and DLC, though numerically WBCs found to be higher in treatment group. All the hematological values were within the normal range of goats. Plasma glucose (mg/dl), total protein (g/d), albumin (g/d), globulin (g/d) levels were found similar between two groups and are under normal range. Blood urea Nitrogen was higher ($P < 0.05$) in treatment group (45.48 mg/dl) compared to control group, though the value found is within the normal range for goats. Blood IgG1 value found to be significantly higher ($P < 0.05$) in treatment group compared to control (11.28 mg/dl). There was no effect in the blood mineral profile with the replacement of concentrate with *M. oleifera* leaf meal. The significant increase ($P < 0.05$) in body weight (kg) in the treatment group was recorded compared to control group (20.94 vs. 22.57). DMI % BW was significantly higher in treatment than control group. Significant higher average milk yield (kg/day) was recorded in treatment group compared to control group. All the milk composition parameters (fat%, protein%, lactose% and SNF%) were found to be significantly higher ($P < 0.05$) in treatment group than control. The BCR found to be better for the treatment group than the control group (2.18 vs. 2.90). On the basis of above results, it may be concluded that replacing 50% of concentrate mixture with *M. oleifera* improves the nutrient utilization, hematological parameters and also increases the production performances with good economic returns.

Feeding of Zinc and Iron Biofortified Wheat Straw-Based Ration on Production Performance of Lactating Murrah Buffaloes

The study was conducted to compare the feeding of biofortified wheat straw (WB 02 variety) with conventional wheat straw on quantity and quality of milk of Murrah buffaloes. Buffaloes were divided randomly in to two groups i.e. Control (T₀) and Treatment (T₁) with 6 animals in each group. Feeding was done as per ICAR (2013) standard for a period of 90 days including 7 days digestibility trial. Control group was fed conventional wheat straw, green fodder and concentrate mixture in the ratio 50:15:35 (on DM basis), respectively. Treatment group was fed biofortified wheat straw, green fodder and concentrate mixture in the same ratio. Proximate analysis showed minor differences between biofortified and conventional wheat straw; however organic matter was lower in biofortified straw (85.88% vs 89.74%). There was no significant difference ($P > 0.05$) among both the groups for daily dry matter intake (T₀: 15.70 ± 0.17 Kg/day/animal vs T₁: 15.75 ± 0.12 Kg/day/animal). Digestibility of DM, CP, EE, NDF, ADF, OM did not differ significantly ($P > 0.05$) between groups. However, means for digestibility of all nutrients except OM were higher in case of biofortified straw. The daily milk yield was also comparable and no significant difference ($P > 0.05$) between the two groups (T₀: 7.65 ± 0.1 Kg/day/animal vs T₁: 7.75 ± 0.08 Kg/day/animal) were observed. Similarly, there was no significant difference ($P > 0.05$) found in SCC and composition of milk (Fat, SNF, Lactose, Protein). Haematological analysis (Hb, PCV, TEC, TLC and DLC) carried out at monthly interval and revealed no significant difference ($P > 0.05$) among two groups.

Livestock-crop Based Technological Interventions for Empowerment of Scheduled Caste Farmers in Selected Districts of Himachal Pradesh, Uttarakhand and Haryana

The creation of livelihood opportunities through farm-based crop-livestock activities and skill development are crucial for empowerment of scheduled caste farmers. Keeping this in view, the present project is taken to improve the existing knowledge and skill in agriculture-based activities of targeted SC farm families.

Table : Selection of beneficiaries for technological interventions

State	District	Block	Villages
Haryana	Yamunanagar	Mustafabad	Panjauri, Mali Majra
Himachal Pradesh	Sirmaur	Paonta Sahib	Patlion
Uttarakhand	Paure Garhwal	Yamkeshwar	Talla Banas

Focused group discussions (FGD) were conducted at each site in the selected villages to identify the resource base, crop and livestock production systems, constraints and problems faced by the SC farmers, and technological solutions to address the problems. Based on need, following technological inputs were provided to the SC farm families under various interventions in selected villages.

The seeds of improved varieties of wheat and paddy were provided to SC farmers along with package of practice for demonstration. The performance of improved wheat varieties was evaluated.

Table : Technological inputs provided to the SC farmers

• Inputs support (Multi-nutrient feed block)	No	280
	Kg	560
• Improved germplasm (Alpine X Beetal Goats)	No	06
• Trainings, demonstration, skill development and capacity building of scientific animal husbandry and poultry rearing (including exposure visits etc)	No of farmers	205
• Preventive health care / medicine kits	No	300
• Inputs support to dairy farmers (mineral mixture, quality seeds, vegetable kits, etc)	No	260
	Kg	6000
• Seed storage bins	No	100

The average grain yield of prevailing wheat varieties (HD 1605 and PBW 343) in the selected area was 4415 kg/ha whereas all the demonstrated varieties produced more yield ranging from 19.71 to 24.24%

Pb1718 developed by the ICAR-IARI and release in 2017, draws its parentage from the widely grown Pusa 1121, has been endowed with two extra genes to fight the bacterial leaf blight disease, thus preventing lodging, besides increasing the yield. PB1718 is gradually being accepted by farmers across Haryana - the key aromatic and long-grain rice-producing region of the country. Farmers reported that the yield has increased to around 23-24 quintals per acre, as against around 18-19 quintals for the widely grown PB 1509.

Table : Performance of wheat varieties at farmers' field

Item	Variety demonstrated			Prevailing Varieties HD 1605 & PBW343
	DBW-222	HD-2967	HD-3226	
No of demonstrations	46	56	45	45
Area (Ha)	20	10	20	20
Yield recorded (kg ha-1)	5285	5730	5828	4415
% Increase over local	19.71	29.78	24.24	--
Yield potential (kg ha-1)	8210	6920	7960	-
Yield gap (kg ha-1)	2925	1190	2132	-

Table : Performance of paddy varieties at farmers' field

Item	Variety demonstrated		
	PB 1718	PB 1509	Local Bashmati
No of demonstrations	50	60	20
Area (Ha)	16	20	10
Yield recorded (kg ha-1)	5750	4625	3550
% Increase over local	38.26	23.24	--
Yield potential (kg ha-1)	6000	5500	-
Yield gap (kg ha-1)	250	875	-

Table : Performance of fodder crops at farmers field

Fodder crop	Qty	Farmers	Area,ha	Yield
Berseem: BL-42	200	105	10	80-100t/ha
Oat: Kent	100	47		185-195 q/ha

Minerals are micro-nutrients which play many important roles in immunity, cellular functions, growth and other productive and reproductive functions in animal system. As minerals are mostly deficient in soil vis-à-vis in feeds/ fodders, animals are also deficient in these minerals. Results of focused group discussion and field survey revealed that farmers used a variety of ingredients for feeding their dairy animals. They used concentrate mixture with available ingredients and very few respondents purchased compound feed from market due to high cost. Chemical composition of the ingredients suggested that values were well within reported range. Only few farmers used common salt or mineral mixture to their animals, due to unawareness of importance of these micronutrients. Therefore, the supplementations of mineral mixture @ 50 g/day /animal were demonstrated to the dairy farmers. Fifty farmers having at least two lactating animals were selected for the study. The preliminary results revealed an increase of about 400 - 950 g/d/animal in milk yield (15-20%) due to supplementation of mineral mixture in cattle and buffaloes.

Table : Demonstration of mineral mixture

Technology demonstrated	Qty, kg	Nos	Result
Mineral Mixture (Chelated)	52	47	Focused group discussion with farmers revealed that an increase of 15-20 per cent in milk production of cattle and buffaloes were observed due to supplementary feeding of mineral mixture after deworming with albendazole
Mineral Mixture (Normal)	403	91	
Albendazole (Bolus)	136	87	
Piperazine (30ml)	104	66	

Capacity building and farmer- scientist interactions: The various capacity building programmes conducted under the SCSP projects given as below.

Name of the program	Date	Place	No of beneficiaries
Training program for unemployed SC youth on 'Artificial Insemination'	August 2 to September 15, 2021	Northern Regional Demonstration & Training Centre, National Dairy Development Board Jalandhar, Punjab	Fourteen unemployed SC youth trained on various aspects of artificial insemination
Farmer-scientist meet	August 13, 2021	Malimajra and Pinajuri, Mustafabad, Yamunanagar	Hundred seed storage bins for storage of the seeds, 650 kg mineral mixture, and dewormer for 350 cattle and buffaloes, and 100 calves were given to the farmers
Veterinary health camp	October 22, 2021	Talla-Banas, Yamkeshwar, Pauri Garhwal	distributed the general-purpose veterinary medicine kit, seeds, vegetable kits, mineral mixture, etc.
Kisan Goshti	October 23, 2021	Gomukh Gaushala	distributed the seed, vegetable kits, bucks, general purpose veterinary medicine kit, mineral mixture, etc. to the identified farmers under the project
Farmer-Scientist Interaction	November 3, 2021	Malimajra, Mustafabad, Yamunanagar	Improved seed of wheat (30 quintal) varieties: DW 187 and HD 3226, Oat: Kent (3 quintal) and Berseem BL 42 (30 kg) and vegetable kits (50) were distributed to 105 scheduled caste farmers/farm women for sowing during rabi season.
Farmer-Scientist Interaction	November 10, 2021	Patlion, Paonta Saheb, Sirmore	Eight quintal improved seed of wheat (DW 187 and HD 3226), were distributed to 15 SC farmers, 100 kg seed of oat to 8 farmers and 10 kg seed of berseem to 10 farmers for demonstration. Vegetable kits were also provided to 30 scheduled caste women for kitchen garden to improve their nutritional security.
Capacity building of SC farm women on Value addition of milk	November 29, 2021	Pinjauri and Malimajra, Yamunanagar	100 SC women and 25 SC male farmers

Prophylactic Use of Kitchen Herbs Against Pathogenic *E coli* Causing Calf Diarrhoea

The incidence of calf diarrhoea is very frequent during the first few weeks of life where *Escherichia coli* easily colonize in duodenum, jejunum and ileum. The problem has been catered by the use of antibiotics but there is the growing concern of antimicrobial resistance (AMR) in livestock therefore, the study is made to find out the importance of these easily available kitchen herbs (Cinnamon, Turmeric and Carom seeds) as prophylaxis against calf diarrhoea. Baseline study made at NDRI, ERS, Kalyani and the surrounding villages of Nadia district reports that 58% of the calves suffering from diarrhoea were aged within 30 days. The virulent genes recovered from *E coli* isolates from calf diarrhoea were *st*, *lt*, *eaeA*, *stx1* and *stx2* where prevalence of *st* was highest (37%) followed by *eaeA* (23%). The incidence of antibiotic resistance was highest for Amoxicillin/Clauvalinic (AMC) > Ampicillin (AMP) > Cefepime (CPM) > Cefuroxime (CXM). Preliminary studies made also threw light in the occurrence of Extended Spectrum Beta Lactamase (ctx-M, OXA, SHV and TEM) enzymes in these isolates.

Addition of kitchen based herb mix @ 1% in combination with probiotics (*L fermentum* NCDC605 and *L rhamnosus* NCDC610 @ 10^{10} cfu/ml) in a litre of milk inhibited the growth of pathogenic *E coli*. Also the herbal formulation fed to the calves showed no signs of milk refusal and USG study of the abomasums clearly predicted normal coagulation of milk with gastric emptying between 4 to 5 hrs in calves within one month of age.

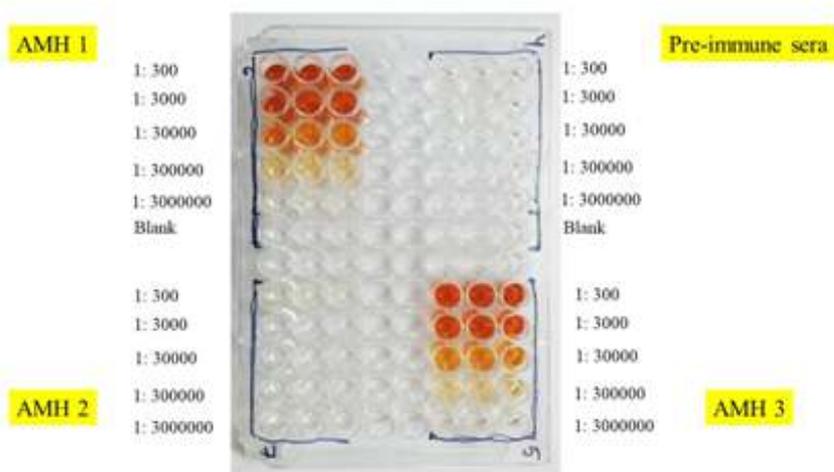


ANIMAL FERTILITY, REPRODUCTION AND DIAGNOSTICS

Development of ELISA for Estimation of Bovine Anti-Mullerian Hormone Using Epitope Specific Antibody

Anti-Mullerian Hormone (AMH) is a direct indicator of ovarian reserve and a promising biomarker of fertility in domestic animals. It is a dimeric glycoprotein and a member of the transforming growth factor (TGF- β) family of growth and differentiation factors. A suitable bovine AMH assay was developed and validated using epitope specific antibodies and to estimate the basal level of AMH in indigenous cows in different age groups. For this purpose, three linear B cell epitope were predicted and synthesized three peptides. The peptides were conjugated to Keyhole limpet hemocyanin (KLH) and emulsified with FCA (Freund's Complete Adjuvant) or FIA (Freund's Incomplete Adjuvant). Nine female rabbits of three months of age were selected and 250 μ g of peptides were administered in the rabbits (n=3) through subcutaneous route with a volume of 0.5 ml (day 0, 14, 28, 42). After final dose, we collected sera, determined antibody titer, purified it and conjugated with HRP. A good titer was observed for AMH 1 and AMH 3 peptides but not in AMH 2. The purified Ig G antibody concentration in serum was found to be 8.005 mg/ml and 10.7725 mg/ml for peptide 1 and 3 group respectively. The antibodies were used for development of direct, competitive and sandwich ELISA. Among three ELISA sandwich was found to be the best and selected for further study. The assay was highly specific as it did not bind with AMH-related members and with non-related members.

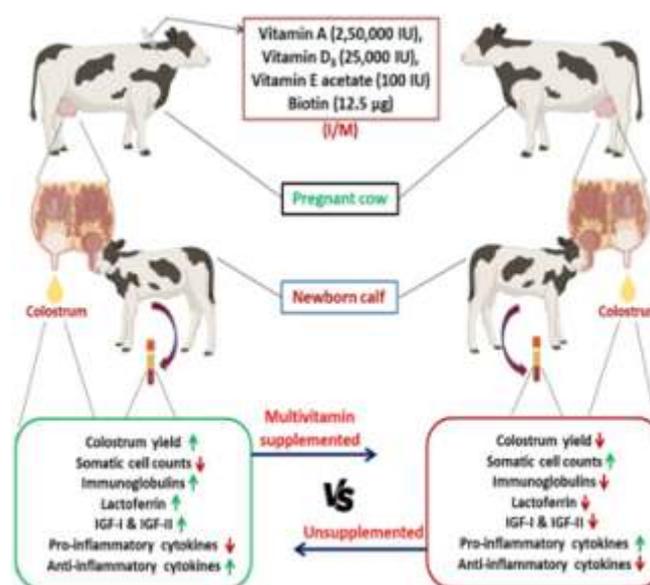
The sensitivity of direct and competitive ELISA was 50 pg/ml and for the sandwich ELISA was 5.0 pg/ml. The intra-assay CV was <6% and the inter-assay CV was <9%. The average recovery percentages were found to be within 88-100%. LLOQ was found to be 5 pg/ml and ULOQ at 50 μ g/ml (CV < 20%). Blood samples (5 ml) were collected from Sahiwal and Tharparkar cattle of 0-10 years of age for standardizing the level of AMH. The concentration of AMH changes with progression of age in both the breeds (p<0.001) but no difference was observed between the breeds. The minimum AMH level was found in 0 to six months of age for both the breeds. Afterwards it increased significantly (p<0.05) and reaches a peak value between 1.5-2.5 years. After attaining the peak value, the level of AMH remained nearly same up to about eight years of age (p>0.05) with slight fluctuations. Thereafter it decreased progressively and reached lowest value at ten years of age. In conclusion, we developed a new highly sensitive ELISA against bAMH using epitope specific antibodies and performed age specific characterization of bAMH in Sahiwal and Tharparkar breeds for the first time.



Indirect ELISA with different AMH antibodies and pre-immune sera

Modulating Cellular Immunity of Cow Colostrum and Milk

To study the effect of various trace elements and vitamins during transition period. Twenty four multiparous pregnant Karan Fries cows in their late gestation were taken and divided into four groups of six each. Group 1 served as control, group 2 was injected with multivitamins (A, B3, E, B Complex), Group 3 was injected with multi minerals; Copper 15mg/ml (total 5 ml, weekly 75mg/week/animal), Zinc (40mg/ml), Selenium (5 mg/ml) and Manganese (10mg/ml). In group four combination of both multivitamins and multi minerals as given to group 3 and 4 were injected respectively. Supplementation of micronutrients significantly ($P < 0.05$) increased the colostrum yield, viability and percentage macrophages in the colostrum of supplemented cows. Colostrum SCC of cows and plasma cortisol in calves were significantly ($P < 0.05$) low in supplemented groups. Lactoferrin, IGF and Anti-inflammatory cytokines were also found to be higher in the supplemented groups. Maximum beneficial effect was observed in the combination group of multi vitamins and multiminerals.



Generation of Milk Somatic Cell Reference Values and Intelligent Predictive Modelling for Monitoring Mammary Profile and Milk Quality of Indigenous Dairy Animals (DBT Project)

Milk sampling was done from 250 Karan Fries cows, 125 Sahiwal cows, 150 goats and 32 buffaloes from farm and field conditions. Samples were screened for milk somatic cells and milk composition. Somatic cells have been isolated and kept for further analysis.

Breeding Bull Fertility Prediction: Identification of Panel of Fertility Associated Sperm Transcripts

Crossbred bulls produced by crossing *Bos taurus* and *Bos indicus* suffer with high incidence of infertility/sub-fertility problems, however, the aetiology remains poorly understood. Therefore, the global differential gene expression between high- and low-fertile crossbred bull sperm was assessed using a high throughput RNA sequencing technique with the aim to identify transcripts associated with crossbred bull fertility. Crossbred bull sperm contained transcripts for 13,563 genes, in which 2093 were unique to high-fertile and 5454 were unique to low-fertile bulls. After normalization of data, a total of 776 transcripts were detected, in which 84 and 168 transcripts were unique to high-fertile and low-fertile bulls, respectively. A total of 176 transcripts were upregulated (fold change > 1) and 209 were down regulated (< 1) in low-fertile bulls. Gene ontology analysis identified that the sperm transcripts involved in the oxidative phosphorylation pathway and biological process such as multicellular organism development, spermatogenesis, in-utero embryonic development were downregulated in low-fertile crossbred bull sperm. Sperm transcripts upregulated and unique to low fertile bulls were majorly involved in translation (biological process) and ribosomal pathway. Using RT-qPCR, selected sperm transcripts were validated in crossbred bulls with different fertility ratings and found that the transcriptional abundance of ZNF706, CRISP2, TNP2 and TNP1 genes was significantly ($p < 0.05$) lower in low-fertile bulls than high-fertile bulls and were positively ($p < 0.05$) correlated with conception rate. It is inferred that impaired oxidative phosphorylation could be the predominant reason for low-fertility in crossbred bulls and transcriptional abundance of ZNF706, CRISP2, TNP2 and TNP1 genes could serve as potential biomarkers for fertility in crossbred bulls.

Fertility Associated SNPs in Crossbred Bull Spermatozoa for Bull Fertility Prediction

Spermatozoa from high- (HF) and low-fertile (LF) breeding bulls were subjected to high throughput Next-generation sequencing to identify important Single nucleotide polymorphisms (SNPs) and novel variants associated with fertility. A total of 7,7036 genome wide SNPs were identified in the crossbred bull spermatozoa with a minimum read depth of 20, and among them, 10,269 were observed to be novel variants. A total of 42,290 and 34,748 variants were recorded in HF and LF bulls respectively, among which 6115 and

4673 were found to be novel in respective group. Higher number of SNPs were identified in HF compared to LF bulls. GO analysis of filtered genes with significant variation in HF bulls indicated their involvement in various important pathways like oxidative phosphorylation and metabolic pathways. On the other hand, GO analysis of filtered genes with significant variation in LF bulls revealed their involvement in Ca^{2+} ion binding, structural constituent of ribosome, and biological processes like translation and ribosomal small subunit assembly. SNPs were identified in candidate genes including TPT1, BOLA-DRA, CD74, RPS17, RPS28, RPS29, RPL14, RPL13 and RPS27A, which are linked to sperm functionality, survival, protection from oxidative stress and bull fertility. The identified SNPs could be used as a tool for identification and selection of bulls for high fertility and the variation in these genes could be established an explanation for the fertility differences in bulls upon validation in large number of bulls.

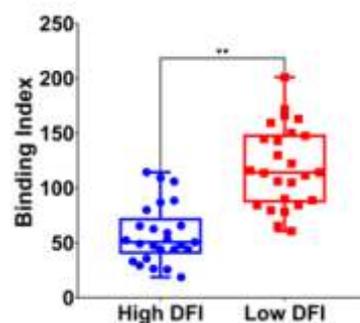


SNPs Variations and Altered Pathways Associated with Poor Semen Quality in Breeding Bulls

High throughput RNAseq analysis of spermatozoa was performed to identify the SNPs present in good and poor-quality semen producing bulls (n=6 each). A total of 21360 and 44650 SNPs were identified in good and poor-quality semen with a minimum read depth of 20, among which 4780 and 8710 novel variants were observed in good and poor-quality semen, respectively. Greater SNPs and indels variations were observed in poor compared to good quality semen. In poor quality semen, SNP variations were observed in ZNF280B, SLC26A2, DMXL1, OR52A1, MACROD2 and REV1 genes, which are associated with regulation of spermatogenesis, post-testicular maturation, Cl^- channel activity, V-ATPase-mediated intracellular vesicle acidification, a mono-ADP-ribosyl hydrolase and ATR-Chk1 checkpoint activation. GO analysis of filtered genes with significant variations between good and poor quality semen showed enrichment in important pathways related to semen quality such as MAPK signalling pathway, Akt signalling pathway, focal adhesion, cAMP signalling pathway, and Rap1 signalling pathway. Network analysis of filtered genes in poor quality semen showed variations in pathways of purine metabolism, pyrimidine metabolism, prolactin signalling pathway and RNA cap binding complex. It is inferred that SNP in genes involved in maintaining sperm functions could be the reason for poor quality semen production in bulls, and the identified SNPs holds potential to be used as biomarkers for semen quality in bulls.

Spermatozoa with High DNA Fragmentation Index Possess Altered Phenotypic Characteristics and Oviduct Binding Ability

In vitro oviduct explants model was for cattle and assessed the oviduct explants binding ability and phenotypic characteristics of spermatozoa obtained from breeding bulls with high- and low-sperm DNA fragmentation index (%DFI). Cryopreserved spermatozoa from Holstein Friesian crossbred breeding bulls with known field fertility were assessed for %DFI and were classified into either high %DFI or low %DFI category. Flow cytometry was used to assess sperm membrane integrity, acrosome reaction status, mitochondrial membrane potential and intracellular calcium concentrations. It was found that spermatozoa from bulls with low %DFI had significantly higher ($P < 0.05$) membrane integrity, acrosome intactness, and mitochondrial membrane potential. To assess the sperm oviduct binding ability, oviduct explants were prepared by incubating the



oviduct cells overnight in TCM-199 medium at 38.5°C under 5% CO₂. Different sperm concentrations and time of incubation was evaluated and found that 2 million spermatozoa and 1-hour incubation yielded high binding index (BI). The BI was also significantly ($P < 0.01$) higher (> 2 times) in the bulls with low-DFI as compared to high DFI bulls. The correlation between binding index and DFI was negative and significant ($r = -.528$; $P < 0.05$). Further, the binding index was positively correlated with conception rate ($r = .703$), intact sperm membrane ($r = .631$), mitochondrial membrane potential ($r = .609$). It is inferred that sperm phenotypic characteristics and oviduct binding ability are impaired in breeding bulls with high sperm DFI%, which might be associated with low conception rates in these bulls.

Spermatogenic Cells Proteins for Early Selection of Superior Bulls

A study was carried out to compare the proteomic profiles of spermatogenic cells of crossbred and zebu cattle in an effort to understand the possible reasons for higher incidence of sub-fertility in crossbred bulls. The spermatogenic cells collected from the testes of pre-pubertal and adult crossbred and zebu males through fine needle aspiration were propagated *in vitro* and proteomic profiling was done using shotgun proteomics approach. Multiple combinations were tried to study the age- and species-specific variations in the expression level of proteins. Among those proteins differentially expressed in spermatogenic cells of pre-pubertal as well as adult zebu and crossbred bulls, 40 proteins were found differentially expressed with ≥ 2 -fold change. Similar expression trend was observed for 20 proteins in both of the age groups. In spermatogenic cells of zebu, 13 proteins were upregulated while 7 proteins were downregulated compared to crossbred bulls. Among the upregulated proteins were RPLP2, PAXIP1, calumenin, prosaposin, GTF2F1, TMP2, ubiquitin conjugation factor E4A, COL1A2, vimentin, protein FAM13A, peripherin, GFPT2 and GRP78. Seven protein which were downregulated in zebu bulls compared to crossbred included APOA1, G patch domain containing protein 1, NAD P transhydrogenase mitochondrial, glutamyl aminopeptidase, synaptojanin 1 fragment, Arf GAP with SH3 domain ANK repeat and PH domain containing protein 1 and protein transport protein sec16B. It was inferred that the proteins associated with sperm function and fertilization process, such as calumenin, prosaposin, vimentin, GRP78 and APOA1 could be studied further to understand the precise cause of subfertility in crossbred bulls.

Aberrations in Fatty Acid Synthesis and Ketone Body Degradations in Semen Associated with Astheno-oligozoospermic in Bulls

Asthenozoospermia (reduced sperm motility) and oligozoospermia (reduced sperm concentration) are the two important reasons cited for idiopathic infertility in crossbred bulls. In this study, using non-targeted LC-MS/MS based approach, we carried out deep metabolomic analysis of spermatozoa and seminal plasma derived from normozoospermic and astheno-oligozoospermic bulls. Using bioinformatics tools, alterations in metabolites and metabolic pathways between normozoospermia and astheno-oligozoospermia were elucidated. A total of 299 and 167 metabolites in spermatozoa, and 183 and 147 metabolites in seminal plasma were detected in astheno-oligozoospermic and normozoospermic bulls, respectively. Among the mapped metabolites, 75 sperm metabolites were common to both the groups while 166 and 50 sperm metabolites were unique to astheno-oligozoospermic and normozoospermic bulls, respectively. Similarly, 86 metabolites were common to both the groups, while 45 and 37 seminal plasma metabolites were unique to astheno-oligozoospermic and normozoospermic bulls, respectively. Among the differentially expressed metabolites, 62 sperm metabolites and 56 seminal plasma metabolites were significantly dysregulated in astheno-oligozoospermic bulls. In spermatozoa, Selenocystine, Deoxyuridine triphosphate and Nitroprusside showed significant enrichment in astheno-oligozoospermic bulls. In seminal plasma, Malonic acid, 5-Diphosphoinositol pentakisphosphate, D-Cysteine and NADP were significantly up-regulated while Tetradecanoyl-CoA was significantly down-regulated in the astheno-oligozoospermia. Spermatozoa from astheno-oligozoospermic bulls showed alterations in metabolism of fatty acid and fatty acid elongation in mitochondria pathways while seminal plasma from astheno-oligozoospermic bulls showed alterations in synthesis and degradation of ketone bodies, Pyruvate metabolism and Inositol phosphate metabolism pathways. It is inferred that fatty acid synthesis and ketone body degradations are altered in the spermatozoa and seminal plasma of astheno-oligozoospermic crossbred bulls. These results open up new avenues for further research and current findings can be applied for modulation of identified pathways to restore the sperm motility and concentration in astheno-oligozoospermic bulls.

Anti-Müllerian Hormone as an Endocrine Biomarker of Reproductive Longevity

Anti-Müllerian hormone as an endocrine biomarker of reproductive longevity and assessment of Single Nucleotide Polymorphisms in AMH gene of *Bos indicus* breeds of Malnad Gidda, Hallikar and Amritmahal cattle: Unique SSCP patterns with different mobility shifts namely pattern A, B and C were observed in Amritmahal, Hallikar, and Malnad Gidda cattle for AMH gene and identified SNP in Exon 5, (position: 21402788) A > G resulted in amino acid change Glutamine (Q) to Arginine (R). The AMH levels decreased with the increasing age and AMH concentration analysis could be considered as a reliable biomarker to assess reproductive efficiency and longevity in *Bos indicus* breeds, this would assist in making suitable decision for herd longevity and implementation of ART to harvest their genetic potential. However, large scale study with defined population at different age groups and precise reproductive data/ status is warranted.

Single Nucleotide Polymorphisms of LHCGR, FSHR, and LEP Genes in Malnad Gidda, Amritmahal and Hallikar Breeds of Cattle

Bos indicus breeds of cattle viz., Malnad Gidda (n=120), Amritmahal (n=80) and Hallikar (n=22) were screened for SNPs in bovine luteinizing hormone choriogonadotropin receptor (LHCGR), follicle stimulating hormone receptor (FSHR), and leptin (LEP) genes using PCR-SSCP analysis and sequencing. Sequence variations in the bovine LHCGR (exons 1,2,3,4 and 5), FSHR (exons 1,2,3 and 4), and LEP (exons 1,2 and 3) genes were investigated using the polymerase chain reaction (PCR) coupled with single-strand conformation polymorphism (SSCP) analysis and DNA sequencing. A total of 45, 35 and 11 SNPs were identified in LHCGR, FSHR, and LEP genes respectively.

Development of On-farm Remote Monitoring Sensor Device and its Evaluation to Predict Parturition in Cows

Observation of behavioral activities and thermographic profile associated with calving process in both Deoni and HF crossbred cows revealed that the behavioural parameters both lying time and rumination time differed significantly ($P < 0.05$) between both the breeds and started to decrease 6 hours prior to calving. Lying Bouts was found to be increased 2 ± 0.26 and 1.17 ± 0.17 in Deoni and HF crossbred cows, respectively and differed significantly ($P < 0.05$) prior to parturition. Eating duration of the both Deoni and HF cross around parturition did not reveal any changes significant changes around the parturition. Among the two breeds Deoni cows showed pronounced behavioural parameters. Digital infrared thermographic profile of eye and vulval temperature revealed that there was significant ($P < 0.005$) and sharp reduction in both eye and vulval skin surface temperature at 12 hours prior to onset of calving in deoni cows with a temperature difference of 0.54 and 0.39 for eye and vulval region. Reduction in both eye and vulval temperature of 0.4-0.5°C at 12 hours could be used to predict calving time in both deoni and HF crossbred cows. It is concluded that thermal biometrics observed 48 hours prior to calving using digital infrared thermal imaging technology could be used as a non-invasive and non-contact technique to predict the onset of calving in cows. Design and Development of electronic wireless sensor device prototype for calving prediction in cattle. The current device works on the principle of electromagnetic wireless sensor with GPS communication system and a buzzer alarm which operates on both battery and electric current. The 3D printed prototype has been developed and tested the device and the prototype is functioning successfully.

Reproductive Management in Dairy Cows- Effect of Bypass Fat on Onset of Puberty and Postpartum Cyclicity

Negative energy balance is one of the main causes responsible for low productive and reproductive performance in dairy animals. To study the effect of bypass fat on postpartum reproductive performances, ration of dairy cows (n=7) was supplemented with bypass fat @ 10g/kg milk yield/cow/day for a period of 150 days from the day of parturition. There was significant effect ($P < 0.05$) of bypass fat supplementation on number of medium follicles (6.89 ± 0.41 vs. 5.23 ± 0.25), ovarian diameter (24.96 ± 1.58 mm vs. 22.66 ± 1.11 mm) and area (1661.27 ± 201.2 vs. 1272.64 ± 99.02 mm²) in postpartum cows. Fat supplementation also had a significant effect ($P < 0.05$) on the onset of first postpartum estrus (24.57 ± 2.16 vs. 31.71 ± 2.04 days), days to first insemination (44.43 ± 2.75 vs. 54.75 ± 1.99 days), conception rate (71.43 vs. 28.57%), daily milk yield (11.45 ± 0.36 vs. 9.18 ± 0.41 kg/day), milk fat % (5.47 ± 0.12 vs. 5.05 ± 0.14 %) and protein % (3.48 ± 0.08 vs. 3.67 ± 0.07 %) than the control group cows (n=7). To study the effect of bypass fat on onset of puberty, heifers (age > 500 days; body weight > 180 kg) were supplemented with bypass fat @ 50g/animal/day for a period of 150 days. Though there was no significant difference ($P > 0.05$) observed between treatment (n=9) and control group (n=9) heifers in the parameters such as mean number of small follicles (6.05 ± 0.46 vs 5.67 ± 0.36), medium follicles (4.83 ± 0.24 vs 4.98 ± 0.37), large follicles (0.91 ± 0.07 vs 0.92 ± 0.08), reproductive tract score (3.42 ± 0.08 vs 3.32 ± 0.11), NEFA, the overall mean uterine horn diameter (16.39 ± 0.40 vs 15.62 ± 0.56 mm), BCS (3.18 ± 0.08 vs 3.00 ± 0.07), body weight (220.47 ± 5.85 kg vs 209.34 ± 4.95 kg), back fat thickness (22.9 vs

4 ± 0.85 21.17 ± 0.61 mm) were significantly ($P < 0.05$) higher in treatment group than in control. 55.00% heifers (5 out of 9) in supplemented group and 33.33% heifers (3 out of 9) in control group attained puberty during the trial period.

Effect of Exogenous Kisspeptin on Follicular Dynamics in Caprine Species

Effects of exogenous GnRH analogue vis-à-vis Kisspeptin-10 on the occurrence of caprine follicular waves were studied. Our results revealed that both GnRH and Kisspeptin-10 can reduce the number of waves in an estrous cycle, but impact of Kisspeptin was considerably stronger (exhibiting only one or two waves; Fig. 1) than GnRH, which culminated always with three waves (Fig. 2). Kisspeptin-10 treated animals had significantly different responses ($P < 0.05$), in terms of decreased ($P < 0.05$) inter-estrus interval, of those greater doses of kisspeptin-10 had the best results. In comparison to GnRH-treated and control animals, Kisspeptin-10 increased the mean diameter of the preovulatory follicle ($P < 0.05$). In terms of wave emergence, the second wave appeared substantially ($P < 0.05$) earlier in all treatment groups' animals than in the control group, whereas no such observation was noticed on other waves. Our results indicated that effect of kisspeptin on several follicular characteristics and wave emergence was much more pronounced than similar effect of GnRH analogue.

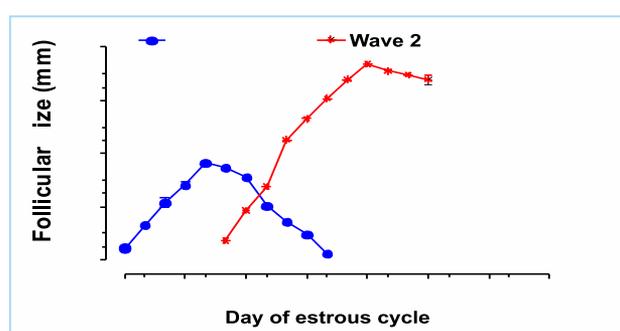


Fig. : Individual follicular wave patterns in the Black Bengal goats treated with KP-10.

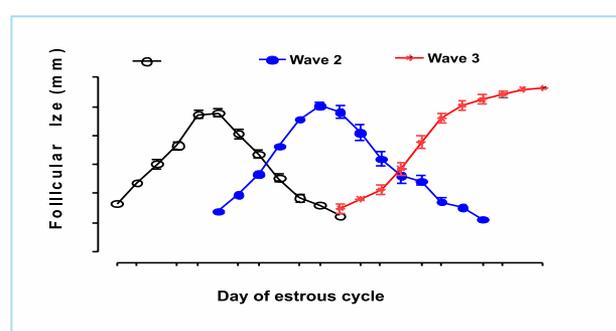


Fig. : Mean (\pm SEM) follicular wave patterns in the Black Bengal goats treated with GnRH analogue

Identification and Prioritization of Genes Regulating Reproduction in Caprine Species

We identified and prioritized genes for 13 traits related to reproduction such as Estrus, Estrus cycle, Duration of estrus, Length of estrous cycle, Preovulatory LH surge, Mean ovulation rate, Service, Parturition, Prolificacy, Fertility, Anestrus, Effect of Kisspeptin on reproduction and Kiss1R. We also prioritized neighbouring genes based on the network analysis. We performed network analysis of both the candidate and neighbouring genes. Also, we identified top 5 gene ontology terms for the prioritized candidate genes. BMPR1B, BMP15 and GDF9 genes seem to regulate most of the reproductive traits. Reproductive hormones and their receptors are also found to be related with most of the reproductive traits. STRA8, BOLL and DAZL genes are among those genes, which are found to be related with prolificacy and parturition but primarily those are found to be related with male sexual development. This could explain the sire component of the breeding strategies. Our identified gene list will be considered as molecular markers and expression studies of those genes could potentiate marker assisted selection programmes.

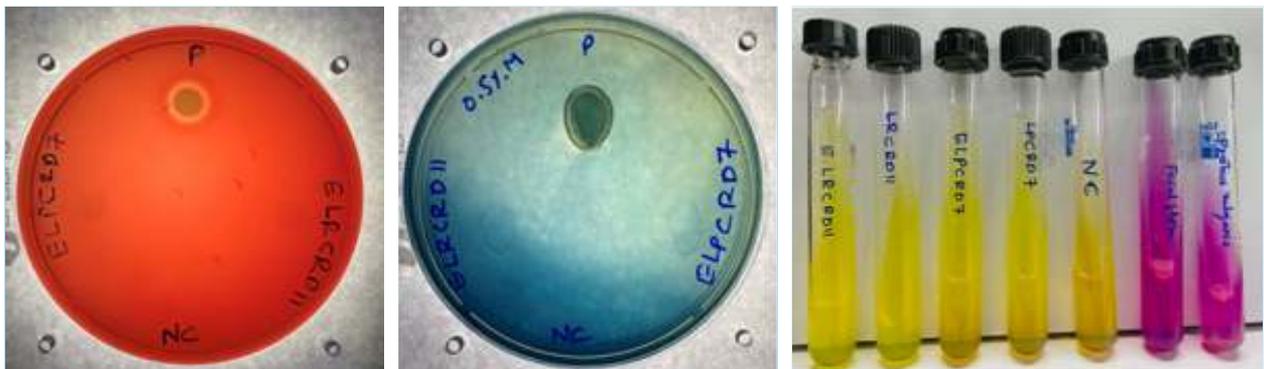
Association of Emergence of PNx-FSH Peaks to Follicular Waves, and Abundance of Transcripts Ending SMIM20 & GPR173 Genes during Reproductive Cyclicity in Crossbred Cows

Our results revealed that three distinct PNx peaks appearing on day (-1), 6 and 12 of the estrous cycle are evident. The PNx peaks were found to be co-existed with the appearance of high amplitude of PNx & FSH resulted follicular wave emergence. Blood PNx concentrations though increased ($P < 0.01$) from early to mid-pregnancy but remain same during last trimester ($P > 0.05$). Definite pattern of expressions of transcript encoding SMIM20 and its receptor, GPR173 do occur during different stages of EC and pregnancy. Abundance of SMIM20 transcripts was the highest ($P < 0.01$) during pro-estrus followed by estrus and met- & di-estrus. Transcripts encoding SMIM20 & GPR173 genes were significantly higher ($P < 0.01$) during mid- & last-trimester of pregnancy than early stage. In addition, a total of 31 candidate genes that regulate PNx have been identified and prioritized in silico. A complete gene network among the candidate and co-expressed genes that are directly and indirectly related to the function of PNx have been framed. The predictive 3-D structure of bovine SMIM20 and protein-protein interactions between bovine SMIM20 & GPR173 have been established for the bovine species.

FEED, FODDER AND ANIMAL PRODUCTIVITY

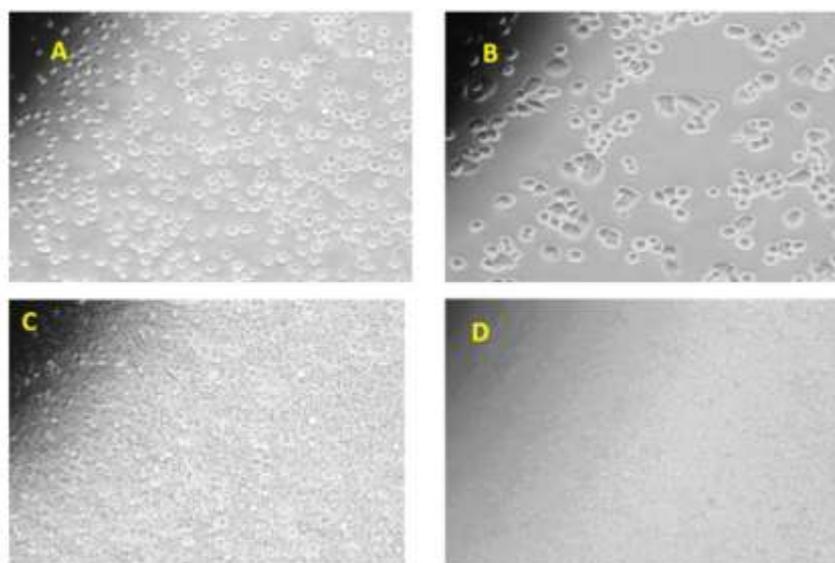
Safety Assessment of Electrohydrodynamic Encapsulated Probiotics and their Effects on Gut Health and Growth Performance in Indigenous Calves

Probiotics have been reported to play a major role in maintaining the balance of microbiota in host. Although probiotic lactobacilli are generally considered safe by various regulatory agencies, safety properties, such as absence of transferable antibiotic resistance, must still be determined for each strain prior to market introduction as a probiotic. Herein, we aimed to test the safety of *Lactiplantibacillus plantarum* CRD7 and *Lacticaseibacillus rhamnosus* CRD11 using in vitro and in vivo approach. In results, these strains were found to be negative for mucin degradation, hemolytic assay, and they did not produce ammonia or biogenic amines (i.e., cadaverine, histamine or tyramine). Additionally, the three strains were susceptible to seven antibiotics according to the European Food Safety Authority (EFSA) cut-off values. In accordance with cell cytotoxicity assay, the tested strains had no cytotoxicity on Caco2 cell lines. Finally, it was also confirmed that there were no dose-dependent mortality and toxicity throughout multi-dose oral toxicity tests in mice. Our findings demonstrated that *Lactiplantibacillus plantarum* CRD7 and *Lacticaseibacillus rhamnosus* CRD11 can be utilised as probiotics safely.



Isolation of Lactobacilli Strains from *Bos Indicus* Calves: Assessment of Techno-Functional Properties for the Design of a Probiotic Formulation

In this study, 105 bacterial colonies were isolated from the feces of newborn healthy *Bos indicus* calves and 37 isolates were confirmed using morphological, biochemical tests, and genus-specific PCR as lactobacilli. 11 strains were then short-listed for in vitro probiotic testing based on their ability to dwell under acid and bile stress. Species-level identification using 16S rRNA gene sequencing revealed that they were *Ligilactobacillus salivarius*. These isolates flourished in 0.4 % phenol, depicting resistance in adverse conditions encountered in the gastrointestinal tract. The results of cell surface hydrophobicity were found to be 74.50% for RBL12 and 62.62% for RBL09 in hexadecane and xylene, respectively, and that of auto-aggregation were highest in RBL26 (58.92%). These isolates also produced digestive enzymes like amylase, protease, and -galactosidase. Further assays reiterated their antimicrobial and coaggregation potential against diarrhea-causing pathogens like *E. coli* ATCC-25922 and *Salmonella arizonae* ATCC-13314. Biosafety assessment revealed that none of the tested isolates were hemolytic and mucinolytic in nature. Furthermore, the antioxidant potential of the isolates was also confirmed using 1, 1 - diphenyl - 2 - picrylhydrazyl (DPPH) and ferric ion reducing antioxidant power (FRAP) assay. Along with efficient utilization of inulin, isolates showed promising adhesion ability to the HT29 cell line. The current findings hence conclude that these *Lactobacillus* isolates can be exploited as animal probiotics for application in young calves to foster gut health and immunity.



A: HT-29 cells on day 1 after seeding
 B: HT-29 cells on day 2 after seeding
 C: HT-29 cells before treatment of probiotics in adhesion assay
 D: HT-29 cells after treatment of probiotic cells for 3h in adhesion assay

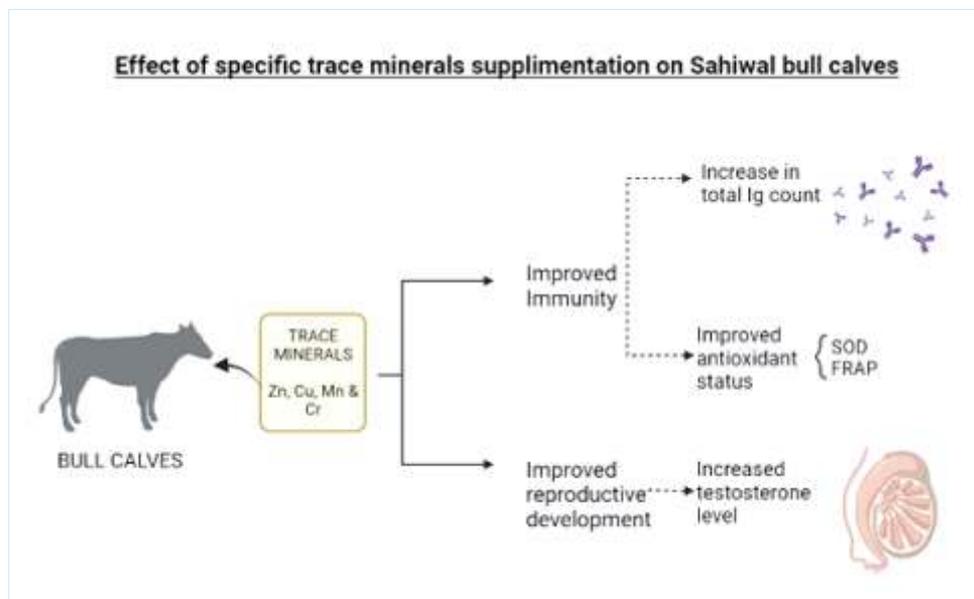
Effect of Zinc, Manganese, Vitamin A and E Supplementation on Growth Performance of Male Sahiwal Calves

The present study was planned to evaluate the effect of supplementing micronutrients on overall performance, of male Sahiwal calves. Eighteen Sahiwal male calves were grouped together as T₁, T₂ and T₃ based on age and body weight and were fed livestock farm practice in control (T₁), NDRI recommendation of Zn, Mn, Vitamin A and E in T₂ and 25% extra over NDRI recommendation of Zn, Mn, Vitamin A and E in T₃ for 4 months. There was no effect in the body weight, DMI, ADG, FCR, digestibility and nitrogen retention among the animals. The haematological parameter viz., RBC count, WBC count, total protein, plasma albumin, plasma globulin remains insignificant ($P > 0.05$) Among the hepatic enzymes the alkaline phosphatase (ALP) activity increased significantly ($P < 0.05$) in T₂ and T₃ and other hepatic enzymes like AST and ALT remains similar in all treatment group. There was rise ($P < 0.05$) in the antioxidant parameter viz., superoxide dismutase (SOD) activity, FRAP activity. Total immunoglobulin level increase significantly ($P < 0.05$) in T₂ and T₃ as compared to T₁. There was rise ($P < 0.05$) in testosterone level after two months of the supplementation in the trial. The scrotal circumference of the animals remained similar among the treatment groups but there was continues increase in the scrotal circumference and infrared thermal thermography shown there was rational decrease in the pole temperature from proximal pole to distal pole which shows a good sign related to the growth of the testis. It was concluded that supplementation of specific micronutrients (Zn, Mn vitamin A and E) at NDRI recommended level is sufficient for the better antioxidant status immunity and overall growth of the male Sahiwal calves.

Effect of Specific Trace Minerals Supplementation on Growth Performance and Immunity in Sahiwal Male Calves

The present study was conducted to find the effect of trace minerals supplementation on growth performance of 18 Sahiwal male calves for 180 d. They were grouped based on body weight and age into three ($n=6$ animals) groups viz, T₁ group, which served as control was fed with the basal diet. T₂ group was supplemented with the specific trace minerals (Zn, Cu, Mn and Cr) as per our recommendation. T₃ group was fed as the T₂ with an extra 25% supplementation of trace minerals. The result revealed that there was no significant effect in the body weight, metamorphic measurements, DMI, ADG, FCR, nutritive value, digestibility, and nitrogen retention of the animals due to specific trace mineral treatment. Plasma alkaline phosphatase (ALP) activity increased ($P < 0.05$) in T₂ and T₃ but other haematological parameters remained similar in all the experimental groups. Superoxide dismutase (SOD) activity, FRAP, and total immunoglobulin concentration increased significantly ($P < 0.05$) in T₂ and T₃ groups. However, catalase activity and IgG level did not change among the groups. Plasma mineral concentrations of Zn, Cu, and Mn increased ($P < 0.05$) in T₂ and T₃ in comparison with T₁ but Cr, Ca, and P remained the same throughout the experiment without any change. Specific trace mineral supplemented

groups (T₂ and T₃) shown an increase (P<0.05) in testosterone level during the 120th and the 180th day of the trial. It was concluded that supplementation of specific trace minerals above the basal level improved antioxidant status, immunity, reproductive development, and overall health of growing male calves.



Nickel Status in Feeds and Influence of Nickel Supplementation on Rumen Fermentation and Nutrient Utilisation in Crossbred Male Calves

a. Nickel Status of Feeds in Northern States of India

Nickel (Ni) is a probably essential trace element and its levels in feedstuffs are not known under Indian situation. Hence, concentration of Ni was estimated in different feeds, which is a pioneering study itself. The levels in grains, by products, oil seed cakes, non-leguminous fodders, leguminous fodders, dry roughages and concentrate mixture from Karnal area (Haryana) contained 1.71, 0.88, 4.35, 1.25, 1.29, 1.16 and 3.53 mg Ni/kg DM, respectively with corresponding concentration of 1.99, 1.04, 4.45, 1.48, 1.63, 1.30 and 3.21 mg Ni/kg in samples collected from Palampur (Himachal Pradesh); 1.44, 1.77, 4.40, 1.56, 1.51, 1.39 and 3.25 mg Ni/kg in samples from Udaipur (Rajasthan) and 1.81, 2.19, 4.71, 0.85, 1.57, 1.67 and 3.45 mg Ni/kg DM in samples from and Jhansi (Uttar Pradesh). Mean Ni concentrations in oil seed cakes, oats, napier hybrid, soy based products and concentrate feed were found to be above average among all feedstuffs.

b. Supplementary effects of Ni on rumen fermentation and nutrient utilisation in Karan Fries male calves

The results of *in vitro* studies indicated that proportion of propionate increased while that of butyrate decreased at and above 10 ppm level of Ni. For *in vivo* experiment, twenty four male KF calves of similar age (10.67 months) and body weight (137.09 kg) were selected from Livestock Research Centre, ICAR-NDRI, Karnal and divided into 4 groups of 6 animals each. All the animals were fed to meet their nutrient requirements (ICAR, 2013), however, the animals in groups T₂, T₃ and T₄ were supplemented with 5, 7.5 and 10 ppm level of Ni, respectively. Dietary Ni up to 10 ppm level did not influence nutrient intake, digestibility of nutrients (DM, OM, CP, EE, NDF and ADF), nitrogen balance, growth rate and feed conversion ratio. The rumen fermentation parameters like pH, total volatile fatty acids, ammonia-N, TCA precipitable-N remained similar in all the groups, however, urease activity in rumen liquor increased (P<0.05) in group T₄. The proportion of propionate increased (P<0.05) while that of butyrate decreased in group T₄, whereas, acetate: proportion ratio remained unchanged. Enteric methane production was not influenced by Ni supplementation up to 10 ppm level. Supplementation of Ni up to 10 ppm level of dietary DM did not show any significant effect on utilisation of Ca, P and Mn. The retention of Ni and its level in blood plasma increased linearly with the increasing level of dietary Ni. The retention of Fe, Zn and their plasma concentrations increased with Ni supplementation and highest values were observed in groups T₄.

Effect of Sodium Sulphate Supplementation on Nutrient Utilization Growth Performance and Enteric Methane Emission in Sahiwal Female Calves

Eighteen Sahiwal female calves of similar age (6.9 months) and body weight (83 kg) were selected from Livestock Research Centre, ICAR-NDRI, Karnal and divided into 3 groups (G1, G2 and G3) of 6 animals each. All the animals were fed to meet their nutrient requirements (ICAR, 2013), however, the animals in groups G2 and G3, were supplemented with sodium sulphate @ 0, 0.15 and 0.30% dry matter (DM) intake, respectively. Supplementation with sodium sulphate at 0.30% level improved average daily gain ($P < 0.05$) and feed conversion ratio (FCR; $P < 0.05$), digestibility of DM, CP and NDF when compared with other groups. Nitrogen balance was higher ($P < 0.05$) in group fed 0.30% level of sodium sulphate as compared to other two groups. Enteric methane emission was lowest ($P < 0.01$) in group G3 which was reduced to the extent of 14.7%. The concentration of TCA-ppt-N, TVFA, propionic acid increased ($P < 0.01$) whereas ammonia nitrogen and A: P ratio decreased significantly ($P < 0.01$) in 0.30% sodium sulphate supplemented group as compared to other groups. Plasma IGF-1 level increased ($P < 0.05$) with the supplementation of sodium sulphate at 0.30% when compared to other groups. Hence, dietary supplementation of sodium sulphate at 0.30% of DMI in Sahiwal female calves increased ADG and FCR, digestibility of DM, CP and NDF, rumen TCA-ppt-N, TVFA and propionate concentration, blood plasma glucose and IGF-1 levels while enteric methane emission was reduced ($P < 0.05$) to extent of 14.7%.

Replacement of Edible Spineless Cactus (*Opuntia Ficus-Indica*) Cladodes for Maize as Forage Source in Goat Kids: Effects on Biochemical and Physiological Parameters

Eighteen (Alpine \times Beetal) male kids were selected from Livestock Research Centre of ICAR-NDRI, Karnal and distributed randomly into 3 groups of 6 animals each based on their body weight and age. In the control group (T_1), maize green fodder and concentrate mixture were supplied in the ratio of 40: 60 (on DM basis) to meet the requirements (ICAR, 2013). In group T_2 and T_3 , the maize fodder was replaced by edible spineless cactus accessions No. 1270 and 1280, respectively during 90 days feeding trial. The cladodes were provided by ICAR-Central Soil Salinity Research Institute, Karnal. The concentration of glucose, total protein, albumin, globulin and blood urea N was not affected due to inclusion of spineless cactus in place of maize fodder. Plasma AST and ALT values were found to be similar in all the three groups and were found to be within the normal range. Activity of plasma GPx was similar in all the groups, however, SOD activity was higher ($P < 0.05$) in groups provided with cactus cladodes. The concentration of plasma growth hormone and insulin was similar in all 3 groups. The values of various blood parameters were within the physiological range. Hence, maize fodder could be fully replaced by edible spineless cactus in male goats without affecting blood biochemical and physiological parameters.

Preparation of Strawlage through Ensiling of Paddy Straw along with suitable Agro-Industrial Byproducts And Additives

Ensiling can be an alternate approach for enhances nutrient storage and utilization of paddy straw and also preventing straw burning. In this experiment Value-addition of paddy straw was attempted, by co-ensiling with wet brewer's grains and peapods (pea canning waste) for 30, 40, and 50 days, paddy straw was ensiled with peapods and brewer's grain in the ratio of 35:50:15. Exogenous fibrolytic enzyme, homofermentor bacteria (*Lactobacillus plantarum* NCDC 221), and heterofermentor bacteria (*Lactobacillus fermentum* NCDC 412) were added to the strawlage materials (paddy straw, peapods, and brewer's grain). At all ensiling durations, i.e., 30, 40, and 50 days, the ensiled combination showed a reduction in pH, ammonia-

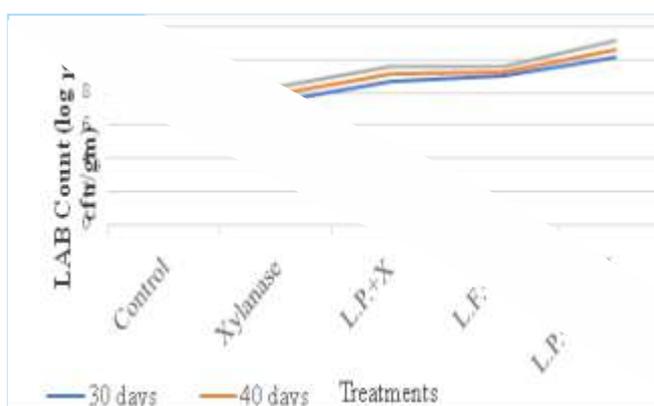


Fig. 1: LAB count of strawlage treated with various additive combinations

N, as well as an increase in protein content and aerobic stability of treatment in which ingredients were supplemented in combination of both bacteria and exogenous enzyme. The higher fleig point and DM recovery suggested that the technology has potential to be utilized as dairy animal feed.

Influence of Different Taste Feed Additives and their Effect on Feed Intake and Growth Performance in Growing Goats

The present study was carried out to evaluate the influence of different taste feed additives and their effect on feed intake, growth performance, digestibility and blood metabolites in growing goats. 90 days growth trial was conducted on thirty-six growing goats of 3-4 months age which were divided into 6 groups of six animals each. Animals in all groups were fed individually as per feeding schedule followed in NDRI, Karnal in Total mixed ration (TMR) to meet the requirement for both maintenance and growth as per ICAR 2013. One group was kept as control (T1) (without any taste supplement) while in other five groups individual taste feed additives were added in their concentrate mixture of TMR. (T2) group was supplemented with food grade sucrose (sweet) at the rate of 75 g/kg DM. (T3) group was supplemented with NaCl (salt) at the rate of 15 g/kg DM. (T4) group was supplemented with food grade Citric acid (sour) at the rate of 10 g/kg DM. (T5) group was supplemented with Urea (bitter) at the rate of 5 g/kg DM. (T6) group was supplemented with food grade Monosodium glutamate (Umami) at the rate of 10 g/kg DM. Blood samples were collected on 0, 45th and 90th day of experiment and digestibility trail of 7 days was conducted on last fortnight of the experiment. The study revealed that significantly higher ($P<0.01$) average DMI (kg/day) was observed in T2 (0.541 ± 0.034) and T3 (0.560 ± 0.041) groups compared to T1 (0.476 ± 0.039). Improvement in DMI (kg/day) was 13.65 % in T2 (sweet) over T1 (control); whereas, in case of T2 (salt), the improvement was 17.50%. Average daily body weight gain (g/d/animal) was 76.36 ± 7.98 , 98.77 ± 7.69 and 100.55 ± 4.76 in T1, T2 and T3 groups, respectively, which was significantly higher ($P<0.01$) in sweet and salt taste supplemented groups (T2 and T3) compared to control (T1). Body measurements including heart girth, withers height, body length and hip height were similar among six treatments. Feed conversion efficiency (kg live weight gain/100 kg DMI) and feed conversion ratio (kg DMI/kg live weight gain) were unaffected due to taste supplementation, but marginally higher FCE and lower FCR were observed in sweet and salt taste supplemented groups. Blood glucose, total protein, albumin, globulin, ALT and AST were similar among six treatments. Significantly higher ($P<0.01$) CP, DCP and TDN intake were observed in both the sweet and salt taste supplemented groups (T2 and T3) compared to control (T1) group. Digestibility coefficients of DM, OM, CP and EE were unaffected due to taste supplementation but NDF ($P<0.01$) and ADF ($P<0.05$) digestibility were increased significantly in sweet taste supplemented group (T2). It was concluded that addition of sweet and salt taste in total mixed ration had a positive impact on feed intake and growth performance in growing goats, while supplementation of sweet taste increased the digestibility of NDF and ADF.

Inclusion of Flavours in Total Mixed Ration and their Effect on Feed Intake and Growth Performance in Calves

The present study was carried out to evaluate the effect of different flavours as a feed additive in total mixed ration using paddy straw and concentrate on feed intake, digestibility and growth performance of calves. The study was executed in two phases. A total of ten flavours were evaluated in phase 1. Two sets had five flavours each. Thirty-six animals were divided into six groups having six animals in each group, keeping one group as control (without flavour supplementation) in each set. Feeding of each set was continued for 21 days. During this period, total DM intake was recorded. Based on TDMI, the two most promising flavours were selected for phase 2. Bodyweight gain and dry matter intake were found to be high ($p<0.05$) in the green grass and milk flavour supplemented group in the first and second trials, respectively. Whereas body weight gain and dry matter intake in both trials were higher in the flavour supplemented group than in control. For phase 2, Eighteen healthy growing calves (about one-year-old) were selected from the Livestock Research Centre of NDRI, Karnal. All the animals were randomly divided into three groups having six animals in each. One group will be kept as control, while in the other two groups, individual flavour (Green grass and milk) was added in their TMR selected from Phase 1. Animals in all groups were fed using paddy straw-based TMR as ICAR (2013) requirements. Average daily gain, dry matter intake and dry matter intake per kg metabolic body weight were significantly higher in the green grass and milk flavour supplemented group compared to the control. Whereas final body weight, DMI/100kg BW and FCR in flavour supplemented groups were found at par with the control.

Table- Average body weight gain and dry matter intake per 100 kg BW in the first trial

Group	BWG	DMI
Control	0.54 ^a ±0.03	2.74 ^{ab} ±0.20
Greengrass	0.77 ^b ±0.07	3.20 ^c ±0.10
Pudina	0.66 ^{ab} ±0.06	3.09 ^{bc} ±0.09
Neem	0.68 ^{ab} ±0.07	2.91 ^{ab} ±0.09
Fresh	0.69 ^b ±0.03	2.79 ^{ab} ±0.16
Till	0.66 ^{ab} ±0.06	2.67 ^a ±0.09

^{abc} - within column are differ significantly (p<0.05)

Table- Average body weight gain and dry matter intake per 100 kg BW in the second trial

Group	BWG	DMI
Control	0.67 ^a ±0.06	2.71 ^a ±0.11
Mango	0.75 ^{ab} ±0.05	2.87 ^a ±0.15
Banana	0.72 ^{ab} ±0.05	2.87 ^a ±0.06
Coconut	0.78 ^{ab} ±0.02	2.78 ^a ±0.08
Milk	0.86 ^b ±0.02	3.29 ^b ±0.09
Hing	0.74 ^{ab} ±0.05	2.72 ^a ±0.10

^{abc} - within column are differ significantly (p<0.05)

Table- Effects of flavour supplementation on BW, ADG, DMI and FCR

Parameters	Control	Greengrass	Milk	PValue
Initial BW	174.71±16.08	174.69±16.57	174.56±16.47	1.000
Final BW	249.57±15.76	263.61±16.69	265.85±17.86	0.763
ADG	0.41 ^a ±0.01	0.49 ^b ±0.02	0.51 ^b ±0.02	0.002
DMI	6.42 ^a ±0.08	6.86 ^b ±0.07	6.98 ^b ±0.10	0.001
DMI/100kg BW	03.02±0.30	03.14±0.70	3.18±0.63	0.128
FCR	02.17±0.40	02.27±0.05	2.27±0.05	0.289
DMI/kg ^{0.75} BW	114.85 ^a ±0.87	120.11 ^b ±1.82	121.67 ^b ±1.64	0.004

Inclusion of Taste and Aroma in the total mixed ration and their Effect on Dietary Preference and Growth Performance of Calves

Feed intake directly affects the performance of domestic animals. Nevertheless, current intensive feeding systems are characterized by feeding animals monotonous diets. The palatability of feed plays an important role in feed intake regulation, and the palatability of a feed can be defined as all the physical (appearance, texture, etc.) and chemical (taste, smell, etc.) characteristics of the feed that act on appetite. Taste is one of five senses that offer the awareness of their environment, in particular food selection, to ruminants and other animals. The sense of taste, which recognizes sweet, bitter, salty, sour and umami basic tastes, is considered important as it is the last sense through that animals can gain information about food before foods are swallowed. Ruminants evolved in diverse environments, consuming arrays of feeds of different chemical and physical characteristics. Feed intake can be increased when some chemical components such as monosodium glutamate, flavour and fragrance are added to the ruminant diets to improve the taste and smell, especially when feed is unpalatable. The present study was conducted to study the dietary preference of calves with different levels of taste and aroma and to evaluate the effects of taste and aroma on feed intake, nutrient utilization and growth performance in calves fed with a total mixed ration. Research experiments will be conducted in two phases. Phase I: Five tastes (sweet, salty, umami, bitter and sour) and four aromas was evaluated. Phase II: Long term feeding trial (4 months) was conducted on twenty-four healthy growing crossbred calves to observe the impact of tastes and aroma on feed consumption. After the completion sequential elimination trial, Sweet and Umami were most preferred by an animal, followed by Salty, Bitter, Sour and Control.

Table- Effects of various tastes on dry matter intake

Slot	Sweet	Umami	Salty	Bitter	Control	Sour
1	5.29±0.26	5.24±0.25	4.58±0.11	4.56±0.35	4.38±0.20	4.32±0.24
2		5.22±0.13	4.91±0.14	4.75±0.28	4.86±0.19	4.82±0.15
3			5.09±0.06	4.89±0.25	4.71±0.10	4.79±0.24
4				4.93±0.18	4.60±0.19	4.57±0.20
5					5.11±0.12	4.98±0.20

Effect of Sewage Water on Berseem-Maize Cropping System under Different Nutrient Management Practices

Water is a vital resource but availability is decreasing in most of countries. There is an urgent need to conserve and protect fresh water and to use the lower quality water for irrigation. Treated or recycled wastewater

appears to be the only water resource that is increasing as other sources are dwindling. Seed, being basic unit of agriculture acts as carrier of technology for a given crop and to upkeep its quality genetic vigour is paramount. Currently, India is facing acute shortage in availability of seeds of many forage crops, berseem being foremost of those. India imports approx. 10000 tonnes of berseem seed annually resulting in huge loss to foreign exchequer. Therefore an experiment was conducted to generate information for researchers and policy planners in shaping water use in agriculture for the future, with a particular reference to sewage water use in agriculture.

An experiment was carried out on berseem-maize cropping system with three levels of water (tube well water, mixing of TW and SW and Sewage water) and four levels of nutrient management (control, 50, 75 and 100% RDF) with three replications.

Significantly higher growth and yield parameters were recorded in berseem with sewage water application and 75% application of fertiliser, which was at par with 100% recommended dose of fertiliser and mixed application of tube well and sewage water. Significantly higher no. of nodules, root length, root volume and dry root weight of berseem were recorded with sewage water application and 50% application of fertiliser, which was at par with higher dose of fertiliser and mixed application of tube well and sewage water.

Evaluation of Oat and Berseem Varieties under Different Agronomic Practices Vis-A-Vis Management of Nitrate Toxicity

The study Evaluation of oat cultivars under different agronomic practices for management of nitrate accumulation was undertaken for two consecutive Rabi seasons of 2018-19 and 2019-20 at Research Farm, Agronomy Section, ICAR-NDRI, Karnal (Haryana). Four varieties (Kent, HJ-8, HFO-114 and JHO-851) were imposed in main plot and combinations of four nutrient management practices (125% RDF, 100% RDF, 75% RDF+PGPR and 75% RDF+PGPR+FYM) and three seed rates (75, 90 and 105 kg/ha) were imposed in subplot.

Among tested varieties, significantly higher plant height, leaf length and leaf width were recorded with Kent and HJ-8 whereas a significantly higher number of tiller per m² and number of leaves per plant were counted with JHO-851 at 30 DAS, first and second cut. Variety JHO-851 (64.4 t/ha and 117.1 q/ha) was at par with HJ-8 (63.1 t/ha and 113.8 q/ha) and significantly higher over Kent (62.1 t/ha and 111.6 q/ha) and HFO-114 (59.7 t/ha and 107.1 q/ha) for total green and dry fodder yield, respectively. Among nutrient management practices, application of 100% RDF remained at par with 125% RDF at first cut and proved significantly superior in terms of growth attributes such as plant height, number of tillers per m², number of leaves per plant, leaf length and leaf width. At second cut, significantly higher values for above-mentioned parameters were evidenced with 100% RDF compared to 75% RDF+PGPR though former one was at par with 125% RDF and 75% RDF+PGPR+FYM. Application of 100% RDF (63.0 t/ha and 113.9 q/ha), 125% RDF (63.5 t/ha and 115.5 q/ha) and 75% RDF+PGPR+FYM (62.2 t/ha and 112.2 q/ha) were found statistically at par with each other for total green and dry fodder yield, respectively and higher as compared to 75% RDF+PGPR (60.5 t/ha 108.0 q/ha).

Among three tested seed rates, 90 kg/ha seed rate resulted in significantly higher total green and dry fodder yield (64.1 t/ha 115.8 q/ha, respectively) as compared to 75 kg/ha (58.5 t/ha 104.9 q/ha, respectively) and it was at par with 105 kg/ha (64.3 t/ha 116.5 q/ha, respectively).

So, it may be concluded that application of 100% RDF with 90 kg/ha seed rate in JHO-851 and Kent varieties in single cut and for multi cut, 100% RDF with 90 kg/ha seed rate in JHO-851 and HJ-8 fodder oat varieties are the better agronomic practices for utmost yield, quality and economics with minimum nitrate accumulation.





Effect of Organic Nutrient Management on Different Fodder Crops

It can be concluded that application of 100% RDN through FYM + PGPR+ 3% Panchagavya spray (maize)- PGPR+3% Panchagavya spray (Berseem)- PGPR+ 3% Panchagavya spray (Cowpea) found promising to improve the growth and yield of the maize-berseem-cowpea cropping system. The application of 100% RDN through FYM + PGPR+ 3% Panchagavya spray (maize)- PGPR+3% Panchagavya spray (Berseem)- PGPR+3% Panchagavya spray (Cowpea) recorded the higher nutrient concentration, ether extract and total ash content. It also recorded the lower fibre fractions in the fodder in the maize-berseem-cowpea cropping system. The maize -berseem-cowpea cropping system help to improve the soil organic carbon, soil nutrient availability (N,P and K), soil enzyme, and microbial population. It also observed that application of 100% RDN through FYM+PGPR+3% Panchagavya spray (maize)- PGPR+3% Panchagavya spray (Berseem)- PGPR+3% Panchagavya spray (Cowpea) increased the net returns with a B:C ration in the tune of Rs 2 for per one Rs invested.

Evaluation of *Moringa Oleifera* L. Cultivars for Quality Fodder Production under Differential Plant Geometry in Eastern Haryana

Objective of the study is evaluated the best performer cultivar of moringa for quality biomass under intensive system of production in prevailing climate condition. Hence, a field experiment was conducted in *split plot design* with three replications. The main plot consisted five cultivars of viz. PKM-1; PKM-2; ODC; ODC-3 and MOL'E and sub plot with three crop geometries, 30×30, 45×30, 45×60. Based on first cutting, plant height, stem girth, leaf biomass and green fodder yield were observed superior in the PKM-2 variety over others. However, stem girth was highest with MOMAX variety. PKM-2 recorded the highest green fodder yield (29.7 t/ha) which remained statistically significant compared to other varieties. The plant geometry 45×30 cm (plant to plant and row to row) was recorded as the highest growth and green fodder yield compared to other plant geometry.

Improvement of Black Bengal Goats for Enhancement of Productivity in Eastern Region of India

Black Bengal is one of the important goat breed due to its high prolificacy, early maturity, low kidding interval as well as for their delicious meat and high quality black skin. The breed is widely distributed throughout West Bengal and adjoining parts of the neighboring states, viz., Bihar, Jharkhand, Orissa, Assam and parts of Tripura. The breed is also prevalent in Bangladesh. However, main home tract of the breed is throughout West Bengal. Important constrains for rearing of Black Bengal goats for commercial mutton production are lower body weight gain both in pre and post weaning phase, higher kid motility particularly for twin and triplet due to lower milk production of mother, lower mature body weight, lack of knowledge regarding scientific feeding and housing under intensive or semi intensive management practices etc. Therefore, attempts were made to improve productivity of Black Bengal goats through scientific intervention particularly on feeding and housing management.

Survey work was done to know the present status of goat rearing practices in the different villages. A total of 110 goat keepers (having 330 goats) from new alluvial zone, West Bengal, had interviewed and observed most of the respondents (53.64%) belong to small category having 1-3 goats and rearing their goats in semi-intensive system. Most of goat keepers (93.64%) were supplemented rice gruel (without common salt) to their animals as indigenous practice. For scientific validation of farmers practices e.g., rice gruel feeding to the goats, one animal experiment of 120 days duration was conducted on growing Black Bengal kids maintained under stall feeding on 60% green fodder and 40% concentrate mixture based diet. Rice gruel (fortified with common salt @1.5% of total rice gruel) was supplemented daily @5% of body weight of the goats. Supplementation of

rice gruel improved growth, productive and reproductive performances without any alteration of physiological, haematological and biochemical parameters in growing Black Bengal goats. Daily feed intake per unit of body weight as well as feed conversion efficiency were higher ($P < 0.01$) in the goats fed/supplemented rice gruel in compare to non supplemented/ control group. Body length, heart girth and wither height were also higher ($P < 0.01$) in the goats supplemented with rice gruels.

Black Bengal goats managed under Intensive Housing System (IHS) in the goat farm at ERS, ICAR-NDRI, Kalyani revealed that from birth, body weight of animals increased linearly up to 4 years of age, thereafter, body weight did not show any significant changes. Body weight changes were stabilized between 3-4 years of age. From birth to 3 months age body weight of Black Bengal goats enhance by 164%, subsequent enhancement of 152% from 3 to 6 months age, then by 14 and 28% in next 3 months intervals, which indicated for needs to target better management at 6-12 months age to achieve better growth for meat production. Season significantly ($P < 0.05$) influence growth rate (g/day), highest in summer (30.78 ± 5.30) and lowest in rainy (24.15 ± 2.10) seasons. Male kids had higher ($P < 0.01$) growth rate (29.72 ± 2.62) than female kids (24.73 ± 2.95) under routine farm management practices. Black Bengal goats had reproductive efficiency of 50.98% singles, 43.14% twins and 5.88% triplets born in intensive housing of management. Age of Black Bengal goat significantly differentiated rectal Temperature ($^{\circ}\text{F}$), pulse rate (beats/ minute) and respiration rate (breaths/ minute) and higher in young goats as compared to adults. Works on effect of flooring patterns in goat house had been initiated. The hygiene condition of the floor has been evaluated by 1-4 scale. The flooring hygiene conditions (1-4 scale) ranged from 3.18 ± 0.08 to 3.72 ± 0.06 in wooden to concrete floorings of goat houses.

Four composite rations (C1, C2, C3 and C4) were formulated to observe the effect of different energy and protein level on nutrient utilization and growth performances of weaned Black Bengal kids under intensive feeding experiment for nine months duration. Ration C1 contain 100% of CP and TDN requirement as per NRC (2007) for 65 g average daily body weight gain of growing kids e.g., 13% of CP and 65% of TDN while C2, C3 and C4 ration contained 75% of CP and TDN, 75% of CP and 100% of TDN and 100% of CP and 75% of TDN requirement, respectively. The experiment is under progress and feeding trial of growing Black Bengal goats is going on for more than last six months.

Effect of chromium supplementation on *in vitro* digestibility and fermentation pattern

An *in vitro* study was conducted using different doses of organic and inorganic chromium (Cr) incubated with diluted ruminal fluid with a 60:40 roughage and concentrate substrate for 24 hours. Treatments consisted of 0 (without Cr), 0.5, 1.0, 1.5, and 2 ppm each dose of organic and inorganic chromium added to the substrate. Results showed that the degradability of dry matter in organic Cr added groups increased linearly as the dose of chromium was increased ($p = 0.088$), yet the same is not valid in inorganic Cr added groups. However, the organic matter degradability of different treatment groups was comparable ($p = 0.627$). Total nitrogen concentration production in Cr added groups were slightly higher ($p = 0.114$), with the highest production observed in the 1.5 ppm organic Cr added group, followed by 1.0 ppm organic Cr. Addition of Cr reduced ammonia nitrogen (NH_3N) concentration in general, and a significantly lower NH_3N concentration was found in all organic Cr added groups and a dose above 1.5 ppm in the inorganic Cr added group ($p = 0.026$). The concentration of TCA precipitated nitrogen ($p = 0.765$) and soluble nitrogen ($p = 0.746$) was comparable among the groups. The addition of organic and inorganic chromium tended to increase the total volatile fatty acids (TVFA) production ($p = 0.067$), with the highest TVFA production observed in the 1.5 ppm organic Cr group, followed by 1.0 ppm organic Cr and 1.5 ppm inorganic Cr added groups. Cr addition did not affect acetate production ($p = 0.110$) and the ratio of acetate to propionate ($p = 0.122$). However, a significant difference was found with respect to propionate ($p = 0.015$) and butyrate ($p = 0.044$) concentration among the groups. The highest propionate concentration was found in the 2.0 ppm organic Cr group, whereas the highest butyrate concentration was found in the 2.0 ppm inorganic Cr added group. It is concluded that addition of organic and inorganic Cr at certain level may have influence on rumen fermentation.

Effect of dietary chromium supplementation on nutrient utilization and growth performance in Black Bengal goats

The present study was conducted to study the influence of inorganic and organic chromium on nutrient intake, nutrient utilization, and growth performance in Black Bengal kids. For this, 30 Black Bengal kids of 3-5 months

were assigned randomly into five groups. The experimental diets consisted of basal diet supplemented with Cr at the rate 0 (basal diet only), 1.0 and 1.5 ppm (inorganic Cr) and 1.0 and 1.5 ppm (organic Cr). The duration of the growth experiment was 150d, followed by a 7d digestibility trial. The total dry matter and crude protein intake of Cr supplemented groups were comparable with the control group ($P=1.00$). The DM digestibility of Black Bengal kids under 0, inorganic Cr (1.0, 1.5 ppm), organic Cr (1.0, 1.5 ppm) supplemented groups were 60.37, 61.67, 64.22, 63.05, and 64.60 %, respectively. The 1.5 ppm organic Cr and 1.5 ppm



inorganic Cr group had significantly higher DM digestibility coefficients in comparison to other groups ($P=0.037$), while the digestibility of DM in the remaining groups was comparable. Similarly, nutrient utilization in the 1.5 ppm inorganic Cr and 1.5 ppm organic Cr groups were better with a higher digestibility coefficient for crude protein, ether extract, organic matter, total carbohydrate, and hemicellulose ($P<0.05$) when compared with the remaining groups. The average daily gain (ADG) of Cr supplemented groups were better than the control group, and the ADG of 1.5 ppm inorganic Cr and 1.5 ppm organic Cr supplemented groups were significantly higher than the rest of the groups ($P=0.039$). The overall average FCR (kg DMI/kg weight gain) of Black Bengal kids under 0, inorganic Cr (1.0, 1.5 ppm) and organic Cr (1.0, 1.5 ppm) supplemented groups were found to be 9.10, 8.92, 8.44, 8.81 and 7.96 respectively. Chromium supplementation tended to improve the feed conversion rate from 30 d onwards from the study; therefore, the mean average FCR in treatment groups was better than the control group, though statistical analysis revealed no significant variation among the different groups ($P=0.09$).

NOVEL APPROACHES IN VALUE ADDITION & FUNCTIONAL FOODS

Development of Edible Antimicrobial Packaging Films for Traditional Dairy Sweetmeats using Metabolites of Lactic Acid Bacteria

Antimicrobial packaging (AMP) films were developed using caseinate protein polymer by casting technique utilizing both the viable bacteria (*W. cibaria* P6 and *L. plantarum* P10) as well as its fermentate containing the antimicrobial metabolites. The developed caseinate based AMP films showed significant antimicrobial activity against all the tested fungi. Another AMP film was also developed that contained both the antifungal *L. plantarum* P10 (5%) and antibacterial pediocin producing *P. pentosus* P34 (5%). The developed AMP film was effective against the bacterial indicators. The developed composite AMP films were tested for various physical and mechanical properties in order to gauge the changes in the properties of the film brought by inclusion of the culture fermentate. The incorporation of both P10 and P10+P34 did not significantly affect the film thickness and penetration force, however, significant differences were recorded among the tensile strength, percentage elongation and the seal strength of the films. Overall, it can be concluded that the mechanical properties and the colour characteristics of both P10 and P10+P34 films were found to be varying compared to control. In the shelf-life study of khoa burfi, treatment of AMP films had a static effect on the total plate count, coliform and yeast and mold counts compared to control and the growth was considerably controlled during its room temperature storage of 9 days. During the storage stability test of the AMP films, better viability of P34 cells and its antimicrobial activity was observed during 1 month refrigeration storage, although the antifungal activity against *Candida* spp. was still visible to a certain extent.

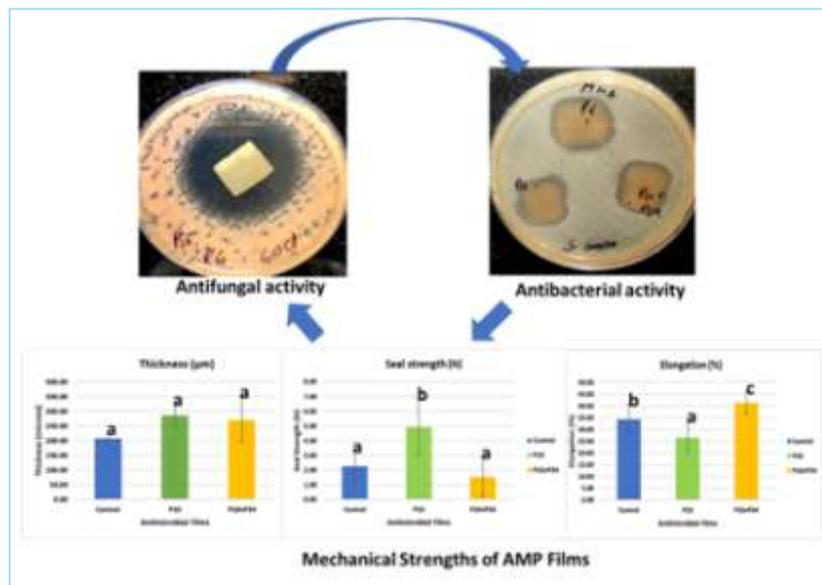


Fig.: Antifungal and antibacterial effect of developed AMP films against indicators along with its mechanical properties

Effect of Process Parameters on the Enzymatic Hydrolysis and Galactooligosaccharide Formation in Concentrated Skim Milk

β -galactosidase derived from *K. lactis* was more effective than *B. licheniformis* for degree of hydrolysis (DH) and galactooligosaccharide (GOS) formation in a model system (phosphate buffer, 16 % lactose, pH 6.7) at 7 °C. β -galactosidase from *K. lactis* exhibited 96.61 % DH and 7.28 % GOS production after 12 h of reaction and hence

was utilized for lactose hydrolysis in concentrated skim milk (40 % total solids). Use of 9.53 U/ml enzyme resulted in significantly high DH (97.06 %) after 12 h with 4.90 g/L of residual lactose. However, maximum GOS formation of 12.01 % with 94.74 % lactose breakdown was obtained after 4 h. Further increase in reaction time up to 12 h resulted in breakdown of tri and tetrasaccharide GOS, thereby, reducing GOS content. Hence, 9.53 U/ml of β -galactosidase was finalized with a reaction time of 12 h to obtain maximum DH along with additional benefit of GOS formation.

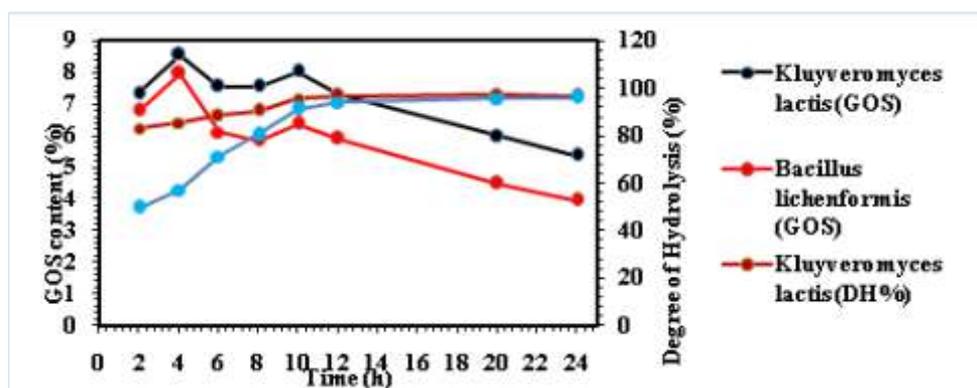


Fig. : Relationship between hydrolytic and transgalactosylation activity of β -galactosidase enzyme from different sources in model system

Preparation of Protein-Polyphenol Conjugates to be used as Food Additives in Functional Food Products

Whey proteins and caseins were conjugated with polyphenolic compounds (caffeic acid and ferulic acid) using both non-covalent (change in pH) and covalent (alkaline, chemical coupling, free radical grafting method). The aim was to prepare conjugates with maximum polyphenolic activity along with good functional properties of proteins, so that these conjugates can be used to enhance protein content with delivery of polyphenolic compounds. The binding of polyphenols was higher in the covalent conjugates (maximum in free radical grafting) than the non-covalent conjugates (maximum seen in pH 7). The conjugates that were prepared by

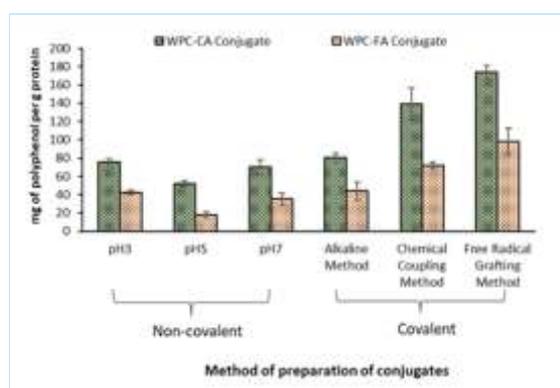


Fig. : Polyphenol content (mg/g protein) in whey protein-ferulic acid (WPC-FA) and whey protein-caffeic acid (WPC-CA) conjugates prepared by the non-covalent methods (at different pH 3.0, 5.0 and 7.0) and the covalent methods (alkaline, chemical coupling, free radical grafting method)

the covalent (free radical grafting) and non-covalent (pH 7) method exhibited much better emulsifying activity and emulsion stability than the alkaline conjugates for both caffeic and ferulic acid. The emulsifying activity, emulsion stability and foam capacity were improved after conjugation with polyphenols. On comparison of the method of conjugation, it was found that the solubility, emulsifying activity, emulsion stability and foam capacity of the non-covalent (pH 7) and covalent conjugates (free radical grafting) of caffeic acid and ferulic acid were better than the covalent conjugates prepared by alkaline method. The solubility of protein slightly decreased after conjugation with polyphenols but the antioxidant activity was enhanced significantly. These results indicate the possibility of using caffeic acid and ferulic acid in improving the functional properties of proteins. The functionality of the prepared conjugates was found to

be affected by type of polyphenol and method of conjugation. The functionality improved the most in the non-covalent conjugates. These functional protein-polyphenol conjugates can be explored for their utilization as food additives in functional food products, as these may provide added benefits of polyphenols along with functional attributes of proteins.

Comparison of Different Derivatizing Reagents and Standardization of Methodology in Identification of Milk Metabolites using GC-MS

Metabolites are low molecular weight (50-1500 Da) biomolecules which are the intermediates and end products of cellular metabolism. In milk, metabolites often reflect metabolic activity in the mammary gland. Gas-chromatography-mass spectrometry (GC-MS) is one of the most commonly used analytical technique to study metabolites. In GC-MS, derivatization is a chemical process during sample preparation that involves enhancing volatility and thermal stability of parent compounds. The three generally used derivatizing reagents (N-methyl-trimethylsilyltrifluoroacetamide (MSTFA), N,O-bis-(trimethylsilyl) trifluoroacetamide (BSTFA) and BSTFA with catalyst (1% trimethylchlorosilane)) were compared for their efficiency in detection of milk metabolites. A total of 61, 75 and 86 metabolites were detected in milk using GC-MS after derivatizing with MSTFA, BSTFA and BSTFA+TMCS, respectively. Among all detected metabolites, 40 metabolites were commonly detected in milk irrespective of derivatizing reagent and rest are specific to specific derivatizing reagents. Organic acids, lipids and amino metabolites were majorly detected in milk derivatized with MSTFA; however, carbohydrate metabolites (sugar and sugar alcohols including pyranose and furanose form of sugar) were mainly detected in milk derivatized with BSTFA and BSTFA+TMCS. Furthermore, it was found that addition of TMCS to BSTFA helps in improving the detection of lipid and amino metabolites in milk. Although BSTFA, BSTFA+TMCS were found to detect a greater number of metabolites including unique metabolites, results suggested that the yield and repeat detection of metabolites was significantly higher in MSTFA. From the results it can be concluded that, the choice of derivatizing reagent in metabolite analysis of milk using GC-MS will be dependent on the type of target metabolite. However, in untargeted metabolite analysis of milk, MSTFA may serve as a better choice of derivatizing reagent because of wide portfolio of metabolites detected in higher frequency. The standardized methodology will be used to identify difference in metabolites of milk from indigenous and cross bred cattle.

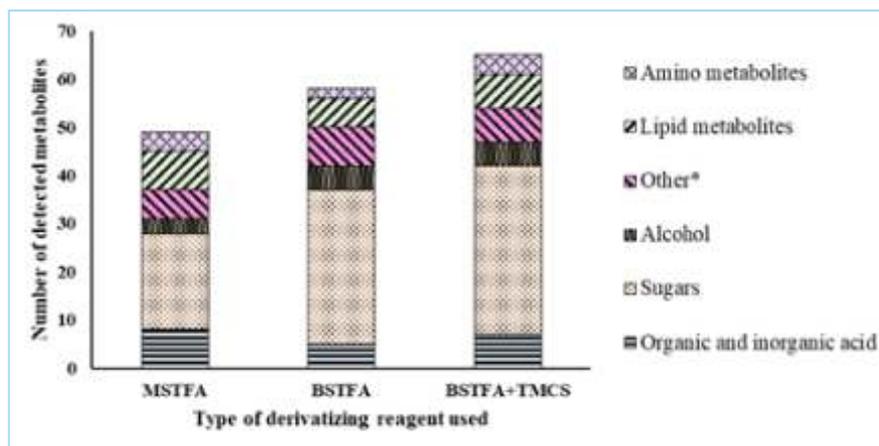


Fig. : Distribution of different categories of metabolites detected in milk after derivatizing with N-methyl-trimethylsilyltrifluoroacetamide (MSTFA), N, O-bis-(trimethylsilyl) trifluoroacetamide (BSTFA) and BSTFA + Trimethylchlorosilane (TMCS)

Quantification of Casomorphin-7 (BCM 7) from Heat Processed Cow Milk after Simulated Gastrointestinal Digestion using RP-HPLC and ELISA Methods

RP HPLC method was standardized for the quantification of Casomorphin 7 (BCM 7) to study the thermal treatment (pasteurization, boiling and sterilization) on release of BCM 7 in milk from A2A2 and A1A1 genotype cows of Karan Fries cross bred. BCM 7 and BCM 7 like peptides were identified only from simulated gastrointestinal extracts of all milk samples from both genotype cows. Concentration of BCM 7 and BCM 7 like peptides in A1 milk was 10-12 times higher than that of A2 milk irrespective to the thermal treatments and

generation of these peptides decreased with increase in the heat treatment. Results obtained by RP HPLC were validated using competitive ELISA assay. MS analysis indicates that release of BCM7 is specific to A1 milk but BCM like peptides were also generated in milk containing A2 variant of -CN during simulated gastrointestinal digestion.

Ricotta cheese with Extended Shelf Life from Cow Milk system

Ricotta is a fresh variety of whey cheese prepared traditionally from whey left over after production of goat and sheep milk cheeses. It inherently has low yield, higher milk solids losses and a delicate texture. Whey being a major environmental concern for the cheese industry, its application for manufacturing whey cheeses is the simplest and least expensive alternative to overcome the problem of disposal. With the goal to utilize Cheddar cheese whey, Ricotta cheese was developed by optimizing i) cheese whey to skim milk ratio in cheese milk, ii) heat treatment and iii) coagulation temperature. The best formulation was selected on the basis of yield, milk solids recovery, physico-chemical, sensory, textural, microstructural and rheological properties. The shelf-life of the optimized product was extended by adding bio-preservatives and using different packaging materials. The optimized formulation favoured maximum milk solids recovery, improved yield, excellent textural and sensory properties and had a shelf life of up to 30 days under refrigeration. The process ensured maximum utilization of cheese whey and hence, helped to reduce environmental problems and effluent treatment costs associated with drainage of whey.

Valorization of Ghee Residue

The studies on “Production and characterization of ghee residue powder” and “Production and characterization of skim milk admixed ghee residue powder” were under taken. Ghee-residue (GR), a by-product obtained during ghee manufacturing, is a rich source of milk components such as milk fat and proteins. However, still it is considered as a dairy waste. Fresh ghee-residue samples were obtained from two commercial dairy plants. After pre-treatments, ghee-residue samples were admixed with either RO water or pasteurized buffalo skim milk (PBSM). A stable dispersion was obtained via mixing of ghee residue and water. However, mixing of PBSM-GR lead to coagulation during heating owing to lower pH of ghee residue. This problem was eradicated with the addition of selected stabilizing salts. Stable dispersions obtained via mixing of ghee residue with water or PBSM were heat treated and spray dried to obtain resultant powders. Manufactured powders were also subjected to their detailed characterization. Filing of a patent on this work is currently under pipeline.

Eggnog: A Beverage developed by the Combination of Whole Egg and Milk

Eggnog is a dairy based beverage and a well-known holiday drink in many parts of the world. Under this study, the eggnog formulation was optimized using box-behnken design of response surface methodology. Analysis of variance indicated that experimental data was well explained with quadratic model with high check values and non-significant lack of fit tests. Optimized eggnog contained higher viscosity, heat stability and lower thermal gelation temperature than control eggnog (Photo given below; also being sent separately in JPG format: Photo 1). Sensory analysis revealed lower sweet and higher, viscosity, smoothness and overall acceptability scores for optimized beverage. The degree of hydrolysis was significantly higher for optimized eggnog than control. Further, SDS-PAGE showed the protein bands at 10-14kDa, 38-55kDa and at 200kDa corresponding to the gastric pepsin, lipase, trypsin and protease enzyme and several apolipoproteins, respectively. No significant difference was observed in the DPPH free radical scavenging among digested samples, however angiotensin-converting enzyme (ACE) inhibitory activity was significantly higher for the optimized eggnog.

Development of Nutri-cereal Incorporated Protein Rich Probiotic Dairy Spreads and Dips

This study was aimed for the development of nutri-cereals incorporated probiotic composite dairy spread. During the period of reporting, the following activities were undertaken. Three different probiotic strains viz. *L. acidophilus*, *L. casei* and *L. plantarum* were procured from NCDC and checked for their purity, acid (pH- 2) and bile (4%) resistance. All the three cultures were found to be pure, acid and bile tolerant. Finger millet malt and sorghum malt were studied for its prebiotic potential and it was found that sorghum malt significantly ($P < 0.5$) increased the viable probiotic *L. plantarum*-and *L. casei* count in the milk -millet composite medium compared to finger millet malt and control. The probiotic curd (PC) was prepared by admixture of sorghum malt (SM), milk protein concentrate (MPC) and skimmed milk powder and inoculated with probiotic *L. plantarum* and *L. casei* (1:1) mixed strains. Thus, prepared probiotic curd was used as an ingredient in

preparation of dairy spread. The levels of other ingredients viz. butter, MPC, SM, PC and stabilizer were optimized using I-optimal mixture design technique (Design expert® software version 10.0.4.1). The ingredients were mixed, heat processed to 85 ° C for 2 min and homogenized using high shear mixer. The probiotic curd was added during homogenization. Formulation with 39% PC, 14% butter, 7.5% MPC, 7% SM and 0.8% stabilizer, 4% cheese, 1% salt and 30% water produced sensorially superior product. The probiotic composite dairy spread was found to have viable probiotic *L. plantarum* and *L. casei* count of 10.36 Log₁₀ cfu/g. Storage study of the developed product is under progress.

Novel DPP-IV Inhibitory Peptides Isolated from Milk Proteins

Kappa-, beta- and alpha-casein, alpha-lactalbumin and beta-lactoglobulin were isolated from Gir cow milk and hydrolysed with select enzymes at different enzyme-substrate ratio. The hydrolysates of alpha-lactalbumin and kappa-casein showed maximum DPP-IV inhibition with IC₅₀ value of 0.78 mg/ml and 61.6 µg/ml, respectively. These hydrolysates were passed through series of ultrafiltration membranes. The retentates of 3 kDa membrane were examined for DPP-IV inhibition activity. These low molecular weight peptides were further chromatographically separated using reverse phase HPLC and time-based fractions were collected every 30 s interval. The HPLC fraction which showed maximum DPP-IV inhibitory activity was analysed through LC-MS/MS analysis and unique peptide sequences were identified. Sequences of less than 15 amino acids were selected and synthesised. These synthesized peptides were evaluated for DPP-IV inhibitory activity. One octa-peptide from kappa-casein, one octa-peptide from alpha_{s1}-casein and one deca-peptide from alpha-casein exhibited better DPP-IV inhibition with IC₅₀ value of 1.79, 1.69 and 2.62 mM, respectively.

Technology for Production of Reduced Sugar Burfi with Natural Sweeteners

Reduced sugar burfi was made with blend of natural low-calorie sweeteners. Three natural sweeteners were selected based on their proximity of sweetness profile to sucrose. Complete sucrose was replaced with low calorie natural sweeteners in the burfi and sweetness profile of the blend prepared was close to sucrose. Furthermore, no bitter taste, and no lingering effect of intense sweetener in burfi was observed. Burfi made with sweetener blend has 5 g dietary fiber per 100 g. Total calorie contribution from sweetener blend was reduced by 55% compared to sugar. Natural sweeteners used in this blend have glycemic index between 0 to 35. Product can be made with existing facility at commercial scale. Reduced sugar burfi contained 15.01±0.17% moisture, 16.63±0.43% fat, 18.43±0.15% protein, 45.26±0.42% carbohydrate, 84.99±0.17% total solids and 4.67±0.09% ash. Whereas, control product had 14.46±0.18% moisture, 17.11±0.22% fat, 17.44±0.24% protein, 46.80±0.38% carbohydrate, 85.53±0.17% total solids and 4.165±0.03% ash. Prepared product was packed in an airtight polypropylene cup and storage stability was examined over a period of 10 days.



DPP-IV Inhibitory Peptides Fortified Protein Rich Snack Bar

The developed product would serve as part of meal replacement or snack for diabetic and sugar scary people. The product is rich in protein (~ 17%), contains no added sugar (sucrose) and contributes 96 kcal energy per serving size of 20 g. Product contains cereal flour, low glycemic index fruit flour, dry fruits, milk fat, FSSAI permitted natural non-nutritive sugar base, milk solids, salt and permitted emulsifier, leavening agent and casein hydrolysate rich in DPP-IV inhibition activity. The casein hydrolysate was prepared using commercially available enzyme for specific duration which showed adequate DPP-IV inhibition activity



(75.83±0.37%) with minimal bitterness score and hence, used as a key ingredient in this formulation. The product was processed through baking process at a specific temperature and for a specific duration to impart appealing flavor and taste to the product. The developed product has shelf life of 2 months at ambient temperature.

Utilization of Ghee Residue for Development of Protein Rich Energy Bar

Ghee residue (GR), a nutrient dense mass, is obtained as a by-product during the preparation of ghee. Despite being rich in various nutrients, it has not been effectively utilized for development of food products. One of the popular segments of food products where ghee residue could be utilized is energy/ snack bars, also called as convenience food products. With this backdrop, present study was conducted to utilize ghee residue for development of protein rich energy bar. In the present study, optimization of levels of GR (30-40%) and liquid glucose (LG: 15-25%) was done for development of protein rich energy bar using the D-optimal mixture design. Samples were subjected to sensory evaluation and determination of hardness. Cubic models were significant ($p < 0.05$) for colour, flavour and overall acceptability scores, while quadratic model was significant ($p < 0.05$) for body and texture scores. Upon optimization, maximum desirability of 0.88 was obtained. Predicted and experimental values were same ($p > 0.05$) for all responses except colour ($p < 0.05$) scores. The acidity and free fatty acid content increased significantly ($p < 0.05$) during storage of bar, while sensory scores were non-significantly ($p > 0.05$) affected during the 45 days storage at $25 \pm 2^\circ\text{C}$ in metallized polyester films. The developed energy bar contained 5.49% fat, 20.82% protein, 9.80% moisture, 2.53% minerals, 1.10% phospholipids, 31.1% antioxidants activity, 15.28% crude fiber and 377.70Kcal/100g total calories, respectively. One developed energy bar (50gm) can provide more than 10gm of protein. Chocolate-coated variant was also developed for the wider acceptance among younger population.

Yoghurt Fortified with Moringa Pod Pulp Powder

Demand for functional food in the market is increasing. Various plant ingredients are also being used for the augmenting the functional benefits. *Moringa oleifera* is one medicinal plant, every part of *Moringa oleifera* is shown to be significant importance towards human health and nutrition. Yoghurt is a popular and widely consumed fermented dairy product and ideally suited for the incorporation of *Moringa oleifera* pod. In the present study, moringa pod powder was prepared using different drying methods like freeze drying, hot air oven tray drying, micro-oven drying and sun drying. The prepared ingredient was analyzed for both physicochemical and biofunctional properties. Further, prepared functional ingredient was incorporated into yoghurt to achieve functional yoghurt. Superior body and texture with firm curd coagulum with enhanced biofunctional properties and shelf life was observed in the developed product.

Cow Ghee Enriched with Natural Polyphenols for Enhanced Antioxidant Activity

Ghee is a clarified milk fat; since ghee imparts excellent flavour and superior mouth feel, as a prominent ingredient it can be used in almost any food application in which a fat source is needed. Ghee spoilage occurs during prolonged storage due to autoxidation of lipid. The use of synthetic antioxidants is prohibited by the regulatory bodies because of their toxicity and carcinogenic effects on the consumer. Traditional knowledge and few studies have shown that natural herbs and spices can be used as source of antioxidants. Therefore, in this work, an inventive methodology for producing combination of herbs and spices as natural ingredients were optimized for addition to ghee. The optimized ingredients when added in the process, results in higher infusion to the ghee and also improves its sensory quality (in terms of color, texture and flavor). This methodology resulted in significant increase in the total phenolic content (159.9 mg Gallic acid equivalent /g ghee); thereby it enhanced the antioxidant activity (approx. 4 times higher than the control ghee) and improved the shelf life. It was also studied that the addition of these ingredients had no effect on the physicochemical and analytical parameters of ghee, and this ghee can be sold as proprietary food.

DEVELOPMENT & VALIDATION OF HEALTH PROMOTING DAIRY FOODS

Anti-obesity and Anti-diabetic Potential of Whey, Casein and Oil-seed Cake-derived Soy and Groundnut Proteins

Both *in-vivo* and *in-vitro* experiments were conducted to comparatively analyse the anti-obesity potential of oil-seed cake proteins extracted by biological method (probiotics) in comparison to milk proteins. The *in-vitro* study provided evidences that protein from both the sources significantly ($p < 0.001$) suppressed adipogenesis and stimulated adipolysis in 3T3L-1 cells in comparison to the control. The *in-vivo* study carried out in mice fed high fat diet (HFD), showed that mice fed with groundnut proteins (acid and probiotic extracted) had lower body weight than mice of the other groups. Body weight increased significantly in casein and soy protein (extracted using probiotics, SPP-B) fed mice after three weeks but after seven weeks of feeding significant increase in body weight was observed only in casein fed group. The kidney and spleen index decreased significantly in SPP-B fed group than the control. BMI and Atherogenic index decreased significantly in all the groups in comparison to high fat diet (HFD). Plasma triglycerides and VLDL-C decreased significantly in all the groups in comparison to HFD but the decrease was more pronounced in oil-seed cake derived proteins than casein protein. *fiat*, *cpt1* and *ppar-* gene expression increased significantly in SPP-A (extracted using acid) and SPP-B fed groups in liver, whereas adiponectin expression was significantly high only in group fed SPP-B. Adiponectin gene expression also increased significantly in visceral fat tissue in groups fed SPP-B, GPP-A (Groundnut protein extracted by acid method) and casein whereas leptin gene was down regulated significantly in all the groups except SPP-A. Based

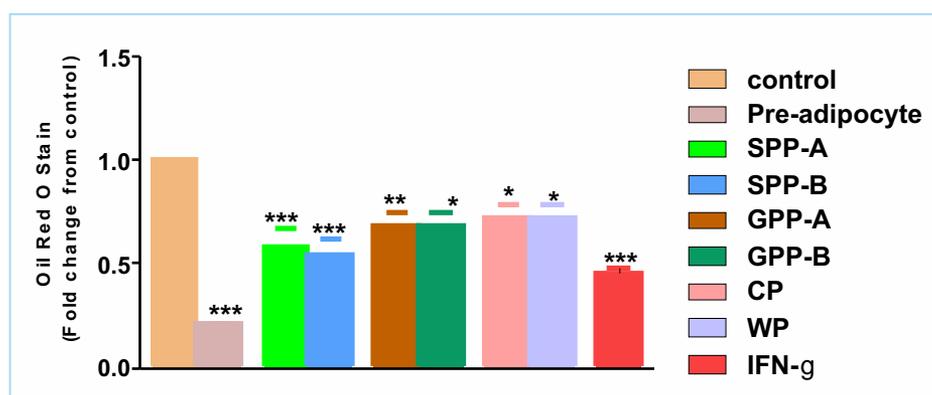
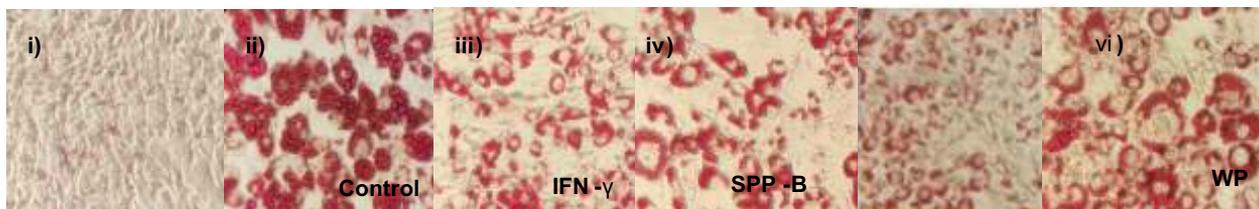


Fig.: Influence of different protein hydrolysates on accumulation of lipid in 3T3L-1 cells. (a) (i) Preadipocytes (undifferentiated cells), (ii) Control cells were not exposed to any compound, (iii) IFN- γ positive control treated cells, (iv) SPP-B, soy protein preparation-probiotic, (v) GPP-B, groundnut protein preparation-probiotic, (vi) WP, whey protein, (b) Quantification of lipid content in cells treated with 50 μ g/ml of protein hydrolysates. The values are expressed as mean \pm S.E.M, of three independent experiments. Significant differences were identified at * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$ as compared to the control group.

on different parameters analysed, it was evident that oil-seed cake derived proteins by biological method had better anti-obesity potential than acid extracted proteins. Among milk proteins, whey protein exhibited better antiobesity potential than casein.

The anti-diabetic potential of milk proteins and oil-seed cake-derived plant proteins extracted by different methods has been compared. *In-vitro* results showed that protein extraction using probiotics increased the digestibility of oil-seed cake proteins than acid extracted proteins. The oil-seed cake-derived protein hydrolysates have better inhibitory activity against α -glucosidase and DPP-IV enzymes than casein protein while whey protein hydrolysates showed better inhibitory activity against α -amylase than oil-seed cake proteins. *In-vivo* study in diabetic rats showed that oil-seed cake-derived proteins helped to lower the hyperlipidemic condition via significant decrease in LDL-C, TC, TG and AI with increase in HDL-C. Oil-seed cake-derived proteins and milk proteins exhibited significant decrease in AST, ALT and ALP activity in plasma and also significant decline in plasma urea, creatinine and uric acid concentration was observed as compared to the diabetic control. Among the oil seed cake proteins, SPI-B showed significant increase in glucose homeostasis and anti-oxidative genes such as CAT, SOD, g6pase, and pck2. Thus overall results depicted that oil-seed cake-derived proteins extracted by probiotics have greater anti-diabetic potential than acid extracted proteins and the antidiabetic potential of whey protein is comparable with probiotic extracted oil-seed cake proteins.

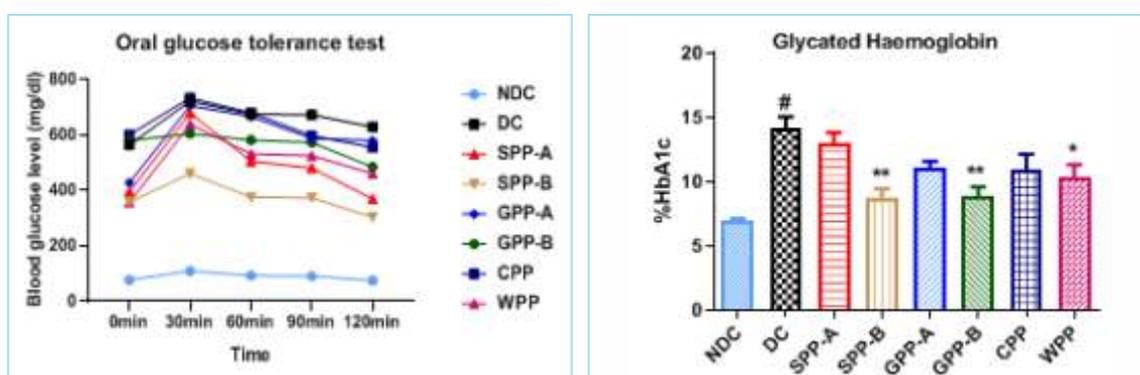


Fig. : Effect of feeding different protein diets on Oral Glucose Tolerance Test (OGTT) and glycated haemoglobin in normal and streptozotocin-induced diabetic male Wistar rats. Values are expressed as Mean \pm S.E.M. (n=6).# P<0.05 as compared to the normal control,*P<0.05, **P<0.01, ***P<0.001 compared with diabetic control group.

Effect of Synbiotic Diets on Estrus Dynamics

Estrus cycle regulation in metabolically disturbed obese mice the mouse estrous cycle lasts 4-5 days and is identified by four stages: diestrus, proestrus, estrus, and metestrus. Estrous stage can be visualized by examining the relative proportions of cell types present in a vaginal cytology swab sample. High estradiol levels in pro-estrus stage result in a proliferation of round nucleated epithelial cells. Transition into estrus, the uterine lining breaks down and sloughs off cornified epithelial cells. In a vaginal smear, these look as dense clusters of flat, irregularly shaped cells and nuclei deficit. Some of these cornified epithelial cells are also visible during metestrus. However, most of them are in fragmented form and the majority of cells at this stage are small, polymorphonuclear leukocytes. Diestrus is mainly characterized by leukocytes (Fig.). However, it can be differentiated from metestrus by an absence of cornified epithelial cells. Nucleated epithelial cells also start to appear in late diestrus, just before to the transition to oestrus. Estrous cycle monitoring: The standard cycle is 4-5 days of diestrus,

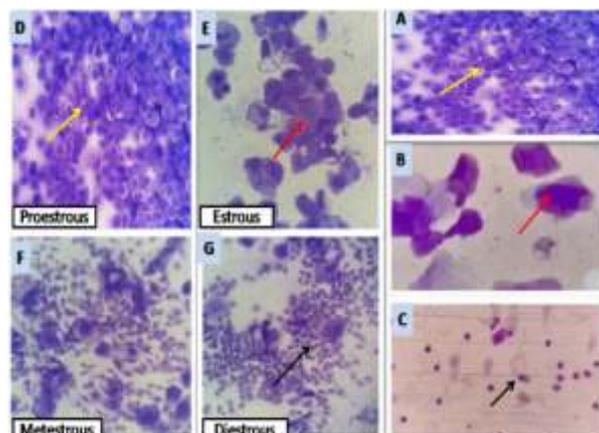


Fig.: Assessment of estrous cycle: Cytological assessment of vaginal smears to identify estrous stage (b) Three main cell types are detected in vaginal smear samples (40 X): (A) nucleated epithelial cells, (B) cornified squamous epithelial cells, and (C) leukocytes. The ratio of these cell types present in the smear can be used to identify mice in (D) proestrus, (E) estrus, (F) metestrus, or (G) diestrus as described in representative results. Red arrows in E and B point to representative cornified squamous epithelial cells. Black arrows in C and G indicated to representative leukocytes. Yellow arrows in D and A highlight representative nucleated epithelial cells.

followed by approximately 1 day each of proestrus, estrus, and metestrus and diestrus. Estrous cycle was monitored for continuous 21 days from 21th week onwards to 23rd week. Some mice exhibit extended diestrus and estrus stages. Moreover, cycle length may change due to factors such as nutrition, stress and age. Thus, vaginal smears should be analyzed over multiple cycles to ensure accuracy for a given strain of mouse. The prevalence of diestrus stages and estrus are more in HFD and SM supplemented group. The hormonal changes happened in response to excessive feeding of high fat diet resulted in poor reproductive traits. Mice particularly fed on HFD and SM was not cycling properly. However, an improved response was observed in case of dahi, FOS and Inulin supplemented diet fed animals.

Different Diets Supplementation Reflects Alteration in Estrous Cyclicity

Alteration in estrus cyclicity in response to different dietary supplementation was traced in mice. To quantify the degree and time course of estrous cycle inhibition, we presented the data as days and percent time spent in each stage of the cycle. In control mice, a regular estrous cycle pattern was observed both during the whole experimental period. The control mice indicated slightly more time spent in estrus and less time spent in metestrus and proestrus. By contrast, HFD and SM fed groups were spending almost 60% time in diestrus stage after 20 weeks (Fig.). Non-fermented group FOS and Inulin were spending 10-30% time in diestrus stage. In fermented group Dahi, PFM-1 and PFM-2 were spending 28%, 15% and 33% respectively as compared to HFD group. Among Synbiotic incorporations in diet SPM-1 (*L. fermentum* NCDC 400 + FOS) was most effective against HFD induced estrus cycle disruption. SPM-1 spent only 10 % time in diestrus stage, while SPM-2, SPM-3 and SPM-4 were spending approximately 20-25% respectively.

Effects of Probiotic Fermented Milk Combination with Prebiotic on Blood Glucose and OGTT

The oral glucose tolerance test (OGTT) for glucose metabolism showed a higher blood glucose level at 30 min after glucose administration as compared to the control animals. However, the serum glucose level was normalized and significant ($P < 0.05$) within 60–120 min in most of the PFMT-HFD fed groups compared to the HFD (High Fat diet) and non-PFMT-HFD fed groups. The area under the curve analysis (AUC) showed a significant ($P < 0.05$) difference between non-PFMT-HFD and PFMT-HFD compared with the control group. To evaluate metabolic condition, fasting blood glucose was measured at 0, 10 and 20 weeks of the treatment. In both 10 and 20 weeks, significantly ($P < 0.05$) higher values were observed for HFD than control groups, while non PFMT-HFD groups were compared with HFD non-significant, but PFMTs-HFD fed groups were significantly ($P < 0.05$) less as compared with HFD and nonPFMT-HFD groups.

Effects of Probiotics Fermented Milk Combination with Prebiotic on Histopathology of Small Intestine

The hematoxylin-eosin staining showed the distortion of microvilli structure and crypts disorientation in HFD and non-PFMTs-HFD groups compared to the control group. Interestingly, we found intestinal microvilli recovery upon treating the HFD animals with probiotic fermented milk (PFMTs-HFD)

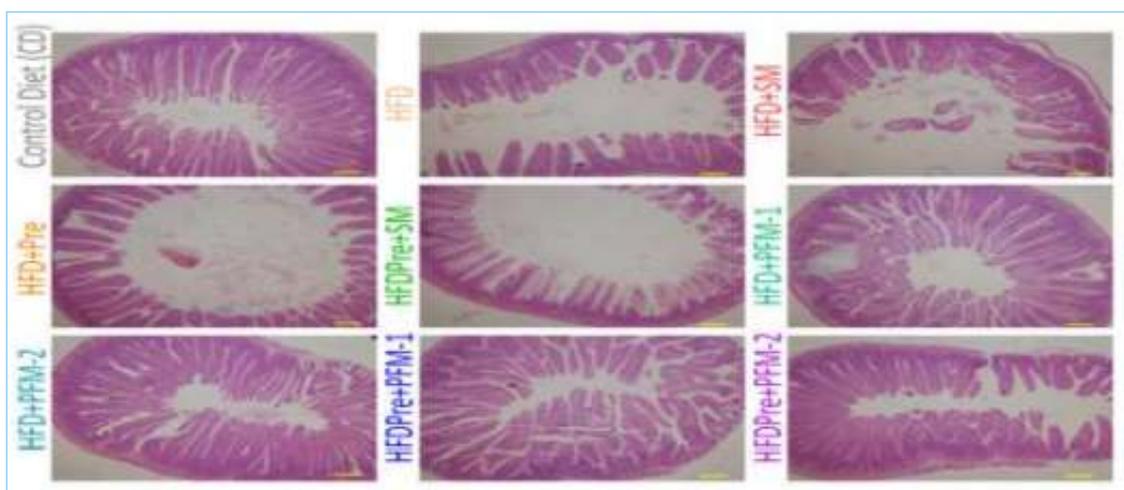


Fig.: Representative ultra-thin histopathological images of different treatment mice groups of small intestine. The different treatment groups were fed their respective diet for 20 weeks (400×magnification).

Cutaneous Tissue Repair with Probiotic *Lactobacillus Fermentum* (MTCC-5898) Preparations

Probiotics exert their positive effects through multiple mechanisms including competitive displacement of pathogenic bacteria, reinforcement of epithelial barrier functions, induction of immune system and migration of fibroblasts and epithelial cells'. Probiotics have been associated with improved healing of intestinal ulcers and infected cutaneous wounds. Under present investigation, the probiotic *Lactobacillus fermentum* (LF) strain as a whole and its cell surface components were evaluated for beneficial effects in cutaneous tissue repair. Probiotic *L. fermentum* based preparations derived from bacterial cells pellet [Milk whole cell (WC) and MRS WC], media supernatants [MRS supernatant (SPN) and fermented milk supernatant (FM-SPN)], cell bound and released exopolysaccharides [Crude EPS (CEPS)/deproteinized EPS (DPEPS)/ released EPS (FM-REPS & M-REPS)] along with peptidoglycan (PGN) were prepared and evaluated for skin keratinocytes (HaCaT) re-epithelialization, anti-biofilm potential, anti-oxidative attributes and improvement in junctional integrity during challenge with *Staphylococcus aureus* and mechanical damage (scratch) respectively. Cytotoxic assessment of all the tested LF preparations appeared safe during *in-vitro* evaluation. Further, LF fermented milk supernatant (FM-SPN) significantly increased ($P < 0.05$) the rate of re-epithelialization during 6-12hrs of incubation, followed by milk WC, MRS WC, and CEPS. Likewise, FM-SPN showed a considerable ($P < 0.05$) scavenging property of around 80% as compared to other preparations using ABTS and DPPH radical scavenging assay. Though majority of LF preparations (FM-SPN, CEPS, milk WC, and MRS WC) showed optimal biofilm inhibition during competition with *S. aureus* but FM-SPN showed efficacious results ($P < 0.05$) during displacement assay also. Improved junctional integrity in cultured keratinocytes was also observed with FM-SPN, milk WC, and MRS WC preparations by trans-epithelial resistance (TEER) generated across the cells. This improved junctional integrity was significantly ($P < 0.05$) maintained with FM-SPN during *S. aureus* challenge also. Increased nitric oxide levels during re-epithelialization of keratinocytes with FM-SPN and milk WC established faster cellular migration at 12 hrs of post-wounding. The keratinocytes repaired with FM-SPN was further confirmed with decreased levels of pro-inflammatory (IL-8 and TNF-) and increased levels of anti-inflammatory (IL-10) cytokines. Likewise, significant impact on transcriptional expression of tight-junction (ZO-1, Claudin, Occludin), matrix stability (MMP-1, MMP-9, TIMP-1), and oxidative stress-related genes (Nrf2, Keap1) were observed. Thus, FM-SPN showed promising effects on cutaneous tissue repair by enhancing junctional integrity through its anti-oxidative, anti-inflammatory, and anti-biofilm attributes.

Immunomodulatory Potential of Bovine Colostrum

Bovine colostrum is nutrient-rich, early milk produced during initial few days following parturition. It not only contains various proteins, carbohydrates, fats, vitamins and minerals but is also enriched with numerous bioactive constituents such as immunoglobulins, growth factors and antimicrobial factors (lactoferrin, lactoperoxidase, lysozyme, etc). Recently, health-promoting efficacy during oral consumption of bovine colostrum towards healing of immune deficiency status in humans has been identified. Bovine colostrum could be one of the promising nutraceuticals which can prevent or mitigate various diseases in newborns as well as in adults. Therefore, researchers have been working in improvising the immunomodulatory potential of bovine colostrum in various different ways including supplementation of dairy cows' ration with several different vitamins, minerals, plant extracts, plant derived essential oil, trace elements, etc. at either their gestation period or lactating period. Hence, the present study was conducted to compare immunomodulatory potential of bovine colostrum obtained from cattle administered with additional vitamin mix (Vit A, Vit D₃, Vit E and Vit B₁, B₃, B₇) and minerals (Zn, Mn, Cu and Se) through intra-muscular route. It was found that colostrum obtained from cattle administered either with additional vitamin mix, minerals or both respectively have significantly ($p < 0.05$) higher levels of immunoglobulins and lactoperoxidase activity as compared to the colostrum obtained from cows, whom no additional micronutrient intervention was made. Likewise, colostrum obtained from cattle administered with minerals and minerals+vitamin mix had significantly higher ($p < 0.05$) lysozyme activity than normal colostrum. Impact of oral administration of these bovine colostrum was also evaluated on cyclophosphamide induced immune-suppressed mice. Immuno-suppressed, model control showed significant reduction ($p < 0.05$) in total WBC, neutrophils, lymphocytes, splenocyte proliferation index and phagocytosis by peritoneal macrophages as compared to control animals. Likewise, considerable decrease ($p < 0.05$) in IgA, IgG and TGF- levels were noticed in intestinal fluid of immune-suppressed mice. On the other hand, intervention in prepartum cows with minerals+vitamin mix produced colostrum that on its feeding significantly ($p < 0.05$)

increased the total WBC and lymphocytes in mice even after induction of immunosuppression by cyclophosphamide. Likewise, colostrum obtained from cattle administered with minerals significantly ($p < 0.05$) increased the splenocyte proliferation index in presence of either of the mitogens (Con-A and LPS) as compared to model control. Similarly, colostrum obtained after intervention with vitamin mix had significantly ($p < 0.05$) higher IgA levels in intestinal fluid and TGF- β levels in splenocytes than model control. Hence it is concluded that feeding of bovine colostrum during immune-suppression improved the immunity irrespective of the type of intervention made in prepartum cows for colostrum production.

Goat Milk Exhibited Anti-obesity Potential via Inhibition of Pancreatic Lipase by Casein and Whey Protein Hydrolysates

Pancreatic lipase enzyme breaks down the triglyceride into monoacyl glycerol and free fatty acids and they are then absorbed by the intestinal cells. Inhibition of pancreatic lipase inhibits the fat digestion and its absorption. The unabsorbed fat is then excreted in the feces. Goat milk casein and whey proteins were isolated and digested by digestive enzymes pepsin (P), trypsin (T) and chymotrypsin (C) and their combinations. The casein and whey protein hydrolysates were assessed for its inhibition potential against pancreatic lipase enzyme. All the hydrolysates (P, T, C, PT, PC, TC and PTC) of casein and whey proteins were significantly more effective than the intact protein in pancreatic lipase inhibition. PTC hydrolysate of casein and whey protein exhibited maximum pancreatic lipase inhibition as compared to other hydrolysates.

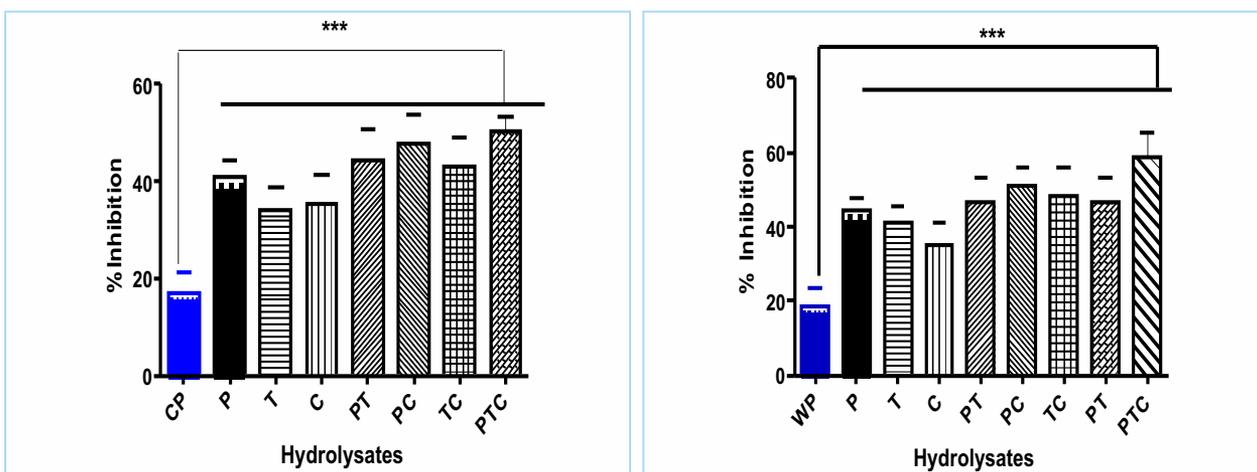
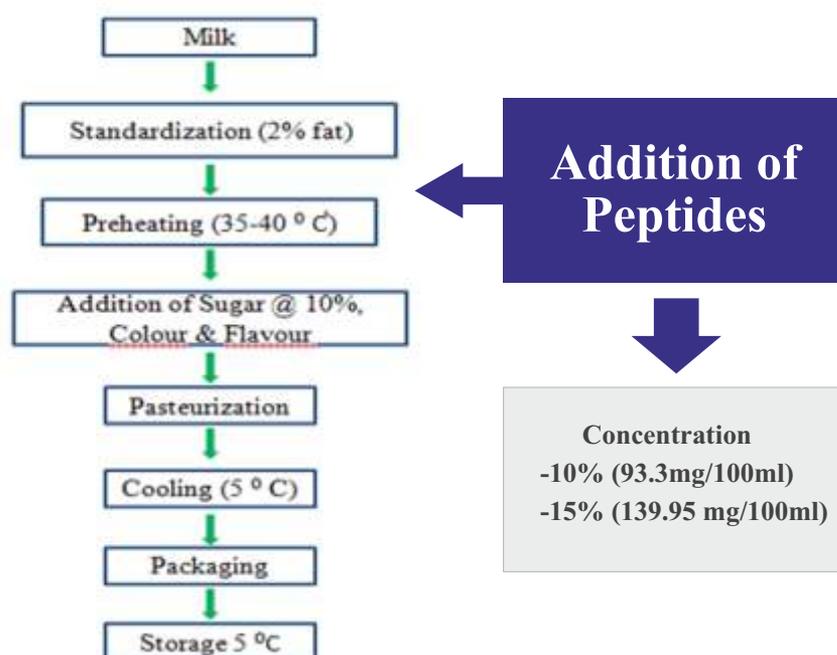


Fig. : Effect of (a) casein protein and casein protein hydrolysates & (b) whey protein and whey protein hydrolysates on pancreatic lipase inhibition. Values are mean \pm SEM where $n = 3$

Development of Colostrum Whey-Derived Bioactive Peptide Ingredients for the Preparation of Bio-Functional Beverage

Colostrum whey derived bioactive peptide ingredients were prepared through *Lactobacillus* fermentation using two cultures *Lactobacillus rhamnosus* C25 and *Lactobacillus plantarum* C2. The peptide fractions were separated and all the fractions exhibited antimicrobial activity with MIC of 0.21–0.32 mg/ml and 0.46–0.8 mg/ml, respectively. 10k Da P exhibited the highest antioxidative activity of 91.44 ± 0.56 and $86.45 \pm 0.06\%$ ABTS radical scavenging activity, respectively. 10kDaP showed ACE Inhibitory activity ($78.82 \pm 0.03\%$ inhibition). Immunomodulatory activity. The peptides were stable at different conditions like temperature, pH and digestive enzymes. The peptides exhibited higher antimicrobial activity, ranging from 15–20 mm zone of inhibition and ABTS % scavenging activity of $80.58 \pm 0.86\%$, corresponding to 1963.54 ± 0.83 mol/ml TEAC even after four weeks of storage at 4°C . C 25 peptides were used as ingredients and added @ 10% and 15% concentrations into flavoured milk. The beverage was found to be bio-functional, and peptides added @ 15% concentration exhibited higher activity like antimicrobial, antihypertensive and antioxidative properties even after the 7th day of storage. At the end of the 7th day of storage, there was a significant decrease in the microbial counts. Thus, the bioactive peptides derived from colostrum whey by microbial fermentation may be used as ingredients for the development of biofunctional dairy beverages.



Milk Derived Bioactive Peptides in Antimicrobial Packaging System for the Enhanced Shelf Life of Indian Sweetmeats

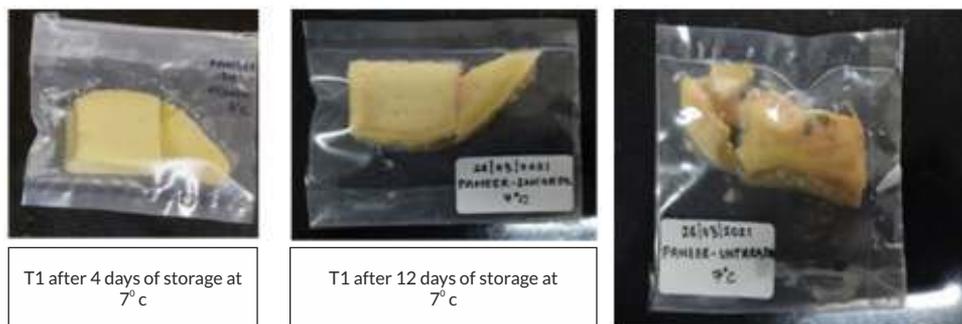
Antimicrobial packaging (AMP) is a novel method to enhance the shelf life of foods. The bioactive peptides were produced via colostrum whey fermentation using *Lactobacillus rhamnosus* C25. The <10 kDa peptides were having antibacterial activity and > 50 kDa peptides showed antifungal activity. The peptide fraction of 50 kDa retentate was fungicidal to all the 7 isolates tested with the smallest MFC of 0.46 mg/ml against *Candida guilliermondii* (NCDC 44). 10 kDa (FR) exhibited the highest antibacterial activity against the native microflora of *kalakand* with a zone of inhibition of 17.83 ± 0.17 mm, and only 50 kDa (FR) showed antifungal activity against the native flora of *kalakand* with a zone of inhibition of 11.67 ± 0.33 mm. The peptides were encapsulated using caseinates as an encapsulation wall material. Encapsulated and free proteins and peptides formulation (F4) showed killing activity against native flora of *kalakand* and significantly reduced bacterial growth after 2h of treatment and fungal growth in one day. Antimicrobial packaging material was prepared by coating protein and peptide Formulation 4 (encapsulated and free) on the cellophane membrane. The prepared antimicrobial packaging material was used to preserve *Kalakand*. The shelf life of the *Kalakand* was extended to 7 days at 37°C and up to 25 days at 4°C. Encapsulated peptides (F4) showed a better and more controlled release of peptides as compared to the free formulation (F4).

Application of Whey-derived Antimicrobial Bioactive Peptides for Biopreservation of Paneer and Khoa

Colostrum whey was fermented using *Lactobacillus rhamnosus* C25 and the ultra-filtered 10 kDa and 50 kDa peptide fractions exhibited good antibacterial properties against test bacteria. The highest antibacterial activity was exhibited by 10 kDa fermentate permeate followed by 50 kDa fermentate retentate. *Micrococcus luteus* was most sensitive with the lowest MIC of 0.24 mg/mL against 10 kDa permeate whereas *Salmonella enterica* was least vulnerable with the highest MIC of 0.55 mg/mL against 50 kDa retentate. Antifungal activity was exhibited only by 50 kDa fermentate retentate. Low molecular weight peptides did not possess antifungal properties. *Candida guilliermondii* was most sensitive with the highest MIC i.e. 0.646 mg/mL. *Aspergillus niger* was found least vulnerable with the highest MIC of 0.958 mg/mL. All peptide fractions had good thermal stability except 50 kDa retentate where the activity got partially reduced. < 10 kDa and >50 kDa fractions gave the highest zones of inhibition against natural flora of *paneer* and *khoa*. Best thermal stability was exhibited by low molecular weight peptides i.e. < 10 kDa. Antimicrobial proteins and peptides formulation F5 was incorporated in *paneer* and *khoa*. The formulation was applied to *paneer* and *khoa* by spraying (T2), direct addition (T1) and a combination of both (T3). The shelf life of both T2 and T3 *paneer* improved from 6 to 12 days at 7°C. At 37°C, T3 *paneer* was found microbiologically acceptable on 1st day whereas control was found spoiled on 1st day. The shelf life of T3 *khoa*

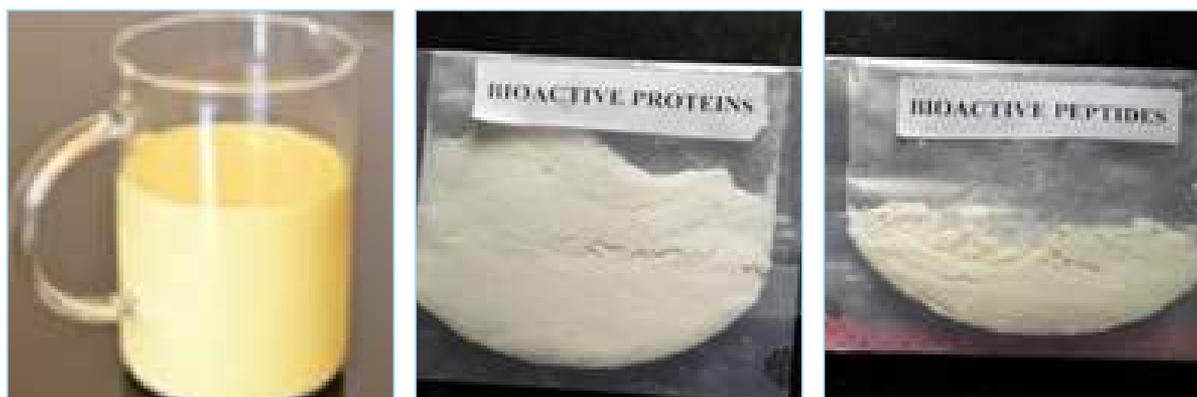
enhanced to 12 days at 7°C and up to 2 days at 37°C. The prepared antimicrobial formulation can be used for the preservation of various traditional dairy products. Moreover, the concentration of formulation could be further increased to obtain better results.

Products	Storage temperature	Control	Direct addition T1	Spray T2	Spray + Direct addition T3
days					
Paneer	7°C	6	9	11	12
Khoa	7°C	7	9	12	13



Buffalo Colostrum Proteins Derived Formulation for Diarrhoea Treatment in Weaning Mice

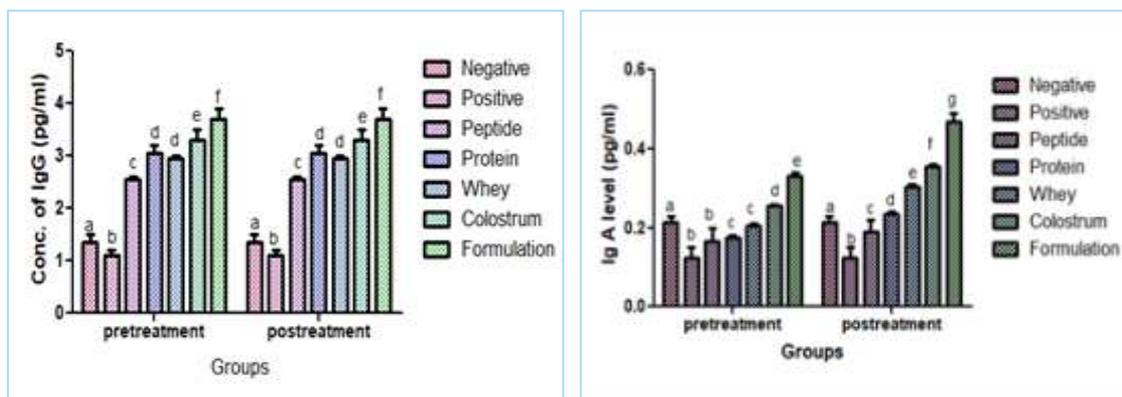
Colostrum whey fermentation by proteolytic lactobacillus cultures generated peptide fractions (10 kDa, 5 kDa and 3 kDa) in the range of 8.5 ± 0.05 to 3.01 ± 0.03 mg/ml. Smaller than 100 kDa protein fractions showed a significantly ($p < 0.05$) immunomodulatory effect i.e. % phagocytosis activity (55.02 ± 0.07) and % cell viability (52.02 ± 0.07) and minimum antimicrobial activity. Whereas, smaller than 10 kDa peptide fraction showed maximum antimicrobial activity (18.7 ± 0.8 - 15.3 ± 0.3) against all pathogenic *E. coli* strains with the MIC concentration of $4.06 \pm .003$ mg/ml. The peptide fractions showed disruption of the membrane by antimicrobial peptides and aggregation of *E. coli* cells by bioactive protein fractions. HPLC chromatogram revealed 134 peptides in 10 kDa fractions. LCMS/MS sequencing of <10 kDa peptide fraction showed multifunctional peptides such as antioxidant, antimicrobial, immunomodulatory and ACE inhibitory properties. Formulation containing bioactive proteins and bioactive peptides was prepared. The formulation showed a significant ($p < 0.05$) decrease in diarrheogenic infection against *E. coli* MTCC 723 (both pre-treatment and post-treatment) in weaning mice. Histopathological examination showed recovery of villi in the formulation feeding group. Whereas, other haematological and serum parameters such as ALT, AST and protein, urea and creatinine were also in range in the entire treatment groups. IgA and IgG were also significantly higher i.e. (3.5 ± 0.22^B - 3.7 ± 0.51^B) and 0.34 ± 0.52 - 0.49 ± 0.21 both in pre and post-treatment and translocation of *E. coli* count in different organs (liver, spleen and kidney) were also significantly minimum ($p < 0.05$) in formulation fed group as compared to other treatment groups. Therefore, the formulation of colostrum whey derived proteins and peptides was helpful in managing diarrhoea caused by diarrheogenic *E. coli* in immunocompromised mice



a. Colostrum

b. Bioactive proteins

c. bioactive peptides



IgG and IgA level

Role of *Lactobacillus rhamnosus* Fermented Cow Colostrum Whey Derived AMPs against Resistance Pathogens

Cow colostrum whey by microbial fermentation by *Lactobacillus rhamnosus* (C25) the peptide sequences in the <10kDa, <5kDa and <3kDa fractions. Some convenient and efficient *in silico* tools were used to identify peptides from LC-MS/MS data. Maximum antimicrobial activity was found in 10 kDa and 5 kDa permeate fraction against *Bacillus cereus* ATCC 13061 (24.33 mm), *Escherichia coli* ATCC 2592 (20.66 mm), *Enterococcus faecalis* ATCC 27736 (19.66 mm), *Staphylococcus aureus* (18.66 mm) and also have antimicrobial activity against resistant pathogens. Isolated AMPs <10kDa was found to have the highest antimicrobial activity against ESBL (Extended-spectrum beta-lactamases) (16.6 mm), and *Acinetobacter* 1379 (7.4mm). A total of 1234 peptide sequences were obtained by LC/MS-MS of which 43 bioactive peptides have a maximum score of 0.80 to 0.90 by peptide ranker. All the 43 bioactive peptides were screened on the basis of their predictive value for toxicity, allergenicity, gastrointestinal stability and intestinal epithelial permeability. Out of 43 peptides, 37 were predicted as antimicrobial peptides. These isolated antimicrobial peptides having sequence VLGPVRGPFIIIV, PPPPPPLL, SFMAIPPKK, MWPKILL, IDQLENNKTLGFIL, GPFPIIV, PNIPLPGF, QEPVLGPVRGPFPII VAPFPEVFG, and SQFLPYYPYAKPVA etc. and GAVKASAGGHPSVQLHGY were having an antimicrobial score of 0.8 each from the data generated, it may be concluded that the antimicrobial peptides released from cow colostrum whey by proteolytic *Lactobacillus* fermentation have application in the treatment of diseases caused by antibiotic-resistant bacteria.

Adaptive Evolutionary Engineering of *Kluyveromyces Marxianus* for High Ethanol Tolerance

Whey, a by-product of the dairy industry, is a substrate for fermentation for the production of bioethanol due to its high lactose contents (5%). Therefore, improved ethanol tolerance yeast is required to utilize high sugar whey for economical production of ethanol. Using adaptive evolutionary engineering techniques, the ethanol tolerance of yeast was done in this study. *Kluyveromyces marxianus* MTCC1389 was adapted up to 12% of ethanol in 110 days in YPL broth. The parent strain produced 8% ethanol, 0.4% trehalose, 4.3g/L cell biomass and residual lactose was 11% when grown in whey. Whereas, adapted strain was able to produce 11.5% (v/v) ethanol in whey medium containing 20% lactose with growth rate (μ_{\max} h⁻¹) 0.39±0.005 in 48 hr incubation at 37°C and 150 rpm. The residual sugar was 3.8% and trehalose content in adapted strain was 0.27% and cell biomass was 4.59g/L. The protein content in parent and adapted yeast were 0.81mg/mL and 0.69 mg/mL, respectively. Thus, the ethanol adapted *K. marxianus* MTCC 1389 strain was able to produce ethanol at a faster rate than the parent strain in whey with higher lactose (20%) and ethanol titer was found 32.1% higher than the parental strain.

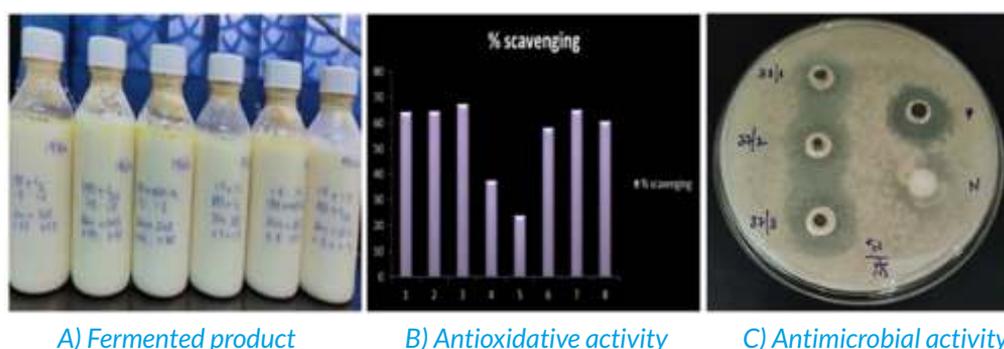
Antidiabetic Efficacy of Fermented Camel Milk

Camel's milk itself is proven for its anti-diabetic potential but the anti-diabetic properties of camel milk reduce with the exposure of temperature. Proteolytic *Lactobacillus* cultures isolated from camel milk are more suitable for the development of fermented camel milk that will be helpful for Diabetic persons. Total 188 strains of lactic acid bacteria have been isolated from camel milk. Among them, only 23 were selected on the basis of primary screening and proteolytic activity. Among them, RL4, RZ18, LG12 and NCDC24 strains are most suitable for camel milk fermentation for their acidity development property. These strains also have good antioxidative, -

glucosidase and DPP-IV inhibitory as well as antimicrobial activities against Gram-positive (*Staphylococcus aureus*, *Bacillus cereus*, and *Enterococcus faecalis*) and Gram-negative (*E. coli* and *Salmonella Typhi*) pathogens. A drinkable fermented camel milk has been prepared using whey protein, casein and gum acacia.

Preparation of Biofunctional Lactic-yeast Fermented Milk

Lactobacilli cultures (*L. acidophilus*, *L. rhamnosus*) and two yeast cultures (*K. marxianus*, *S. cerevisiae*) were used for the preparation of the lactic-yeast fermented milk. The cultures showed evident antibacterial activity, acid and alcohol production individually and in combination when grown for 24h at 37°C. Around 1% alcohol was produced by the yeast cultures in cow milk at appropriate incubation conditions. Further, the biofunctional properties like antimicrobial and antioxidative activities were also shown by the resultant fermented product. Co-incubation of lactobacilli with the yeast results showed a stronger antioxidant activity. Optimized conditions of 1% lactic culture and 3% yeast culture as the best combination in terms of antioxidant, antimicrobial and ACE-inhibitory activity etc. A significant improvement in the body weight and feed and water intake other parameters were shown in the Swiss albino group fed with optimized product in comparison to other groups after treatment with ETEC *E.coli* strain.



Development of Immunomodulatory Exopolysaccharides Containing Healthy Fermented Dairy Foods

Phagocytosis experiment revealed that EPSWHW1, EPSKri 3, and GOV5 showed greater macrophage activity. Among all the EPS, EPSWHW1 exhibited highest rheological and immunomodulatory properties. HPLC analysis showed that EPSWHW1 was a heteropolysaccharides comprising glucose and mannose, latter in a higher proportion. FTIR spectra revealed various groups in a EPSWHW1 that might contribute to functionality of EPS. NMR analysis indicated presence of alpha 1-4 linkages and glycosidic bonds in EPSWHW. Based on the results obtained from Textural analysis, addition of EPSWHW1 50 mg/ml improved Textural properties of FMP. Even though, EPSWHW1 50 mg/ml had shown better viscosity values than NCDC75 and β -glucan in the flow curve analysis, its firmness and consistency values were found to be lesser than the remaining samples. Oscillatory rheology indicated that WHW1 sample had highest G' and G'' values followed by EPSWHW1 200 mg/ml and β -glucan throughout the frequency range (0.1 to 10 Hz) employed during frequency sweep analysis. Storage and loss modulus indicated shear thinning behavior of FMP made by EPSWHW1. Upon increasing concentration of EPSWHW1, gel strength was increased. Addition of EPSWHW1 at 100 mg/100 ml showed nearly similar results to β -glucan used at 100 mg/100ml and higher when used at 200 mg/100ml.

Isolation, Identification and Characterization of Lactic Acid Bacteria (VTCC-ICAR Network project)

A total of 23 LAB isolates were obtained from homemade curd samples collected from different places in Haryana. The samples were processed and appropriate dilutions were plated on MRS and M17 agar media. Typical LAB colonies were transferred into MRS or M17 broth and sterilized RSM (12%, w/v). Based on the curdling pattern and phenotypic characteristics, 14 were rod shaped while 09 were cocci shaped bacteria. Phenotypic identification indicated that the LAB isolates belongs to *Lactobacillus*, *Streptococcus* and *Lactococcus* genus. In addition, few LAB strains producing biomolecule were evaluated for functional attributes mainly iron binding capability. Out of eight, three strains namely *L. rhamnosus* VTCC DM0000656B (Ram12), *L. rhamnosus* VTCCDM 314B (Kar1) and *L. fermentum* VTCC DM0000311B exhibited greater iron binding (>60%) with iron salt i.e. ferrous sulphate. EPSNDC400 showed higher zeta potential than EPSRam12 and EPSKar1. Purified EPSs contained higher amount of sugar ($92.35 \pm 3.33\%$) and negligible amount of protein ($0.38 \pm 0.12\%$) as compared to

crude EPS. Three EPSs showed presence of group such as C=O, and S-O group by FTIR analysis which might be assisting in iron binding ability of the strains.

Isolation and screening of bacteriophages for Removal of *Bacillus* and *Geobacillus* biofilm from Dairy Surfaces

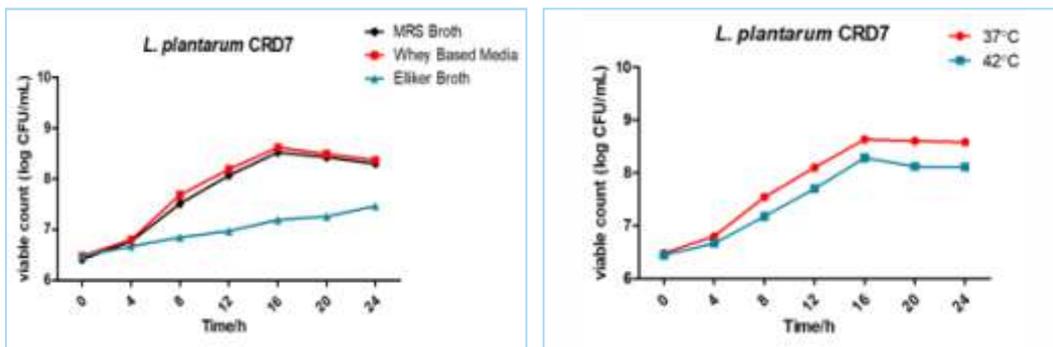
Using plaque and spot assay, 10 phages, 7 for reference strains and 3 for isolated *Bacillus licheniformis* strains were obtained. In the case of *Geobacillus* sp. 3 phages for reference strains and 24 phages for *G. stearothermophilus* strains were isolated from the samples such as pasteurizer section, powder plant and other sources. All the isolated phages were purified by repeatative plaque formation technique followed by propagation and storage in SM buffer at -20 °C. For further characterization of phages, titre estimation was performed for BL and GS phages which ranged between 10^8 to 10^{10} PFU/ml. Lytic assay indicated that majority of the phages showed lytic nature. The *B. licheniformis* phage designated as ADM2 formed bigger plaques of size around 0.90 ± 0.096 mm, Phage ADM1 and ADM4 formed medium size plaques 0.60 ± 0.113 to 0.65 ± 0.008 mm and Phage ADM6 formed smaller plaques of size around 0.30 ± 0.014 mm. Phages ADM1, ADM4 and ADM6 were shown broader host range amongst the *B. licheniformis* phages. *G. stearothermophilus* phages such as GBS16, GBS1, GBS9, GBS11 and GBS12 shown broader host range and were able to show lysis in some *Bacillus* species. However, it was found that in general GS phages as compared to BL phages have comparatively lower host range among the studied hosts.

In Vitro Immunomodulatory Activity of Custom Synthesized Peptides Derived from *Lactobacillus Rhamnosus* NCDC24 Fermented Milk

Immunomodulatory activity of four synthesized peptides (VLPVPQKA, ALPMHIR, AGWNIPM, and YLGYLEQLLR) from *L. rhamnosus* NCDC 24 was investigated. These peptides were selected from 1-3 KDa of peptide fraction by *in silico* approach using BIOPEP-UWM database. AGWNIPM, ALPMHIR, VLPVPQKA, and YLGYLEQLLR scavenge 2,2'-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) free radical, with half maximal inhibitory concentration (IC₅₀) value of 69.49 ± 0.43 µg/mL, 281.54 ± 4.15 µg/mL, 336.17 ± 1.04 µg/mL, and 87.62 ± 0.63 µg/mL, respectively. Further, the immunomodulation potential of strong antioxidant peptides (AGWNIPM and YLGYLEQLLR) was evaluated in mouse peritoneal macrophages challenged with lipopolysaccharide (LPS), a potent pro-inflammatory stimulus. All the peptides concentration (12.5, 25, 50, 100, and 200 µM) did not show cytotoxic effects as compared to the control cells. Two peptides AGWNIPM and YLGYLEQLLR significantly increased ($P < 0.001$) the anti-inflammatory cytokine (IL-10) and reduced the nitric oxide (NO) generation in LPS-stimulated mouse macrophages in a concentration dependent manner. The phagocytic activities of macrophages treated with peptides (AGWNIPM and YLGYLEQLLR) increased significantly ($P < 0.001$) with increase in concentration of peptides ($P < 0.001$). Therefore, the findings support the potential use of multifunctional peptides in the development of new antioxidant and therapeutic agents for immunomodulation.

Development of Cost Effective Whey Based Medium for Probiotic Biomass Production

Lactic starters act as heart of fermented milk manufacturing industry. Conventional propagation of starters is cumbersome which also encounters contamination that result economic loss due to poor quality fermented milk products. Observations on compatibility by agar well diffusion assay of probiotic lactobacilli revealed their compatibility to each other as no zone of inhibition around wells was observed, hence these strains can be used for preparation of multiple probiotic DVS dairy starters for manufacture of probiotic fermented dairy foods. For preparation of probiotic direct vat sat (DVS) starters cost effective whey based medium (WBM) was developed by supplementation of nutrients. The WBM is about 1/5 cost as compared to commercial growth media. Developed WBM was compared with MRS and Elliker media for growth performance of selected 13 strains of *Lactocaseibacillus rhamnosus* and *Lactiplantibacillus plantarum* by recording optical density, pH and viable counts at 4 h time interval of incubation upto 24 h. The WBM showed almost similar growth performance of selected strains as that of MRS which was superior to Elliker. Thus, WBM was selected for further investigations w.r.t. optimization of incubation temperature and time, initial pH and inoculums levels. Incubation temperature and time of 37°C/16 h was optimized for *L. plantarum* CRD7, *L. rhamnosus* CRD9, *L. plantarum* HD48 and *L. plantarum* HD51 as it resulted higher growth performance. However, it was 37°C/20 h in case of *L. rhamnosus* CRD11 and *L. rhamnosus* CRD14. Highest biomass production was recorded at 2 percent inoculums level under optimized conditions of incubation temperature and time of 37°C/16-20 h. Maximum probiotic cell biomass was documented at pH 6.5. Thus, optimized cultural growth conditions for selected probiotic lactobacilli were: growth media (WBM); incubation temperature and time (37°C/16-20h), initial pH 6.5, and inoculums level 2 percent.

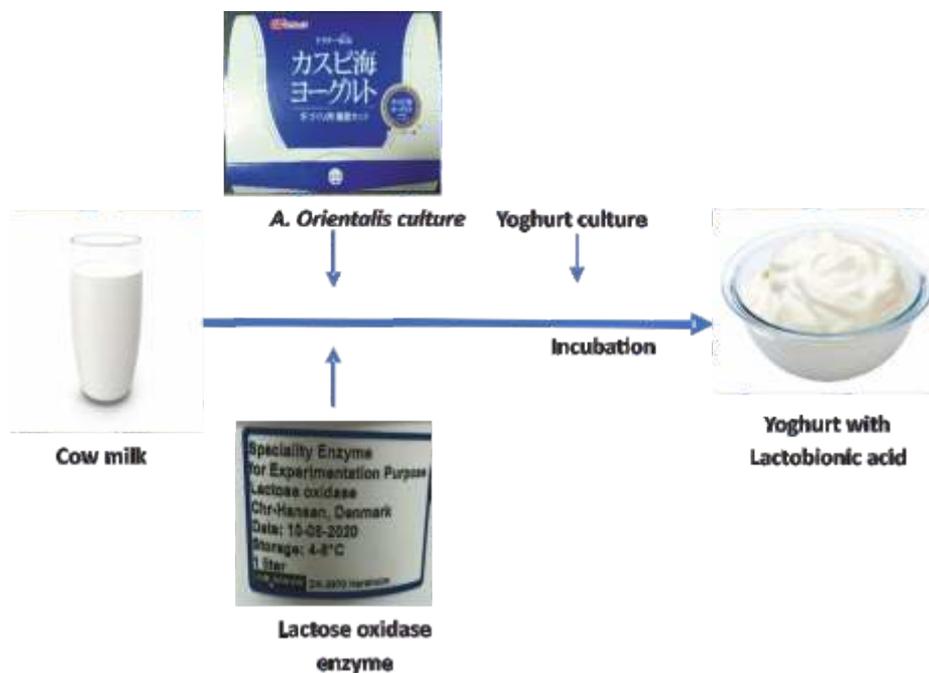


Effect of growth media, incubation time temperature on viable counts of probiotic *L. plantarum* CRD 7

Lactobionic Acid Enriched Yoghurt

In-situ Lactobionic acid enriched yoghurt was manufactured using starter culture or lactose oxidase enzyme. The aim was to manufacture yoghurt with improved calcium absorption. Process parameters have been optimized for maximizing lactobionic acid production in yoghurt (Photo given below; also being sent separately in JPG format: Photo 2). Efficacy of the product to improve calcium absorption is to be studied.

Schematic representation for manufacturing yoghurt with lactobionic acid Development of Milk-Flaxseed



based Probiotic Beverage for Female Health

Milk-flaxseed based Fermented food products containing probiotic organisms can be a very attractive option for overall health management of female population. The research project aimed to develop a beverage for female health. Roasting operation significantly improved the nutritional quality of flaxseed flour by reduction of antinutritional level, and improved the aroma and sensory quality of the flaxseed flour. The respective phytoestrogen level (SDG) content of raw and roasted flaxseed flour were 10.44 and 10.32 mg per g of flaxseed as observed by HPLC analysis. Probiotic organism *Lactobacillus rhamnosus* (RSI 3) was selected based on maximum specific growth rate (k) and minimum generation time (t_g) in the milk medium. The fermentation time was restricted to 10 h by increasing the inoculums level in order to achieve quick fermentation. The optimized product was having 3.12% of roasted flaxseed flour. The beverage was having 2.59% of fat, 4.465% of protein with a probiotic count of 108 CFU/ml of beverage. The SDG content of product calculated as 32.14 mg per 100 mg of product. (The work had been conducted under the DST funded project DST/SEED/WS/58)



Milk-Flaxseed based Probiotic Beverage

Field Level/Large Scale Trial of 'Technology of Haldi Ghee from Cow Milk' and 'Technology of Haldi lassi'

Haldi (Turmeric) is a famous Indian spice that possesses numerous functional/biological attributes such as immunostimulatory, antiviral, anti-inflammatory, anti-Alzheimeric, antioxidant, antidiabetic, antibacterial, hypotensive, hypocholesteremic, etc. The technology developed at lab scale for incorporation of turmeric and curcumin (the principal biologically active compound present in turmeric) in ghee and *lassi* was conducted at the large scale to ascertain the efficacy of developed technologies in the dairy industries. Creamery butter method was found to be the most suitable method for the preparation of turmeric fortified cow ghee. For *haldi lassi* preparation, a blend of curcumin and *haldi* powder added to the curd along with sugar syrup. The product developed may possess higher anti-oxidant activity in terms of free radical scavenging ability as compared to the conventionally prepared products. Diet containing turmeric fortified products may also have hypocholesterolemic effect in terms of reduced total serum cholesterol, serum triglyceride, LDL, VLDL-cholesterol and atherogenic index and increase in HDL- cholesterol level. Thus, the developed product (*haldi ghee and haldi lassi*) may possess great potential as a 'functional products' with anti-oxidative and hypo-cholesterolemic activity because of the addition of natural functional ingredients from *haldi*.



Haldi ghee and Haldi Lassi prepared at Experimental Dairy Unit, NDRI

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Development of vitamin B₁₂ Rich Ready to Reconstitute Milk-cereal Based Composite Nutrimix

P. freudenreichii isolated from Emmental cheese was inoculated into composite milk cereal based composite medium and incubated under anaerobic condition and aerobic conditions. The optimization of fermentation medium was done using D-optimal factorial design. The optimized medium recorded the highest B₁₂ content of 40.15mg/100g. The optimization of vitamin B₁₂ rich composite nutrimix was carried out using D-optimal mixture design technique. The optimized formulation produced sensorially superior product with good reconstitution properties. The ready to reconstitute nutrimix developed recorded Vit. B₁₂ content of 16 mg/100g, 13.5% protein and 2.19% fat.

Development of Sorghum Incorporated Protein Rich Composite Dairy Dip

In view of low glycemic index and good phytochemical content of sorghum, its malt having reduced phytic acid content which is an anti-nutritional factor, was utilised in formulating a composite dairy dip. In this study, eight ingredients were used. Out of these, proportions of water (31%), salt (1%) and matured Cheddar cheese (3%) were kept constant based on preliminary studies, and the proportion of others were optimized by conducting experiments in I - optimal mixture statistical design. The optimized formulation of the composite dip was: milk protein concentrate: 5.4%, sorghum malt: 4.2%, curd: 38.8% trisodium citrate: 1.5% and butter: 15.2% and the above-mentioned fixed ingredients. The processing parameters optimized were: heat treatment 80°C for 2 min and high-speed shearing 15850 RPM for 82 sec. The developed composite dip has protein, fat, carbohydrate, ash, crude fibre content of 9.45%, 12.21%, 6.12%, 2.93%, 270 mg/100gm, respectively. The developed dip was analyzed for physicochemical characteristics. The studies indicated that the composite dip packed in 100 g polystyrene cups had a good shelf life up to 16 days at refrigerated temperature.

MECHANIZATION AND PROCESS ENGINEERING

Development of Low Cost Farm Level Milk Cooling System

The developed milk cooling system was found effective in enhancing the milk cooling performance and reduces the cooling time of milk. Optimization of heat transfer process between refrigerant and milk, as well as between air/water and refrigerant was done. The prepared refrigerant by using different ratio of various chemical compositions could be used as the thermal energy storage material in milk cooling system. The power consumption is also proportional to the cooling time and it was reduced, since the cooling rate of milk increased in the developed milk cooling system. The various composite subzero temperature liquids (CSZTLs) were prepared and the thermal and physical properties were determined. Performance evaluation and analysis of the developed low cost milk cooling system was done after the initial trials conducted for the transient cooling of milk. The characteristic features of the developed low cost milk cooling system at farm level are saving of time, energy, labour and hence the overall cost of milk cooling. The developed system could be useful to small and medium dairy farmers at farm level.

Development of Mechanised Feed and Fodder Distribution and Feeding System

The physical and engineering properties of selected feed materials (oats green, wheat straw and concentrate mixture) were determined. The conceptual diagram of proposed feed and fodder distribution wagons were finalised. The details about the structure and dimensions of proposed feeding system for cattle were finalised. Bulk density of Oat straw, Wheat straw and concentrate mixture were 455.03 ± 11.52 , 40.42 ± 1.76 , and 504.25 ± 1.82 kg/m³, respectively. The moisture content of Oat straw, Wheat straw and concentrate mixture were determined as 64.27 ± 11.45 , 12.07 ± 0.88 , 11.74 ± 0.71 %, respectively. Two green fodder wagons and one grain wagon were selected for centre of gravity determination. Centre of gravity was determined at empty condition. The position of centre of gravity behind front wheel axle (X_{cc}), above the ground level and midway between the wheels (Y_{cc}) and height of centre of gravity from the line joining the front and rear axles (Z_{cc}) were determined.

Development of Automatic Integrated Hybrid Solar System for Fermented Dairy Products

Conceptual diagram of the proposed Hybrid Solar system, detailed CAD drawing with dimensions of thermal cabinet and flat plate solar collector were finalized. The assembled integrated hybrid solar system with data logger was installed on the roof top and preliminary data on the performance of solar collector were collected. Fixing the GI sheet and spraying of Black paint on the top surface of the GI sheet (Black-body: Higher Absorptivity) was accomplished. The design aspects of Solar Thermal Cabinet were evaluated; fabrication of the wooden frame for panel, holes provided to fit the connecting pipe for convection of hot air to the insulated cabinet, Hinge fitting for glass cover over the Flat plate solar collector were completed. Angle of elevation, $\tan^{-1}(p/b)$, for $\theta = 22.5^\circ$, $\tan(22.5^\circ) = 0.4142 = (4.142/10)$ and dia.=4.25 inch of circular hole, GI-sheet fitted in wooden (tapered) solar-panel as per the angle of elevation height of wooden stand was fixed. The fabrication of solar thermal unit and Sample placement shelf was completed.



Development of Multipurpose Automatic Controlled Rate Heating System for Production of Paneer and Greek Yoghurt

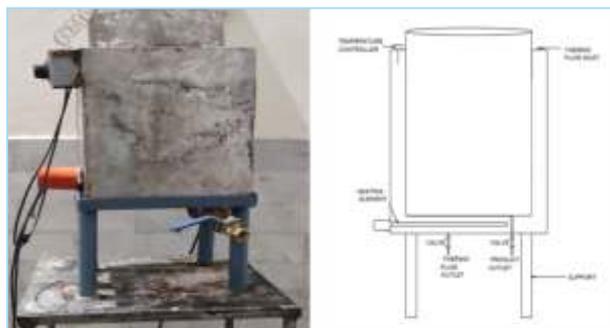
The feasibility study of fabricated prototype (5 kg capacity) for milk heating using controlled rate heating technology was planned for its conduction. The controlled heating rate and agitator speed had significant effect on temperature profile during heating & cooling of milk and reduces the fouling problem. The effect of different heating methods on quality characteristics of yoghurt was also considered.

Development of Improved Bioreactor Prototype for Cattle Waste Management

Simulation program was developed to determine various rheological properties viz. viscosity, activation energy and consistency coefficient of manure slurry for better understanding of bioreactor process dynamics. Different rheological properties of cow manure slurry under dynamic conditions were determined. Equation AFE1 produced excellent outcomes with high activation energy $E_a = 225 \text{ J/mol}$ as compared to other equations. Manure slurry can be prepared in the system with the help of rotor blade assembly and can also be prepared externally.

Development of Thermic Fluid Based Small Scale Mechanized Process Unit for Rasogolla Cooking

Different components required were identified for the fabrication of the prototype for studying heating pattern of thermic fluid. Heating element was selected among available designs with given power rating. U-type heating element with variable power rating was selected (out of rod shaped, micro-tubular, coil shaped and U shaped heating element) based on convenience for use in the developed system and the same was procured. Bimetallic temperature sensor based thermostatic controller was also procured along with SS304 plate and ball valve. The CAD drawing and images of the fabricated prototype during and after fabrication were prepared. Therminol-55 was selected as the thermic fluid based on required thermal and flow properties. Experimental setup for determination of heating rate, thermal efficiency, total heat load and power consumption for heating pattern studies of thermic fluid, was designed and fabricated.



Development of Magnetic Induction based Milk Heating System for Paneer

Conceptual diagram and prototype of magnetic induction heating (MIH) unit was finalised. Details about major components of MIH and its selection criteria were identified. Trials were conducted using water in the developed prototype of MIH unit. The energy efficiency of conventional milk heating process for paneer making was also calculated.

Development of Inline Milk Coagulation cum Coagulum Pressing Unit for Paneer Manufacturing at Small Scale

Design calculations for different components of the inline system were completed including vessel capacity, heater rating, required heat and time for water and milk heating, critical insulation thickness and cylindrical shell thickness etc. Preliminary trials of paneer making were done on paneer making gadget and it was observed that heating temperature of water to 98-99°C is required for heating of milk up to 90°C.

Optimization of Ultrasonication and Microwave Process Parameters for Extraction of Phospholipids from Ghee Residue

Optimization of ultrasonication and microwave process parameters was carried out for extraction of phospholipids from ghee residue. Taguchi orthogonal array design was followed for optimization of ultrasound power, treatment temperature, time and solvent: solid (S:S) ratio with phospholipid content and antioxidant activity as the response variables. The phospholipid content and antioxidant activity of the extracted samples varied from 18.54 to 23.89% and 47.01 to 50.64%, respectively. The power level of 80%, 80°C temperature, S:S ratio of 15 and 4 minutes of sonication resulted in maximum extraction of phospholipids (24.12%).

Through one factor at a time approach, levels for microwave operational parameters were established as power (540, 36 and 180W), time (40, 50 and 60s) and S:S ratio (5, 7.5 and 10 w/v). Using Taguchi optimization technique, parameters were optimized as 540 W power, 60s of treatment time and 7.5 S:S ratio for phospholipids yield. At optimized level of operation, the phospholipids yield was reported as 21.84% on dry fraction basis.



Fig. Ultrasonication of pre-treated ghee residue for extraction of phospholipids

Process Technology for Convenience Mix for Kheer and Phirni

Product formulation and process parameters for a convenience mix of *Kheer* and *Phirni*, two variants of rice-based milk pudding, were standardised. The mixes were formulated with optimized combination of rice, milk solids and sugar. The mix was prepared using a dry-crystallization method in a custom designed mechanical vat, for which the process conditions of steam pressure, rotor speed and process time were optimised using Response Surface Methodology. The reconstitution protocol for the product was also standardised by cooking the mix in milk for 10-15min. The reconstituted product scored high for sensory acceptance (with a score >7.5) during its consumer acceptability trials. Stability of the product evaluated based on physico-chemical, microbial and sensory properties indicated a shelf life of 6 months under ambient conditions, when packed suitably.

Development of a Single Screw Perforated Extruder for Whey Drainage and Paneer Pressing

A single screw perforated extruder for whey expulsion and *paneer* pressing was conceptualized and designed considering the data determined using consolidation studies on test cells and with basic engineering calculations and stress analysis. A customized die with heat exchanger was designed and integrated to the unit for blocking and cutting with cyclic timer to aid in texturizing the coagulum. The process parameters for preparation of *Paneer* in the developed single screw extruder was optimized using Taguchi L_{18} ($2^1 \times 3^2$) experimental design. The product obtained was analysed for rheological parameters, moisture, colour profile and sensory scores for optimization. The product characterization and rheological properties produced under optimized conditions in the developed machine were comparable to the conventionally prepared *paneer* samples. The developed machine is suitable for retail manufacturing of *paneer* on a small to medium scale enterprise.

Microencapsulation of Probiotic Bacteria by Spray Drying

Microencapsulation of *L. rhamnosus* and *L. plantarum* was attempted to improve the viability and survival rate of microorganisms by spray drying. Suitable wall material, lyoprotectants were used along with prebiotics. Spray drying of the lactic acid bacteria was done at inlet air temperature of 170°C temperature, 50 Nm³/h flow rate and feed flow rate of 4 mL/min. The survival percentage after spray drying and viability during storage were determined. The probiotic properties of both microorganisms such as acid and bile salt tolerance, live-dead assay of microorganisms, catalase test and fermentation kinetics were studied. The morphology of encapsulated probiotics was also studied.

Development of Portable Machine for Cutting Block of Frozen Untempered Butter

A portable machine for cutting a block of frozen untempered butter was developed. The machine comprises of isothermal blades, a process control system, a pressure plate, one or more pneumatic cylinders, and a movable trolley. The block is mechanically driven against the isothermal blades equipped with Joule heating element for in place heat generation. A programmable logical controller-based control system controls the surface temperature of the blade set, through one or more silicon-controlled rectifiers and electromechanical control elements, for cutting the block of frozen butter without prior thawing or tempering. The pressure plate uniformly distributes the pressure on the butter block for developing and maintaining contact pressure at the cutting edges. The movable trolley collects pieces of frozen butter as well as molten liquefied fraction of the block of frozen butter during cutting process.

RISK ASSESSMENT AND NEW GENERATION METHODS TO ASSESS THE QUALITY AND SAFETY OF MILK AND MILK PRODUCTS

Development of Strip-Based Test for detection of Sub-clinical and Clinical Mastitis in Milking Animals

Mastitis is a major problem affecting all milk producing animals worldwide and is one of the chief reasons for decreased milk quality. Mastitis is the inflammation of udder. Milk from mastitis animals cannot be used for human feeding because it has altered chemical configuration and organoleptic properties. It results in increase in somatic cell count, decrease in lactose and endogenous milk proteins such as caseins, upsurge in the level of whey proteins, decreased fat quality and alteration in the blood-milk barrier which result in outflow of blood components, serum proteins and salts into milk. Additionally, milk from diseased animals undesirably affects the milk shelf-life and processing of final products. Dairy Farm is looking forward for real time field level Technology for routine monitoring of mastitis in milk. Enzyme based kit developed on paper strip under INDIA-UK DOSA project funded by DBT, at NDRI, employs enzyme substrate principle. The kit is superior over existing prior art especially in terms of sensitivity, selectivity, stability, color development etc.

A paper strip test for the detection of mastitis in milking animals was developed at ICAR-NDRI which is based on the principle of enzyme-substrate reaction. A marker enzyme found in somatic cells react with the chromogenic substrate present on the paper strip, as a result, colorless paper strip shifted to blue color. Development of blue color on the strip indicates mastitis in the milking animal. The developed test is very cheap and user friendly which includes the dipping of the developed test strips into the fresh milk and incubate at 45°C for 15-30 minutes. If the color develops in 15 minutes indicates clinical mastitis and color development in 30 minutes indicates subclinical mastitis. The color intensity also differs in clinical and subclinical mastitis. In the case of clinical mastitis, the color intensity will be high while in subclinical mastitis the color intensity will be low.

Novel Features

- Test detects subclinical and clinical mastitis based on cell count within 30 min with differentiation in color development on strip.
- Test is cost effective, robust, reproducible, sensitive, selective with no interference of inhibitors & No false positive/negative results.
- The results are obtained in 30 min with semi-quantitative information on somatic cell counts.
- Test has been validated with reference Somatic cell counter.
- Technology can be used for routine monitoring of mastitis in raw milk at dairy farm/ farmer level in village, milk collection center (s) and dairy reception dock of dairy plant.
- Stability of test strip is up to 6-7 months under ambient storage in vacuum packed condition.

Validation of developed mastitis strip results with Somatic cell counter: Using digital somatic cell counter 400 samples were evaluated. Based on these findings the comparative data of both developed strip results and their somatic cell counts were presented in the Table.

Validation of developed mastitis strip results with CMT: The 653 results of the developed mastitis test were compared with CMT.

The developed mastitis strip has an accuracy of 89.89%, precision of 0.96, sensitivity to 66.84%, and specificity of 98.9%.

Validation of developed mastitis strip results with EMCCD: The 653 results of the developed mastitis test were compared with EMCCD

Table Comparison between Somatic cell counter results and Developed enzyme strip results

Somatic Cell Counter Results (count in range)	Developed Mastitis Strip test result		
	Normal	SCM	CM
< 5 Lakhs (250)	247	2	1
5- 10 lakhs (48)	4	44	
10-20 lakhs or above (102)		4	98
Total (400)	251	50	99

Table Comparison between CMT and developed enzyme strip results

CMT Score Results	Developed Mastitis Strip test result		
	Normal	SCM	CM
0, trace & 1 (469)	464 (91.3%)	4 (5.1%)	1 (1.5%)
2 (91)	33 (6.5%)	58 (73.4%)	0
3 (93)	11 (2.2%)	17 (21.5%)	65 (98.5%)
Total (653)	508	79	66

Table Comparison between EMCCD and the developed enzyme strip results

Average somatic cell counts	Normal	SCM	CM
0-75 (504)	503 (99.01%)	0	1 (1.51%)
76-200 (81)	5 (0.99%)	76 (96.20%)	0
>200 (68)	0	3 (3.79%)	65 (98.48%)
Total (653)	508	79	66

In terms of Average somatic cell counts the developed mastitis strip has an accuracy of 98.6%, precision of 0.99, sensitivity to 94.6%, and specificity of 99.8%.

Validation of developed mastitis strip results with PortaSCC quick test: About 225 results of developed mastitis strip results were compared with PortaSCC quick test results and the data was presented in Fig. 4. These evaluated results were compared with developed mastitis strip and the data was represented in the tabular form in the Table 4. 143 results were in the range of < 5 lakh cells/ml in which 140 results were TN and 1 were FP. 34 samples were in the range of 5-10 lakh cells/ml in which 5 results were FN, 27 were TP and 2 were FP results. 50 samples were in the range of 10-20 lakh cells/ml or above, in which 14 were FN and 36 were TP.

Table : Comparison between Porta SCC and Developed enzyme strip

SCC Range	Normal (148)	Sub-clinical (39)	Clinical (38)
< 5 Lakhs (141)	140	1	0
5- 10 lakhs (34)	5	27	2
10-20 lakhs or above (50)	3	11	36
Total (225)	148	39	38

A total of 197 enzyme strip findings out of 225 samples matched with PortaSCC results. In terms of PortaSCC quick mastitis test the developed enzyme strip has an accuracy of 90%, precision of 0.95, sensitivity to 76.8%, and specificity of 98%.

Concept on Rapid Assay for Detection of ESBL, AMPC β -lactamase and Carbapenem Resistance in *E. coli* in Milk

The present invention was aimed to develop rapid colorimetric antibiotic sensitivity test for detection of ESBL, ACBL and Carbapenem resistant *E. coli* using the selective nutrient media and targeting specific marker enzyme activity. Current Global guidelines by FAO, CAC, WHO and EFSA recommend *E. coli* as an indicator organism for antimicrobial resistance in gram-negative bacteria. The developed assay is working on the principle of growth of β -lactam resistant *E. coli* in a specific nutrient media and interaction of its marker enzyme with specific chromogenic substrate which indicates the presence or absence of ESBL / ACBL / Carbapenem resistance in *E. coli*. The assay primarily involves two steps i.e., Preparation of Antibiotic disc functionalized with *E. coli* selective medium (ECSM) and chromogenic substrate and second step involve addition of functionalized antibiotic disc in *E. coli* culture tube. The change in color from light yellow to bluish green within 5 hours of incubation indicate the presence of β -lactam resistant *E. coli*, whereas no change in color suggested the absence of β -lactam resistant *E. coli*. Shelf-stability of Disc based assay was up to 6 months under vacuum

packaging conditions when stored at -20°C . Altogether, the developed assay is cost-effective, rapid (5-6 h), user-friendly and would be of immense use for AMR based screening of dairy farm animals. Under one health approach the developed technology can be applied in rapid diagnosis of *E. coli* from dairy, health, fisheries, poultry, environment and any healthcare sector, where it will help in the correct prescription of antimicrobials and hence the usage of antibiotics will be reduced. The novel features of the developed marker enzyme based assay have been filed in the form of an Indian patent with title "Rapid Antimicrobial susceptibility assay for detection of Extended spectrum β -Lactamase, Ampicillinase C- β -Lactamase and Carbapenem resistance in *E. coli* isolated from milk" with application no. 202111007462.

Novel features of Rapid AST assay

The present invention is superior over existing prior art due to following reasons:

- A rapid, cost effective test in Disc based format with visual color based interpretation.
- Rapid AST assay for detection of ESBL, AmpC β -lactamase and Carbapenem resistant *E. coli* within 5 hours under similar optimization conditions.
- Provide information about Resistant/Sensitive pattern of *E. coli* at antibiotic breakpoint concentration employing CLSI guidelines.
- Developed assay detect β -lactam resistant *E. coli* directly from cell colonies without going for multiple enrichment and processing steps like cell lysis, centrifugation and culture washing.
- The assay results can be detected visually. No requirement for special equipment's and trained personnel to read results. Appearance of blue color indicates growth of β -lactam resistant *E. coli* whereas no color change indicates no growth and absence of β -lactam resistant *E. coli*
- As "one health approach" the developed Disc based assay will be helpful in rapid diagnosis of *E. coli* in health sector, animal sector and environment sector.
- Developed assay was successfully evaluated and validated with the conventional Kirby-Bauer disk diffusion susceptibility test and automated BD phoenix system.
- Developed assay demonstrated no false-positive results with the non β -lactamase, non-ESBL, non-Carbapenemase producing *E. coli*
- The developed test is reproducible, robust, sensitive and shelf-stable up to 6 months in vacuum packaged conditions when stored at -20°C .
- The antibiotic, nutrient media and chromogenic substrate were functionalized on the same disc and thus making a rapid, miniaturized, and cost-effective method.

Technology on Antibiotic Residues Screening in Fish, Shrimp & Feed Samples using Spore Based Kits

Spores based kits working on spore germination principle for detection of antibiotics have been developed successfully at ICAR-NDRI. In India –UK project, our aim was to extend its scope to aqua-products like feed, shrimp powder, fresh fish and prawn. Spore based kits were produced for optimization and evaluation work on presence of antibiotics in Feed, fish, prawn and shrimp powder. Sample preparation parameters like sample quantity, reconstitution ratio, centrifugation speed/time for Feed, Shrimp Powder, Fresh Fish and additional steps like filtration through $0.2\ \mu\text{m}$ tips & heating at 80°C for 5 min in case of fresh Prawn samples were optimized. Quantities of sample and incubation time steps were also optimized for kit assay protocols. LODs for 13 antibiotics in Feed, Shrimp Powder, Fresh Fish and Prawn samples were attained by evaluating the optimized protocols of spore based kits after spiking the samples at their MRLs. LODs obtained with DPA kits are better compared with strip based test. In majority of cases LODs were complying with regulatory limits. The optimized protocols developed for Feed, Shrimp Powder, Fresh Fish and Prawn were evaluated with 33 samples received from CIFT, Kochi and Karnal using spore based kits. All the samples were found negative (below the MRL) with Spore based kits. Samples received from CIFT–Kochi in all categories were also found negative with ELISA based kit when tested at CIFT, Kochi Lab. The working protocols developed for feed, fish, Prawn and Shrimp Powder with Spore based technology will be useful in exploring these kits in "Aqua-products" apart from dairy sector. Currently comprehensive third party / external lab validation using ELISA/LC-MS technique is under process at CIFT Kochi.

Technology on Spore Based Strip for Rapid Detection of β -Lactam Group in Milk

Paper Strip assay has been developed for the specific detection of β -lactam group of antibiotics in milk which works on the induction principle. In *Bacillus* spores, specific enzyme is induced in presence of inducer i.e. β -lactam antibiotics. A chromogenic substrate having β -lactam ring functionalized on strip undergoes color

change from yellow to red due to hydrolysis of amide bond by specific marker enzymes induced in spores in presence of β -lactam antibiotic present in milk and detection of antibiotic is done based on color change of chromogenic substrate from yellow to red. Kit has capability to detect all beta lactam group of antibiotic at MRL limits set by codex/FSSAI standards and is superior over existing strip based tests.

Novel features:

- Kit can detect all β -lactam group as specified by FSSAI / CODEX / EU \leq MRL level
- Test can detect the presence of β -lactam group within 1 hr and it is highly selective & sensitive for target group of antibiotic residues.
- No interference of non- β -lactam group, pesticide, aflatoxin M1, heavy metals and other inhibitors (sodium hypochlorite, hydrogen peroxide, detergent and formalin) was observed in working of strip based test.
- Test is cost effective (Rs.30 per test), rapid, robust, reproducible with no false positive and negative results.
- Kit components i.e lyophilized spores & nutrient discs at 4°C, functionalized paper strip at -20°C are Stable up to 9 months.
- Kit was evaluated and validated with AOAC approved CHARM ROSA strip test and 100% correlation was established with spiked and natural raw milk, pasteurized milk and dried milk powder.

Evaluation of Strip Based Analytical Device under Field Conditions: 200 raw milk samples were collected from different organized and unorganized dairy farms and tested with developed strip based analytical device and tested with DPA/Paper strip test kits. Out of 200, 18 samples were found contaminated with antibiotics when tested with DPA/Paper strip test kits. Out of 200, 7 samples were found contaminated for β -lactam group. The obtained results were also validated with AOAC approved ROSA test and found 100% correlation with all the technologies.

Optimization of Assay Conditions for the Detection of β -lactam Group in Milk

Optimization of assay parameters (sample volume, substrate volume and incubation temperature) was carried out using penicillin antibiotic (positive control) to obtain the best combination of these parameters for the detection of β -lactam group in milk using pillar based miniaturize biosensor for high throughput analysis.

Pillar-Based Analytical Device for Detection of β -Lactam Group in Milk

Pillar-based Analytical Device was fabricated at the University of Southampton by using AutoCAD software, nine pillars of 4 mm diameter x 1 mm height and nine wells of 4.5 mm wide x 2.4 mm deep were fabricated on a Poly-methyl methacrylate (PMMA) surface using micro milling machine. Filter papers (Whatman Grade 3) of 4mm (diameter) were fixed on the pillars via a double-sided tape. The dimensions of the chip was 20 x 20 x 3 mm (width x length x height).

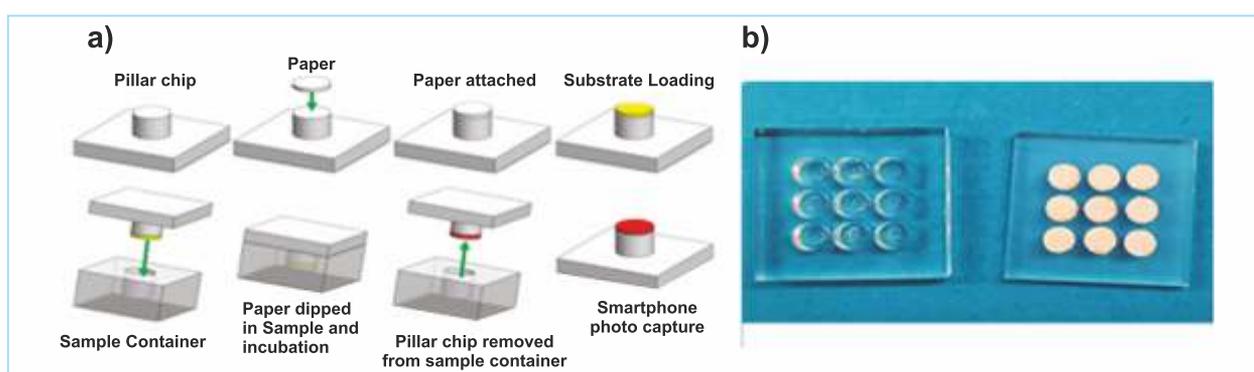


Fig. : Designing and fabrication of Pillar-based Devices: Schematic of the Pillar-based Biosensor for detection of Beta-lactam antibiotics in milk. b) Photograph of the Pillar-based Biosensor

Screening of Rapid AST Assay for Detection of ESBL, ACBL, Carbapenem Resistant *E. coli*"

The present concept of RAPID AST assay is based on the growth of β -lactam resistant *E. coli* in *E. coli* selective medium and interaction of its marker enzyme with the specific chromogenic substrate, which indicates presence of β -lactam resistant *E. coli*. The assay primarily involves two steps i.e. preparation of functionalized antibiotic disc containing *E. coli* selective medium and chromogenic substrate and second step involve addition of functionalized disc in *E. coli* culture tube. The change in color from light yellow to bluish-green within 5 hours

of incubation indicated the presence of ESBL, ACBL and Carbapenem resistant *E. coli*, whereas no change in color indicated the absence of β -lactam resistant *E. coli*. For screening of ESBL, ACBL, Carbapenem resistant *E. coli* using the rapid AST Assay, 120 milk samples and 50 rectal swab samples were collected from both cow and buffalo. Out of 170 milk and rectal swab samples, 28 (16.5%) were found to be confirmatory positive for *E. coli*. All the 28 *E. coli* isolates were screened for the detection of ESBL, ACBL and Carbapenem resistance using developed "Disc based assay" against Ceftazidime (CAZ), Cefotaxime (CTX), Cefpodoxime (CPD), Ceftriaxone (CTR), Cefoxitin (CX), Cefoxitin- cloxacillin (CXX), Ceftazidime-clavulanic acid (CAC) and Imipenem (IPM). Further the Developed AST Assay was successfully evaluated and validated with reference conventional and rapid automated method. Out of 28 *E. coli* isolates, 3 were found to be positive for ESBL production and one *E. coli* isolates was found to be ESBL and AmpC co-producer by conventional double disc synergy test as well as automated BD phoenix system. Thus, the findings showed that the developed rapid AST assay can detect ESBL and ACBL producing *E. coli* within 5 hours incubation at 37°C along with 100% test sensitivity and specificity.

Enzyme Strip for Early Detection of Clinical and Sub-clinical Mastitis

In current research program "Enzyme strip" was developed that works on enzyme-substrate reaction for early detection of clinical and sub-clinical mastitis that could be used in dairy farms. Different enzymes are produced during mastitis infection; functionalized enzyme strip was prepared by immobilizing respective chromogenic substrate of targeted enzymes. Different enzymes were screened for detection of mastitis. The enzyme activity was improved by introducing the activator solution; helps in accelerating the enzyme reaction by breaking the cell membrane of somatic cells secreted during mastitis in milk. The optimum temperature of the selected enzyme was identified by performing the assay at different incubation temperatures. The parameters of assay include sample volume, activator volume, substrate volume, and incubation time and incubation temperature was optimized. The substrate volume was optimized by processing the assay with strips having different volumes of substrate solution and selection was based on better color development on the strip. The incubation time was also optimized. The optimized protocol developed for mastitis detection was evaluated with 653 milk samples collected from animal health complex and milking section of cattle yard at NDRI. These results were validated with California mastitis test, Average Somatic Cell counts and Porta SCC quick mastitis test. The accuracy of this developed mastitis kit with above mentioned validating methods is as follows 89.89%, 98.62% and 87.55% respectively. The sensitivity 66.84%, 94.63% & 86.56% respectively.

Optimization of Paper Strip Based Assay for Detection of β -lactam Antibiotic in Aquaculture Products

Paper strip based kits which works on the principle of enzyme induction has been developed successfully by ICAR-NDRI for their application in dairy sector. In current research work, the objective of the research is to extend the scope of this Paper strip based assay kit for detection of β -Lactam antibiotics in fresh fish, shrimp powder, fish feed and aquaculture water. Paper strip based kits (Substrate functionalized strips-730 nos and β -Lactam spore kits- 475 nos) were produced for optimization and evaluation work on presence of β -Lactam antibiotics in Aquaculture products. Assay conditions like incubation time and incubation temperature were optimized on paper strip based assay for aqua products. Sample preparation parameters like reconstitution ratio, centrifugation speed/ time for Feed, Shrimp Powder, Fresh Fish and aqua water. LODs for 4 antibiotics recommended for Feed, Shrimp Powder, Fresh Fish and aqua water were evaluated after spiking at their MRLs. The optimized protocol developed for Feed, Shrimp Powder, Fresh Fish and Aquaculture water were evaluated with 25 samples received from CIFT Kochi, KVK-Karnal and Karnal local market using paper strip based assay kits for the presence of β -Lactam antibiotics. All the samples were found negative. Samples received from CIFT-Kochi were also tested at Kochi Lab and found negative with ELISA based kit. The working protocols developed for Paper strip based assay technology will be useful in exploring these kits in "Aqua-products" apart from dairy sector. Work on Pillar based microchip and Comprehensive validation work with ELISA/LC-MS proposed at CIFT, Kochi could not be completed because of Covid -19 pandemic.

Prevalence of Antimicrobial Resistance in Dairy Lactic Starters in Haryana Region

A total of 437 tentatively identified Lactic acid bacteria were isolated from >64 dairy samples of *Dahi* and raw milk samples. Initially, a total of 211 lactococci isolates were confirmed based on PCR reaction. The identified 211 lactococci isolates were then assayed for antibiotic susceptibility against 29 different antibiotics using disc diffusion method. Apart from the high level of intrinsic resistance, extrinsic resistance was observed against Beta-lactam group [Cephalosporins (42-CXM; 7-CTX; 22-CPM)], Clindamycin (21.9%), Rifampicin (13.3%), Macrolides (10.9%) and Meropenem (7.14%). The tested lactococci isolates were found to be highly susceptible towards Chloramphenicol and Tetracycline. High level of MIC was seen in resistant isolates against Clindamycin. Further, a total of 21 lactococci were also confirmed to be positive for ESBL production using the double disk assay. Among the 21 isolates, 20 lactococci isolates were detected with *bla*_{TEM} gene and 3 with *bla*_{OXA}

gene. The isolates were also tested for the presence of mobile genetic elements viz. integrase genes *int1*, *int1* gene cassette and *int2* by using specific primers. In gene cassette amplification, three product sizes of ~150 bp, ~250 bp and ~1500 bp were mainly detected. The *int1* gene cassette of ~150 bp detected in lactococci isolates showed the presence of integron based aminoglycoside resistance gene.

Unveiling the Microbial Diversity of Traditional Indian Fermented Milk Product 'Dahi' through Culturomic and Metagenomic Approaches

Metagenomics and culturomics were used as complementary approaches to study the bacterial composition of traditional Indian fermented milk product 'Dahi'. During the period under the review, the metagenomics data *Dahi* collected from North India was compared with that of culturomics data. A total of 48 isolates were sequenced for 16S rRNA gene and were identified using the NCBI data base. Through culturomics approach, *Dahi* samples were found to have majority of bacteria that belonged to *Lactococcus lactis* group (34.14%), followed by *Lactobacillus delbrueckii* (19.5%), *Streptococcus thermophilus* (17%), *Leuconostoc species* (7.31%), *Staphylococcus species* (7.3%), *Macroccoccus caseolyticus* (4.87%), *Bacillus subtilis* (4.8%) and *Enterococcus* strains (2.4%). On comparing metagenomics and culturomics data, we find quite similarities in both data sets, as in both approaches *Firmicutes*, most of which have gram-positive cell wall structure appeared as major phyla with *Lactococci*, *Streptococci*, *Lactobacilli* and *Leuconostoc* emerged as major genera of LAB with total abundance of 80-90%. Where as, the genera such as *Staphylococcus*, *Bacillus*, *Macroccoccus* and *Enterococcus* were observed as environmental contaminants in both approaches. From the data obtained out of the study, it is quite clear that, both metagenomics and culturomics are highly complementary approaches and can push forward the field of microbiota research in the field of traditional fermented milk products. Hence, both approaches have been used to study the bacterial community of *Dahi* collected from South India, a total DNA from 9 individual samples of *Dahi* was extracted, pooled (4:1) and sequenced using Oxford Nanopore technology platform. The bacterial taxonomics clearly indicated *Firmicutes* as the major phyla (92.69-96.87% abundance) followed by *Proteobacteria* (1.5 to 5.6%). Further analysis revealed *Enterococcus*, *Aerococcus*, *Staphylococcus* and *Bacillus* as major environmental contaminants. Sankey plot of *Dahi* metagenomic data from the three regions revealed prevalence of lactic acid bacterial genera such as *Lactobacillus*, *Streptococcus*, *Lactococcus*, and *Enterococcus* along with the environmental bacteria like *Bacillus* and *Staphylococcus*.

Surveillance of Dairy Products for Antibiotic Resistant Zoonotic Bacterial Pathogens Under Field Conditions

Four out of Thirteen antibiotic-resistant zoonotic pathogens confirmed by PCR including 2 ESBL *E. coli*, one *mecA* resistant *S. aureus* and one vancomycin-resistant *Enterococcus faecium* were sent for whole genome sequencing (WGS) (Outsourced). Sanger sequencing of the isolates have shown 88, 94, 95, and 90% identity with *E. coli*, *E. coli*, *Staphylococcus aureus*, and *Enterococcus faecium*, respectively. These isolates were further evaluated for WGS using the illumina platform. Data generated was analyzed for de novo genome assembly, gene prediction and annotation, AMR analysis and virulence factor analysis, pathway analysis using different tools. De novo analysis has shown the highest homology with their respective reference genome. There were 83, 87, 31 and 15 antimicrobial genes observed with 70% (query coverage and identity percent) homology against CARD proteins for samples 1, 2, 4 and 5 respectively. Five *E. coli*, 3 *S. aureus*, and one *Enterococcus faecium* isolates resistant to ESBL, *mecA*, and vancomycin, respectively have shown the presence of plasmid in their genome. WGS data has also shown the harboring of virulence genes in the respective bacterial genome which are responsible for production of virulence proteins. Correlation study of antibiotics present in milk and AMR pathogens has shown inverse relation due to all 250 samples have shown no presence of antibiotic residues in milk.

Method based on paper strip sensor for detection of total plate count in milk using PANI-PEC nanoparticles with a detection limit of 4.0 log cfu/ ml with 4 ½ h at 30°C has been developed under IRC project. Further this technology has been evaluated and validated with spiked and natural milk system in comparison with IS 5402: 2012 and AOAC approved methods. PANI-PEC paper strip sensor was evaluated with antibiotic residues, pesticides residues, detergents, preservatives, psychrotropic bacteria, fermentative bacteria, coliforms, G+ve, G-ve bacteria, thermotolerant bacteria, and aerobic spore forming bacteria in spiked milk samples at 10⁸ cfu/ml of SPC level. In the presence of preservatives like formalin and hydrogen peroxide, the performance of the paper strip sensor was completely inhibited with no colour change from blue to green due to inhibition of microorganisms present in the sample. Whereas in case of detergent like NaOH and urea, there was no effect on its performance was observed. In case of different bacterial groups (psychrotropic bacteria, fermentative bacteria, coliforms, G+ve, G-ve bacteria, thermotolerant bacteria), no significant difference in terms of time taken for colour change was observed except in bacterial endospore formers, where time was extended to 30 min for colour change as compared to positive control samples. Further developed sensor was evaluated with raw milk, pasteurized milk, butter, ice cream and milk powder for its scope of detection of total plate count in

comparison with IS 5402: 2012 and AOAC approved methods. The data obtained through this evaluation with different milk and milk products have evaluated for its features using statistical software wherein it has shown an accuracy of 0.9871, precision of 2.21% at 4 log counts, Biasness of 1.184, linearity (R^2) of 0.9548, and repeatability of 0.7898 at 4 log counts. Based on the data evaluation, it was confirmed that the developed PANI-PEC paper strip sensor for detection of TPC in milk and milk products is a potential tool for the detection of TPC in raw, pasteurized milk, butter, ice cream, and milk powder due to its better accuracy, precision, biasness, linearity, and repeatability at reception dock, manufacturing unit, R&D centers, etc.

Two methods for Rapid Methods for Detection of Sorbitol Adulteration in Milk

(i) A method for the qualitative detection of sorbitol in both cow and buffalo milk was standardized. In the presence of sorbitol, a violet color was observed on the addition of mixed indicator and boric acid (Fig. 1). Using this method, the minimum amount of sorbitol added to milk i.e. 0.5% could be detected. Carbohydrates, urea and ammonium sulphate spiking did not affect the color change in sorbitol spiked samples and the results were same as in case of control and sorbitol spiked samples.

(ii) DPPH impregnated dried paper-based disc sensors and tube sensors (Fig. 2) were developed to detect vegetable oils addition in ghee on the basis of synthetic antioxidants present in vegetable oils. The disc and tube sensors worked well and their response time was dependent on their concentration of antioxidants present.

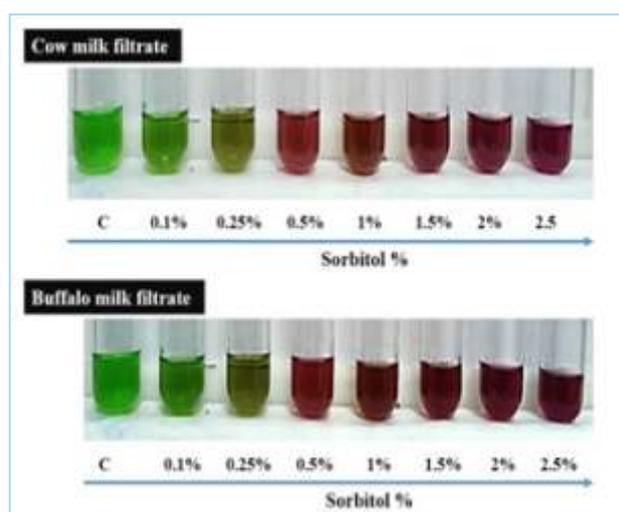


Fig : Dye based method to detect sorbitol adulteration in milk.

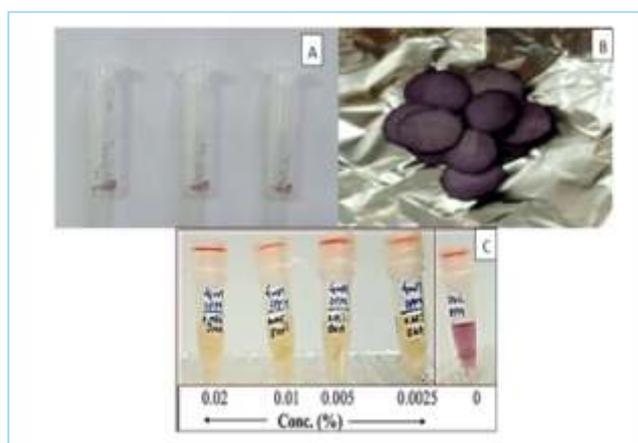


Fig.: Detection of vegetable oils in ghee using DPPH method. (A) Tube based sensor, (B) Paper disc based sensor and (c) Colour change in presence of antioxidant

Using the developed color-based disc sensors, a distinct color change from violet to yellow/ colorless was observed in cow ghee samples spiked with vegetable oils (palm oil, sunflower oil) @ 1% and above. The storage stability of tube and disc sensor determined in terms of their response time to change color in pure solutions was found to be 15 and 30 days, respectively at ambient temperature (30 β) and 30 and 90 days, respectively at refrigerated temperature (4-6 β).

Attenuated Total Reflectance-fourier Transform Infrared Spectroscopy Coupled with Chemometrics to Detect Mineral and Coconut Oil in Ghee

Functional group regions of the mixed ghee, coconut oil and mineral oil were almost similar except at 1743.65 cm^{-1} for mineral oil, while definite differences in their finger print regions were observed. PCA applied in the regions of 1170-1141 and 1117-1100 cm^{-1} for coconut oil and 1350-950 and 1800-1600 cm^{-1} for mineral oil showed distinct grouping of all samples.

SIMCA approach applied in the selected regions showed 100% classification efficiency for ghee, mineral oil and coconut oil. ATR-FTIR coupled with chemometrics could detect even 2% of both coconut and mineral oil in ghee.

Migration of Chemical Additives from Low Density Polyethylene (LDPE) into Dahi

Dahi is widely used fermented milk product in India. Low Density Polyethylene (LDPE) is the most extensively used packaging material for *Dahi* in India. The present study was conducted to develop the analytical methods for extraction and migration study of chemical additives from LDPE into *dahi*. Characterization of *dahi* packaging materials collected from five different firms was done by Fourier Transform Infrared Spectroscopy (FTIR). For extraction of additives from the packaging material, focused ultrasound solid liquid extraction (FULSE) method was observed to be better as compared to solid liquid extraction (SLE) method as the former extracted maximum additives from the LDPE. Out of total 76 chemical additives extracted from LDPE, only eight (10.52%) matched with the existing positive list of polyolefins prescribed by Bureau of Indian Standards (BIS). The overall migration of chemical additives from all the LDPE samples was below their maximum limit as given by BIS standards. Chemical additives which migrated into the simulants included the antioxidants, fatty acids and their derivatives, unreacted hydrocarbons, plasticizers, lubricants and surfactant etc.

Protein and Fat Profiling of Milk from Hariana Breed Cattle

Milk samples of Hariana breed cattle showed an average fat and SNF level corresponding to 3.59% and 9.39% respectively and the level of crude protein, true protein, casein and whey protein corresponded to 3.75%, 3.62, 2.95 and 0.67% respectively. Based on RP-HPLC the retention time of α_{s1} -casein fraction was found to be at 23 minutes, α_{s2} -casein at 13 minutes, β -casein at 28 minutes whereas κ -casein was the first fraction to be eluted out at 8 minutes. Except κ -casein (Fig. 1), no variability in different protein fractions was observed. Based on fatty acid profiling, the level of saturated, monounsaturated and polyunsaturated fatty acid corresponded to 65.64%, 31.74% and 2.62%, respectively.

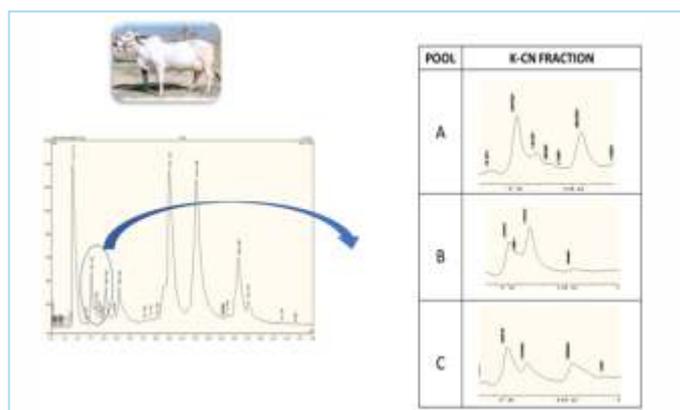


Fig. : Protein profile of milk from Hariana breed cattle

DAIRY DEVELOPMENT: POLICY ANALYSIS, STRENGTHENING DATABASE & IMPACT ASSESSMENT

Impact Evaluation of Anionic Mineral Mixture Technology

Anionic Mineral Mixture (AMM) technology was developed and commercialised ICAR-NDRI for reducing milk fever in cows and buffaloes as a pre-partum approach. AMM was opened to commercial production for the first time in the year 2016-17. Milk fever is causing annual economic losses to the extent of Rs.873 crores in Haryana. The occurrence of milk fever also acts as a gateway for other diseases; a cow with milk fever is 8 times more likely to experience mastitis, 3 times more likely to have dystocia and have a retained placenta. The randomised controlled design was used to evaluate the impact of the AMM by selecting 200 dairy animals (100 cows and 100 buffaloes) randomly assigned to treatment and control groups. Economic surplus model was used to estimate the overall welfare gains of the technology under different adoption and success rates. The study found that AMM supplementation reduced milk fever incidence (from 21% to 2%) and improvements in milk yield (14%) and farmer's profit (35%).

The impact was higher on farmers with older animals, small herd size (< 6 animals) and among those farmers who were having formal training on dairying. The demand for AMM was highly sensitive to the prices. A one per cent increase in prices led to an 18.4 per cent fall in demand. The cost incurred per unit of a milk fever case averted was estimated to be Rs.14,217 and for every additional gain of milk yield was Rs. 5 per litre. The implementation of AMM scheme in Haryana to prevent milk fever cases is going to Rs. 611 crores. But the potential economic welfare gains are much higher to the extent of Rs. 4,862 crores if all the farmers adopt the technology at 100 per cent rate of success. Taking into account the price sensitivity, costs of implementation and the impact of AMM, it was found that the welfare gains is more than the costs in Haryana if 18 per cent (@ 71% success rate) of the dairy farmers adopt the technology. To achieve the 18 per cent adoption level, the AMM should be distributed at a minimum of 60 per cent subsidy.

Technical Efficiency and Total Factor Productivity of India's Livestock Sector

A study has been made to understand whether India's livestock sector has experienced technological progress or not? Estimation of total factor productivity (TFP) growth and its decomposition has been carried out to identify the sources of productivity growth. Along with the TFP, the measures of technical efficiency (TE) and scale efficiency (SE) for 16 major states for the period: 1990-91 to 2015-16 have also been estimated. During last two and a half decades (1990-2016), the TFP of livestock sector has grown at an annual rate of 3.9%. However, there are significant variations in it across the states. It is estimated very high in Tamil Nadu (8.7%), Andhra Pradesh (7.6%) and Odisha (7.6%); and extremely low in Jammu & Kashmir (0.6%), Himachal Pradesh (-0.4%) and Bihar (-4.3%). Interestingly, TFP growth of livestock has been driven by technical change. The estimates of SE indicate scope of raising output by about 30% even at the existing levels of input-use. The findings suggest the need for greater investment in animal scientific research and development (R&D), especially, in the states that have poorly performed on technological front.

Adoption of Food Safety Practices in the Informal Milk Processing Units of Haryana – A Value Chain Approach

To trace level of food safety measures adopted at different stages in milk value chain, primary data were collected from upstream actors, i.e., 50 milk suppliers including dairy farmers and milk vendors; downstream actors, i.e., 20 traders; and main actors, i.e., 27 processing units in Karnal district of Haryana. Food safety index (FSI) of two identified milk procurement systems, viz., own collection centres, and private vendors, were compared. Processing units with own collection centres in production catchments have been able to establish better linkages with dairy upstream actors and resulted in better overall FSI (0.66) than those processing units procuring milk from private vendors (with FSI as 0.51). Further, the profitability of the processing unit is positively associated with the FSI, as consumers are willing to pay higher prices for safe milk. In order to strengthen food safety compliance in the milk value chain of the informal sector, there is a need to design efficient milk procurement systems; efficient milk transportation systems and processing technology along with training in post-milking handling and safety for dairy farmers, small vendors and processors.

An Economic Analysis of Milk Production in Haryana

Economics of milk production was estimated based on primary data from 120 dairy farm households of Karnal and Jind districts of Haryana state. These selected households were classified as 49 small (2-8 milch animals), 55 medium (9-16 milch animals) and 16 large (17-36 milch animals) herd size categories. Overall cost of milk production per litre was estimated at Rs. 31.88, it was highest in case of buffalo milk (Rs. 40.35/litre) and lowest for crossbred cow milk (Rs. 29/litre). The net returns were highest for crossbred cows (Rs. 3.29/litre) followed by buffalo (Rs.3.12 /litre) and indigenous cows (Rs.1.28/ litre). Negligible net returns, i.e., Rs. 0.73/litre of milk production from indigenous cow in case of small category—call for improvement in productivity and profitability of indigenous cow through high pedigree bull selection, artificial insemination, scaling up herd size, and adoption of good dairy farming practices.

Impact Assessment of Selected Technologies of NDRI

The data on cost components and monthly semen production were collected from Animal Breeding Research Centre (ABRC) for the period January to August, 2021. The average cost of semen production was estimated to be Rs. 24.50/dose considering active bulls in service. ICAR-NDRI is extending implicit subsidiary support to the tune of Rs. 4.50 to the beneficiary farmers, since sale price fixed at Rs. 20/dose. Total average cost curve was found downward slopping 'L' shaped consistent with modern cost curves theory. Break-even output was observed for the month July, 2021 with 34 active bulls producing 16558 doses (Fig. 2). Sensitivity analysis reveals that ABRC has potential to generate net returns of approximately Rs. 1.0 crores per annual under optimal capacity utilisation.

Performance and Impact of Dairy Co-operatives in Gujarat

In the largely scattered milk production system of India, the institutional mechanism of dairy co-operatives is proven to be a potential tool for improving the livelihood of dairy farmers, especially for landless labourers, small and marginal farmers. However, their performance and impact have varied regionally due to various reasons, which are external and internal to the co-operatives. In this context, a study was conducted in Mainland and Saurashtra-Kutch regions of Gujarat, to assess the performance and impact of dairy cooperatives and to estimate the factors affecting it. To assess the performance of cooperatives, a composite performance index (CPI) was calculated using Iyengar and Sudarshan approach and impact was determined by applying two-stage Heckman method and Blinder-Oaxaca decomposition approach. The study found that the overall performance of DCSs has improved by 33.15 per cent from CPI value of 0.253 (2011-12 to 2014-15) to 0.336 (2015-16 to 2018-19) with variation from society to society. The CPI was higher for the DCSs of Kaira (0.468) and Mahesana (0.448) milk unions of Mainland region than the DCSs of Surendranagar (0.282) and Junagadh (0.186) milk unions in Saurashtra-Kutch region. The study observed that better physical performance augments the probability (0.278) of DCSs to have good financial performance and concludes that physical performance is prelude to the financial performance of DCS. The probability of DCSs to have high performance increases by 1.10 per cent, 62 per cent and 12.90 per cent with decrease in proportion of poor households, with increased AI services and distribution of annual bonus, respectively. The impact analysis showed that in Mainland, the net returns per SAU including bonus increased by Rs.7.45 and Rs.9.95 with per unit increase in animal milk productivity and access to information, respectively; while the co-operative membership (0.458) and access to information (0.469) had significant positive impact on the animal productivity. In Saurashtra-Kutch region, the experience in dairying, access to information, herd size and animal milk productivity were the factors significantly enhanced the net returns of the farmers. The endowment gap explained 65.99 per cent of the total gap in the performance of DCSs between Mainland and Saurashtra-Kutch regions. Thus, endowment of DCSs must be enhanced by bringing in operational diversity and improving the germplasm of dairy animal through selection and crossbreeding programme.

Women Empowerment and its Contribution to Livelihood of Livestock Based Households in Odisha

Since women are the major players in deciding the household's food intake, the major aim of women empowerment is the attainment of household food security. Hence, livestock could be seen as an important medium for women empowerment, thereby strengthening the livelihood, food security and nutritional security of the households. To study the issues related to it, the study measured the levels of women empowerment in the study area using the Women Empowerment in Agriculture Index followed by identification of dominant dimensions and sub-dimensions of women empowerment using the Principal Component Analysis. The factors of women empowerment promoting self-reliance of primary women in the study area was assessed using Multinomial Logit. Similarly, Household Food Insecurity Access Scale (HFIAS) followed by Ordered Logit was used to determine the food security status. The vulnerability of the livestock

based household to food insecurity and impact of women empowerment on the livelihood outcomes of the sampled households was also studied. The study was carried out in the state of Odisha. The state of Odisha has been divided into ten agro-climatic zones. Therefore, from each agro-climatic zone of Odisha, one district was selected on the basis of highest Rural Female Labour Force Participation Rate (RFLFPR) purposively. Two villages from each of the selected districts were sampled randomly. From the chosen villages, 300 farm households were selected based on Probability Proportional to Size (PPS). Both econometric and tabular analytical techniques were used to achieve the objectives of the study. The results of this study revealed that

- The women involved in the livestock enterprises in tribal areas of Odisha are more empowered in all the domains (5DE) than those of central and coastal regions whereas the coastal regions fair well in terms of Gender Parity Index (GPI).
- Increase in crop and livestock production skills of the primary woman makes her more self reliant thereby reducing the dependence of the household of remittances and social grants by 54 and 52 per cent, respectively.
- Similarly, the enhancement of crop and livestock management skills of the primary woman reduces the dependence of the households on remittances and social grants by 49 and 53 per cent, respectively.
- The likelihood of women with high levels of vocational empowerment, the reliance of the primary woman on remittances decreases by 40.8 per cent. Thus, training and educational programmes related to livestock sectors need to be designed keeping in view the convenience and need of women beneficiaries.
- It was also discovered that dependency ratio increases the likelihood of a household being vulnerable to food insecurity by 29 per cent. Dependency ratio of the sampled household was seen as a major constraint towards self-reliance and food security in the study area.
- Increase in Economic Agency of the primary woman in terms of enhancement of the bargaining power, motivation, confidence and self-reflection of women reduces the likelihood of the household to be in the Severely Food Insecure (SFI) category by 56 per cent and increases the likelihood of being in MF12 and FS categories by 31 and 21 per cent, respectively.
- Enhanced Social Capital Empowerment of the primary female reduces the likelihood of the household to be in the SFI category reduces by 16 per cent and increases the likelihood of being in Mildly Food Insecure (MF12) and Food Secure (FS) categories by 9 and 6 per cent, respectively.
- This study has found that livestock based enterprises are a viable option for the upliftment of women through collective action.

Consumption Pattern and Consumer Preferences for Milk and Milk Products in Hassan City of Karnataka

The importance of milk and milk products in the human diet has been recognised since the beginning of Vedic literature. An analysis of consumption pattern and consumer preferences for milk and milk products is essential to formulate suitable dairy development policies in the study region and to develop marketing strategies for successful marketing. Accordingly, this study was carried out in Hassan city of Karnataka. The research findings indicated that 100 per cent of the total sample households consumed milk in liquid and tea/coffee form; and also consumed curd. The consumption of ghee, butter and paneer was observed to be 85 per cent, 16.5 per cent and 24.5 per cent, respectively. The per capita availability of milk was higher in vegetarian families (353 grams/day) compared to non-vegetarian families (298 grams/day). Milk constituted largest share in the total per capita monthly expenditure (PCME) on milk and milk products both in salaried (61.54 per cent) and non-salaried households (65.4 per cent). In case of milk, the average PCME in vegetarian is (399.9/-), which is significantly different from non-vegetarian (340.2/-). With the increase in monthly expenditure on milk and milk products, the proportion of MPCE on paneer increased. The PCME on milk and milk products for vegetarian group (647) was higher than that of overall PCME (569). Milk and milk products had major share (26.5) in the total PCME on food items succeeded by fruits and vegetables (23.9 per cent), cereals and pulses (17.9 per cent), meat, fish and egg (17.4 per cent) and other food items (14.1 per cent). Factors such as PCME on cereals and pulses, fruits and vegetables, other food items and family size had a significant and positive impact on milk and milk products. Chi-square values represented that there was no significant association between socio-economic variables and respondents' preference for milk and milk products. The results of conjoint analysis for milk and milk product attributes revealed that consumers preferred fat level as the most important attribute in case of milk. Cow ghee was mostly consumed by respondents among different levels of ghee attributes. The respondents selected quantity as the most preferred attribute in case of curd. The relative importance scores of attributes of 'Mysore Pak' showed that

the types of 'Mysore Pak' had larger average importance scores (40.15) compared to reason for purchase (29.59), price (20.97). Consumers indicated higher utility for the quality of 'Peda' (0.787) compared to pleasure of having it (-1.151) as the motive behind purchasing.

Economic losses due to Clinical Mastitis and Reproductive Disorders in Crossbred Cows: A Study in Ahmednagar District (Maharashtra)

The present economic scenario of dairy farm managerial practices demands that the individual dairy animal should be a high producer and also profitable. This put extra pressure to produce increased milk yield but it also leads to an increased risk of incidence of diseases and reduced fertility over a period of time. Better herd management can reduce the occurrence of diseases and fertility problems but this may increase the cost of production. Secondary data comprising a total of 2168 calving and 2004 lactation records over a period of 20 years from 1995 to 2014 in Phule Triveni crossbred cows at RCDP on cattle farm, MPKV Rahuri, Maharashtra, and primary data of crossbred cows that suffered from clinical mastitis were collected from high, medium and low rainfall regions of Ahmednagar district from 180 households. The study mainly focused on clinical mastitis and reproductive disorders such as calving abnormalities, uterine health problems and fertility problems. The calving abnormalities comprised abortion and dystocia; uterine health problems included retention of foetal membrane, metritis and prolapse, while fertility problems comprised repeat breeding and anestrus. The number of cases of clinical mastitis, abortion, dystocia, retention of fetal membrane (RFM), metritis, prolapse, repeat breeding and anestrus were 472, 126, 50, 98, 110, 18, 240 and 130, respectively. The corresponding figures for incidence rate were 23.55, 5.81, 2.3, 4.52, 5.07, 0.83, 11.07 and 6.00, respectively. The highest incidence rate of clinical mastitis was 28.34 per cent during the rainy season. Late stage of lactation and high milk producing animals exhibited higher incidence rate of 26.54 and 28.48 per cent, respectively. Per animal treatment cost due to clinical mastitis turned out to be ₹1443.09 however the total cost including production cost (₹904.0) during the clinical mastitis was ₹2348.86. The average total loss due to abortion was highest, i.e., ₹2271.73 during rainy season. The maximum total loss of ₹2438.65 was observed in 4th parity due to dystocia. The highest total loss and treatment cost of ₹606.00 and ₹562.03, respectively, was noted in high milk producing cows in RFM. The highest average total loss of ₹1423.28 was observed in very low milk producing cows in repeat breeding. Level of production showed a positive, while parity for the occurrence of abortion exhibited a negative association at significance level ($P \leq 0.01$). Parity had negative and significant ($P \leq 0.01$) effect on probability of occurrence of RFM. The probability of occurrence of metritis was negatively associated with parity, while it was positively associated with level of production. Season had positive and parity had negative association with occurrence of anestrus at significance level ($P \leq 0.01$). The projected economic losses due to clinical mastitis in Ahmednagar district and in Maharashtra state was 14.19 crores and 49.03 crores, respectively.

It is concluded from this study that non-genetic factors such as rainy season, multiparity, late stage of lactation and very high milk producing cows are predisposing factors for more occurrence of clinical mastitis in Phule Triveni crossbred cows, so more emphasis should be given to managerial practices followed at farm as well as field level. Treatment cost is the main component of economic losses due to clinical mastitis, so early diagnosis of clinical mastitis will prevent the extent of economic losses by proper selection of antibiotics. Many of the reproductive disorders, such as dystocia, prolapse, metritis and repeat breeding showed maximum total economic losses in summer season. It is further concluded that summer season requires more care of animals to manage stress level of animals due to hot climatic conditions and prevent the chances of incidence of reproductive disorders.

Economic Analysis of Dairy Farmer Collectives in Saurashtra and Kutch Region of Gujarat

There have been plenty of studies to evaluate the determinants and impacts of dairy co-operatives on their members. This work was an attempt to perform a similar analysis for a well-established milk producer company (MPC) in addition to a dairy co-operative. Further, it also compared the financial performance of both these farmer collective organisations. It was found that dairy households with annual income of ₹10.0 lakhs or more were less likely to become members of a dairy co-operative and more likely to become members of the MPC, while small and marginal farmers were less likely to become MPC members. Regardless, membership of both the farmer collective organisations was found beneficial to members. Membership reduced the TVC by 20 per cent in case of local cow; the overall TVC decreased by 8 per cent. Cost per litre for local cow decreased by 16 per cent for the members. In buffalo milk production, there were no significant effects of membership on labour cost, feed cost, and TVC. For members of farmer collectives, net returns from local cow and buffalo increased by ₹3700, and ₹6400, respectively. The overall net returns from dairy exhibited an increase of ₹10,000. For the member households, the share of dairy in total household income increased by 14 per cent and the share of milk sold increased by 1 per cent. The comparison of financial ratios of the two farmer collectives showed that

Maahi MPC exhibited better liquidity compared to the cooperative union. The union was more leveraged than Maahi, which implies that it has more debt than equity; and this difference in terms of indebtedness is highly significant. In profitability, the rate of return to equity after taxes ratio, and the rate of total capital employed before interest and taxes ratio, both differed significantly for the two farmer collectives.

Economic Impact of COVID-19 Pandemic on Dairy Farmers of Karnataka State

COVID-19 not only limited the movement of people across the country but also led to the implementation of the policies like quarantines, containment zones, social distancing, travel restrictions etc. These policies have affected every sector of the Indian economy including the dairy sector. Against this backdrop, the present study was undertaken to assess the economic impact of COVID-19 pandemic on dairy farmers. The study covered pre-lockdown, lockdown and post-lockdown phases up to December 2020. The data was collected from 200 dairy farmers across Bengaluru Rural and Chikkaballapura districts of Karnataka state. A large majority of the farmers from Bengaluru Rural (81%) and Chikkaballapura (87%) districts reported loss in their income from dairying during lockdown and post-lockdown periods. In both the districts the crossbred cattle were dominant (90%). In Bengaluru Rural district, the net return per litre of milk of crossbred was reduced to the extent of 33.06% during lockdown and by 48.64% during post-lockdown as compared to pre-lockdown period. In Chikkaballapura district, the net return per litre of milk of crossbred was reduced to the extent of 20.90% during lockdown and by 22.77% during post-lockdown as compared to pre-lockdown period. The loss in net return was attributed to reduction in procurement prices of milk, increased feed cost and decline in milk yield in that order respectively.

Antimicrobials Use and their Indications in Dairy Animals Maintained under Unorganized Production Conditions in Southern India

Antimicrobial use (AMU) is the key driver for development of antimicrobials resistant (AMR) pathogen in human and veterinary medicines. Therefore, understanding AMU pattern is prerequisite for focused intervention on AMR. About 6097 treatment records for two years (2019-2020), from different seasons (summer: March-June; winter: November-February and rainy: July-October) under field conditions were collected from Devanahalli taluk (Bengaluru rural district) of Karnataka and analyzed by log-linear model. It was observed that udder health disorders, digestive disorders and endemic and infectious diseases are most common health issue and accounted for about 75% of the total antimicrobials usage. Among the antibiotics, aminoglycosides, cephalosporins and tetracyclines group of antibiotics were most commonly used for all the health disorders.

EXTENSION APPROACHES FOR SOCIO-ECONOMIC UPLIFMENT THROUGH DAIRYING

Empowering Farmers through Selective Interventions in Salt Affected Agroecosystems of Ghaghar Plains (Farmers FIRST Project)

In order to ameliorate the adverse effect of heat stress and to improve the growth rate of growing buffaloes. Twenty four growing buffaloes (6-9 months) were selected and equally divided into four groups i.e. group-I (control), and treatments viz. group-II (supplemented cumin @15g/100kg BW/ day/ animal), group-III (supplemented Molasses 10% of /kg concentrate/ animal/ day) and group-IV (combination of cumin and molasses). THI during the study varied from 78.73 to 83 during experimental period indicating the heat stress on the buffaloes. The physiological parameters (RT, RR and ST) and body measurement (body length and height at withers) was found to be significantly higher ($P<0.05$) in treatment groups compared to control group. The thermal imaging of growing buffaloes showed higher skin temperature in the head region compared to other parts of the body (neck, shoulder, ventral and flank). Head temperature showed close relation with the core body temperature of the animals.

Mineral mixture (@50-60 g/day/ animal) supplementation to lactating buffaloes during summer season (THI >80) indicated an increase in the milk yield from 0.5 to 1.2 lit./ animal/ day compared to control animals. Body condition score, shining of hairs and skin was improved in treatment animals compared to control group. Prill fat supplementation @100g/day/animal to lactating buffaloes during summer heat stress also showed increase in milk yield (7-10%) and fat %. In another trial, supplementation of anionic mixture @100g/ day/ animal showed increase in udder size and the skin become shiny. Timely expulsion of placenta was around 83% in treatment group compared to 50% in control animals. Increase in milk (7-10%) was also observed in treatment group.

In another study, 424 breedable bovines were inseminated using the NDRI bull semen. These animals were also supplemented mineral mixture @50-60 g/day/ animal during the study. Inseminated cow and buffaloes were checked through rectal palpation after three months of insemination. The overall conception rate for the whole period was 51.42%.

Distribution of dewormer and mineral mixture under NICRA project in the adopted villages

Under NICRA project dewormers, mineral mixture packets were distributed to 200 farmers families on regular basis for their animals in the adopted villages namely Budhanpur, Bhaini Khurd, Chogawan and Hansu Majra in District Karnal. The growth and reproductive performance improved significantly ($P<0.05$) by providing mineral mixture and probiotics to the animals in the all adopted villages. The mortality rate of calves was seen to be significantly ($P<0.05$) decreased. The farmers are also being educated regarding the livestock management by giving them technical support and scientific inputs in the adopted villages.



Details of NICRA adopted villages in terms of animal performance after introduction of scientific inputs for improving management in cattle and buffaloes

Sr.No.	Name of Village	Total No. of families	Total No. of animal			Productivity increased (%)	Calf mortality rate decreased (%)
			Buffalo	Cow	Calf		
1)	Hansu Majara	45	33	30	45	20	70
2)	Chogawan	45	54	60	55	20	80
3)	Bhudhanpur	45	48	39	35	15	80
4)	Baini Khurd	45	44	55	53	25	85

Mitigation of Stubble Burning through Custom Hiring Centers for Agricultural Machinery in Trans-gangetic Plain Region of India

Activities on mitigation of stubble burning through Custom Hiring Centers in Trans-Gangetic Plain Region of India was organized SWOT analysis was undertaken for the study i.e., strength, weakness, opportunities and threats perceived by farmers in mitigation of stubble burning and adoption of custom hiring centers. Results indicated that strength and opportunities for mitigation of stubble burning and adoption of custom hiring centers outweighs weakness and threats. So, increasing the prospects for strength and opportunity enables enhanced adoption of stubble burning mitigation activities and Custom Hiring Centres. Strength, weakness, opportunities and threats received priority weights of 0.322, 0.296, 0.307 and 0.258 respectively. The rankings given to these four factors (Strength, Weakness, Opportunities and Threats) based on their priority weight are 1st, 3rd, 2nd and 4th respectively.

Direct Purchase Behaviour of Urban Consumers for Agricultural Produce in North Bengal

A study on Direct Purchase behaviour of Urban Consumers for Agricultural produce in North Bengal was conducted in purposively selected Darjeeling and Jalpaiguri district of North Bengal. It was found that majority of the respondents purchased vegetables (72.00%), fresh fruits (67.33%), meat (48.67%) and milk products (33.33%) from primary producers and consumers strongly perceived that food products purchased from farmer fields were healthy (48.00%), nutritious (47.33%) and free from chemical residues. The urban consumers had favorable behavior towards direct purchase of agricultural produce from farmer's field. Attitude and Perceived behavioural control have a positive significant effect on the direct purchase intention of agricultural produces. Financial benefit to both seller and consumers (85.33%) was the most important factor for symbiotic relation. It was found that 27.33% of the peoples would accept block chain technology if price goes "from 0 to 10%" in addition to regular price. Efforts should direct towards the improvement of knowledge towards direct purchase agricultural produces and block chain technology so that consumer and producer can use it in a beneficial way in near future.

Improving Adaptive Capacity of Women Farmers of Haryana through Climate Resilient Dairy Farming Practices

An inventory of climate resilient dairy farming practices was prepared. Further, a stakeholder analysis was conducted to test their suitability to be used as the climate resilient dairy farming practices in Haryana and finally, Kendall coefficient of concordance was applied to identify the significant practices. It was found that "Deworming followed by supplementation of essential mineral mixture, vitamin in non-pregnant anestrous animal" had lowest mean ranked (2.28) and considered as the best among the climate resilience capacity of practices related to "Healthcare Management Practices" as perceived by stakeholders. "Balanced concentrate mixture with buffer (Sodium bicarbonate and magnesium oxide specially in high yielding dairy animals)" had lowest mean ranked or best practices among climate resilience capacity of practices related to "Feeding and Nutritional Management Practices" as perceived by stakeholders. "Preparation value added milk product" has received lowest ranked or best practices among climate resilience capacity of practices related to other practices as perceived by the stakeholders.

Socio-ecological Sustainability of Belahi Cattle Rearing in the Shivalik Foothill of Haryana

Belahi cattle rearers possessed medium to higher knowledge and low level of favourable attitude towards scientific dairy farming practices, but there were resource constraints (unavailability of AI facility etc.) in the Shivalik foothill region of Haryana. Majority of the respondents were having good knowledge level about management practices, but very lower level of knowledge about breeding practices. A very few (9.44%) women participated in migratory system. The average ecological sustainability (0.54) was more as compared to social sustainability (0.45). Majority of Belahi cattle rearers were having medium (42.78%) level of socio-ecological sustainability. Majority of the respondent faced constraints due to deforestation of forest and declined pastureland. There is very poor transport facility and lack of milk vender. Hence, arrangement of artificial

insemination (A.I.) facility at the migratory route may facilitate to conserve this breed. Degraded pastureland may also be rejuvenated as pasturelands are the lifeline of the migratory system of livestock rear

Development of Climate Services for Murrah Buffalo Farmers of Haryana

Daily Thermal-Humid (THI) Index of the Murrah buffalo breeding tracts (Jind, Hisar Bhiwani and Rothak district) of Haryana was calculated during the heat stress months (May-September) of the year 2021 as an indicator to appraise the impact of climate change on the milk production. It was found that THI of these months indicated that dairy animals were in severe heat stress. Incidences of THI were comparatively more prevalent in the month of July. A fixed effect panel data regression was applied to understand the impact of different climatic parameters on the milk production of buffalo, crossbred cow, and indigenous cattle.

It was also found that Potential evapo transpiration (PET) had significant negative affect on the milk production along with THI. This study is the first time of its kind to report the impact of PET on milk production. Milk production and milk yield of buffalo, crossbred cattle and indigenous cattle were also negatively associated with THI and PET of May, June, July and August months. Incidence of cold waves were having significant negative affect on the milk production and milk yield of buffalo. Whereas, incidence of heat waves was having significant negative consequence on milk production and milk yield of crossbred cattle.

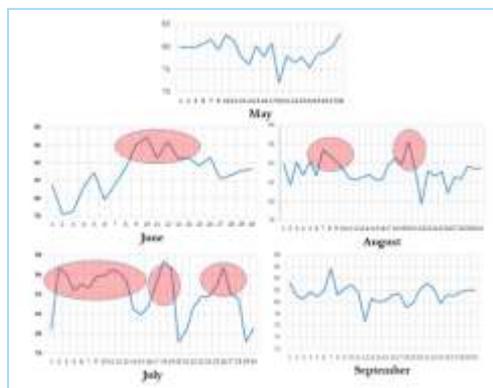
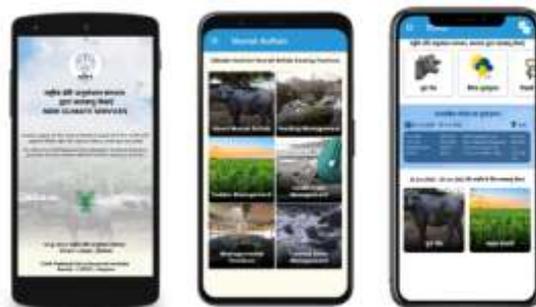


Fig. : Daily THI during the heat stress season in the Murrah buffalo breeding tract in 2021

Development of NDRI Climate Services Mobile Application to Promote Climate Resilient Livestock Rearing Practices

“NDRI Climate Services” Mobile Application was developed for the Murrah Buffalo rearing farmers of Haryana to cope up with the adverse effect climate change. The major objective of this mobile application is to provide district specific Temperature-Humidity Index (THI) based weekly climate advisory services to promote climate resilient Murrah buffalo rearing practices. Farmers will get two types of information from this application viz. static and dynamic. Static information is on climate resilient livestock rearing practices with special emphasis on Murrah buffalo which is further divided into thermal stress management, feeding management, healthcare management, fodder management etc. This app will guide the famers on the managerial practices during the both heat stress as well as cold stress. Dynamic information will provide weekly weather forecast on eight climatic parameters (Maximum Temperature, Minimum Temperature, Relative Humidity, Rainfall etc.) and specific 'Temperature-Humidity Index (THI)' based weekly climate advisory services for the Murrah buffalo rearing farmers. The climate services are also being provided to the Murrah buffalo rearing farmers through SMS every Tuesday or Wednesday.



Resilience Capacity of 7 Murrah Buffalo-Based Livestock Production System of Haryana in Changing Climatic Scenario

'Climate Resilience Index' was developed to measure the resilience capacity of Murrah buffalo-based livestock production system in Haryana. It was found that the foremost contributing factor to the resilience capacity to climate change of the Murrah buffalo-based livestock production system was observed to be the absorptive capacity with a mean index value of 0.60 followed by adaptive capacity and transformative capacity with a mean index value of 0.38 and 0.31, respectively. In overall, resilience capacity of the Murrah buffalo production system was low with mean index value 0.42. Categorization of household based on their absorptive capacities was revealed that farmers fall under medium to high (38.12 %) level of absorptive capacity, whereas, 42 per cent of the farmers falls under low level of transformative capacities. In overall, 43.13 percent of the farmers were having medium resilience capacity followed by the poor and high resilient capacity. Regression analysis between selected independent variables and resilience capacities indicative of that except dependency ratio, all other variables i.e., age, income, herd size, land holdings and education of the respondents have significant positive contribution towards resilience.

Impact of the Agromet Advisory Services on the Farmers' Operational Decision in Thiruvananthapuram District of Kerala

IMD and ICAR is providing location specific agromet advisory services to the farmers to help them in taking appropriate operational decision in day to day farm management. The intervention provided while conducting the study helped in the significant improvement in the percentage of farmers who have realized the utility of agromet advisory services in day-to-day management of various farm activities and suggested that farmers were having need of the such services. The study revealed that even though almost all farm operations had a positive treatment effect, but only land preparation, seed sowing, irrigation scheduling, fertilizer application, and pesticide and herbicide spray scheduling in banana, vegetable, and coconut cultivation followed by the experimental group farmers. There was no significant treatment effect of agromet advisory services was found on any of the operational decisions related to dairy farming practice. The findings revealed that adequate and relevant agromet advisory services were not provided for dairy farming practices and suggested that as the dairy animals are vulnerable to climate change. Therefore, weather related advisory services relevant for dairy farmers should also be included in the agromet advisory services disseminated from the agromet field units.

Performance and Sustainability of Commercial Dairy Farms in Punjab and Haryana

The study was undertaken to understand the performance level and sustainability of commercial dairy farms by drawing a sample of 30 farms each from Punjab and Haryana during 2019-20 through snowball sampling technique. Data collection was done by using semi-structured interview schedule and observation method. Descriptive statistics, t-test, regression analysis, principal component analysis and garret ranking were employed to analyze the data. The farmers of Punjab were found to be efficient in production and entrepreneurial dimension of performance while, the farmers of Haryana were better in marketing dimension. Overall, 60 per cent of respondents in Punjab had medium level of performance, while, 43.33 per cent of them in Haryana belonged to low performance category. Economic and ecological sustainability level of farmers in Punjab was observed to be high; in contrast, the farmers of Haryana were relatively more sustainable in social dimension. In overall sustainability of commercial dairy farming, 43.33 per cent of respondents in Punjab and 53.33 per cent of respondents in Haryana belonged to medium and low category respectively. Extension contact emerged as the highly significant variable affecting sustainability. Further, the factors such as education, proportion of land used for fodder cultivation, farm mechanization, net income per standard animal unit and diversification were also positive and significant with sustainability. Difficulty in attracting customer, securing reliable market and reduction of profit margin due to adulteration of milk and milk products were observed to be establishment and maintenance constraints respectively. The study suggests to incentivise the farmers with credit, insurance, training; facilitating other inputs; market for animal sale and product sale as well as strengthening farmers groups at cluster level so as to enable the sustainability and profitability of commercial dairy farms in the country.

A Comparative Study of Milk Vendor Operations in Different Regions of Uttar Pradesh: An Extension Perspective

A study was undertaken to ascertain the motivation of vendors, effectiveness of vendorship, the economics of venture and constraints in practising milk vendorship. The study was conducted in 2020-21 with 120 randomly chosen vendors at the rate of 30 from each of four regions viz., Eastern, Western, Central and Bundelkhand representing the whole state of Uttar Pradesh. The collected primary data were analysed using frequency, percentage, correlation, regression and Garatte ranking techniques. The findings revealed that majority of the respondents represented middle aged group (55.83 %) and marginal land holding (58.00%). They were also practising dairy farmers (83.33%) with a medium herd size (40.83%). Family tradition (75.83%) sustained them in this venture with full cooperation of family members (98.33%). Their limited social participation and no participation in any training programme made them outside the purview of formal capacity building in scientific dairying. Among the four regions of the study area, vendors in Western region exhibited higher annual income and marketing efficiency. An index developed to evaluate the level of vendorship effectiveness indicated that 40.00 per cent respondents obtained medium index value followed by 35.00 per cent in low and 25.00 per cent in high index value respectively. The vendors were also found to provide credit, inputs and other support as requested by their client farmers. Vendors enhanced the milk sale price by almost 25 per cent after procuring milk from farmers. Their average net return per day from milk sale was found to be Rs.311.35. Stiff competition from other market players, increasing operational expenditure, switching loyalty of customers and seasonal fluctuation in milk availability were perceived to be the major constraints of vendors. They expected support and encouragement from government agencies for their better future. The study calls for recognition of vendors in formal dairy sector through regular extension programmes, incentives for quality milk supply and credit support from banks.

Capacity Building of Resource Poor Farmers in Paddy-wheat cum Dairy Production System through Farmer FIRST Programme under Irrigated Agro-Eco Region of Haryana

The project is implemented in Karnal district of Haryana in a cluster of seven villages namely: Kamalpur Roran, Garhi Gujran, Nagala Roran, Churni, Samora, Chand Samand and Dabkoli Khurd in which 24 technological interventions based on crop, dairy, horticulture and enterprise based modules were advocated towards the doubling the income of the farmers. Varietal trials of paddy like PB-1509 & PB-1692 were introduced and 191 demonstrations were conducted for paddy growers which covering the area of 76.4 hectares. Average yield of PB-1509 was recorded 58.00 q/ha and PB-1692 was 57.00 q/ha. Near about 100 demonstration of new wheat varieties of wheat DBW-222 & DBW-303 were also conducted and average yield of these varieties were recorded 50 q/ha and 56 q/ha; respectively. Inadequate availability of green fodder particularly in the lean period (May-June and November-December) and round the year in general is major problem in the area and to overcome this issue, More than 180 farm families were advised to use Maize variety J-1006 in Kharif and 50 new demonstrations of Berseem BL-42 & BL-44 in Rabi were conducted and farmers were able to get from this crop rotation 1150-1175 q/ha in a year. Mineral mixture, rumen protected amino acid and Bypass fat supplementation to dairy animals improved their productive and reproductive condition. Significant increase in milk yield, fat and SNF was reported by farmers. Continuous Ecto and Endo parasite control measures resulted in control of parasites in adopted villages and overall improvement in health of dairy animals was observed. The extent of Knowledge under dairy based intervention was highest in case Mastitis controls (98.21%) followed by endo-parasite control (93.47%) and Thelieoresis vaccination (92.59%). Improved production of crop as well as dairy farming help to enhance the socio-economic condition of farmers. Under this project, 10 scientists -farmers' interaction, 5 exposure visits of farmers and 7 Kisan sanghoshthies and other programmes, 11 training programmes, 6 animal and 2 plant health camps were organized to educate the farmers and Solve their problems on day to day basis.

Status of Artificial Insemination Services in Dairy Animals of Jharkhand

The contemporary study was conducted in three districts of Jharkhand to know the present status of artificial insemination. The data was collected from 204 respondents (180 farmers and 24 service professionals) with the help of pre structured interview schedule. The study revealed that 67.22 percent of the respondents served their animals using artificial insemination. Still 12.22 percent of the respondents were practicing natural breeding in their animals. Near about 68 percent of the respondents used A.I in non-descript cattle whereas 88.89 percent were using in crossbred cattle. About 78.00 percent of the respondents availed the service from Lay Inseminators and cent percent of the inseminations were done at farmers home. Almost 93.00 percent of the respondents identified heat in cattle through bellowing whereas in buffalo 73.68 percent of the respondents identified heat through string of mucus hanging from vulva. Only 2.53 percent of the respondents knew about sexed semen. Around 89 percent of the respondents self-diagnosed the pregnancy in animal. Missing heat was the prominent method to detect pregnancy in animal by 92.22 percent of the respondents. More than half of the respondents served their animals six months after calving. Overall 67.42 percent of the respondents continued the adoption. Breed improvement was the major reason of adoption by 92.41 percent of the respondents. With maximum average weighted score, respondents were most satisfied by the service of NGO (BAIF) followed by Government Veterinarians. Repeat breeding with maximum average Garet score followed by poor conception rate and incompetent inseminators were the top three constraints in implementation of artificial insemination of the farmer respondents. For veterinarians, lack of skilled subordinate staff for help during artificial insemination, lack of awareness among farmers for breeding activities and engagement of veterinarians in other activities were the major top three constraints in implementation of artificial insemination.

Dairy Extension Delivery System in Karnataka State: A Stakeholder Analysis

The primary data pertaining to the role performance and its effectiveness of multiple dairy extension service providers in Karnataka State as perceived by the dairy farmers (n=400) was collected and analyzed. The study revealed that the Department of Animal Husbandry & Veterinary Services (DAH&VS) hold a significant role and very effective in providing breeding and health care services with a weighted mean score of 281.0 and 267.50 respectively. The Dairy Cooperative Societies (DCS) were very significant and very effective in extending assured market facility, input supply and extension advisory services (EAS) with a weighted mean score of 294.80, 252.59 and 285.55, respectively. In order to measure the dairy progressiveness at district level, Dairy Development Index (DDI) was developed by using the secondary data pertaining to different dimensions of dairy development at district level for the past six years (2014-2020). The Dairy Development Index is a composite index consisting of these indicators and its values ranges between 0-1. The region wise

time series analysis of DDI reveals that the dairy development in Southern region was progressing well as compared to the other regions viz., Malnad & Coastal region and Northern region of Karnataka State. For the year 2019-20, the calculated DDI mean value for the Karnataka State was 0.71. The minimum DDI value of 0.43 was for Bagalkote District and maximum DDI value of 0.92 for Hassan District. Based on the calculated index values, dairying in Karnataka State could be classified as 'progressive districts', 'moderately progressive districts' and 'less progressive districts'. The analysis of the study clearly showed the disparities in dairy development across the Karnataka State and the developed DDI shall be useful for monitoring the dairy development across the Karnataka State.

Sustainable Livelihood Development of Scheduled Caste Farmers through Livestock based Technological Interventions in Kolar District of Karnataka

The present study is being conducted in Kolar District of Karnataka State, selected purposefully having significant percentage (30.32%) of Scheduled Caste (SC) population. From Kolar District, three villages viz., Seethappanahalli (98.31%) from Kolar Taluk and Karisandra (90.99%) and Hunasikote (28.84%) from Malur Taluk were identified and selected as a study area. A total of 100 SC dairy farm families from the three villages were selected as beneficiaries/primary respondents of the present study. As per the need assessment, various technological interventions viz., 'balanced feeding, green fodder production, cattle health & infertility management, clean milk production and backyard poultry' were implemented among the selected beneficiaries through distribution of critical technical inputs, organizing on-farm demonstrations and training programmes, animal health camps and interaction meeting with the beneficiary-farmers. The periodic monitoring of implementation of suggested technological interventions by the beneficiaries is being carried out through regular visits and on-farm support and accordingly its impact on improved milk productivity and enhancement of their livelihood is being assessed and documented.



Enriching Knowledge-Integrating Technology and Institutions for Holistic Village Development in Horticulture based Farming System

During the period under report, the proposed and planned activities executed in the project villages, included, continued green fodder production campaign with sensitisation among clientele for green fodder production, fodder seeds / stem cuttings of improved fodder varieties of fodder maize, fodder sorghum and hybrid napier were provided to fifty farm beneficiaries, for ensuring balanced feeding with ample availability of green fodder for the dairy cows. For mastitis management, institute interventions comprised distribution of critical inputs and sensitization with expert talks, interactive sessions and animal health camps, demonstration & orientation to beneficiaries of CMP Kits was organised in the adopted villages and CMT kits were distributed to sixty beneficiary farm families. For addressing reproductive problems in the dairy cows of beneficiary farm families, dairy animal infertility and healthcare camps were organized in the project villages. Veterinary Health and Animal Infertility Camp organised in the project villages, covered 102 HF cross-bred dairy cattle of 60 beneficiary farm families and the problems attended, included Reproductive Problems Pregnancy Diagnosis Digestive Problems Mastitis Wounds/Injuries/Warts and curative medicines & mineral mixture supplement were provided for the benefit of the famer beneficiaries adopted villages. Technical know-how on clean milk production, balanced feeding, care and maintenance of dairy animals & animal housing was periodically sensitized among target beneficiaries through interactive sessions. Recognition of their contribution to dairying was done through incentivization to the farm families for enhancing their participation in dairying. Highest milk pourers in the Dairy Co-operative Society and active participation in the dairy activities were selected among farmers, farm women and farm youth in the Village Dairy Cooperative Society maintaining clean and well-maintained cow shed and clean animal was judged by the team and were recognised and rewarded for their active participation in dairying.

Fodder Crop Management Interventions through Bio-fertilizers and bio-pesticide for Sustainable Dairy Farming

It was observed from the demonstration of maize fodder crop in the farmers field, that the yield in Chakdaha block was 349.30 ± 9.99 qtl/ha, in Ranaghat-1 block was 344.50 ± 17.33 qtl/ha and in Santipur block was 342.50 ± 13.13 qtl/ha. The overall mean cost of cultivation of berseem fodder crop was Rs. 35687.00 ± 385.97 . The average benefit derived from cultivation of berseem crop in Chakdaha block was Rs. 99880.00 ± 14824.79 , in Ranaghat-1 block was Rs. 109450.00 ± 6129.37 , in Shantipur block was Rs. 110433.33 ± 6752.86 . The overall mean benefit accrued from cultivation of berseem fodder crop was Rs. 106653.33 ± 5589.43 . The overall benefit to cost ratio analysis for cultivation of oats fodder crop by using bio-fertilizer and bio-pesticide, suggested that the ratio was $2.01 \pm .08$. It was observed from the demonstration of sorghum fodder crop in the farmers field that, the yield in Chakdaha block was 586.60 ± 24.69 qtl/ha, in Ranaghat-1 block was 618.75 ± 20.65 qtl/ha and in Santipur block was 611.63 ± 18.15 qtl/ha. In the demonstration plots, the BC ratio of cultivation of sorghum fodder crop in Chakdaha block was $1.69 \pm .11$, in Ranaghat block was $1.74 \pm .06$ and in Santipur block was $1.87 \pm .04$. Videography for production of multimedia was completed and video of more than 10 hours duration was shot. Several training programmes were organized to train and sensitize farmers about bio-fertilizers and bio-pesticide based fodder crop production. In the training programmes, doubts of farmers pertaining to fodder crop production by using bio-fertilizers and bio-pesticide were also cleared. Benefits as perceived by the farming community with respect to use of bio-fertilizers and bio-pesticides in fodder crop production were: simplicity in use, increased economic returns, quick vegetative growth, improved fodder quality, reduction in cost and higher yield.

Formulating Coping up Strategies for Extreme Weather Events in Sundarbans Region through Livestock Based Integrated Farming System: A Societal Perspective

One 'livelihood security index' was developed under the project and block wise distribution of farming community according to the livelihood security score revealed that, the livelihood security score was maximum in case of Namkhana block (55.79 ± 0.92) whereas it was lowest in case of Hingalganj block (36.80 ± 0.34). The highest nutritional security score was observed in case of Namkhana block (55.12 ± 1.61) and lowest nutritional security score was observed in case of Hingalganj block (30.41 ± 0.65). In case of infrastructural security it was found that the Gosaba block was having the lowest score (16.47 ± 0.47). Farmers who belonged to general category (51.51 ± 0.50) and OBC category (51.74 ± 1.01) were having better overall livelihood security score, whereas the farmers who belonged to Scheduled Caste community (41.96 ± 0.38) were having the lowest livelihood security score. Majority of the farming community belong to general caste, Scheduled Tribe and all the farmers from OBC community has perceived that extreme weather events has increased in last one decade. In case of Scheduled Caste farming communities, majority respondents who were engaged in horticultural crop production disagree with the notion that 'extreme weather events is not affecting horticultural crop very much'. The farmers used to update themselves for the upcoming natural disasters through the various Govt. offices (Police Office, B.D.O. and Gram Panchayat etc.), news and social media well in advance. Farmers used to take shelter in flood relief centers. In the flood relief centre, arrangement of keeping livestock was available. Indigenous breeds of cattle were more resistant to disease and they were more adaptive towards the local conditions. Majority of the farming community of Sundarbans were rearing indigenous cattle due to their traditional custom and belief. Financial help in the construction of pucca animal shed' and 'Salt tolerant high yielding varieties of crops' were highest ranked and second highest ranked 'felt needs' irrespective of the caste of farming community. Other needs like 'Re-establishment of road connectivity immediately after extreme weather events' and 'Rapid information sharing through communication tools' were also got higher ranks in need analysis.

Upliftment of Socio-economic Condition of Tribal People through Integrated Livestock Farming in North Eastern Hill Region/ Eastern part of India (TSP)

The works were continued in tribal dominated villages/ clusters of Birbhum, Bardhaman and Nadia districts in West Bengal and some villages of north eastern hill states (Namsai district in Arunachal Pradesh, Paren district in Nagaland and Dhalai district in Tripura) during 2021. Tribal farmers in such areas were motivated to rear livestock for strengthening farming with integrated approach for enhancing the family income and improving the nutritional status of their family members. Therefore, superior breeds of piglets, female goats, chicks and ducklings were distributed as a component of direct benefit transfers (DBTs) to the beneficiary resource-poor tribal farmers for integrating these animals/birds in their traditional farming practices. Sufficient quantity of feeds, mineral mixture, supplements, dewormers, poultry feeders and waterers, buckets and metallic feeders for goats/piglets and other inputs were also distributed to the farmers for enhancing the production potential of such animals/ birds reared by the tribal farmers and strengthening animal husbandry practices. Total of 738

goats and 31150 kg goat feed; 101 piglets along with 8600 kg of pig feed; 3623 chicks and 3993 ducklings along with 20250 kg chick/ duckling feed were distributed to 1242 beneficiary farmers along with other inputs. Off-farm Interaction-cum-Training sessions were also conducted to train these Tribal farmers on different aspects of dairy farming, goat husbandry, pig farming, poultry and duck farming.

Beneficiary tribal farmers in West Bengal (Birbhum District) increased goat population by 480% when they were distributed elite Black Bengal goats along with feeds etc. in 2016-2019. They have earned additional income of Rs. 14481/farmer due to improved practices in goat husbandry. Tribal farmers achieved additional income by Rs. 6440/farmer due to sale of eggs and ducks, when they were distributed with ducklings, feeds and other inputs. Beneficiary tribal farmers in Bardhaman dist. increased goat population by 48.08% when they were distributed elite Black Bengal goats in 2019. They have earned additional Rs. 5077/ farmer due to goat farming. Tribal farmers benefited with distribution of piglets gained additional income of Rs. 3714/farmer in Nadia dist. Distribution of poultry chicks and ducklings to the tribal farmers along with feeds and other materials benefitted such farmers by additional income of Rs. 20642/farmer in Nadia dist. Tribal Farmers improved their livestock feed resource base for their animals through fodder production. Knowledge upgradation of trainee tribal farmers helped such Tribal farmers for enhancement of adoption rate of different demonstrated technologies in relation to dairy/goat/poultry farming. Knowledge support through Mobile SMS services (24x7) were also provided regularly to the tribal farmers on different issues of livestock/ poultry farming.



Improving the Livelihood through Dairy Farming in North Eastern region of India (NEH)

Different livestock based developmental works were continued in some villages/ clusters of north eastern hill states (Namsai district in Arunachal Pradesh, Paren district in Nagaland, Dhalai and Udaypur districts in Tripura, Morigaon district in Assam, East Sikkim district in Sikkim) during the period under report. Farmers in such areas were encouraged to rear livestock/poultry birds for strengthening traditional farming with integrated approach for enhancing the family income, livelihood security and improving the nutritional status of their family members. Therefore, superior breeds of piglets, female goats, chicks and ducklings were distributed as a component of direct benefit transfers (DBTs) to the beneficiary resource-poor NEH region farmers for integrating these animals/birds in their traditional farming practices. Sufficient quantity of feeds, mineral mixture, supplements, dewormers, poultry feeders and waterers, and other inputs were also distributed to the farmers for supporting the farming and enhancing the production potential of such animals/birds reared by the NEH farmers and strengthened animal husbandry practices. Total of 200 goats and 4500 kg goat feed; 175 piglets along with 19250 kg of pig feed; 13220 chicks and 2000 ducklings along with 21000 kg chick/duckling feed were distributed to 1048 beneficiary farmers along with other inputs. Cattle feed (3750 kg) along with mineral mixture were also provided to the beneficiary farmers for enhancing the milk production potential of dairy animals. Off-farm Interaction-cum-Training sessions were also conducted to train these farmers on different aspects of dairy farming, goat husbandry, pig farming, poultry and duck farming. In the on-line training programme a total of 52 poultry farmers participated. Different aspects of poultry farming like poultry nutrition, housing management, health care aspects were covered under the programme.

Beneficiary Farmers in Arunachal Pradesh increased the population of pigs by 333.3% when they were given piglets along with feeds and other inputs in 2016-17 as direct benefit transfer and they increased profit by 131.3%. Similarly, other group of farmers in this state increased poultry population by 185.7% when they were distributed chicks along with chick feed and other inputs before 3 years back with profit enhancement by 124.7%. Beneficiary farmers in Tripura adopted goat farming after distribution of elite Black Bengal goats along with feeds and other inputs in 2016-17. They increased the goat population by about 151.7% and current net income from goat farming was Rs. 23,800/farmer. Due to introduction of goat farming under integrated approach the current net income was Rs. 95360/farmer due to goat rearing and cropping

practices by the beneficiary farmers in Tripura. Such farmers increased their net income by 96.4%. Similarly, other beneficiary farmers of different NEH states (Sikkim, Meghalaya, Tripura, Arunachal Pradesh, Nagaland, Mizoram) under the NDRI-NEH component adopted and improved their livestock (goat/ pig/ cattle) and

poultry (poultry birds/ ducks) farming with integrated approach due to provision of livestock (goats/ piglets) and chicks/ ducklings along with sufficient quantity of feeds (for goats, cattle, pigs, poultry birds), mineral mixture, supplements, medicines/ vaccines and other inputs (as Direct Benefit Transfers).

Enhancement of Socio-economic Condition of Scheduled Caste Farmers through Livestock Based Integrated Farming in Eastern India (SCSP)

The project was undertaken in 6 villages (2 villages from 3 districts) from 3 districts namely, Nadia, Burdwan and Birbhum districts of West Bengal with an aim to uplift the socio-economic condition of scheduled caste people in SC dominated areas of West Bengal through integrated livestock farming. After collecting the baseline information regarding population dynamics, socio-economic condition of villagers, existing dairy husbandry practices, production performance and animal diseases occurrence etc. of the 150 beneficiaries (25 beneficiaries from each village of each district) from all the districts and identifying the major problems faced by the farmers/rearers for livestock rearing, the different technological needs as perceived by the farmers' were assessed and ranked. The infertility of cattle, calf mortality and high disease occurrence are the main problems for livestock rearing in these areas. Rank given by respondents from Nadia, Birbhum and Burdwan district with respect to perceived needs were highly correlated, which suggested that the perceived need of the farmers from these three districts were similar and hence the similar type of technological intervention may be given to the farmers of these three districts. On the basis of technological needs, a total of 150 pure Bengal goats were distributed among the beneficiaries of three districts. Other inputs like supply of goat feed, mineral mixture, dewormer, vaccine, medicines etc. were also distributed among the farmers' in the project area. Several animal health camps and scientists-farmers' interaction meet were organized in the project areas of different districts of West Bengal.

4. RESEARCH PRIORITIZATION, MONITORING AND EVALUATION

The objective of Research Prioritization, Monitoring and Evaluation (PME) Cell is to put in place a robust mechanism for managing research functions and for developing and strengthening the research ecosystem. The essential elements of such an ecosystem, viz., generation of knowledge and facilitation of research, innovation and technology development for industrial & societal benefits, are addressed by human resource, intellectual capital, governance and financial resources, information management system, research promotion & guidance, Integrity and ethics, capacity building and research monitoring. The PME creates a conducive environment for enhanced research productivity, encourages collaboration across industry, government, community based organizations, and agencies at the local, national, and international levels and to facilitate research through mobilization of resources and funding. PME Cell at ICAR-NDRI coordinates and manages research activities and facilitates the decision support system with the following terms of reference:

- To co-ordinate and synthesize the recommendations of QRT, RAC, IRC and Vision document of Institute and ICAR.
- To recommend research priorities of the institution for short-listing researchable problems at Institute level.
- To co-ordinate and arrange for annual monitoring of each on-going project and evaluation of completed projects through internal and external experts.
- To co-ordinate and arrange for technology validation and impact assessment of successful technologies through internal and external experts.
- Regularly sensitizing and capacity building of research managers and scientists through training programmes.
- Maintaining a database on all publications, technologies developed, IPRs, consultancy projects undertaken in the past and on-going projects.

Research Advisory Committee (RAC)

The new Research Advisory Committee (RAC) for ICAR-NDRI, Karnal was constituted as per the provisions of 'functions' of RAC provided under clause 71C of the ICAR Society rules, which includes, among other functions: (i) to suggest research programs in national and global context of research in thrust areas, and (ii) to review the research achievements of the Institute and deliberate as per the program developed by the institute and the provision 71F of the ICAR Society rules. The meeting of RAC of ICAR-NDRI was conducted on February 5, 2021 under the Chairmanship of Dr S. L. Goswami, Ex-Vice-Chancellor, Banda University of Agriculture & Technology, Banda and Former Director, NAARM, Hyderabad.

Institute Research Committee (IRC)

The key functions of Institute Research Committee (IRC) are to critically review the on-going and completed research projects, to consider the new research proposals and to advise on fostering of linkages between the groups / divisions of the Institute in respect of multi-disciplinary / multi-locational projects. The IRC meetings to evaluate the outcome of the completed research projects and to consider new research projects proposals were held on-line on May 17-21 and July 20, 2021 for ICAR-NDRI, Karnal, SRS, Bengaluru and ERS, Kalyani. The completed and new research projects were critically discussed in order to address current emerging issues of the dairy sector. The mid-term review of IRC projects of ICAR-NDRI was taken up on November 16-27, 2021 at ICAR-NDRI, Karnal, The virtual meetings were conducted under the Chairmanship of Director and convened by Joint Director (Research), ICAR-NDRI, Karnal.

Screening and Evaluation of Concept Proposals of Externally Funded / Contract / Consultancy Projects

The meetings of the PME Unit were convened for thorough deliberations on the functions envisaged under the purview of PME Cell with the overall objective of facilitating the decision support system of ICAR-NDRI, Karnal. PME also screened and evaluated Externally Funded / Contract / Consultancy research proposals received from time to time. Twenty four PMC Meetings were conducted on 2.01.2021, 8.01.2021, 21.01.2021, 29.01.2021, 3.02.2021, 12.02.2021, 20.02.2021, 1.03.2021, 5.03.2021, 8.03.2021, 16.03.2021, 26.03.2021, 27.03.2021, 28.06.2021, 23.08.2021, 2.09.2021, 6.09.2021, 9.09.2021, 10.09.2021, 20.09.2021, 29.09.2021, 08.11.2021, 25.11.2021 and 14.12.2021 to screen and consider 69 Nos Externally Funded / Contract / Consultancy research proposals.

Besides, a total of 11 research proposals were considered, screened and evaluated online and forwarded them to external funding agencies such as Dept of Science and Technology (DST); Dept of Biotechnology (DBT); SERB; DAHD; BIRAC-PACE Scheme, Ministry of Food Processing Industries (MoFPI), New Delhi; National Fund; RKVY-RAFTAR; HSPCB; Ministry of Health (Grant-in-Aid Scheme); SERB-Power Grant; National Gender Resource Centre in Agriculture New Delhi and DST SERB Power Grant.

Formulation of Guidelines

In order to provide robust mechanism for developing and strengthening the research ecosystem, PME cell formulated guidelines related to submission of Project Proposals for External Funding / Consultancy / Contract Research.

PME Cell also convened meeting of Institute Technology Management Unit (ITMU) on 09.07.2021 and prepared Proceedings / guidelines for smooth function of the Unit by way of defining roles to be performed by the members of the ITMU.

MoUs Signed and Implemented

PME Unit provided all the logistic support for scrutinizing / finalizing the following MoUs signed between ICAR-NDRI and Other State Agricultural Universities and Central Universities.

- MoU signed with Sh. Venkateswara Veterinary University, Tirupati on 31.05.2021.
- MoU signed with PAU, Ludhiana on 7.06.2021.
- MoU signed with University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand on 19.08.2021.
- MoU signed with Agrinnovate India Limited: Schreiber Dynamix Dairies Pvt. Limited 215 Atrium Bldg., C-Wing, 108, 10th Floor, Andheri Kurla Road East, Mumbai-400093 on 31.08.2021.
- MoU signed with Gurukula Kangri Deemed to be University, Haridwar, Uttarakhand on 10.09.2021.
- MoU signed with GLA University, Mathura (UP) on 13.09.2021.
- MoU signed with Assam Agricultural University, Khanapara, Guwahati, Aasam-22 on 18.11.2021.

Project Information Management System (PIMS)

The PME Unit implemented on-line database / computerization of research projects under PIMS introduced in collaboration with IASRI. The unit acted as a nodal agency to facilitate and coordinate with PI of the project at IASRI, New Delhi and PIs of all the on-going and completed research projects at ICAR-NDRI for smooth functioning of PIMS activity.

Research Projects Database Management

A database through PIMS package of research projects was updated for all the research projects in operation during the year 2021. The database of research projects containing the targets and achievements of the preceding half yearly and targets fixed for the next six months was updated in HYPM package.

Technical Screening Committee Meetings

Technical Screening Committee constituted under the Chairmanship of Joint Director (Res.) evaluated the manuscripts for publication in the form of books, technical bulletins, manuals etc. Based on the recommendations of the committee, the manuscripts were also sent to outside experts for evaluation. The same were again evaluated in light of the comments received from experts and the contents of the publications got modified and subsequently got published as Institute publications. During the period under report, the following manuscripts were screened and evaluated:

- Laboratory Manual on 'Semen Preservation and Artificial Insemination'
- Manuscript of Booklet on 'Compositional Status of Milk from Indigenous Breeds of Cattle'
- Doodh mein uplabadh dheik koshikaon se doodh ki goonvatta ka anumann'
- Acchi goonvatta wali khees se bacchre ki rog pratirodhak shamta baday'

Selection Process for ICAR-PDF at ICAR-NDRI

PME Unit provided the logistic Support in Selection of ICAR-PDF at ICAR-NDRI in framing the guidelines for ICAR-NDRI as per ICAR guidelines, publicizing it widely by issuing the letter to all Vice Chancellors for selection of ICAR-PDF fellows, scrutiny of applications for PDFs and selection of the candidates at ICAR-NDRI as per the ICAR directives.

Research Documentation and Publication

The PME Cell of the Institute is responsible for documentation and dissemination of research output through Annual Reports, Half Yearly Reports, Quarterly Reports, Monthly Reports, Technical Reports / Bulletins, etc. During the period under report, the following publications were prepared, edited and published through this cell:

- Annual Report -2020.
- ICAR-NDRI News Letter-a quarterly newsletter in English.
- Director's Report for the 19th Convocation.
- Research Projects (2021).
- Institute Research Committee (IRC) Proceedings (2 No) under the identified research programmes of the Institute.
- Research achievements of ICAR-NDRI for inclusion in ICAR / DARE Annual Report 2021-2022.

XIII Plan EFC Memo Document (2021-26)

- Formulation of EFC plan document under the theme No. 17: "Dairy Production & Technology Development" amounting to Rs. 440 Crores comprising Sub-scheme 17(i): ICAR-NDRI, Karnal with total outlay of (Rs.242.00) Crores; 17(ii): ICAR-CIRB, Hisar with total outlay of (Rs.63.00) Crores; 17(iii): ICAR-CIRB, Network Project on Buffalo Improvement, Hisar with total outlay of (Rs.35.00) Crores; 17(iv): ICAR-CIRC, Meerut with total outlay of (Rs.35.00) Crores; 17(v): ICAR-CIRC, All India Co-ordinated Research Project, Meerut with total outlay of (Rs.32.00) Crores, 17(vi): ICAR-NRC on Camel, Bikaner with total outlay of (Rs.33.00) Crores and submitted for consideration and final approval.
- Prepared replies of comments received on EFC document from various appraisal agencies and Ministries including Niti Aayog etc.
- Prepared Action Taken Report on actionable points for Animal Science Division on suggestions made by the Hon'ble Agriculture Minister & MoS (A & FW) during the presentations on SFC / EFC of SMD. The provision of budget (Rs. 3.84 Crores) earmarked for promotion of research and technologies on adulterants and contaminants checking in milk products at National Referral Centre for quality and safety at NDRI, Karnal
- Prepared information regarding justification of continuation / extension of on-going schemes proposed under EFC document of the Institute for the period (2021-26) alongwith significant achievements of XIII Plan and year-wise outputs / deliverables of XIV Plan.

Half Yearly / Quarterly / Monthly Reports

- PME unit consolidated the Half Yearly/Quarterly/Monthly/Weekly Reports of the Institute in the prescribed formats and submitted to the Council. Likewise, quarterly reports were consolidated in terms of financial and physical targets of TSP activities being carried out at Eastern Campus, Kalyani.
- Quarterly, Half Yearly and Annual progress report were consolidated with respect to implementation of Tribal Sub Plan (TSP), North-Eastern Hill (NEH) Region and SCSP schemes being carried out at Eastern Regional Station, Kalyani.

Assessment / Retention Cases of Scientists

PME Unit also processed the documents for Assessment and Retention of the scientists of ICAR-NDRI, Karnal. The meeting for assessment cases of scientists were held in September 2021.

Action Taken Reports (ATRs) and Information Collation

This Unit also prepared the following **Action Taken Reports** on recommendations emerged during the following meetings and submitted the same to the Animal Science Division of ICAR, New Delhi.

- Observation (s) / suggestion (s) made in the cabinet meeting regarding UID (S): OBS / 2878 comprising initiatives taken / achievements and success stories during last two years (2019-20 and 2020-21).
- Progress of Atma Nirbhar Bharat (ANB) package.
- Proceedings of the meeting of the committee Chaired by DDG (AS) regarding planning of programmes / activities for the event of ICAR@100 held on March 9, 2021.
- eSamikSha status on the important observation(s) / suggestion(s) with respect to Department of Agriculture Research and Education (DARE) as on June 25, 2021.
- Status report on the PM Independence Day speeches of last seven years.
- Senior Officers' Committee Meeting held on March 5, 2021 and June 8, 2021.
- 92 Annual General meeting of ICAR Society held on January 27, 2021.
- Directors' Conference held on December 5, 2020 and July 2, 2021.
- Minutes of the meeting of conveners of sectoral groups / sub-groups of secretaries for implementation of important action points made for Ministries / Departments and Bharat Ka Amrit Mahotsav held on April 6, 2021 at Rastrapati Bhawan, Delhi.
- Atma Nirbhar Bharat Announcements and Measures to stimulate demand sought by Hon'ble Union Agriculture Minister & Farmers Welfare.
- Proceedings of virtual meeting held on July 20, 2021 regarding policy change for commercialization of public sector varieties / planting material / breeds to different seeds producing.
- Review meeting held on October 27, 2021 at ICAR under the Chairmanship Hon'ble MoS on disposal of pending matters and swachhata campaign.
- Establishing India- Denmark Center for agriculture technologies like food safety, cold chain, food processing, and fertilizers, agriculture, fisheries, etc.
- Agenda items discussed during the meeting of Directors and PME In-charges held on October 13, 2021 under the chairmanship of DDG (AS).
- Scaling up and promotion vaccine / health management protocols and reproductive technologies developed by the ICAR Institutes emerged during the meeting of the committee constituted under the Co-Chairmanship of Secretary (A & FW) and Secretary (DARE) & DG, ICAR to discuss the agenda topics / issues submitted by various divisions of the Council.
- Senior Officers' Committee Meeting held on 4th October, 2021.

- 8th meeting of the BIMSTEC Expert Group on Agricultural Co-operation held on August 8, 2021.
- Cabinet meeting held on October 26, 2021.
- Proceedings of the Annual Conference of VCs of Agricultural Universities held on September 28, 2021.
- DAHD-ICAR Interface meeting held on January 2, 2021.
- Minutes of the meeting held under the Chairmanship of Additional Secretary, DARE & Secretary, ICAR to review the preparedness for ICAR Foundation Day celebrated on June 16, 2021.
- PMO communication regarding research be conducted on best indigenous practices of cattle feed for example drumstick plant waste is being used to improve cattle feed in Surat District and deliberations on the best practices may be planned at National, State and District level to ensure wider dissemination of these best practices among farming community.
- Recommendations emerged out with respect to ICAR- NDRI, Karnal during the meeting chaired by PM on priority performance.
- Non- bovine milk review meeting chaired by PM.
- Proceedings of the meeting held on December 15, 2021 at ICAR, New Delhi regarding implementation of Kisan Sarthi Programme.
- Greater R & D focus on post production activities (traceability, assaying, package, higher shelf life and waste to wealth) sought by MoA & FW.
- Preparation and formulation of guidelines made by the ICAR for import of animal feed including DDGS.
- Summary of records of the DADH- ICAR Interface meeting held in June, 2021 through video conferencing to discuss the research priorities for DAHD which could be undertaken by ICAR.
- Roadmap for carrying out research activities on non-bovine milk & milk products.
- Task Force Committee on Agricultural Development.
- Ministry wise actionable points derived from various PPTs.
- Activities / task / mission with regard to celebration of 75th Anniversary of India's independence.
- Status report on the celebration of Mahila Kisan Divas celebrated on October 15, 2021.
- Research targets for the year 2021- 2022 for implementation of TSP / NEH / SCSP Programmes.

Besides, PME Cell also collated information towards agenda and action taken reports on the recommendations of ICAR- Regional Committees No. I, II, V, VI, VII and VIII held from time to time. The Unit also collated information sought by the Council from time to time on the Institute activities, achievements, technologies, training programmes, initiatives undertaken for the growth of dairy sector for realizing various components of white revolution scheme for next 5 years, GB meetings as well as for third party evaluation at SMD level. PME Cell also prepared the information on formulation of vision and strategy to the agriculture sector in view of vision of India@2047.

Research Papers

Research papers submitted by the scientists were processed by the unit for publishing in various journals of National and International repute. In addition, a large number of abstracts of papers were also processed for presentation at various Seminars / Symposia / Workshops / Conferences etc.

Information for Parliamentary Standing Committees and Parliament Questions

PME cell consolidated information for Parliamentary Standing Committee on Agriculture on the performance review of NDRI; ATRs on the recommendations / observations contained in the 39th Report based on comprehensive agricultural research based on "Geographical Conditions and Impact of Climatic Changes to Ensure the Food Security in the Country" of Parliamentary Standing Committee on Agriculture. During the period under report, a total number of 47 parliament questions (Lok Sabha & Rajya Sabha) were attended.

Promotion of National and International Linkages

The unit also acted as a catalyst to promote and strengthen linkages with other Institutions of national and international repute. Visits of international delegations and distinguished visitors at the national level were coordinated and through scientific interactions / deliberations, agenda for mutual collaboration was chalked out with a view to arrive at MoUs for promotion of research and educational endeavours.

Highlights of Major Activities of PME Unit

• In-house Research Projects	:	85
• New Research Projects	:	22
• Externally Funded Projects (National)	:	68
• Externally Funded Projects (International)	:	06
• Externally Funded Projects Proposals Screened	:	69
• Contract / Consultancy Projects Proposals Screened	:	09
• MoUs Screened / Signed	:	07
• IRC Meetings Convened and Co-ordinated	:	02
• Manuscripts of Technical Bulletins / Books Scrutinized / Evaluated	:	04
• NDRI-Annual Report (2020)	:	01
• Quarterly NDRI News Letter (4 Issues)	:	04
• Proceedings of IRC	:	02
• Proceedings of RAC	:	01
• Reports Collated	:	120
• Action Taken Reports / Status Reports	:	57
• Half Yearly Reports	:	02
• Parliament Questions Attended	:	47
• Monthly Reports	:	12
• Quarterly Reports	:	04
• Assessment Cases of Scientists Handled	:	34

Research Projects 2021 (In-House)

SN	Project Title	PI
1)	Production of CRISPR-Cas9 mediated β -lactoglobulin gene edited buffalo embryos. (A-65)	Satish Kumar
2)	Exploring the use of Panchagavya and Mesenchymal Stem Cells for treatment of diabetes and cancer in rats. (A-69)	D. Malakar
3)	Productivity enhancement in hill cattle (Badri) conserved by SC, ST and other communities of Uttarakhand (SC / ST Funded). (A-70)	Vikas Vohra
4)	Strategic modelling of reference population for effective implementation of advanced selection strategies. (A-71)	G.R. Gowane
5)	Use of mesenchymal stem cells for prevention of mastitis and metritis in cattle. (A-72)	Dhruva Malakar
6)	Peptidomic surveillance of urine in Sahiwal cows to evaluate its antibacterial potential against staphylococcus aureus. (A-73)	Sudarshan Kumar
7)	Assessing Genetic Relationship among Production, Functional and Linear Type Traits for selection of elite sires in indigenous and crossbreds dairy cattle. (A-74)	Sabyasachi Mukherjee
8)	Genome-wide scan for Autozygosity, Selection signature and Genomic inbreeding in Karan fries and Sahiwal cows. (A-75)	Anupama Mukherjee
9)	Evaluation of functional traits and their effect of production and reproductive traits of crossbred cattle interventions. (A-76)	Ajoy Mandel
10)	Elucidating the Dynamics of Phoenixin during Reproductive Cyclicity and Elements of Kiss1 / KiSS1R & SMIM20 / GPR173 system in bovine ovary. (A-77)	M. Mondal
11)	Deciphering the modifications in miRNA binding region of DNA repair genes in concurrence with thermal stress among dairy cattle. (A-78)	Rani Alex
12)	Delineation of mucins and carbohydrates associated with salivary crystallization patterns at estrus in buffaloes. (A-79)	Suneel Kumar Onteru
13)	Optimization of the method to produce cloned embryos of indigenous cows. (A-80)	Naresh Selokar
14)	Genetic evaluation of Alpine x Beetal and Saanen x Beetal goat for prospective dairy goat breeding. (A-81)	G.R. Gowane
15)	Harnessing geothermal energy for cooling and Heating of Animal Shed. (B-48)	Pawan Singh

16)	Effect of moringa supplementation on hastening puberty in buffalo heifers. (B-52)	A.K. Roy
17)	Development of on-farm remote monitoring sensor device and its evaluation to predict parturition in cows. (B-53)	S. Jeyakumar
18)	Monitoring various physio-pathological conditions by Infra Red Thermography (IRT) in dairy animals for efficient management decision. (B-54)	Mukesh Bhakat
19)	Livestock-crop based technological interventions for empowerment of scheduled caste farmers in selected districts of Himachal Pradesh, Uttarakhand and Haryana (SC / ST Funded). (B-55)	Arun Kumar Misra
20)	Improvement of Black Bengal goats for enhancement of productivity in eastern region of India products. (B-56)	A. Santra
21)	Augmentation of fertility in jersey crossbred cows through nutritional and hormonal interventions. (B-57)	M. Karunakaran
22)	Enhancement of socio-economic condition of Scheduled Caste farmers through livestock based integrated farming in Eastern India interventions. (B-58)	Ajoy Mandel
23)	Faster multiplication of Sahiwal germplasm through OPU-IVF-Assisted Reproductive Technology. (B-59)	T.K. Mohanty
24)	Strengthening dairy based integrated farming system and optimization of resource utilization. (B-60)	Arun Kumar Mishra
25)	Augmentation of ovarian, testicular function and fertility in buffaloes during low-breeding summer season by dietary supplementation and hormonal intervention. (B-61)	Rubina K. Baithalu
26)	Selective use of antimicrobial alternatives in cryopreservation of crossbred bull semen. (B-62)	Nishant Kumar
27)	Development and Characterization of progesterone loaded nanofibre for controlled breeding in dairy cattle. (B-63)	Vedamurthy G.V.
28)	Evaluation of recycled manure solids as a potential cow bedding material. (B-64)	Mukund A. Katakaltware
29)	Effect of biostimulation in overcoming seasonal sub-fertility and infertility in buffaloes. (B-65)	M.L. Kamboj
30)	Evaluation of oat and berseem varieties under different agronomic practices vis-à-vis management of nitrate toxicity. (C-52)	Rakesh Kumar
31)	Evaluation of Seaweeds as novel products to augment ruminant production performance. (C-56)	Asit Das
32)	Therapeutic efficacy and immunomodulatory role of trisodium citrate and nano-minerals supplementation of subclinical mastitis in dairy cows (Lead Station. (C-57)	A. Manimaran
33)	Evaluation of Moringa oleifera L. cultivars for quality fodder production under differential plant geometry in eastern Haryana. (C-58)	Rajesh Kumar Meena
34)	Supplementation of micronutrients on attaining early sexual maturity of males. (C-59)	Goutam Mondal
35)	Priobiotics, Prebiotics and phytogetic medicinal extracts exploration of their role in augmenting neonatal calf gut health and growth performance. (C-60)	Sachin Kumar
36)	Flavour and taste ingredient as feed additives and their effect on feed intake and growth performance of cattle calves. (C-61)	Raman Malik
37)	Effects of ameliorant in rations with different levels of aflatoxin B1 on nutrient use, production performance and carryover rate in milk in bovines. (C-62)	Chander Datt
38)	Utilisation of paddy straw as strawlage: a complete feed solution for dairy animals. (C-63)	Nitin Tyagi
39)	Evaluation of Herbal Plant mix vis-à-vis Herbal Plant Probiotic mix on the growth and health performance of young Jersey Crossbred Calves. (C-66)	Saroj Rai
40)	Nutritional enrichment of rice straw: evaluation and utilization in crossbred cattle Ration. (C-67)	A. Chatterjee
41)	Effect of sewage water on seed production of Maize-Berseem cropping system under differential nutrient management practices. (C-68)	Hardev Ram
42)	Protein profiling of milk from native indigenous breeds (cow and buffalo) in relation to their bioactive potential. (D-56)	Rajesh Kumar
43)	Unveiling the microbial diversity of traditional Indian fermented milk product 'Dahi' through culturomic and metagenomic approaches. (D-58)	Rashmi H.M
44)	Development of nutria-cereal based protein rich probiotic dairy spreads and dips. (D-59)	Devaraja H.C
45)	Development of direct vat set (DVS) probiotics for preparation of fermented milk products. (D-60)	Chand Ram
46)	Development of colostrum whey-derived bioactive peptide ingredients and preparation of protein-rich fermented whey beverage. (D-61)	Shilpa Vij
47)	Profiling of milk constituents from indigenous breeds of cattle and buffalo. (D-62)	Rajesh Kumar
48)	Development of processed cheese from milk protein ingredients. (E-45)	Yogesh Khetra
49)	Development of fermented whey with enhanced bio accessible iron content. (E-46)	Writdhama G Prasad
50)	Development of mechanised feed and fodder distribution and feeding system. (E-47)	Ankit Deep Scientist
51)	Technology for Moringa oleifera enriched cheese spread (Lead Division: Dairy. (E-48)	Neelam Upadhaya
52)	Technology Development for the Production of Ghee Residue Powder. (E-49)	G.S Meena
53)	Development of automatic integrated hybrid solar yogurt making system. (E-50)	Chitranayak
54)	On-package smart sensor as freshness indicator for set-type fermented dairy products. (E-51)	Narendar Raju Panjagari

55)	Development of Convective-Electrohydrodynamic Drying System for Paneer. (E-52)	F.Magdaline Eljeeva Emerald
56)	Valorization of ghee residue as a source of phospholipids for application in select food products. (E-53)	Monika Sharma
57)	Development of multipurpose automatic controlled rate heating system for production of paneer and Greek yogurt. (E-54)	Vairat Amita Dinkar
58)	Development of improved bioreactor prototype for cattle waste management. (E-55)	P.S. Minz
59)	Metabolomics-assisted elucidation of compositional and technological variations among milks of different goat breeds. (E-56)	Heena Sharma
60)	Development of an energy efficient method for ghee preparation from butteroil. (E-57)	Writhdama Prasad
61)	Development of thermic fluid based small scale mechanized process unit for rasogolla cooking. (E-58)	Priyanka
62)	Development of Magnetic Induction based milk heating System for Paneer. (E-59)	Hima John
63)	Development of Integrated Milk Coagulation cum Coagulum pressing unit for Paneer manufacturing at small scale. (E-60)	P. Barnwal
64)	Development of analytical tools to assess quality of milk-protein based health supplements. (F-26)	Rajan Sharma
65)	Quality evaluation of butter and Ghee prepared from Milk of indigenous and cross bred cattle. (F-27)	Raman Seth
66)	Functional analysis of urine of indigenous vis-à-vis crossbred cows. (F-28)	Mamta
67)	Biological smart time temperature indicator for monitoring thermal abuse and quality of paneer. (F-29)	Gourav Kumar Deshwal
68)	Detection of Sorbitol as an adulterant in milk. (F-30)	Vivek Sharma
69)	Development of lateral flow immunoassay to detect buffalo milk in cow milk. (F-31)	Kamal Gandhi
70)	Isolation & screening of bacteriophages for removal of Bacillus & Geobacillus biofilm from dairy surfaces. (F-32)	Pradip Behare
71)	“Development of analytical strategy for estimation of endogenous water-soluble vitamins in milk”.(F-33)	Richa singh
72)	Attenuated total reflectance-fourier transform infrared spectroscopy coupled with chemometrics to detect foreign fats in ghee. (F-34)	Kamal Gandhi
73)	Exploring the anti-obesity potential of protein hydrolysates derived from goat, camel, cow and buffalo milk. (F-35)	Sunita Meena
74)	Fodder crop management interventions through bio-fertilizers and Bio-pesticide for sustainable dairy farming. (G-68)	Asif Mohammad
75)	Impact assessment of COVID-19 pandemic on Indian dairy sector. (G-69)	Gunjan Bhandari
76)	Impact assessment of selected technologies of NDRI. (G-70)	Anil K. Dixit
77)	Development of climate services for Murrah buffalo farmers of Haryana. (G-71)	Sanjit Maiti
78)	Sustainable Livelihood Development of Scheduled Caste Farmers through Livestock based Technological Interventions in Kolar District of Karnataka. (G-72)	S. Subhash
79)	Improving adaptive capacity of women farmers of Haryana through climate resilient Dairy farming practices. (G-73)	Sanchita Garai
80)	Promotion of dairy farming for upliftment of socio-economic status of tribal farmers through technological interventions in Meghalaya. (G-74)	B.S. Meena
81)	Identification of indigenous milch breeds of cattle through computer vision. (G-75)	A.k. Sharma
82)	Estimation of life time economics of selected breeds of dairy animals in field conditions. (G-76)	B.S. Chandel
83)	Dairy startups in Karnataka State: An ecosystem analysis. (G-77)	S. Subhash
84)	Breed-wise economics of milk production in Gujarat-A Comparative analysis. (G-78)	Udita Choudhary
85)	Livelihood augmentation of resource poor Scheduled Caste farm households in Western Dry Region of Rajasthan. (G-79)	Gopal Shankhala

New Externally Funded Projects Sanctioned during 2021

Sl. No.	Name of the Project	Name of PI / CCPI	Name of Associate (s)	Funding Agency	Duration	Cost in Lakhs
1)	Development of polarized angular scattering and microfluidics technology for bovine sperm sexing (Lead Centre- IIT Indore)	T.K. Mohanty	Mukesh Bhakat	DBT	2021- 2023	157.04
2)	Production of dairy powder from by-products (ghee residue and butter milk); characterization and application in heat desiccated products/ convenience formulations	G.S. Meena	A.K. Singh, Sumit Arora & Yogesh Khetra	MOFPI	2021- 2023	43.52

3)	Characterizing milk colostrum of ladakhi Cows and Yak for identification of Biomolecules with therapeutic potential	Sudarshan Kumar	Jai Kumar Kaushik	SERB-DST	2020-2023	349.43
4)	Production of Double Muscled-Mass Farm Animal using CRISPR	Naresh Selokar	S. De, S. Lathwal, M.K. Singh & M.S. Chauhan	NASF	2021-2023	165.93
5)	Production and shelf-life enhancement of phospholipids rich instant lassi powder from desi chhach	G.S. Meena	Ashish Kumar Singh	HSCSIT	2021- 2023	15.00
6)	CRP on biofortification: suitability of incorporating biofortified cereal straw in animal studies	Arun Kumar Misra	Chander Datt & Rajan Sharma	ICAR-NIANP	2021-2023	10.00
7)	Development of quantitative molecular assays for rapid enumeration of viable probiotics from probiotic food products	Saurabh Kadyan / Rashmi HM	Diwas Pardhan	ICMR	2021-2024	43.90
8)	Genomic based approaches for characterization of the microbial antibiotic resistance and resistome in Dairy production system	Rashmi H.M.	Diwas Pradhan, Saurab Kadyan & Sunita Grover	ICMR	2021-2024	49.33
9)	Development of phyto-immunobiotic for reduction of bovine intra mammary infections: comparative studies on bioactive compounds and whole extract effects	A. Manimaran	-	SERB	2021-2024	46.20
10)	Process for the preparation of lactose free skim milk powder with approaches to minimize maillard reaction	Sumit Arora	Vivek Sharma, Ashish Kumar Singh, Priyanka Singh Rao & Richa Singh	DBT	2021-2024	44.45
11)	Application of nano-immobilized β -Galactosidase for production of galactooligosaccharides from dairy by-product	Manoj Kumar C.T.	Latha Sabiki, Abdul Hussain & Rajan Sharma	MOFPI	2021-2023	43.94
12)	ICAR Network programme on precision agriculture	T.K. Mohanty	A.K.Mishra, S.S. Lathwal & Mukesh Bhakat	ICAR-NEPPA	2021-2026	332.00
13)	Generation of milk somatic cell reference values and intelligent and predictive modelling for monitoring mammary profile and milk quality of indigenous dairy animals	A.K. Dang	Gourav Kumar Deshwal & Adesh Deshwal & Adesh x	DBT	2021-2024	73.06
14)	Protein Based Optical sensors for detection of listeria monocytogenes in milk	Raghu H.V.	Rashmi H.M. & Naresh kumar	ICMR	2021-2024	43.30
15)	Dairy entrepreneurship development among rural youth and women in aspirational districts of Karnataka State	S. Subash	K.P. Ramesha, S. Jeyakumar, & H.C. Devaraja	RKVY	2021-2024	232.00

5. EXTRA-MURAL FUNDING AND COLLABORATIONS

The scientists of the Institute maintained close liaison with various organizations to exchange information and acquire current and advanced knowledge in basic and applied fields of Dairy Science. The scientific competence and excellence of past performance in conducting various research programmes attracted funds from different organizations/ agencies.

International Collaborations:

Sl.No.	Title	PI	Associates	Funding Agency	Duration
1)	Development of probiotic fermented food for prevention of childhood diarrhea against Indian diarrheal pathotypes	Suman Kapila	-	Indo-Spain Project	2020-2023
2)	DOSA-Diagnostics for one health and user driven solutions for AMR.	Naresh Kumar	-	Indo-UKDBT	2018-2021
3)	Explaining the biogenesis and interaction of Pirnas and PIWI proteins in buffalo testes in relation to bull fertility	Rakesh Kumar	T.K. Datta	SERB, ASEAN-INDO Collaboration	2020-2022
4)	Molecular markers for improving reproduction of cattle and buffaloes	Rakesh Kumar PI of NDRI Component	Dheer Singh, Suneel Onteru, Rubina K. Baithalu, A.K. Mohanty, Sudarshan Kumar, T.K. Mohanty, J.K. Kaushik & Mukesh Bhakat	Bill & Melinda Gates Foundation, USA	2018-2023
5)	-do-	A. Kumaresan PI of SRS Component	A. Manimaran and K.P. Ramesha	-do-	-do-
6)	The mechanism behind formation of coocable milk gels (GELCOOK)	Yogesh Khetra	S.A. Hussain	University of Copenhagen, Denmark	2019-2022

National Collaboration:

Sl. No.	Title	PI	Associates	Funding Agency	Duration
1)	Application of nano-immobilized β -Galactosidase for production of galactooligosaccharides from dairy by-product	Manoj Kumar CT	Latha Sabikhi, Abdul Hussain, Rajan Sharma	MOFPI	2021-2023
2)	Capacity building of resource for farmers in paddy-wheat cum dairy production system through Farmer First Programme.	Gopal Sankhala	B.S. Meena, H.R. Meena, S.S. Lathwal, Rakesh Kumar, Ajmer Singh, A.K. Singh, V.K. Pandita (IARI), Nitin Tyagi, Sanket Borad, Heena Sharma, Sachin, Omvir Singh	ICAR	2016-2022
3)	Characterizing milk colostrum of Ladakhi Cows and Yak for identification of Biomolecules with therapeutic potential	A. K. Mohanty	Jai Kumar Kaushik & Sudarshan Kumar	SERB-DST	2020-2023
4)	Cow dung processing and its conversion to bio-fortified fertilizer: A pilot study- National Fertilizer Limited (An Undertaking of Govt. of India), Noida	K.P. Ramesha	Mukund A. Katakaware, Menon Rekha Ravindran, S. Jeyakumar	National Fertilizer Limited, Noida	2018- 2021
5)	CRISPR/ CAS9 guided functional analysis of genes regulation early embryonic in buffalo.	D. Malakar	Satish Kumar	NASF	2018-2022
6)	CRP on bio-fortification: suitability of incorporating bio-fortified cereal straw in animal studies	Arun Kumar Misra	Chander Datt & Rajan Sharma	ICAR- NIANP	2021-2023

7)	Design of functional traditional sweetmeats through 3-D Food Printing.	Kaushik Khamrui	Writdhama Prasad	IIT Delhi/ ICAR	2019-2022
8)	Detection of Subestrus/ anoestrous behaviour in water buffalo.	T. K. Mohanty	Mukesh Bhakat	IIT Delhi/ ICAR	2020-2022
9)	Development of a rapid & robust high throughput reporter cell-based bioassay for detection of xenobiotics in milk.	Dheer Singh CCPI	Suneel Kumar Onteru & Vedamurty G.V.	NASF/ ICAR	2018-2022
10)	Development of Calcium enriched high milk protein powder for convenience formulations of traditional dairy products.	Sumit Arora	Vivek Sharma, A. K. Singh & G.S. Meena	MOFPI	2019-2021
11)	Development of Dairy Business School Model for Farmers: An Action Research	Gopal Sankhla	A.K.Singh, Gaurav Deswal, S.S. Lathwal, T.K. Mohanty, K.S. Kadian & Hema Yadav	(NIAM)	2020-2021
12)	Development of early pregnancy diagnostic assay through discovery of biomarkers in cattle and buffalo.	A.K.Mohanty & A.K. Dang	Rubina K. Baithalu, T.K. Mohanty, Sudarshan Kumar & Rajiv Kapila	DBT	2018-2021
13)	Development of edible antimicrobial packaging films for traditional dairy sweetmeats using metabolites of lactic and bacteria.	Diwas Pradhan	Rashmi H.M. & P.N. Raju	DST	2017-2021
14)	Development of flaxseed-rich probiotic dairy foods to address menopause symptoms	Sangita Ganguly	Neelam Upadhyay	DST	2020-2023
15)	Development of immunomodulatory exopolysaccharides containing healthy fermented dairy foods.	Pradip Behare	S.K. Tomar, S.A. Hussain & Suman Kapila	MOFPI	2019-2021
16)	Development of methods to assess the chemicals migration from the packaging used for dairy products	Rajan Sharma	Bimlesh Mann, Kamal Gandhi & Narender Raju Panjagari	MOFPI	2019-2021
17)	Development of phyto-immunobiotic for reduction of bovine intra mammary infections: comparative studies on bioactive compounds and whole extract effects	A. Manimaran	-	SERB	2021-2024
18)	Development of polarized angular scattering and microfluidics technology for bovine sperm sexing	Sharad Gupta	T.K. Mohanty & Mukesh Bhakat	DBT	2021-2023
19)	Development of quantitative molecular assays for rapid enumeration of viable probiotics from probiotic food products	Saurabh Kadyan (Rashmi HM)	Diwas Pradhan	ICMR	2021-2024
20)	Differential carriage of extracellular vesicles (EVs) in seminal plasma of cattle & buffalo bulls as a novel fertility indicator	Rakesh Kumar ABTC	T.K. Datta & Mukesh Bhakat	DBT	2021-2023
21)	Electrohydrodynamic encapsulation of probiotics in prebiotic nanofibres for food applications	P.Heartwin Amaladhas	Sachin Kumar & Nitin Tyagi	DST	2020-2023
22)	Empowering farmers through selective interventions in salt affected agroecosystems of Ghaghar Plains (Farmer's First Programme)	Sohanvir Singh CCPI	K. Ponnusamy	ICAR	2018-2021
23)	Enriching knowledge-integrating technology and institutions for holistic village development in horticulture based farming system.	B.Balakrishna, IIHR, Bengaluru	M.C.A. Devi & S. Subhash	ICAR	2016-2022
24)	Evaluation and impact of dairy farmer collectives in Gujarat: A study in Saurashtra and Kutchh Regions)	R. Malhotra	Udita Chaudhary, A.K. Dixit & Gunjan Bhandari	IRMA	2019-2021
25)	Evaluation of the efficacy of oral probiotics supplementation in children with Autism Spectrum disorders (ASDs): a randomized double blind, placebo controlled trial.	Rashmi H.M.	Sunita Grover	AIIMS Delhi	2019-2021
26)	Exploring molecular basis of seasonal variation of seminal attributes and identification of potential biomarkers for selection of buffalo bulls with quality semen	Pawan Singh	Ranjit Singh Kataria (NBAGR, Karnal) & Pardeep Kumar (CIRB, Hisar)	DBT	2020-2023

27)	Fitness Black Box: Deciphering the Ovar-MHC variability in sheep breeds of India.	G.R. Gowane	-	DST-SERB	2019-2021
28)	Formulating coping up strategies for extreme weather events in Sundarbans region through livestock based integrated Farming System: A societal perspective.	Asif Mohammad	T.K. Dutta & A. Chatterjee	ICSSR	2019-2021
29)	Genome editing of MFGE8 and S100 genes in bovine mammary epithelial cells to understand their role in milk production.	A.K. Mohanty	Sudarshan Kumar, J.K. Kaushik & D. Malakar	SERB-DST	2018-2021
30)	Genomic and proteomics approaches to develop specific diagnostic assay for detection of estrus / silent estrus in buffaloes.	Rubina K. Baithalu	A.K. Mohanty, Sudarshan Kumar, T.K. Mohanty & A. Kumaresan	DBT	2018-2021
31)	Genomic based approaches for characterization of the microbial antibiotic resistance and resistome in Dairy production system	Rashi H.M.	Diwas Pradhan, Saurab Kadyan & Sunita Grover	ICMR	2021-2024
32)	Identifying factors affecting health behavior of tribes of Uttarakhand and developing dairy based interventions to improve their health and livelihood status.	Nishant Kumar	Pawan Singh, S.S. Lathwal, M.L. Kamboj, T.K. Mohanty & K. Ponnusamy	ICMR	2019-2021
33)	Impact of mineral mixture on performance of dairy animals	B.S. Meena	K.S. Kadian, H.R. Meena, A.K. Dixit & Sachin Kumar	CAR Network I Project	2019-2021
34)	Improving the livelihood through dairy farming in North Eastern region of India.	T. K. Dutta	M.K. Ghosh, S.K. Das, A. Santra, C. Bhakat, A. Mandal, A. Chatterjee, D.K. Mandal, Mohan Mondal, M. Karunakaran, A. Mohammad, S. Rai, R. Behera, Chander Dutt & (Samiran Bandopadhyay, S. Naskar & P. Dandapat from IVRI-ERS-Kolkata)	ICAR	2017-2026
35)	Improving the usability of buffalo spermatozoa by sperm surface remodelling and immune acceptance in female reproductive tract.	Rakesh Kumar	S.M. Deb, T.K. Mohanty, J.K. Kaushik & Sarika (IASRI)	NASF / ICAR	2018-2021
36)	Incentivizing research in agriculture "Project-V Semen Sexing in cattle.	T. K. Mohanty (Component-A)	Mukesh Bhagat, A. Kumaresan, Pawan Singh & R. K. Baithalu	ICAR	2017-2021
37)	Incentivizing Research in Agriculture Project-V Semen sexing in cattle.	A.K. Mohanty	Sudarshan Kumar	ICAR	2017-2021
38)	Indigenous breed program (Sahiwal Cattle).	Anupma Mukherjee	Vikas Vohra, T.K. Mohanty, S.S. Lathwal & Mukesh Bhakat	ICAR	2021-2026
39)	Mastitis related antibiotic resistance pattern mapping in three districts of Haryana.	S. De	Rakesh Kumar & Raghu H	SERB-DST	2019-2022
40)	Mitigation of stubble burning through custom hiring centres for agricultural machinery in trans genetic plain region of India.	H.R. Meena	K.S. Kadian, B.S. Meena & Gopal Sankhala	ICSSR, New Delhi	2019-2021
41)	Mitochondrial DNA Haplotypes as candidate biomarkers for prediction of reproductive efficiencies in buffalo.	Sadeesh E.M.	Sudarshan Kumar & S. De	DBT	2018-2021
42)	Modulating the immune-cellular components and their signaling molecules in bovine colostrum and milk after micro-nutrient interventions and their functional validation under ex-vivo and in vivo animal models.	A.K. Dang	Sujata Pandita, S.S. Lathwal & Rajeev Kapila	DBT	2019-2022
43)	Monitoring of drug residues and other environmental pollutants-outreach project of ICAR	N. K. Goel	Raghu H.V.	ICAR	2017-2025

44)	National Innovations in climate resilient Agriculture (NICRA) (Budget for 2020-21)	Ashutosh	Mahendra Singh, S.S. Lathwal, Nishant Kumar, Nitin Tyagi, Ashwani Roy, Anjali Aggarwal, M.K.Singh, Sunita Meena, Rani Alex, B.S. Meena, Ritu Chakravarty, Richa Singh, Sachin Kumar, Madhu Mohini & Biswa Bhaskar	CRIDA (ICAR)	2017-2025
45)	Network programme on veterinary type culture (VTC)-Rumen Microbes.	Sachin Kumar	Nitin Tyagi	ICAR	2009-2023
46)	Network project on buffalo Improvement-Field Unit (CIRB Hisar)	Vikas Vohra	I.D. Gupta, Vikas Vohra & Om Vir Singh	ICAR	2021-2026
47)	Network project on buffalo Improvement-Institute herd-ICAR (CIRB Hisar-125001)	Vikas Vohra	Pawan Singh, T.K. Mohanty, Mukesh Bhakat & Vikas Vohra	ICAR	2021-2026
48)	Preparation of inventory of GHG emissions from Indian Livestock for the year 2019	Gautam Mandal	Nitin Tyagi	MoE&F Th.- Inspire Network for Environment	2016-2022
49)	Prevalence of Antimicrobial resistance in dairy starter bacteria in Haryana region	Diwas Pradhan	Rashmi H.M. & Saurabh Kadyan	ICMR	2019-2022
50)	Process development for production of dipeptidyl peptidase-IV (DPP-IV) inhibitory peptides from milk of Gir Cows and their encapsulation through double emulsification technique.	Satish Kumar M. H.B.C. Ghosh, Laxmana Naik, N	Latha Sabikhi, Yogesh Khetra, Shaik Abdul Hussain & Sunita Meena	NASF / ICAR	2018-2022
51)	Process for the preparation of lactose free skim milk powder with approaches to minimize milk lard reaction	Sumit Arora	Vivek Sharma, Ashish Kumar Singh, Priyanka Singh Rao & Richa Singh	DBT	2021-2024
52)	Process technology for instant mixes for varieties of Payasam, Kheer and Phirni using Dry Crystallisation Approach	Menon Rekha Ravindra	Monika Sharma & Devraja H.C.	MOFPI	2019-2021
53)	Production and shelf-life enhancement of phospholipids rich instant lassi powder from desi chhach	G.S. Meena	Ashish Kumar Singh	HSCSIT	2021-2023
54)	Production of dairy powder from by-products (ghee residue and butter milk); characterization and application in heat desiccated products / convenience formulations.	G.S. Meena	A.K. Singh, Sumit Arora & Yogesh Khetra	MOFPI	2021- 2023
55)	Production of Double Muscled-Mass Farm Animal using CRISPR	Naresh Selokar	S. De, S. Lathwal, M.K. Singh & M.S. Chauhan	NASF	2021-2023
56)	Production of multiple copies of elite buffalo bulls using animal cloning technology.	M.K.Singh	M.K. Singh, S.S. Lathwal & Subhash Chand	NASF-ICAR	2018-2022
57)	Proteo-Genomic Approach to Elucidate Productive and Reproductive Performance of Malnad Gidda, Deoni, and Hallikar Breeds of Cattle.	K. P. Ramesha	M.A. Katakataware, S. Jeyakumar, A. Manimaran & D.N. Dass	KLDA-MoEF	2017-2022
58)	Scheme on Dairy Microbes under Network Mode.	P.V. Behare	A.K. Puniya	ICAR Network Project	2010-2022
59)	Study of fodder crop assessment for dairy industry and potential areas of intensification of state level.	Magan Singh PI of NDRI Component	V.K. Meena & Sanjiv Kumar Centre, Ahmedabad	Space Application	2016-2023
60)	Surveillance of dairy products for Antibiotic resistant zoonotic bacterial pathogens under field conditions.	Raghu H. V.	Rashmi H.M.	SERB-DST	2018-2021
61)	Targeted immobilization of Y-bearing spermatozoa and modulation of oviduct milieu for skewing sex ratio towards female offspring in dairy cattle.	A. Kumaresan	S. Jeyakumar, A. Manimaran & K.P. Ramesha,	NASF / ICAR	2018-2022
62)	Targeted immobilization of Y-bearing spermatozoa and modulation of oviduct milieu for skewing sex ratio towards female offspring in dairy cattle-NASF	Rakesh Kumar	T.K. Datta & S.K. Das (ERS)	NASF	2018-2022

63)	Understanding extracellular vesicles (EVs) protein cargo of seminal plasma as a reason for poor fertility in cattle & buffalo bulls.	Rakesh Kumar	T.K. Datta & Mukesh Bhakat	SERB-DST	2019-2021
64)	Understanding the aetiology of infertility associated with prolonged follicle dominance in bovine and its therapeutic management.	A.Kumaresan	Jeyakumar S, A. Manimaran & K.P. Ramesha	DBT	2018-2021
65)	Upliftment of socio-economic condition of tribal people through integrated livestock farming in north eastern hill region / eastern part of India.	T. K. Dutta	M.K. Ghosh, S.K. Das, A. Santra, C. Bhakat, A. Mondal, A. Chatterjee, D.K. Mondal, Mohan Mondal, M. Karunakaran, Asif Mohammad, S. Rai & R. Behera	ICAR	2020-2026
66)	Utilization of crude glycerol obtained in biodiesel production as an alternate to glycogenic feed supplement for dairy cows	B. Srinivas	S.N. Sondur (KSCST, IISC, Bangalore)	DST-NDRI & KSCST, IISC, Bangalore	2017-2021
67)	Valorisation of industrially produced soybean and groundnut de-oiled meals/ cakes by extraction, purification and production of protein isolates.	Suman Kapila CCPI	Sanket Borad	NASF / ICAR	2018-2023
68)	Water budgeting and improving water productivity livestock based farming.	Ashutosh	Mahendra Singh, Sunita Meena & Satish Kumar	ICAR	2020-2025

6. INTELLECTUAL PROPERTY MANAGEMENT

Institute Technology Management Unit (ITMU)

Institute Technology Management Unit at NDRI is managed by Institute Technology Management Committee (ITMC). ITMC is the highest body which takes important decisions for the intellectual property management at NDRI viz., filing of patents, approval of the technology for commercialization, pricing of the technologies ready for commercialization etc. ITMC is chaired by the Director.

Six ITMC meetings were held during the year 2021:

- 48th ITMC meeting on February 25, 2021
- 49th ITMC meeting on March 10, 2021
- 50th ITMC meeting on May 12, 2021
- 51st ITMC meeting on August 27, 2021
- 52nd ITMC meeting on October 4, 2021
- 53rd ITMC meeting on December 29, 2021

At these meetings, pricing of technologies and examination of patent applications for their novelty and commercial applicability before filing patent applications were taken-up.

During the year 2021, a total of 20 no. of technologies were developed and approved for commercialization at the Institute and 6 no. of technologies were transferred to 6 no. of commercial houses through 06 different License agreements thereby earning a total of **Rs. 19.50 Lakhs** (excluding Service Tax) for the Institute through technology transfer fee. The lists of technologies transferred and other activities are as follows

Technologies approved for commercialization during 2021

- 1) Paper-based strip for the rapid detection of formalin in milk, (Inventors: Kamal Gandhi, Farin Sayyad, Rajan Sharma, Priyae Brath Gautam, Harshitha CG), Dairy Chemistry Division, ICAR-NDRI.
- 2) Technology for the preparation of low lactose Khoa (Inventors: Raman Seth, Ankur Aggarwal, Kamal Gandhi) Dairy Chemistry Division, ICAR-NDRI.
- 3) PCR ready Template DNA preparation by Quick Bacterial Lysis solution (Inventors: Sachinandan De, Rajib Deb, Parul Chaudhary) Animal Biotechnology Centre, ICAR-NDRI.
- 4) Cation Based mineral supplement for lactating dairy animals (Inventors: Veena Mani, Chander Datt, Goutam Mondal, Shimla Yadav) Animal Nutrition Division, ICAR-NDRI.
- 5) PANI-PEC paper strip sensor for the detection of E. coli in milk (Inventors: Raghu HV, Anjali MK, Bharat G, Naresh Kumar) Dairy Microbiology Division, ICAR-NDRI.
- 6) PANI-PEC paper strip sensor for the detection of total bacterial count in milk (Inventors: Raghu HV, Mohit Singh, Prajapathi M, Naresh Kumar) Dairy Microbiology Division, ICAR-NDRI.
- 7) Technology for the preparation of Indian artisanal cheese (Inventors: Latha Sabikhi, Pravin Bhongle, Jeetmal Meena, Sathish Kumar MH and Yogesh Khetra) Dairy Technology Division, ICAR-NDRI.
- 8) Paper staph assay for visual detection on staphylococcus species in bovine milk (Inventors: Sachinandan De, Rajib Deb, Prasanna Pal and Ashutosh Ludri) Animal Biotechnology Centre, ICAR-NDRI.
- 9) Autochthonous calves-origin probiotic *Lactobacillus reuteri* BF-E7 (Inventors: Sachin Kumar, A.K. Tyagi, Nitin Tyagi, Rashmi, Anukarna Singh and Vinay, V.V.) Animal Nutrition Division, ICAR-NDRI
- 10) Anionic mineral mixture for reducing postpartum problems in cattle and buffaloes (Inventors: Harjit Kaur, Veena Mani and Amrish Tyagi) Animal Nutrition Division, ICAR-NDRI.
- 11) Technology for preparation of protein rich cheese squeeze. (Inventors: Devaraja, HC., K. Jayaraj Rao, Sathish Kumar M.H, Monika Sharma and Manoj Kumar C.T.) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru.
- 12) Technology for preparation of Milk-millet based protein rich dairy dip (Inventors: Devaraja, HC., K. Jayaraj Rao, Monika Sharma, Sathish Kumar M.H. and Gopal Gadewar) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru
- 13) Technology for preparation of Milk-millet based composite dairy spread (Inventors: Devaraja, HC, K.

Jayaraj Rao, Monika Sharma, F. Magdaline Eljeeva Emerald and Omkar) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru.

- 14) Cow-ghee enriched with natural polyphenol antioxidants (Inventors: Laxmana Naik, Shivli Jha, Priyanka Singh Rao, K. Jayaraj Rao, Sathish Kumar M. H., Menon Rekha Ravindra and F. Magdaline Eljeeva Emerald and Omkar) Dairy Chemistry Section, ICAR-NDRI, SRS Bengaluru.
- 15) Technology for production of reduced sugar burfi with natural sweeteners (Inventors: Sathish Kumar M. H., Amal Biswas, K. Jayaraj Rao, Devaraja, HC and Laxmana Naik) Dairy Chemistry Section, ICAR-NDRI, SRS Bengaluru.
- 16) Technology of ghee residues incorporated energy bar (Inventors: Monika Sharma, Amanchi A Sangma, K. Jayaraj Rao, Menon Rekha Ravindra and Laxmana Naik) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru.
- 17) Process technology for dry-crystalized gasagase payasam mix (Inventors: Menon Rekha Ravindra, Monika Sharma and Devaraja, HC), Dairy Technology Section, ICAR-NDRI, SRS Bengaluru.
- 18) Process technology for dry-crystalized kheer mix (Menon Rekha Ravindra, Monika Sharma and Devaraja, HC) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru
- 19) Process technology for dry-crystalized phirni mix (Inventors: Menon Rekha Ravindra, Monika Sharma and Devaraja, HC) Dairy Technology Section, ICAR-NDRI, SRS Bengaluru.
- 20) A process for the separation of glycomacropeptide and other protein fractions from cheese whey (Inventors: Neelima Sharma, Rajan Sharma and Kamal Gandhi) Dairy Chemistry Division, ICAR-NDRI.

Technology commercialized during 2021

Sl.No.	Name of the technology	Date of Licensing	Price of Technology	Name of the firm
1)	Preparation of milk-based spray dried nanoencapsulated curcumin formulation	04.01.2021 through Agrinnovate	3.00 Lakhs	Anthocyanin Naturals Indian Pvt. Ltd, Kerala
2)	Process technology for Palada Payasam Mix Preparation by Dry Crystallization Method in a Mechanical Unit.	11.01.2021 through Agrinnovate	3.00 Lakhs	Eastern Condiments Pvt Ltd, Kerala
3)	Milk Protein-enriched Bajra Snacks	01.02.2021 (through ICAR-NDRI)	1.00 Lakhs	Sarvagya Ayur and Pharma (OPC) Private Limited Maharashtra
4)	Spore based kit for detection of antibiotic residues in milk at dairy farm	31.08.2021 through Agrinnovate	4.00 Lakhs	Schreiber Dynamix Dairies Pvt. Ltd., Mumbai
5)	Milk Protein enriched Iron fortified Bajra Biscuit	22.09.2021 through Agrinnovate	1.50 Lakhs	Chandigarh sweets, Chandigarh
6)	Spore based kit for detection of antibiotic residues in milk at dairy farm	14.10.2021 through Agrinnovate	4.00 Lakhs	Tirumala Milk Products Private Limited, Chennai
Total = 06			19.5 Lakhs excluding GST	

Technology Transfer Photos:



Transfer of technology of "Milk Protein enriched Bajra Snacks" to M/s Sarvagya Ayur and Pharma (OPC) Private Limited, Maharashtra on 01.02.2021



Transfer of technology of "Spore Based Kit for Detection of Antibiotic Residues in Milk at the Dairy Farm" to "Tirumala Milk Products Private Limited, Chennai" on 14.10.2021

Revenue generated during 2021

- Rs. 19.50 Lakhs excluding Service Tax

Patents filed during 2021

Sl. No.	Title of the patent	Name of Inventors	Date of Filing	Application Number
1)	A process for preparation of milk protein fortified eggless muffins	Kasushik Khamrui, Rishi Kumar Puri and Writdhama G Prasad	03.02.2021	202111004592
2)	Label for indicating freshness of Indian Dairy Products and preparation method thereof	P.N. Raju, Rakesh Kumar Raman, Karpurapu Uma, Ashish Kumar Singh and Sangita Ganguly	03.02.2021	202111004590
3)	Label for indicating freshness of Milk Millet composite complement food and preparation method thereof	P.N. Raju, Rakesh Kumar Raman, Karpurapu Uma, Ashish Kumar Singh and Sangita Ganguly	03.02.2021	202111004587
4)	A process for production of antimicrobial coagulant formulation for making extended self life Paneer	Pradip Vishnu Behare, Rallapalli Vembar Rajanikar, Sudhir Kumar tomar, Diwas Pradhan, Rajan Sharma and Sanket Borad	23.02.2021	202111007461
5)	Rapid antimicrobial susceptibility assay for Detection of Extended spectrum	Naresh Kumar, Avinash Jaswal, Raghu H. Vishweshwaraiah	23.02.2021	202111007462
6)	Self-stable metal ion-based nano-dispersion for thermal energy storage and exchange and method of preparation	Ravi Prakash, Menon Rekha Ravindra, Devaraja Hosapalya Chikkathimmaiah	15.06.2021	202111026625'
7)	Peptide sequences and epitope specific antibodies for detection of bovine Anti-Mullerian hormone (bAMH)	Prasanna Pal, Anjali Aggarwal, Sachinandan De, Rajib Deb, Vinay Joshi and Avijit Halder	25.08.2021	202111038528
8)	In vitro Proteomic Analysis of the uterine fluid for detection of subclinical uterine infection	Arumugam Kumaresan, Kurati Sunny Praveen, Kerekoppa Puttaiah Bhatta Ramesha, Sakthivel Jeyakumar, Ayyasamy Manimaran	28.08.2021	202111039076'
9)	Novel probiotic formulations to improve the growth and health of buffalo calves	Sachin Kumar, A.K. Tyagi, Nitin Tyagi, Rashmi H. M., Vinay V V and Anukarna Singh	01.10.2021	202111044603
10)	A system device facilitating monitoring and prediction of calving process in dairy animals	S. Jeyakumar, A. Kumaresan, Mukund A Kataktalware, K.P. Ramesha	06.10.2021	202111045493
11)	A novel method for Ghee preparation with lesser energy requirement".	Writdhama G Prasad, Shubham Kumbhare, Kaushik Khamrui and Shaik Abdul Hussain	23.12.2021	202111060140

Request for examination filed during 2021

Sl. No	Title of Patent	Inventors	Date of Filing	Application Number	Request for Examination
1)	A Preservative formulation for Milk and Milk Product Samples Stored for Analytical Purpose	Richa Singh, Bimlesh Mann, Sumit Arora, Mitul Bumbadiya, Priyanka Singh Rao and Diwas Preadhan	09.08.2019	201911032383	23.02.2021
2)	Detection of A2 milk derived peptide (BCM9A2) by aptamers	AK Mohanty, Abhishek Parashar and Sudarshan Kumar	13.01.2020	202011001446	03.09.2021
3)	Milk based spray Dried nanoencapsulated curcumin formulation and method thereof	Bimlesh Mann, Ankita Hooda, Rajan Sharma, Rajesh Kumar and Richa Singh	07.08.2020	202011033806	03.09.2021
4)	Detection of BCM-7 peptide in urine sample by aptamers	AK Mohanty and Abhishek Parashar	08.06.2020	202011023895	23.12.2021

Patents granted from 01.01.2021-31.12.2021

Sl.No.	Title of the technology	Name of the inventors	Patent App. Number	Date of Filing	Grant of Patent	Patent Grant Date
1)	A strip-based test for detection of detergent in milk	YS Rajput, Gulab Singh & Rajan Sharma	750/DEL/2015	19.03.2015	363588	30.03.2021
2)	A strip for detection of added urea in milk and process for the same	Rajan Sharma, Panchal Bhavesh Kumar and Y.S. Rajput	3472/DEL/2013	18.12.2013	363894	31.03.2021

Sl.No.	Title of the technology	Name of the inventors	Patent App. Number	Date of Filing	Grant of Patent	Patent Grant Date
3)	Peptide sequence and polyclonal antibodies for the detection of cow and buffalo luteinizing hormone	Varij Nayan, Suneel Kumar Onteru and Dheer Singh	1854/DEL/2015	23.06.2015	364236	07.04.2021
4)	Development of enzyme spores based assay for monitoring antibiotic residues in milk	Naresh Kumar, Ali Khan, Shivani Arora, Falguni, Meenakshi Dahyia, Raghu H V, Mandeep Balhara, Pradeep Kumar Sharma and Suleman Shaikh	2213/DEL/2014	08.05.2014	365074	21.04.2021
5)	Marker enzymes and spore germination based assay for detection of E. coli in milk and milk products	Naresh Kumar, Ramakant Lawaniya, Avinash, Bhawna Arora, Raghu H.V.; Mandeep Balhara, Saurabh Kadyan and Vinai Kumar	2214/DEL/2014	05.08.2014	367110	20.05.2021
6)	Method and system for automatic identification and estrous detection in buffaloes on their vocalization patterns	Yajuvendra Singh, S. P. Lathwal, T. K. Mohanty, A.P. Ruhil and Shiv Prasad	3090/DEL/2011	31.10.2011	378373	30.09.2021
7)	Caseinophosphopeptides-divalent Metal (Iron/ zinc) nanocomplexes and method of preparation thereof	Bimlesh Mann, Prabin Sarkar, Rajan Sharma, Rajesh Bajaj and Munmun Sen	201711010975	28.03.2017	385768	31.12.2021

Reply of First Examination report filed during 2021

Sl. No.	Title of Patent application	Name of the inventor	Date of Filing	Patent Number Application	Date of Filing FER
1)	Composition for Modulating Fertility.	Kaushik Kumar Jai, Mangottil Ayyappan, Shalini	15/12/2014	3703/DEL/2014	12.01.2021
2)	Mangifera indica flower panicles' extract stablized gold nanoparticles and method for making the same.	Varij Nayan, Suneel Kumar Onteru, and Dheer Singh	24/03/2015	807/DEL/2015	20.01.2021
3)	Antimicrobial Nanoemulsion of Clove Oil stabilized with milk protein and a process thereof.	Bimlesh Mann, Minaxi, Rajesh Kumar and Rajan Sharma	31/03/2015	913/DEL/2015	20.01.2021
4)	Caseinophosphopeptides-divalent Metal (Iron/ zinc) nanocomplexes and method of preparation thereof	Bimlesh Mann, Prabin Sarkar, Rajan Sharma, Rajesh Bajaj and Munmun Sen	28/03/2017	201711010975	28.01.2021
5)	High fiber reduced calorie biscuits from dairy-multigrain composite.	Latha Sabikhi, Dipesh Aggarwal and Ashish Kumar Singh	20/03/2015	758/DEL/2015	16.02.2021
6)	Stabilization of non-ionic surfactant based Nanovesicles loaded with resveratrol using stearic acid and method of preparation thereof.	Surendra Nath Battula, Jaya Sravani Vankayala, Ruchmani Kandasamy, Grover Antoniraj, Mariya Antoniraj, Pushpadadass Heartwin Amaladhas, Naik Laxman Naik and Franklin Magdaline Eljeeva Emerald	08/02/2018	201811004766	29.07.2021
7)	Design and development of nanofluids based extended surface module and milk cooling.	Ravi Prakash, Chikkamutharayappa, guruvanna Mahesh Kumar, Kerekoppa Puttaiah Bhaatta Ramesha, Giriya pura Basavarajappa Darshan, Menon Rekha Ravindra, Battula Surender Nath and Pushpadass Heartwin Amaladhas	08/06/2018	201811021472	28/06/2021
8)	An Indicator and the indicator impregnated strip for detection of neutralizers in milk	Rajan Sharma, YS Rajput, GP Brath and Bimlesh Mann	08/10/2018	201811030055	26/08/2021
9)	A process for manufacture of low -fat chakka and Shrikhand by using exopolysaccharides producing bacteria	Pradip V Behare, Sanket Borad, Harisha and SK Tomar	09/05/2018	201811033236	02/11/2021
10)	A Preservative formulation for Milk and Milk Product Samples Stored for Analytical Purpose	Richa Singh, Bimlesh Mann, Sumit Arora, Mitul Bumbadiya, Priyanka Singh Rao and Diwas Preadhan	09/09/2019	201911032383	07/10/2021

7. ENTREPRENEURSHIP DEVELOPMENT, BUSINESS INCUBATION ACTIVITIES AND CONSULTANCY SERVICES

CONSULTANCY PROCESSING UNIT

The consultancy processing unit facilitates and coordinates the professional service functions of the Institute by offering different services to organizations, individuals, industries and entrepreneurs. The services include contract research, consultancy services, contract services and training programmes. Contract research comprises all research activities undertaken through specific contractual agreements with external agencies for the purpose. Consultancy services include professional services rendered to external agencies in terms of scientific, technical, engineering or other professional advice/assistance based on the expert knowledge and skill available at the Institute. Contract services mean services rendered to the external organizations/ clients/ customers, or assistance of minor nature based on available knowledge, expertise, skills and facilities of the institute.

Contract Research

Institute is engaged in active collaboration with industry, government agencies and other stakeholders for executing the research projects funded by them. In year 2021, five contract research projects were received out of which two contract research projects were continuing and other three were in the process of approval and signing of MOU. The continuing contract research projects are given below:

Sl. No.	Project Name	Name of the bilateral/multilateral organisation	Name of Consultant
1)	Estimation of productions and Utilization pattern of milk and milk products in India	National Accounts Division, National Statistical Office, Ministry of Statistics and Plan Implement, Sardar Patel Bhawan, Parliament Street, New Delhi	Dairy Economics Division
2)	Generation of basic engineering properties data and process validation of curd maestro 2.0 refrigerator suitable for India, US and European market	M/s Samsung India Electronics Pvt. Ltd., Gurgaon	Dairy Technology Division

Consultancy Projects

Institute is offering both general and advisory consultancy to individuals or organization on various aspects of dairy production, processing and management. **Seven** advisory consultancy assignments were undertaken by the scientists of the Institute during the period. These assignments were advisory in nature and clients included AA Agro Tech Solutions, Inventis Technosys Pvt. Ltd., CEBSI, Gurugram, Floreecer Services Pvt. Ltd., and Aagam Arts, Dahisar. Eight consultancy projects were taken-up by the scientists. The details of consultancy projects are given below:

Sl. No.	Project Name	Firm Name	Name of consultant
1)	Development of Easy Paneer Maker	M/s Samsung India Electronics Pvt. Ltd., Gurgaon	Dairy Technology Division
2)	Validation study on the NIR based equipment (spexnano) for rapid assessment or quality of milk.	M/S Agnext Technologies, Punjab Validation study on the Milkochill for instant chilling of milk	Dairy Chemistry Division M/S Prompt Innovation Pvt. Ltd., Navrangpura, Ahmedabad Dairy Engineering Division Dairy Microbiology Division
3)	Performance evaluation of automated colony counter for Jupiter glass works	M/S Jupiter Glass Works, New Delhi	Dairy Microbiology Division
4)	validation study on the O'Right equipment for rapid assessment of composition and quality of milk	M/S Qboid O'Right, Gurugram	Dairy Chemistry Division
5)	Validation study on the Indescope FTI milk analyser for assessment of composition and quality of milk.	Everest Instruments Pvt. Ltd, Ahmedabad, Gujarat	-do-
6)	Verification of Cryoscope for determining freezing point of milk and added water in milk	M/S Benny Impex Pvt. Ltd.	-do-
7)	Preparation of Processed cheese on Pilot Scale	Sanzyme Biologics, Hyderabad	Dairy Technology Division

Contract Services

Institute assisted stakeholders through offering the services of analysis, supply of testing kits, cultures and other services. Through contract services institute offered 71 services of analysis, 24 supplies of kit and culture and four other services to different organizations, individuals and industries.

Training Programmes

A total number of 26 students from other universities and educational organizations were imparted training for 1 to 6 months duration in various divisions and sections of the Institute during the period and 6 non-students were imparted training from different organizations.

Professional Service Functions at a glance		
Sl.No.	Services	Number
1)	Contract Research Projects	2
2)	Consultancy Projects	8
3)	Contract Services	
	i) Analytical Services	71
	ii) Supply of Kits and Culture	24
	iii) Other Services	04
4)	Training Programmes	
	i) Student Training	26
	ii) Non-Student Training	06

TECHNOLOGY INCUBATION CENTRE

A total of five Entrepreneurship Development Programs (three on Commercial Dairy Farming, one on Processing of Milk and Milk Products and one Exposure Program on Milk Production and Milk Products) were undertaken during 2021. A total number of 77 Participants was trained in these programs. Apart from it, three incubatees joined at SINED-TBI.

A total revenue of Rs. 9,19,500/- was generated during this period. Details of Entrepreneurship Development Programs are as follows:

Title	Period	No. of Trainees	Co-ordinator
Commercial Dairy Farming-online mode	February 1-6, 2021	17	Dr. A.K. Singh
Commercial Dairy Farming-online mode	August 2-7, 2021	15	Dr. Kaushik Khamrui
Commercial Dairy Farming	September 20-25, 2021	11	Dr. Kaushik Khamrui
Processing of Milk & Milk Products	October 21-30, 2021	13	Dr. Writhdhama Prasad
Exposure Program on Milk Production & Milk Products	November 22-28 2021	21	Dr. B.S. Meena & Dr. G.S Meena

Name and address of the incubatees	Products
Ravi Prakash, Hosur Rd, Ayappa Garden, Adugodi, Bengaluru, Karnataka 560030	Nano - Phase Change Material based Milking-Cum- Cooling Pail for Small to Marginal Dairy Farmers
Mr. Vikas Gulia, M/s Delvik Nutrition Pvt. Ltd, 190/17, Opp. Jagbir Furniture House, Arya Nagar, Jhajjar, Haryana - 124103	Yogurt, smoothies, shakes and high protein ice cream
Dr. Parul Sarwalia, BoviEdge Research LLP, House No: 946-H, Sector-9, Urban Estate, Karnal, Haryana-132001	Early Pregnancy Diagnosis in Cattle and Buffaloes

8. DAIRY EDUCATION

Education and Training

ICAR-National Dairy Research Institute is the premier Institution of International repute in Human Resource Development for the growing dairy industry in India. ICAR-NDRI conferred deemed to be university status vide Govt. of India, Ministry of Human Resource Development, Department of Education, and Notification No. F. 9-15/85-U.3 dated March 28, 1989, is well equipped and staffed to meet emerging needs of the 21st Century of the Dairy Industry. The university offers academic programmes at under-graduate and post-graduate levels in the field of Dairy Science and Technology. The following courses were offered by NDRI Deemed University during the academic session 2021-22. The courses have been so designed as to provide broad base as well as specialized training on different aspects of dairying.

B.Tech. (Dairy Technology)

This four years degree programme offers intensive training in processing and quality control of milk and milk products; and engineering aspects of milk processing plants.

Master's and Doctoral Degree Programmes

The Institute offers Master's degree programme in the following disciplines:

SN	Discipline	SN	Discipline
1)	Dairy Microbiology	9)	Livestock Production and Management
2)	Food Safety and Quality Assurance	10)	Animal Nutrition
3)	Dairy Chemistry	11)	Animal Physiology
4)	Dairy Technology	12)	Agricultural Economics
5)	Dairy Engineering	13)	Agricultural Extension Education
6)	Animal Biochemistry	14)	Agronomy
7)	Animal Biotechnology	15)	Veterinary Gynaecology and Obstetrics
8)	Animal Genetics and Breeding		

The Institute offers Doctoral degree programme in the all the above disciplines.

Scholarship and Fellowship

Masters in Dairying and Ph.D. students are awarded Institute scholarship at the following rates in accordance with the prescribed rules and regulations of ICAR.

Institute Scholarships

Master's Degree	Rs. 7,560/- per month for two years and Rs. 6,000/- per annum as contingency
Ph.D.	Rs.25,000/- per month for first two years, Rs.28,000/- per month during third year and Rs. 10,000/- per annum as contingency
Ph.D. (In-service)	Rs. 3,000/- per month for three years and Rs. 10,000/- per annum as contingency

ICAR Junior/ Senior Research Fellowship

Master's Degree	Rs. 8,640/- per month (for Non Veterinarians) & Rs. 12,000/- per month (for veterinarians) for two years and Rs. 6,000/- per annum as contingency
Ph.D. Degree	Rs. 31,000/- per month for first two years as Junior Research Fellowship and Rs.35,000/- during third year as Senior Research Fellowship

National Talent Scholarship

The National Talent Scholarship (NTS) @ Rs.3,000/- per month is awarded by ICAR on merit provided that the university/ institute is located outside the state of his/ her domicile.

Career guidance, Training and Placement Cell

The placement Cell provides career guidance, training and placement services for the passing out students in various disciplines of the Deemed University. B. Tech. (Dairy Technology) and Master's students were provided employment in reputed organizations through campus interviews. Passed out students of NDRI are getting employment in Dairy/ Food Industry (Government/ Cooperative/ Multinationals). Salary ranges from Rs. 20,000/- to 60,000/- per month. In addition to employment, a number of students also opt for higher studies in India and abroad. The major functions of the Cell are as follows:

- To counsel the undergraduate and post graduate students in career planning.
- To compile a directory of corporate and academic bodies at the National and International level engaged in the area of Dairying and Food Processing.
- To prepare a compendia of resume of the final year students for facilitating placement/screening with prospective employers.
- To evolve mechanism for placement of Graduate/Postgraduate students from various disciplines by arranging campus interviews.
- To arrange seminars/workshops/presentations to maintain closer liaison between student community and industry.

Counselling for Admissions

Online Counselling for admission to UG/PG programmes was held by the Education Division of ICAR New Delhi.

Admissions

Admission for the Academic Session 2021-22 to B.Tech. (Dairy Technology), M.Sc./ M.V.Sc./ M.Tech. and Ph.D. programmes were made.

Courses	Students Admitted
B.Tech. (Dairy Technology)	37
Masters' programme	127
Ph.D. Programme	101

Meetings

- 92nd meeting of the Standing Committee on Course Curricula and Academic Affairs was held on March 17, 2021.
- 79th meetings of the Standing Committee on Faculty, Students Problems and Discipline were held on March 20, 2021.
- 41st meeting of Standing Committee on Scholarship, Financial Assistance and Academic Progress was held on July 26, 2021.
- 50th meeting of Academic Council was held on April 6, 2021.

18th Convocation of NDRI Deemed University

Eighteenth Convocation of NDRI Deemed University was held on August 22, 2021 in On-line Mode. Hon'ble Dr. Tricholan Mohapatra, Secretary, DARE and Director General, Indian Council of Agricultural Research, New Delhi presided over the Function and delivered the convocation address. A galaxy of eminent guests, Dr. R.C. Agrawal, Deputy Director General (Education) Dr. B.N. Tripathi, Deputy Director General (Animal Sciences), Indian Council of Agricultural Research, Krishi Bhavan, New Delhi-110001, Hon'ble members of the Board of Management and Academic Council, Directors of sister ICAR Institutes graced the Convocation in on-line mode. Dr. M.S. Chauhan, Director & Vice Chancellor, NDRI Deemed University presented the Convocation Report. A total of 457 students were conferred different degrees i.e. B.Tech. (DT)-82, Masters-243 and Doctoral-132.

Three topper students each in B. Tech. (DT), Master's and Doctoral programs were awarded Director's Gold, Silver and Bronze Medals for overall performance in Course work:

B.Tech. (DT)-2019-20

S.No.	Student Name	Medal
1)	Diksha	Gold
2)	Sakshi	Silver
3)	Avineesh Arora	Bronze

Master's Programme-2019-20

S.No.	Student Name	Degree	Discipline	Medal
1)	Aditi Agrawal	M.Sc.	Agricultural Economics	Gold
2)	Abhijeet Fernandes	M.V.Sc.	Veterinary Gynaecology & Obstetrics	Silver
3)	Dayananda Patil	M.Sc.	Agricultural Extension Education	Bronze

Doctoral Programme-2019-20

S.No.	Name of the Student	Discipline	Medal
1)	Mohanned Naif Alhussien	Animal Physiology	Gold
2)	Ramya H R	Agricultural Extension Education	Silver
3)	Aneet Kour	Animal Genetics & Breeding	Bronze

Dean's Honour Awards (OGPA 9 & above) to B.Tech. (DT)/ Master Students**B.Tech. (DT)-2019-20**

Student Name
Diksha

Master's programme- 2019-20

Student Name	Degree	Discipline
Aditi Agrawal	M.Sc.	Agricultural Economics

Oration Awards

- Dr. D. Sundaresan Memorial Oration Award-2020 was bestowed on Professor (Dr.) A.K. Misra, Chairman, Agricultural Scientists Recruit Board, New Delhi. Dr. Misra delivered the lecture on March 26, 2021 in Dr. D. Sundaresan Auditorium on the topic "Dairy Farming in India: Challenges and Opportunities". The award carries an amount of Rs. 20,000, a citation, shawl and a certificate
- Dr. K.K. Iya Oration Award-2020 was bestowed on Professor (Dr.) V. P. Kamboj, FNASC., FNA, President of the National Science Academy of India (NASAC; 2005-2006) and Ex-Director, CDRI, Lucknow and CSIR Emeritus Scientist.
- Professor (Dr.) Rathore delivered the lecture on April 3, 2021 in Dr. N.N. Dastur Auditorium on the topic "Covid-19 Vaccines: Speedy Development and use to be saviour of humanity". The award carries an amount of Rs. 20,000, a citation, shawl and a certificate.
- Dr. N. N. Dastur Memorial Oration Award-2020 was bestowed on Padam Shri Professor J.S. Rajput, former Director, NCERT and Founder Member, National Council for Teacher Education (NCTE), New Delhi. Professor delivered the oration on April 12, 2021 in the Dr. D. Sundaresan Auditorium of NDRI on the topic: "Emerging canvas of Indian Education". The award carries an amount of Rs. 20,000/-, a citation, shawl and a certificate.
- Best Division Award for Academic Achievements and Innovations in Teaching: The Different Heads of Divisions presented the innovations and significant achievements in education/ research and consultancy during Academic Celebrations. The "Best Division Award" was presented to Animal Biochemistry Division.
- Best Thesis Awards for Master's theses (one each in Production, Processing and Management Groups) carrying a citation, a certificate and Rs. 5,000/- were awarded. Two theses in each programme were recommended by committees in each discipline. The students presented their theses before the Award Committee. The award committees evaluated the theses and gave their recommendations for the Best Thesis Awards in their respective groups as given below:

Best thesis award carries a Citation, Certificate and a cash prize of Rs. 5,000/- for Best Master's Thesis and a Citation, Certificate and Gold Medal for Doctoral Thesis.

Masters Programme- 2019-20

Group	Student Name	Name of the Guide	Discipline
Production	Rajneesh	Dr. Arun Kumar Misra	Livestock Production & Management
Processing	Shruti Nayyar	Dr. Diwas Pradhan	Dairy Microbiology
Social Science & Management	Soumya S. Mohapatra	Dr. Sendhil R.	Agricultural Economics

Gold Medals for best thesis research work in Ph.D. Programme of Production, Processing and Management Group were awarded. The award carries Gold Medal, Citation and Certificate. Two theses in each programme were recommended by committees in each discipline. The students presented their theses before the Award Committee. The award committees evaluated the theses and gave their recommendations for the Best Thesis Awards in their respective groups as given below:

Best Teacher Award for Excellence Teaching

Doctoral Programme- 2019-20

Group	Name of the Student	Name of the Guide	Discipline
Production	Mohanned Naif Alhussien	Dr. A.K. Dang	Animal Physiology
Processing	Taruneet Kaur	Dr. Suman Kapila	Animal Biochemistry
Social Science & Management	Vikash Kumar	Dr. H.R. Meena	Agricultural Extension Education

Best Teacher Awards at Under-graduate teaching and post-graduate levels at NDRI, Karnal to recognize and promote teaching excellence and motivate the faculty to adopt high standards for content preparation, delivery of lectures, motivation of students and overall development of students were conferred upon.

The award carries a certificate and letter of commendation from the Director & Vice Chancellor, Monetary award of Rs.50,000/- and profile of the Award winning teacher will be uploaded on Institute's website for giving wider recognition.

Year-2019-20: Dr. K. Ponnusamy, Principal Scientist, Dairy Extension Division, ICAR-National Dairy Research, Institute (ICAR-NDRI), Karnal

Dr. S.K. Sirohi Memorial Award of the Outstanding Young Researcher

Year-2020: Dr. Shiva Pratap Singh, Senior Scientist, Animal Physiology and Reproduction Division, ICAR-Central Institute for Research on Goats (ICAR-CIRG), Makhdoom

Year-2021: Dr. Naresh L. Selokar, Scientist, Animal Biotechnology Division, ICAR-National Dairy Research, Institute (ICAR-NDRI), Karnal

Institutional Development Plan Project (NAHEP)

Different activities under four broad objectives viz. strengthening academic programmes, leveraging alumni network, nurturing soft skills of the students, and equity action plan plus green campus initiatives were conducted by IDP (NAHEP) project during the year 2021. A total of 24 webinars and 4 workshops have been conducted in virtual mode. Under the physical mode three events viz. a National Training Program on "Chemical and Microbiological Quality Assessment of Milk and Milk Products" was organized from October 6-26, 2021; A six days Hands-on Entrepreneurship Development Programme on "Starter Culture and Fermented Milk Products" was organized during November 22-27, 2021 and A Session on Study Abroad Summit-Ask Me Anything (AMA) was organized on September 24, 2021 by Alumni of NDRI. Awareness posters viz. Fire Extinguisher, Fire Breakout, Laboratory Safety Rules were displayed at common facilities under Environmental Safeguards policy.

Webinars

Twenty-four webinars have been conducted during January to December, 2021 in virtual mode in which 39 International Speakers delivered lectures:

Workshops

Sl. No.	Name of the Webinar	Name of the Speaker	Number of Participant	Name of the Organizer	Duration
1	Women Empowerment	Dr. S. Lakshmi Devi, Honorary Director, Centre for Entrepreneurship and Career Oriented Program, University of Delhi and Dr. Shiva Durga, Assistant Prof., Faculty of Education, GLA University, Mathura.	300	Dr. Meena Malik, Prof. (English) & Nodal Officer IDP (Soft Skills) & Convener, Student Empowerment Unit	January 28, 2021
2	Advances in Application of Membrane Processing in Dairy & Food Industry	Prof. Ulrich Kulozik, Prof., Food and Bioprocess Engineering Technical University of Munich, Germany, Dr. Ritika Puri, Marie Curie Career- FIT Research Fellow, University College Cork, Ireland and Dr. Jorg Vogel, VP of Technology Development, Aquaporin A/S, Denmark.	124	Dr. Yogesh Khetra, Scientist, ICAR-NDRI, Karnal	February 17, 2021
3	Metabolomics and Proteomics in Food Science	Dr. Ranjith Ramanathan, Associate Prof., Department of Animal and Food Science, Oklahoma State University, Stillwater, OK, USA, Dr Emmanuel Hatzakis, Assistant Prof., Department of Food Science and Technology, The Ohio State University, Columbus, OH, USA and Prof (Dr) Michelle Colgrave, Principal Research Scientist (Proteomics) and Lead (Future Protein), CSIRO Agriculture and Food, Brisbane, QLD, Australia.	157	Dr. Heena Sharma, Scientist, ICAR-NDRI, Karnal	March 1-3, 2021
4	Trends in Food Packaging	Dr. Eva Almenar, Associate Prof., School of Packaging, Michigan State University, USA), Prof. Bambang Kuswandi, Head, Chemo and Biosensors Group, Faculty of Pharmacy, University of Jember, Indonesia and Prof. Asgar Ali, Director, Centre of Excellence of Postharvest Technology, University of Nottingham, UK, Malaysia Campus, Malaysia	112	Dr. P. Narender Raju, Senior Scientist, ICAR-NDRI, Karnal	March 5, 2021
5	Unravelling the Digestion Behaviour of Milk	Prof. Pete Wilde, Research leader, Food Structure, Colloids and Digestion, Quadram Institute, Norwich, U.K.	60	Dr. Rajesh Kumar Bajaj, Principal Sci., ICAR-NDRI, Karnal	March 17, 2021
6	Recent advances in the processing of high-value dairy products	Dr. Hari Meletharayil, Ph.D, Vice President-Product Research, National Dairy Council/ Dairy Management Inc., USA and Dr. Rohit Kapoor, Ph.D, Vice President-Product Research, National Dairy Council/ Dairy Management Inc., USA.		Dr. Richa Singh, Scientist, ICAR-NDRI, Karnal	March 20, 2021
7	Structures and digestion of milk and milk products	Prof. Harjinder Singh, PhD, FRSNZ (Distinguished Prof. and Director of the Riddet Institute, Massey University, New Zealand) and Dr. Debashree Roy, Research Scholar, Riddet Institute, New Zealand	120	Dr. Kamal Gandhi, Scientist, ICAR-NDRI, Karnal	March 31, 2021
8	Protein Supplementation in Dairy and Food Products: Opportunities and Challenges	Dr. Chenchiah Marella, Vice President, Research and Product Development at Idaho Milk Products, Jerome, USA and Ms. Pratishtha Verma, MS, Research and Development Scientist, Idaho Milk Products, Jerome, USA	70	IDP-NAHEP, ICAR-NDRI, Karnal	April 23, 2021 & May 7, 2021
9	Making a Startup Successful - Mastering the Skill to Fund Your Ideas	Dr. Shekhar Patel, Senior Vice-president of USHydrations, USA	120	Dr. Richa Singh, Sci., ICAR-NDRI, Karnal	April 29, 2021
10	Wear behavior of cheese and its correlation with rheology and sensory behaviours	Dr. Fariba Zad Bagher Seighalani, Department of Nutrition, Dietetics and Food Science, Utah State University, USA.	85	IDP-NAHEP, ICAR-NDRI, Karnal	April 30, 2021

11	Impact of milk seasonality on product quality and delivery of bioactive compounds	Dr Alejandra Acevedo-Fan and Dr Siqi Li, Riddet Institute, Massey University, New Zealand.	250	Dr. Kamal Gandhi, Scientist, ICAR-NDRI, Karnal	May 11, 2021
12	Sustainability and the search for novel water antimicrobials for use in post-harvest processing of various foods to enhance microbial safety	Prof. Karl R. Matthews, Prof. and Chair, Department of Food Science, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA	120	Dr. Bimlesh Mann, Principal Scientist, ICAR-NDRI, Karnal	May 17, 2021
13	Advances in Aseptic Processing and Packaging	Dr. Dharmendra K Mishra, Department of Food Sciences, Purdue University, USA and Dr. Patnarin Benyathiar, Food Technology Division, Mahidol University, Thailand	198	Dr. Manoj Kumar C.T., Scientist, ICAR-NDRI, Karnal	May 31, 2021
14	Innovations and Entrepreneurship Development in Agriculture	Dr. Matthew Clancy, Assistant Prof., Agricultural Entrepreneurship Initiative, Iowa State Univ. USA and Prof. Kevin Kimle, Prof. & Director, Agril. Entrepreneurship Initiative, Iowa State University, USA.	110	Dr. S. Subash, Scientist, SRS of ICAR-NDRI, Bengaluru	June 17, 2021
15	Impact of Oxidative Stress on Male and Female Reproduction	Dr. Robert John Aitken, Distinguished Laureate Prof., School of Environmental and Life Sciences, University of Newcastle University Drive, Callaghan, Australia	350	Dr. Mukesh Bhakat, Principal Scientist, ICAR-NDRI, Karnal	July 1, 2021
16	Host-microbial interactions in Neonatal calves	Dr. Nilusha Malmuthuge, Research Scientist, Agriculture Agri-Food, Lethbridge Research and Development Centre, Canada	150	Dr. Sachin Kumar, Scientist, ICAR-NDRI, Karnal	July 5, 2021
17	Colonization and Establishment of Rumen Microbiota- opportunities to Influence the Livestock Productivity	Dr. David Yanez- Ruiz , Senior Research Scientist, Estacion Experimental del Zaidin (CSIC), Granada, Spain	160	Dr. Sachin Kumar, Scientist, ICAR-NDRI, Karnal	July 20, 2021
18	Milk Proteins for the future	Dr. Kasper Hettinga, Associate Prof., Food Quality and Design, Wageningen University and Research and Dr. Etske Blijl, Assistant Prof., Food Quality and Design, Wageningen University & Research.	150	Dr. Yogesh Khetra, Scientist, ICAR-NDRI, Karnal	July 22, 2021
19	Diet-Microbe Interactions and Human Health	Dr. Ravinder Nagpal, Assistant Prof., Florida State University, Tallahassee, FL, USA and Dr. Stephen R. Hennigar, Assistant Prof., College of Health and Human Sciences, Florida State University, Tallahassee, FL, USA.	100	Dr. Rajeev Kapila, Principal Scientist, ICAR-NDRI, Karnal	August 21, 2021
20	Genomic Dairy Cattle Breeding in Developed Countries with a view to its applications in India	Prof. Besnt Guldstrandtsen University of Copenhagen, Denmark	172	Dr. Sabyasanchi Mukharjee	September 30, 2021
21	Lactose: Properties and Processing	Dr. Venkateswarlu Sunkesula, Associate Director of Research and Technical Services, Idaho Milk Products, Idaho, USA	108	Dr. S.A. Hussain, Scientist, ICAR-NDRI, Karnal	November 19, 2021
22	Biotechnological Interventions in Dairy Processing	Dr. P.S. Panesar, Dean (Planning & Development), Department of Food Engg. & Technology, SLIET, Punjab	134	Dr. S.A. Hussain, Scientist, ICAR-NDRI, Karnal	November 27, 2021
23	Membrane Separation of Dairy Streams: An Industrial Perspective	Mr. Alan Franks, head Technical Team, Hydranautics, USA, Mr. Sachin Pawar, Technical Manager, Hydranautics, India, Mr. Madhusudhan Joshi, Sr. Tech. Manager, Hydranautics, India and Mr. Rajashekhran, NDRI alumnus & Dairy Process Expert, JM Filtration, India.	130	Dr. G.S. Meena, Scientist, ICAR-NDRI, Karnal	November 29, 2021

24	Exploration of genomic data: Applications in livestock and beyond	Dr. GÁBOR MÉSZÁROS, Associate Prof., University of Natural Resources and Life Sciences, Vienna Division of Livestock Sciences, Vienna, Austria	130	Dr. Sabyasachi Mukherjee, PS Dr. Anupama Mukherjee, PS, ICAR-NDRI, Karnal	December 16, 2021
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Four workshops have been conducted during January to December 2021 in virtual mode in which 9 International Speakers gave lectures:

- A National Training Program on “Chemical and Microbiological Quality Assessment of Milk and Milk

Sl. No.	Name of the Webinar	Name of the Workshop	Number of Participants	Organizer Name	Duration
1.	Food Safety	Professor Arun Kumar Bhunia, Food Microbiology, Professor Bruce M. Applegate, Food Science, Department of Food Science, Purdue University, USA and Dr. Andrew Gehring, USDA, USA	151	IDP-NAHEP & ICAR-NDRI	January, 4-7, 2021
2.	Innovative and Emerging Technologies for Food Safety & Nutritional Quality	Professor Mukund V. Karwe, Distinguished Professor Dean of International Programs, School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA and Professor Qingrong Huang, Department of Food Science, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA.	270	Dr. Bimlesh Mann, Principal Scientist, ICAR-NDRI, Karnal	May 12-13, 2021 & May 25, 2021
3.	Recent advances in design and emerging applications in lateral flow assay	Dr. Aart van Amerongen, Professor, BioSensing & Diagnostics, Wageningen Food & Biobased Research, Wageningen University & Research, Wageningen, The Netherlands	200	Dr. Rajan Sharma, Principal Scientist, ICAR-NDRI, Karnal	May 18-21, 2021
4.	Scientific Writing	Dr. John P. Kastelic, ACT Professor, Cattle Reproductive Health-Therigenology Head, Department of Production Animal Health, Canada and Ms. Rose M. Kastelic.	270	Dr. Mukesh Bhakat, PS ICAR-NDRI, Karnal	June 23-24, 2021

Products” was organized during October 6-26, 2021. The objective of this training was to acquaint the participants with the principle and analytical methodology for assuring the quality of dairy foods using various advanced instruments. A total of 25 participants attended the training programme.

- A Virtual Certificate Course on "Advanced Dairy Animal Nutrition Management: The Way Forward" was organized during December 13-18, 2021.
- A 6 days Hands-on Entrepreneurship Development Programme on “Starter Culture and Fermented Milk Products” was organized during 22-27 November, 2021. A total of 10 participants attended the programme.
- A Session on Study Abroad Summit-Ask Me Anything (AMA) with experts was organized on September 24, 2021 by Alumni of NDRI to guide students who are willing to study abroad.
- Taxonomical evaluation of B.Tech. (Dairy Technology) student was carried out on October 11, 2021 as a part of their selection criterion for Overseas Internship. A total of 63 eligible UG students had appeared for the examination.
- Online Exam for English Language Course was conducted on October, 10 2021. A total of 43 students appeared in the English exam. All the students have successfully cleared the exam.
- NAHEP HR team visited the ICAR-NDRI campus on November 26, 2021 to interact directly with beneficiaries of the IDP-NAHEP Project, students and faculty as a part of assessing the HR requirements in Agri- and allied sectors in India.



A six days Hands-on Entrepreneurship Development Programme on “Starter Culture and Fermented Milk Products” was organized during November 22-27, 2021.

9. TECHNOLOGY DISSEMINATION AND EXTENSION PROGRAMMES

Dairy Extension Division

Field/Farm Technician (FFT) Laboratory

The Field/ Farm Technician (FFT) Laboratory of Dairy Extension Division provided a base for extension work in the adopted villages around Karnal including the newly adopted villages such as Shahpur, Hemda and Dadupur. The FFT Laboratory was being operated through Stockman Centres. The Stockmen are the grass-root level workers through which a live contact between scientists and farmers was established.

In order to upgrade the existing breeds of dairy animals, cross-breeding was continued in cows and selective breeding in local buffaloes through A.I. using high pedigree bulls. To reduce age at maturity and to minimize inter-calving interval, infertility and veterinary aid campaigns were conducted in adopted villages.

Activities conducted in adopted villages

Sl. No.	Activities	No. of Cases
1)	A.I. in cows	681
2)	Conception rate	44.66%
3)	A.I. in buffaloes	432
4)	Conception rate	42.33%
5)	No. of crossbred calves born	389
6)	No. of buffalo calves born	312
7)	General treatment cases	489

Infertility and Veterinary aid Campaigns: 17

A total of nineteen were organized in Kulwari, Daniyalpur, Subhri and Jhanjhari villages. During the Campaigns, animals were treated for reproductive disorders and various other Vety. ailments. Ectoparasitic control campaign & Deworming programmes for control of endo-parasites were also conducted. Special attention was given to improve the productive & reproductive parameters of animals by diagnosis and proper treatment.

Sl. No.	Activities	Numbers
1)	Infertility and veterinary aid campaign	17
2)	Repeat breeding cases	57
3)	Anoestrus and late maturity	31
4)	Pyrexia	15
5)	Mastitis	51
6)	Prolapsed of uterus	23
7)	Tick control	766
8)	Deworming (endo-parasite)	813
	Total	1756

Kisan Sangosthies

Twenty three Kisan Sangosthies were organized at village level and following topics were discussed in detail:-

- 1) Management of dairy animals during Transition period
- 2) Control of ticks in dairy animals
- 3) Awareness on ecto and endo parasite infestation
- 4) Role of mineral mixture in animal diet
- 5) Round the year green fodder production
- 6) Balanced ration preparation for dairy animals at Home
- 7) Adaptation practices during extreme climate variability
- 8) Preparation of value added milk products
- 9) Management or reproductive problems in dairy animals
- 10) Management of calf
- 11) Management of growing Heifer

Question/ Answer sessions were also arranged in these sessions which provided excellent opportunities to the farmers and explained the solutions to their day to day problems and also the feedback collected on the extension programmes.

Dairy Education at Farmers' Door (DEFD)

A new Extension Education Programme "Dairy Education at Farmers' Door" is initiated to strengthen the effective dissemination of dairy production and processing technologies among farming community. Under this programme, a team of NDRI scientists including subject matter specialists from production, processing and management group organized Dairy Education at Farmers' Door in various villages on 2nd Saturday of every Month. Scientists also obtained the feedback from the participating farmers.

Issues Addressed

Sl.No.	Farmers query	Solutions by the NDRI Team	Participants
1)	Anoestrus problem in dairy animals	<ul style="list-style-type: none"> Feeding of mineral mixture @ 50g/day/ cow and buffalo Awareness regarding heat symptoms of cow and buffalo particularly in late evening and early morning 	623
2)	Repeat breeding in dairy animals	<ul style="list-style-type: none"> Proper care during transition period of dairy animals Proper feeding of dairy animals Feeding of mineral mixture @ 50g/day/ cow and buffalo 	681
3)	Breed improvement of dairy animals	<ul style="list-style-type: none"> Maintain pedigree record of dairy animals Call recognized veterinarian for insemination of cow/ buffalo Details of semen i.e. bull No. source, dams yield, etc. 	582
4)	Service period	<ul style="list-style-type: none"> Balanced nutrition to the animals Awareness regarding service period 	426
5)	Preventive measure of Mastitis	<ul style="list-style-type: none"> Maintain Clean and hygiene environment in animals houses Provide balanced nutrition to lactating animals Milking of lactating animals, Recommended udder health care practices and the. 	436
6)	Round the year green Fodder management	<ul style="list-style-type: none"> Improved varieties of fodder crops Sowing of Green fodder and Perennial grass, Silage making 	653
7)	Endo-ecto parasite infestation	<ul style="list-style-type: none"> Suitable treatments to control endo-ecto parasite infestation 	883
8)	Clean milk production	<ul style="list-style-type: none"> Clean milk production practices 	810
9)	Value addition of milk to enhance profit to farmers	<ul style="list-style-type: none"> Awareness of values addition milk through Paneer 	566
Total			6283

Farmers Farm School: A new initiative of NDRI for farmers

National Dairy Research Institute (NDRI) has started an ambitious programme wherein farmers of Haryana State are being provided formal Education in the field of Dairying, Horticulture and Agriculture through Farmers Farm School. In this School, farmers would interact with the scientists of the Research Institutes and there is class room teaching as well as practical classes. There is provision of enrolling 25 farmers in one batch on first come first basis and the course duration is for one year. The 7th batch consisting 21 farmers of village Johar Majra was in progress.

Dairy Samachar

Quarterly Hindi Magazine "Dairy Samachar" were compiled, edited and published by Division Dairy Extension, NDRI, Karnal and a total of 3000 copies were published and distributed.

Educational Visits and Tours (2021):

A total of 824 visitors (students & Faculty) of 08 colleges/ Institutions/ Universities visited the institute, which were coordinated by the division. The groups were sensitized about the different research, teaching and extension achievements and facilities available in the Institute among them 06 visits were organised on virtual mode.

Educational Visits and Tours

Sl.No.	Particulars	No.
1)	Number of Institutions/ organization/ Colleges	08
2)	Boy students	407
3)	Girl students	381
4)	Male faculty	17
5)	Female Faculty	19
6)	Total visitors	824

Advisory Services

Division provided regular advisory services through post, e-mails, phone to individuals farmers/ NGO's/ relevant departments all over the country in response to their particular/ general queries regarding latest technologies of the Institute and modern dairy farming practices

Technological interventions/ demonstration at farmer's fields

Module/ Intervention	Village covered	Area Covered (ha) / Animal (No.)	House Covered of Hold
A. Crop Based			
• Varietal Trial of Paddy (PB-1509 & PB-1692)	7	76.40	191
• Varietal Trial of Wheat DBW-222 DBW-303	7	20.00	100
• IPM in Paddy	7	95.00	80
• Weed control in wheat	7	24.00	55
• INM in Wheat	7	31.00	68
• Round the year green fodder	7	10.00	50
• Crop Residue Management	7	128	285
B. Horticulture based			
• Vegetable (bottle guard)	2	1	10
• Fruit Plantation	2	0.20	10
C. Dairy Based			
• Balanced feeding	7	75	40
• Reducing Negative energy balance	7	38	29
• Anionic Mineral Mixture	7	150	120
• Cationic Mineral Mixture	7	210	210
• Minerals Mixture supplementation	7	460	245
• Protected Amino Acids	7	52	29
• Ecto parasite	7	1634	1245
• Endo parasite	7	520	275
• Theilariosis Vaccination & treatment	7	58	56
• Mastitis treatment	7	24	18
• Estrus synchronization	7	72	58
• Ovulation synchronization	7	62	48
• SMS Portal	7	All Households	Full Coverage
D. Enterprise based			
• Processing of milk	2	15	15

Sr. No.	Name of Training	Date	No. of Participant
1)	Paddy Varietal Trial (PB-1509) intervention	12-05-2021	191
	Paddy Varietal Trial (PB-1692) intervention	11-06-2021	
		18-05-2021	
2)	Anionic mineral mixture feed supplementation	18-09-2021	38
Sr. No. Name of Training Date No. of Participant			
3)	Green Fodder Intervention Berseem (BL-42 & BL-44)	11-11-2021	50
		12-11-2021	
4)	Varietal Trial of Wheat DBW-222& DBW-303	25-10-2021	100
		14-10-2021	
5)	Training of Milk Processing	23 to 25-09-2021 & 13 & 14-10-2021	8
6)	Training of Milk Production	14 to 18-09-2021	8
7)	Training of Dairy Marketing	20 to 23-12-2021	8
8)	Training on Goat Farming	2 to 6-08-2021	2
9)	Cationic mineral mixture feed supplementation	18-09-2021	30
10)	Mastitis testing	28-08-2021	4

Krishi Vigyan Kendra (KVK)

KVK was actively involved in imparting need based training to farmers, farmwomen and rural youths for gaining not only knowledge but also employment and sustainable income by providing latest technical know-

how on regular basis in different areas related to agriculture and allied areas to improve their competence. In the year 2021 KVK, Karnal conducted 18 trainings in which 413 farmers, farmwomen and rural youths participated. Apart from the on-campus training program effective extension activities were conducted to create an environment in which informal contact and learning could take place. KVK has intensified and concentrated efforts in conducting various extension activities in to create awareness and mobilize proven and acceptable technologies and also accelerate technology transfer process. Field level demonstration (FLD) is a unique approach that provides a direct interface between scientific community and farmers. It provides an opportunity to scientists and extension personnel for understanding the farmer's resources and to find and modify technologies for easy adoptability at farmer's field (need based technology development). During 2021 CFLD of summer moong variety IPM 205-7 (Virat) was carried out under the supervision and guidance of the Kendra in which 50 demonstrations were conducted in 20ha area where an average yield of 8.1qtl were recorded. To transfer the technological packages under prevailing farming situations, activities like field days, seminars, training and other interactive sessions were conducted.

Category	Block Level	District level	Total
Advisories	672	84	756
Special Advisories	Related to Heat and Tauktee Cyclone		

KVK Karnal also issued weather based agro-advisories twice in a week for the farming community using different modes of dissemination. In addition to this, special advisories are also issued. Twenty nine whatsapp groups were created covering 2664 farmers.

Mandate of KVK

- Technology assessment and demonstration for wider application in operational area.
- Capacity development programmes for stakeholders (Practising farmers, farm women, extension functionaries, line departments and rural youth/entrepreneurs).
- Technology product and inputs production and promotion.

Thrust Areas

This Kendra has identified following thrust areas for perspective planning and achievements.

- Vocational training for the unemployed rural youth for self-employment.
- Dissemination of latest technologies in the field of Dairying and allied fields through training.
- Diversification of cereal based farming systems with introduction of Oilseeds, Pulses, Horticultural Crops, Fisheries and Bee-keeping for increasing nutritional level, production and income per unit area.
- Awareness on Natural Resource Conservation and Management.
- Integration of crops and livestock system.
- Promoting the processing of dairy products, value added agricultural products and preservation of fruits and vegetables.
- To fill-up the technological gaps in crops and livestock production by training of practicing farmers.
- Training of grassroot level extension workers to have wider area coverage of extension activities.
- To conduct on-farm trial of the newly released technologies on farmers' fields to see its economic feasibility and get the feedback from fields.
- To create awareness among farm-women to have better home management.
- Promoting preparation of vermi compost and its importance in organic farming.
- Women empowerment.

Infrastructural Facilities Available

Instructional farm: Total land under (35 Acres)

Instructional Units

- Crop & Seed Production (30 Acres)
- Horticulture (2 Acres)
- Bee-keeping (45 Bee Colonies)

- Fish Farming (3 Acres water area)
- Vermicompost (4 beds size 10'x3')
- Laboratories: Home science

Training Programmes

On-Campus

KVK provided strong training support to disseminate need-based and skill-oriented technology for various target groups for achieving a production breakthrough in Dairying, Agriculture and allied subjects. Need-based short and long-term (on and off-campus) trainings on various disciplines, viz. Dairy Production, Dairy Processing, Agriculture, Horticulture, Vermiculture, Bee-keeping, Fish Farming and Home Science were organized for farmers, farm-women, rural youth, in-service personnel and rural leaders.

On-campus Training Programmes (January to December, 2021)

Title of the course	Duration(days)	No. of Courses	No. of Trainees
Dairy Production			
District-Karnal	5	5	6
Other district-Sponsored	1	153	30
Dairy Processing/ Home Science			
District-Karnal	5	1	17
Other district-Sponsored	5	2	25
Crop Production (CRM)	4	2	56
Crop Diversification	1	1	28
RAWE training	40	1	10
Bee-keeping	4	3	78
Fish Farming	4	4	128
Goat Farming	5	3	65
Vermicompost making	4	2	50
Horticulture (Exotic Vegetable Production)	4	1	25
Sub-Total (a)		27	665
Short Visit-cum-Training Programmes (b)	1-5	32	1209
Total (a+b)		59	1874



Glimpses of training programmes

Off-Campus

Off-Campus Training Programmes

Title of the course	Duration(days)	No. of courses	No. of trainees
Crop Production	1	9	212
Horticulture	1	4	71
Soil Health and Fertility Management	1	6	103
Live stock Management	1	10	190
Home Science/ Women empowerment	1	4	51
Plant Protection	1	5	72
Crop Residue Management	1	28	819
Fisheries	1	3	64
Total		69	1482

On-line Training/ Webinars Organized

Title of the course	Date	Participants
Webinar on world bee day	20-05-2021	35
Virtual webinar on Jal Shakti Abhiyan	28-05-2021	55
Webinar on world milk day	01-06-2021	85
Farmers' awareness program on 'balanced use of fertilizers'	18-06-2021	145
Total		1540



Glimpses of webinar organized

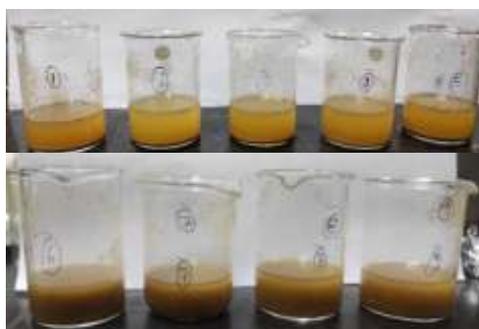
Exposure Visits-cum-Short Training Programmes Organized

A 31 visits were organized in which 1209 number of farmers and farm women participated from Haryana, Uttar Pradesh, Chhattisgarh, Gujarat, Uttarakhand, Rajasthan, Orissa, Delhi, Jharkhand and Bihar.

- **On-Farm Trials**
- **OFT 1: Evaluation of spiced Whey beverage for women entrepreneurs**



Clarified Whey



Spiced whey drink prepared using combinations of different spices

- The spiced whey-drink was prepared using different combinations of spices (g per 100 g clarified whey).

Front Line Demonstrations on Oilseeds, Pulses, Cereals and Fodder

During the year 2021, the crops sown during Rabi 2020 under FLD, organized by KVK, were harvested and analyzed for performance so as to popularize the latest released varieties and to promote crop diversification. The following demonstrations were organized by KVK in various villages of Karnal district.

Results of FLD's during 2021

SN	Crop	Variety	Total No. of Demo.	Area(ha.)	Av. Yield (q/ha)	BC Ratio	
1)	Pulses	Gram	HC-5	54	20.00	12.30	1:2.17
		Summer Moong	IPM-205-7	50	20	8.1	1:2.60
2)	Oilseed	Mustard	CS-58	125	50	18	1:3.06
3)	Fodder	Berseem	BL-43	14	2.43	975	1:3.22
4)	Cereals	Wheat	DBW-187	20	4	58.51	1:3.44
			HD-3226	10	4	54.28	1:3.19
5)	Vegetable	Okra	Bhindi-5	4	1.6	212	1:3.20
		Green Manuring	Dhaincha	CSD-123	13	5.22	
Total				277	102.03	-	-

Results of FLD's on Livestock during 2021

Category	Thematic area	Name of the technology demonstrated	No. of Farmer	No. of Units (Animal/Poultry/Birds)	Major parameters		% change in major parameter	Economics of demonstration (in Rs.)				Economics of Check (in Rs.)			
					Demo	Check		Gross Cost	Gross Return	Net Return	BCR (R/C)	Gross Cost	Gross Return	Net Return	BCR (R/C)
Cattle	Animal Nutrition Management	Poly-Herbal Feeding	10	10	8.96	7.16	25.14	113	358.4	245.4	1:3.17	97.5	284.0	186.5	1:2.91

Field Demonstrations carried out during the year 2021

SN	Crop	Variety	No of Demo.	Area (ha.)
1)	Pulses	Gram	HC-5 and HC-7	30 10
2)	Oil Seed	Mustard	PM-32, RH-725, RH-761	103 41.2
3)	Cereal	Wheat	DBW-303	20 4.82
			DBW-187	8 3.21
Total				209 78

FLD Field visits organized

During the period under the report, KVK organized 34 field visits benefitting 462 farmers in different villages of Karnal district.



Glimpses of field visits and field days organized

Performance of Crop Demonstration Unit of KVK during 2021

Seed and other bio-products produced at KVK

This KVK maintained live demonstration units in fish farming, bee keeping, vermi-culture, horticulture and crop production for imparting practical training for skill development, demonstration of technologies and production of quality seed material of latest varieties for sale to farmers. The products from these units particularly seed were sold through ATIC to farmers. The performance of instructional farm (Crops production) including seed production during the year 2021 is given in the following table:

Seed produced at crops production unit during the year 2021

Name of the Crop	Date of Sowing	Date of Harvest	Area (acre)	Details of Production		
				Variety	Type	Qty (Qtls.)
Seed Cereal Wheat	Nov, 2020	April, 2021	13.05	HD-3226	Seed	240
			13.85	DBW-187		275
Paddy	June, 2021	Oct, 2021	6.25	PB-1509	Seed	110 approx
			5.0	PB-1718		90 approx
			16.35	PR-114		290 approx
			1	PB-1692		10 approx
Fodder	Nov, 2020	May, 2021	3.60	BL-42	Seed	5.76
			0.50	BL-43		1.30
Green Manuring						
Dhaincha	May, 2021	Oct, 2021	0.50	CSD-123	Seed	4.00

Production from other demonstration Units

SN	Products	Species/ Varieties	Quantity
1)	Fish	Rohu, Katla & Mrigal	12 Q
2)	Fish Fingerlings	-do-	-
3)	Earthworm	Eisenia foetida	-
4)	Vermicompost	Eisenia foetida	760 kg
5)	Honey production	Apis mellifera	90 kg

Seed and bio-products sold to farmers during the year 2021

The seeds and bioproducts produced from KVK demonstration units were sold not only to farmers of Haryana but also to those from other states. During 2020, KVK made available the following seed material of various crops and bio-products to the farmers as given below

Seed sold during 2021

SN	Crop	Variety	Quantity	No of Farmers
1)	Paddy Seed (produced in Kharif 2020)	PB-1509	167.40	215
		PB-1718	97.75	200
		PUSA 44	123.20	110
	Wheat Seed(2020-21)	DBW-187	275	222
		HD-3226	240	110
2)	Berseem Seed (produced in Rabi 2020-21)	BL 42	5.74	Seed Provided to the Farm Section
		BL-43	1.30	

Bio-products sold during 2021

Bio-products	Varieties	Quantity	No of farmers
Fish sold	Rohu, Catla & Mrigal	560 Kg	-
Fish (fingerlings)	Rohu, Catla & Mrigal	26000 Nos	3
Earthworm	Eisenia foetida	-	-
Vermicompost	Eisenia foetida	460 kg	72
Honey	Apis mellifera	90 Kg	52

Projects/Schemes Implemented by KVK

This KVK implemented the following projects and schemes of DOAC&FW, ICAR and IMD during the year 2021 and continued to carry out various assigned activities under these.

- Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of NCT Delhi and Haryana.
- Cluster Front-line Demonstrations (Pulses) under the scheme NFSM.
- Cluster Front-line Demonstrations (Oilseed) under the scheme NFSM.
- Frontline Demonstrations(Vegetables)
- Training for Skill Development in Vermiculture on behalf of ASCI.
- Establishment of District Agro Meteorology Unit at KVK.
- Nutri Sensitive Agricultural Resources and Innovation (NARI).
- Farm Machinery & Equipments under submission on Agricultural mechanization.

Field Extension Activities

- **Meeting of Scientific Advisory Committee-2021:** The scientific advisory committee was held on February 12, 2021 under the chairmanship of Dr. Manmohan Singh, Director, NDRI, Karnal to review the progress of KVK during the year 2020 and action plan for the year 2021. Forty Five members of Scientific Advisory Committee including Director ICAR-ATARI, Director, ICAR-CSSRI, Karnal, Head of IARI Regional station, Karnal, Head of Department ICAR-NDRI, Karnal, staff of KVK, Karnal and progressive farmers and farm women graced the occasion.

- **National Horticulture Fair-2021:** KVK, Karnal participated in National Horticulture Fair Organized by ICAR-IIHR, Bangalore in virtual mode on 09.02.2021. KVK invited the farmers from different villages of the district Karnal. Forty five farmers actively participated in this event.
- **National Science Day, 2021:** KVK, Karnal organized National Science Day, 2021 on February 28, 2021 at KVK campus. A total of 70 participants attended the event in which 44 students of Govt. Senior Sec. School, Dabri participated. Experts delivered short lecture on various activities carried out in KVK. Students were encouraged to take agriculture as professional courses after their school. a short orientation session was held to create awareness among students regarding the courses they can take after their school. These students were taken to different demonstration units of KVK to expose them to the KVK activities.
- **International Women Day-2021:** KVK-Karnal organized International Women's Day and Kissan Goshti on March 8, 2021 at KVK campus. About 91 farm women and 30 farmer's participated in this event. During the Progammme, Dr. M.S. Chauhan, presided over the function and shared his view on women education and empowerment and he also educate the women about atam narbhar bharat. Smt. Madhu Pathak, Women's and Child welfare officer graced the function as Chief Guest. She spoke about the significance of International Women's Day, first 1000 days for child and the challenges being faced by women in today's society. She encouraged all the women participants to take a pledge on this International Women's Day to become empowered women.
- **World Water Day-2021:** KVK, Karnal celebrated World Water Day on March 22, 2021 at ICAR-NDRI, Karnal. In this event about 90 farmers and farm women participated. The chief guest of the occasion WAS Dr S K Gupta (EX-PS, CSSRI-Karnal). The Director, ICAR-NDRI, was presiding over the function. Lectures on value of water and its conservation methods was delivered.
- **World Bee Day-2021:** KVK celebrated World Bee Day on May 20, 2021 at KVK campus in both on-line and Off-line mode. In virtual mode 45 farmers participated and in off-line mode 25 persons participate. Awareness on Apiculture and its benefits to farming community was discussed.
- **World Milk Day-2021:** KVK celebrated World Milk Day on June 1, 2021 at KVK campus in both on-line and Off-line mode. In this event about 267 farmers and farm women participated. The chief of the occasion was Dr. T. Mohapatra, DG, ICAR. Lectures on different aspects of dairying and its products were delivered by the experts.
- **World Environment Day-2021:** KVK celebrated World Environment Day on June 5, 2021 at KVK campus. Prime Minster also participated in this via video conferencing. The event was jointly organized by the Ministry of Petroleum & Natural Gas and the Ministry of Environment, Forest and Climate Change. Promotion of bio-gas was the main theme of the programme. In this event 25 farmers and KVK staff participated.
- **World Zoonoses Day-2021:** KVK celebrated World Zoonoses Day on July 6, 2021 at village-Phurlak. In this event about 23 farmers participated. Experts delivered lecture on Zoonoses and educated the farmer on the diseases spread between animal and human.
- **ICAR 93rd Foundation Day-2021:** KVK celebrated 93rd foundation day on July 16, 2021 at KVK. In this event different lecture on agricultural and allied subject was delivered to the farmers, farmwomen and students. A tree plantation campaign was also organized. About 70 participants took part in this event.
- **World Breast feeding Week:** KVK organized World breast feeding day at village Dahajagir on August 7, 2021. 19 farmwomen participated in the program. The participants were given classes on the importance of breast feeding, infant nutrition and the advantages of colostrum to the new born.
- **Parthenium Awareness Week:** KVK organized awareness week on Parthenium weed eradication from August 16-22, 2021 at village Bheni Khurd. A lecture on biological control of Parthenium weed was delivered to farmers and farmwomen. Twenty five participants took part in the event.
- **Food and Nutrition for Farmers:** KVK organized 'Food and Nutrition for Farmers' program under Azadi Ka Amrit Mahotsav at KVK, Karnal on August 26, 2021. Lectures on balanced diet, bio-fortified cereals and pulses and nutritional garden were given to the farmers and students. In all 60 farmers and 31 school students participated.

- **Poshan Abhiyan and Tree plantation Campaign:** KVK organized Poshan Maah and Tree Plantation campaign in collaboration with IFFCO, Karnal on September 17, 2021. The chief guest of the event was Mrs Tavleen (Good Governance Officer, CM office). Mrs Madhu Pathak Guest of honour (CDPO, Karnal), Dr. M S Chauhan Presided over the programme (Director, ICAR-NDRI, Karnal), Dr. Dheer Singh Joint director research ICAR-NDRI, Karnal and Dr Niranjan Singh (IFFCO, Karnal). A total number of 207 persons participated. out of this 71 girls, 136 farm women of Karnal district participated. Five lectures on different aspects of millet nutrition, value addition, use of Nano fertilizers, importance in daily nutrition of millets particularly in adolescent girls, lactating mothers and aged women were delivered. Live telecast of Hon'able Minister of Agri. Farmers Welfare Sh. Narendrer Singh Tomar was attended by all participants including VIPs.
- **PM-Kisan Interaction Program:** KVK telecast PM-Kisan interaction program on September 28, 2021 at NDRI auditorium. In this event 152 farmers and farmwomen participated. The chief guest of the event was Dr. Aseema Gakhar. In this event PM released 34 new varieties of crops/seeds and inaugurated National Institute of Biotic Stress and Management.
- **Mahila Kisan Diwas, 2021:** KVK organized Mahila Kisan Diwas on October 15, 2021 at Village-Gagsina, Karnal. The chief guest of the function was Dr. Dheer Singh (Joint director, NDRI, Karnal). KVK experts delivered lectures on different aspects of women empowerment. In this program 86 farm women participated. A total of about 107 people participated.
- **World Food Day, 2021:** KVK organized World Food Day on October 16, 2021 at village-Kamalpur Rodan. KVK experts delivered lectures on balanced diet, bio-fortified crop varieties etc. A awareness on crop residue management and minimum use of pesticides was also given. In this program 73 farmers participated.
- **World Soil Health Day:** To create awareness on the importance of soil health in crop production, KVK organized "Soil Health Day" on December 5, 2021. The theme of the program was is **Halt soil salinization, boost soil productivity**. The chief guest of the function was Dr. Dheer Singh (Joint director (Research), NDRI, Karnal. In this event 115 farmers and farm women participated. Soil health card were given to the farmers.
- **PM-Kisan Interaction on Natural Farming:** PM's interactive program on Natural farming was live telecasted as a part of 'Pre-vibrant Gujarat Summit' on December 16, 2021. The online telecast of the event took place in KVK, in which 152 farmers/farmwomen participated.
- **Kisan Mela and Kisan Divas:** KVK organized Kisan Mela and Kisan Diwas on December 23, 2021 at KVK campus. Theme of the event was 'Management of paddy crop residue'. Dr M.S Chauhan, Director, NDRI, Karnal presided over the function. In this event, 385 farmers and farm women of different villages of Karnal district participated. Those farmers who did excellent work in conservation agriculture, crop diversification, integrated farming, dairy farming and milk processing were honoured in the function by the Director. Automatic Weather Station (AWS) was inaugurated in the presence of Director and Joint Director, ICAR-NDRI.



Field Days Organized

- Field day on Gram Crop was organized at village Sultanpur on June 4, 2021, where in a total of 18 farmers took part and discussed regarding Seed varieties, fertilizers, bio-fertilizers, soil and treatment with *Trichoderma viride*.
- Field Days on Summer Moong Crops were organized at village Kamalpur Rodan on June 15, 2021 participated by 22 farmers and village Rasin on June 28, 2021 participated by 65 farmers and watch crop

performance and discussion regarding Seed variety IPM-205-07 (Virat), fertilizer, bio fertilizer, soil and treatment with *Trichoderma viride* were main points of discussion which liked by the farming community.

- Field Day on Fish farming was organized at village Kamalpur Rodan on 08.08.2021. Lecture on fish seed management, mortality control, disease management and predator control were given. The farmers discussed the problem faced by them in their farms. The experts encouraged more farmers to start fish farming. In this event 37 farmers participated.

Revenue Generation in KVK during 2021

KVK generated following revenue for the Institute and revolving fund through various activities:

Revenue generated by KVK during the year 2021

Source	Amount (Rs.)
i) Training fee from sponsored courses	97,330
ii) Crop production unit	20,54,758
iii) Vermi-compost unit	4,600
iv) Horticulture unit	95,000
i) Bee-keeping unit	27,820
ii) Fisheries unit	96,000
Total	23,75,508

Demonstrations on *In-situ* management of crop residue:

KVK was able to demonstrate in-situ management of paddy straw with the help of mulcher, shrub master, hydraulic reversible M B plough, Happy Seeder and Zero Till seed drill in different villages of Karnal district. Sowing of wheat was also demonstrated in two adopted villages namely Nabipur and Phurlak of Karnal district with the help of happy seeder and zero tillage to check the stubble burning.

Demonstrations on *in-situ* crop residue management organized during 2021

Sl. No	Village	Total	
		Area (Acre)	No. of Farmers
1)	Nabipur	78	35
2)	Phurlak	81	18
	Total	159	53



Mobilization of school students against crop residue burning and crop residue management

The students of government schools of different villages of Karnal district were also involved to convey the message against crop residue burning in their respective villages. Students, along with the staff of KVK, took part in conducting elocution competition and drawing competition on the theme "Ill effects of crop residue burning". Students were given lectures on the adverse effect of crop residue burning on health as well as environment by the expert and were also encouraged to dissuade their farmer parents, neighbors and relatives from burning of paddy residue in their fields.

Mobilization of school and college students

Sl.No	Name of Activity	Date	Place of activity (Village)
1)	Drawing Competition against crop residue burning	22-01-2021	Gheer
2)	Drawing and Elocution competition against crop residue management	12-11-2021	Kendriya Vidyalaya, Karnal
3)	Drawing and Elocution competition against crop residue management	27-11-2021	Government Sr. Sec. School, Nilokheri

Mobilization of farmers in villages

SN	Name of activity	Date	Place of activity(Village)	No. of students participated
1)	Prabhat pheri	17.11.2021	Nabipur	85
2)	Prabhat pheri	23.11.2021	Phurlak	172

Publicity on crop residue management

KVK developed pamphlets and folders on *In-Situ* crop residue management for distribution among the farmers in different villages and to those coming to KVK to attend various training programmes. KVK also created slogans to resist farmers from paddy straw burning and encourage them for *In-situ* crop residue management using happy seeder, zero tillage and MB plough. Wall paintings with slogans, against crop residue burning and to encourage crop residue management, were done on prominent public places in two adopted villages namely Nabipur and Phurlak, to generate mass awareness on crop residue management. The selected places on highways, near by the adopted villages, were also painted with slogans. Hoardings and banners, conveying the message on *In-situ* crop residue management were placed at prominent places, like mandis, ICAR institutes and main gates of railway stations, for maximum outreach among farmers in the district.

Awareness programmes organized in KVK and villages

During the period under report KVK organized 17 awareness programme and kisan goshtis participated by 819 farmers to sensitize farmers on against burning of crop residue in the fields and use of machines for *In-situ* management of crop residue.

Women Empowerment

KVK organized following programmes to empower farmwomen/rural women.

Awareness Programme Organized	Number	No. of Participants
World Breast-Milk feeding day	1	19
Poshan maah celebration	1	207
Mahila Kisan Divas	1	86
Training on vermicompost for rural ladies	1	26



Poshan Maah celebration at KVK

Kisan Mela on Crop Residue Management (CRM)

KVK organized a 'Kisan mela' on *in-situ* crop residue management on December 23, 2021. The event was attended by more than 389 farmers and experts from various ICAR institutes of Haryana.

Agricultural Technology Information Centre (ATIC)

Agricultural Technology Information Centre at ICAR-NDRI Karnal became operational in November 2004. The centre is engaged in disseminating information on dairying and allied agricultural fields to the visitors. Besides NDRI, relevant information available from other research stations of ICAR and state institutions located at Karnal are utilized by this centre for the benefit of farmers and other stakeholder visiting the institute. A large number of entrepreneurs, practising farmers, extension workers and students are availing the services of ATIC regularly.



CRM Mela organized at KVK campus

relevant information available from other research stations of ICAR and state institutions located at Karnal are utilized by this centre for the benefit of farmers and other stakeholder visiting the institute. A large number of entrepreneurs, practising farmers, extension workers and students are availing the services of ATIC regularly.

Mandate

- To provide a single window delivery system for agricultural information as well as products and technologies developed by the research institute with a view to deliver quality services to the clientele.
- To strengthen the farm advisory services by adopting a multi disciplinary approach to problem solving.
- To provide mechanism for feedback from the end users to the research system.
- To function as a repository of agricultural information pertaining to farming skills and practices, farm inputs and agricultural education.
- To offer consultancy services to the different stakeholders in the state.
- To arrange training to unemployed youth to equip them to become job providers, rather than job seekers.

Dissemination of Technological Information:

Presently, ATIC-NDRI is using following approaches for dissemination of information to its users:

- 1) Personal interaction with visiting farmers
- 2) Audio/Video shows/documentary of the institute/ICAR
- 3) Visits to Dairy farms of Karnal district and outside
- 4) Attending queries of farmers on toll free telephone number (1800-180-1199) placed at ATIC
- 5) Providing Publications of Hindi and English language of ICAR-NDRI to the visitors
- 6) Selling agricultural and allied inputs of KVK and other departments like improved seed varieties, vermicompost, eggs etc.
- 7) Providing information of the institute through emails
- 8) Regularly sharing latest information of agriculture and dairy subject of the Government of India and Govt. of Haryana on WhatsApp group with hundreds of farmers

Facilities available with ATIC

- Seed storage facility with available 3 rooms
- Well equipped classroom with projector facility
- Posters of technologies displayed on walls
- Toll-free number 1800-180-1199 to address queries of farmers
- Library with more than different types of 60 books/manuals on dairy and allied topics authored by NDRI scientists. Total copy of books/manuals available 6000.
- Magazines, folders, pamphlets and calendars of NDRI publications.
- Different demonstration tools like honey separator, sprayer machine, zero tillage machine, seed treatment equipment etc.
- NDRI made dairy products samples/wrappers.

Note: The ATIC facilitated the sale of PAU, Ludhiana seed through seed counter of ATIC. The PAU sold seed of paddy varieties,

Services rendered in Agricultural Technology and Technology Products from 01-01-2021 to 31-12-2021

Sr. No.	Detail of services	No. of Services given	No. of Persons benefitted
1)	Dairy/ Agriculture related information through Video shows and Lectures	16	518
2)	Personal discussion with Subject-Matter-Specialist on Dairy Farming	53	108
3)	Information through Dairy/ Agriculture Literature	68	95
4)	Information on Agriculture (Seed/Fertilizer/Compost etc)	562	640
5)	Information through telephone (Toll-free) on Agriculture and Dairying etc.	650	650
6)	Information through e-mails on Agriculture and Dairying etc.	36	180
7)	Information through Whatapp group on Agriculture & Dairying etc.	54	1650
	Total	1438	3841

Total Sale during 2021

Sl.No.	Item	Amount (Rs.)
1)	Books (NDRI Publications)	24905
2)	Agriculture Inputs(seeds, fertilizers etc obtained from KVK NDRI, Farm Production Section NDRI,	2072491
3)	Sale in Integrated Farmer System	40259
	Total	21,37,655

PR-114, PR-124, and wheat varieties, improved PBW-343, PBW-550 and they also sold vegetable kits to the farmers.

10. WOMEN EMPOWERMENT AND MAINSTREAMING OF GENDER ISSUES

Women Empowerment Lab in Dairy Extension Division

Women empowerment lab was established in Dairy Extension division in 2013 for capacity building of different self help groups of NDRI, DRDA and NGOs. This lab was established with the objective to create awareness and impart skills in the field of dairy processing and fruit and vegetable preservation and also mobilize these groups to take up vocation in these areas. For this laboratory, all items of Dairy Processing Unit viz. Eco Milk Testing Machine, Refractrometer, pH Meter, Moisture Balance were procured. Regular women empowerment trainings and campaigns through this Women Empowerment laboratory were organized to create awareness among rural farm women in the field of dairying and home science and also impart skill in these areas so that farm women could generate more income from dairying and maintain healthy atmosphere in their respective families.

Four Women empowerment training programme-cum-demonstration were organized with the objective to create awareness in the field of dairying, also impart skill in these areas so that farmwomen could generate more income from dairying, and maintain healthy atmosphere in their respective families. These programme trained 72 farmwomen.

On Campus Women Empowerment Training Programme-cum-Demonstrations (2021)

Sl. No.	Title	No. of trainings	No. of Participants
1)	Training programme for value added milk product of rural women (SHG)	1	22
2)	Exposure cum skill upgradation Training programme of value-added milk products for farm women	1	25
3)	Demonstration cum training programme on value added milk product	1	11
4)	Training programme for value added milk products of rural women (SHG) (off campus, Rohtak)	1	14
Total		4	72

A gender sensitisation and dairy products demonstration was held in Gohana in Sonapat district on January 19, 2021, Sadarpur village on February 17, 2021, Bharatpur village on March 6, 2021, Manoli village and Agwanpur village in Sonapat district on March 24, 2021, Gohana on March 25, 2021 and Pattilalyana village in Panipat district on March 25, 2021. About 100 SC women and 25 SC male farmers were trained on November 29, 2021 in Pinjauri and Malimajara, Yamunanagar for preparation of value added milk and milk products.

Formation of women SHGs

Four women self-help groups were formed each in Bhigan, Kami, Rajpur and Tajpur villages of Murthal block in Sonapat district for the purpose of preparation and marketing of dairy products in the nearby places.

Gender Advancement for Transforming Institution (GATI): A Pilot Program of KIRAN Division (DST)

ICAR-NDRI was selected as one of the pilot 30 Institutes pan India to join the program of Gender Advancement for Transforming Institutions (GATI) initiated by Department of Science and Technology (DST) under the aegis of the WISE-KIRAN Division. With the initiation of the GATI program at NDRI, the Institute aims towards the betterment of working environment and empowerment of faculty, staff and students especially women. As a first step, the Institute organized several gender sensitization events. Some of these events included logo designing competition, felicitation of women scientists for publishing research papers in high impact journals as a mark for motivating them to do even better and organizing webinars on gender advancement. The problem of gender gap of women scholars and women professionals needs to be addressed at societal as well as at the policy and institutional level. ICAR-NDRI is committed to design gender sensitive policies and infrastructure to bridge the gender divide; and tenaciously believe that increased participation of women in science and policy making is a sine-quo-none for sustainable development of both science and society.

Training Programme on Role of Women Power in Environmental Protection

One day training program was organized by ICAR-National Dairy Research Institute, Karnal under National Innovation in Climate Resilient Agriculture (NICRA) project with the theme of “Role of women power in environmental protection” on January 27, 2022. A practical training was also given to all the participants for making “*Ghan-jivaamrit*” and its use in the field and further all participants visited a vegetable unit developed purely by using *Ghan-jivaamrit* as an organic manure. In this programme a total 25 women had participated from different backgrounds like advocates, social workers, teachers, naturopathies, school girls, progressive women farmers, NGO's etc.



11. HONOURS AND AWARDS

Institute Awards

- ICAR-NDRI ranked first among 72 Agricultural Universities and Deemed Universities consecutively five times for the year 2020 conferred in 2021 by the Education Division of Indian Council of Agricultural Research, New Delhi.
- ICAR-NDRI was conferred Global Water Award on August 22, 2021 for work carried out on water saving and reuse technologies in 5th World Water Summit 2021.
- Team NDRI (Puniya AK (Team Leader), Dasriya V, Dhillon HS and Chaudhary V) won 'Zonal Level Technical Evaluation', KRITAGYA (HACKATHON 2.0) for the year 2021 organized by 'National Agricultural Higher Education Project (NAHEP)' and Animal Science Department of Indian Council of Agricultural Research, New Delhi.

ICAR Awards/Best Teacher Awards

- Dr. Sanchita Garai, Senior Scientist (Extension) received “Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2020 from Indian Council of Agricultural Research, New Delhi on July, 2021.
- Dr. K. Ponnusamy Principal Scientist (Dairy Extension) and Dr. Nishant Kumar, Senior Scientist (Veterinary Gynaecology and Obstetrics) received Best Teacher Award of the Institute at 18th Convocation held on August 24, 2021.
- Dr Anurag Saxena received Best Teaching Award, Global Teaching Excellence Award 2021.
- Dr. P. Barnwal, PS and Acting Head, DE Division received “Engineering Excellence Award-2021” from The Institution of Engineers (India) Rajasthan State Centre, Jaipur” on the occasion of 75th Independence Day on August 15, 2021 at Jaipur.
- Dr. Rakesh Kumar was awarded Dr. Sarvepalli Radhakrishnan Best Teacher Award 2021 in Agronomy on September 5, 2021 by Center for professional advancement (A unit of MGRF Registered with Govt. of India NITI Aayog NGO Darpan), Vijayawada, India.

Best Oral Presentation Awards

- Bharti Deshmukh, Archana Verma, Ishwar Dayal Gupta and Neeraj Kashyap received Best Oral Paper Award for the paper “Identification of Single Nucleotide Polymorphisms in SPAG11 Gene and their association with Fertility Traits in Murrah Bulls” (Theme-2: Breeding and Genetics) in the National Symposium of Indian Society for Buffalo Development held at GADVASU Ludhiana during December 10-11, 2021.
- Sakshi Kaith and J. K. Kaushik, Animal Biotechnology Centre was given Best Oral Presentation Award at the Virtual Conference on Proteomics in Agriculture and Healthcare, organized by University of Hyderabad, March 13-14, 2021.
- Nidhi Sukhija, Anoop Anand Malik, Aishwarya Dash, KangabamBidyaxmi, Anjali Choudhary, Rekha Sharma, I.D. Gupta, Jayakumar Sivalingam and Archana Verma received Best Oral Presentation Award on 'Genome-wide identification of selective sweeps and diversity in Gir and Tharparkar cattle' during V Annual Convention of SVBBI and National Symposium organized by Department of Veterinary Biochemistry, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura during March 24-25, 2021.
- Thamizan, P., Chander Datt, Shambhvi, Kuldeep Dudi, Anupam Thakuria, Prateek Singh, Goutam Mondal and Veena Mani received First prize for oral presentation on “Influence of supplementary nickel on feed intake and nutrient utilisation in Murrah buffalo calves” during National Symposium of Indian Society for Buffalo Development (ISBD) On “Scientific Interventions To Address Challenges For Sustainable Buffalo Production” at GADVASU, Ludhiana-141004, Punjab, India during December 10-11, 2021.



- S. Ragulraj, M. Bhakat, T.K. Mohanty, S. Maiti, G.S. Lal, M.S. Rajput, N. Shah and R. Dewery received Best Presentation Award (Oral) on “Early prediction of neonatal calf diarrhoea in Murrah buffalo through daily infrared temperature monitoring” in the National Symposium organized by C.V.Sc. (Ludhiana), GADVASU, in National symposium of ISBD on Scientific Interventions to address challenges for sustainable buffalo production during December 10-11, 2021.
- Atul S. Rajput, Mukesh Bhakat and T.K. Mohanty received Best Oral Presentation in the online conference Emerging trends in agriculture and biological sciences (January 14-15, 2022) organized by Society for Bioinformatics and Biological Sciences and Applied Research and Development Organization, India under session VIII: Veterinary Sciences-III on the title “Identification of estrus using infrared thermography in indigenous dairy animals”.
- Sandeep Kumar got Best Oral Presentation Award entitled, 'Bifunctional HPrK/P enzyme: A potential target for antibiotics discovery against resistant Enterococcus faecalis in the International Conference on Emerging Strategies in Antimicrobial Agents and Bio-innovation' organized by the Department of Microbiology, School of Science, RK University on December 18-19, 2020.
- Reenu Kashyap and Shilpa Vij received First Prize for oral presentation on “Buffalo colostrum proteins derived formulation for management of diarrhea in immune compromised patients. 27th International conference on Advances in Food Science and Technology (October 26-28, 2021) Meghalaya, India.
- M. Kumari and P. V. Behare received Best Oral Presentation Award for Immunomodulatory potential of exopolysaccharide produced by Streptococcus thermophilus NCD399 at 10th International Conference on Fermented Foods, Health Status and Social Well-being held on December 17-18, 2021 at the Faculty of Agriculture, University of Peradeniya, Sri Lanka.
- Shivaswamy G.P. received RT Doshi Best Paper Presentation Award for a research paper, “An assessment of magnitude and drivers of India's virtual water trade in major food products” in the 29th Annual Conference of Agricultural Economics Research Association, held at OUAT, Bhubaneswar during October 27-29, 2021.
- S. Subash received Two 'Best Paper Presentation Awards –II Place' for a paper presented in the “International Virtual Conference "Transforming Agricultural Advisory Services to Mitigate the Effects of the Pandemic for Farmers Welfare”- (ICTAAS-2021) Jointly Organized by VIT, TANUVAS, Bule Hora University, Ethiopia and Al Neelain University, Sudan held during November 12-13, 2021.
- Suwalke R., Panjagari N.R., Ganguly S., Singh A.K., Sharma R. and Raghu H.V. received Best oral presentation entitled 'Performance of On-package freshness indicator of set type dahi as affected by starter cultures' at 10th International Conference on Fermented Foods, Health Status and Social Well-being. Organized by the University Research Council of University of Peradeniya, Sri Lanka in collaboration with SASNET-FF at December 17-18, 2021 (virtual mode).
- Kathan Raval, Manish Kumar Sinha, Elango Kamaraj, Nilendu Paul, Thirumala Rao Talluri, Pradeep Nag, Ebenezer SKPJ, Arumugam Kumaresan received Best Young Scientist Award (2021) by ISSAR for the paper

“RNA Sequencing Unveils Alteration in Gene Expression Involved in Important Biological Processes Related to Fertility in Crossbred Bull Semen with High DNA Damage”.

- Manish Kumar Sinha, Arumugam Kumaresan, Thirimala Rao Talluri, John Peter Ebenezer Samuel King, Mani Arul Prakash, Aranganathan V received Best Young Scientist Award (2021) by ISSAR (2021) for the paper “SNP study related to genomics differences for fertility in crossbred bull spermatozoa”.
- Kamini Sharma, Heena Sharma, A K Singh, G K Deshwal and S. Kadyan received Third Prize for the Oral Presentation in 4th International Conference on Food and Nutrition organized by Universal Society of Food and Nutrition (USFN) on September 23-24, 2021.
- Singh, N; Mann, B; Sharma, R; Raju, P N; Verma, A; Gandhi, K. received Third Prize in Oral Presentation for the paper Identification of intentionally and non-intentionally added substances in milk packaging materials by GC-MS/MS. Orally presented at the International Conference on “Convergence of Technology and Policy for Sustainable Meat Production” organized by the Association of Meat Scientists and Technologists (AMST) and Meat Technology Unit and Dept. of LPT, Kerala Veterinary and Animal Sciences University (KVASU) in association with Association of Food Scientists and Technologists (India) and Indian Dairy Association (Kerala Chapter) in October, 2021.

Best Paper Awards

- Pradeep Nag, Kumaresan A., Ankur Sharma, Nilendu Paul received Best Research Paper Award (2021) by ISSAR for the paper “DNA fragmentation is associated with alterations in sperm phenome and oviduct binding ability in cattle”.
- Kamaraj Elango, Arumugam Kumaresan, Ankur Sharma, Pradeep Nag, Mani Arul Prakash, Manish Kumar Sinha, Ayyasamy Manimaran, Ebenezer Samuel King John Peter, Sakthivel Jeyakumar, Sellappan Selvaraju, Kerekoppa P. Ramesha and Tirtha K. Datta received Dr. G. B. Singh Memorial Award (2021) for the best research paper published in International Journal entitled “Sub-fertility in crossbred bulls: deciphering testicular level transcriptomic alterations between zebu (*Bos indicus*) and crossbred (*Bos taurus* x *Bos indicus*) bulls”.
- Narendra Singh Rohila, B. P. Singh, Satyavir and Lakshman received “Best Paper Award” for the presentation of their paper “Zotero: A Personal Research Assistant for Researchers” during International Conference on “Management of Knowledge Resource Centre in the Networked Digital Environment: Trends, Challenges and Opportunities” jointly organised by University of Agricultural Science and Association of Agricultural Libraries and Documentalists of India (AALDI) held at University of Agricultural Science, Bengaluru during February 25-26, 2021.
- Meena, D. C., Garai, S., Maiti, S., Dutta, S., Meena, B. S. and Kadian, K. S. received Best research paper award on the paper of “Migration pattern of *Raika* pastoralists of Marwar region of Rajasthan. *Range Management and Agroforestry*”, 42(1): 167-174.
- Paul, R.K., Chandel R., Onteru S.K. received Best Article Award for the paper titled “Male reproductive tract origin sperm-quiescent proteins: prospects in semen cryopreservation of livestock species” published in *Animal Reproduction Update*, Vol I, doi: 10.48165/aru.2021.
- Udita Chaudhary received Best Article Award for the article “Gender Discrimination in Labour Markets in India” (Article ID 10086, published in Vol. 3, Issue 1 (January, 2021) of *Agriculture and Food e-Newsletter* (ISSN: 25818317).

Best Poster Awards

- S. Chhotaray, Vikas Vohra, G.R. Gowane, Rani Alex, A. Mukherjee, Archana Verma and S.M. Deb received Best Poster Presentation Award for the paper "GWAS in Indian buffalo unmasks novel genes for lactation" (Theme-2: Breeding and Genetics) in the National Symposium of Indian Society for Buffalo Development held at GADVASU, Ludhiana during December 10-11, 2021.

- S. Chhotaray, Vikas Vohra, G.R. Gowane, Rani Alex, A. Mukherjee, Archana Verma and S.M. Deb received Best Poster Presentation Award for the paper for the paper "GWAS unravels novel genes for lactation yield and persistency in Murrah buffalo" in the National Conference of 'Indian Society for Animal Genetics and Breeding' on "Animal Breeding Strategies in the Era of Genomics and Phenomics" held at ICAR-NBAGR, Karnal during December 17-18, 2021.
- Pooja Joshi, Archana Verma, Rani Alex, I.D. Gupta, Destaw Worku and G.R. Gowane received Best Poster Presentation Award for the poster "Estimation of co(variance) components for growth traits in Murrah buffaloes" in Technical Session I during National Conference of 'Indian Society for Animal Genetics and Breeding' on "Animal Breeding Strategies in the Era of Genomics and Phenomics" held at ICAR-NBAGR, Karnal during December 17-18, 2021.
- Nidhi Sukhija, Anoop Anand Malik, Kousalya Devi M, Jayakumar Sivalingam and Archana Verma received Best Poster Presentation Award for the poster "Adaptational Consequences of Selective Sweeps in Gir and Tharparkar cattle" in Technical Session II during National Conference of 'Indian Society for Animal Genetics and Breeding' on "Animal Breeding Strategies in the Era of Genomics and Phenomics" held at ICAR-NBAGR, Karnal during December 17-18, 2021.
- Ravi Kumar D, Archana Verma, Nandhini P B, Joel Devadhasan M, I D Gupta, S K Niranjana, R S Kataria M S Tantia and Jayakumar Sivalingam received Best Poster Award on 'Identification of genomic regions associated with reproduction traits in Indian Murrah buffalo using single-step gBLUP' under the Technical Session- Molecular Genetic techniques for Animal Breeding and Improvement in the Virtual International Conference on "Promising Genetic and Genomic Technologies - Frontier in Selection and Animal Improvement" jointly organized by Department of Animal Genetics and Breeding, Veterinary College and Research Institute, Orathanadu and Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Pookode during January 27-28, 2021.
- Pandey, Y., Panda, B.S.K., Somagond, M. and Dang, A.K. received Best Poster Award on the paper entitled, "Isolation, characterization and LC-MS exosomes in dairy cows" in the APA CON-2021, held at DUVASU, Mathura, India.
- Dipti, T.K. Mohanty, M. Bhakat, R. Dewery, M. Sethi and N. Shah received Best Presentation Award (Poster) on "Combination of semen additives improves sperm cryopreservability and *In-vitro* sperm functionality test in Murrah buffalo" in the National Symposium organized by C.V.Sc. (Ludhiana), GADVASU, in National symposium of ISBD on Scientific Interventions to address challenges for sustainable buffalo production on December 10-11, 2021.
- R. K. Dewry, T.K. Mohanty, M. Bhakat, S. Nath, H. P. Yadav, S. Tiwari, N. Shah and M. Sethi received Best Young Scientist in respect of poster presentation of scientific paper entitled "Prediction of bull fertility based on *in-vitro* sperm function tests and seasonal semen quality variables in Sahiwal bulls" in National seminar on innovative biotechnological approaches for enhancing fertility, health and productivity of livestock to boost the farmers economy and VIII annual convention of the society for veterinary science and biotechnology held at ANDUAT, Kumarganj, Ayodhya (UP) during December 17-18, 2021.
- e-Poster entitled 'Lactic acid bacteria isolated from indigenous were conferred Best Poster Award in the Convener Coordinator Organizing Secretary Ref. No. GADVASU/ DM/2021/443 International e-Symposium on Probiotics, Prebiotics and Gut Microbiome : Key Regulators for Human and Animal Health' organized by Department of Dairy Microbiology, College of Dairy Science and Technology, Guru Angad Dev Veterinary and Animal Sciences University on November 11, 2021 under the aegis of Probiotic Association of India.
- Rakesh Chouraddi, Sachin Kumar and Vinay VV et al., received Best Poster Award (First Place) from Probiotic Association of India, 2021.
- K.Ponnusamy was awarded best poster award for the topic Success story of women empowerment through value addition in milk and milk products in Hindi Ullas Mahotsv-2021 at NDRI, Karnal.
- Best Poster Award (2021) by ISSAR to Nilendu Paul, Talluri T R, Raval Kathan, Kamaraj Elango, Verma A., Kumaresan A for the poster on "Nanopurification of bull semen for enrichment of functionally competent spermatozoa".

- Ms. Ankita Kumari was awarded “Young Investigator Poster Presentation Award” for presentation entitled “Probiotic *Lactobacillus fermentum* mediates its immunoregulatory function by targeting epigenomic modulations” in 11th India Probiotic symposium “ Role of Gut Microbiota and Probiotics in reducing viral infections –Mechanisms to combat them” organized by the Gut Microbiota and Probiotic Science Foundation (India) in online mode from March 13-14, 2021.
- Dr. Dhruva Malakar was awarded Best poster award at National Conference on "Animal Breeding Strategies in the Era of Genomics and Phenomics" at NBAGR, Karnal December 17-18, 2021.
- Nidhi Sukhija, Kousalya Devi M, Ravi Kumar D, Anoop Anand Malik, Anjali Choudhary, Aishwarya Dash, Kangabam Bidyalaxmi, Rekha Sharma, I.D. Gupta, Jayakumar Sivalingam and Archana Verma received Second best poster award received for Genome wide identification of selective sweeps and QTL intersection in Gir cattle in the XVIII Annual Convention and National Webinar on Harnessing Potential of Indigenous Animal Genetic Resources for Enhancement of Productivity and Profitability, organized by Society for conservation of Domestic Animal Biodiversity (SOC DAB), Karnal and ICAR-National Bureau of Animal Genetic Resources, Karnal, India, February 11-12, 2021.
- Tamal Sarkar received First position in Poster presentation award at National Conference on *Moringa* Food Conclave-2021 organized by CSA University of Agriculture and Technology, Kanpur during September 28-29, 2021.
- Dr. A. Maniaran Secured second prize in poster presentation for research paper entitled “Salivary biochemical parameters discriminate energy balance based on average blood glucose level in early lactating cows” during third Animal Physiologist Association (APA) conference at DUVASU Mathura during September 24-25, 2021.
- Shivam Bhardwaj, Sanjeev Singh, Indrajit Ganguly, A. K. Bhatia and S.P. Dixit received Second Best Poster Presentation Award for the poster presentation “Deciphering Genomic Basis of Local Adaptation of Native Indian Cattle (*Bos indicus*) Breeds using Landscape Genomics” in Technical Session IV during National Conference of 'Indian Society for Animal Genetics and Breeding' on "Animal Breeding Strategies in the Era of Genomics and Phenomics" held at ICAR-NBAGR, Karnal during December 17-18, 2021.
- Rizwan M, Upma V, Cahndhni PR, Daraksha I and Shilpa Vij received Third prize for poster presentation on topic “Isolation of *Lactobacillus* strain with α -glucosidase inhibitory and DPP-IV inhibitory activities from camel milk” in 27th International Conference of International Academy of physical sciences (CONIAPS XXVII) on “Advances in Food Science and Technology” October 26-28, 2021.

Fellows and Other Individual Awards

- Dr. Dheer Singh, Joint Director (Research) secured NAAS Fellow-2021.
- Dr Anurag Saxena received Fellow Award-2021 conferred by Agricultural and Environmental Technology Development Society (AETDS) during GIAFAS-2021 at Dehradun in recognition of outstanding contribution and recognition in Agronomy.
- Dr Ashish Kumar Singh received Award of Fellow of NAAS, India on January 1, 2021.
- Dr. A. Maniaran was conferred with Associate Fellow of Indian Society of Veterinary Pharmacology and Toxicology (2021).
- Dr. Chitranayak, PS, DE Division received National Academy of Dairy Science (INDIA) NADSI Fellow Award.
- Dr. Nishant Kumar received membership of the National Academy of Veterinary Sciences, India (NAVSI) on September 25, 2021
- Dr. Dhruva Malakar was awarded “Lifetime Achievement Award” in the International Scientist Awards on Engineering, Science and Medicine. ALPHA Scientist Award 2021 Chennai, India.
- Dr. Dhruva Malakar was awarded “Outstanding Achievement Award-2021” from Advances in Agriculture, Environmental and Biosciences for Sustainable Development August 5-7, 2021.

12. PUBLICATIONS

RESEARCH PAPERS

Animal Biotechnology

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Batra, V, Bhushan, V, Ali, SA, Sarwalia P, Pal A, Karanwal S, Solanki S, Kumaresan A, Kumar, Rakesh and Datta, TK (2021). Buffalo sperm surface proteome profiling reveals an intricate relationship between innate immunity and reproduction. <i>BMC Genomics</i> 22, 480, https://doi.org/10.1186/s12864021-07640	3.969	9.59
2.	Behera, M, Ghorai, SM, De, S and Kaur, H (2021). Understanding eco-immunology of bacterial zoonoses and alternative therapeutics toward "One Health". <i>International Journal of One Health</i> . 7(1):104-15.	0.40	-
3.	Beniwal, A, Saini, P, De, S, Vij, S (2021). Harnessing the nutritional potential of concentrated whey for enhanced galactose flux in fermentative yeast. <i>Lebensmittel-Wissenschaft und-Technologie</i> 141:110840.	3.98	10.95
4.	Bhardwaj A, Nayan V, Kumar S, Sharma P, Kumar S, Chakarvarty N, Kumar S, Pal Y, Yadav SC, Mohanty AK and Tripathi BN (2021). Expression analysis of recombinant equine chorionic gonadotropin in three host systems: E. coli BL21C, Sf insect cell lysate and COS-1 mammalian cells. <i>Indian Journal of Animal Research</i> . 55(1):40-45. doi: 10.18805/ijar.B-3917.	-	6.44
5.	Chera, JS, Kumar, S, Vats, A, Kushwah, P, Behera, M and De, S (2021). PU.1 is involved in the transcriptional up-regulation of RNA and DNA sensing pathway genes in buffalo fibroblasts. <i>Veterinary Immunology and Immunopathology</i> 242:110349.	2.04	8.05
6.	Chopra, M, Badhopadyay, S, Singh, RK and De, S (2020). Genome based phylogeny and virulence factor analysis of mastitis causing <i>Escherichia coli</i> isolated from <i>Indian cattle</i> . <i>Indian Journal of Animal Sciences</i> 90 (12): 1577–1583.	0.18	6.32
7.	De, AK, Sawhney, S, Ponraj, P, Bhattacharya, D, Sujatha, T, Sunder, J, Ravi, SK, Kundu, A, Mondal, S and Malakar D (2021). Origin, genetic diversity and evolution of Andaman Local Duck, a native duck germplasm of an insular region of India. <i>Plos One</i> https://doi.org/10.1371/journal.pone.0245138 .	3.24	8.74
8.	De, Arun Kumar, Sawhneya, Sneha, Ponraj, Perumal, Ravi, Sanjay Kumar, Malakar, Dhruba, Alyethodi, RR, Mondal, Samiran, Sunder, Jai, Banik, Santanu, Kundu, Anandamoy and Bhattacharya, Debasis (2021). Maternal lineage of nicobari pig (<i>sus scrofanicobaricus</i>) correlated with migration of nicobarese, a native tribal population of Andaman and Nicobar Islands (India). <i>Animal Biotechnology</i> , https://doi.org/10.1080/10495398.2021.1950742 .	2.282	7.49
9.	Deepika, S, Gautam, D, Meena, S, Ali, M, Meena, AS, Vats, A, Verma, M, Rout, PK and De, S (2021). Heterogeneity and diversified distribution of S2 casein variants in Indian goats. <i>Small Ruminant Research</i> 204 (2021) 106501	1.89	7.61
10.	Dholpuria, S, Kumar S, Kumar, Manish, Sarwalia, Parul, Kumar, Rakesh and Datta, TK (2021). A novel lincRNA identified in buffalo oocytes with protein binding characteristics could hold the key for oocyte competence. <i>Molecular Biology Reports</i> . doi: 10.1007/s11033-021-06388-9.	2.316	7.40
11.	Doreswamy, R, Deb, R and De, S (2021). Potential use of piggery excreta as a viable source of bioethanol production. <i>Journal of Cleaner Production</i> 316:128246.	9.27	15.30
12.	Dua, D, Tripathi, G, Alam, A, Chauhan, Palta, P and Singh, MK (2021). Optimization and comparison of three-dimensional culture conditions in different media of coculture and encapsulation system for in vitro follicular development in <i>Bubalus bubalis</i> . <i>Cellular Reprogramming</i> , 23(1):26-34.	1.98	7.98

13.	Gautam, D, Vats, A, Pal, P, Haldar, A and De, S (2021). Characterization of anti-müllerian hormone (AMH) gene in buffaloes and goats. <i>Frontiers in Veterinary Science</i> :8, 217	3.47	9.41
14.	Ghai, S, Verma, VN Ansari, S, Saini, S, Thakur, A, Kumar, A, Kumar S and Malakar, D (2021). Mesenchymal stem cells as a regenerative therapy for the prevention of subclinical mastitis in cattle. <i>Reproduction, Fertility and Development</i> 34(2):316-17 https://doi.org/10.1071/RDv34n2Ab157 .	2.311	7.72
15.	Jaiswal, Sarika, Jagannadham, Jaisri, Kumari, Juli, Iquebal, Mir Asif, Nayan, Varij, Angadi, Ulavappa B, Kumar, Sunil, Kumar, Rakesh, Datta, Tirtha Kumar, Rai, Anil and Kumar, Dinesh (2021). Genome wide prediction, mapping and development of genomic resources of mastitis associated genes in water buffalo. <i>Frontiers in Veterinary Science</i> . doi.org/10.3389/fvets.2021.593871 .	3.12	8.25
16.	Jaswal, S, Anand, V, Ali, SA, Jena, MK, Kumar, S, Kaushik, JK and Mohanty, AK (2021). TMT based deep proteome analysis of buffalo mammary epithelial cells and identification of novel protein signatures during lactogenic differentiation. <i>The FASEB Journal</i> 35 (6):e21621. https://doi.org/10.1096/fj.202002476RR .	5.90	11.19
17.	Joshi, H, Mathur, M, Mohanty, AK, Kumar, S, Kaushik, JK, Mohanty, TK and Kumar, D et al (2021). Semen Sexing in Bovine: Current Status and the Need to Develop Alternative Techniques. <i>Animal Reproduction Update</i> 1, No. 1:17-31.	-	-
18.	Kumar, R, Ali, SA, Singh, SK, Bhushan, V, Kaushik, JK, Mohanty, AK and Kumar, S (2021). Peptide profiling in cow urine reveals molecular signature of physiology-driven pathways and in-silico predicted bioactive properties. <i>Scientific Reports</i> 11, No. 1:1-16.	4.99	10.38
19.	Kumar, S and Chauhan, MS (2021). Relative abundance of pluripotency-associated candidate genes in immature oocytes and in vitro produced buffalo embryos (<i>Bubalus bubalis</i>). <i>Zygote</i> . Apr 5:1-9.	1.442	7.26
20.	Kumar, S, Singh, MK and Chauhan, MS (2021). Expression of the developmental important candidate genes in oocytes, embryos, embryonic stem cells, cumulus cells and fibroblast cells of buffalo (<i>Bubalus bubalis</i>). <i>Gene Expression patterns</i> . 41:119200.	1.224	6.90
21.	Maharana, J, Maharan, D, Bej, A, Sahoo, BR, Panda, D, Wadavrao, SB, Vats and De, S et al (2021). Structural Elucidation of Inter-CARD Interfaces involved in NOD2 Tandem CARD Association and RIP2 Recognition. <i>Journal of Physical Chemistry</i> 125:49: 13349-365.	3.2	8.99
22.	Mehra, Vinay Kumar and Kumar, Satish (2021). The Application of CRISPR/Cas9 Technology for Farm Animals: A Review. <i>Agricultural Review</i> . R2163, pp.1-8.	-	4.63
23.	Ponraj, P, De, AK, Mondal, S, Ravi, SK, Sawhney, S, Sarkar, G, Bera, AK, Malakar, D, Kumar, A, Singh LB, Ahmed, SKZ, Mu-niswamy, K, Jerard, BA and Bhattacharya, D (2021). Tri-model therapy: combining macrocyclic lactone, piperazine derivative and herbal preparation in treating humpsores in cattle. <i>Veterinary Science</i> , 13:8(2):27.	2.314	8.31
24.	Roshan, M, Dua, D, Sharma, A, Tiwari, M, Singh, MK, Singla, SK, Palta, P, Manik, RS, Chauhan, MS (2021). Supplementation of L-ascorbic acid improves the in vitro development of buffalo (<i>Bubalus bubalis</i>) embryos and alters the expression of apoptosis-related genes. <i>Asian Pacific Journal of Reproduction</i> , 10(1):36-42.	-	-
25.	Roshan, M, Parmanand, Arora, D, Behera, M, Vats, A, Gautam, D, Deb, R, Parkunan, T, De, S (2021). Virulence and enterotoxin gene profile of Methicillin-resistant <i>Staphylococcus aureus</i> isolates from Bovine Mastitis. <i>Comparative Immunology, Microbiology and Infectious Diseases</i> 80:101724.	2.72	8.27
26.	Sarwalia, Parul, Raza, Mustafa, Soni, Apoorva, Dubey, Pratiksha, Chandel, Rajeev, Kumar, Rakesh, Kumaresan, A, Onteru, Suneel Kumar, Pal, Ankit, Singh, Kalpana, Iquebal, Mir Asif, Jaiswal, Sarika, Kumar, Dinesh and Datta, TK (2021). Establishment of repertoire of placentome associated microRNA and their appearance in blood plasma could identify the early establishment of pregnancy in buffalo (<i>Bubalus bubalis</i>). <i>Frontiers in Cell and Developmental Biology</i> . doi:10.3389/fcell.2021.673765 .	6.684	11.20
27.	Sharma, AK, Sah, S, Singla, SK, Chauhan, MS, Manik, RS and Palta, P (2021). Exposure to pulsed electromagnetic fields improves the developmental competence and quality of somatic cell nuclear transfer buffalo (<i>Bubalus bubalis</i>) embryos produced using fibroblast cells and alters their epigenetic status and gene expression. <i>Cellular Reprogramming</i> , 25(5):304-15.	1.98	7.98

28.	Shivani, Malpotra, MK Singh and Palta, P (2021). MeDIPsequencing for profiling global DNA methylation in buffalo embryos produced by <i>in vitro</i> fertilization. <i>Animal Biotechnology</i> , doi: 10.1080/10495398.2021.1981356.	2.28	8.28
29.	Singh, KP, Mohapatra, SK, Kaushik, R, Singh, MK, Palta, P, Singla, SK, Manik, RS and Chauhan, MS (2021). Parthenogenetic activation of buffalo (<i>Bubalus bubalis</i>) oocytes: comparison of different activation reagents and different media on their developmental competence and quantitative expression of developmentally regulated genes. <i>Zygote</i> , 29(1):49-58.	1.44	7.44
30.	Singh, R, Bhaskar, V, Saini, S, Kumar, A, Thakur, A, Kumar, S and Malakar, D (2021). Therapeutic efficacy and safety of adipose tissue-derived mesenchymal stem cells in treating mastitis and metritis in dairy cattle. <i>Reproduction, Fertility and Development</i> 33(2):179-179 https://doi.org/10.1071/RDv33n2Ab143 .	2.311	7.72
31.	Vats, P, Kaushik, R, Rawat, N, Sharma, A, Sharma, T, Dua, D, M.K. Singh, MK, Palta, P, Singla, SK, Manik, RS, Chauhan, MS (2021). Production of transgenic handmade cloned goat (<i>Capra hircus</i>) embryos by targeted integration into Rosa 26 locus using transcription activator-like effector nucleases. <i>Cellular Reprogramming</i> , 23(4):250-62.	1.98	7.98
32.	Verma, AK, Ali, SA, Singh, P, Kumar, S and Mohanty, AK (2021). Transcriptional Repression of MFG-E8 Causes Disturbance in the Homeostasis of Cell Cycle Through DOCK/ZP4/STAT Signaling in Buffalo Mammary Epithelial Cells. <i>Frontiers in Cell and Developmental Biology</i> , 9, 568660. https://doi.org/10.3389/fcell.2021.568660 .	6.08	12.68
33.	Verma, VN, Ghai, S, Ansari, S, Saini, S, Thakur, A, Kumar, A, Kumar S and Malakar D (2021). Umbilical cord blood-derived mesenchymal stem cells (UCB-MSC) used for the prevention of metritis in cattle. <i>Reproduction, Fertility and Development</i> 34(2) 317-17 https://doi.org/10.1071/RDv34n2Ab158 .	2.311	7.72

Animal Genetics and Breeding

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Alyethodi, RR, Singh, U, Kumar, S, Alex, R, Sengar, GS, Raja, TV, Deb, R and Prakash, B (2021). Designing, optimization and validation of whole blood direct T-ARMS PCR for precise and rapid genotyping of complex vertebral malformation in cattle. <i>BMC Biotechnol.</i> 21(1):36.	2.409	8.56
2.	Dar, MR, Singh, M, Thakur, S and Verma, A (2021). Exploring the relationship between polymorphisms of leptin and IGF-1 genes with milk yield in indicine and taurine crossbred cows. <i>Trop. Animal Health Production</i> 53, 413. https://doi.org/10.1007/s11250-021-02866-1 .	1.559	7.56
3.	Dige, MS, Rout, PK, Singh, MK, Bhusan, Saket, Kaushik, Rakesh, Mahala, Sudarshan and Gowane, GR (2021). Use of Random regression model for modeling growth trajectory in Jamunapari goat in the semi-arid region of India. <i>Livestock Science</i> . 253; 104713, ISSN 1871-1413, https://doi.org/10.1016/j.livsci.2021.104713 .	1.943	7.94
4.	Dige, MS, Rout, PK, Singh, MK, Dass, G, Kaushik, R & Gowane, GR (2021). Estimation of co (variance) components and genetic parameters for growth and feed efficiency traits in Jamunapari goat. <i>Small Ruminant Research</i> 196 106317. https://doi.org/10.1016/j.smallrumres.2021.106317	1.61	7.61
5.	Gowane, GR, Sharma, LM, Misra, SS, Mallick, PK, Kumar, A (2021). Farmer's participatory approach for breed improvement in Malpura sheep. <i>Journal of Animal Breeding and Genetics</i> . 138:403-417. https://doi.org/10.1111/jbg.12519	2.38	8.38
6.	Illa, Satish Kumar, Mukherjee, Sabyasachi, Nath, Sapna, and Mukherjee, Anupama (2021). Insights into the putative genomic regions controlling milk composition traits and coat colour in Sahiwal cattle under selection: De-correlated composite of selection signals approach. <i>Frontiers in Genetics</i> . 12:699422. doi: 10.3389/fgene.2021.699422.	4.599	10.60
7.	Kour, Aneet, Deb, Sitangshu Mohan, Nayee, Nilesh, Niranjana, Saket Kumar, Raina, Varinder Singh, Mukherjee, Anupama, Gupta, Ishwar Dayal and Patil, Chandrashekhara Santosh (2021). Novel insights into genome-wide associations in <i>Bos indicus</i> reveal genetic linkages between fertility and growth. <i>Animal Biotechnology</i> . 1-17 https://doi.org/10.1080/10495398.2021.1932520	2.282	8.28
8.	Krishnaswamy, N, Jeyakumar, S, Tamil Selvan, Gowane, GR, Mahadappa, P, Vijayapillai, U, Dechamma, HJ, Patel, BHM, Saravanan, P, Ramesha, KP and Sanyal, A (2021). Short-term effect of foot-and-mouth disease (FMD) vaccination on the milk yield in the Deoni and crossbred cows. <i>Tropical Animal Health and Production</i> 53:217. https://doi.org/10.1007/s11250-021-02653 .	1.559	7.56
9.	Kumar, A, Mallick, PK, Misra, SS, Sharma, RC and Gowane, GR (2021). The Morphometric Scale to Predict the Live Weight of Malpura Sheep in Semi-arid Region of Rajasthan. <i>Indian Journal of Animal Research</i> . 10.18805/IJAR.B-4147	0.44	6.44

10.	Kumar, A, Misra, SS, Chopra, A, Narula, HK Sharma, RC and Gowane, GR (2021). Sheep breeding in north-western arid and semi-arid regions of India: an overview. <i>Indian Journal of Small Ruminants</i> 27(1):1-10. doi: 10.5958/0973-9718.2021.00013.1	0.081	5.95
11.	Kumar, A, Misra, SS, Sharma, RC and Gowane, GR (2021). Genetic parameters for sex ratio in an organised sheep farm. <i>Indian Journal of Small Ruminants</i> 27(1):31-36. doi: 10.5958/0973-9718.2021.00014.3	0.081	5.95
12.	Kumar, Rakesh, Gupta, Ishwar Dayal, Verma, Archana, Singh, Sohanvir, Kumari, Ragini and Verma, Nishant (2021). Genetic polymorphism in HSPB6 gene and their association with heat tolerance traits in Indian Karan Fries (<i>Bos taurus x Bos indicus</i>) cattle. <i>Animal Biotechnology</i> , https://doi.org/10.1080/10495398.2021.1899939 .	2.282	8.28
13.	Pandian, SJ, Kumar, J, Sonawane, GG, Gowane, GR, Swarnkar, CP and Sharma, SR (2021). Soil-borne speticacemic Colibacillosis in Neonatal lambs: Salient observations. <i>Indian Journal of Animal Research</i> . doi: 10.19905/IHAR.B-4327.s	0.44	6.44
14.	Singh, R, Deb, R, Sengar, GS, Raja, TV, Kumar, S, Singh, U, Das, AK, Alex, R, Kumar, A, Tyagi, S, Pal, P, Patil, NV (2021). Differentially expressed microRNAs in biochemically characterized FrieswalTM crossbred bull semen. <i>Animal Biotechnol.</i> 9:1-14.	2.282	8.28
15.	Sinha, R, Sinha, B, Kumari, R, Vineeth, MR, Sharma, N, Verma, A and Gupta, ID (2021). Effect of nongenetic factors on udder and teat morphometric traits in Sahiwal and Karan Fries cows. <i>Indian Journal of Animal Research</i> . doi:10.18805/IJAR.B-4444.	0.44	6.44
16.	Vohra V, Singh NP, Chhotaray S, Raina VS, Chopra A, Kataria RS (2021). Morphometric and microsatellite-based comparative genetic diversity analysis in Bubalus bubalis from North India. <i>Peer Journal</i> 9:e11846. https://doi.org/10.7717/peerj.11846 .	2.984	8.98
17.	Vohra, V, Chhotaray, S, Gowane, G, Alex, R, Mukherjee, A, Verma, A and Deb, SM (2021). Genome-Wide Association Studies in Indian Buffalo Revealed Genomic Regions for Lactation and Fertility. <i>Frontiers in Genetics</i> , 12, 696109. https://doi.org/10.3389/fgene.2021.696109 .	4.599	10.60
18.	Worku, Destaw, Gowane, GR, Kumar, Ravi, Joshi, Pooja, Gupta, ID and Verma, Archana (2021). Estimation of genetic parameters for production and reproductive traits in Indian Karan-Fries cattle using multi-trait Bayesian approach. <i>Tropical Animal Health and Production</i> 53, Article number: 369. https://doi.org/10.1007/s11250-021-02806-z .	1.559	7.56

Animal Physiology

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Alhussien, MN, Tiwari, S, Panda, BSK, Pandey, Y, Lathwal, SS and Dang, AK (2021). Supplementation of antioxidant micronutrients reduces stress and improves immune function/ response in periparturient dairy cows and their calves. <i>Journal of Trace Elements in Medicine and Biology</i> , 65: 126718.	3.755	-
2.	Devi, P, Singh, M, Somagond, YM and Aggarwal, A (2021). Alleviation of heat stress by <i>Chlorophytum borivilianum</i> : impact on stress markers, antioxidant and immune status in crossbred cows. <i>Tropical animal health and production</i> , 53(3):1-10.	1.55	7.56
3.	Kumar, M, Aggarwal, A and Kaul, G (2021). Novel and known miRNAs in zebu (Tharparkar) and crossbred (Karan-Fries) cattle under heat stress. <i>Functional & Integrative Genomics</i> , 21(3):405-19.	3.058	9.41
4.	Kumar, P and Singh, S (2021). Growth rate, feed intake, physiological responses and hormonal profile of Murrah buffaloes implanted melatonin during summer season. <i>The Indian Journal of Animal Sciences</i> , 91(5):386-90.	0.32	6.32
5.	Lakhani, N, Tyagi, N, Agarwal, A, Kumar, S and Tyagi, A (2021). Optimizing fiber and protein levels in diet of lactating Murrah buffaloes to ameliorate heat stress: Effect on physiological status and production performance. <i>Journal of Thermal Biology</i> , 96, 102838.	2.80	8.90
6.	Pandey, Y, Panda, BSK, Bhatt, N, Tiwari, S, Somagond, YM and Dang, AK (2021). A study of changes in colostrum and transition milk immune cells along with growth factors in dairy cows. <i>The Pharma Innovation Journal</i> ; SP-10(10):336-41.	-	5.0
7.	Singh, SV, Somagond, YM and Deshpande, A (2021). Nutritional management of dairy animals for sustained production under heat stress scenario. <i>The Indian Journal of Animal Sciences</i> , 91(5):337-49.	0.32	6.32

8.	Somagond, YM, Singh, SV, Deshpande, A, Sheoran, P, Chahal, VP (2021). Infrared thermography to assess thermoregulatory reactions of buffaloes supplemented with antioxidant and dense energy source in summer season. <i>Journal of Agrometeorology</i> , 23(3):243-48.	0.577	6.55
9.	Somagond, YM, Singh, SV, Deshpande, A, Sheoran, P and Chahal, VP (2021). Effect of dietary supplementation of astaxanthin, prill fat and their combination on antioxidants and immunity status of lactating buffaloes during heat stress. <i>Buffalo Bulletin</i> 40(3):451-63.	0.18	6.17
10.	Tiwari, S, Lathwal, SS, Pandey, Y, Burman, D, Praveen, S, Jamwal, S, Somagond, YM and Dang, AK (2021). Changes in the Composition of Colostrums, Transition Milk and Milk of Crossbred Cows due to Transition Period Supplementation of Vitamin A, E and Zinc. <i>Journal of Animal Research</i> 11(6):1-10.	-	6.44

Livestock Production and Management

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Abdullah, M, Mohanty, TK, Bhakat, M, Yadav, SK, Kumaresan, A and Gupta, AK (2021). Thermal imaging to measure scrotal surface temperature and its use as a tool for breeding soundness evaluation of Zebu bulls. <i>The Indian Journal of Animal Sciences</i> 91 (11):906-9.	0.316	6.32
2.	Abdullah, M, Mohanty, TK, Bhakat, MA, Kumaresan, A, Singh, A Mondal, S and Kerketta, S (2021). Testicular biometry for breeding soundness evaluation of sahiwal males reared under tropical conditions. <i>Indian Journal of Animal Research</i> 55(7):796-800.	0.44	6.44
3.	Bipate, M and Misra, AK (2021). Effect of polyherbal supplementation on milk production and postpartum reproduction in Murrah buffaloes fed forage based rations. <i>Range Management and Agroforestry</i> 42(2):357-361.	0.37	6.37
4.	Bishist, R, Raina, VS, Bhakat, M, Lone, SA, Mohanty, TK, Sinha, R and Kumar, R (2021). Effect of cholesterol loaded cyclodextrin on cryosurvivability of buffalo spermatozoa, <i>Buff. Bulletin</i> 40(1):115-21.	0.172	6.17
5.	Choudhary, S, Kamboj, ML, Sahu, D, Dutt, S, Singh, P, Kumar, N, Ungerfeld, R and Parsad, CK (2021). Biostimulation, growth rate and reproductive development of Bos indicus dairy heifers. <i>Tropical Animal Health and Production</i> , 54:138.	1.93	7.56
6.	Fahim, A, Kamboj, ML, Bhakat, M, Mohanty, TK, Sirohi, AS and Prasad, S (2021). Effect of parlour relocation on behaviour and post-adaptation milkability of lactating dairy cows. <i>Indian Journal Dairy Science</i> , 74(6):509-15.	-	5.95
7.	Joshi, H, Mathur, M, Mohanty, AK, Kumar, S, Kaushik, JK, Mohanty, TK (2021). Semen sexing in bovine: current status and the need to develop alternative techniques. <i>Animal Reproduction Update</i> 1(1):17-31.	-	-
8.	Kantwa, SC and Mohanty, TK (2021). Socio personal and economic profile of the migratory sheep farmer in arid region of Rajasthan. <i>The Pharma Innovation Journal</i> ; SP-10(5):673-76.	-	5.23
9.	Kerketta, S, Mohanty, TK, Kumaresan, A, Bhakat, M, Gupta, R, Malhotra, R, Baithalu, R, Mohanty, AK, Singh, SRK and Rahim, A (2021). Moosense pedometer for oestrus detection and ovulation time prediction for artificial insemination in karan fries cows. <i>Indian Journal of Animal Research</i> . doi:10.18805/IJAR.B-4248.	0.44	6.44
10.	Kumar, V, Meena, HR, Kadian, KS, Sankhala, G, Mohanty, TK and Lathwal, SS (2021). Performance, proficiency and training need of para-vets in the four states of India. <i>Indian Journal of Animal Sciences</i> 91(12):1089-102.	0.316	6.32
11.	Kumar, V, Meena, HR, Kadian, KS, Sankhala, G, Mohanty, TK and Lathwal, SS (2021). Comparative analysis of minor-veterinary services rendered by paraveterinarians in four different states of India: Stakeholders' perspective. <i>Society for Community Mobilization for Sustainable Development</i> 16(2):529-39.	-	-
12.	Lone, SA, Mohanty, TK, Bhakat, M, Yadav, HP, Paray, AR and Dewry, RK (2021). Cholesterol-loaded cyclodextrin attenuates dilution effect and improves quality of bovine low sperm insemination doses during cryopreservation. <i>Andrologia</i> 53(10):e14202	2.775	8.78
13.	Mondal, G, Talukdar, P, Das, TK, Bhakat, M and Mohini, M (2021). Influence of metabolizable energy and protein levels on age and weight at puberty in male buffalo. <i>Indian Journal of Animal Sciences</i> 91(6):487-91.	0.316	6.32

14.	Rajneesh, Misra, AK, Sharma, Rajan & Chauhan, Prince (2021). Effect of bypass fatty acid and <i>Tinospora cordifolia</i> supplementation on production performance and milk fatty acid profiling in Murrah buffaloes (<i>Bubalus bubalis</i>). <i>Tropical Animal Health and Production</i> 53(3):383 PMID:34195883	1.93	7.56
15.	Rajpoot, V, Singh, P and Prasad, K (2021). Feeding and Breeding Management Practices of Dairy Animals in Muzaffarnagar District of Uttar Pradesh. <i>Ind J Vet Sci and Biotech</i> :10.21887/ijvsbt.17.2.12.	-	5.58
16.	Sethi, M, Shah, N, Mohanty, TK, Bhakat, M, Dewry, RK, Yadav, DK, Gupta, VK and Nath, S (2021). The induction of cyclicity in postpartum anestrous buffaloes: A review. <i>J. Exp. Zool. India</i> 24, 000-000. DocID:https://connectjournals.com/03895.2021.24.000.	-	5.25
17.	Singh, A, Meena, BS and Bhakat, M (2021). Prevalent ethno-veterinary practices for management of transition period among dairy farmers of Uttar Pradesh. <i>Ruminant Science</i> , 10(1)	-	5.47
18.	Singh, A, Meena, BS and Bhakat, M (2021). Validating e-learning information module on transition period of dairy animals for enhancing knowledge of dairy farmers. <i>Haryana Vet.</i> 60(2):271-74.	-	5.58
19.	Singh, Ajmer, Chandel, BS, Chauhan, AK, Kamboj, ML and Singh, Shweta (2021). Sustainability of gaushala: Do size and patronage matter? <i>Agricultural Economics Research Review</i> , 34 (1):79-90.	-	5.84
20.	Singh, Ajmer, Chandel, BS, Chauhan, AK, Kamboj, ML and Singh, Shweta (2021). A study on cow welfare vis-a-vis sustainability of Gaushalas (cow orphanages). <i>Indian J. of Dairy Science</i> , 75 (2):1-7.	-	5.95
21.	Sinha, R, Bhakat, M, Mohanty, TK, Kumar, R, Ranjan, A, Rahim, A Lone, SA, Shah, N, Paray, AR, Patil, CS and Singh, A (2021). Seasonal variation of sperm kinematics in Murrah bulls under the tropical climatic condition. <i>Buffalo Bulletin</i> 40 (1):87-98	0.172	6.17
22.	Tiwari, S, Mohanty, TK, Bhakat, M, Kumar, N, Baithalu, RK and Nath, S (2021). Comparative evidence support better antioxidant efficacy of mitochondrial-targeted (Mitoquinone) than cytosolic (Resveratrol) antioxidant in improving in-vitro sperm functions. <i>Cryobiology</i> 101, 125-34.	2.487	8.49
23.	Vikram, R, Dewry, RK, Mohanty, TK, Yadav, HP, Nath, S, Bhakat, M and Devi, I (2021). Digital analysis of testicular ultrasound image can classify buffalo bulls with high sperm production capacity. <i>Buffalo Bulletin</i> 40 (1):107-14.	0.172	6.17

Animal Nutrition

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Banakar, PS, Kumar, S, Vinay, VV, Dixit, S, Tyagi, N and Tyagi, AK (2021). Supplementation of Aloe vera extract in lactating goats' diet: effects on rumen fermentation efficiency, nutrient utilization, lactation performance and antioxidant status. <i>Tropical Animal Health and Production</i> , 53(5):1-10.	-	7.56
2.	Bhatt, N, Tyagi, N, Chandra, R, Meena, DC and Prasad, CK (2021). Growth Performance and Nutrient Digestibility of <i>Azolla pinnata</i> Feeding in Sahiwal Calves (<i>Bos indicus</i>) by Replacing Protein Content of Concentrate with <i>Azolla pinnata</i> during Winter Season. <i>Indian Journal of Animal Research</i> , 1, 6.	-	6.44
3.	Chauhan, N, Singh, D, Kumari, N and Tyagi, N (2021). Impact of lactic acid bacteria and enzymes on the fermentation processes of sugarcane tops silage at a particular time interval. <i>The Pharma Innovation</i> , 10(2):332-36.	-	5.23
4.	Khanday, ZB, Malik, R, Chauhan, P and Naliyapara, HB (2021). Effect of different additives on bale silage quality of maize fodder. <i>Indian Journal of Animal Nutrition</i> , 38(2):167-72.	-	-
5.	Khanday, ZB, Malik, R, Naliyapara, HB, Pradhan, D, Chauhan, P and Kedare, GM (2021). Effect of Paddy Straw Incorporation on Bale Silage Quality of Maize Fodder. <i>Indian J. Anim. Nutr.</i> , 38(1):48-54.	-	-
6.	Lakhani, N, Tyagi, N, Agarwal, A, Kumar, S and Tyagi, A (2021). Optimizing fiber and protein levels in diet of lactating Murrah buffaloes to ameliorate heat stress: Effect on physiological status and production performance. <i>Journal of Thermal Biology</i> , 96, 102838.	-	8.90
7.	Lakhani, Neeti and Tyagi, Nitin (2021). Comparative evaluation of in vitro techniques for predicting metabolizable energy content of total mixed ration for Murrah buffaloes. <i>The Indian Journal of Animal Sciences</i> . Vol. 91 Issue 3 220-24.	-	6.32

8.	Manisha, RK, Ram, H, Tyagi, N, Meena, RK, Kumar, D, Kumar, R and Singh, K (2021). Effect of zinc fertilization on nutritional quality of cowpea cultivars. <i>Legume Research-An International J.</i> , 1, 7.	-	6.59
9.	Mondal, G, Talukdar, P, Das, TK, Bhakat, M and Mohini, M (2021). Influence of metabolizable energy and protein levels on age and weight at puberty in male buffalo. <i>The Indian Journal of Animal Sciences</i> . 91 (6), 487-491.	-	6.316
10.	Sharma, Vijay, Kundu, Shivalal, Datt, Chander, Magotra, Ankit and Prusty, Sonali (2021). Effect of gene callipyge and non-genetic factors on growth traits in murrah calves. <i>Gene Reports</i> . https://doi.org/10.1016/j.genrep.2021.101292 .	-	-
11.	Singh, A, Kumar, S, Vinay, VV, Tyagi, B, Choudhury, PK, Rashmi, HM and Tyagi, AK (2021). Autochthonous <i>Lactobacillus</i> spp. isolated from Murrah buffalo calves show potential application as probiotic. <i>Current Research in Biotechnology</i> , 3, 109-19.	-	8.46
12.	Singh, A, Kumar, S, Vinay, VV, Tyagi, B, Choudhury, PK, Rashmi, HM, Banakar, PS, Tyagi, N and Tyagi, AK (2021). Autochthonous <i>Lactobacillus</i> spp. isolated from Murrah buffalo calves show potential application as probiotic. <i>Current Res. in Biotechnology</i> , 3, pp.109-19.	-	-
13.	Singh, D, Tyagi, N, Yadav, S, Sharma, B and Chauhan, N (2021). Growth performance, nitrogen balance and blood biochemical parameters on feeding TMR diet containing sugarcane tops silage supplemented with lactic acid bacteria inoculants and exogenous fibrolytic enzymes in crossbred calves. <i>Indian J. of Animal Res.</i> (1):8.	-	6.44
14.	Singh, M, Kumar, S, Banakar, PS, Vinay, VV, Das, A, Tyagi, N and Tyagi, AK (2021). Synbiotic formulation of <i>Cichorium intybus</i> root powder with <i>Lactobacillus acidophilus</i> NCDC15 and <i>Lactobacillus reuteri</i> BFE7 improves growth performance in Murrah buffalo calves via altering selective gut health indices. <i>Tropical Animal Health and Production</i> , 53(2):1-9.	-	7.56
15.	Srivastava, A, Kumar, S, Tyagi, A, Shrivastava, N, Varma, A and Tyagi, AK (2021). <i>Butyrivibrio fibrisolvens</i> F7 dietary supplementation increases levels of cis 9-trans 11 conjugated linoleic acid in the gut and adipose tissue in mice. <i>Current Research in Biotechnology</i> , 3:300-7.	-	-
16.	Srividhya, S, Malik, R, Naliyapara, HB and Dey, D (2021). Effect of plane of nutrition on nutrient utilization in pre-partum murrah buffaloes and birth weight of their calves. <i>Indian J. Anim. Nutr.</i> , 38(3):260-65.	-	-
17.	Thakur, S, Mohini, Madhu, Malik, TA, Howal, S, Varun, TK, A, Madavi, Yadev, RD, Mondal, G and Datt, Chander (2021). Performance of crossbred goat kids fed with diets varying in concentrate-to-forage ratio: intake, nutrient utilization, enteric methane emission and body weight changes. <i>Biological Rhythm Research</i> . https://doi.org/10.1080/09291016.2019.1627644 . 52:1334-41.	-	7.22

Forage Research and Management Center

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Baljeet, Meena, BL, Singh, M, Kumar, S, Bhattcharjee, S and Onte, S (2020). Effect of potassium and foliar spray of zinc on yield, nutrient biofortification and economics of fodder maize (<i>Zeamays L.</i>) <i>Annals of Agricultural Research</i> 42(4):382-90.	-	4.78
2.	Bhakar, A, Singh, M, Kumar, S, Meena, RK, Meena, BL, Kumar, R and Meena, VK (2021). Growth, productivity and profitability of fodder sorghum and cluster bean as influenced by mixed cropping and nutrient management. <i>Legume Research-An International Journal</i> , 44(11):1308-314.	0.59	6.59
3.	Dutta, S, Singh, M, Meena, RK, Onte, S, Basak, N, Kumar, S and Meena, VK (2021). Effect of organic and inorganic nutrient sources on growth, yield, nutrient uptake and economics of fodder cowpea [<i>Vigna unguiculata</i> (L.) Walp.]. <i>Legume Research-An International Journal</i> 44(9):1046-52.	0.59	6.59
4.	Ginwal, DS, Kumar, R, Ram, H, Meena, RK, Yadav, MR, Makarana, G, Chauhan, A, Manjunath, SK and Kumar, U (2021). Evaluation of productivity and quality of forage sorghum and legumes crops under varying intercropping combinations. <i>The Indian Journal of Animal Sciences</i> , 91(9):754-59.	0.32	6.32
5.	Khapte, PS, Meena, HM, Kumar, Pradeep, Burman, Uday, Saxena, Anurag and Kumar, Praveen (2021). Influence of different protected cultivation structures on performance of cucumber (<i>Cucumis sativus</i> L.) in Indian hot arid region. <i>J. of Agrometeorology</i> 23(3):265-71.	0.50	6.50

6.	Kumar, D, Ardeshta, RB, Singh, M, Makarana, G, Meena, RK, Kumar, S, Kumar, R & Prajapat, B (2021). Sustainable Production of Sesamum through Legume Intercropping: A Review. <i>Indian Journal of Ecology</i> , 48(5):1403-13.	0.50	6.50
7.	Kumar, D, Meena, RK, Kumar, R, Ram, H Kumar, R and Koli, GK (2021). Fodder Beet: a boon to improve livestock productivity through quality forage production in arid and semiarid regions of India-A Review, <i>Forage Research</i> , 47 (3):257-63.	-	5.79
8.	Kumar, D, Singh, M, Kumar, S, Meena RK, Yadav, MR, Makarana G, Kushwaha, M, Dutta S and Kumar R (2021). Enhancement in productivity and quality of fodder maize cultivars through integrated nutrient management strategies. <i>Indian J. Agril. Sciences</i> 92(1):126-130.	-	4.84
9.	Kumar, D, Singh, M, Kumar, S, Meena, RK and Kumar, R (2021). Fodder quality and nitrate estimation of oats grown under different nutrient management options. <i>Indian J. of Dairy Science</i> 74(4) 331-37.	0.21	6.21
10.	Kumar, Dinesh, Ardeshta, RB, Singh, Magan, Makrana, Govind, Meena, RK, Kumar, Sanjeen, Kumar Rakesh and Prajapat, BS (2021). Sustainable production of sesamum through legume intercropping: A Review. <i>Indian Journal of ecology</i> 48(5):1403-413.	-	5.95
11.	Kumar, Dinesh, Singh, Magan, Kumar, Sanjeev, Meena, RK, Yadav, Malu Ram, Makarana, Govind, Kushwaha, Manish, Dutta, Susanta, Kumar, Rakesh & Rajesh (2021). Productivity and quality enhancement in fodder maize (Zea mays) cultivars through nutrient management strategies. <i>Indian Journal of Agricultural Sciences</i> 92 (1):126-30.	-	5.79
12.	Kumar, S, Dhar, S, Barthakur, S, Rajawat, MVS, Kochewad, SA, Kumar, S, Kumar, D and Meena, LR (2021). Farmyard manure as K-fertilizer modulates soil biological activities and yield of wheat using the integrated fertilization approach. <i>Frontiers in Environmental Sciences</i> 9:764489. doi:10.3389/fenvs.2021.764489	0.21	6.21
13.	Kumar, Y, Kumar, R, Leharwan, M and Bhardwaj, M (2021). A Review on fog and smog: impact, mode of action and remedial measures under COVID-19 pandemics. <i>Bhartiya Krishi Anusandhan Patrika</i> , 36(1):1-6.	-	-
14.	Manisha, Kumar, R, Ram, H, Meena, RK, Kumar, D, Kumar, R and Singh, K (2021). Productivity and profitability of fodder cowpea cultivars under various zinc management practices in IGP of India. <i>Legume Research-An International Journal</i> , 44(10):1211-218.	-	3.07
15.	Manisha, RK, Ram, H, Tyagi, N, Meena, RK, Kumar, D, Kumar, R and Sing, K (2021). Effect of zinc fertilization on nutritional quality of cowpea cultivars. <i>Legume Research</i> , 44 (12):1-7.	0.59	6.59
16.	Pooniya, V, Zhiipao, RR, Biswakarma, N, Jat, SL, Kumar, D, Parihar, CM, Swarnalakshmi, K, Lama, A, Verma, AK, Roy, D, Das, K Majumdar, Satyanarayana, T, Jat, RD, Ghasal, PC, Ram, H, Jat, R and Nath, A (2021). Long-term conservation agriculture and best nutrient management improves productivity and profitability coupled with soil properties of a maize-chickpea rotation. <i>Nature: Scientific Reports</i> 11(1):1-13. doi: 10.1038/s41598-021-89737-9.	4.38	10.38
17.	Raghuvanshi, MS, Saxena, Anurag, Stanzin Landol, Jigmat Stanzin, Pandey, Latika and Raza, Mohd (2021). Alleopathic potential and medicinal uses of agropyron repens in cold arid Ladakh. <i>Food and Scientific Reports</i> 2(6):31-33.	-	-
18.	Rajesh, Kumar, R, Kumar, Manoj, Meena, Ravi Kumar, Singh, Kuldeep, Kumar, Vijendra and Kumar, Dinesh (2021). Soil microbial and enzymatic responses as influenced by various sources through Nano nitrogen in fodder oats. <i>Frontiers in Crop Improvement</i> , 9:3668-672.	-	4.67
19.	Rundan, V, Singh, M, Kumar, S, Meena, BL, Dutta, S and Parveen BR (2021). Assessment of nutrient management practices on productivity and profitability of fodder maize+ricebean intercropping under irrigated condition. <i>Indian Journal of Ecology</i> 48(5):1397-402.	-	5.85
20.	Saxena, Anurag, Raghuvanshi, MS and Truptimayee Suna (2021). Traditional water management of subsistence agriculture system in cold arid Ladakh: A Review. <i>International Journal of Scientific and Engineering Research</i> 12 (4):1019-28.	-	-
21.	Singh, K, Ram, H, Kumar, R, Meena, RK and Kumar, R (2021). Fodder quality and yields of mung bean as influenced by different weed management practices. <i>Indian Journal of Anim. Nutrition</i> , 38(3):233-39.	0.37	6.37

22.	Singh, M, Ram, H, Meena, RK, Kumar, U, Meena, VK, Onte, S, Kumar, S and Dutta, S (2021). Effect of seed rates of berseem and ryegrass on yield and quality of fodder in mixed cropping. <i>Range Management and Agroforestry</i> , 42 (1):125-30.	-	5.66
23.	Soni, ML, Birbal, Saxena, Anurag, Nangia, Vinay, Yadava, ND (2021). Intercropping with vegetables on productivity and economic returns of Kinnow in arid region. <i>Indian J. of Horticulture</i> 78(2):211-15.	0.50	6.50

Animal Biochemistry

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Behera, A, Sravanthi, K, Kumar, LK, Vedamurthy, GV, Singh, D and Onteru, SK (2021). Association of taurine with ovarian follicular steroids and postpartum anestrus condition in Murrah buffaloes. <i>Domestic Animal Endocrinology</i> , 74, 106511. doi:10.1016/j.domaniend.2020.106511	2.29	8.29
2.	Bhawal, S, Kumari, A, Kapila, S and Kapila, R (2021). Physicochemical characteristics of novel cell-bound exopolysaccharide from probiotic <i>Limosilactobacillus fermentum</i> (MTCC 5898) and its relation to antioxidative activity. <i>Journal of Agricultural and Food Chemistry</i> , 69(35):10338-349	5.895	11.28
3.	Choudhary, U, Sabikhi, L and Kapila, S (2021). Double emulsion-based mayonnaise encapsulated with bitter gourd extract exhibits improvement in vivo anti-diabetic action in STZ induced rats. <i>3 Biotechnology</i> , 11(8):1-14	2.406	-
4.	Deepika, S, Gautam, D, Meena, S, Ali, M, Meena, AS, Vats, A, Verma, V, Rout, PK & De, S (2021). Heterogeneity and diversified distribution of S2 casein variants in Indian goats. <i>Small Ruminant Research</i> , 204:106501. doi:10.1016/j.smallrumres.2021.106501	1.611	7.61
5.	Dev, K, Kaul, G and Dhanda, S (2020). Cytotoxicity evaluation of MWCNTs and silica nanoparticles on caprine spermatozoa: an in vitro comparative study. <i>Annals of Biology</i> , 36(3):366-71.	1.24	3.95
6.	Gawande, K, Kolhekar, M, Kumari, M, Kapila, S, Sharma, Behare, P (2021). Lactic acid bacteria based purified exopolysaccharide showed viscofying and hypercholesterolemic capabilities. <i>Food Hydrocolloids for Health</i> , 1:100042. doi:10.1016/j.fhfh.2021.100042	11.504	17.504
7.	Goud, TS, Upadhyay, RC, Pichili, VBR, Onteru, SK and Chadipiralla K (2021). Molecular characterization of coat color gene in Sahiwal versus Karan Fries bovine. <i>Journal of Genetic Engineering and Biotechnology</i> , 19(1):22. doi:10.1186/s43141-021-00117-2	3.818	9.818
8.	Govatati, S, Pichavaram, P, Mani, AM, Kumar, R, Sharma, D, Diemel, A, Meena, S, Puchowicz, MA, Park, EA, Rao, GN (2021). Novel role of xanthine oxidase-dependent H ₂ O ₂ production in 12/15-lipoxygenase-mediated de novo lipogenesis, triglyceride biosynthesis and weight gain. <i>Redox Biology</i> , 47:102163. doi:10.1016/j.redox.2021.102163	11.8	17.8
9.	Gupta, T, Kaur, H, Kapila, S and Kapila R (2021). <i>Lactobacillus fermentum</i> (MTCC 5898) alleviates <i>Escherichia coli</i> induced inflammatory responses in intestinal epithelial cells by modulating immune genes and NF- κ B signalling. <i>Journal of Applied Microbiology</i> , 131(6):3008-17.	4.061	9.77
10.	Gupta, T, Kaur, H, Kapila, S and Kapila R (2021). Potential probiotic <i>Lactocaseibacillus rhamnosus</i> MTCC-5897 attenuates <i>Escherichia coli</i> induced inflammatory response in intestinal cells. <i>Archives of Microbiology</i> , 203(9):5703-13.	2.552	8.55
11.	Hebbar, A, Chandel, R, Rani, P, Onteru, SK and Singh, D (2021). Urinary cell-free miR-99a-5p as a potential biomarker for estrus detection in buffalo. <i>Frontiers in Veterinary Science</i> , 8,643910. doi:10.3389/fvets.2021.643910	3.12	9.41
12.	Kalyan, S, Meena, S, Kapila, S, Yadav, R and Deshwal, GK (2021). In Vitro Assessment of Antioxidative Potential of Goat Milk, Casein and its Hydrolysates: Comparison of Goat Milk with Bovine and Buffalo milk. <i>Indian J. of Dairy Science</i> , 74(5). doi:10.21203/rs.3.rs-546200/v1	4.034	5.95
13.	Kaur, H, Gupta, T, Kapila, S and Kapila, R (2021). Protective effects of potential probiotic <i>Lactobacillus rhamnosus</i> (MTCC-5897) fermented whey in reinforcement of intestinal epithelial barrier function in colitis induced mice model. <i>Food and Function</i> , 12:6102-116.	5.396	11.40
14.	Kaur, T, John, AA, Sharma, C, Vashisht, NK, Singh, D, Kapila, R and Kapila, S (2021). miR300 intervenes Smad3/ β -catenin/ RunX2 crosstalk for therapy with an alternate function as indicative biomarker in osteoporosis. <i>Bone</i> , 143:115603. doi:10.1016/j.bone.2020.115603	4.147	10.40

15.	Kaur, T, Upadhyay, D, Vij, R, Kapila, R and Kapila, S (2021). Milk peptide induced miRNA-369 facilitates bone functions in the rat osteoblasts. <i>Indian Journal of Animal Sciences</i> , 91(8).	0.316	6.32
16.	Keswani, C, Dilmashin, H, Birla, H, Roy, P, Tyagi, RK, Singh, D, Rajput, VD, Minkina, T and Singh, SP (2021). Global footprints of organochlorine pesticides: a pan-global survey. <i>Environmental Geochemistry and Health</i> , 44(1):149177.	4.609	10.61
17.	Kumar, M, Aggarwal, A & Kaul, G (2021). Novel and known miRNAs in zebu (Tharparkar) & crossbred (Karan-Fries) cattle under heat stress. <i>Functional and Integrative Genomics</i> , 21(3-4):405-19.	3.674	9.41
18.	Kumar, M, Aggarwal, A and Kaul, G (2021). Novel and known miRNAs in zebu (Tharparkar) and crossbred (Karan-Fries) cattle under heat stress. <i>Functional and Integrative Genomics</i> , 21(3-4):405-19.	3.674	9.41
19.	Kumar, R, Mada, SB, Reddi, S, Kaur, T, Kapila, R & Kapila, S (2021). Comparative evaluation of the protective effects cow, buffalo and goat milk in glucocorticoid-induced bone alterations in mice. <i>International Journal of Dairy Technology</i> , 74(2):316-23.	4.374	10.37
20.	Kumar, S, Hussain, A, Bhushan, B and Kaul, G (2020). Comparative toxicity assessment of nano-and bulk-phase titanium dioxide particles on the human mammary gland in vitro. <i>Human and Experimental Toxicology</i> , 39(11):1475-86.	2.171	8.90
21.	Kumari, S, Chaurasiya, V, Onteru, SK and Singh, D (2021). Regulation of granulosa cell functions through NRP-1 mediated internalization of follicular fluid non-exosomal miR-210. <i>Journal of Cell and Tissue Research</i> , 386:649-60.	3.043	4.39
22.	Mohan, G, Kumar, A, Khan, SH, Kumar, NA, Kapila, S, Lathwal, SS, Sodhi, M and Niranjana, SK (2021). Casein (CSN) gene variants and parity affect the milk protein traits in crossbred (Bostaurus x Bosindicus) cows in sub-tropical climate. <i>Tropical Animal health and Production</i> . 53:289	1.559	7.56
23.	Nayan, V, Onteru, SK and Singh, D (2021). Epitope-based insilico peptide design yields peptide-directed antibodies that recognize the buffalo luteinizing hormone. <i>International Journal of Biological Macromolecules</i> , 176:260-71.	8.025	12.95
24.	Pandey, M, Singh, C, Goud, ESK, Vedamurthy, GV, Singh, D and Onteru, SK (2021). Effect of vedic music on steroidogenic gene expression in 3D-cultured buffalo granulosa cell spheroid model system, a pilot study. <i>Reproduction in Domestic Animals</i> , 56(2):231-38.	2.005	8.01
25.	Pandey, M, Singh, S, Yadav, M, Singh, D and Onteru, SK, 2021. Transcriptome analysis of buffalo granulosa cells in three dimensional culture systems. <i>Molecular Reprod. & Development</i> , 88(4):287-301.	2.609	8.61
26.	Paul, RK, Chandel, R and Onteru, SK (2021). Male reproductive tract origin sperm- quiescent proteins: prospects in semen cryopreservation of livestock species. <i>Animal Reproduction Update</i> , 1:10-16.	2.145	-
27.	Rana, S, Arora, S, Gupta, C, Bodemala, H and Kapila, S (2021). Evaluation of in-vivo model for vitamin A bioavailability from vitamin A loaded caseinate complex. <i>Food Bioscience</i> , 42:101174. doi:10.1016/j.fbio.2021.101174	4.24	10.24
28.	Ratha, P, Chaurasiya, D and Kaul, G (2020). Can plastics be ever replaced in the dairy industry? <i>Current Science</i> , 119(9):1411-16.	1.102	7.10
29.	Saipriya, K, Deshwal, GK, Singh, AK, Kapila, S and Sharma, H (2021). Effect of dairy unit operations on immunoglobulins, colour, rheology and microbiological characteristics of goat milk. <i>International Dairy Journal</i> , 121:105118. doi:10.1016/j.idairyj.2021.105118	3.032	9.03
30.	Saxena, VK, Vedamurthy, GV, Swarnkar, CP, Kadam, V, Onteru, SK, Ahmad, H and Singh R (2021). De novo pathway is an active metabolic pathway of cysteine synthesis in <i>Haemonchus contortus</i> . <i>Biochimie</i> . 187:110-20.	4.079	10.08
31.	Shanmugam, V, Kapila, S, Tanedjeu, KS, Reddi, S, Kapila, R, Subramanian, M and Durairaj, R (2021). Isolation and Characterization of Angiotensin Converting Enzyme Inhibitory Peptide from Buffalo Casein. <i>Int. J. of Peptide Research and Therapeutics</i> 27(2):1481-91.	1.931	-
32.	Sharma, D, Kumari, S, Rani, P, Onteru, SK, Roy, P, Tyagi, RK, Singh, SP and Singh, D (2021). Dieldrin upregulate Organochlorine pesticide proximal promoter (PII) driven CYP19A1 gene expression and increases estrogen production in granulosa cells. <i>Reproductive Toxicology</i> , 106, 103-8.	2.771	9.14

33.	Sharma, D, Rani, P, Onteru, SK, Roy, P, Tyagi, RK, Singh, SP & Singh, D (2021). Reverse transcription-Loop mediated isothermal amplification (RT-LAMP) assay for detection of Ah Receptor responsive xenobiotics. <i>Toxicology Mechanisms and Methods</i> , 31(5):359-66.	1.476	-
34.	Sharma, R, Singh, PK, Onteru, SK and Singh, D (2021). Faecal microbiome analysis reveals Clostridiales and Bacteroidales as signature gut microbes during estrus of buffalo. <i>Reproductive Biology</i> , 21 (2), 100509.	2.089	8.38
35.	Surla, GN, Hebbar, A, Kumar, V, Nayan, V, Vedamurthy, VG, Singh, D and Onteru, SK (2021). Validation of salivary ferning based estrus identification method in a large population of water buffaloes (<i>Bubalus bubalis</i>) using Foldscope. <i>Reproductive Biology</i> , 21(3):100528. doi: 10.1016/j.repbio.2021.100528	2.089	8.38
36.	Yadav, K, Ali, S, Kumar, A, Muthusamy, E, Subaharan, K and Kaul, G (2021). MSN, MWCNT and ZnO nanoparticle-induced CHO-K1 cell polarisation is linked to cytoskeleton ablation. <i>Journal of Nanobiotechnology</i> , 19(1):1-24.	11.509	16.44

Dairy Microbiology

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Ali, S Azmal, Singh, AK, Tomar, SK and Behare, PV (2021). Genome Sequence of <i>Lactocaseibacillus rhamnosus</i> Strain NCDC610, Isolated from a Traditional Cereal-Based Fermented Milk Product (Raabadi). <i>Microbiology Resource Announcements</i> , 10:00672-21.	0.887	6.887
2.	Bade, Shubham, Bhardwaj, Divya, Jaswal, Avinash, HM, Rashmi Kumar, Naresh and H.V. Raghu (2021). Isolation and phenotypic identification of <i>Campylobacter</i> in dairy supply chain. <i>Indian Journal of Animal Health</i> , 60(2).	-	5.25
3.	Balasubramaniam, C, Mallappa, RH, Singh, DK, Chaudhary, P, Bharti, B, Muniyappa, SK and Grover, S (2021). Gut bacterial profile in Indian children of varying nutritional status: a comparative pilot study. <i>European journal of Nutrition</i> , 60(7):3971-85.	4.449	11.61
4.	Chandhni, PR, Pradhan, D, Sowmya, K, Gupta, S, Kadyan, S, Choudhary, R and Grover, S (2021). Ameliorative effect of surface proteins of probiotic lactobacilli in colitis mouse models. <i>Frontiers in Microbiology</i> , 1973.	5.64	11.64
5.	Dasriya, Vaishali, Joshi, Ritu, Ranveer, Soniya, Dhundale, Vishal, Kumar, Naresh and Raghu, HV (2021). Rapid detection of pesticide in milk, cereal and cereal based food and fruit juices using paper strip-based sensor. <i>Science Rep.</i> 11, 18855. https://doi.org/10.1038/s41598-021-96999	4.379	10.38
6.	Gawande, K, Kolhekar, M, Kumari, M, Kapila, S, Sharma, P, Ali, SA and Behare, PV (2021). Lactic acid bacteria based purified exopolysaccharide showed viscofying and hypercholesterolemic capabilities. <i>Food Hydrocolloids for Health</i> , 1:100042.	9.147	15.15
7.	Iram, Daraksha, Sansi, Manish Singh, Zanab, Sameena, Vij, Shilpa, Ashutosh, Meena, Sunita (2021). In silico Identification of antidiabetic and hypotensive potential bioactive peptides from the sheep milk proteins- A Molecular Docking Study. <i>Journal of Food Biochemistry</i> , Manuscript ID JFBC-09-21-1447.R1	2.72	8.72
8.	Jena, R, Choudhury, PK, Puniya, AK and Tomar, SK (2021). Efficacy of BOX-PCR fingerprinting for taxonomic discrimination of bifido-bacterial species isolated from diverse sources. <i>3-Biotech</i> , 11(6):1-6	3.203	8.41
9.	Kadyan, S, Rashmi, HM, Pradhan, D, Kumari, A, Chaudhari, A and Deshwal, GK (2021). Effect of lactic acid bacteria and yeast fermentation on antimicrobial, antioxidative and metabolomic profile of naturally carbonated probiotic whey drink. <i>LWT</i> , 142, 111059.	4.952	10.95
10.	Kumar, N, Sharma, G, Leahy, E, Shome, BR, Bandyopadhyay, S, Deka, RP and Lindahl, JF (2021). Understanding antibiotic usage on small-scale dairy farms in the Indian states of Assam and Haryana using a mixed-methods approach-outcomes and challenges. <i>Antibiotics</i> , 10(9):1124.	4.639	10.639
11.	Kumar, Naresh, Raghu, Vishweswaraiah, Hirikyathanahalli, Kumar, Amarjeet, Hogarehalli, Mallappa, Rashmi, Jaswal, Avinash and Kumar, Brijesh (2021). Genotypic identification of extended spectrum β -lactamase producing <i>Escherichia coli</i> in dairy supply chain. <i>Indian Journal of Dairy Science</i> . 74(1):61-67.	-	5.95
12.	Kumari, M, Bhushan, B, Kokkilgadda, A, Kumar, V, Behare, P V and Tomar, SK (2021). Vitamin B12 biofortification of soymilk through optimized fermentation with extracellular B12 producing <i>Lactobacillus</i> isolates of human fecal origin. <i>Current Research in Food Science</i> , 4,646-54.	6.031	12.03

13.	Nataraj, B H, Ramesh, C and Mallappa, RH (2021). Characterization of biosurfactants derived from probiotic lactic acid bacteria against methicillin-resistant and sensitive. <i>Staphylococcus Aureus Isolates</i> . <i>LWT</i> , 151, 112195.	4.952	10.95
14.	Nataraj, BH, Ramesh, C and Mallappa, RH (2021). Characterization of antibiotic resistance and virulence traits present in clinical methicillin-resistant <i>Staphylococcus aureus</i> isolates. <i>Current Microbiology</i> , 78(5): 2001-14.	2.19	8.19
15.	Nataraj, BH, Ramesh, C and Mallappa, RH (2021). Extractable surface proteins of indigenous probiotic strains confer anti-adhesion knock and protect against methicillin-resistant <i>Staphylococcus aureus</i> induced epithelial hyperpermeability in HT-29 cell line. <i>Microbial Pathogenesis</i> , 158, 104974.	3.68	9.74
16.	Nataraj, BH, Ramesh, C and Mallappa, RH (2021). Functional group characterization of lactic bacterial biosurfactants and evaluation of antagonistic actions against clinical isolates of methicillin-resistant <i>Staphylococcus aureus</i> . <i>Letters in Applied Microbiology</i> , 73(3):372-82.	2.858	8.86
17.	Patel, M, Prasad, W, Naithani, H, Nataraj, BH, Arora, S and Behare, PV (2021). Comparative evaluation of in situ and ex-situ iron-complexing ability of exopolysaccharides producing lactic acid bacteria in whey medium. <i>Food Science and Technology-LWT</i> , 147:111598.	4.952	10.95
18.	Rani, S, Singh H, and Ram, C (2021). Efficacy and mechanism of carvacrol with octanoic acid against mastitis causing multi-drug-resistant pathogens. <i>Brazilian Journal of Microbiology</i> . https://doi.org/10.1007/s42770-021-00639-4	2.476	8.5
19.	Veena, N, Hundal, JS, Wadhwa, M and Puniya, AK (2021). Factors affecting the milk yield, milk composition and physico-chemical parameters of ghee in lactating crossbred cows. <i>Indian Journal Dairy Science</i> 74(1):68-73	-	5.95

Dairy Chemistry

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Athira, S, Mann, B, Sharma, R, Pothuraju, R, Kumar BR (2021). Preparation and characterization of iron-chelating peptides from whey protein: An alternative approach for chemical iron fortification. <i>Food Research International</i> . 141:110-13 https://doi.org/10.1016/j.foodres.2021.110133	6.475	12.48
2.	Baria, Bhavesh, Singh, Ashish Kumar, Raju Panjagari, Narender, Arora, Sumit and Minz, PS (2021). Colouring properties and stability of black carrot anthocyanins in yoghurt. <i>Journal Food Science Technology</i> 58(10):3953-62	2.701	8.70
3.	Borad, SG, Singh, AK, Meena, GS, Arora, S, Raju, PN and Sabikhi, L (2021). Optimization of spray drying of colostrum protein ingredients- a rheological approach. <i>Journal of Food Engineering</i> , 288:110247	5.354	11.35
4.	Bumbadiya, Mitul, Singh, Richa, Arora, Sumit, Mann, Bimlesh and Rao, Priyanka Singh (2021). Effect of optimized formulation (combination of bronopol and kathon) on compositional and physico-chemical parameters of milk samples. <i>Indian Journal Dairy Science</i> 74(5):395-401	-	5.95
5.	Gandhi, K, Devi, S, Gautam, PB, Sharma, R, Mann, B, Ranvir, S and Kuldip (2021). Effect of incorporation of iron-whey protein concentrate (Fe-WPC) conjugate on physicochemical characteristics of dahi (curd). <i>Journal of Food Science and Technology</i> 25,1-10	2.701	8.70
6.	Gandhi, K, Gautam, PB, Kumar, K, Sharma, R and Mann, B (2021). Physico-chemical characteristics of biscuits fortified with whey protein concentrate-iron sulphate (WPC-FeSO ₄) complex <i>Journal of Food Measurement and Characterization</i> 15, 2831-41	2.431	8.43
7.	Parmar, Alka and Sharma, Vivek (2020). Effect of LP-system activation using externally added potassium thiocyanate, glucose oxidase and glucose on total bacterial count and pH variability in raw buffalo milk. <i>International J. Chemical Studies</i> , SP-8(5):141-44.	-	-
8.	Patel, Maulik, Prasad, Writdhama, Naithani, Harshita, Nataraj, Basavaprabhu Haranahalli, Arora, Sumit, Behare, Pradip V (2021). Comparative evaluation of in situ and ex-situ iron-complexing ability of exopolysaccharides producing lactic acid bacteria in whey medium. <i>LWT-Food Science and Technology</i> 147 (2021) https://doi.org/10.1016/j.lwt.2021.111598	4.952	10.95

9.	Pathania, Parul, Sharma, Vivek, Rao, Priyanka Singh and Arora, Sumit (2021). A distinction of cow and buffalo ghee using principal component analysis of triglyceride composition. <i>International J of Dairy Technology</i> . 74(2):352-358. doi:10.1111/1471-0307.12768	4.374	10.37
10.	Patil, O Srushty, Bajaj, R, Mann, B and Sharma, R (2021). Preparation and characterization of Sodium caseinate-maltodextrin conjugate by dry heating method. <i>International Journal of Chemical Studies</i> 2021; 9(4):31-38	-	-
11.	Rana, Seema, Arora, Sumit, Gupta, Chitra, Bodemala, Harisha and Kapila, Suman (2021). Evaluation of in-vivo model for vitamin A bioavailability from vitamin A loaded caseinate complex. <i>Food Bioscience</i> 42:101174. https://doi.org/10.1016/j.fbio.2021.101174	4.24	10.24
12.	Sehrawat, Renuka, Sharma, Rekha, Ahlawat, Sonika, Sharma, Vivek Thakur, Mohan Singh, Kaur, Manjeet, Tantia, Madhu Sudan (2021). First Report on Better Functional Property of Black Chicken Meat from India. <i>Indian Journal Animal Research</i> , 55 (6):727-33.	0.316	6.44
13.	Sharma, N, Sharma, R, Rajput, YS, Mann, B, Gandhi, K (2021). Distinction between glycomacropptide and α -lactoglobulin with 'stains all' dye on tricine SDS-PAGE gels. <i>Food Chemistry</i> . 340, 127923, ISSN 0308-8146, https://doi.org/10.1016/j.foodchem.2020.127923 .	7.541	13.51
14.	Sharma, N, Sharma, R, Rajput, YS, Mann, B, Singh, R and Gandhi, K (2021). Separation methods for milk proteins on polyacrylamide gel electrophoresis: Critical analysis and options for better resolution. <i>International Dairy Journal</i> , 114, 104920.	3.032	9.03
15.	Sharma, R, Verma, Archana, Mann, B, Gandhi, K (2021). Adulteration of cow's milk with buffalo's milk detected by an on-site carbon nanoparticles-based lateral flow immunoassay. <i>Food Chemistry</i> . 351, 129311. https://doi.org/10.1016/j.foodchem.2021.129311	7.541	13.51
16.	Sharma, Vivek, Rao, Priyanka Singh, Arora, Sumit, Naik, Laxamana, Sihag, Manvesh, Meghwal, Karuna and Kumar, Kuldeep (2021). A comparative study on the s-values of cow and buffalo ghee calculated using equations specified in ISO (17678) method of determining the milk fat purity by gas chromatographic analysis of triglycerides. <i>Indian J. Dairy Science</i> 74(2):117-23	-	5.95
17.	Singh, Payal, Rao, Priyanka Singh, Sharma, Vivek, Arora, Sumit (2021). Physico-chemical aspects of lactose hydrolysed milk system along with detection and mitigation of maillard reaction products. <i>Trends in Food Science and Technology</i> 107:57-67	12.563	18.56
18.	Singh, Payal, Rao, Priyanka Singh, Sharma, Vivek, Arora, Sumit (2021). Physico-chemical aspects of lactose hydrolysed milk system along with detection and mitigation of maillard reaction products. <i>LWT- Food Science and Technology</i> 151:112069. https://doi.org/10.1016/j.lwt.2021.112069	4.952	10.95
19.	Singh, R and Amamcharla, JK (2021). Effect of pH on heat-induced interactions in high-protein milk dispersions and application of fluorescence spectroscopy in characterizing these changes. <i>Journal of Dairy Science</i> , 104(4):3899-915.	4.034	10.03
20.	Suvarthan, R, Sharma, R, Gandhi, K, Nikam, P and Mann, B (2021). Physico-chemical changes during processing and storage of UHT milk. <i>Indian Journal of Dairy Science</i> 74(1) 39-47.	-	5.95
21.	Syama, MA, Arora, Sumit, Gupta, Chitra, Singh, AK (2021). Loading of vitamin D2 in native and modified sodium caseinate: Delineation of physicochemical and in-vitro bioaccessibility attributes. <i>LWT-Food Science and Technology</i> 155: https://doi.org/10.1016/j.lwt.2021.112992	4.952	10.95

Dairy Technology

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Baig, D, Sabikhi, L, Khetra, Y and Kumar, D (2021). Effect of casein to fat ratio of camel milk on solids losses in cheese whey and their recovery in camel milk cheese, <i>International Dairy Journal</i> , doi:10.1016/j.idairyj.2021.105185	3.032	9.03
2.	Bhagwat SK, Ganguly S, Khetra Y, Panjagari NR, Shelke PA, Sakhala S (2021). Effect of Ricotta matrix on viability of probiotic organism exposed to simulated gastrointestinal (GI) digestion. <i>LWT-Food Sci Technol</i> , 151, 112099.	4.952	10.95

3.	Chand, P, Kumar, MD, Singh, AK, Deshwal, GK, Rao, PS, Tomar, SK and Sharma, H (2021). Low calorie synbiotic yoghurt from indigenous probiotic culture and combination of inulin and oligofructose: Improved sensory, rheological and textural attributes. <i>J Food Process Preserv</i> , 45 (4):e15322	2.190	7.71
4.	Ganguly, S, Sabikhi, L and Singh, AK (2021). Evaluation of nutritional attributes of whey-cereal based probiotic beverage, <i>LWT - Food Sci. Technol.</i> , doi:10.1016/j.lwt.2021.112292	4.952	10.95
5.	Ganguly, S, Sabikhi, L, Singh, AK (2021). Effect of probiotic fermentation on physico-chemical and nutritional parameters of milk-cereal based composite substrate. <i>J Food Sci Technol</i> , https://doi.org/10.1007/s13197-021-05350-8 .	2.70	8.70
6.	Ganguly, S, Sabikhi, L, Singh, AK (2021). Evaluation of nutritional attributes of whey-cereal based probiotic beverage. <i>LWT-Food Sci Technol</i> , 152, 112292	4.952	10.95
7.	Kumar, A, Hussain, SA, Prasad, W, Singh, AK and Singh, RRB (2021). Effect of oxygen tolerant probiotic strain, stabilizers and copper addition on the storage stability of Aloe vera supplemented synbiotic lassi, <i>Future Foods</i> , 3, 100021.	-	-
8.	Kumbhare, S, Prasad, W, Khamrui, K, Wani, AD and Sahu, J (2021). Recent innovations in functionality and shelf life enhancement of ghee, clarified butter fat. <i>J Food Sci Technol</i> , 1-13. doi.org/10.1007/s13197-021-05335-7	2.701	7.95
9.	Malik, A, Khamrui, K and Prasad, W (2021). Effect of hydrothermal treatment on physical properties of amaranth, an underutilized pseudocereal. <i>Future Foods</i> , 3, 100027. doi.org/10.1016/j.fufo.2021.100027	-	-
10.	Maurya, N, Khamrui, K and Prasad, WG (2020). Studies on curcumin fortification in different lassi types using tween-80 as the binding material. <i>Indian Journal of Dairy Science</i> , 73(6),628-631	-	5.95
11.	Meena, S, Gote, S, Prasad, W and Khamrui, K (2021). Storage stability of spray dried curcumin encapsulate prepared using a blend of whey protein, maltodextrin and gum Arabic. <i>Journal of Food Process Preserv</i> , 45(5):e15472.	2.190	7.71
12.	Meena, S, Prasad, W, Khamrui, K, Mandal, S and Bhat, S (2021). Preparation of spray-dried curcumin microcapsules using a blend of whey protein with maltodextrin and gum arabica and its in-vitro digestibility evaluation. <i>Food Biosci</i> , 41, 100990.	4.24	9.07
13.	Patil, AT, Meena, GS, Upadhyay, N, Khetra, Y, Singh, A K and Borad, SG (2021). Buffalo milk protein concentrate 60: Effect of skim milk heat treatment on its reconstitutability and functionality. <i>LWT- Food Sci Technol</i> , 148, 111638.	4.952	10.95
14.	Roy, S, Hussain, SA, Prasad, WG and Khetra, Y (2021). Effect of emulsifier blend on quality attributes and storage of high protein buffalo milk ice cream, <i>LWT-Food Sci Technol</i> , 150, 111903.	4.952	10.01
15.	Saipriya, K, Deshwal, GK, Singh, AK, Kapila, S and Sharma, H (2021). Effect of dairy unit operations on immunoglobulins, colour, rheology and microbiological characteristics of goat milk. <i>International Dairy Journal</i> , 121, 105118.	3.032	9.03
16.	Sharma, H and Ramanathan, R (2021). Gas chromatography-mass spectrometry based metabolomic approach to investigate the changes in goat milk yoghurt during storage. <i>Food Research International</i> , 140, 110072	6.475	12.48
17.	Sharma, H, Singh, AK, Deshwal, GK and Borad, S (2021). Processing stability and debittering of <i>Tinospora cordifolia</i> (giloy) juice using ultrasonication for potential application in foods. <i>LWT</i> , 134, 110117	4.952	10.95
18.	Sharma, H, Singh, AK, Deshwal, GK, Rao, PS, Kumar, MD (2021). Functional <i>Tinospora cordifolia</i> (giloy) based pasteurized goat milk beverage: Impact of milk protein-polyphenol interaction on bioactive compounds, anti-oxidant activity and microstructure. <i>Food Biosci.</i> , 12, 101101	4.24	9.07
19.	Sharma, Heena, Rassi, GD, Lathrop, A, Dobрева, VB, Belem, TS and Ramanathan, R (2021). Comparative analysis of metabolites in cow and goat milk yoghurt using GC-MS based untargeted metabolomics. <i>International Dairy Journal</i> , 117, 105016.	3.032	9.03
20.	Tiwari, S, Upadhyay, N and Malhotra, R (2021). Three ways ANOVA for emulsion of carotenoids extracted in flaxseed oil from carrot bio-waste. <i>Waste Management</i> , 121, 67-76.	7.145	13.15

Dairy Engineering

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Ammu, VK, Minz, PS, Vairat, AD, Singh, AK, Sinha and Chitranayak (2021). Application of centrifugation technology for production of chhana-An Indian soft cheese. <i>International Journal of Dairy Technology</i> , 74(3), https://doi.org/10.1111/1471-0307.12775	4.374	10.37
2.	John, H, Chandra, P, Giri, SK & Sinha, LK (2021). Effect of Processing Methods on 11S/7S Protein and Nitrogen Solubility Index of Soy Protein Isolate. <i>Journal of The Institution of Engineers(India):Series A</i> , 102(4):989-94.	-	5.00
3.	Kumar, Mahesh, Ravindra, G, Nagajjanavar, MR, Juvvi, K, Sinha, P, Chitranayak, Manjunatha, M and Basava, S (2021). Design and development of sub-baric thermal processer for frying of Gulab jamun: A deep-fat fried dairy product. <i>Journal of Food Process Engineering</i> , e14005. https://doi.org/10.1111/jfpe.14005	2.356	8.36
4.	Sinha, Chitranayak, Jaiswal, P, Minz, PS, Vairat, Amita D, Kumari, Khushbu, Raju, PN (2021). Quality Dahi Preparation in Automated Controlled Ambient Conditions. <i>International Journal of Bio-resource and Stress Management; IJBSM 2021</i> , 12(2):082-088,	-	5.11
5.	Sinha, Chitranayak, Manjunatha, M, Jayaraj Rao, K, Sinha, P, Kumari, K, G Kumar, M and Dabas, JK (2021). Microstructure of paneer prepared by automated pressing technique. <i>Journal of Food Process Engineering</i> , 44(9):e13786. https://doi.org/10.1111/jfpe.13786 ,	2.356	8.36
6.	Sukre V, Barnwal P, Chavhan B, Deep A and Bhagat, P (2021). Evaluation of selected physico-chemical, colour and textural characteristics of market Gulabjamun. <i>Indian Journal of Dairy Science</i> , 74(6):479-85.	-	5.95

Dairy Economics

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Acharya, KK, Malhotra, R, Sendhil, R and Kumari, B (2021). Profit efficiency among peri-urban dairy farms in Odisha: An application of the stochastic frontier function. <i>Agricultural Economics Research Review</i> , 34(2):207-215. doi: https://doi.org/10.5958/0974-0279.2021.00029.X .	-	5.84
2.	Agrawal, A, Chaudhary, U and Raju, R (2021). Estimation of potential economic benefits of livestock farming in rural Madhya Pradesh. <i>Indian Journal of Extension Education</i> , 57(4):49-53.	-	5.95
3.	Bhandari, G, Lal, P, Chaudhary, U, Haritha, K, Malhotra, R and Chandel, BS (2021). Assessing snowball effect of COVID-19 pandemic on Indian dairy sector. <i>Indian Journal of Animal Sciences</i> , 91(12):1011-17.	0.316	6.32
4.	Cariappa, AG, Adeeth and Chandel, BS (2020). Interlink between factor and product markets: Opportunity for the future of Indian agriculture. <i>Agricultural Economics Research Review</i> , 33:61-74.	-	5.84
5.	Chaudhary, U and Thorat, V (2021). Dairying as vehicle to raise incomes of small farmers in Haryana. <i>The Haryana Veterinarian</i> , 60(1):51-56.	-	5.58
6.	Kathayat, B and Dixit, AK (2021). Paddy price forecasting in India using ARIMA model. <i>Journal of Crop and Weed</i> , 17(1):48-55. doi: https://doi.org/10.22271/09746315.2021.v17.i1.1405 .	-	5.46
7.	Kathayat, B, Dixit, AK and Chandel, BS (2021). Inter-state variation in technical efficiency and total factor productivity of India's livestock sector. <i>Agricultural Economics Research Review</i> , 34 (Conference Issue):59-72. doi: https://doi.org/10.5958/0974-0279.2021.00015.X .	-	5.84
8.	Mohapatra, S, Sendhil, R, Singh, A, Dixit, AK, Malhotra, R. and Ponnusamy, K (2021). An economic analysis of milk production in Haryana. <i>Indian Journal of Dairy Science</i> , 74(2):159-66. doi: https://doi.org/10.33785/IJDS.2021.v74i02.009 .	-	5.95
9.	Rathore, R, Malhotra, R and Mishra, S (2021). Analysis of constraints faced by members of women dairy self-help groups in Rajasthan, India. <i>Indian J. of Extension Education</i> , 57(1):233-36.	-	5.95

10.	Sharma, AK, Bhatia, AK, Kulshrestha, A and Sawhney, IK (2021). Intelligent modeling of moisture sorption isotherms in Indian milk products using computational neurogenetic algorithm. <i>Springer Nature Computer Science Journal</i> , 2:289. doi:https://doi.org/10.1007/s42979-021-00693-7.	-	-
11.	Singh, A, Chandel, BS, Chauhan, AK, Das, J and Ravishankara, KM (2021). Economics of milk processing in cooperative sector of Haryana. <i>Indian Journal of Dairy Science</i> , 74(1):255-61.	-	5.95
12.	Singh, A, Chandel, BS, Chauhan, AK, Kamboj, ML and Bijla, S (2021). Sustainability of Gaushalas: Do size and patronage matter? <i>Agricultural Economics Research Review</i> , 34(1):79-90.	-	5.84
13.	Singh, R, Chiphang, S and Singh, A (2021). Constraint analysis of dairy sector in north eastern region: A producers and consumers perspective. <i>Indian Journal of Dairy Science</i> , 74(3):277-79.	-	5.95
14.	Sinha, M, Sendhil, R, Chandel, BS, Malhotra, R, Singh, A, Jha, SK and Sankhala, G (2021). Are multidimensional poor more vulnerable to climate change? Evidence from rural Bihar, India. <i>Social Indicators Research</i> . doi: https://doi.org/10.1007/s11205-021-02827-Z.	2.935	8.94
15.	Thakur, A, Dixit, AK, Kumar, S and Bhandari, G (2021). Value chain analysis of informal dairy processing units in Haryana (India): A system dynamic approach. <i>Agricultural Research</i> , 10(2):307-13.	-	5.95
16.	Thakur, A, Dixit, AK, Sharma, AK, Kumar, S, Sendhil, R & Singh, AK (2021). Adoption of food safety practices in the informal milk processing units of Haryana, India – A value chain approach. <i>Indian Journal of Dairy Science</i> , 74(6):516-25. doi:https://doi.org/10.33785/IJDS.2021.v74i06.008.	-	5.95
17.	Thorat, VS and Chaudhary, U (2021). Role of dairy farming as a stimulant to enhance livelihood of rural farm households in Gujarat. <i>International Journal of Livestock Research</i> , 11(4):88-94.	-	N/A
18.	Wakchaure, N, Malhotra, R, Chaudhary, U and Deokar, D (2021). Non-genetic factors affecting the incidence of calving abnormalities in crossbred cows. PARIPEX – <i>Indian Journal of Research</i> , 10(7):19-22. doi:https://doi.org/10.36106/paripex.	-	N/A
19.	Yadav, P, Chandel, BS and Agarwal, P (2021). Total factor productivity of livestock sector in Gujarat: Evidence of technological changes and sustainable growth of livestock sector. <i>Indian Journal of Agricultural Economics</i> , 76(1):173-86.	-	5.3

Dairy Extension

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Anuradha, Kadian, KS, Meena, MS, Meena, HR and Prashanth, CS (2021). Farmers' perspective to mitigate crop residue burning in Haryana state of India. <i>Indian Res. J. Ext. Education</i> 21(2/3):154-60.	-	5.22
2.	Behera, J, Jha, SK, Maiti, S and Garai, S (2021). A study on housing management strategies adopted by livestock-rearers in flood-prone districts of Odisha, <i>Journal of Community Mobilization and Sustainable Development</i> , 16(1):223-28.	-	5.67
3.	Bhatt, A, Meena, BS and Paul, P (2021). Valuable wisdom in the Himalayas: ITKs in bullock rearing. <i>Indian Journal of Traditional Knowledge</i> , 20(1):244-52.	0.76	6.76
4.	Chakravarty R, Ponnusamy K and Sendhil R (2021). Prioritization of climate induced gender specific vulnerability issues in crop and dairy enterprises. <i>Indian Journal of Animal Sciences</i> 91(7):577-81.	0.29	6.32
5.	Chakravarty, R, Ponnusamy, K and Sendhil, R (2021). Micro-level evaluation of socio-technological interventions to address climate change-induced stresses in dairy enterprises. <i>Indian J Dairy Science</i> 74(5):449-54.	0.1	5.95
6.	Garai, S, Maiti, S, Ghosh, M, Bhakat, C, Garai, S and Kadian, KS (2021). Assessment of livelihood security of dairy farmers of Nadia district, West Bengal: A microlevel analysis. <i>Indian Journal of Animal Sciences</i> , 91(1):73-76.	0.32	6.32
7.	Kadian, KS, Meena, MS, Prashanth, CS and Kishnawat, LS (2021). Constraints perceived by farmers in adoption of sustainable residue management practices in Haryana state of India. <i>J. of Community Mobilization & Sustainable Development</i> , 16(3):738-42.	-	5.67

8.	Kambale, P and Sankhala, G (2021). A test to measure knowledge of the farmers about intervention under farmer first programme of NDRI, Karnal. <i>Frontiers in Crop Improvement, 9(Special Issue-V):2342-47.</i>	-	4.67
9.	Kambale, P and Sankhala, G (2021). Economic performance of crop based intervention under farmer first programme of National Dairy Research Institute (NDRI), Karnal. <i>International Journal of Economic Plants</i> 2021, 8(4):222-25	-	4.37
10.	Kumar, K, Meena, HR, Kadian, KS, Meena, BS, Bhandari, G & Kaur, J (2021). Farmers' attitude towards custom hiring centers: an exploratory study in Punjab. <i>Current Journal of Applied Science and Technology</i> , 40(21):70-78.	-	4.71
11.	Kumar, V and Meena, HR (2021). Challenges and Barriers Perceived by Paravets and Veterinarians in Delivery of Minor- veterinary Services at Farmers' Door- step: An Exploratory Study in Four States of India. <i>Indian Journal of Dairy Science</i> 74(2):179-88.	-	5.95
12.	Kumar, V and Meena, HR (2021). Role perception and performance of privately practicing paravets in delivery of animal health services at farmers' doorstep: an exploratory study in India. <i>Tropical Animal Health and Production</i> , 53:278.	1.56	7.56
13.	Kumar, V and Meena, HR (2021). Satisfaction of Dairy Farmers from Para-veterinary Services: An Exploratory Study. <i>Indian Journal of Extension Education</i> , 57(3):37-40.	-	5.95
14.	Kumar, V, Meena, HR, Kadian, KS, Sankhala, G, Mohanty, TK, Lathwal, SS and Kar, Priyajoy (2021). Performance, proficiency and training need of para-vets in the four states of India. <i>Indian Journal of Animal Sciences</i> 91 (11):1089-1102.	0.37	6.37
15.	Kumar, V, Meena, HR, Kadian, KS, Sankhala, G, Mohanty, TK, Lathwal, SS and Kar, Priyajoy (2021). Comparative analysis of minor-veterinary services rendered by paraveterinarians in four different states of India: stakeholders' perspective. <i>Journal of Community Mobilization and Sustainable Development</i> , 16(2):319-29.	-	5.95
16.	Madhavan, MM, Sankhala, G, Maiti, S and Meena, HR (2021). Development and application of a psychometric scale to measure awareness of the dairy farmers on animal waste management in urban and peri-urban areas of national capital region (NCR), India. <i>J. of Community Mobilization and Sustainable Development</i> 16(3):771-76.	-	5.67
17.	Madhu Latha, C, Kadian, KS, Meena, BS, Manjunath KV & Meena, DC (2021). Development of an index to measure the farmers' perception towards input dealers as para extension workers. <i>Indian Research Journal of Extension Education</i> , 21(4):92-98.	-	5.22
18.	Meena, DC, Garai, S, Maiti, S, Dutta, S, Meena, BS and Kadian, KS (2021). Migration pattern of Raika pastoralists of Marwar region of Rajasthan. <i>Range Management and Agroforestry</i> , 42(1):167-74.	0.37	6.37
19.	Meena, DC, Garai, S, Maiti, S, Meena, BS, Chadda, A, C Latha, M (2021). Adoption of improved sheep husbandry practices among the raika pastoralists of Marwar region of Rajasthan. <i>Indian Research Journal of Extension Education</i> , 21 (4):14-18	-	5.22
20.	Meena, Deepak Chand, Garai, Sanchita, Maiti, Sanjit, Meena, BS, Chadda, Akshita and Latha C, Madhu (2021). Adoption of improved sheep husbandry practices among the raika pastoralists of Marwar region of Rajasthan. <i>Indian Res. J. of Extension Edu.</i> , 21 (4):14-18.	-	5.22
21.	Meena, HR, Kumar, K, Kadian, KS, Meena, BS and Bhandari, G (2021). SWOT analysis of custom hiring centers and training need of farmers regarding stubble management. <i>International Journal of Agriculture Sciences</i> , 13(8):10851-854.	-	4.73
22.	Ponnusamy K and Padaria, RN (2021). Research in agricultural extension: review of its contribution and challenges. <i>Indian Journal of Agricultural Sciences</i> , 91 (5):659-65.	0.37	6.37
23.	Ponnusamy K, Singh V and Chakravarty R (2021). Research in agricultural extension: Review of its contribution and challenges. <i>Indian Journal of Animal Sciences</i> 91 (6):430-37.	0.29	6.32
24.	Singh, A, Meena, BS and Bhakat, M (2021). Validating e-learning information module on transition period of dairy animals for enhancing knowledge of dairy farmers. <i>Haryana Vet.</i> 60(2):271-74.	-	5.58
25.	Singh, A, Meena, BS and Bhakat, M (2021). Prevalent ethno-veterinary practices for management of transition period among dairy farmers of Uttar Pradesh. <i>Ruminant Science</i> , 10(1):13-18.	-	5.47
26.	Yadav, P, Maiti, S, Jha, SK, Meena, HR, Bhakat, M and Dixit, AK (2021). Participatory Evaluation of Effectiveness of Farmer-Led Adaptation Strategies to Climate Change in Eastern Uttar Pradesh. <i>Indian Journal of Extension Education</i> , 58(1):146-50. https://doi.org/10.48165/IJEE.2022.58140	-	5.95

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S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Ashokan, M, Ramesha, KP, Hallur, Sweta, Karthikkeyan, Gayathree, Rana, Ekta, Azharuddin, N, Raj, Reshma, Jeyakumar, S, Kumaresan, A, Kataktalware, Mukund A, Das, DN, Prasad, TS Keshava (2021). Differences in milk metabolites in Malnad Gidda (Bos indicus) cows reared under pasture-based feeding system. <i>Scientific Report</i> 11, 2831.	4.99	10.99
2.	Beegum, PP Shameena, Sharma, Monika, Manikantan, MR, Pandiselvam, R, Gupta, RK and Hebbar KB (2021). Incorporation of coconut milk residue in pasta: Influence on cooking quality, sensory and physical properties. <i>J of Plantation Crops</i> . 49 (2):128-35.	-	4.66
3.	Das A, Sivaram, M and Thejesh S (2021). Economic impact of COVID-19 pandemic on dairy sector: A meta-analysis. <i>Indian Journal of Animal Sciences</i> 91 (7):582-94.	0.31	6.32
4.	Das, Gupta, M, Kumaresan, A, Saraf, KK, Karthikkeyan, G, Prasad, TK, Modi, PK, Ramesha, KP, Jeyakumar, S and Manimaran, A (2021). Preliminary comparative deep metabolomic analysis of spermatozoa from zebu and crossbred cattle suggests associations between metabolites, sperm quality and fertility. <i>Reproduction, Fertility and Development</i> , 33(6):427-36.	2.31	8.31
5.	Devaraja, HC, Jayaprakasha, HM and Rao, K Jayaraj (2021). Evaluation of potential of selected prebiotics on probiotic L. acidophilus and L. casei strains. <i>Indian J. of Animal Health</i> , 60(2)- Special Issue:174-82.	-	5.25
6.	Devaraju, P, Amaladhas, Heartwin F Magdaline Eljeeva Emerald, B Surendra Nath, Naveen V Padaki, Naik, Laxmana N (2021). Nanoencapsulation of milk peptides within electrospun nanofibres. <i>Journal of the Science of Food and Agriculture</i> , 102(4):1684-98. doi:10.1002/jsfa.11509.	3.64	9.64
7.	Elango, Kamaraj, Kumaresan, Arumugam, Ashokan, Manokaran, Karuthadurai, Thirumalaisamy, Nag, Pradeep, Bhaskar, Mulinti, Prasad, Bakthavathsalam Arun, Jeyakumar, Sakthivel, Manimaran, Ayyasamy, Bhat, Vinod and Ramesha, Kerekoppa (2021). Dynamics of mitochondrial membrane potential and DNA damage during cryopreservation of cattle and buffalo bull spermatozoa. <i>Indian Journal of Animal Sciences</i> 91(1):9-14.	0.31	6.32
8.	Gupta, Mohua Das, Kumaresan, Arumugam, Saraf, Kaustubh Kishor, Paul, Nilendu, Thankappan, Kumar, Sajeev, Karthikkeyan, Gayathree, Prasad, TSK, Modi, PK, Ramesha, Kerekoppa, Manimaran, Ayyasamy, Jeyakumar, Sakthivel (2021). Deciphering metabolomic alterations in seminal plasma of crossbred (Bos taurus X Bos indicus) bulls through comparative deep metabolomic analysis. <i>Andrologia</i> , e14253.	2.78	8.78
9.	Jadhao, VM, Kumar, MHS, Rao, KJ and Matche, RS (2021). Evaluation of beeswax coated coconut shells for packaging of set-type dahi: an Indian fermented product. <i>Journal of Food Science and Technology</i> , 58(5):2019-27.	3.12	8.70
10.	Karthik, D, Devi, MCA, Subash, S, Dixit, PK, Ramesha, KP, Jayaraj Rao, K and Sivaram, M (2021). Profile characteristics of youth in dairying in Telangana state, India. <i>The Pharma Innovation Journal</i> 2021; SP-10(3):215-19.	-	5.23
11.	Karuthadurai, T, Chakravarty, AK, Kumaresan, A, Das, DN, Selvan, AS, Chandrasekar, T, Nag, BP and Kour, A (2021). Genetic Polymorphism in Prolactin Gene and its Effect on Test Day Milk Production Traits in Sahiwal Cattle. <i>Indian Journal of Animal Research</i> . doi:10.18805/IJAR.B-4394	0.44	6.44
12.	Kumar, MHS, Sabikhi, L and Lamba, H (2021). Emulsification properties of sodium caseinate-based conjugates with selected polysaccharides. <i>International J. of Dairy Technology</i> , 74 (1):44-51.	4.37	10.37
13.	Kumar, R, Kataktalware, MA, Senani, S, Sivaram, M, Letha Devi, G, Niketha, L, Ramesha, KP (2021). Risk factors associated with the lameness in crossbred dairy cattle maintained under field conditions. <i>Journal of Animal Research</i> . 11(3):1-9.	0.44	6.44
14.	Kumar, Rohit, Kataktalware, MA, Senani, S, Sivaram, M, Letha Devi G, Niketha, L and Ramesha, KP (2021). Risk Factors Associated with the Lameness in Crossbred Dairy Cattle Maintained Under Field Conditions. <i>Journal of Animal Research</i> , 11 (3):01-09.	-	5.43
15.	Kumaresan, A, Elango, K, Datta, TK and Morrell, JM (2021). Cellular and Molecular Insights into the Etiology of Subfertility/Infertility in Crossbred Bulls (Bos taurus X Bos indicus): A Review. <i>Frontiers in Cell and Developmental Biology</i> . 9:696637.	6.68	12.68
16.	Lavanya, M, Archana1, SS, Swathi, D, Ramya, L, Arangasamy, A, Binsila, B, Dhali, A, Krishnaswamy, N, Singh, SK, Kumar, H, Sivaram, M and Selvaraju, S (2021). Sperm preparedness and adaptation to osmotic and pH stressors relate to functional competence of sperm in Bos taurus. <i>Scientific Reports</i> 11:22563. https://doi.org/10.1038/s41598-021-01928-6 .	4.38	10.38

17.	Letha, Devi G, Pal, DT, Arangasamy, A, Giridhar, K, Mech, A, Kataktalware, MA, Reddy, GBM, Narayanaswamy, B, Ramamurthy, V, Chahal, VP, Chaithra, GJ and Bhatta, R (2021). Improving livelihood security of farmers through technological interventions for sustainable livestock farming. <i>Indian Farming</i> . 71(10):146-48.	-	-
18.	Makkarabbi, G, Dixit, PK, Sivaram, M and Devi, MCA (2021). Impact of dairy co-operatives membership on income and employment of dairy farmers in Karnataka state. <i>Haryana Vet</i> . 60(1):111-14.	-	5.58
19.	Manimaran, A, Wankhade, PR, Kumaresan, A, Patbandha, TK, Sivaram, M and Jayakumar, S and Rajendran, D (2021). Peripheral blood concentration of toll-like receptor-4 and its accuracy for prediction of postpartum performances of transition zebu (<i>Bos indicus</i>) cows. <i>Indian Journal of Animal Sciences</i> 91 (8):628-31.	0.31	6.32
20.	Manjunatha, BM, Emerald, F Magdaline Eljeeva, Dhotre, Anant V, Pushpadass, Heartwin A, Shivanand, A, Arputharaj, Mandhyan, Pradeep Kumar and Patil, PG (2021). Mitigation of fouling during milk processing in PTFE-TiO ₂ coated plate heat exchanger. <i>Journal of Food Process Engineering</i> e13836. doi.org/10.1111/jfpe.13836.	2.36	8.36
21.	Mor, Sonia, Surendra, B, Battula, N, Swarnalatha, G, Pushpadass, Heartwin, Naik, Laxmana N and Franklin, Magdaline (2021). Preparation of casein biopeptides-loaded niosomes by high shear homogenization and their characterization. <i>Journal of Agricultural and Food Chemistry</i> , 69 (15):4371-80.	5.28	11.28
22.	Nag, P, Kumaresan, A, Sivamanikandan, A, Manimaran, A, Rajendran, D, Paul, N, Sharma, A, Karuthadurai, T, Kaustubh, S, Jeyakumar, S and Ramesha, K (2021). Sperm phenotypic characteristics and oviduct binding ability are altered in breeding bulls with high sperm DNA Fragmentation index. <i>Theriogenology</i> 172:80-87.	2.74	8.74
23.	Narayanan, K, Jeyakumar, S, Tamil Selvan, RP, Gowane, GR, Priyanka M, Umapathi V, Dechamma, HJ, Manjunatha Patel, BH, Saravanan, P, Ramesha, KP and Sanyal A (2021). Short-term effect of foot-and-mouth disease (FMD) vaccination on the milk yield in the Deoni and crossbred cows. <i>Tropical Anim. Health and Prod</i> . 53 (2):1-6.	1.56	7.56
24.	Nilendu, Paul, Thirumala, Rao, Talluri, Yashpal, Legha, RA, Nag, Pradeep, Kumaresan, Arumugam (2021). Dual staining identifies a greater proportion of moribund spermatozoa in stallion semen with poor cryotolerance. <i>Indian Journal of Animal Reproduction</i> 41(2):28-31.	-	-
25.	Panditrao, DG, Menon, RR, Jose, N, Nath, BS and Sivaram, M (2021). Process optimization for the mechanized dry crystallisation of rice flake-milk pudding mix. <i>International Journal of Dairy Technology</i> . https://doi.org/10.1111/1471-0307.12834 .	4.37	10.37
26.	Pandule, VS, Sharma, Monika, Devaraja, HC, Ravindra, MR (2021). Temporal changes in the physicochemical, textural and sensory attributes of butter fortified with vegetarian source of omega-3 fatty acid. <i>Indian Journal of Dairy Science</i> . 74 (4):283-93.	-	5.95
27.	Paul, N, Talluri, TR, Nag, P & Kumaresan A (2021). Epididymosomes: A potential male fertility influencer. A Review. <i>Andrologia</i> doi:10.1111/and.14155.	2.78	8.78
28.	Prakash, MA, Kumaresan, A, King, JPES, Nag, P, Sharma, A, Sinha, MK, Kamaraj, E and Datta, TK (2021). Comparative transcriptomic analysis of spermatozoa from high- and low-fertile crossbred bulls: Implications for fertility prediction. <i>Frontiers in Cell and Developmental Biology</i> , 9:647717.	6.68	12.68
29.	Rajesh, K, Menon, Rekha R and Sharma, Monika (2021). Application of supercritical fluid extraction for extraction or enrichment of phospholipids in egg and dairy products: a review. <i>Journal of Food Process Engg</i> . 44 (6):June2021:e13692. doi:10.1111/jfpe.13692.	2.36	8.36
30.	Ramya, HR, Devi, MCA, Naveena, N and Subash, S (2021). Constraints Analysis in Integrated Farming System in Select Agro-Climatic Zones of Karnataka State. <i>International Journal of Curr. Microbiol. App. Sci</i> . 10(03):1220-34.	-	-
31.	Reshma, Raj S, Das DN, Mondal, S, Ashokan, M, Thota, Lakshmi Narasimha, Karuthadurai, T, Tej, Nikhil Kumar and Ramesha, KP (2021). Expression analysis of pro-apoptotic BAX and anti-apoptotic BCL-2 genes in relation to lactation performance in Deoni and Holstein Friesian crossbred cows. <i>Animal Biotechnology</i> . doi:10.1080/10495398.2021.2025066.	2.28	8.28
32.	Rohith, S, Pradeep, S, Sivaram, M and Subash, S (2021). Economic sustainability analysis of Gaushalas in selected districts of Telangana state. <i>Indian J Dairy Science</i> , 74(6):526-32.	-	5.95

33.	Rupesh, P Datir, Menon, Rekha Ravindra, Manjunatha, M, Sharma, Monika (2021). Optimization of recombination of milk at different fat levels in a small volume disperser unit. <i>Journal of Food Science and Technology</i> , 58 (4):1389–1400.	2.70	8.70
34.	Shivaswamy, GP, Kallega, HK, Anuja, AR and Singh, KN (2021). An assessment of India's virtual water trade in major food products. <i>Agricultural Economics Research Review</i> , 34 (29):133-41.	-	5.84
35.	Singariya, M, Pagote, CN and Jayaraj Rao, K (2021). Effect of sugar syrup concentration and soaking time-temperature on some physico-chemical characteristics of khoa-jalebi. <i>Journal of Pharmacy and Chemistry</i> , 15(1):3-11.	-	-
36.	Sowmya, D, Padmaja, A, Yadav, GM, Vijaya Geeta, V, Anupama, M and Jayaraj Rao, K (2021). Incorporation of extracts of pulse sprouts in market milk. <i>J. of Pharmacy and Chemistry</i> , 15(2):3-11.	-	-
37.	Subash, S, Girish, V, Devi, MCA and Sivaram, M (2021). An Analysis of Constraints and Suggestions for effective Dairy Extension Delivery System in Karnataka State: Multi Stakeholders Perspective. <i>Indian Journal of Extension Education</i> . Vol. 57, No. 3, 2021.	-	5.95
38.	Subash, S, Girish, V, Devi, MCA and Sivaram, M (2021). Analysis of role performance and effectiveness of dairy extension service providers in Karnataka State. <i>Indian J. Dairy Science</i> 74(6):533-38.	-	5.95
39.	Thejesh, Sadananda, Das, Abhijit, Gururaj, Makarabbi, Khalandar S, Somasekaran, Subash and Muniandy, Sivaram (2021). Economic impact of COVID-19 pandemic on dairy farmers of Karnataka. <i>Indian J. Animal Science</i> , 92 (1):126–31.	0.31	6.32
40.	Tomar, AK, Rajak, SK, MK, MA, Chhikara, N, Ojha, SK, Nayak, S, Chhillar, S, Kumaresan, A and Yadav, S (2021). Sub-fertility in crossbred bulls: Identification of proteomic alterations in spermatogenic cells using high throughput comparative proteomics approach. <i>Theriogenology</i> , 169:65-75.	2.74	8.74
41.	Wankhade, PR, Manimaran, A, Kumaresan, A, Patbandha, TK, Sivaram, M and Jayakumar, S and Rajendran, D (2021). Prediction of postpartum performances of transition Zebu (<i>Bos indicus</i>) cows using receiver operating characteristics analysis. <i>Indian Journal of Animal Sciences</i> , 91(3):188–95.	0.31	6.32

ERS, Kalyani

S.No.	Research Papers	Impact Factor	NAAS Rating
1.	Aswal, M, Prasad, S, Kumar, N, Rajpoot, V, Mondal, M (2021). The haemato-metabolic profile of high producing dairy cows during the transition period. <i>Vet. Arhiv</i> 91, 249-259. doi:10.24099/vet.arhiv.1037.	-	6.50
2.	Baneh, H, Ghaderi-Zefrehei, M, Pouryaei, R, Mandal, A (2021). Genetic analysis of sexual size dimorphism in Markhoz goats. <i>Trop. Anim. Health Prod.</i> , 53 (1):1-11.	-	7.56
3.	Behera, R, Mandal, A, Rai, S, Karunakaran, M, Mondal, M and Ghosh, MK (2021). GenotypeEnvironment Interaction on Milk Production Traits of Crossbred Dairy Cows under Tropical Climatic Condition of India. <i>Indian J. Anim. Res.</i> , doi:10.18805/IJAR.B-4121.	-	6.44
4.	Bhakat Champak, Mohammad, A, Mandal, DK, Mandal, A, Karunakaran, M, Dutta, TK, Rai, S, Chatterjee, A and Ghosh, MK (2021). Effect of dry period duration on udder health, milk production and body condition of Jersey crossbred cows at lower Gangetic tropics. <i>Indian Journal of Animal Research</i> , 55 (8) 985-89.	-	6.44
5.	Chaturvedi, I, Dutta, TK, Singh, PK, Chatterjee, A, Mandal, DK and Das AK (2021). Effect of herbal feed additives on intake, rumen fermentation, availability of nutrients and energetic efficiency of feeds in Barbari kids reared under confined condition. <i>Indian Journal of Animal Sciences</i> , 91 (8) ISSN0367-8318.	-	6.32
6.	Das, S, Nandi, PR, Sarkar, P, Tudu, KC, Rai, S, Behera, R, Mandal, A, Mondal, M and Karunakaran, M (2021). Effect of superoxide dismutase, catalase and glutathione reductase supplementation on cryopreservation of Black Bengal buck semen. <i>Tropical Anim. Health and Prod.</i> 53:552, https://doi.org/10.1007/s11250-021-02995-7 .	-	7.56
7.	Debbarma, K, Karunakaran, M, Sarkar, D, Mondal, M, Mandal, A, Koloi, S, Tripura S and Debbarma, A (2021). Effect of bypass fat supplementation on growth, onset of puberty, biochemical metabolites and reproductive parameters in Jersey crossbred prepubertal heifers. <i>Indian J Animal Nutrition</i> , 38(2):151-59.	-	5.66

8.	Kedare, GM, Vipin, Karunakaran, M, Mandal, A Ghosh, MK & Naskar, S (2021). Effect of area specific mineral mixture supplementation on milk production, biochemical and blood mineral status of Black Bengal goats. <i>Indian J. Dairy Sci.</i> , 74(2):145-49.	-	5.95
9.	Kumar, A and Mandal, A (2021). Evaluation of animal models to explore the influence of maternal genetic and maternal permanent environment effect on reproductive performance of Jersey crossbred cattle. <i>Reprod.Domest. Anim.</i> , 0:1-8.	-	8.01
10.	Mahendra, S, Sarkar, D, Karunakarn, M, Teja, A and Kinkar, D (2021). Surgical management of deep tongue laceration in a cow: A case report. <i>Indian J. Anim. Health</i> . doi: https://doi.org/10.36062/ijah.2021.06021 .	-	5.25
11.	Mandal, A, Baneh, H and Notter, DR (2021). Modeling the growth curve of Muzaffarnagari lambs from India. <i>Livest. Sci.</i> , 251, 104621.	-	7.94
12.	Mandal, A, Baneh, H, Roy, R and Notter, DR (2021). Genetic diversity and population structure of Jamunapari goat in India using pedigree analysis. <i>Trop. Anim. Health Prod.</i> , 53:218.	-	7.56
13.	Mandal, DK, Bhakat C and Dutta, TK (2021). Impact of environmental factors on physiological adaptability, thermo-tolerance indices and productivity in Jersey crossbred cows. <i>International Journal of Biometeorology</i> , 65(12):1999-2009 (https://doi.org/10.1007/s00484-021-02157-2).	-	9.79
14.	Mandal, DK, Mandal, A, Bhakat, C and Dutta, TK (2021). Effect of stress amelioration through open-ridge ventilated thatched roof housing on production and reproduction performance of crossbred Jersey cows <i>Tropical Animal Health & Production</i> , 53(1):144. doi:10.1007/s11250-021-02574.	-	7.56
15.	Medhi, D, Ali, E, Choudhury, LC, Baruah, KK, Santra, A, Dubey, S, Agarwal, P and Chakravarty, P (2021). Isolation, identification and characterization of rumen bacteria and estimation of their fibre degradable enzymes in yak (<i>Bos grunniens</i>). <i>Indian Journal of Animal Sciences</i> . 91(12):1081-84.	-	6.32
16.	Mohammad, A and Chatterjee, A (2021). Cultivation of Berseem (<i>Trifolium alexandrinum</i>) and Oats (<i>Avena sativa</i>) fodder crops by using biofertilizers and biopesticide: An experience from farmers' field in Nadia district of West Bengal. <i>International Journal of Bio-resource and Stress Management</i> . 12(3):211-15.	-	5.11
17.	Mohammad, A and Chatterjee, A (2021). Location-wise variation with respect to livelihood security of farmers in Sunderbans region of India:an extreme weather event perspective. <i>International Research Journal of Modernization in Engineering Technology and Science</i> . 3(6):3420-23	-	-
18.	Santra, A, Tripura, S, Vipin and Das SK (2021). Effects of dietary supplementation of <i>Mallotus philippensis</i> leaf powder on rumen fermentation pattern, enzyme profile and ciliate protozoal population in growing crossbred calves. <i>Indian Journal of Animal Sciences</i> , 91(11):940-46.	-	6.32
19.	Satapathy, D, Dutta, TK, Chatterjee, A, Karunakaran, M, Ghosh, MK and Mohammad, A (2021). Evaluation of ameliorative efficiency of vitamin E and <i>Saccharomyces cerevisiae</i> yeast on arsenic toxicity in black Bengal kids. <i>Small Ruminant Research</i> . 202:106473.	-	7.61
20.	Singh, AK, Bhakat, C, Mandal, DK, Mandal, A, Chatterjee, A, Ghosh, MK, Dutta, TK and Karunakaran, M (2021). Factors Associated with Negative Energy Balance and Its Effect on Behavior and Production Performance of Dairy Cows: A Review. <i>Iranian Journal of Applied Animal Science</i> 11(4):641-53.	-	-
21.	Tudu, KC, Mandal, A, Mondal, M, Das, SK, Ghosh, MK, Rai, S, Bhakat, C and Karunakaran, M (2021). Effect of Butylated Hydroxytoluene and Tocopherol Supplementation on In vitro Sperm Characters during Cryopreservation of Black Bengal Buck Semen. <i>Indian Journal of Animal Research</i> . doi:10.18805/IJAR.B-4349.	-	6.44
22.	Tudu, KC, Sarkar, D, Mandal, A, Mondal, M, Das, SK, Rai, S, Behera, R, Bhakat, C and Karunakaran, M (2021). Effect of L-cysteine Supplementation on Cryopreservation of Black Bengal Buck Semen. <i>Indian J. of Animal Research</i> . doi:10.18805/IJAR.B-4718.	-	6.44
23.	Umdor, SB, Karunakaran, M, Mandal, DK, Santra, A and Das, SK (2021). Enhancement of developmental competence of immature oocytes supplemented with growth factors in culture media. <i>Indian J. of Animal Research</i> . 55(5):493-497. doi:10.18805 /IJAR.B-3994.	-	6.44

Books/ Books Edited:

- Megh Goyal, Monika Sharma and Preeti Birwal (2021). *Handbook of Research on Food Processing and Preservation Technologies: Design and Development of Specific Foods, Packaging Systems and Food Safety*. (Vol. 4) under Book series: Innovations in Agricultural and Biological Engineering. Apple Academic Press (with exclusive worldwide distribution by CRC press), USA. p 290.
- Megh Goyal, Preeti Birwal, Monika Sharma (2021). *Handbook of Research on Food Processing and Preservation Technologies: Non-Thermal and Innovative Food Processing Methods*. (Vol. 1) under Book series: Innovations in Agricultural and Biological Engineering. Apple Academic Press (with exclusive worldwide distribution by CRC press), USA. p 291.
- Monika Sharma, Megh Goyal, Preeti Birwal (2021). *Handbook of Research on Food Processing and Preservation Technologies: Emerging Techniques for Food Processing, Quality and Safety Assurance*. (Vol. 5) under Book series: Innovations in Agricultural and Biological Engineering. Apple Academic Press (with exclusive worldwide distribution by CRC press), USA. p 350.
- Preeti Birwal, Megh Goyal and Monika Sharma (2021). *Handbook of Research on Food Processing and Preservation Technologies: Non-Thermal Food Preservation and Processing Novel Strategies*. (Vol. 2) under Book series: Innovations in Agricultural and Biological Engineering. Apple Academic Press (with exclusive worldwide distribution by CRC press), USA. p 294.
- Preeti Birwal, Megh Goyal and Monika Sharma (2021). *Handbook of Research on Food Processing and Preservation Technologies: Computer-Aided Food Processing and Quality Evaluation Techniques*. (Vol. 3) under Book series: Innovations in Agricultural and Biological Engineering. Apple Academic Press (with exclusive worldwide distribution by CRC press), USA. p 319.
- Sanchita Garai, Gouranga Mazumder and Sanjit Maiti (2021). *Self Help Groups in Eastern India: Women Empowerment, Information Communication Behaviour and Group Dynamics*. Published by LAP LAMBERT Academic Publishing, Germany on October 20, 2021. (ISBN-10: 6204212516 ISBN-13: 978-6204212517; Total page: 168)
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Book Chapters:

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Review Articles

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Institute Publications

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- Seth, R, Bajaj, R and Singh, R (2021). Status of Milk from Indigenous Breeds of Cattle. (NDRI Publication No. 175/2021)

13. TRAINING AND CAPACITY BUILDING

Human Resource Management (HRM) unit has been established at NDRI for effective coordination and implementation of training programmes in accordance with the Govt of India National Training Policy in 2012 based on the tenet of competency based training for all. The training plan of NDRI addresses the gap between the existing and the required competencies and provides opportunities to the employees to develop their competencies.

(A) Deputations Abroad

- Dr. Nishant Kumar, Senior Scientist (Animal Reproduction & Gynaecology) was Deputed for training at Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Washington State University, Pullman, Washington (USA) from September 28, 2021 to November 27, 2021 under IDP-NAHEP Project.

(B) Trainings (Category-wise)

Name of the Employee	Name of Training Programme	Duration	Organizing Institute
Dr. Mohan Mondal, Senior Scientist	ICAR-HRM virtual training programme on Health and Mental Well Being of ICAR-Staff for Enhancing Proficiency	February 25-27, 2021	ICAR-Indian Institute of Wheat & Barley Research, Karnal
Dr. Khushbu Kumari, Scientist	On-Line training programme on MOOC on Theoretical foundations of Education Technology	June 1-30, 2021	ICAR-NAARM, Hyderabad
Dr. A.K. Singh, PS Dr. Rakesh Kumar, PS	Online training on Management Development Programme on Leadership Development (a Pre-RMP programme)	June 14-25, 2021	ICAR-NAARM, Hyderabad
Dr. S.K. Das, PS Dr. Champak Bhakat, PS	Online Collaborative Training Program on Enhancing Agricultural Resilience through Index-based Flood Insurance and Post-flood Management Interventions in India	June 29-30, 2021	ICAR-Indian Institute of Water Management and International Water Mgmt. Institute
Dr. Narender Raju Panjagari, Scientist Dr. Raghu H.V., Scientist	Sensitization of Agril. Scientist on Entrepreneurship Development and Start-up Ecosystems NABL Assessors Training course on ISO/IED 17025:2017	July 5-9, 2021 August 25-27, 2021	ICAR-NAARM, Hyderabad NABL
Dr. Neelam Upadhyay, Scientist Dr. Sangita Ganguly, Scientist	Application of Bioinformatics in Agricultural Research and Education Attended a two weeks online training on General Management Programme for Women Scientists	September 20-24, 2021 December 6-17, 2021	ICAR-NAARM, Hyderabad Administrative Staff College of India (ASCI), Hyderabad

Technical Staff

Name of the Employee	Name of Training Programme	Duration	Organizing Institute
Dr. Rahul Singh Tomar, TA Dr. Rahul Kumar Meena, TA	One week International e-training program on Gene Cloning Advances and Application in Veterinary Science	May 5-Jun 6, 2021	ICAR-NAHEP, Mumbai
Sh. Anil Kumar, ACTO	Training programme on Good Agricultural Practices (GAPs) for higher productivity, profitability and resource-use	August 8-16, 2021	ICAR-NDRI, Karnal
Mr. Naresh Kumar Dahiya, ACTO Ms. Teena Chopra, TO	5 days training programme on e-Governance Application in ICAR	September 6-10, 2021	ICAR-IASRI, New Delhi
Dr. Vikas, TA Sh. Mukesh Onkar, TA Sh. Ram Bahadur, STA	Training on Chemical and Microbiological Quality Assessment of Milk and Milk Products Training Programme on Upskilling Professionals in Scientific Dairying	October 6-26, 2021 October 21-30, 2021	NAHEP, ICAR-NDRI, Karnal DES&M, ICAR-NDRI, Karnal
Sh. Ashwani Kumar, TO	Online Training Programme on Motivation Positive Thinking & Communication Skills	November 25- 30, 2021	NAARM-Hyderabad

Administrative Staff

Name of the Employee	Name of Training Programme	Duration	Organizing Institute
Sh. Brahm Prakash, AAO	Online Training Programme on Reservation in Service	June 28-30, 2021	ICAR-NAARM, Hyderabad
Sh. Vishal Acharya, AAFO	Online Training Programme on Accrual Account for Administrative & Finance Staff of ICAR institutes	July 26-30, 2021	ICAR-NRRI, Cuttack
Sh. Kunal Kalra, SFAO	Online Training Programme on Accrual Account for Administrative & Finance Staff of ICAR institutes	September 20-24, 2021	ICAR-NRRI, Cuttack
Sh. Kunal Kalra, SFAO	Online Training Programme on Train the Trainers	October 25-29, 2021	ASCI, Hyderabad
Smt. Veena Rani, UDC	Online training programme on Establishment Matters for LDCs and UDCs	November 15-20, 2021	ICAR-IISR, Lucknow
Sh. Karambir, UDC			

(C) Participation in Conferences/Seminars/Workshops within India

Name and Designation	Title of Workshop/ Seminar/ Conferences	Period
Dr. Latha Sabikhi, PS	Online meeting organized by Cohesion Foundation (Ahmadabad), an NGO run by NDRI alumni Mr. Rajesh Kumar to participate in the Role Model Interaction for STEM program	January 5, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Marketing of Agricultural Commodities: Challenges and Opportunities	January 2-14, 2021
Dr. K.P. Ramesha, PS	95th meeting of Board of Management of Karnataka Veterinary, Animal & Fisheries Sciences University, Bidar	January 16, 2021
Dr. Champak Bhakat, PS Dr. Ajoy Mandal, PS Dr. Dilip Kumar Mandal, PS	Webinar on Women Empowerment	January 28, 2021
Dr. K.P. Ramesha, PS	Online lecture at XVIII Annual Convention and National Webinar (SOC DAB) on Harnessing Potential of Indigenous Animal Genetic Resources for Enhancement of Productivity and Profitability at NBAGR, Karnal	February 11-12, 2021
Dr. Sudarshan Kumar, Scientist	11 days Online Workshop on Basic & Advanced Proteomics Approaches Workshop-2021 faculty development course at IIT, Bombay sponsored by DST, New Delhi	February 15-26, 2021
Dr. S.K. Das, PS	Webinar on Gene editing research in agriculture: Key Initiatives in India	February 17, 2021
Dr. S.K. Das, PS	International Conference organized by Indian Society for the study of reproduction and fertility (ISSRF), 2021	February 19-21, 2021
Dr. Yogesh Khetra, Scientist	Online Data Visualization and Agricultural Research Training sponsored by ICAR-NAARM, Hyderabad	February 22-27, 2021
Dr. Mohan Mondal, Sr. Sci.	Seminar on Agriculture Research through Knowledge Discovery	February 23, 2021
Dr. Mohan Mondal, Sr. Sci.	ICAR/IDF Webinar on Frameworks for animal welfare assessment and meeting stakeholder needs	February 24, 2021
Dr. Praveen Kumar, PS Dr. Sohan Vir Singh, PS Dr. Mohan Mondal, Sr. Sci.	XXIX Annual conference on Recent approach to escalate livestock productivity under current socio-economic scenario organized by Bihar Veterinary College, Patna	February 25-26, 2021
Dr. K.P. Ramesha, PS	96th meeting of Board of Management of Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar	March 3, 2021
Dr. Suman Kapila, PS Dr. Menon Rekha Ravindra Dr. F. M. Eljeeva Emerald	Online Leadership Development for Women Scientist programme organized by ICAR-NAARM, Hyderabad	March 8-10, 2021
Dr. Ashok Santra, PS	Centennial Symposium (webinar) on, 100 years of Animal Nutrition Research in India	March 11-12, 2021
Dr. T. K. Dutta, PS Dr. Mohan Mondal, Sr. Sci. Dr. Saroj Rai, Scientist	11th India Probiotic Symposium (webinar) Role of gut microbiota and probiotics in reducing viral infections- Mechanisms to combat them	March 13-14, 2021
Dr. K.P. Ramesha, PS	Online talk on Organic Livestock in Regional Centre of Organic Farming, Bangalore	March 15, 2021

Er. Ankit Deep, Scientist	Seminar on the theme Entrepreneurship Development in Dairy Sector at College of Dairy Technology, UDGIR, Latur (MS)	March 15, 2021
Dr. T. K. Dutta, PS	International webinar on Unraveling the digestion behaviour of milk	March 17, 2021
Dr. Anupam Chatterjee, PS	Virtual National Conference on Strategic Reorientation for Climate	March 17-19, 2021
Dr. Champak Bhakat, PS	Smart Agriculture V-AGMET, 2021 organized by Ludhiana Chapter,	
Dr. Sohan Vir Singh, PS	Association of Agrometeorologists & Department of Climate Change and Agriculture Meteorology, PAU, Ludhiana.	
Dr. M. Karunakaran, PS	Diamond Jubilee Celebration of Indian Journal of Animal Health Meet the scientists on National research prospects in Animal & Fishery Sciences and Biotechnology	April 3, 2021
Dr. M. Karunakaran, PS	International E Workshop on recent trends in quality control of bovine semen- A paradigm shift	April 22, 2021
Dr. Champak Bhakat, PS	Webinar on Response to Covid 19 crisis for improving Animal and Human	April 24, 2021
Dr. Anupam Chatterjee, PS	Webinar on Response to Covid 19 crisis for improving Animal and Human	
Dr. A. Kumaresan	health among rural households	
Dr. M. C. A Devi	National Webinar on Innovative Extension Strategies for sustainable livestock development at Department of Veterinary & AH Extension, MVC-TANUVAS Chennai	April 29, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Clomiphene Resistance What next?	May 5, 2021
Dr. S. Subash	National Webinar on Resilience and Cope up Strategies in Pandemic through Agricultural Engineering Interventions-Womens Perspective at ICAR-CIAE, Regional Station, Coimbatore.	May 9, 2021
Dr. Manoj Kumar C.T.	International Webinar on Impact of milk seasonality on product quality and delivery of bioactive compounds at Dairy Chemistry Division, ICAR-NDRI, Karnal	May 11, 2021
Dr. M. C. A Devi	Online Training Programme on Innovative Ideas for Entrepreneurship Development in Livestock Sector at MANAGE, Hyderabad.	May 11-14, 2021
Dr. M. C. A Devi	Webinar on, Extension of Shelf Life of Pasteurised Milk at IDA	May 12, 2021
Dr. M. C. A Devi	International Web-Workshop on the topic titled Innovative and Emerging Technologies for Food Safety & Nutritional Quality at IDP-NAHEP Project.	May 12-13 & May 25, 2021
Dr. Manoj Kumar C.T.	International Webinar on Innovations and Entrepreneurship Development in Agriculture at SRS of ICAR-NDRI, Adugodi, Bengaluru	May 17, 2021
Dr. A. Kumaresan	International Web Workshop on Recent advances in design and emerging applications in lateral flow assays at NAHEP, ICAR-NDRI	May 18-21, 2021
Dr. K. Ponnusamy	National Conference on Empowerment of Rural Community through NSS organized by Avinashilingam Institute for Home Science and Higher Education for Women.	May 19, 2021
Dr. A. Kumaresan	Webinar on Revisiting MSP-Remunerative pricing for crop and livestock produce in Haryana and Rajasthan region at NAAS Regional Chapter, Karnal	May 22, 2021
Dr. A. Kumaresan	NADS (I) Foundation Day and convocation at NADS (I)	May 26, 2021
Dr. S. Subash		
Dr. H. C. Devaraja	International Webinar on Advances in Aseptic Processing and Packaging at	May 31, 2021
Dr. Manoj CT	SRS of ICAR-NDRI, Adugodi, Bengaluru	
Dr. Monika Sharma		
Dr. MCA Devi		
Dr. Satish Kumar M.H.		
Dr. S. Subash	International Webinar Advances in Aseptic Processing and Packaging at Southern Regional Station ICAR-NDRI	May 31, 2021
Dr. M. Karunakaran, PS	Webinar on World Milk Day	June 1, 2021
Dr. A. Kumaresan		
Dr. M. Sivaram, PS		
Dr. Bimlesh Mann, PS	Lecture on Advances in Health Benefits of Milk and Dairy Products in the Webinar organized by Indian Dairy Association	June 1, 2021
Dr. S. Subash	Webinar on: Issues related to Gashala and Dairy Entrepreneurs at NDRI.	June 1, 2021
Dr. M. Sivaram	Online Faculty Development Programme on Application of Mathematics and Programming in Science and Technology at Karunya Institute of Technology and Sciences, Coimbatore	June 1-11, 2021

Mrs. Khushbu Kumari, Scientist	On-Line training Programme on MOOC on Theoretical foundations of education technology at NAARM, Hyderabad.	June 1- 30, 2021
Dr. S. Subash	Online Sensitization program for Agricultural Scientists on Entrepreneurship Development and Start-Up Ecosystem at ICAR-NAARM	June 5-9, 2021
Dr. K.P. Ramesha, PS	A speaker for the OIE Virtual Workshop for Vete Education Establishments and to participate in the Special Seminar on Antimicrobial Resistance (AMR)	June 6-9, 2021
Dr. S. Subash	National Webinar on Agripreneurship in India - Scope, Opportunities and Challenges faced by Agripreneurs & Strategies for a successful Agri-Startup growth at ANGRAU-RARS, Tirupati	June 7, 2021
Dr. K.P. Ramesha, Head	OIE Virtual Workshop for Vety Education Establishments and to participate in the Special Seminar on Antimicrobial Resistance (AMR) in Virtual mode.	June 7-9, 2021
Dr. M. Karunakaran, PS	Webinar on Ovum pick up unit procedures and its solutions	June 8, 2021
Dr. M. C. A Devi	Participated in Webinar on Opportunities and Challenges in Translational Research- its relevance to the India of tomorrow at Team KIIT-TBI TTO	June 9, 2021
Dr. A.K. Singh, PS	Online training Programme on Management Development Programme on Leadership Development (Pre-RMP programme) at NAARM, Hyderabad.	June 14-25, 2021
Dr. Rakesh Kumar, PS		
Dr. M. C. A Devi	Online Training Programme on Promotion of Farmer Producer Organization in Livestock Sector at MANAGE Hyderabad	June 15-17, 2021
Dr. Satish Kumar M.H.	International Webinar on Innovations and Entrepreneurship Development in Agriculture at SRS of ICAR-NDRI, Adugodi, Bengaluru under the IDP-NAHEP Project	June 17, 2021
Dr. S. Subash		
Dr Mukund A. Kataktalware	DDCI-Dutch Dairy Days Webinar (3)-Milking technology/ farm management	June 17, 2021
Dr. Ajoy Mandal, PS		
Dr. M. Sivaram, PS	International Webinar on Innovations and Entrepreneurships Development in Agriculture	June 17, 2021
Dr. S.K. Das, PS	Expert Lecture on Bio-safety regulations and guidelines in India	June 19, 2021
Dr. Dilip Kumar Mandal, PS	International Workshop on Scientific Writing	June 23-24, 2021
Dr. Champak Bhakat, PS		
Dr. S. Subash		
Dr. Monika Sharma		
Dr. MCA Devi		
Dr. Anupam Chatterjee		
Dr. A. Kumaresan		
Dr. Mohan Mondal, Sr. Sci.	International Workshop on Indo-US Workshop on Application of Data Science in Biological Systems	June 23-24, 2021
Dr. S.K. Das, PS	Webinar of Honble Minister of State, Animal Husbandry, Dairying and Fisheries and Micro, Small and Medium Enterprises	June 24, 2021
Dr. S. Subash	Webinar on Start up Ecosystem in Agriculture at M. S. Swaminathan School of Agriculture- Centurion University of Technology and Management.	June 24, 2021
Dr. M. C. A Devi	Participated in Webinar on Start up Ecosystem in Agriculture at Department of Agricultural Extension, M.S. Swaminathan School of Agriculturz- Centurion University of Technology and Management.	June 24, 2021
Dr. Champak Bhakat	Webinar on Role of Rural India on Sustainable Development at ICAR-NDRI, Karnal	June 26, 2021
Dr. Anupam Chatterjee		
Dr. Mohan Mondal		
Dr. S. Subash		
Dr. M. C. A Devi		
Dr. A. Kumaresan	Online Dr. K.K. Iya Memorial Lecture on Challenges and Road Map for Indian Dairying Beyond 2021 at Indian Dairy Association, South Zone, Bengaluru.	June 26, 2021
Dr. S. Subash		
Dr Mukund A. Kataktalware	Webinar on Brain Storming on Potential of Non-bovine Milk Confirmation at NAAS, India	June 29, 2021
Dr. K. Ponnusamy	ICAR-IIWM and IWMI collaborative online training programme on Enhancing Agricultural Resilience through Index-based Flood Insurance and Post-flood Management Interventions in India organized by Indian Institute of Water Management, Bhubaneswar and International water management Institute, Sri Lanka	June 29-30, 2021
Dr. S. Subash	Online Zonal Workshop 2021 at ICAR-ATARI, Bengaluru	June 30, 2021
Dr. S.K. Das, PS		

Dr. A. Kumaresan, PS	International webinar on the topic Impact of oxidative stress on male and female reproduction	July 1, 2021
Dr. S.K. Das, PS	Webinar/motivational talk on Principles to make a synergy amongst physical, mental and spiritual health: A way forward to mitigate stress and to develop positive thinking in work life	July 3, 2021
Dr. Mohan Mondal	Optimization of embryo & oocyte cryopreservation program organized by ISAR	July 3, 2021
Dr. S.K. Das, PS	Webinar on World Zoonosis Day	July 5, 2021
Dr. S. Jeyakumar	Ag-Incubation at NDRI Incubation Centre at e-Workshop on	July 5-9, 2021
Dr. Narender Raju Panjagari	Entrepreneurship & Start-up Ecosystem at ICAR-NAARM, Hyderabad	
Dr. S. Subash	Webinar on Zoonoses and One Health at SRS of ICAR-NDRI & Alumni Association of SRS of ICAR, NDRI, Bengaluru.	July 6, 2021
Dr. A. Kumaresan	Webinar on Know your dairy food from farm to fork at All India Food Processor Association	July 10, 2021
Dr. A. Kumaresan	Guest Lecture webinar on Can gene editing contribute to livestock agriculture? at NAAS Regional Chapter, Bengaluru	July 15, 2021
Dr. S.K. Das, PS	Webinar on Biological Diversity Act 2002 with Special Reference to Access and Benefit Sharing	July 17, 2021
Dr. Champak Bhakat, PS		
Dr. Dilip Kumar Mandal, PS		
Dr. Manoj Kumar C.T.	Webinar on Cold chain technologies, convergence and capacity building at ASSOCHAM	July 17, 2021
Dr. Monika Sharma		
Dr. M. C. A Devi	Participated in Webinar on, Rethinking on Extension Strategies at MANAGE, Hyderabad & AAU, Assam	July 19, 2021
Dr. Mohan Mondal, Sr. Sci.	International Webinar on Colonization and establishment of rumen microbiota-opportunities to influence the livestock productivity	July 20, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Artificial Intelligence for Smart Agriculture	July 22, 2021
Dr. Champak Bhakat, PS		
Dr. Dilip Kumar Mandal, PS		
Dr. Anupam Chatterjee, PS		
Dr. Mohan Mondal, Sr. Sci.		
Dr. Asif Mohammad, Sr. Sci.	International webinar on Milk Proteins for the Future	July 22, 2021
Dr. Mohan Mondal	ILSI India Symposium on Safety and Benefits of Nano technology with focus on its application in Agriculture, Water Safety, Food & Food Safety, Nutrition and Packaging	July 26, 2021
Dr. Manoj Kumar C.T.		
Er. Ankit Deep, Scientist	ऑनलाइन राष्ट्रीय अधिवेशन कोविड-19 जनित परिस्थितियों में देश के आर्थिक विकास एवं आत्मनिर्भरता में कृषि अभियांत्रिकी की भूमिका at ICAR-CIAE, Bhopal	July 28-29, 2021
Dr. M. Karunakaran, PS	Webinar on Large animal model: Status of Cloning and Gene Editing	July 30, 2021
Dr. M. C. A Devi	Online Training Programme on Developing Work-life Well-being for Women Extension Functionaries at MANAGE, Hyderabad and PAMETI, Ludhiana.	August 2-5, 2021
Dr. A. Kumaresan	Stephen J Roberts Memorial Lecture at Veterinary College and Research Institute, Orathanadu, TANUVAS	August 5, 2021
Dr. S.K. Das, PS	Webinar on Harnessing potential of protein engineering to combat diseases by TIGS group	August 10, 2021
Dr. M. Karunakaran, PS		
Dr. Mukund A. Katakaltware	Digital Discussion Series 2020 on Gender and Pandemic: Challenges and Opportunities at ICAR-ATARI, Bengaluru	August 10-12, 2021
Dr. S. Subash	Virtual NADSI- Brainstorming Session on Potential of Small Ruminants in Dairying at NADSI	August 16, 2021
Dr. T. K. Dutta	International webinar on Diet- microbe interactions and human health	August 21, 2021
Dr. S.K. Das		
Dr. Ajoy Mandal		
Dr. Anupam Chatterjee		
Dr. M. Karunakaran		
Dr. Asif Mohammad		
Dr. Champak Bhakat, PS	IDA webinar on Impact of feeding herbs to cattle on the properties of milk	August 21, 2021
Dr. Dilip Kumar Mandal, PS		
Dr. Raghu H.V., Scientist	NABL Assessors Training Course on ISO/IED 17025:2017	August 25-27, 2021

Dr. M. Karunakaran, PS Dr. Mohan Mondal, Sr. Sci.	Webinar on Agricultural Residues Conversion To Biofuels Through Solar Powered Microwave Pyrolysis	August 27, 2021
Dr. S.K. Das, PS Dr. M. Karunakaran, PS	National Webinar on Recent Advances in Animal Genetics for Improving Poultry Productivity organized by Indian Council of Agricultural Research-Research Complex for Eastern Region, Patna.	August 28, 2021
Dr. S.K. Das, PS	International Webinar entitled Diet-Microbe Interactions and Human Health by Dr Ravinder Nagpal (Assistant Professor), Department of Nutrition & Integrative Physiology, Florida State University, Tallahassee, FL (USA) have been scheduled on August 28th from 3:30PM onwards on the topic We and our micro biome: diet microbe interactions in our health & disease.	August 28, 2021
Dr. A. Kumaresan, PS Dr. Asif Mohammad, Sr. Sci.	Webinar on Analysis of obviousness requirement in Indian Patent System	August 28, 2021
Dr. S.K. Das, PS	Webinar on Climate change and Agriculture; Role of Extreme Events on the occasion of Azadi Ka Amrut Mahotsav. Organized by ICAR-Indian Institute of Oilseeds Research (IIOR),	August 31, 2021
Dr. A. Kumaresan	Six-week online agMOOCs course on Management of infertility in cattle – Completed with distinction at TANUVAS, Chennai, IIT, Kanpur and Commonwealth of Learning, Canada	August 31, 2021 to October 15, 2021
Dr. A. Kumaresan, PS	2nd International online Flow Cytometry course on Flow cytometry and its application in biomedical sciences at Trust for Education and Training in Cytometry	September 1-4, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Nutritional Security in India : Issues and Way Forward	September 4, 2021
Dr. S.K. Das, PS Dr. Ajoy Mandal, PS Dr. M. Karunakaran, PS Dr. Asif Mohammad, Sr. Sci.	Webinar for Developing Practical Leadership Skills by Major Priya Jhingan organized by NDRI, Karnal	September 13, 2021
Dr Mukund A. Kataktalware	Webinar on Production Diseases in Farm Animals- Part-I at Intas Polivet	September 13, 2021
Dr. M. Karunakaran, PS	Webinar on Leadership in the creation of a New Scientific endeavour - Role of a Visionary	September 16, 2021
Dr. S.K. Das, PS Dr. Champak Bhakat, PS Dr. Anupam Chatterjee, PS Dr. Mohan Mondal, Sr. Sci.	National webinar on Scientific Goat Farming: From the Livelihood to Financial Security for the Farmers, organized by ICAR Research Complex for Eastern Region	September 18, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Exploring Identities in Peer review: A look at Author, Reviewer, and Journal Perspectives	September 20, 2021
Dr. Neelam Upadhyay, Scientist	Application of Bioinformatics in Agricultural Research and Education	September 20-24, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Author and Reviewer Experiences: Building a bridge of empathy	September 21, 2021
Dr. Mohan Mondal, Sr. Sci.	Webinar on Behind the scenes: How a Peer Reviewer Reviews a Manuscript	September 22, 2021
Dr. Asif Mohammad, Sr. Sci.	IRMI Webinar: Funding Opportunities from India Research Management Initiative-2021 organized by India Alliance	September 24, 2021
Dr. S. Subash	Online 19th Annual Convocation cum Scientific Convention (Virtual Mode) on Transforming Livestock health and production with innovative technologies and policy reforms to boost farmers income at National Academy of Veterinary Sciences (I)	September 24, 2021
Dr. S.K. Das, PS	19th Annual Convocation-cum-Scientific Convention of NAVS 24-25 sep21	September 24-25, 2021
Dr. A. Kumaresan Dr. A. Manimaran	3rd Annual Conference of Animal Physiologists Association (APA) and National Symposium on-Physiological Interventions for the augmentation of sustainable Animal Production at DUVASU Mathura, Uttar Pradesh	September 24-25, 2021
Dr Mukund A. Kataktalware	Webinar on Production Diseases in Farm Animals- Part-II at Intas Polivet	September 27, 2021
Dr. S. Subash	International Webinar Conference on Alternate Cropping Systems for Climate Change and Resource Conservation at ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut	September 29, 2021 to October 1, 2021
Dr. S.K. Das, PS Dr. Ajoy Mandal, PS Dr. Dilip Kumar Mandal, PS	International Webinar on Genomic Dairy Cattle Breeding in Developed Countries - with a view to its application in India under the aegis of IDP-NAHEP, organized by Animal Genetics & Breeding Division of ICAR-NDRI, Karnal	September 30, 2021

Dr. S.K. Das, PS Dr. Champak Bhakat, PS Dr. Anupam Chatterjee, PS Dr. S.A. Hussain Dr. Gunjan Bhandari	National webinar on Gandhian Philosophy and Current Scenario in Agriculture	October 2, 2021
Dr. Laxmana Naik N	Participated in 5 days online training programme on Innovations in Educational Technology at ICAR-NAARM, Hyderabad	October 4-8, 2021
Dr Mukund A. Katakataware	Webinar on Lesser-Known Animal Genetic Resources of India: An Overview at ICAR-NBAGR, Karnal	October 5, 2021
Dr. Rakesh Kumar, PS Dr. S. Subash	International Conference on Moringa Pariyakulam, Tamilnadu	October 6-8, 2021
Dr. S.K. Das, PS Dr. S. Subash	National Webinar on Agro-Environmental Ethics at ICAR-NDRI Webinar on Entrepreneurship in Food Industry at Alumni Association of SRS of ICAR, NDRI, Bengaluru	October 7, 2021 October 16, 2021
S. Jayakumar	International Symposium on Novel Knowledge, Innovative practices and Research in Theriogenology (Attended through online) at Dept. of Animal Reproduction, Gynaecology and Obstetrics, College of Veterinary Sciences, Mannuthy, KVASU.	October 19-20, 2021
Dr. Archana Verma, PS	Online Management Development programme (MDP) on Management & Leadership Development Programme at Institute of Rural Management Anand (IRMA), Gujarat	October 21-22, 2021
Dr. S.K. Das, PS	National Webinar on Engineering Self-reliance in Dairy Industry (Through Virtual Mode) Organized by: Indian Dairy Engineers Association (IDEA) & Dairy Engineering Division, NDRI	October 23, 2021
Dr. Rajeev Kapila, PS	Directors/ Divisional Heads/ Chief Scientists/ Senior Scientists Policy for Science and Science for Policies (Online) by Ministry of Science and Technology, Govt. of India.	October 25-29, 2021
Dr. Nitin Tyagi, PS	Training cum Workshop on Livestock methane emission assessment, impact and amelioration strategies organized by ICAR-NIANP Bangalore.	October 26-28, 2021
Dr. Bimlesh Mann, PS	Lecture on Migration of Chemical Additives from Food Packaging Material -New Generation contaminants in the International Conference on Convergence of Tech. and Policy for Sustainable Meat Production organized by Association of Meat Scientists & Technologies (AMST), Meat Tech. Unit (MTU), Kerala Vet. & Animal Sciences University (KVASU) in virtual mode.	October 26-28, 2021
Dr. S.K. Das, PS	Webinar on Application of Multi -Omics in Animal Production organized by ICAR-National Bureau of Animal Genetic Resources Speaker: Dr. James M. Reecy, Professor, Associate Vice President of Research, Department of Animal Science, College of Agriculture & Life Sciences, Iowa State University, USA	October 27, 2021
Dr. Shivaswamy G.P.	Oral presentation on An assessment of magnitude and drivers of Indias virtual water trade in major food products at 29th Annual Conference of Agricultural Economics Research Association, OUAT, Bhubaneswar	October 27-29, 2021
Dr. K.P. Ramesha, PS	Radio Talk on Breeds of cows and Buffaloes of Karnataka to be broadcast on Rajyotsava Day.	November 1, 2021
Dr. M. C. A Devi Dr. S. Subash	International Virtual Conference Transforming Agricultural Advisory Services to Mitigate the Effects of the Pandemic for Farmers Welfare- (ICTAAS-2021) at VIT, TANUVAS, Bule Hora University, Ethiopia and Al Neelain University, Sudan	November 12-13, 2021
Sh. Dhiraj Sharma, Dy. Director	वाराणसी स्थित व्यापार केन्द्र में दो दिवसीय अखिल भारतीय राजभाषा सम्मेलन में प्रतिभागिता।	November 13-14, 2021
Dr. Ashok Santra Dr. Nitin Tyagi Dr. Rajani Kumar Paul Dr. A. Manimaran Dr. Sachin Kumar Dr. A. K. Singh Dr. T.K. Mohanty	XV Agriculture Science Congress & ASC Expo (Online) by BHU, Varanasi under DST Project	November 13-16, 2021

Dr. Sanjit Maiti, Sr. Sci.	Workshop on Researchable ideas and methods: Improving competency of social scientists under the 5th Faculty Development Program of IDP-NAHEP at CAU, Imphal.	November 15-20, 2021
Dr. Meena Malik, Professor (English) Dr. P.S. Minz, Sr. Sci. Dr. Chitranayak, Sr. Sci. Dr. Hima John, Scientist	51st Annual Conference of ELTAI-A four day Virtual Conference (two weekends) Online	November 20-21, & November 27-28, 2021
Dr. Vairat Amita Dinkar, Scientist	International symposium on Emerging trends in Agricultural Engineering Education, Research and Extension (Online). Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar	November 23-25, 2021
Dr. Vairat Amita Dinkar, Scientist	55th Annual Convention of Indian Society of Agricultural Engineers on Challenges and Technological Solutions for Ensuring Food, Water and Energy Security	November 23-25, 2021
Dr. Sanjeev Kumar, Scientist	Lecture in the 5th International Agronomy Congress Agri. Innovations to Combat Food and Nutrition Challenges at PJTSAU, Hyderabad	November 23-25, 2021
Dr. Asutosh, PS	5th International Agronomy Congress at PJTSAU, Hyderabad	November 25-27, 2021
Dr. Ajoy Mandal, PS	Webinar on Sustainable Development in Dairy Sector- Clean Milk Production (online)	November 26, 2021
Sh. Rakesh Kumar, Asstt. Director	चब्द शेखर आजाद कृषि एवं प्रौद्योगिकी विश्वविद्यालय(कैलाश भवन सभागार, कानपुर, उत्तर प्रदेश में आयोजित किए गए उत्तर क्षेत्र-1 तथा 2 के एक दिवसीय क्षेत्रीय राजभाषा सम्मेलन एवं पुरस्कार वितरण समारोह	November 27, 2021
Dr. Shivaswamy G. P	Attended a National Workshop on `Farmers Income and Research Impact Assessment at ICAR-NIAP	November 29, 2021
Dr. Asif Mohammad, Sr. Sci.	Management of Water Surplus - Deficit Dichotomy in North Eastern Agriculture to enhance the Productivity organized by NIRDPR-NERC, GUWAHATI in association with ICAR-Research Complex-North Eastern Hill Region, Meghalaya	November 30, 2021
Dr. S.K. Das, PS	Webinar on Protection of plant varieties, the Key to Improved Agricultural Commerce & Growth	December 1, 2021
Dr. S.K. Das, PS	Webinar on How to Write Claims in a Patent Application? organized by Institute Technology Management Unit (ITMU) at ICAR-NDRI, Karnal	December 1, 2021
Dr. Ajmer Singh, PS Dr. B. S. Chandel, PS Dr. A. K. Dixit, PS	81st Annual Conference of Indian Society of Agricultural Economics at Shri Mata Vaishno Devi University Katra, Jammu & Kashmir.	December 1-3, 2021
Dr. Asif Mohammad, Sr. Sci.	Geospatial Approach for Water management in Urban and Rural Areas organized by ICAR Research Complex for Eastern Region, Patna, Bihar-800014	December 3, 2021
Dr. K. Jayaraj Rao	Workshop on Waste to Wealth – Use of Food Industry Waste as Animal Feed and Beyond at National Academy of Agricultural Sciences, New Delhi	December 3, 2021
Dr. Champak Bhakat, PS Dr. Anupam Chatterjee, PS	ISCAR Webinar on Sustainable Integrated Farming System for Coastal India	December 4, 2021
Dr. Satish Kumar M.H. Dr. MCA Devi	Online webinar Enhancing Resilience through Entrepreneurship at ICAR-NAAR	December 6-10, 2021
Dr. Sangita Ganguly, Scientist	Two week training on General Management Programme for Women Scientists in Online Mode from Administrative Staff College of India (ASCI), Hyderabad.	December 6-17, 2021
Dr. K.P. Ramesha, PS Dr. S. Subash	Birth Centenary Celebrations of Dr. Verghese Kurien by Indian Dairy Association (South Zone) at Hotel Abu Sarover Protico, Chennai	December 8, 2021
Dr. Menon Rekha Ravindra	Online training programme on Statistical Design and Analytical Methods for Multifactorial Experiments at ICAR-CMFRI	December 8-17, 2021
Dr. Champak Bhakat, PS Dr. Anupam Chatterjee, PS	5th Webinar on Implementation and Use of Agril. Research Management System	December 9, 2021
Dr. Bimlesh Mann, PS Dr. Vikas Vohra, PS	National symposium of Indian Society for Buffalo Development (ISBD) on Scientific Interventions to Address Challenges for Sustainable Buffalo	December 10-11, 2021

Dr. M. Karunakaran, PS Dr. Pawan Singh, PS Dr. Chander Datt, PS Dr. Gautam Mandal, PS Dr. M.L. Kamboj, PS Dr. Manoj K. Singh, Sr. Sci. Dr. Sudarshan Kumar, Sr. Sci. Dr. Rubina K. Baithalu, Sci. Dr. Naresh Selokar, Scientist	Production (online) organized by GADVASU, Ludhiana	
Dr. G. R. Gowane, Sr. Sci.	Annual Conference and Presented a paper at Avikanagar.	December 13-14, 2021
Dr. Hardev Ram, Scientist	International Conference at SKRAU, Bikaner	December 13-15, 2021
Dr. Raman Malik, PS	Management Development Programmes on Leadership Development (Online) ICAR-NAARM, Hyderabad	December 13-24, 2021
Dr. Monika Sharma	Pre-Vibrant Gujarat Summit 2021, Agro and Food Processing: Entering a new Era of Cooperation at Agriculture, Farmer Welfare and Co-operation department, Government of Gujarat.	December 14-16, 2021
Dr. K.P. Ramesha, PS	A talk on the activities of SRS of ICAR-NDRI at All India Radio studio, Bangalore for the benefit of Researchers, Farmers and others.	December 16, 2021
Dr. Sohanvir Singh, PS	Lead lecture on Heat Stress: Impact and ameliorative measures for adaptation and animal welfare during the National Seminar at college of veterinary science and AH, ANDU&T, Ayodhya.	December 17-18, 2021
Dr. Pradip Behre, Scientist	10th International Conference on Fermented Foods, Health Status and Social Well-being (Online) University of Research Council of University of Peradeniya, Sri Lanka	December 17-18, 2021
Dr. Naresh Selokar, Dr. Manoj K. Singh Dr. Archana Verma, PS Dr. Suneel Kumar Onteru, PS	National Conference on Animal Breeding Strategies in the Era of Genomics and Phenomics ICAR-NBAGR, Karnal Oral presentation in the National Conference at NBAGR, Karnal A lead talk on Prospective of functional markers for postpartum anestrus in Murrah buffaloes during one of the scientific session on Functional genomics for trait specific characterization and value addition in livestock and poultry in Online at ICAR-NBAGR, Karnal	December 17-18, 2021 -do- -do-
Dr. S. Subash	Online training programme on Impact Assessment of Agricultural Research and Technologies at ICAR-NAARM, Hyderabad	December 18-22, 2021
Dr. S.K. Das, PS Dr. Asif Mohammad, Sr. Sci.	International Webinar and Memorial Orations of Indian Society of Veterinary Pharmacology and Toxicology (ISVPT)-2021	December 21, 2021
Dr. Asif Mohammad, Sr. Sci.	Agro-Biodiversity Conservation use for Climatic Resilience and Livelihood Improvement of Small Holder Farmers by ICAR-VPKAS, Almora under UN Environment GEF Project	December 23, 2021
Dr. M. Karunakaran, PS Dr. A. Kumaresan, PS Dr. Asif Mohammad, Sr. Sci.	International Symposium of the Indian Society for Study of Animal Reproduction (ISSAR) on Novel knowledge, Innovative Practices and Research in Theriogenology	December 27-29, 2021
Dr. K.P. Ramesha, PS	Dr. C.M. Singh Memorial Birth Centenary Year Lecture in virtual mode.	December 30, 2021

14. MAJOR EVENTS

1)	Workshop on Food Safety	January 4-7, 2021
2)	Webinar on Nutritional Strategies to Minimize the Risk of Hypocalcemia	January 7, 2021
3)	Marketing of Agricultural Commodities-Challenges and Opportunities	January 12-14, 2021
4)	The Foundation Day of Probiotic Association of India (PAI)	January 23, 2021
5)	Webinar on Women Empowerment	January 28, 2021
6)	Webinar on Advances in Application of Membrane Processing in Dairy & Food Industry	February 17, 2021
7)	International Webinar on Metabolomics and Proteomics in Food Science	March 1-3, 2021
8)	Trends in Food Packaging	March 5, 2021
9)	Kishan Gosthi for SC Farmers Organized at NDRI Farmers Service Center at Lalukheri (Muzaffarnagar, UP)	March 6, 2021
10)	Webinar on Trends in Food Technology	March 15, 2021
11)	Unravelling the Digestion Behaviour of Milk	March 17, 2021
12)	Inaugural Program of SCSP Project' cum Farmers Training on 'Scientific Livestock Farming' at SRS of ICAR-NDRI	March 19, 2021
13)	Webinar on Recent advances in the processing of high-value dairy products	March 20, 2021
14)	Atal Incubation Centre-SRS-ICAR-NDRI Foundation, Bengaluru Inaugurated	March 20, 2021
15)	World Water Day	March 22, 2021
16)	Malnad Gidda Farmers training at Gokarna	March 26, 2021
17)	Upscaling Women-Centric Dairy Processing Technologies	March 30, 2021
18)	SC-SP sub-fund of Network Project on Buffalo Improvement	March 31, 2021
19)	Webinar on Structures and digestion of milk & milk products	March 31, 2021
20)	Webinar on Protein Supplementation in Dairy and Food Products: Opportunities and Challenges	April 23, 2021 & May 7, 2021
21)	Webinar on Making a Startup Successful - Mastering the Skill to Fund Your Ideas	April 29, 2021
22)	Webinar on Wear behavior of cheese and its correlation with rheology and sensory behaviours	April 30, 2021
23)	Webinar on Impact of milk seasonality on product quality and delivery of bioactive compounds	May 11, 2021
24)	Workshop on Innovative and Emerging Technologies for Food Safety & Nutritional Quality	May 12-13 and 25, 2021
25)	Webinar on Sustainability and the search for novel water antimicrobials for use in post-harvest processing of various foods to enhance microbial safety	May 17, 2021
26)	Workshop on Recent Advances in Design and Emerging Applications in Lateral Flow Assay	May 18-21, 2021
27)	Webinar on Advances in Aseptic Processing and Packaging	May 31, 2021
28)	World Milk Day: Problem and Solutions for Gaushalas and Dairy Entrepreneurs	June 1, 2021
29)	Webinar on Innovations and Entrepreneurship Development in Agriculture	June 17, 2021
30)	Webinar on Dairy Vavsaya Hetu Hara Chara Utpadhan evm Sarakshan	June 22, 2021
31)	Workshop on Scientific Writing	June 23-24, 2021
32)	Webinar on Role of Rural India in Sustainable Development	June 26, 2021
33)	The 99th Foundation Day of ICAR-NDRI, Karnal	July 1, 2021
34)	The 99th Foundation Day of ICAR-NDRI by the Alumni Association of Southern Regional Station (SRS), Bangalore	July 1, 2021
35)	Webinar on Impact of Oxidative Stress on Male and Female Reproduction	July 1, 2021

36)	Webinar on Host-microbial interactions in Neonatal calves	July 5, 2021
37)	Webinar on Zoonosis and one Health (SRS)	July 6, 2021
38)	One day Lecture on Biological Diversity Act 2002 with Special Reference to Access and Benefit Sharing	July 17, 2021
39)	Webinar on Biological Diversity Act	July 19, 2021
40)	International Symposium on 'Harnessing the potentials of genome editing tools to augment the productivity and health of farm animals	July 19-20, 2021
41)	Webinar on Colonization and Establishment of Rumen Microbiota-opportunities to Influence the Livestock Productivity	July 20, 2021
42)	Webinar on Milk Proteins for the future	July 22, 2021
43)	Webinar on Career Opportunities in Dairy Sector	August 19, 2021
44)	Webinar on Diet-Microbe Interactions and Human Health	August 21, 2021
45)	Hands-on training on Techniques in Molecular Biology	August 21-30, 2021
46)	Webinar on Dietary Interventions for Addressing Menopausal Symptoms	August 27, 2021
47)	One day lecture on Analysis of obviousness requirement in Indian Patent System.	August 28, 2021
48)	Webinar on Developing Practical Leadership Skills	September 13, 2021
49)	International Webinar on Genomic Dairy Cattle Breeding in Developed Countries- with a view to its application in India	September 20, 2021
50)	International Webinar on Genomic Dairy Cattle Breeding in Developed Countries	September 30, 2021
51)	Training programme on "Entrepreneurship Development in Dairying"	October 1-5, 2021
52)	Webinar on "Gandhian Philosophy and Current Scenario of Agriculture"	October 2, 2021
53)	National Training programme on "Chemical and Microbiological Quality Assessment of Milk and Milk products"	October 6-26, 2021
54)	Webinar on "Agro-Environmental Ethics"	October 7, 2021
55)	World Food Day	October 16, 2021
56)	World Zoonoses Day	October 16, 2021
57)	National Training Programme on Upskilling of Extension Professionals in Scientific Dairying	October 21-30, 2021
58)	National Webinar on "Engineering Self-reliance in Dairy Industry"	October 23, 2021
59)	Interaction workshop for exploring technology transfer for new dairy products	November 11, 2021
60)	Webinar on Lactose: Properties and Processing	November 19, 2021
61)	Milk Day Celebrations	November 26, 2021
62)	Release of MobileApp "Milksafecon"	November 26, 2021
63)	National Milk Day	November 26, 2021
64)	Webinar on Biotechnological Interventions in Dairy Processing	November 27, 2021
65)	Webinar on Membrane Separation of Dairy Streams- An industrial perspective	November 29, 2021
66)	Online Awareness Programme 'Flaxseed: Processing, Quality Evaluation and Health Benefits'	November 30, 2021
67)	One day lecture on "How to write claims in a patent application"?	December 1, 2021
68)	First Memorial Lecture in the name of late Dr. C.P. Anantakrishnan	December 11, 2021
69)	International Webinar on "Exploration of genomic data: Applications in livestock and beyond"	December 16, 2021
70)	Orientation Programme Fit India Freedom Run-2.0	December 29, 2021

15. PERSONNEL

Institute Staff

As on 31st December, 2021

Director's Cell

M.S. Chauhan, PhD	Director
Nirmala Kumari, BA	Private Secretary

Joint Director (Research) Cell

Dheer Singh, PhD	Joint Director
Shakuntla Rani, BA	Private Secretary

Research Prioritisation, Monitoring and Evaluation Unit

Meena Malik, BA, MPhil, PhD	Professor (English)
Braj Kishor, MA, BLib Sci	Assistant Chief Technical Officer
Lakshman, BCom	Technical Officer

Joint Director (Academics) Cell

R.R.B. Singh, PhD	Joint Director
Santosh, BA	Private Secretary

Academic Affairs Management Unit

Nitin Tyagi, PhD	Academic Coordinator
Ravinder Malhotra, PhD	Controller of Examinations
Bhagwan Das, BA	Assistant Administrative Officer

Administrative Wing

Vivek Purwar, MTech	Chief Administrative Officer &
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Joint Director (Administrative) & Registrar {Acting}

Abhishak Rana, BE	Senior Administrative Officer
Ram Niwas, BA	Administrative Officer
Rajbir, BA	Assistant Administrative Officer
S.S. Meena, BA	Assistant Administrative Officer
Bhagwan Dass	Assistant Administrative Officer
Subhash Chand, BA	Assistant Administrative Officer
Ajit Singh, BA	Assistant Administrative Officer
Ram Pal, BA	Assistant Administrative Officer
Gurjeet, MPharma	Assistant Administrative Officer
Subhash Chander	Assistant Administrative Officer
Ram Dhari Singh	Assistant Administrative Officer
Raj Kumar	Assistant Administrative Officer
Chiranjee Lal	Assistant Administrative Officer
B.L. Meena	Assistant Administrative Officer

Right to Information Act (RTI)

Dheer Singh, PhD	Appellate Authority
Bimlesh Mann, PhD	Central Public Information Officer

Rakesh Kumar, PhD	Transparency Officer
S. Jeyakumar, PhD	Assistant Public Information Officer
T.K. Dutta, PhD	Assistant Public Information Officer
Gurjeet Singh, MPharma	Assistant Public Information Officer
Veenu, MCA	Technical Officer

Finance Wing

D. D. Verma, MCom, PGDFM	Comptroller
R. K. Singh,	Senior Finance & Account Officer
Kunal Kalra, BCom, PGDM	Finance & Accounts Officer
Vishal Acharya, MA	Assistant Finance & Account Officer

Animal Genetics & Breeding Division

Archana Verma, PhD	Principal Scientist & Head
Sabyasachi Mukherjee, PhD	Principal Scientist
Anupama Mukherjee, PhD	Principal Scientist
Vikas Vohra, PhD	Principal Scientist
Gopal R. Gowane, PhD	Senior Scientist
Rani Alex, PhD	Scientist
Satish Kumar Rathee, PhD	Scientist
Vinod Kumar	Technical Officer

Livestock Production & Management Division

Arun Kumar Misra, PhD	Principal Scientist & Head
Pawan Singh, PhD	Principal Scientist
T.K. Mohanty, PhD	Principal Scientist
M.L. Kamboj, PhD	Principal Scientist
S.S. Lathwal, PhD	Principal Scientist
Mukesh Bhakat, PhD	Principal Scientist
Ramesh Chandra, PhD	Senior Scientist
Nishant Kumar, PhD	Senior Scientist
Rubina Baithalu, MVSc	Scientist
Shiv Kumar, MSc	Assistant Chief Technical Officer

Animal Nutrition Division

Raman Malik, PhD	Principal Scientist & Head
Chander Datt, PhD	Principal Scientist
Nitin Tyagi, PhD	Principal Scientist
Goutam Mondal, PhD	Principal Scientist
Sachin Kumar, PhD	Scientist (SS)
Uttam Kumar, PhD	Chief Technical Officer
Gyan Singh, MSc	Assistant Chief Technical Officer
Sumit Narayan, MSc	Senior Technical Officer

Animal Physiology Division

Parveen Kumar, PhD	Principal Scientist
Sohanvir Singh, PhD	Principal Scientist
A.K. Dang, PhD	Principal Scientist
Anjali Aggarwal, PhD	Principal Scientist
A.K. Roy, PhD	Senior Scientist
Manju Ashutosh, PhD	Senior Scientist

Ashutosh, PhD	Senior Scientist
Y.P. Singh, BSc	Technical Officer
Dheeraj Kumar	Technical Officer
Avnish Kumar, BCom	Personal Assistant

Animal Biotechnology Centre

S. De, PhD	Principal Scientist & Head
J.K. Kaushik, PhD	Principal Scientist
A.K. Mohanty, PhD	Principal Scientist
D. Malakar, PhD	Principal Scientist
Satish Kumar, PhD	Principal Scientist
Rakesh Kumar, PhD	Principal Scientist
M.K. Singh, PhD	Scientist
S. Kumar, PhD	Scientist

Animal Biochemistry Division

Gautam Kaul, PhD	Principal Scientist & Head
Rajeev Kapila, PhD	Principal Scientist
Suman Kapila PhD	Principal Scientist
Suneel Kumar Onteru, PhD	Senior Scientist
Suneeta Meena, MSc	Scientist
Sadeesh E. M., PhD	Scientist
Ravi Kant, PhD	Assistant Chief Technical Officer
Anita Rani, BA	Private Secretary

Dairy Technology Division

A.K. Singh, PhD	Principal Scientist & Head
Latha Sabikhi, PhD	Principal Scientist
Kaushik Khamuri, PhD	Principal Scientist
P. Narender Raju, PhD	Senior Scientist
G.S. Meena, PhD	Scientist (SS)
Yogesh Kehtra, PhD	Scientist (SS)
Shaikh Abdul Hussain, PhD	Scientist (SS)
Gunvantsinh Rathod, MTech	Scientist
Writdhama G. Prasad, PhD	Scientist (SS)
Sangita Ganguly, PhD	Scientist
Heena Sharma, PhD	Scientist
Gourav Kumar Deshwal, MTech	Scientist
Sunita Chaudhary, BA	Private Secretary

Experimental Dairy

Surinder Kumar	Chief Technical Officer & In-charge
Lehri Singh, MSc	Chief Technical Officer
Sanjeev Kumar, MA	Assistant Chief Technical Officer
Gurpartap Singh, MTech	Technical Officer
Jagdish, BA	Technical Officer
Pardeep Singh, MTech	Technical Officer

Dairy Chemistry Division

Raman Seth, PhD	Principal Scientist & Head
Bimlesh Mann, PhD	Principal Scientist
Sumit Arora, PhD	Principal Scientist

Vivek Sharma, PhD	Principal Scientist
Rajan Sharma, PhD	Principal Scientist
Rajesh Bajaj, PhD	Principal Scientist
Richa Singh, PhD	Scientist
K. P. Indumati, MSc	Scientist
Kamal Gandhi, PhD	Scientist
Rajani Gandhi, BA	Private Secretary

Dairy Microbiology Division

A. K. Puniya, PhD	Principal Scientist & Head
Naresh Kumar, PhD	Principal Scientist
Shilpa Vij, PhD	Principal Scientist
Chand Ram, PhD	Principal Scientist
P. V. Behare, PhD	Scientist (SS)
Raghu H.V., PhD	Scientist (SS)
Rashmi H. M., MTech, PhD	Scientist (SS)
Diwas Pradhan, MTech, PhD	Scientist
Saurabh Kadyan, MTech	Scientist
Seema Rani, BA, BEd	Personal Assistant

Dairy Engineering Division

P. Barnwal, PhD	Principal Scientist & Head
Chitranayak, PhD	Senior Scientist
P.S. Minz, PhD	Scientist (SS)
Amita Vairat, PhD	Scientist
Ankit Deep, MTech	Scientist
Khushbu Kumari, MTech	Scientist
Priyanka, MTech	Scientist
Hima John, PhD	Scientist
Sunil Kumar, MTech	Assistant Chief Technical Officer
ManjuBala, Diploma	Technical Officer
Varinder Hans, BA	Technical Officer
Suraj Singh Meena, BSc, DMLT	Private Secretary

Dairy Economics, Statistics and Management Division

B. S. Chandel, PhD	Principal Scientist & Head
Ravinder Malhotra, PhD	Principal Scientist
Ajmer Singh, PhD	Principal Scientist
A. P. Ruhil, PhD	Principal Scientist
A. K. Sharma, PhD	Principal Scientist
Anil Kumar Dixit, PhD	Principal Scientist
Udita Chaudhary, MSc	Scientist
Gunjan Bhandari, MSc	Scientist
Tara Chand, BSc	Assistant Chief Technical Officer

Dairy Extension Division

K. S. Kadian, PhD	Principal Scientist & Head
Gopal Sankhala, PhD	Principal Scientist
K. Ponnusamy, PhD	Principal Scientist
B. S. Meena, PhD	Principal Scientist
H. R. Meena, PhD	Principal Scientist
Ritu Chakravarty, PhD	Senior Scientist

Raj Kumar, PhD	Senior Scientist
Sanjit Maiti, PhD	Scientist
Sanchita Garai, PhD	Scientist
Anjana, BA, BEd	Private Secretary

Forage Research and Management Centre

Rakesh Kumar, PhD	Principal Scientist & In-charge
Magan Singh, PhD	Senior Scientist
Hardev Ram, PhD	Senior Scientist
Sanjeev Kumar, PhD	Scientist (SG)
Rajesh Kumar Meena, PhD	Scientist (SG)
Vijender Kumar Meena, PhD	Chief Technical Officer

Agricultural Technology Information Centre (ATIC)

Raj Kumar	Principal Scientist & In-charge
Ashwani Kumar	Senior Technical Officer

Krishi Vigyan Kendra/ TTC

Pankaj Kumar Saraswat, PhD	Principal Scientist & Head
Ramesh Chandra, PhD	Senior Scientist
Neelam Upadhyay, PhD	Scientist
Satish Kumar, PhD	Subject Matter Specialist
Jitender Singh Rana, PhD	Subject Matter Specialist
Rakesh Kumar Tonk, PhD	Subject Matter Specialist
Deepa Kumari, BSc, MA	Technical Officer
Arun Kumar T.V., PhD	Technical Officer
Munish Kumar, MSc	Technical Officer
Yogesh Kumar, PhD	Subject Matter Specialist
Mamta Bhardwaj, MSc	Agromet Observer
Raj Kumar, BCom, BEd, DCOM	Assistant Administrative Officer

Forage Production Section

Anurag Saxena, PhD	Principal Scientist & In-charge
Satish Kumar, PhD	Chief Technical Officer
Anil Kumar Dagar, MSc	Assistant Chief Technical Officer
Ravi Rawat, MSc	Senior Technical Officer
Mahender Pal	Technical Officer

Livestock Research Centre

S. S. Lathwal PhD	Principal Scientist & In-charge
Nishant Kumar, MVSc	Senior Scientist
Rubina Kumari Bithalu, MVSc	Scientist
Pramod Kumar, MSc	Assistant Chief Technical Officer
Amarpal Singh, PhD	Senior Technical Officer
Ashwani Kumar, MSc	Senior Technical Officer
Rajbir	Technical Officer
Samar Singh	Technical Officer

Animal Health Complex

Parveen Kumar, MVSc	Chief Technical Officer
S. Raju, MVSc	Chief Technical Officer
J. K. Pundir, BVSc	Assistant Chief Technical Officer
Sahdev Singh, MSc	Assistant Chief Technical Officer

Artificial Breeding Research Centre

Pawan Singh, PhD	Principal Scientist & In-charge
T. K. Mohanty, PhD	Principal Scientist
Mukesh Bhakat, PhD	Senior Scientist
Subhash Chand, BVSc	Senior Technical Officer
Kaushal Kumar	Technical Officer
Ghanshyam Meena	Technical Officer

National Library in Dairying

A.K. Puniya, PhD	Principal Scientist & Head
B. P. Singh, MA, PGDCA, MLIBSc	Assistant Chief Technical Officer
Narendra Singh, MCA, MLIBSc	Senior Technical Officer
Sunil Sharma, MSc	Senior Technical Officer
Deen Dayal Kumar, MLIBSc	Technical Officer

Computer Centre

Udita Chaudhary, PhD	Scientist & In-charge
Naresh Kumar Dahiya, MTech	Assistant Chief Technical Officer
Des Raj, Diploma CSP	Technical Officer

Communication Centre

Diwas Pradhan, MTech, PhD	Scientist & In-charge
Saurabh Singh, MTech	Technical Officer

Vehicle Maintenance Section

Sanjeev Kumar, BTech, MSc	Technical Officer
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Official Language Unit

Dhiraj Sharma, MA, PGJMC	Dy. Director
Rakesh Kumar, MA	Assistant Director
Kanchan Choudhary, MA	Assistant Chief Technical Officer

Security Section

Ashutosh, PhD	Senior Scientist & In-charge
Deepak Chopra, BA	Security Officer
Rajvir Singh, MA, PGDCA	Security Supervisor

Maintenance Section

JK Dabas, PhD (Mechanical Eng.)	Chief Technical Officer
Balbir Singh, ITI (Electrical)	Technical Officer
Mohan Lal, MTech (Electrical Eng.)	Technical Officer
Ravinder Singh, BTech (Civil Eng.)	Technical Officer
Namo Narayan Meena, Diploma (Mechanical Eng.)	Technical Officer

Human Health Complex

Suneel Onteru, PhD	Principal Scientist & In-charge
Manoj Kumar, MBBS	Senior Medical Officer
Richa Walia, Diploma	Technical Officer
Saroj Kathuria, Diploma	Technical Officer
K. S. Khanna	Technical Officer

Saroj Bala, Diploma	Technical Officer
Anuradha, Diploma	Technical Officer
Deepak	Technical Officer

Hospitality Cell

Pradip Vishnu Behare, PhD	Scientist & In-charge
Sanjiv Kumar, BTech, MSc	Technical Officer
Navdeep Singh, BTech	Technical Officer

Sports Section

A. K. Singh, PhD	Principal Scientist & In-charge
G. S. Meena, PhD	Coordinator
Sandeep Deswal,	Sports Instructor

Estate Section

Sushil Kumar Kamboj, MSc	Chief Technical Officer & In-charge
P. M. Meena, MSc	Assistant Chief Technical Officer

Southern Regional Station, Bengaluru

K. P. Ramesha, PhD	Principal Scientist & Head
Bandla Srinivas, PhD	Principal Scientist
K. Jayaraj Rao, PhD	Principal Scientist
D. N. Das, PhD	Principal Scientist
M. C. Arunmozhi Devi, PhD	Principal Scientist
A. Kumaresan, PhD	Principal Scientist
S. Jeyakumar, PhD	Principal Scientist
P. Heartwin Amala Dhas, PhD	Principal Scientist
M. Sivaram, PhD	Principal Scientist
Menon Rekha Ravindra, PhD	Principal Scientist
Mukund A. Katakataware, PhD	Principal Scientist
F. Magdaline Eljeeva Emerald, PhD	Principal Scientist
Mamta, PhD	Senior Scientist
S. Subash, PhD	Senior Scientist
A. Manimaran, PhD	Senior Scientist
Monika Sharma, PhD	Senior Scientist
H.C. Devaraja, PhD	Senior Scientist
Sathish Kumar, M.H., PhD	Senior Scientist
Vedamurthy, PhD	Scientist
Priyanka Singh Rao, PhD	Scientist
S. Varalakshmi, PhD	Scientist
Laxman Naik. N., PhD	Scientist
P. Muruganantham, MLib Sci	Chief Technical Officer
V.R.V. Surendranath Naik, MD	Chief Technical Officer
B.K. Rajashekaraiyah, BSc	Chief Technical Officer
P.G. Satish, BVSc	Chief Technical Officer
Siddaramanna, PhD	Senior Technical Officer
Gurunath Gouda Patil, BSc	Assistant Technical Officer
Janakshi, MCA	Assistant Technical Officer
Meganathan, Diploma	Senior Technical Officer
K.P. Lakshminarayanappa, DME	Senior Technical Officer
K. Ningaraju, MVSc	Assistant Technical Officer
M.S. Nagarajaiah, Diploma	Senior Technical Officer

Vimala, BSc
K. Ramakrishna Prasad, MSc

Senior Technical Officer
Technical Officer

Eastern Regional Station, Kalyani

S.M. Deb, PhD	Principal Scientist & Head
T.K. Dutta, PhD	Principal Scientist
Subrata K Das, PhD	Principal Scientist
A. Santra, PhD	Principal Scientist
Champak Bhakat, PhD	Principal Scientist
A. Mandal, PhD	Principal Scientist
D.K. Mandal, PhD	Principal Scientist
A. Chatterjee, PhD	Principal Scientist
M. Karunakaran, PhD	Principal Scientist
M. Mondal, PhD	Senior Scientist
Asif Mohammad, PhD	Scientist
Saroj Rai, PhD	Scientist
Rajalakshmi Behra, PhD	Scientist
Alokesh Goswami, MSc	Chief Technical Officer
Amitava Ghosh, MVSc	Chief Technical Officer
Somnath Dutta, MVSc	Chief Technical Officer
P. Saha, MSc	Chief Technical Officer
D. Munjani	Technical Officer
Sukhdev Singh	Assistant Administrative Officer
S. Roy Deb	Private Secretary

PERSONALIA

Joining/ Appointments/ Promotions

- Dr. Anurag Saxena, Principal Scientist joined ICAR-NDRI upon his transfer from ICAR-Central Arid Zone Research Institute, Jodhpur w.e.f. 18.12.2020 vide office order No. F.12-60/11/E.I(S)/Vol.II- dated 4.01.2021.
- Sh. Biswajit Sen, Scientist joined ICAR-NDRI, Karnal upon transfer from, ICAR-NAARM, Hyderabad w.e.f. 4.01.2021 vide this office order No.F.10-49/2014/E.I(S)/Vol.III-169-177 dated 20.01.2021.
- Dr. Naresh Lalaji Selokar, Scientist joined ICAR-NDRI on transfer from CIRB, Hisar w.e.f. 18.01.2021 vide this office order No.F.12-60/11/E.I(S)/Vol.II-214-221 dated 28.1.2021.
- Dr. Pankaj Kumar Saraswat, Senior Scientist & Head, KVK-Tamenglong, Manipur joined ICAR-NDRI w.e.f. 20.01.2021 vide this office order No. F.6-48/20/HOD/E.I(S)/Vol.III-254-262 dated 2.02.2021.
- Dr. Rajani Kumar Paul, Scientist in Animal Biochemistry discipline joined ICAR-NDRI upon transfer from ICAR-CSWRI, Avikanagar, Rajasthan w.e.f. 8.04.2021.
- Dr. Dheer Singh joined as Joint Director (Research) w.e.f. 27.04.2021 at ICAR-National Dairy Research Institute, Karnal.
- Smt. Meenu Rani, PA joined to the post of Private Secretary in the Pay Level-7 (44900-142400) on regular basis at ICAR-NDRI, Karnal with effect from 14.6.2021
- Following Scientists were promoted to the next higher Research Grade Pay under CAS w.e.f. date mentioned against each:-

Sr.No.	Name, Designation & Division of the Scientist	Promoted to Next higher Grade Pay	Date of Promotion
1)	Dr. Vedamurthy G V, Scientist, ABC	RGP of Rs. 7000/-	1.01.2019
2)	Dr. Priyanka Singh Rao, Scientist, DC	RGP of Rs. 7000/-	1.01.2018
3)	Dr. Richa Singh, Scientist, DC	RGP of Rs. 7000/	1.01.2018
4)	Dr. Diwas Pradhan, Scientist, DM	RGP of Rs. 7000/	1.01.2018

5)	Dr. Writdhama G Prasad, Scientist, DT	RGP of Rs. 7000/-	1.01.2019
6)	Dr. Neelam Upadhyay, Scientist, Food Technology	RGP of Rs. 7000/-	1.01.2019
7)	Dr. Sachin Kumar, Scientist, Animal Nutrition	RGP of Rs. 7000/-	1.01.2019
8)	Dr. Manoj Kumar Singh, Scientist, ABTC	RGP of Rs. 8000/-	10.02.2018
9)	Dr. Sudarshan Kumar, Scientist, ABTC	RGP of Rs. 8000/-	21.04.2018
10)	Dr. Prashant Saurabh Minz, Scientist, AS&PE	RGP of Rs. 8000/-	10.02.2019
11)	Dr. P. Narender Raju, Scientist, FS&T	RGP of Rs. 8000/-	15.12.2018
12)	Dr. A. Manimaran, Scientist, Veterinary Pharmacology	RGP of Rs. 8000/-	7.02.2019
13)	Dr. Sanjit Maiti, Scientist, Vet. Ext. Education	RGP of Rs. 8000/-	21.10.2018
14)	Dr. Asif Mohammad, Scientist, Vet. Ext. Education	RGP of Rs. 8000/-	4.11.2018
15)	Dr. S. Subash, Scientist, Vet. Ext. Education	RGP of Rs. 8000/-	4.11.2018

- Sh. G.G. Harakangi, CAO joined his duties to the post of Chief Administrative Officer (Senior Grade) on 2.09.2021 at ICAR-NDRI, Karnal.
- Sh. Ram Dhari, Assistant was promoted to the post of Assistant Administrative Officer under Promotion Quota in the Pay Level-7 at ICAR-NDRI, Karnal w.e.f. 15.09.2021.
- Sh. Gajanand Yadav, SAO joined his duties in the forenoon of 08.10.2021 at ICAR-NDRI, Karnal.
- Sh. Ravinder joined his duties to the post of SAO in the forenoon of 14.10.2021 at ICAR-NDRI, Karnal.
- Sh. Jagdish Chander joined his duties to the post of SF&AO in the forenoon of 14.10.2021 at ICAR-NDRI, Karnal.
- Sh. Rajbir, Assistant Administrative Officer joined his duties on promotion as AO on 3.11.2021 at ICAR-NDRI.
- The following Assistants were promoted to the post of Assistant Administrative Officer under Promotion Quota at ICAR-NDRI, Karnal:-

SN	Name	Date of Placement
1	Sh. Raj Kumar	25.10.2021
2	Sh. Chiranjeel Lal	25.10.2021
3	Sh. Babu Lal Meena	25.10.2021

- The following Senior Scientists were promoted to the post of Principal Scientists w.e.f. the date mentioned against each:-

SN	Name of Senior Scientist	Date of Placement
1	Dr. Ashutosh	03.06.2009
2	Dr. F. Magdaline Eljeeva, Emerald	31.10.2020
3	Dr. Chitranayak	08.11.2020

Transfer/Retirement/Relieving

- Dr. Tirtha Kumar Datta, Principal Scientist & In-charge, ABTC was relieved from ICAR-NDRI, Karnal in the FN of 15.01.2021 to join as Director, ICAR-CIRB, Hisar.
- Dr. S.K. Tomar, Principal Scientist, DM Division retired on attaining the age of superannuation on 31.01.2021 from ICAR Services.
- Dr. B.C. Ghosh, Principal Scientist, DT, SRS, Bengaluru retired on attaining the age of superannuation on 31.01.2021 from ICAR Services.
- Dr. Manoj Kumar C.T. was transferred from NDRI, Karnal to SRS, Bengaluru vide this O.O. No.F.12-60/11/E.I(S)-Vol.II/7128 dated 4.2.2021.
- Dr. Sujeet Kumar Jha, Principal Scientist was relieved from ICAR-NDRI, Karnal on 27.02.2021 to join his duties at ICAR-IISWC, Regional Station, Chandigarh.
- Dr. I.D. Gupta, Principal Scientist, AG&B Division retired on attaining the age of superannuation on 27.02.2021 from ICAR Services.
- Smt. Prem Kumari, Private Secretary retired on attaining the age of superannuation on 30.04.2021 from ICAR Services.

- Dr. (Mrs.) Madhu Mohini, PS Animal Nutrition Division retired on attaining the age of superannuation on 31.05.2021 from ICAR Services.
- Dr. Parveen Kumar, PS Animal Physiology Division retired on attaining the age of superannuation on 31.05.2021 from ICAR Services.
- Sh. Arvind, Senior Finance & Accounts Officer was relieved from his duties at ICAR-NDRI, Karnal in the afternoon of dated 23.06.2021 to enable him to join his duties at new place of posting at ICAR-CTRI, Rajahmundry-533105, Andhra Pradesh.
- Dr. (Mrs.) Veena Mani, PS, Animal Nutrition Division retired on attaining the age of superannuation on 31.07.2021 from ICAR Services.
- Dr. Asit Das, PS, Animal Nutrition was transferred to ICAR-IVRI, Bareilly vide Council's order dated 24.09.2021 and relieved from ICAR-NDRI w.e.f. 27.10.2021.
- Dr. Rajalaxmi Behera, Scientist, AG&B was transferred from ERS-ICAR-NDRI, Kalyani DPR, RS, Bhubaneswar vide Council's order dated 24.09.2021 and relieved from ICAR-NDRI w.e.f. 30.09.2021.
- Sh. Brahm Prakash, Assistant Administrative Officer was relieved on 05.11.2021 from ICAR-NDRI on promotion as AO at ICAR-CSSRI.

Additional Responsibility

- Dr. Anurag Saxena, Principal Scientist was entrusted with the responsibility of In-charge, FRMC and FPS, ICAR-NDRI, Karnal w.e.f. 18.12.2020.
- Dr. S. De, Principal Scientist was entrusted with the responsibility of In-charge, ABTC, ICAR-NDRI, Karnal for a period of six months w.e.f. 15.01.2021.
- Dr. A.K. Misra, PS was entrusted with the responsibility of Acting Head, LPM, ICAR-NDRI, Karnal w.e.f. 8.02.2021.
- Dr. A.K. Dang, PS was entrusted with the responsibility of Acting Head, Animal Physiology, ICAR-NDRI, Karnal w.e.f. 1.06.2021.
- Dr. Raman Malik, PS was entrusted with the responsibility of Acting Head, Animal Nutrition, ICAR-NDRI, Karnal w.e.f. 1.08.2021.
- Dr. Archana Verma, PS was entrusted with the responsibility of Acting Head, Animal Breeding, ICAR-NDRI, Karnal w.e.f. 23.07.2021.
- Dr. R.R.B. Singh, Principal Scientist was entrusted with the responsibility of Acting Head, DT Division, ICAR-NDRI, Karnal for a period of six months w.e.f. 30.03.2021
- Dr. Kaushik Khamrui, Principal Scientist was entrusted with the responsibility of Secretary, SINED (TBI) in place of Dr. A.K. Singh, Principal Scientist w.e.f. 17.05.2021.
- Dr. Dheer Singh, Joint Director (Research) was entrusted with the following responsibilities.
 - ✓ National Referral Lab on Milk Quality & Safety
 - ✓ ITMU
 - ✓ TBI/ BPD
 - ✓ Consultancy Cell
 - ✓ Human Health Complex
 - ✓ ATIC
 - ✓ Press
- Dr. A.K. Dang, Principal Scientist, Animal Physiology Division was nominated to handle the twitter/ face book account of the Institute in place of Dr. Gautam Kaul.
- Dr. Neelam Upadhyay, Scientist, DT Division was nominated as General Secretary of ICAR-NDRI, Staff Club in place of Dr. Gautam Kaul.
- Dr. Bimlesh Mann, Principal Scientist, DC Division was nominated as Chairman, Consultancy Cell in place of Dr. A.K. Singh, Principal Scientist.
- Dr. Bimlesh Mann, Principal Scientist, DC Division was nominated as CPIO of the Institute in place of Sh. Abhishek Rana, SAO.

- Dr. Suneel Kumar Onteru, Principal Scientist, Animal Biochemistry was entrusted with the responsibility to act as Officer In-charge, Human Health Complex, ICAR-NDRI, Karnal in place of Dr. Dheer Singh, JD(Research).
- Dr. Vikas Vohra, Principal Scientist, AG&B was entrusted with the responsibilities of Coordinator, Dairy Production and Management wing of the Placement Cell w.e.f. 13.07.2021.
- Dr. A.K. Puniya, Principal Scientist was entrusted with the responsibilities of In-charge, Library Services w.e.f.22.07.2021.
- Dr. A.K. Mishra, PS & Acting Head, LPM was entrusted with the responsibilities of Chairman, Animal Allotment Committee w.e.f. 22.07.2021.
- Dr. Udit Chaudhary, Scientist, Dairy Economics was assigned the responsibilities of In-charge, Computer Centre and EPABX w.e.f.29.07.2021.
- Sh. G.G. Harakangi, CAO (SG) was entrusted with the responsibility of Head of Office w.e.f 03.09.2021.
- Dr. Dheer Singh, Joint Director (Research) was entrusted with the responsibilities of Nodal Officer of 'Gender Advancement for Transforming Institutions (GATI) w.e.f. 03.09.2021.
- Dr. Dheer Singh, Joint Director (Research) was entrusted with the responsibilities of Chairman of "Lab to Wheel" Committee w.e.f.03.09.2021.
- Dr. M.S. Chauhan, Director was entrusted with responsibilities of Chairman of Library Advisory Committee (LAC) w.e.f. 07.09.2021 and Chairman of Institute Technology Management Committee (ITMC) w.e.f. 27.09.2021.
- Dr. Ravinder Malhotra, Principal Scientist, DES&M and CEO, ICAR-NDRI, Karnal was entrusted with the responsibilities of Nodal Officer for RTI-MIS portal facilities w.e.f. 23.09.2021.
- Dr. A.K. Mishra, PS & Acting Head, LPM was entrusted with the responsibilities of Chairman, LRC Committee w.e.f. 06.10.2021.
- Sh. G.G. Harakangi, CAO (SG) and I/c JD(Administration) & Registrar was nominated to act as Member, Institute Deputation Committee (IDC) in place of Sh. Vivek Purwar, CAO w.e.f. 28.10.2021.
- Sh. Ravinder, SAO was nominated to act as Convener, Institute Deputation Committee (IDC) in place of Sh. Ram Niwas Panchal, former AO w.e.f. 28.10.2021.
- Dr. Rajesh Bajaj, PS, DC Division was entrusted the responsibilities to act as Chairman, Proprietary Item Committee in place of Dr. Dheer Singh, JD(Research) w.e.f. 11.11.2021.
- Dr. Manoj Kumar Singh, Scientist, ABTC was entrusted with the responsibilities to act as Liaison Officer (OBC) w.e.f. 17.11.2021.
- Dr. Dheer Singh, JD (Research) was entrusted with the responsibilities to act as Chairman of the Committee for verification/validation of applications against various posts advertised by the ASRB.
- Dr. Suneel Kumar Onteru, PS, ABC was nominated to act as Member, Proprietary Item Committee in place of Dr. Rajesh Bajaj, PS, DC Division w.e.f. 30.11.2021.
- Consequent upon the relieving of Sh. D.D. Verma, Comptroller from this Institute, Sh. Jagdish Chander, SF&AO was nominated in place of Sh. D.D. Verma in all Committees.

17. MAIN CAMPUS, ICAR-NDRI, KARNAL

RESEARCH DIVISIONS

ANIMAL GENETICS & BREEDING

The Division of Animal Genetics and Breeding was established in the 1960s in the Main Campus of ICAR-NDRI, Karnal. This Division is the part of the chequered history of dairy cattle crossbreeding in India for increasing the milk production at the national level which was started in the early 1970s, and as a result of which, India became a milk-sufficient state from the milk-deficient one. Development of two high-yielding dairy cattle crossbreds-Karan Fries and Karan Swiss was the signature of this glorious achievement.

Animal Genetics & Breeding Division has been actively involved in conducting research in the areas of animal genetics and breeding including cytogenetics and molecular genetics. The research thrust areas of the division are genetic improvement of indigenous and crossbred cattle and Murrah buffaloes by progeny testing of breeding males, faster multiplication of indigenous cattle, development of sustainable breeding plans, part and complete characterization of genes and their association with production/reproduction traits, disease resistance, screening of young breeding males for genetic disorders and assessment of reproductive efficiency of cattle and buffaloes.

The division also fulfills the mandate of extension in the area of Animal Genetics and Breeding through training programs in KVK, TBI and Dairy Extension Division, Consultancy services to farmers and various dairy stake holders, supplies superior germplasm in the form of frozen semen and surplus breeding males to farmers, livestock developmental agencies, state governments and other stake holders involved in dairy development in the country.

The organizational structure for research consists of Animal Breeding Lab., Biometrical Genetics Lab., Buffalo Breeding Lab., Molecular Genetics Lab., DNA Bank for cattle and buffaloes, Livestock Record Cell and besides this, breeding herds of cattle (Karan Fries, Sahiwal, Tharparkar & Gir) and Murrah buffaloes is also the integral part of the research component of Animal Genetics and Breeding Division. The Divisional Library has 436 books, 253 M.Sc./ M.V.Sc. and 152 Ph.D. theses.

LIVESTOCK PRODUCTION AND MANAGEMENT

The Livestock Production and Management (LPM) section came into being in June, 2009 after being carved out of Dairy Cattle Breeding Division of the institute. Separate faculty of LPM along with board of studies was in existence since 1976 and post graduate and doctorate degree programmes in LPM were continuing. The faculty of LPM is engaged in conducting research in the frontline areas of all applied aspects of dairy animal production and has been successful in evolving many transferable technologies and development of package of practice on the routine care and management of dairy animals. The faculty of LPM is engaged teaching both at UG and PG levels. The LPM faculty is also shouldering the responsibility of the routine management of the cattle yard and breeding bulls maintained at the Animal Breeding Research Center of Institute besides supporting the training and extension activities of the institute.

The mandate of the section includes, (i) To maintain elite germplasm repository of dairy animals of the identified breeds, (ii) Development of state-of-art dairy animal management facilities and infrastructure for high yielding dairy animals, (iii) To carry out research, in collaboration with different divisions, in the upstream areas of dairy animal production, (iv) To standardize the package of management practices and to demonstrate the state of the art dairy animal production system to clients and (v) To provide consultancy to the needy farmers and entrepreneurs for establishment of commercial dairy farms.

The organizational structure for research consists of Sensor and Animal behavior lab, Molecular Reproduction lab, ABRC, Andrology and semen preservation lab, milk analysis lab, ARGO lab in LRC, Livestock research center.

ANIMAL BIOTECHNOLOGY

Biotechnology was initiated at NDRI, Karnal during mid-eighties under a UNDP 'Centre of Excellence on Biotechnology' programme. The urgent need for application of recent biotechnological advances in reproduction and production of superior females of dairy breeds of ruminants for improving animal productivity in our country formed the basis for the establishment of a state-of-the-art Embryo Biotechnology Centre (EBC) with financial support from the Department of Biotechnology. Biotechnology was further strengthened by establishment of Livestock Genome Lab and Molecular Biology Unit. Animal Biotechnology Centre was reorganized in June 1999 by consolidating all the infrastructure facilities created under various programmes on biotechnology. Besides research on areas relevant to biotechnology in dairy production and processing, the Centre also offers M.Sc./ M.V.Sc./ M.Tech. and Ph.D. (Animal Biotechnology) programmes.

The objectives of the proposed Division are 1) To undertake biotechnology oriented basic and applied research programmes for improving animal productivity and for developing innovative dairy processes for producing superior quality, safe and wholesome dairy products, 2) To train manpower in application of Biotechnology in Dairy Production and Dairy Processing and 3) To organize Masters and Ph.D. programmes in Biotechnology for the NDRI Deemed University.

ANIMAL PHYSIOLOGY

Animal Physiology used to function as a section of the erstwhile Dairy Husbandry Division and subsequently as Dairy Cattle Nutrition and Physiology Division till the end of the 6th Five Year Plan. The discipline of Animal Physiology received the status of an independent division in 1984. The division made a humble beginning with limited resources at its disposal. The scientists of the division have contributed to the development of infrastructural facilities to initiate research in the area of Embryo Biotechnology centre and now the same has been established as Animal Bio-Technology Centre. The division not only succeeded in establishing the state-of-the-art research facilities, but also earned fame in publishing the best quality research papers at the Institute. The scientists and the students have earned exemplary recognitions while working at this division and abroad during training and postdoctoral programs. The alumni of the division have achieved higher positions in research and management in the Institute and in ICAR/ SAUs. The division has always taken a lead in organizing various brain storming sessions, conferences, symposia and training programs for the benefit of scientific and technical community engaged in research.

The division has been committed to conduct Research, Teaching, and Extension activities in the different areas of Animal Physiology Discipline that are Environmental and Stress Physiology, Lactation and Immuno Physiology, Growth and Reproductive Physiology, and Endocrinology. In particular, the division has always come forward to solve the problems of dairy farmers. The division has developed certain useful technologies like induction of lactation, rBST to augment milk production, milk SCC for udder health and CMP and application of mist and fan to alleviate summer stress, which have been adopted several progressive farmers of the area. A large Animal Treadmill was indigenously developed for the draft evaluation system and work-rest cycle in working bullocks. Somatic Cell Counts as an index of clean milk production and udder health in milch animals have been a major focus for a package of practices. A modern custom-designed shelter with automatic control systems has been installed in Livestock Research Centre to ameliorate the heat stress. Water-saving/ purification demonstration units have been installed at the animal farm and are ready to use by the dairy farmers. Modern state-of-the-art facilities are available at National Innovations on Climate Resilient Agricultural Research Centre (NICRA).

ANIMAL NUTRITION

Dairy Cattle Nutrition Division was established in the year 1972, as Dairy Cattle Nutrition and Physiology Division. Later in the year 1978, it was bifurcated into independent division as Dairy Cattle Nutrition and Dairy cattle Physiology. Research and teaching in the field of animal nutrition has been the main focus of the division. Dairy Cattle Nutrition Division was renamed as Animal Nutrition Division in the year 2016. Animal Nutrition Division undertakes basic and applied research in field of post-graduate programmes of education and participates in the process of extension education through various training programmes and field level technology development and refinement in the discipline of animal nutrition and forage production. Work on various aspects of energy and

protein nutrition in cattle and buffalo was initiated in context of Indian scenario since inception of this division. Milk replacer and calf starter based on locally available sources were developed along with their feeding schedule. Utilization of NPN compounds upto 33% of the requirement was worked out and recommended. Protection of protein and fat was carried out resulting into efficient utilization of protein and decrease in bio-hydrogenation of fats leading to production of unsaturated fatty acids in milk. Work was also done on nutrient requirements of cattle, buffalo and goats. Utilization of Zn and vitamin A and iodine was studied.

Degcure mixture was developed as a cure for degnala disease. Sulphur requirements with NPN compounds were also standardized. Sources of minerals were evaluated for their availability and chelated minerals were prepared and evaluated. Utilization of various newer feed resources and improvement of nutritive value of straw by biological treatment, block making and detoxification of anti-nutritional factors had been carried out. Surveys have been carried out to find the prevalence of pesticide and toxic metals as well as essential trace minerals.

Recently work has been initiated on newer feed resources and trace elements, utilization of various newer feed resources and improvement of nutritive value of straw to curb the shortage of feed resources for the livestock. With the emergence of one health concept more focus has been diverted into value addition of milk and meat products, probiotics and prebiotics application in animal nutrition, mineral nutrition, and methane emission and its mitigation strategies.

Animal Nutrition Division has many national, international and collaborative research projects which are externally funded by agencies like ICAR, DBT, DST, NABARD, NDDDB and MoE. Every year this division publishes several research papers in national and international journals which are on par with the international research papers. In recognition of the research work, faculty of Dairy Cattle Nutrition division has received various awards like Vasvik research award, NAAS fellow, ANA fellow and Dr. K. Pradhan Young Scientist Award and several. Scientists of the division are actively involved in extension activities, and village awareness programs such as Swachh Bharat Abhiyan and also involved in educating dairy farmers on ration balancing through technical bulletins, folders and manuals of feed formulations. This division offers Ph.D. and Masters Program in Animal Nutrition discipline. Students of animal nutrition have bagged various national and international scholarships like PM international scholarship, JENESYS International fellowship and are being placed in various institutes as scientist, assistant professors and also in industry.

The research laboratories are equipped with modern analytical instruments for chemical and physical analysis. The Division has developed excellent laboratory facilities, which are central facilities for research and education, not only for the Institute but also for various sister organizations seeking such support from time to time. The central facilities include central fine instrumentation laboratory, laboratory for anaerobic rumen microbial work, laboratory for environment related studies including methanogenesis, quality control laboratory, feed processing unit and nutritional biotechnology laboratory. Some of the sophisticated instruments available include atomic absorption spectrophotometer, gas-liquid chromatography, HPLC system, ¹⁵N-Analyzer, methane analysis equipment using SF₆ technique, spectrophotometer, PCR machine etc. Research on precision nutrition is being undertaken since the past few years.

FORAGE RESEARCH & MANAGEMENT CENTER

Agronomy Section (Forage Research and Management Centre) was established as a sister section of forage production section in July, 2013 to strengthen the research and teaching and extension activities related to round the year forage production and quality improvement of forages through agronomic manipulations. The mandate of section includes, generating the human resource in Forage Agronomy, developing the agro-techniques for enhancing the fodder productivity and quality through efficient management of resources and to disseminate the knowledge about new agro-techniques for forage crop production and management to the dairy farmers/extension functionaries. At present, intake of students is 5 for masters and 4 for doctoral programmes. There are facilities for quality analysis of forage and about 10 acre land for conducting research experiments.

ANIMAL BIOCHEMISTRY

The Division of Animal Biochemistry came into being in September 1984 with the merger of the discipline of Animal Biochemistry of Dairy Chemistry Division and the Division of Human Nutrition and Dietetics. Research endeavours of the Division are presently directed towards development of probiotic foods, dairy

nutraceuticals and their mechanism of action, validation of health benefit claims of Indian dairy products, characterization of genes related to fertility in buffalo, signal transduction mechanism in sperm functions, identification of fertility markers, and bioinformatics in dairy processing and production.

The salient research achievements of the Division are: development of different types of probiotic dahi and validation of their health-benefits in reducing serum cholesterol levels, protection against gastrointestinal cancer and management of diabetes in animal models, validation of nutraceutical attributes of dairy ghee in coronary heart diseases, gastro-intestinal and mammary cancer and improvement of immune system, and elucidation of its molecular mechanism, bioavailability of vitamins and minerals from dairy products, levels of conjugated linoleic acid in milk products, characterization of 8 amino acid transport systems in mammary gland and their induction at the onset of lactation, antiatherogenic properties of milk and its mechanism, hormonal profile of reproductive phases of buffalo, biochemical changes in sperm maturation, capacitation, acrosome reaction and semen freezing, signal transduction mechanism of sperm function, expression and hormonal regulation of fertility related ovarian genes in buffalo, SSCP analysis of CYP19 aromatase gene in anestrus buffaloes, transduction pathways (PI3K and MAPK) in cattle granulosa cells during steroidogenesis and apoptosis, estrus identification in buffaloes by typical fern-like patterns of saliva, health benefits of bovine and non-bovine milk, osteoanabolic peptides from casein and whey proteins, antiaging, antiallergy, immunomodulatory, antidiabetic and hypocholesterolemic effect of three probiotic cultures *Lactobacillus fermentum* (MTCC: 5898) and *Lactobacillus rhamnosus* (MTCC: 5897) & *Lactobacillus rhamnosus* (MTCC: 5957), Molecular basis of resistance against pediocin and nisin by *Enterococcus faecalis* and nanosafety of anthropenic nanomaterials.

The organizational structure for research consists of Functional Foods and therapeutics lab; Immunochemistry lab; Molecular Endocrinology, Functional Genomics and Systems Biology Lab; Mammalian cell culture lab, Laboratory of mitochondrial biology of farm animals; Non-bovine milk lab and Nanotechnology lab. In addition, The Division has instrument rooms with modern equipments viz. Alpha- and Beta-counters, Ultra-centrifuge, High speed centrifuges, Micro-centrifuges, UV-visible spectrophotometers, Spectrofluorometer, PCR, Real Time PCR, ELISA Plate readers, High Pressure Liquid Chromatography, Gas Liquid Chromatography, Inverted and fluorescent microscopes, Ice flaking machines, Water purification systems, Freeze dryer, Gel documentation (Imaging) systems, ultra filtration unit, Ultra-low temperature freezers and Carbon dioxide incubators.

DAIRY CHEMISTRY

The mandate of Division is to conduct fundamental and applied research for understanding chemistry of milk and milk products, to impart educational programmes for undergraduate and postgraduate courses and to provide R&D support towards chemical-quality control related problems of the dairy industry.

Credited with nearly 32 industrial licenses of different technologies in last five years, Division's work on detection of adulteration in milk and milk products and low cholesterol ghee has won it wide national and international acclaim. Dairy Chemistry Division has generated significant quantum of intellectual property (more than 17 in last five years) in addition to quality research publications of high impact factor. The impact of scientific contributions is reflected through recognitions to its faculty which include Fellowships of the national academies, prestigious awards by ICAR, NAAS, NRDC, Professional Societies and research funding from national and international agencies.

The divisional academic program leading to Master of Science/ Technology and Doctor of Philosophy degrees provides a solid background in dairy chemistry while allowing for specialization in the areas of chemistry of milk constituents, chemistry of milk products, or food chemistry and analytical chemistry. Since our curriculum is grounded in basic science, graduates are able to pursue careers in a wide variety of professional and technical fields.

The Division has contributed significant knowledge on the chemistry of milk and milk products. The salient achievements are: evaluation of physico-chemical properties of buffalo milk and alteration in its calcium and casein levels; casein micelle stability in relation to manufacture of quality dairy products and encapsulation of bioactive components; triglyceride profile of cow and buffalo milk fat; revealing chemistry of ghee and ghee residue flavour; chemical makeup and structural integrity of milk fat globule membrane; influence of various

processing parameters on the water soluble vitamins, major minerals and trace elements and their partitioning; lactoferrin structure and its bacteriostatic role; characterization and crystallization of buffalo lactoperoxidase; functional properties of milk protein products; production and characterization of milk protein derived bioactive peptides enriched ingredients; calcium fortified milk, low cholesterol ghee; nanoencapsulation of bioactive components and nutrients for their application in functional foods; preparation of spray dried milk protein-vitamin A/ vitamin D complexes for fortification of various food products; Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy based analytical method for assessment of proteolysis in UHT milk; A method for analysis of the panchgavya components; rapid and simple methods for the determination of SNF in milk; modification of Gerber test for simultaneous estimation of milk fat; simple tests for the detection of adulteration of milk and milk products; a platform test for detection of detergent in milk; a colour based test to detect adulteration of milk with soya milk; Strip based tests developed for the detection of added Urea, Neutralizers, Hydrogen peroxide, Glucose, Maltodextrin, salt and sucrose in milk; A Method for Vegetable oil detection in ghee using RP-HPTLC; Nanotechnology based method for detection of melamine and pesticide; formulation of quality standards of milk and milk products which are now prescribed Food Safety and Standards Authority under Ministry of Health as well as Bureau of Indian Standards.

Division is also supplying a kit for detection of nine different adulterants in milk to various dairy industries on their demand. A wide range of science-based analytical services are offered to food and allied industries through the consultancy cell for compliance under the provision of FSSA 2006, Bureau of Indian Standard (BIS), AGMARK, and other national and International standards. The Faculty from the division is also managing the activities of Chemical Section of National Referral Centre of Milk Quality and Safety. This facility is ISO 17025:2005 certified and has been accredited for more than 175 analytical parameters for chemical testing of milk and milk products.

The Division has state-of-the-art air conditioned Seminar room, Lecture room equipped with interactive board, LCD projectors, Visualiser, Podium etc., Quality control Lab, Undergraduate and Postgraduate labs, Instrument room (equipped with HPLC, GLC, Mastersizer, Ultra filtration, Electrophoresis, Imaging system, Refrigerated water bath, Dual beam digital Spectrophotometer, Water purification system, BOD incubator, Sonicator etc.), Research labs (lipids, proteins and bioactive peptides, minerals, functional foods/nutraceuticals and quality assurance), chemical section of National Referral Centre for Milk Quality and Safety.

DAIRY TECHNOLOGY

The Dairy Technology Division is one of the oldest Divisions of the Institute. The Division contributes significantly to the teaching, research, training and consultancy activities of the Institute. The educational programmes include the flagship programme of B.Tech. (Dairy Technology), Masters and Ph.D. (Dairy Technology) and Masters (Food Technology). The research efforts of the Division faculty are brought to fruition through sponsored as well as in-house projects including dissertations of post graduate students. Basic and applied studies to refine processing and packaging technologies for traditional, composite, western and dried dairy products constitute the major focus of research activities.

The Division has developed strong expertise in the area of membrane processing, biotechnological applications, fermented dairy products, composite dairy and food products and their packaging. It has successfully organized 40 National Training Programs under the ICAR-sponsored Centre for Advanced Faculty Training in Dairy Processing (earlier, Centre for Advanced Studies in Dairy Technology) since 1994, for teaching faculty of State Agricultural Universities and other institutions.

The Division of Dairy Technology has received a number of awards in recognition of the outstanding scientific contributions made by the scientists, students and staff, such as Fellow of the National Academy of Agricultural Sciences (NAAS), Fellow of the Indian Dairy Association (IDA), Best Employee Award from ICAR, Best Teacher Awards, Rafi Ahmed Kidwai Awards, Jawaharlal Nehru Award, DAAD Fellowships, Humboldt Fellowships and several others, including Best Research Paper awards. Under the recently awarded Institutional Development Plan under the National Agricultural Higher Education Project for the incentivisation of undergraduate program, several activities for the improvement of faculty and students are in progress in the Division. The most noteworthy contribution of the Dairy Technology Division to the Indian Dairy Industry has been the industry's human resource pool, in addition to the repository of technologies.

DAIRY MICROBIOLOGY

The major objectives of the Division are, (i) To serve as a center of excellence for carrying out basic and applied research in different areas of Dairy Microbiology, both at the level of milk production and processing, (ii) To provide technical support and consultancy to dairy industry in all the areas related to microbiological aspects of milk and milk products and their value addition through intervention of micro-organisms for improving health and nutrition along with their safety and quality and (iii) To conduct teaching programme at UG and PG level for NDRI Deemed University.

The Division is currently engaged in research, teaching, consultancy, training and technology transfer in specialized field of Dairy Microbiology. Broadly, the research work of the division covers the areas related to starter cultures and fermented milk products; direct vat starters (DVS); indigenous probiotics, their functional efficacy and gut microbiota, prebiotics and synbiotics; diversity of traditional fermented milk products by metagenomic, metabolomic and culturomic approaches, bioactive peptides, microbial metabolites and bio-preservatives; biosensors, quality assurance and food safety. The Division has played a key role in establishing National Collection of Dairy Cultures' (NCDC) with current repository of more than 800 cultures and National Referral Centre for Milk Quality and Safety. The Division has transferred technologies on two indigenous strains of probiotics, Misti Dahi, rapids kits for antibiotic residues, *Listeria monocytogenes* and *Enterococci* to potential stake holders in our country for their industrial application. Few more such products like vitamin B12 rich propioni-yoghurt, blueberry fortified Probiotic Dahi, real time test for detection of *E. coli* and antibiotic residues in milk have been developed and are under process of validation for their commercialization.

The faculty is also involved in imparting teaching and guidance for both under-graduate and post-graduate programmes. The Division offers M. Tech and Ph.D. programmes in Dairy Microbiology as well as Food Safety and Quality Assurance. Besides, Division is also contributing in teaching Microbiology courses to B. Tech (Dairy Technology) students. Division also offers contractual and consultancy/ training services such as supply of starter cultures, freeze-drying of cultures, microbiological analysis and setting standards for regulatory compliance of dairy products in our country. The Division regularly organizes need based specialized short term symposia/ conferences/ seminars covering basic and applied areas of dairy microbiology including quality assurance, food safety, starter cultures and fermented health foods for HRD development in our country. The Division also coordinates the activities of National Referral Centre on milk quality and safety.

DAIRY ENGINEERING

The mission of the Dairy Engineering Division includes, (i) To develop engineering database required in design of dairy process equipments/ instruments; (ii) Process mechanization for Indian dairy products. (iii) To design and develop the equipments/instruments to meet the requirement of dairy industry; (iv) Teaching/ Training to UG/ PG students. (v) Transfer of technology, technical training, and consultancy services etc. It is established as one of the major research divisions since inception of the institute. It has been contributing to teaching, research, training and industrial consultancy since the inception of the Institute. The Division has research laboratory facilities to cater to the needs of specific areas and programmes such as process engineering, process equipment design, thermal, electronics and instrumentation. In addition to this, there are post-graduate teaching laboratories, Research & Development workshop and equipment testing hall to support both research and teaching activities.

During the past three decades, the Division has achieved breakthroughs in developing a number of process equipment for manufacturing indigenous milk products. Many of these equipment have been patented and efforts are being made to transfer them to the equipment manufacturers. The Division has tie-ups with equipment manufacturers and users for their collaboration in development or in adoption of the research efforts.

The Division has developed equipment for the manufacture of Khoa, Burfi, Basundi, Ghee etc on industrial scale. Recent research achievements include development of weight based filling system for Kheer, machine vision system for colour measurement of dairy products, turbo assisted scraped surface heat exchanger (SSHE) etc. Current research areas focus on development of weight based filling system for Rabri and equipment for mechanized production of Kheer and Rabri. The Division also conducts specialized training to graduate engineers during summer.

DAIRY ECONOMICS

A Division of Dairy Economics, Statistics and Management (DES&M) was created in 1972 from erstwhile Statistics Section which was constituted at NDRI in 1960. Dr. R. K. Patel joined as the first Head of the Division. He steered the Division to expand its research and teaching activities and the discipline of Dairy Economics got real impetus under his able leadership.

The Division occupies central place location-wise and academically in the national institution of higher learning in the field of dairying. The Division is an amalgamation of three disciplines, that is, Agricultural Economics, Agricultural Statistics and Computer Application. The Division offers post-graduate programs at Master and Doctoral levels in Agricultural Economics. Our faculty members teach variety of courses at undergraduate level also, that is, B. Tech. (DT). The issues of economics and statistics are central to all research studies in the institute and our Division addresses them. The alumni of the Division are well placed in academia, banking and the development sector. The Division provides unique opportunities for aspiring post-graduate students by offering an ambient academic environment, professional learning and analytical skills.

Apart from conducting research on various economic aspects of dairy sector at national and international level, the Division attempts to understand the complex array of forces that influence the level and behaviour of agricultural products. In the present context, the Division endeavours to further advance the knowledge in economic and statistical analysis techniques pertinent to research work and to assess technologies, programs and policies to make informed judgments about the trade-offs in allocating scarce resources and predicting resulting changes or their economic consequences. The Division harnesses the emerging tools, techniques and research methods in econometrics and statistics to provide direction in designing policies & program, developing institutional mechanisms and facilitating decision-making process of the stakeholders at micro, meso and macro levels.

DAIRY EXTENSION

Dairy Extension Division was established at NDRI, Karnal in May, 1961 to undertake extension activities, besides teaching and research in Extension Education. Research endeavors of the Division are in the areas of information and communication technologies, organizational behaviour, information management, participatory technology development and impact studies of dairy innovations. The faculty has also been engaged in human resource development through post graduate and doctoral programmes of NDRI. The objectives of the division are, (i) To carry out extension research as per clientele needs, (ii) To enable the end-users to adopt the innovations in dairy farming, (iii) To facilitate technology assessment and refinement of dairy innovations evolved by NDRI, (iv) To undertake HRD programmes in dairy extension, and (v) To promote convergence and collaboration for sustainable dairy farming.

The main extension programme of the Institute such as Dairy Mela and demonstrations, field days, etc. are organized by the Division. Research-Extension-Industry-Farmer Interface is also organized by the Division to provide an opportunity for the convergence of all stake holders working together for dairy development. Interface not only helps the dairy organizations to find solutions for today's problems, but also to realize the vision for the future. The Division also organizes technology transfer campaigns, infertility and veterinary aid campaigns, Kisan Sanghoshthies and field workshops at the adopted villages regularly. These activities strengthen the linkages with end users, helps in understanding the problems of farmers and better dissemination of technologies as well as easy availability of feedback from the farmers. A new Extension Education Programme "Dairy Education at Farmers' Door" was initiated in February 9, 2009, to strengthen the effective dissemination of dairy production and processing technologies among farming community.

A new Extension Approach "Farmers' Farm School" in village was initiated in 2014 for updating farmers knowledge in the field of dairy farming in particular and agriculture in general. Need based technology development and refinement are continuous processes in which research and extension components work hand in hand. The Institute extension service maintains live and intimate links with the research departments on one hand and the field level functionaries of different state departments, development agencies and farmers on the other. The Institute constituted an Extension Council in the year 1989, which is a decision making body for the purpose of assessment and execution of extension programmes. The Council works under the chairmanship of the Director, NDRI and meets twice a year for formal planning and execution of extension activities of the Institute.

SUPPORT SECTIONS

LIVESTOCK RESEARCH CENTRE

The total milk production of the herd during the current year was 754881.1kg. The production performance of the two crossbred strains developed by the NDRI viz. Karan Swiss and Karan Fries was 9.9 and 11.3kg per head per day, respectively. The milking average of Sahiwal cows 6.5 milking average of Gir Cows and Murrah buffaloes was 5.4 and 7.6kg per animal per day respectively. One Sahiwal cow (SW-2188) produced best milk yield of 20.5kg in peak lactation. Best yield in Murrah buffalo (MU-7025) was 18.0kg per day during the current year. The peak milk yield by the KF and KS crossbred cows was 26.0kg (KF-7763) and 17.0kg (KS-4465) respectively.

Month-wise Milking Average (kg.) of Cows, Buffaloes and Goats Maintained at NDRI, Karnal during 2021

Months	Cows						Buffaloes		Goats							
	Sahiwal		Tharparkar		Gir		Karan Swiss		Karan Fries		Murrah		Alpine x Beetal		Sannen x Beetal	
	*	#	*	#	*	#	*	#	*	#	*	#	*	#	*	#
January	46	7.0	13	6.7	23	3.9	03	11.5	53	12.5	106	8.2	58	1.6	19	1.6
February	53	7.0	16	6.8	17	5.0	03	9.1	64	12.2	104	8.4	58	1.4	19	1.4
March	60	6.9	20	5.8	13	6.6	03	10.0	64	13.0	98	8.0	56	1.7	18	1.5
April	59	7.0	16	6.1	17	7.5	03	9.8	65	12.9	88	7.5	56	1.7	17	1.6
May	58	6.9	14	6.0	18	5.2	03	9.2	64	12.9	81	7.4	60	1.4	17	1.5
June	58	6.6	14	5.0	19	4.5	03	6.2	64	12.1	75	7.3	48	1.3	12	1.3
July	59	6.3	15	4.7	17	4.5	03	2.0	63	11.3	71	6.8	38	1.4	09	1.4
August	64	5.8	18	3.9	17	4.5	01	3.1	64	9.9	68	6.8	57	1.3	17	1.5
September	67	5.3	22	3.1	19	4.5	01	3.2	67	9.2	70	7.2	42	1.5	13	1.7
October	61	6.3	19	3.5	19	4.7	02	5.8	57	9.1	85	7.3a	33	1.5	10	1.6
November	58	6.5	11	5.2	23	5.2	02	8.0	62	9.8	95	7.7	43	1.4	13	1.5
December	62	6.6	13	3.9	20	7.7	02	14.6	62	11.0	100	8.3	60	1.4	18	1.3
Average	59	6.5	16	4.9	18	5.4	02	9.9	63	11.3	87	7.6	51	1.4	15	1.5

(*)=Av. No. of animals in milk per day

(#)=Milk yield Av. (kg) per animal per day

Age group	Cattle						Buffaloes	Total Bovines
	Sahiwal	Tharparkar	Gir	KS	KF	Total	Murrah	
Male up to 06 months	30	07	16	01	19	73	51	124
Female up to 06 months	26	12	13	02	21	74	27	101
Heifers	178	63	62	05	102	410	148	558
Cows/Buff	144	59	66	05	94	368	169	537
Young Male Stock	37	18	12	-	11	78	06	84
Bulls	06	-	05	-	10	21	13	34
Teaser Bulls	-	-	-	-	-	-	04	04
Total	421	159	174	13	257	1024	418	1442

Flock Herd Strength of Goats as on 31-12-2021

Age Group	Alpine x Beetal	Sannen x Beetal	Total Female
Kids upto 06 months	63	08	71
Yearling	87	19	106
Goats	68	20	88
Male			
Kids upto 06 months	39	19	58
Bucks	20	10	30
Total	277	76	353

Sale of Livestock during the Year 2021 (01-01-2021 to 31-12-2021)

Mode of Disposal	Cattle	Buffaloes	Goats	Total
Public Auction	1096590 (229)	2448000 (97)	390800 (67)	3935390 (393)
On Book Value	130506 (02)	165242 (12)	211605 (38)	507353 (52)
Grand Total	1227096 (231)	2613242 (109)	602405 (105)	4442743 (445)

- Auction of animals was conducted on 16.03.2021, 17.03.2021 & 18.03.2021 and 27.09.2021, 28.09.2021 & 29.09.2021

Fodder and Concentrate Fed to Animals during the Year 2021

Months	Type of Fodder (q)			Concentrate (kg.)
	Green	Dry/Hay	G. Total	
January	25488	1870	27358	83209
February	21342	135	21477	106366
March	22714	245	22959	121037
April	17495	329.35	17824.35	106165
May	14149	1150	15299	110005
June	18023	259	18282	119828
July	21236	290	21526	127550
August	21050	190	21240	111578
September	19203	240	19443	97633
October	18572	230.75	18802.75	75234
November	16689	251	16940	75706
December	20752	190	20942	121630
Total	236713	5380.10	242093.10	1255941

Total milk production and milk supplied to Experimental Dairy during the year-2021

Month	Total Milk Production	To Calves/ Kids	To other Divisions	Total Disposal of Milk	Total Milk Sent to Expt. Dairy	Total Milk Received by Expt. Dairy
January	70594.9	15928.0	338.5	16266.5	53972.3	54034.0
February	66384.0	12940.6	281.2	13221.8	52878.5	52932.0
March	74120.0	13314.0	496.8	13810.8	60143.0	59628.0
April	68690.2	12767.4	653.0	13420.4	55112.7	55195.0
May	66193.4	13164.3	611.0	13775.3	52374.5	52107.0
June	58792.7	10636.8	108.5	10745.3	48040.7	48132.0
July	55727.9	10510.4	156.5	10666.9	44815.7	44659.0
August	53423.3	11477.4	214.0	11691.4	41439.1	42092.0
September	52465.9	13292.8	184.5	13477.3	38747.6	38745.0
October	56289.0	15693.5	846.95	16540.45	39384.25	39383.0
November	60788.9	16203.6	603.4	16807.0	43363.2	43348.0
December	71410.9	17826.7	313.85	18140.55	52850.05	52866.0
Total	754881.1	163755.5	4808.2	168563.7	583121.6	583121.0

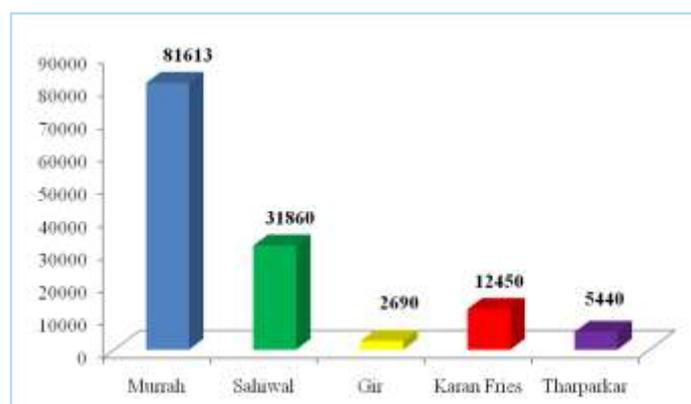
ARTIFICIAL BREEDING RESEARCH CENTRE

The Artificial Breeding Research Centre (ABRC) is maintaining 114 breeding bulls (Sahiwal-36, Tharparkar-6, Karan-Fries- 18, Karan Swiss -01, Murrah - 50, Gir-3) and as is engaged in progeny testing programme for Sahiwal and Murrah bulls. ABRC has capacity to maintain 140 breeding bulls.

Production of superior germplasm

The centre is involved in production and conservation of superior male germplasm of cattle and buffaloes. During 2021 (Jan to Dec) a total of 134053 doses of frozen semen were produced.

	Murrah	Sahiwal	Gir	KF	TP
Semen dose production	81613	31860	2690	12450	5440



Breed wise Frozen Semen Dose Production in 2021 (Jan to Dec)

Dissemination of superior germplasm

The centre is disseminating superior male germplasm for genetic improvement programme of cattle and buffaloes (Table). During the year ABRC disseminated 121595 ml doses liquid semen of Sahiwal, KF and Murrah bulls to local farmers and also disseminated / supplied 69599 doses frozen semen of Sahiwal, Tharparkar, KF and Murrah bulls to farmers and various Dairy development organizations / Institutes / Gaushalas of 12 states viz., Haryana, Punjab, Uttarakhand, Delhi, U.P, Rajasthan, Bihar, Himachal Pradesh, Bihar, J&K and Maharashtra.

Month-wise Dissemination of Semen Doses during 2021

Month	Liquid semen doses (ml) to Farmers	Frozen semen doses to Farmers/ Institutes/ Dairy Development Agencies
January	8695	9482
February	8090	6872
March	8640	8806
April	7895	2702
May	8395	1622
June	8925	5261
July	9445	18471
August	10495	3572
September	11435	9143
October	13010	10605
November	12000	9414
December	14570	9725
Total	121595	95675

Distribution of breeding bulls: The centre distributed 39 surplus breeding bulls (Karan Fries-3, Murrah-14, Sahiwal-10, Tharparker-9, and Gir-3) to government agencies/farmers.

Reproductive status of NDRI Herd in 2021

The center performed 1413 artificial insemination in the Institute Livestock Research Center (Table) and monitored the reproductive efficiency of NDRI herds (Table).

A.I. and PD of Breeding Bulls at NDRI Herd during 2021

Month	Sahiwal		KF		KS		Tharparkar		Murrah	
	AI	PD	AI	PD	AI	PD	AI	PD	AI	PD
January	31	13	29	16	2	0	5	1	45	26
February	18	14	17	8	2	1	16	6	33	12
March	30	13	25	7	0	0	11	7	17	6
April	22	12	12	4	1	0	13	6	23	10
May	28	17	22	15	1	1	9	6	9	4
June	35	27	36	16	4	1	13	9	14	4
July	49	23	22	3	0	0	7	4	14	6
August	22	6	20	4	1	0	12	6	7	2
September	11	6	8	2	0	0	11	7	16	7
October	18	12	13	5	0	0	7	6	32	18
November	14	8	10	3	1	0	12	6	38	16
December	22	13	18	7	0	0	6	5	45	17
Total A.I.	300	164	232	90	12	3	122	69	293	128

Reproductive Status of NDRI Herd during 2021

Particulars	Breed SW	TP	KS	GIR	KF	MU
Cow/ Buffalo						
No. of Observations	73	38	2	44	35	68
Service Period (days)	137.35	123.89	352.5	154.70	188.82	141.94
No. of Service/Conceptions	1.42	1.47	2.0	1.54	1.48	1.26
Heifer						
No. of Observations	69	23	2	22	41	43
Av. age at Maturity (Month)	32.66	38.17	39.5	36.40	35.85	37.83
Av. age at Conception (Month)	33.39	39.73	43.0	37.36	37.95	40.30

No. of Service/Conception	1.37	1.52	1.5	1.40	1.70	1.58
	Conception Rate (%)					
Conception Rate 1st Service	58.79	55.26	-	57.83	42.60	49.10
Conception Rate 3rd Service	86.81	86.84	42.85	89.15	75.65	71.25
Overall Conception Rate	54.66	56.55	25.0	55.71	38.79	43.68

Revenue generation:

ABRC has generated Rs. 26,08,530/- as revenue for the institute through the sale of liquid and frozen semen during 2021. A total of Rs. 9,33,616/- revenue was generated through the sale of breeding bulls. The month wise revenue generated is as follows:

Revenue Generated through the Sale of Semen

Month	Frozen Semen (Rs.)	Liquid Semen (Rs.)	Total (Rs.)
January	162500	86950	249450
February	83520	80900	164420
March	155980	86400	242380
April	50300	78950	129250
May	23340	83950	107290
June	52260	89250	141510
July	259780	94450	354230
August	60440	104950	165390
September	152960	114350	267310
October	174460	130100	304560
November	70740	120000	190740
December	146300	145700	292000
Total	1392580	1215950	2608530

Allocation of the Land to Different Units at NDRI

Sr. No.	Unit	Area (Acres)	Area (Hectare)
1)	Forage Production Section &RFS (Seed)	775.78	314.08
2)	Farm Building, Road Drains, Channel & Silo Pit.	106.21	43.00
3)	Area under Eucalyptus trees (Farm)	5.01	2.03
	Total Land under Forage Production Section	887	359.11
Land under Campus, Buildings and other Institute activities:-			
1)	Narmada Hostel, Kalki Bhawan, Plantation area and Dairy Mela Ground	46.36	18.77
2)	Institute campus and Building	324.53	131.39
3)	Dairy Demonstration & other schemes, KVK	33.39	13.52
4)	Animal Breeding Complex, Block-5	10.00	4.05
5)	Model Dairy Plant	20.50	8.30
6)	NICRA	04.00	01.62
7)	ATIC	03.50	01.42
8)	Agronomy Section	13.00	05.26
9)	Exhibition Unit	02.91	01.18
10)	Examination Hall	0.89	0.36
11)	Estate Section	2.00	0.81
	Sub Total	461.08	186.68
Land handed over to other agencies:-			
1)	Indian Railway	0.49	0.20
2)	33KVA H.S.E.B., Karnal (Station)	0.49	0.20
3)	N.B.A.G.R. (ICAR)	74.99	30.36
4)	DWR	47.97	19.42
	Sub Total	123.94	50.18
	Overall Land with NDRI, Karnal	1472.02	595.97

The foremost responsibility of Forage Production Section is to produce adequate quantity of good quality green fodder to meet the nutritional requirements of the Institute herd. After meeting the day-to-day requirement of fodder, some area was utilized for production of fodder seed and other grain crops to meet the requirements for transfer of technology programmes of Institute and partial fulfillment of the grain component of feed and to generate revenue.

Fodder/Feed Production and Supply

Good quality of, 263163.00 q. Green Fodder, 1063.00 q. Dry Fodder and 3613.00 q. Straw was produced from high yielding varieties of fodder crops of Maize, Sorghum, Napier Grass, Sugargraze and Cowpea during Kharif season and Berseem, Oats, Chinese cabbage and winter Maize in Rabi season. Similarly, seed/ grain crops of Oats, Berseem, Wheat, Mustard with a total production 5642.22 q. grains were also grown. During the period under report a total of 267839.00 q of fodder including 263163.00 q. Green Fodder 3613.00 q. Straw and 1063.00 q. Dry Fodder was supplied to cattle yard and other sections.

Production and Productivity of Forage Crops in terms of Green Fodder & Dry Fodder at Forage Production Section (Rabi 2020-21 & Kharif 2021)

Sl.No.	Crop	Area(ha)	Production (in q)	Average Yield (q/ha)
Rabi Season				
1)	Oats+Mustard	6.48	2068	319.14
2)	Berseem+Mustard	64.41	73635	1143.22
3)	Oats	75.62	37565	496.76
4)	Napier Grass+Mixture	8.91	5282	592.82
5)	Napier Grass	5.67	2006	353.79
Kharif Season				
1)	Jowar (Multi Cut)	120.49	36766	305.14
2)	Maize+Jowar (Single Cut)	2.83	787	278.09
3)	Maize	114.40	48749	426.13
4)	Maize+Cowpea	5.06	2341	462.65
5)	Jowar (Single Cut)	34.62	12901	372.65
6)	Cowpea	12.43	2036	163.80
7)	Napier Grass+Mixture	13.00	10287	791.31
8)	Wonder-Leaf (Bajra)	26.34	18655	708.24
9)	Napier Grass	5.47	2949	539.12
	Total	495.73	256027	516.46

Production and Productivity of Grain Crops at Forage Production Section during 2021 (Rabi 2020-21)

Sl.No.	Crop	Area(ha)	Average Yield(q/ha)	Total Production(q)
1)	Oats	76.73	13.97	1071.80
2)	Berseem	1.82	2.81	5.12
3)	Wheat	80.91	55.58	4497.30
4)	Mustard	4.05	16.79	68.00
	Total	163.51		5642.22

Production and Productivity of Straw at Forage Production Section during 2021 (Rabi 2020-21)

Sl. No.	Crop	Area (ha)	Av. Yield (q/ha)	Production (q)
1)	Oats Straw	57.53	27.00	1553.50
2)	Wheat Straw	80.91	25.29	2046.50
3)	Berseem Straw	1.82	7.14	13.00
	Total	140.26		3613.00

Monthly Fodder Supply to Cattle Yard/ DCN during 2021

Month	Green(q)	Dry Fodder(q)	Total(q)
January	27490		27490
February	22922		22922
March	24626		24626
April	19381	292.00	19673
May	16336	750.00	17086
June	20222	21.00	20243
July	23618		23618
August	23394		23394
September	22017		22017
October	20987		20987
November	19019		19019
December	23151		23151
Total	2,63,163	1063.00	2,64,226

Calculated Cost of Fodder Supplied to Livestock Research Centre during 2021 (Rabi 2020-21 & Kharif 2021)

Sl.No.	Crop Name	Quantity (q.)	Rate (Rs./q.)	Amount (Rs.)
1)	Green (Jan. to May)	110755.00	150/-	16613250.00
2)	Green (June to Dec.)	152408.00	160/-	24385280.00
3)	Dry Fodder	1063.00	100/-	106300.00
4)	Straw	1566.50	550/-	861575.00
Total				4,19,66,405.00

Revenue Generation by Sale and Supply of Different Item at Forage Production Section 2021 (January-December, 2021)

Sr. No.	Kind	Supplied (kg.)	Sold (kg.)	Rate per kg.	Amount (Rs.)	Remarks
1)	Oats Seed	1800	-	40/-	72000/-	Supplied to ATIC, ERS Kalyani Agronomy
2)	-do-	-	30.00	38/-	1140/-	Supplied to Farmers
3)	-do-	61025	-	15/-	915375/-	Supplied to Central Store
4)	-do-	-	27988.50	40/-	1119540/-	Supplied to Farmers
5)	-do-	7500.50	-	40/-	300020/-	For Sowing FPS
6)	FYM Lose	-	2300	0.50/-	1150/-	Supplied to Farmers
7)	-do-	-	1250	1.00/-	1250/-	-do-
8)	Napier Root	-	25100	1.00/-	25100/-	-do-
9)	-do-	-	150	2.00/-	300/-	-do-
10)	Fuel wood (< 6" dia)	-	100	4.00/-	400/-	-do-
11)	Fuel wood	-	50	5.00/-	250/-	-do-
12)	Mustard C. Cabbage	-	52600	100/-	526000/-	-do-
13)	-do-	1028	-	100/-	102800/-	Supplied to ERS Kalyani, KVK, LPM, Agronomy
14)	-do-	137.10	-	100/-	13710/-	For Sowing FPS
Total					3079035/-	

Revolving Fund Scheme on Seed Production

Unavailability of good quality seeds of improved varieties of fodder and wheat crops is the biggest constraint in increasing the productivity of above crops. Thus, a Revolving Fund Scheme on Seed Production was initiated at NDRI, Karnal in 80 hectare area to produce the seeds of improved varieties of fodder and wheat crops for cultivation at Institute's Farm at Institute's Regional Station for sale to Farmers and other Agencies.

Production and Calculated cost of Green fodder and straw at RFS, Seed Production and supplied to LRC and ABRC through Forage Production Section during the year 2020-21 (Rabi 2020-21 & Kharif 2021)

Sr. No.	Kind of Fodder	Production(q.)	Rate(Rs./q.)	Calculated cost (Rs.)	Remarks
1)	Green Fodder	45151.00	160/-	7224160.00	Supplied to LRC
2)	Bhusa	764.25	550/-	420337.50	Supplied to ABRC
3)	Bhusa	1282.25	550/-	705237.50	Supplied to LRC
Grand Total				83,49,735.00	

Total Calculated Cost of Seed and Grain Supplied to Institute

Sr. No.	Kind	Quantity(q.)	Rate(Rs./q.)	Amount(Rs.)	Remarks
1)	Oats breeder seed	45.75	7250/-	331687.50	Supplied to FPS
2)	Oats grain	90.50	1500/-	135750.00	Supplied to LRC
Grand Total				467437.50	

Total Revenue Generation by Sale of Seed under RFS (Seed Production) 2020-21

Sr. No.	Kind	Supplied (q.)	Sold (q.)	Rate per (q.)	Amount(Rs.)
1)	Wheat Seed	-	4497.30	2468.75	11102709.37

EXPERIMENTAL DAIRY

Experimental Dairy was setup in this Institute in 1961 with the objective of providing necessary infrastructure facilities to the scientists for the scaling up of new products/processes developed in the laboratories on the

pilot scale as well as to provide training facilities to the students in the operation of dairy plants. After meeting the requirement of research and teaching, the plant is used for converting the surplus milk into variety of dairy products. During the year 2021, Experimental dairy manufactured and sold Skimmed Milk Powder (Roller)- 17366.5 kg., Pasteurized table butter 308.0 kg, Ghee 13741.0 kg, Paneer 30809.25 Kg, Kalakand – 32611.5 kg, Ice-cream (100 ml) – 36681 cups, Processed Cheese Slices (200 g) – 883 pkts. Gulab Jamun Mix 3541.5 kg. Pizza Cheese (200g) 2405 pkt, Cheddar Cheese 57.25 kg, Khoa – 273.0 kg, Mozzarella Cheese – 6.5 kg, Table Cream 1.0 kg. and Cooking Butter – 8.5 kg. Experimental dairy provides facilities for practicals, teaching and training to students and research facility to scientists of NDRI Deemed University. It also provides training facility to outside students of various universities/colleges and entrepreneurs from across the country in the dairy field. Four students from several institutions were provided practical training during the year 2021 in the experimental dairy. This self sustaining Experimental Dairy has been running under Revolving Fund Scheme since 1989-90. Revenue generated through scheme is being utilized for development of infrastructure and maintenance of this dairy. Experimental Dairy is a Quality management system ISO 22000: 2018 certified dairy. The revenue generated from the sale of milk and milk products during the year 2021 was Rs.4,50,45,965/- only.

COMPUTER CENTRE

Computer Centre is a central facility to provide computational support to the scientists and administration; and to impart training to students/ scholars. The Computer Centre offers two Computer Science courses to under-graduate students and one course to post-graduate students including PhD scholars. There is a well established Computer Laboratory for students' teaching, which is equipped with state-of-the-art 64-bit i5 computer systems together with multi-function laser printers. These computer systems are equipped with different software, i.e., operating systems such as Unix/Linux, MS-Windows; and statistical/ scientific computing systems like SAS 9.3 with JMP, MATLAB, R Studio, WEKA, etc. Also, compilers for various programming languages are available, which include FORTRAN 90, C, C++, R, Python, etc. Computer Centre manages various computing and communication facilities throughout the campus and state-of-the-art campus wide network over the Optical Fiber Cable. The Institute has got 1 Gbps connectivity among NKN networked institutions along with 200 Mbps Internet Bandwidth under National Knowledge Network (NKN), MHRD, Govt. of India, thereby providing connectivity to all the scientists, technical/administrative staff and students. Computer Centre also provides design and implementation services for computer network in the Institute and also provide the support in the office automation activities like E-office, PFMS and ERP (MIS/ FMS) implementation. The EPABX team Implemented the Farmer Calls Transfer Service in Agricultural Technology Information Centre (ATIC), ICAR-NDRI, Karnal without investing any additional cost.

Teaching and Training

R programming concepts as well as Microsoft Excel tools are being taught (using animal sciences/ dairying related case studies) to PG Students (including PhD scholars) of all disciplines of dairying under common-for-all course CS-621: Software Packages for Statistical Computing.

Besides, the Centre imparts training on advanced topics in Soft Computing and Machine Learning using open source R Programming language, WEKA etc. to several externally sponsored students through consultancy scheme.

Management Information Service

Computer Centre continued to prepare various MIS reports relating to milk production, supply of feeds and fodders, herd performance, animal management system, etc., for decision support to the farm managers/heads of divisions using in-house developed software.

Agriculture Knowledge Management Unit

The Agriculture Knowledge Management Unit (AKMU) is fully functional with the Internet and e-mail connectivity through National Knowledge Network (NKN) node provided by the National Informatics Centre (NIC) Govt. of India. AKMU is also undertaking the implementation of ICAR programmes like Personnel Information Management System, E-office KRISHI etc. The AKMU team is supporting and making the smooth

conduct of virtual meetings, Webinars, and other official meetings in virtual mode. The Computer Centre also procured a Zoom Licensee to cater to the demand of institute users for online meetings.

Website

The new responsive Website (<http://www.ndri.res.in>) of the Institute is live with more dynamic contents, single click to the access of social media pages of the Institute. It disseminates latest information to its various stakeholders and end-users about Research, Teaching, Faculty, News, Success Stories, Related Links, Opportunities, Tenders, Office Circulars, Forthcoming Workshop/ Conference/ Summer/ Winter School announcements, Institute Publications (Annual Reports/ Newsletters), RTI related information, Telephone Directory, University Information (B.Tech., M.Sc. and Ph.D. Rules, Admission Notice).

NATIONAL LIBRARY IN DAIRYING

The Institute Library has an impressive collection of literature on Dairy Science and related subjects. More than 44 scientific periodicals were subscribed to keep track of the current scientific/ technical developments. There are 96,089 volumes which include books, bound journals, theses, standards and annual reports. In addition of that 1,307 e-books of different foreign and Indian publishers are available for perpetual access at NDRI Campus. Library has an excellent computer section having fifty workstations for students and staff of the institute. Students use these to get current information in the advanced research areas and for communication.

The Library provides Internet, Email, Documentation, Reference, Current Awareness Services, CD- ROM Literature scanning through CD-ROM of CAB Abstract, Food Science Technology Abstract, AGRIS, Derwent Biotechnology Abstract, Indian Standards and ISO Standards on food products including milk and dairy products on CD-ROM. The Library also provides Photocopying, Document Scanning, Printing and Computerized Issue-Return and reservation facilities.

The Library, NDRI is an active partner CeRA (Consortium for e-Resources in Agriculture) and provides single point search for consortia subscribed, Library subscribed and open access journals to its users under institute's IP addresses.

The Library provides instant Document Delivery Services to users of ICAR's Sister Institutes, State Agricultural Universities and other participating Institutions on their request. During the year 2021, 485 no. of requests for Document Delivery were fulfilled.

The Library is also an active partner of Agricat (a sub-portal under WorldCat). Presently **53,813** catalogue records of Library, NDRI available on Agricat/ WorldCat and all the users worldwide participating institution may access catalogue records of national Dairy Research Institute though URL: <http://www.worldcat.org> or www.agricat.worldcat.org.

Library uploaded 6631 digitized records, which includes valuable books, institutional publications, M.Sc. and Ph.D. Dissertations, reports, conference proceedings and reprints etc. on KrishiKosh- Institutional Repository of Indian National Agricultural Research System. In addition of above complete online library catalogue is also available on URL: library.ndri.res.in by using Koha-Library Management System.

COMMUNICATION CENTRE

Communication Centre has Photo & Video and Audio-visual Laboratories for providing services to the staff and students of the Institute. The Centre executed Photo & Video coverage of 355 events of the Institute consisting of National seminars, Workshops, meetings, conferences, cultural programme, Cattle shows, Kissan Sangoshties, Exhibition & other functions of the institute.

The Audio Visual Lab handled the Sound and projection system in Dr.D.Sundaresan Auditorium, Dr. Dastur Auditorium, Pinaki Hall, Committee Room of university, ABTC Conference hall. Audio Visual lab has also extended the facilities of Sound and Projection System in playground, Animal Auction, General Auction and Hostels for student activities.

Exhibitions organized during 2021

SN	Event	Date	Place
1)	CSSRI, kishan Mela	February 18-19,2021	Habdi, Kaithal
2)	World food day	October 16, 2021	Milk Parlour, NDRI, Karnal
3)	Kisan Mela	October 21-23, 2021	Yamkeshwar Tala Banas,Rishikesh, UK
4)	Indian Science Congress, Banarsh Hindhu Vishwvidhalaya	November 13-16, 2021	Varanshi, U.P
5)	Buffalow Calf Rally	November 29, 2021	Vill. Khedi Mann Singh, Karnal
6)	Buffalow Calf Rally	December 6, 2021	Vill. Shekhupura Shuhana, Karnal
7)	Buffalow Calf Rally	December 12, 2021	Vill. Khedi Mann Singh, Karnal
8)	Kisan Mela	December 24, 2021	Rishikesh, UK

Video Shows/ Visits in the Exhibition Unit:- 8 No.

MAINTENANCE ENGINEERING SECTION

In the year 1979, the Institute took over the maintenance works from CPWD and UHBVNL and created an in-house centralized maintenance facility named as Maintenance Engineering Section to operate the essential services of electric supply, water supply and sewerage water disposal and provide maintenance services of all kinds to the whole institute. The following works/ functions are included in the mandate of M.E. Section.

- Operation and Maintenance of the water supply through bore wells and water supply lines throughout campus and sewage disposal system through sewage pumps/ sewage lines and ETP of the Institute.
- Operation and Maintenance of Electric-Sub-Station, Electrical-overhead -lines, street lights, service connections, electric supply of the office area as well as whole residential area of the Institute including meter reading/ billing of the residential quarters.
- To provide uninterrupted electric supply to the whole Institute by providing generator supply to office & residential area including International, Girls & Boys Hostels, Guest House and Scientist Home in case of power failures.
- To provide maintenance services in the field of civil, electrical, mechanical and refrigeration/ AC Engg. which includes repair/ renovation of buildings, complete plumbing installations, electric installations and ACs/ AC plant and specialized refrigeration equipment/ deep freezers in the labs.
- Preparation of Civil/ Electric estimates of all kinds of new and repair/ renovation works required in the Institute.
- Liaison works with UHBVN, CPWD and Haryana State Pollution Control Board etc., for execution of various works of the Institute and other compliances.
- To provide addition/alterations required in the various labs of the Institute for creating better environment conducive for research activities.
- To keep charge of all the residential quarters, shopping complex and maintain their occupation/ vacation records and also prepare electricity bills of residential quarters, shopping complex, married & international hostel.
- To process the cases of House Building Advances of the employees and conducting house inspections at different stages of construction before releasing of loan-installments by the Administration.
- Planning and inspection of new buildings in the Institute and maintenance of plinth area records of all the Institute's buildings.
- Operation and Maintenance of the ETP of the Institute as per CPCB/ HSPCB norms.

- Generation and processing of purchase proposals to purchase parts and consumables to be used in maintenance and keeping the inventory by maintaining Civil and Electric stores.
- To monitor solar power generation of 100 MW rooftop solar power plant and to keep liaison with solar power producer.

During the year 2021 the following repair/ renovation works completed satisfactorily by the Maintenance Section through private contractors by inviting tenders/ Quotations at the Institute level:-

S.No.	Name of Work	Amount (Rs.)
1)	Repair and Replacement of fiber glass sheet 3 mm of roofs the lawn canopy etc. at Director's Residence, ICAR-NDRI, Karnal.	1,12,100
2)	Fixing of wall tiles in clone calf shed at LRC, ICAR-NDRI	13,965
3)	Repairing and repainting of AGRO Lab in E.T.T. Building, (L.R.C.), ICAR-NDRI, Karnal.	1,37,550
4)	Interior and exterior painting of IFSC Project Shed of LRC, ICAR-NDRI, Karnal.	50,221
5)	Wooden polishing at Main and Mini Auditorium at ICAR-NDRI	85,735
6)	Painting of pipe grills /railing ground path at LRC, ICAR-NDRI	1,17,200
7)	Repair & renovation of cement concrete flooring and wall plastering in Garima shed at LRC, ICAR-NDRI, Karnal.	86,692
8)	Providing and fixing of aluminum cupboard leaf under RCC slab at IVF Lab at ABTC, ICAR-NDRI, Karnal.	91,050
9)	Replacement of broken glass and rubber gasket of Auditorium building, ICAR-NDRI, Karnal.	98,766
10)	Wooden polishing at Main and Mini Auditorium at ICAR-NDRI	85,735
11)	Different civil and electrical work at Room No. 114, DT Division+ ICAR-NDRI, Karnal	1,98,873
12)	Renovation of Lab. No.103, DM Division, ICAR-NDRI, Karnal.	2,28,129
13)	Installing & commissioning of Electromagnetic Flow meter 2 Nos. (150 mm) at water supply bore wells of ICAR-NDRI, Karnal	1,18,000
14)	Installing & commissioning of Ultrasonic flow meter at the inlet of Effluent Treatment Plant of ICAR-NDRI, Karnal	60,180

During the Year 2021, Maintenance Section initiated & got completed the following major works through CPWD.

Sl.No.	Name of Work	Cost (Rs.)
1)	P&F of Shed for protection of Elect. Gen Set at Sub-station and M.S. wire mesh shutters to the Students' Room of Krishna Hostel at ICAR-NDRI	28,15,300
2)	Renovation of three rooms in Admn. Block i.e. Audit Section, Purchase Section and Establishment-II/ E-III room by providing aluminium window, false ceiling & complete white washing at ICAR-NDRI, Karnal	64,71,200
3)	Providing R.C.C. water tank including water connection for sprinkler system at NDRI, Karnal.	9,90,500
4)	R&R of Sewage Line manholes in the campus, one water tank of Satluj Hostel and Parking shed of M.E. Section at NDRI, Karnal.	9,95,600
5)	Repair & Renovation of NICRA Building and Structures at ICAR-NDRI	29,59,800
6)	Construction of Ladies and Gents Toilets and outside staircase in Library of ICAR-NDRI, Karnal	9,66,200
7)	Repair & Renovation of JD(R) office & PME Cell Office.	10,05,900

Award of AMCs through open tender

Sl.No.	Name of AMC	Cost (Rs.)
1)	Repair and Maintenance of Window and Split ACs (800 Nos.)	2,85,103
2)	Maintenance of Central AC Plant, 11 KVA substation at ABTC and operation of water supply pumps in the campus	7,56,249
3)	Servicing and maintenance of Generators 110 kVA to 1000 kVA (9 Nos.)	7,06,820
4)	Repair/ rewinding of Induction motors	1,75,000

In addition to the above works/ services procurement, the purchase of items/ parts/ consumables etc. for a total amount Rs. 22,39,833/- was also done by the Maintenance Section for use in the general maintenance of Institute carried out by in-house technical staff of the section.

MODEL DAIRY PLANT

A state-of-the-art commercial Model Dairy Plant (MDP) was established in 1996 at NDRI, Karnal through the financial assistance and installed on turnkey basis by the National Dairy Development Board. The Plant has been designed to handle 60,000 liters of milk per day initially and is presently handling 1,30,000 to 1,40,000 liters per day. Model Dairy Plant is presently certified under the Food Safety Management System ISO 22000:2018



Special Features

- Model Dairy Plant provides six months In-plant training to the students of B.Tech. (DT) of the NDRI Deemed University during the 4th year of the course curriculum.
- The students are provided with complete infrastructure for training, which helps them in gaining sufficient experience in managing the modern commercial Dairy Plant and instills confidence in handling real life problems in production management.
- It also provides infrastructure facilities to the scientists of NDRI for scaling up R&D concepts from laboratory scale to industrial scale under commercial environment.
- Model Dairy Plant (MDP), an Autonomous Unit of I.C.A.R., is independently managed by a committee, whose Chairman is the Director of NDRI and a member from ICAR (i.e. ADG), MD Mother Dairy, NDDB, Head, Dairy Technology and General Manager, Model Dairy Plant.

Procurement of Milk

MDP does not have its own infrastructure for milk procurement and is receiving milk on behalf of Mother Dairy Fruit and Vegetable Ltd. from the new generation cooperatives of Punjab, Rajasthan etc. The average milk procurement is 1.18 lakhs liters per day, which is sufficient to meet day to day demand of different milk variants like Full Cream Milk (Premium), Full Cream Milk, Toned Milk, Double Toned, Super T, Cow Milk being packed at MDP.

Liquid Milk Processing and Packaging

Model Dairy Plant is currently engaged in processing and packaging of milk for Mother Dairy in different variants (Full Cream(Premium), Full Cream, Toned Milk, Double Toned Milk, Super T and Cow Milk). MDP is presently processing and packing 1,30,000 LPD of polypack Milk in all the varieties for Mother Dairy Fruit and Vegetable Pvt Ltd, Delhi. The plant is running in three shifts and the supplies from MDP are dispatched in the evening and morning to Delhi market and nearby cities thereby utilizing the plant to more than its full capacity.

Ghee Manufacturing

MDP manufactures Cow Ghee from Cow Butter purchased from different State Federations and its production is taken as per demand. The average production/sale of ghee is 35-40 metric tons per month. All the Ghee manufactured at MDP is being sold through the MDP Sale Counter.

Cheese and Paneer

MDP is also engaged in training students in manufacturing of Cottage Cheese, Processed Cheese, Paneer on trial basis. The section is operated occasionally for the purpose of taking trials and making the students familiar with the manufacturing details.

Pinni Manufacturing

Pinni launched in the thirteenth Convocation of N.D.R.I. Deemed University on 14th February, 2015 and developed by the students of batch 2010-14. Total Sale of Pinni was 52.45 metric tons during 2021.

Training to the Students

Model Dairy Plant provides In-plant training to the 4th B.Tech. (DT) students of NDRI Deemed University. The

students are provided with In-plant Training Manual comprising of unit wise operation covering all the sections of the Dairy Plant. Since its inception in 1996, Model Dairy Plant has provided training to twenty five batches of B.Tech. (DT) students. The student trainees are provided Rs.1500/- per month as stipend. So far, 606 students have been trained at MDP. Students are given hands on experience for plant operations and are trained to manage the shift activities of the plant under the guidance of trained technical staff. In addition to the above, students are also made to involve in other activities like KAIZENS, Small Group Activities etc. The feedback regarding Inplant Training, from the student's trained at MDP and now working in different capacities with different organizations is quite positive and encouraging.

Highlights of the year 2021:

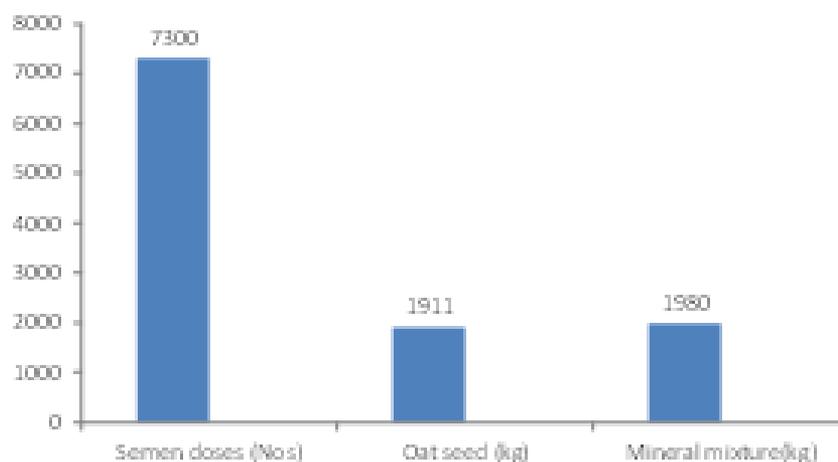
- All wooden doors of processing are replaced with SS doors.
- Billing machine at parlor installed.
- Two Ghee storage tanks installed.
- New Ghee Clarifier installed.

SERVICE CENTERS

Kisan Seva Kendra at Lalukheri (Muzaffarnagar, UP)

A service center of ICAR-NDRI being run at village Lalukheri district Muzaffarnagar (UP) is providing inputs services to the farmers for genetic improving their dairy animals for higher milk production and fertility. At this center, quality seed of different fodder and grain crops, mineral mixture and frozen semen doses of buffalo, Sahiwal and Tharparkar breeds are distributed to the farmers of different villages around the center. Kishan Gosthis are also organized time to time at the center and in surrounding villages, and farmers are apprised for various animal husbandry practices viz. importance of breed improvement for higher milk production, role of mineral mixture for improving fertility in dairy animals, preparation of balance ration at their home using domestically available ingredients and its importance in improving productivity of dairy animals and importance of AI with elite breeding bulls frozen semen from renowned institutions for getting better return through dairying. Training are organized for AI workers, those who take frozen semen from this center, for improving their skill for AI in dairy animals for improving conception rate. These AI workers come from the surrounding villages of Lalukheri center. Lectures related to frozen semen handling, estrus detection, right time of AI, proper method of AI and sources of frozen semen are delivered to them by the experts from NDRI. Therefore the demand of fodder crops seed, mineral mixture and frozen semen doses has also increased many folds among the farmers at the center.

Input supplied through kisan Seva Kendra at village Lalukheri (UP) during 2021



18. REGIONAL CAMPUS

SOUTHERN REGIONAL STATION, BENGALURU

The National Dairy Research Institute was started at Bengaluru in 1923 as Imperial Institute of Animal Husbandry and Dairying. It was the forerunner institution in starting dairy education programmes to meet the manpower requirements of the dairy industry. Upon shifting the institute Head Quarters to Karnal in 1955, the establishment at Bengaluru continued as the Southern Regional Station of NDRI. The station has been catering to the research, training and extension needs of the dairy farmers and dairy industry of the southern region.

The Campus is endowed with necessary infrastructure in terms of qualified staff, farmland, dairy herd, laboratories, library, staff dispensary, hostel facilities etc. The Campus has a land area of about 46 hectares. About 16 hectares of land is utilized for the cultivation of various forage crops for meeting the feeding requirement of the dairy herd.

The Campus has good laboratory and infrastructural facilities for carrying out research work on animal genetics and breeding, dairy animal production and reproduction, screening of microbes, chemical and microbiological analyses of dairy products, testing of dairy equipments, manufacturing of various dairy products, etc. The research, training and transfer of technology programmes at the campus are carried out through different sections. To cater the needs of the students, the library is stocked with books, journals, theses and reprints. Hostel and guest house facilities also exist at the campus for students and visitors.

EDUCATION

Education and Training Section

The coursework for M.Tech. (Dairy Engineering) and M.Tech. (Dairy Technology) are being conducted at the Campus. The students in the disciplines of Dairy Technology, Dairy Chemistry, Dairy Engineering, Animal Genetics & Breeding, Animal Nutrition, Veterinary Gynaecology and Obstetrics, Livestock Production Management, Animal Biochemistry Agricultural Economics, and Agricultural Extension Education are being guided for their Doctoral and Masters dissertation work. Besides, PG students from other Universities are also guided to carry out their Project Work. Further, the Station serves as Study Centre for the Post Graduate Diploma in Food Safety and Quality Management (PGDFSQM) of the Indira Gandhi National Open University (IGNOU). During 2021, 64 students registered for their PGDFSQM at SRS.

EXTENSIONACTIVITIES

- Advisory services were provided to 432 clientele comprising farmers and entrepreneurs, through digital connect, telephonic advice and during their personal campus visits. The advisory profile included, establishing new dairy farm, scientific dairy farming, scientific feeding of dairy cows, training programme for preparation of milk products, recommended feeding modules for cross-bred cows, small-scale production & marketing of cattle feed, maintenance of dairy units, technology of milk products and regulatory guidelines for product manufacture for marketing overseas.
- A large number of visitors including Hon'ble Union Minister of State, progressive farmers, students from various educational Institutes, visited the institute. The visitors were briefed about the institute profile and ongoing research, academic and extension activities followed by visits to sections as per their needs.
- Participated in the National Horticultural Fair-2021 from February 8-12, 2021 (5 days) at IIHR, at ICAR-IIHR Campus, Hesaraghatta, Bengaluru. NDRI stall depicted updated technical know-how from dairy production & processing for the benefit of the farming community, with participation of farmers, entrepreneurs, research scholars and students from the State.

- Participated in the Krishi Mela 2021 organised by University of Agricultural Sciences, at GKVK Campus, Bangalore from November 11-14, 2021. NDRI Stall depicted key focus areas of improved green fodder production, indigenous breeds of Southern Region, Quality Milk Production and Milk Products of SRS, to benefit the visiting farming community. The event was well-attended by farmers, farm women and farm youth, progressive farmers, entrepreneurs, students of schools & colleges, research scholars and general public and visit profile to NDRI stall was around 5000 clientele per/ day.
- **On-farm Outreach Activities-** Various project activities and institute interventions were organized under Azadi ka Amrit Mahotsav Programme under DAPSC project in adopted villages of Kolar and Malur Block of Kolar district and in Kanakapura Taluk, Ramnagara District of Farmer First Project villages. The details are enlisted in the table below:

Date	Venue-Project Villages	Details of the Outreach Programme Organized	No. of Farmers
January 27-28, 2021	Kudige, Kushalnagar	Training Session on 'Scientific Dairy Farming'	25
March 19, 2021	Seethappanahalli	Inaugural Program of SCSP project activities and on-farm Training on 'Improved Dairy Farming Practices'	25
March 23, 2021	Karisandra	<ul style="list-style-type: none"> • Conducted On-farm demonstrations on use of 'California Mastitis Kit' and improved fodder crop varieties to the farmers-beneficiaries • Conducted Animal Infertility cum Health Camps 	35
July 13, 2021	Karisandra	Farmers' Interactive Meeting	55
July 17, 2021	Karisandra	Demonstration programme on Mastitis Management and Dairy Animal Infertility and Health Camp	50
August 6, 2021	Hunasikote	Sensitization Programme on Green fodder production & distribution of improved fodder seeds	50
August 11, 2021	Vasappana Doddi Balepura	Dairy Animal Infertility & Health camp	50
September 29, 2021	Karisandra	<ul style="list-style-type: none"> • Conducted Infertility cum Health Camps and Farmers Interaction Meeting on Health Management' • Conducted on-farm demonstration of 'Vermi Compost' preparation & distributed earthworms to the beneficiary farmers. 	35
September 30, 2021	Hunasikote	Animal Health Camp & Calf Rally Technical session on 'Clean Milk Production and Scientific Feeding of Dairy Animals'	100
October 3, 2021	Karisandra Hunasikote	Front Line Demonstration Programme on commercial fodder crops	70
October 26, 2021	Karisandra Hunasikote	Farmers Interaction Meeting and 'Swachhata Campaign and Cleanliness Drive in Villages' under special Swachhta Campaign (October 2-30, 2021)	50
December 23, 2021	Karisandra	'Kisan Diwas' and 'Swachhata Pakhwada' Expert talk on Scientific Feeding of Dairy Animals and Improved Practices for Clean Milk	55

- Improved Varieties of Maize (African Tall) – 50 acres, Lucerne (RL88) 20 acres, Multi cut Sorghum (CoFS-31), Hedge Lucerne 20 acres, Super Napier/ Dharwad Hybrid Napier (Sampoorna) stem cuttings 10 acres, Stylo Grass (Hamata) 20 acres were given under Fodder FLD program for the benefit of 85 farmers under SCSP project.
- Visits were made by the extension team to the selected villages under Dairy Education of Farmers Door Programme. Necessary technical advice was rendered on various aspects of scientific dairy farming, green fodder production, clean milk production and dairy animal management aspects to the farmers and farm women at their doorsteps.
- The adopted villages were visited under Mera Gaon-Mera Gaurav Programme by the extension team under the outreach programme and need-based technical advice on scientific dairy farming aspects, general health and hygiene aspects were rendered to the farmers, farm women and farm youth by the team.

Women Empowerment:

Institute Interventions in the Project Villages of Farmer First Project, comprised sensitization of Women Self-

Help Groups and the Women groups, orientation to importance of clean milk production, balanced feeding, dairy animal health care, through interactive sessions, expert talks, demonstrations and input distribution for the benefit of women clientele groups of project villages- Vasappana Doddi, and Balepura in Kanakapura Hobli of Ramnagara Taluk.



A Women based SHG was motivated and trained to take up the dairy as a livelihood activity through SHG. A women based SHG known as 'Sree Sakthi' SHG comprised of 21 women members was supported trained on 'Scientific dairy farming practices and value addition of Milk' under DAPSC project activities. Various technological interventions were implemented among the SHG member-beneficiaries through distribution of critical technical inputs, organizing on-farm demonstrations and training programmes, animal health camps and interaction meeting with the beneficiary-farmers.

Patents Applied:

- A system and device facilitating monitoring and prediction of calving process in dairy animals. Inventors: S. Jeyakumar, A. Kumaresan, Mukund A Katakataware, K.P. Ramesha. Application No 202111045493; Date of filing 06-10-2021
- *In vitro* proteomic analysis of uterine fluid for detection of subclinical uterine infection. Inventors: A. Kumaresan, K.S Praveen, K.P. Ramesha, S. Jeyakumar and A. Manimaran. Application No 202111039076; Date of filing 28.08.2021
- Apparatus for extruding coagulum of one or more materials. Rajasekhar Tellabati and Menon Rekha Ravindra. Application No. 202111050313 Date of filing 02.11.2021
- Self-Stable Metal Ion Based Nano-dispersion for Thermal Energy Storage and Exchange and the Method of Preparation Thereof. Ravi Prakash, Menon Rekha Ravindra and H C Devaraja. Application No. 202111026625. Date of filing 15.06.2021
- Portable machine for cutting blocks of frozen untampered butter. Ananta V. Dhotre, F. Magdaline Eljeeva Emerald, P. Heartwin Amaladhas and K. Jayaraj Rao. Application No. 202111048927. Date of filing October 26, 2021.

EASTERN REGIONAL STATION, KALYANI OF ICAR-NDRI

The National Dairy Research Institute (NDRI) is a premier institute devoted to research on dairying. The main institute (Head Quarter) is located at Karnal, Haryana. The main objective of establishing the Eastern Regional Station is to identify the major constraints of dairy production in eastern and north eastern India and to offer solutions through research and extension activities to these problems. It serves as a vital link between the NDRI, Karnal and the far-flung areas of the eastern and north eastern regions of the country for transfer of technology developed at the institute and provides appropriate feedback after trial for perfection. The research work undertaken at this station is mainly strategic and applied in nature and the thrust of research is to improve the socio-economic condition of dairy farmers of this region.

The Eastern Regional Station was established at the Central Dairy in Calcutta in 1964 and was shifted during 1966 to Kalyani, Nadia district; about 50 km north of Calcutta and was located in the Administrative Building of Kalyani University. The Regional Animal Nutrition Research Centre of the I.C.A.R. till then located at Haringhata, West Bengal, was merged with the ERS of NDRI with effect from June 1, 1968. In 1978 the Government of West Bengal granted 100 acres of land at Kalyani where cattle sheds, forage unit, staff quarters etc. were gradually built up. The Station built its own laboratory building and the entire station started functioning within the same campus from May, 1987.



The research work during the period of 1964-1972, were mainly related to Animal Nutrition, that during the period of 1972-1976, were related to Animal Nutrition and Dairy Chemistry and Bacteriology, that during the period of 1977-1985, related to Animal Nutrition, Animal Breeding, Soil Science, Dairy Economics and Dairy Extension, that during the period of 1986-1991, were related to Animal Nutrition, Livestock Production and Management, Animal Breeding, Forage Production, Dairy Economics & Statistics and Dairy Extension and that during the period of 1992-1997, were related to Animal Nutrition, Livestock Production and Management, Animal Breeding, Forage Production, Dairy Economics & Statistics and Dairy Extension. Animal Biotechnology Section started functioning during 2005. The Animal Physiology and Reproduction Laboratory were also established in 2013-14. Goat Farm was also established in 2014-15 in a small scale for research, education and training purposes. Krishi Vigyan Kendra-II, Nadia District of West Bengal was sanctioned in 2016-17 for establishment in the Campus of ERS-NDRI, Kalyani.

The Eastern regional station of ICAR-National Dairy Research Institute has infrastructure facilities like Research Laboratories, Cattle Herd, Fodder Farm, Library, Computer Section, Academic Cell, Hostels and Guest House, Estate Section etc.

Keeping in view the enormous demand for milk in the eastern region, low milk production potential of the native stock, shortage of feed and fodder resources and diversified agro-climatic and socio-economic conditions; this research station has a great role to play in the field of dairy development in this region.

EXTENSION ACTIVITIES

Training Programme Organized

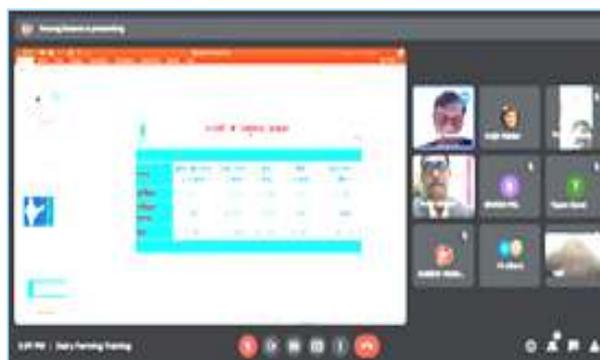
Online Training Programme on “Scientific Goat Rearing Practices”

On the occasion of ICAR foundation day one day online training programme on “Scientific Goat Rearing Practices” was organized by ICAR-National Dairy Research Institute, Eastern Regional Station, Kalyani, West Bengal on July 16, 2021. During the occasion lecture on “Care and Management of Goats” to promote scientific goat rearing practices like feeding, breeding, housing and health care managements was delivered. A panel discussion with experts cum question answer session was conducted where all the scientists,

technical officers actively participated in addressing the questions of farmers to clear their doubts. Farmers were made aware about scientific goat rearing, importance of goat milk, value addition to mutton, leather, importance of de-worming & vaccination, feeding practices etc. A total number of 106 farmers from villages like Rangabelia, Jatirampur, Dulduli, Pakhirala, Gosaba, Rajapur, Uttardanga of West Bengal, Sonarpur, Budge Budge –II, Joynagar participated in the programme.

Five days Online Training on 'Scientific Dairy Farming for Sustainable Economic Security'

Eastern Regional Station of ICAR- National Dairy Research Institute and ICAR- Agricultural Technology Application Research Institute, Kolkata have jointly organized 'Five days online training' on 'Scientific Dairy



Farming for Sustainable Economic Security' during December 6-10, 2021, for the progressive farmers from West Bengal and Odisha. In the training programme a total of 16 lectures were delivered by the Scientists from ICAR-National Dairy Research Institute, ICAR-Indian Veterinary Research Institute and expert from NABARD. A total of 74 participants including 11 Subject Matter Specialists from KVK system attended in the training programme.



On-line Training Programme for Sikkim farmers

Eastern Regional Station of ICAR- National Dairy Research Institute has organized one online training on 'Scientific Poultry Farming in Hill region of Sikkim' on December 23, 2021 for the poultry farmers from Sikkim. The programme was jointly organized in collaboration with ICAR- Research Complex for NEH region, Sikkim Centre. In the training programme a total of 52 farmers participated. Different aspect of poultry farming like poultry nutrition, housing management, health care aspects were covered under the programme.

Special Programmes Organized

National Campaign on 'Food and nutrition for farmers'

On the occasion of National Campaign on 'Food and nutrition for farmers' one training programme by involving 50 farmers was organised by KVK- Additional- Nadia on August 26, 2021. During the occasion farmers were sensitised about the programme and importance of proper nutrition. One lecture was delivered on the topic 'Animal husbandry for sustainable nutritional security for tribal farmers'. On the topic 'Importance of dairy farming for economic development of tribal farmers', the importance of dairy farming in accomplishing economic security and subsequently achieving overall livelihood security on sustainable basis was discussed throughly. One presentation on the topic 'Food and nutrition for farmers' was also made. During the programme, direct telecast from ICAR headquarters, New Delhi was shown to the farmers. Farmers were also engaged in active interaction with the presenters during the programme.

Curtain Raiser of 'International Year of Millets 2023' and Vegetable Seed Distribution among Farmers

One program was organized on September 17, 2021 in the occasion of curtain raiser of 'International year of millets 2023'. In the program, a total of 88 farmers attended. Seed packets of several vegetable crop which can be grown in the kitchen garden was also distributed among the farming community. A total of 1225 number of planting material was also distributed among the farming community. A special tree plantation drive was also organized in the event. In the programme several lectures on importance of dairy farming for rural livelihood, importance of animal husbandry for attaining sustainable nutritional security and nutri- cereal and their role on human health was discussed.

Observation of National summit on Agro and Food processing with focus on "Natural Farming"

ICAR-NDRI, ERS, Kalyani (WB) observed three days (December 14-16, 2021) National summit on Agro and Food processing with focus on "Natural Farming". On December 14, 2021, a total of 42 farmers from Banamalipara and Ichhapur villages and on December 15, 2021, a total of 39 farmers from 3 blocks (Kalyani, Chakdah, Ranaghat-I) were attended. On December 16, 2021, a total of 91 farmers from different villages (Banamalipara, Ichhapur, Phulia Nidhkur, Nakashipara, Nandighat, Chandamari, Bir-shidhu nagar) attended the honorable Prime Minister's lecture on natural farming. Farmer interaction meets in all the 3 days were conducted by ERS, NDRI and KVK (Nadia- additional).

Major Field Activities under TSP

Livestock Development program at Ruppur, Birbhum, West Bengal

One day programme on awareness about goat rearing, demonstrations regarding uses of various inputs along with distribution of various inputs (goats, goat feed, mineral mixures, vitamin supplement and deworming) in a remote village Ruppur of Birbhum district, West Bengal were jointly organized by ICAR-National Dairy Research Institute (NDRI), Eastern Regional Station (ERS), Kalyani, West Bengal collaboration with Bolpur

Manab Jamin on January 30, 2021 under TSP Project. Total 50 black Bengal goats, 1500 kg of goat mash feed, 27 kg of mineral mixture, vitamin supplement and deworming were distributed among 27 tribal farmers.

On Campus Scientists-Farmers Interaction Session cum Input Distribution Camps under TSP

A total of 2 on-campus scientists- farmers' interaction session cum input distribution camps under TSP programme were organized during January, 2021 to March, 2021. The first programme was organized on February 10, 2021 and during the programme, 2600 kg pig starter mash, 9700 kg goat mash, 36 piglets and 91 goats were distributed among farmers. Another programme was organized on February 27, 2021 and during the programme 80 goats, 2000 kg goat mash, 20 piglets, 1000 kg pig starter mash, veterinary medicine and utensils used for dairy farming were distributed among the tribal farmers.

Livestock Development Program at Budbud, Burdwan, West Bengal

One day programme on awareness about goat rearing, demonstrations regarding uses of various inputs along with distribution of various inputs (goats, goat feed, mineral mixtures, vitamin supplement and deworming) in Budbud KVK of Burdwan district, West Bengal were jointly organized by ICAR-National Dairy Research Institute (NDRI), Eastern Regional Station (ERS), Kalyani, West Bengal collaboration with Budbud KVK of Burdwan on February 12, 2021 under TSP Project. Total 56 black Bengal goats were distributed among 14 tribal farmers.

Off-campus Scientists-farmers Interaction Session cum Input Distribution Camp

ICAR-NDRI, ERS, Kalyani, West Bengal, organized one day programme on Livelihood Improvement through Livestock Interventions on September 3, 2021 at Paruldanga village of Birbhum district, West Bengal in collaboration with NGO, Bolpur Manab Jamin. A scientist-farmer interaction meeting was conducted on that day. A total of 100 farmers were participated in that interaction meeting. Some need base inputs for goat rearing were distributed to 30 tribal woman farmers. A total of 60 female goats, two goats to each farmer, along with one 50 kg bag of concentrate mixture feed (EPIC goat mash) were distributed. Additionally, each of tribal farmers was provided with two kg of mineral mixture, vitamin supplements, veterinary fast-aid kit, anthelmintic and some other essential medicines. The body weight of each goat distributed was recorded and ear tagged for identification of animal for further recording under this project. Scientists also visited a goat farm of a progressive farmer.

On Campus Scientists-Farmers Interaction Session cum Input Distribution Camp

Science scientist's farmers interaction session and input distribution camp was organised at the ERS of ICAR-NDRI campus on September 28, 2021. A total of 60 tribal farmers attended the programme. During the program several lectures on role of animal husbandry for securing sustainable economic development was discussed with the tribal farmers. Interaction session with the tribal farmers was also organized and the queries raised by the farmers were answered. In the programme, a direct telecast of lecture and interaction session of Honorable Prime Minister of India was also shown to the farming community. In the program several inputs were distributed among the tribal farmers. Each tribal farmer beneficiary got two bags of pig feed and all of them also got dairy utensils and packets of mineral mixture.

Scientist Farmers Interaction Session cum Input Distribution

One scientists-farmers interaction session cum input distribution camp was organized under TSP project on October 11, 2021 at ERS of ICAR-NDRI campus. In the program, a total of 55 tribal farmers and farm women got benefit under the project. A total of 40 farmers got 80 goat kids (2 goat kids each farmers) and 15 tribal farmers got 30 piglets (2 piglets each farmers). Apart from these, all the farmers got 50 kg of animal feed. Veterinary medicines and mineral mixture were also distributed among the farming community. Each farmer got 1kg of mineral mixture and veterinary medicines were also distributed. Tribal farmers got firsthand experience about scientific animal husbandry practices through the interaction with the Scientists and Technical officers of ICAR-NDRI. Tribal farmers were encouraged to rear livestock in a scientific way so that their livelihood can be secured in the long run. Tribal farmers were hugely motivated and they ensured Scientists and Technical officers of the Institute that, they will rear these animals in a scientific manner.

Front Line Demonstration of Mustard Crop

One programmed under 'TSP' was organized on November 2, 2021 in Banamalipara village of Nadia district of West Bengal State. The programme was organized jointly by KVK (Additional) Nadia and Eastern Regional Station of ICAR-National Dairy Research Institute. The programme was started with the interaction with progressive farmers about package of practices also farmers queries were addressed and sensitizing them about the cultivation of mustard seeds. Various inputs including seeds, chemical fertilizers, seeds treatment material were distributed among tribal farmers for cultivation. A total of 64 farmers were selected from tribal community for conducting Front Line Demonstration of mustard crop under TSP.

Extension Activities under SCSP

A total of 7 extension programmes were organized under SCSP programme during January, 2021 to December, 2021. Those programmes were organized in Birbhum district and Nadia district of West Bengal. On January 22, 2021, Scientists-Farmers Interaction Session cum Animal Vaccination, Health and Input Distribution Camp was organized at Supur village of Birbhum district and in the camp 50 Goats, 1250 kg Goat Feed and 100kg Mineral Mixture was distributed among Scheduled Caste farmers. Another Scientists-Farmers Interaction Session and Input Distribution Camp were organized at NDRI-ERS, Kalyani campus February 10, 2021 and in the programme 50 Goats, 1250 kg goat feed was distributed among farmers. On February 12, 2021, Scientist-Farmers Interaction Session and Input Distribution Camp was organized at Burdwan KVK campus and through the programme 50 Goats, 1250 kg goat feed was distributed among farmers belong to scheduled caste community. One animal health and vaccination camp was organized under SCSP project on March 9, 2021 at South Chandamari village of Nadia district of West Bengal and in the programme, animal vaccination campaign was carried out at the farmers' door step. One 'Animal health camp cum *Kisan Gosthi*' was organized on November 11, 2021 under 'Scheduled Caste Sub Plan' project in South Chandamari village of Nadia district of West Bengal State. The programme was organized jointly by KVK (Additional) Nadia and Eastern Regional Station of ICAR-National Dairy Research Institute. The programme was started with the interaction with dairy farmers about the importance of vaccination and time-bound treatment of the livestock. Tips and suggestions were also given to the farmers regarding the care and management of different livestock. A total of 99 cows, 39 calves and 21 goats were vaccinated during the event. Livestock were vaccinated against 'Foot and mouth Diseases', 'Hemorrhagic septicaemia', 'Black Quarter' and PPR. In the event 40kg mineral mixtures were distributed among the farmers who were belong to SC community. The farmers appreciated the initiative and thanked the team for their effort and promised for their cooperation and involvement in future also. On-campus visit cum awareness programme for tribal farmers was organized on December 23, 2021. In the programme farmers were sensitized about the importance of animal husbandry in nutritional security and importance of gender equality in agriculture. During the programme demonstration of different management practices pertaining to maintenance of cleanliness in the animal farm was explained to the farming community. Another input distribution cum awareness programme was organised on December 24, 2021. In the programme goats and livestock feed was distributed among 25 farmers.

Extension Activities under NEH Project

Nagaland

Under NEH projects scientist farmers' interaction session cum input distribution camps were organized at Dungki village, old Jalukie village, Dist. Peren, Nagaland. In camps several inputs viz. chicks, poultry feeds, feeders, drinkers, drinkers stand etc were distributed among farmers. In the camp organized at Dungki village and old Jalukie village, Dist. Peren, Nagaland total 5000 chicks, pre-starter feed 1750 kg, starter feed 2000 kg, 100 feeder, 100 drinker and 100 stand for drinker were distributed among 116 farmers.

Arunachal Pradesh

Three visits were organized at Namsai district of Arunachal Pradesh. The first visit was carried out during February 19-20, 2021. In the visit, scientists farmers interaction session were organized and several inputs like veterinary medicines, Poultry Feed (2000 kg), Pig Feed (1500 kg), Chicks (1000 Nos.), Piglets (30 Nos.) were distributed under NEH project. During March 26-27, 2021 another visit to Arunachal Pradesh was organized and in that visit, 40 kg mineral mixture, Poultry Feed (5000 kg), Pig Feed (129.5 Qtl.), 2000 Ducklings Nos. Pig

Feed (95.75 Qtl.) and 81 Piglets has been distributed to farmers under NEH project. Apart from that, 496 ducklings and 623 poultry bird were also distributed during the programme. ERS of ICAR-NDRI, in collaboration with Krishi Vigyan Kendra (KVK), Namsai has organized one 'Scientists-farmers interaction session cum input distribution programme' on December 15, 2021. During the visit, scientists and technical officer from ICAR-NDRI, Eastern Regional Station, interacted with the farmers and advised several scientific livestock rearing technologies for improving their livelihood through livestock based farming system. In the programme 38 piglets, 1000 poultry Birds were the distributed and 2900 kg animal feed were also provided to the participating farmers. Efficient utilization of scientific technologies pertaining to animal husbandry was also demonstrated to the farmers.

Tripura

In Tripura two visits were arranged during the period under report. The first visit was organised on March 12, 2021 and in the visit 60 kg mineral mixture, 1500 kg Pig Feed, 1250 kg Goat Feed, 30 Goats and 30 Piglets were distributed among farmers under NEH project. Another programme was organized at Dhalai KVK of Tripura and one off-campus training programme was organized during the visit. In the programme, veterinary medicine, 108 Kg mineral mixture, 110 goats were distributed among farmers under NEH project. ERS of NDRI organized scientist farmers Interaction session at Salema, District: Dhalai, Tripura in collaboration with Dhalai KVK on December 21, 2021 under ongoing NEH Project. Discussions were made on scientific livestock/goat rearing. Inputs such as goats, poultry birds, animal feeds, mineral mixture, and medicine were distributed among beneficiaries. Chairman of *panchayat samati* and chairman of block advisory committee also participated in the programme. 65 farmers were present in this programme. 25 Black Bengal female goats were distributed among 25 farmers and 850 chicks were distributed among 45 farmers. Moreover, 2000 kg chick starter feed, 1250 kg goat feed, 130 kg mineral mixture, dewormer, medicine etc were distributed among farmers.

Sikkim

ICAR-NDRI, ERS, Kalyani, West Bengal organized two days programme on "Livelihood Improvement NEH Farmers through Livestock Interventions" at Sanjong village of East Sikkim District (Sikkim) on November 10-11, 2021 under NDRI-NEH Project Component. The programme was conducted in collaboration with ICAR Research Complex for NEH Region, Gangtok, Sikkim. Different aspects of scientific livestock/poultry farming like transportation stress, breeding, feeding practices, fodder production, housing and general management, reproductive management, deworming, vaccination, mortality issues etc.

were discussed. Some need base inputs were distributed to 40 hill farmers (40 chicks, 2 poultry feeders, 2 waterers, 1 kg mineral mixture and supplement per beneficiary poultry farmer) as a component of direct benefits transfer under the NEH project. 50 cattle farmers were provided 50 kg cattle feed/farmer along with mineral mixture (1 kg/farmer) and supplement. 70 kg pig feed/farmer along with mineral mixture (1 kg/farmer) and supplement were also distributed among 20 beneficiary pig farmers. A total of 2000 Banaraja chicks, 2250 kg poultry feed, 80 poultry feeders, 80 waterers, 100 kg mineral mixture, 2500 kg cattle feed, 1400 kg of pig feed and 100 jars (3lit each) of supplements (Calposvet) were distributed to 100 beneficiary hill farmers.

Assam

ICAR-NDRI, ERS, Kalyani,(WB) organized two days programme on "Livelihood Improvement NEH Farmers through Livestock Interventions" at Jhargram village of Morigoan District (Assam) on December 21-22, 2021 under NDRI-NEH Project Component. The programme was conducted in collaboration with KVK, Morigoan dist (AAU). Survey of surrounding villages, a Scientists-Farmers' Interaction and a Training programme was conducted during December 21-22, 2021. A Total of 94 NEH farmers participated in the Scientists-Farmers' Interaction-cum-Training session. Some need base inputs were distributed to 64 farmers (40 goats, 60 mineral mix packets, 100 bags feed and essential vet medicines).



Activities of KVK (Additional)-NADIA

Front Line Demonstration on Blackgram Crop and Maize Fodder Crop

Improved package of practices for kharif season pulse crop seeds production of Black gram crop were carried out at 50 farmer's fields. PU-31 variety of black gram pulse crop for seeds production was demonstrated with bio-pesticide *Trichoderma* and bio-fertilizer *Rhizobium* as seed treatment, biofertilizer PSB application as seed treatment, use of specific pre-germination weedicide (Pendimethalin 30EC) and application of micro-nutrients Zinc and Boron as spray on standing crop at specific day(s) intervals after germination. A total area of 3.33 hectare was covered under the FLD. Improved package of practices for kharif season fodder production of Maize crop was carried out at 60 farmer's fields. J1006 Maize crop for fodder production with bio-pesticide and *Carbendazim* as seed treatment, use of specific pre-germination weedicide (Atrazine) was demonstrated at farmers' field. A total area of 2 hectare was covered under the FLD.

On Farm Testing on Varietal Trial of Sorghum Fodder Crop and Bio-fertilizers and Bio-pesticides on Yield Potentiality of Maize

Varietal trial of improved varieties of sorghum fodder with three technical options i.e Sugargaze, MFSH-4 and PC-23 were carried out at 17 farmer's fields (17 replications). Technical option I. (Sugargaze) Recorded the highest yield (344.5t/ha) followed by Technical option II (MFSH 321 t/ha) and Technical option III (P.C-23) 275.1 q/ha. Though, highest Infestation of red rot was recorded in Sugargaze variety. Use of both Bio-fertilizers and bio-pesticides in fodder maize crop cultivation was carried out in 15 locations. Technical option II (Use of both Bio-fertilizers and bio-pesticides in fodder crop production) recorded the highest yield (345.30 t/ha) followed by Technical option I (Use of Bio-fertilizers in fodder crop production). This suggested that farmers can get best result of fodder maize cultivation through using of bio-fertilizers and bio-pesticides both.



Trainings

Total no. of 46 training conducted on different topic like Weed Management, Integrated Farming, Fodder Production, Water Management, Soil fertility management, Dairy Management, Piggery Management, Disease Management, Goat Farming, Production of Bee colonies and wax sheets, Integrated Farming Systems, Integrated Pest Management, Integrated Nutrient management etc. Through those training programmes a total of 1015 male participant and 896 female participants were benefited.

Awareness Campaign cum Kisan Gosthi

One programme under 'Special Swachhta Campaign' was organized on October 12, 2021 in South Chandamari village of Nadia district of West Bengal State. The programme was organized jointly by KVK (Additional) Nadia and Eastern Regional Station of ICAR-National Dairy Research Institute. Scientists and Technical officer of the station actively participated in the programme. The programme was started with the interaction with progressive farmers and sensitizing them about the maintenance of general cleanliness. One procession with local farmers and school children was taken out with banners and placards to sensitize the farming community about the importance of cleanliness and maintaining hygiene at the household level. Visit to farmers' doorstep was organized to motivate the farmers in adopting general cleanliness measures. Treatment facility for

livestock was provided by the visiting team members and suggestion for better animal husbandry practices were also given to the farming community. School children were very much enthusiastic about the campaign and they were also sensitized about the Covid appropriate behavior.

Animal Health Camp cum Kisan Gosthi under SCSP

One 'Animal health camp cum *Kisan Gosthi*' was organized on November 11, 2021 under 'Scheduled Caste Sub Plan' project in South Chandamari village of Nadia district of West Bengal State. The programme was organized jointly by KVK (Additional) Nadia and Eastern Regional Station of ICAR-National Dairy Research Institute. Scientists and Technical officer of the station actively participated in the programme. The programme was started with the interaction with dairy farmers about the importance of vaccination and time-bound treatment of the livestock. Tips and suggestions were also given to the farmers regarding the care and management of different livestock. A total of 99 cows, 39 calves and 21 goats were vaccinated during the event. Livestock were vaccinated against 'Foot and mouth Diseases', 'Hemorrhagic septicaemia', 'Black Quarter' and PPR. In the event 40 Kg mineral mixtures were distributed among the farmers who were belong to SC community. The farmers appreciated the initiative and thanked the team for their effort and promised for their cooperation and involvement in future also.

Observation of National summit on Agro and Food processing with focus on “Natural Farming”

ICAR-NDRI, ERS, Kalyani (WB) observed three days (December 14-16, 2021) National summit on Agro and Food processing with focus on “Natural Farming”. On December 14, 2021, a total of 42 farmers from Banamalipara and Ichhapur villages and on December 15, 2021, a total of 39 farmers from 3 blocks (Kalyani, Chakdah, Ranaghat-I) were attended. On December 16, 2021, a total of 91 farmers from different villages (Banamalipara, Ichhapur, Phulia Nidhkur, Nakashipara, Nandighat, Chandamari, Bir-shidhu nagar) attended the honorable Prime Ministers's lecture on natural farming. A farmer interaction meet in all the 3 days were conducted by ERS, NDRI and KVK (Nadia- additional).

Forage Farm

Forage Farm section is engaged in cultivation of quality fodder crops in about 27-30 hectares area and manages harvesting and supply of fodder crops either chaffed or unchaffed to the Cattle Yard. Besides cultivation of fodder crops, the Forage Section also has a mini workshop for regular servicing of agricultural machineries including tractors, chaffcutter etc. There is a small vermi-compost unit used for training and demonstration purpose. There is an agri-meteorological observatory where regular observations are taken for various meteorological parameters like relative humidity, max. and min. air temperature, soil temperature at different depth, wind speed and direction, Rainfall etc. There are more than 1000 plants of teak, sheesham, mango, coconut etc. growing around the Institute premises. Mango and guava based agro-forestry have been developed in the ERS campus. Every year staff of ERS used to plant several saplings of different useful species in the campus. Besides, there is a fodder herbarium for training and demonstration purpose. The Forage Section has necessary facility for covering the theoretical and practical part of training on fodder crop production.

Library

The Library of ERS contains 1818 books, 4078 volumes of bound journals and other periodicals in the field of Dairying. Besides, Annual Reports of different Institutes and proceedings of various workshops and seminars are also available for reference. Presently Indian Journals are subscribed for students and Scientists.

Computer Cell

The computer center facilitates the maintenance of databases and analysis of research data. The institute has high speed Internet connectivity through NKN, which is being used by Masters' and Ph.D. students for academic and research purposes and by other staff for official and administrative activities of the Institute. The Computer cell has extended the Internet facility to Hostels, Guest house and different sections like cattle yard, Forage and Estate section of the Institute.

Livestock Farm

Annual Performance of ERS-NDRI, Kalyani Herd during 2021

Particulars	Jersey Cross
Herd Strength as on December 31, 2021	236
Av. no. of cow's in milk/day	71
Wet Average (kg)/day	7.27
Age at First Calving (month)	32.8
No. of Pregnant	75
Service period (days)	107
Mortality (%)	5.5

Milk Production Performance at ERS-NDRI, Kalyani Herd

Months	Milk Production (Kg.)	Wet Average (Kg.)	Herd Average(Kg.)	Average FAT %	Average SNF %
January	16895.0	6.69	5.25	5.14	9.13
February	14109.0	6.75	5.00	4.99	9.11
March	15668.5	6.88	4.67	4.86	8.98
April	16084.0	7.43	4.91	4.64	8.92
May	18658.5	7.95	5.42	4.66	8.87
June	18339.5	8.12	5.47	4.63	8.80
July	17127.0	7.69	5.00	4.64	8.79
August	15550.0	7.10	5.00	4.75	8.69
September	14395.5	7.28	5.40	4.63	8.66
October	13775.5	7.17	5.00	4.73	8.76
November	13623.5	7.17	5.00	4.81	8.92
December	14665.0	7.00	5.10	5.02	9.07
Total Milk	188891.0				
Overall Average	15740.917	7.27	5.10	4.79	8.89

Academic Cell

M.Sc./ M.V.Sc. and Ph.D. students of different disciplines like Animal Nutrition, Livestock Production and Management, Animal Physiology, Animal Reproduction, Animal Biotechnology, Animal Genetics & Breeding and Dairy Extension are allotted to pursue their dissertation/ research work at Eastern Regional station, Kalyani. During the year 2021, ten Master degree students and two Ph.D. students have successfully completed their thesis works and awarded the respective degrees. Presently, twelve Master degree students and fifteen Ph.D. students are pursuing their research work. Other than academics, some cultural, sports and literary activities were organized in which students took keen interest.

Fodder production and supply to the Institute Farm, ICAR-NDRI-ERS, Kalyani, during 2021

Sl. No.	Particulars of fodders	Quantity (Qtls.)
1)	Berseem/ Berseem+Chinese cabbage	1569.40
2)	Oats/ Oats+ Chinese cabbage	1828.40
3)	Sorghum/Sorghum sudan grass hybrid(SSG)/ SSG+Cowpea	4775.25
4)	Maize/ Maize+ cowpea	2342.90
5)	Perennial fodder (Hybrid napier grass, Guinea grass)	1166.40
6)	Cowpea	358.80
	Total	12,041.15

19. BUDGET AND EXPENDITURE

The financial outlays in terms of actual expenditure for Grants for the year 2021-2022 was Rs. 23,444.33 lakhs and the sanctioned budget for Grants in 2021-22 was Rs. 23,449.96 lakhs. These figures include the financial outlays for Regional Campuses.

Financial Outlays and Expenditure during 2021-22

NDRI including ERS, Kalyani

Sl.No.	Head	Grants (Rs. in Lakhs)	Budget Expenditure
1)	Grant in Aid- Capital	351.26	351.14
2)	Grant in Aid- Salaries	7,764.17	7,764.17
3)	Grant in Aid- General	13,200.53	13,200.48
	Total	21,315.96	21,315.79

SRS, Bengaluru

Sl.No.	Head	Grants (Rs. in Lakhs)	Budget Expenditure
1)	Grant in Aid- Capital	40.00	39.75
2)	Grant in Aid- Salaries	1,290.00	1,287.14
3)	Grant in Aid- General	804.00	801.65
	Total	2,134.00	2,128.54

Revenue Generation

The Revenue Receipts of the Institute and its Regional Campuses for the year 2021-22 were Rs. 1,033.17 lakhs:-
(Rs. in Lakhs)

Sl.No.	Head	Amount
1)	Sale of milk/ farm produce	312.48
2)	Sale of old vehicle/ equipment etc.	50.85
3)	Sale of livestock	45.63
4)	Sale of publications	0.47
5)	License fee	75.78
6)	Interest earned on loans and advances	8.58
7)	Leave salary and pension contribution	78.96
8)	Receipt from scheme	1.12
9)	Analytical and testing Fee	10.07
10)	Interest earned on short term deposits	12.22
11)	Income generated from internal resource generation	89.04
12)	Recovery of loans and advances	29.00
13)	Miscellaneous receipts	318.97
	Total	1,033.17

Position of Manpower at NDRI, Karnal and its Regional Stations as on 31.12.2021

Type of Posts	Sanctioned/Approved Posts	In-Position Posts	Vacant Posts
Scientific	195	138	57
Administrative (Group: A&B)	40	37	3
Technical	317	168	149
Administrative (Group: Non-Gazetted)	91	93	+2
Supporting	384	268	116
Total	1027	704	327

20. राजभाषा गतिविधियां - 2021

भारत सरकार की राजभाषा नीति के अनुपालन में राजभाषा हिंदी के प्रचार, प्रसार एवं कार्यान्वयन हेतु संस्थान में वर्ष 1979 में राजभाषा एकक की स्थापना की गई। राजभाषा एकक द्वारा संस्थान के अधिकारियों, वैज्ञानिकों, मंत्रालयिक स्टाफ, तकनीकी स्टाफ आदि को राजभाषा हिंदी में कार्य करने के लिए प्रोत्साहित करते हुए हर संभव प्रयास/ सहयोग भी प्रदान किया जा रहा है। संस्थान के द्वारा वर्ष 2021 में निम्नलिखित गतिविधियों का आयोजन किया गया।

संस्थान राजभाषा कार्यान्वयन समिति की बैठकें

- संस्थान में राजभाषा हिन्दी के प्रयोग की प्रगति की समीक्षा हेतु डा. एन.एन. दस्तूर सभागार में 30 मार्च 2021 को कोविड संबंधी निर्देशों की पालना के साथ 90वीं तिमाही समीक्षा बैठक का आयोजन किया गया।
- संस्थान राजभाषा कार्यान्वयन समिति की 91वीं तिमाही बैठक का 31 मई 2021 को वर्चुअल आयोजन किया गया।
- 7 सितंबर 2021 को कोविड संबंधी निर्देशों की पालना के साथ 92वीं तिमाही बैठक का आयोजन किया गया।
- संस्थान राजभाषा कार्यान्वयन समिति की 93वीं तिमाही समीक्षा बैठक का 30 दिसंबर 2021 को कोविड संबंधी निर्देशों की पालना के साथ संस्थान के पिनाकी हॉल में आयोजन किया गया।

हिन्दी कार्यशालाएं, संगोष्ठियां एवं प्रशिक्षण

- दिनांक 16.01.2021 को "ज्ञान-विज्ञान व तकनीकी लेखन में हिन्दी की भूमिका व संभावनाएं" विषय पर वर्चुअल माध्यम से एकदिवसीय वैज्ञानिक तकनीकी संगोष्ठी का आयोजन किया गया, जिसमें आई.सी.ए.आर. के करनाल स्थित सभी शोध संस्थानों व नगर राजभाषा कार्यान्वयन समिति के सदस्य कार्यालयों के 70 अधिकारी एवं 24 कर्मचारी शामिल हुए। संस्थान के राजभाषा विभाग के संयुक्त तत्वावधान में आयोजित इस संगोष्ठी में वैज्ञानिकों ने ज्ञान विज्ञान एवं तकनीकी लेखन में हिन्दी भाषा की महत्वपूर्ण भूमिका के बारे में विचार विमर्श एवं आत्ममंथन किया। केन्द्रीय औशधि अनुसंधान संस्थान, लखनऊ से सेवानिवृत्त संयुक्त निदेशक डा. विजय नारायण तिवारी ने मुख्य वक्ता के रूप में अपने संबोधन से प्रतिभागियों को लाभान्वित किया। इस वर्चुअल कार्यक्रम के अंत में प्रतिभागियों की शंकाओं व प्रश्नों पर भी विस्तारपूर्वक चर्चा की गई।
- प्रभारी, राजभाषा एकक तथा उप निदेशक (राजभाषा) ने दिनांक 30.03.2021 को "संसदीय राजभाषा समिति के निरीक्षण हेतु तैयारी" विषय पर आयोजित चर्चा संगोष्ठी में संस्थान के 15 अधिकारियों तथा 5 प्रतिभागियों को महत्वपूर्ण मार्गदर्शन प्रदान किया। उन्होंने सभी प्रतिभागियों को संसदीय समिति के द्वारा हिन्दी संबंधी कार्यों के निरीक्षण की प्रक्रिया तथा सभी प्रभागों, अनुभागों व पदाधिकारियों के द्वारा राजभाषा नीति, नियमों व व्यवस्थाओं के अनुपालन हेतु ध्यान में रखी जाने वाली महत्वपूर्ण जानकारी प्रदान की तथा प्रतिभागियों की शंकाओं का समाधान भी किया।
- नगर राजभाषा कार्यान्वयन समिति के तत्वावधान में संस्थान के द्वारा दिनांक 25 मई 2021 को नगर स्तरीय वर्चुअल हिन्दी कार्यशाला मय चर्चा संगोष्ठी का आयोजन किया गया। संगोष्ठी के मुख्य अतिथि डा. ए.पी. राय, उप महानिदेशक, भारतीय भूविज्ञान सर्वेक्षण, कोलकाता ने 93 प्रतिभागियों को संसदीय राजभाषा समिति की संरचना, समिति की निरीक्षण की कार्यप्रणाली, निरीक्षण हेतु की जाने वाली तैयारियों, माननीय संसद सदस्यों की गरिमानुसार संबंधित व्यवस्थाएं करने, निरीक्षण प्रश्नावली भरने, कार्यालय में कार्यालय प्रमुखों के द्वारा राजभाषा नीति, नियमों व व्यवस्थाओं तथा संवैधानिक नियमों के अक्षरशः अनुपालन के लिए महत्वपूर्ण मार्गदर्शन प्रदान किया।
- राजभाषा एकक के द्वारा दिनांक 29 सितंबर 2021 को संस्थान के 5 कर्मचारियों को उनके कंप्यूटर पर हिन्दी फोंट व ई-हिन्दी टूल्स का प्रयोग करने के बारे में डेस्क प्रशिक्षण प्रदान किया गया।
- उप निदेशक (राजभाषा) ने दिनांक 31 दिसंबर 2021 को "राजभाषा हिन्दी : समस्याएं एवं समाधान" विषय पर आयोजित हिन्दी कार्यशाला में संस्थान के 12 कर्मचारियों को प्रशिक्षण प्रदान किया।

हिन्दी दिवस/ हिन्दी उल्लास महोत्सव एवं वार्षिक पुरस्कार वितरण समारोह

- संस्थान में हिन्दी दिवस से प्रारंभ करके दि. 14.09.2021 से 09.12.2021 तक की अवधि में राजभाषा हिन्दी उल्लास महोत्सव का कोविड संबंधी निर्देशों के मद्देनजर आयोजन किया गया। इस महोत्सव के दौरान हिन्दी टंकण

परीक्षा (16.09.2021), हिन्दी श्रुत लेखन प्रतियोगिता (18.09.2021), हिन्दी निबंध लेखन प्रतियोगिता (21.09.2021), हिन्दी टिप्पण/आलेखन प्रतियोगिता (23.09.2021), नगर- स्तरीय हिन्दी भाषण प्रतियोगिता (05.10.2021, पूर्वाह्न) एवं वैज्ञानिकों तथा विद्यार्थियों के लिए हिन्दी शोध पत्र पोस्टर प्रदर्शन प्रतियोगिता (05.10.2021, अपराह्न) का आयोजन किया गया। संस्थान के द्वारा दिनांक 10.12.2021 को आयोजित किए गए वार्षिक राजभाषा पुरस्कार वितरण समारोह में उक्त महोत्सव के दौरान आयोजित प्रतियोगिताओं के विजेताओं के साथ-साथ वार्षिक हिन्दी मूल हिन्दी टिप्पण आलेखन प्रतियोगिता (2019-20), वार्षिक हिन्दी ईमेल प्रोत्साहन प्रतियोगिता (2020-21), अधिकारियों की वार्षिक हिन्दी डिक्टेशन प्रतियोगिता (2020-21), वैज्ञानिक एवं तकनीकी हिन्दी लेखन प्रोत्साहन योजना के विजेताओं को संस्थान प्रमुख के द्वारा प्रमाण-पत्रों से सम्मानित किया गया। सितंबर, 2021 माह में संस्थान के दक्षिणी क्षेत्रीय केन्द्र, बंगलूरु एवं पूर्वी क्षेत्रीय केन्द्र, कल्याणी के द्वारा भी हिन्दी दिवस/सप्ताह का आयोजन किया गया।

राजभाषा के उत्कृष्ट कार्यान्वयन संबंधी पुरस्कार/उपलब्धियां

नगर स्तरीय उत्कृष्ट हिन्दी कार्यान्वयन पुरस्कार:

- नराकास करनाल के द्वारा राजभाषा के क्षेत्र में उत्कृष्ट कार्य हेतु संस्थान को "केन्द्रीय कार्यालय श्रेणी" में "प्रथम पुरस्कार" के रूप में "चल वैजयन्ती" एवं "प्रमाणपत्र" से सम्मानित किया गया।

गृह मंत्रालय, भारत सरकार के द्वारा क्षेत्रीय राजभाषा पुरस्कार:

- राष्ट्रीय डेरी अनुसंधान संस्थान के अध्यक्षीय समन्वय में नगर राजभाषा कार्यान्वयन समिति, करनाल को राजभाषा विभाग, गृह मंत्रालय, नई दिल्ली के द्वारा उत्तर क्षेत्र-1 के अन्तर्गत "क" क्षेत्र में स्थित 109 नराकासों में राजभाषा हिन्दी के प्रचार, प्रसार व कार्यान्वयन की दिशा में उत्कृष्ट कार्य हेतु "क्षेत्रीय राजभाषा पुरस्कार 2019-20" के अंतर्गत "द्वितीय पुरस्कार" से सम्मानित करने की घोषणा की गई है। भारत सरकार के माननीय गृह राज्य मंत्री श्री अजय कुमार मिश्रा ने कानपुर क्षेत्रीय राजभाषा सम्मेलन के दौरान संस्थान के श्री विवेक पुरवार, प्रभारी संयुक्त निदेशक(प्रशासन) को "चल वैजयन्ती" एवं श्री राकेश कुमार, सहायक निदेशक एवं सदस्य सचिव, नराकास करनाल को "प्रशस्ति प्रमाणपत्र" से सम्मानित किया।

न.रा.का.स. करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार:

- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी शोध पत्र श्रेणी" के अंतर्गत संस्थान के डा. के.पोन्नुशामी, प्रधान वैज्ञानिक एवं अन्य के हिन्दी शोध पत्र "शीर्षक: डेरी पशुओं में उच्च उत्पादकता के लिए देशी दवा का उपयोग करके चिचड़ियों की रोकथाम एवं प्रबंधन" को "प्रथम पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी शोध पत्र श्रेणी" के अंतर्गत संस्थान के डा. योगेश कुमार, विशय विशेषज्ञ एवं अन्य के हिन्दी शोध पत्र "शीर्षक: कोहरा व कुहासा की समीक्षा: कोविड-19 में इसके प्रभाव, कार्य करने की विधि और उसके निदान के तरीके" को "तृतीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी समाचार पत्रक/न्यूज बुलेटिन श्रेणी" के अंतर्गत संस्थान के डेरी समाचार, त्रैमासिक विस्तार पत्रिका, वर्ष 50, अंक-2, अप्रैल-जून, 2020 को "द्वितीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी तकनीकी हिन्दी बुकलेट/बुलेटिन/प्रशिक्षण पुस्तिका श्रेणी" के अंतर्गत संस्थान के डा. के.पोन्नुशामी, प्रधान वैज्ञानिक एवं अन्य की तकनीकी पुस्तक (शीर्षक: ग्रामीण महिलाओं के कौशल विकास हेतु मूल्य वर्धित दुग्ध उत्पादों की तकनीक) को "द्वितीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी तकनीकी हिन्दी बुकलेट/बुलेटिन/प्रशिक्षण पुस्तिका श्रेणी" के अंतर्गत संस्थान के डा. सोहनवीर सिंह एवं अन्य की पुस्तक (शीर्षक: सतत् पशु उत्पादन हेतु पशुपालकों के लिए उपयोगी जानकारियां) को "द्वितीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी तकनीकी हिन्दी बुकलेट/बुलेटिन/प्रशिक्षण पुस्तिका श्रेणी" के अंतर्गत संस्थान के डा. निशान्त कुमार एवं अन्य की तकनीकी पुस्तक (शीर्षक: वैज्ञानिक विधि से पशुपालन) को "तृतीय पुरस्कार" से सम्मानित किया गया।

- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की "उत्कृष्ट हिन्दी तकनीकी हिंदी बुकलेट/बुलेटिन/प्रशिक्षण पुस्तिका श्रेणी" के अंतर्गत संस्थान के डा. उत्तम कुमार एवं अन्य की तकनीकी पुस्तक (शीर्षक: पशुपालन हेतु हरे चारे का महत्व एवं प्रबंधन) को "तृतीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी फोल्डर श्रेणी" के अंतर्गत संस्थान के डॉ. सोहनवीर सिंह एवं अन्य के हिन्दी फोल्डर (शीर्षक: फार्मर फर्स्ट परियोजना के अन्तर्गत भैसों की उत्पादकता बढ़ाने की ओर एक पहल : ग्रीष्म ऋतु में भैसों का प्रबंधन) को "तृतीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी फोल्डर श्रेणी" के अंतर्गत संस्थान के डॉ. मदन लाल कम्बोज एवं अन्य के हिन्दी फोल्डर (शीर्षक: सूखे के दौरान पशु प्रबंधन) को "प्रोत्साहन पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी लीफलेट श्रेणी" के अंतर्गत संस्थान के डॉ. डॉ. के. पोन्नूशामी एवं अन्य के हिन्दी लीफलेट (शीर्षक: नीम और निरगुंडी के पौधे की पत्ती से हर्बल (देशी) दवा बनाकर डेरी पशुओं में चिचड़ी और जूँ की रोकथाम) को "प्रथम पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी लीफलेट श्रेणी" के अंतर्गत संस्थान के डॉ. निशान्त कुमार एवं अन्य के हिन्दी लीफलेट (शीर्षक: डेयरी पशुओं में मद के लक्षणों की पहचान) को "तृतीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी आलेख श्रेणी" के अंतर्गत संस्थान के डॉ. पी.बर्नवाल एवं अन्य के हिन्दी आलेख (शीर्षक: कुल्फी: एक प्रसिद्ध पारंपरिक भारतीय डेरी उत्पाद) को "प्रोत्साहन पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी आलेख श्रेणी" के अंतर्गत संस्थान के डॉ. सोहनवीर सिंह के हिन्दी आलेख (शीर्षक: मौसम का पूर्वानुमान: परंपरा से विज्ञान तक) को "द्वितीय पुरस्कार" से सम्मानित किया गया।
- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी आलेख श्रेणी" के अंतर्गत संस्थान के डॉ. सोहनवीर सिंह के हिन्दी आलेख (शीर्षक: मौसम का पूर्वानुमान: परंपरा से विज्ञान तक) को "द्वितीय पुरस्कार" से सम्मानित किया गया।
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- नराकास करनाल के द्वारा नगर स्तरीय उत्कृष्ट हिन्दी प्रकाशन पुरस्कार (2020-21) की उत्कृष्ट हिन्दी आलेख श्रेणी" के अंतर्गत संस्थान के डॉ. उत्तम के हिन्दी आलेख (शीर्षक: किसान भाइयों के लिए मिलावटी एवं नकली उर्वरकों की पहचान विधियाँ) को "प्रोत्साहन पुरस्कार" से सम्मानित किया गया। अन्य उल्लेखनीय गतिविधियाँ:
- राजभाषा नियम 1976 के नियम 10(4) के तहत संस्थान भारत सरकार के राजपत्र में अधिसूचना संख्या: 13-5/95-हिन्दी दिनांक 10.03.1995 के तहत अधिसूचित है। तदनुसार संस्थान के सभी 43 प्रभागों व अनुभागों को नियम 8(4) के अंतर्गत अपना समस्त प्रशासनिक कार्य शतप्रतिशत हिन्दी में निष्पादित करने के लिए विनिर्दिष्ट किया गया है।
- राजभाषा हिन्दी के प्रगामी प्रयोग से संबंधित सभी रिपोर्टें एवं बैठकों के कार्यवृत्त परिषद मुख्यालय तथा राजभाषा विभाग को ऑनलाइन प्रेषित किए जाते हैं। तिमाही हिन्दी बैठकों के कार्यवृत्तों/तिमाही प्रगति रिपोर्टों पर परिषद मुख्यालय/राजभाषा विभाग, नई दिल्ली से प्राप्त हुई अभ्युक्तियों एवं मार्गदर्शन के अनुसार अक्षरशः अनुपालना की जाती है तथा इंगित की गई कमियों का तत्काल निराकरण किया जाता है।
- संस्थान के दक्षिणी क्षेत्रीय केन्द्र, बेंगलूरु व पूर्वी क्षेत्रीय केन्द्र, कल्याणी में भी संस्थान राजभाषा कार्यान्वयन समितियाँ गठित की गई हैं। दोनों केन्द्रों में भी प्रत्येक तिमाही में हिन्दी बैठक का आयोजन करके तिमाही प्रगति रिपोर्ट के साथ बैठक का कार्यवृत्त संस्थान मुख्यालय करनाल को प्राप्त होते ही उसकी समीक्षा कर आवश्यक निर्देश जारी किये जाते हैं। संस्थान के उप निदेशक/सहायक निदेशक के द्वारा क्षेत्रीय केन्द्रों को राजभाषा हिन्दी के कार्यान्वयन के संबंध में आवश्यक मार्गदर्शन भी प्रदान किया जाता है।

- संस्थान के डेरी कैलेण्डर को विगत वर्षों की भाँति कृषकों व पशुपालकों के हित को ध्यान में रखकर उनसे संबंधित उपयोगी जानकारी को संक्षिप्त रूप में केवल हिन्दी में तैयार कर प्रकाशित किया गया।
- संस्थान के विभिन्न प्रभागों द्वारा किसानों व जनसामान्य के लिए आयोजित किए जाने वाले सभी कार्यक्रमों में हिन्दी भाशा में प्रशिक्षण प्रदान किया गया। सभी प्रचार-सामग्री प्रशिक्षण सामग्री भी हिन्दी अथवा द्विभाषी में प्रकाशित करवाया गया।
- संस्थान के निदेशक, नगरस्तरीय नगर राजभाषा कार्यान्वयन समिति, करनाल के पदेन अध्यक्ष भी हैं। उनकी अध्यक्षता में समिति की दो बैठकें, प्रथम बैठक दिनांक 14 जून 2021 को एवं दूसरी बैठक दिनांक 22 नवंबर 2021 को संपन्न हुई हैं। नराकास की छमाही बैठकों में करनाल स्थित केन्द्र सरकार के सभी सदस्य कार्यालयों के प्रशासनिक प्रमुख व भारत सरकार, राजभाषा विभाग के प्रतिनिधि अधिकारी शामिल हुए।
- संस्थान के शोधरत छात्र-छात्राओं के शोधपत्रों के सारांश को हिन्दी में अनुवाद कर प्रस्तुतीकरण की व्यवस्था की गई। इसी प्रकार संस्थान के मास्टर्स और पी.एच.डी. छात्र-छात्राओं के लिए हिन्दी नॉन क्रेडिट कोर्स की कक्षाओं का पाठ्यक्रमानुसार नियमित रूप से संचालन किया गया।
- संस्थान के वैज्ञानिकों से प्राप्त वैज्ञानिक एवं लोकप्रिय लेख, छात्रों के शोध सारांश, वार्षिक प्रतिवेदन, प्रशासनिक पत्र, परिपत्र, ज्ञापन, विभिन्न समारोहों की प्रेस विज्ञप्ति, गण्यमान्य अतिथियों, मंत्रियों आदि के संबोधन, व्याख्यान एवं अन्य सामग्री का अनुवाद कार्य संस्थान के राजभाषा एकक द्वारा किये गये।

21. SWACHH BHARAT ABHIYAN: CLEAN & GREEN NDRI

ICAR-NDRI took vigorous initiatives to not only keep its premises clean and green, but also it mobilised the community to maintain hygienic and healthy environment in rural areas under the novel programme, Swachh Bharat Abhiyan led by the Union government. This encompasses organizing cleanliness campaigns, motivational talks on cleanliness, awareness camps, etc. in the Institute campus and as well as in the adopted villages of NDRI. The residents of the Institute's campus and the villagers were also educated to make the campaign effective and successful. All the scientists, students and staff of the Institute made a massive sanitation drive not only in campus but also in nearby villages of the Institute during the year 2021. Further, in order to inculcate the value of maintaining health and hygiene at household- level, especially among the residents of the campus of the Institute, several environment friendly dustbins were kept at multiple locations inside the premises of the Institute.



Dr M S Chauhan, Director with students during cleanliness campaign at NDRI premises

Awareness Campaigns

Awareness campaigns were organised extensively in the adopted villages of the Institute. The team of scientists educated the villagers about the wider adoption of the bio-waste management towards processing of bio-wastes into clean and environment-friendly bio-fuels and organic manures. Further, when scientists, technical officers, staff and students of the Institute visited the nearby villages for programmes like field oriented research programmes (Farmers' FIRST, DST, NICRA, SCSP, ICMR etc); Dairy Education at Farmers' Doors, Farmers' Farm School and Mera Gaaon Mera Gaurav, they gave due emphasis about significance of Swachh Bharat Abhiyan, thereby inculcating a sense of responsibility for cleanliness among them.

Parthenium Weed Eradication Campaign

ICAR-NDRI, Karnal organized a Parthenium weed eradication campaign on September 25, 2021 in order to create awareness among the residents of NDRI campus and maintain cleanliness. *Parthenium hysterophorus* is an alien invasive weed, producing 5000 to 25000 seeds per plant and easily gets dispersed to distant places due to its light weight seed. It affects the health of animals, plants, people and environment as it is present everywhere including crop lands, city dwellings and rail and road sides. The strategies for control of this obnoxious weed include community mobilization involving all sections of the society, organising regular meetings and demonstrations for awareness creation, uprooting the weed before flowering and making compost by pit method, spraying herbicides like glyphosate (1.0 to 1.5 %) or 2, 4-D (1.0 to 1.5 %) and releasing bio-control agents such as *Zygogramma biocolorata* in infested areas during rainy season.



Volunteers uprooting Parthenium in NDRI campus

Special Swachhta Campaign

ICAR-NDRI carried out 18 special Swachhta campaigns with a total participation of 1833 stakeholders. A cleanliness campaign as part of Special Swachhta Campaign was organized on October 2, 2021 to commemorate the 152nd birth anniversary of the Father of our nation Shri Mohandas Karamchand Gandhi. The entire faculty and students / inmates of eight hostels cleaned their respective premises.



Farmers participating in Swachh Bharat Campaign in Chand Samand village

A Special Swachhta Campaign was organized at Karan Lake on October 26, 2021. About 200 faculty and students of NDRI has actively participated by dividing into three groups and covered the whole lake premises. The face masks printed with NDRI logo were distributed to all the visitors and participants. The faculty educated the tourists and visitors about cleanliness, non-use of single use plastics, non-spitting on the road and public places, putting the water bottles and other wastes in dust bins, wearing face masks while going out and in public places and adhering to all Covid-19 guidelines.

ICAR-NDRI organised a special swachhta campaign in Subri villages on October 9, 2021. Villagers were sensitised about maintaining clean and hygienic environment and lead a stress free healthy life. In the campaign women, girls, boys and male family members as well as scientists and students of NDRI actively participated in the cleaning of streets, roads and common premises in the village. During the discussion, the information on health, nutrition, sanitation and various local herbal preparations for remedy of various ailments. Later scientists visited and examined the shelter, feeding and health management practices of dairy animal followed by the farmers. Remedial measures were suggested to queries related to reproductive problems of dairy animals, marketing of milk, various health issues of dairy animals were given. Farmers were also encouraged to form producer companies and link with urban consumers directly to realise the better price for their produces.



About 774 files were weeded out in NDRI during Special Swachhta Campaign from October 2, 2021 to October 30, 2021.

Swachhta Pakhwada Activities

ICAR-National Dairy Research Institute, Karnal organized Swachhta Pakhwada from December 16, 2021 to December 12, 2021. Various activities including taking pledge, organising farmers interaction meets, celebration of Kisan Diwas, competition for school children and college students, campaign on crop residue management. Cleaning of tourist places, disposal of pending files, stock taking of solid waste management, selection of clean division, sections and residential quarters have been organized on daily basis. Clean environment is the basis of healthier life and sound mind. Swachhta Pakhwada is an occasion to create awareness and further motivate the good performers and highlight the achievements of clean India. This initiative started by our Hon'ble Prime Minister in 2014 is likely to change the face of our nation as vibrant living place.



MERAGAONMERA GAURAV (MGMG)

Mera Gaon Mera Gaurav (MGMG) is being implemented by ICAR-NDRI as per the guidelines of ICAR since its inception in 2015. At present, 22 teams comprising of 4 Scientists each from multiple disciplines of the Institute are involved in carrying out the MGMG activities in 120 villages. The major purpose behind this innovative field oriented approach is to promote the 'Direct Interface' of Scientists with the farmers to step up the lab-to-land dissemination process, while providing the farmers with the required information, knowledge and advisory services on a regular basis via adoption of villages. A total of 1135 field activities were conducted in 120 villages benefitting 7100 farmers.

The approach lies in identifying the key resource persons of the village, facilitation of interaction with the villagers through them and taking the feedback from the interaction meetings to the concerned stakeholders for addressing them. Every MGMG team created a Whatsapp group for regular communication with key resource persons. Meanwhile, the field oriented research projects are also linked with MGMG villages for enhancing the visibility of the activities and the institute. Many farm centric interventions were popularized among the farmers in the MGMG villages.

Although Institute centric interventions were given prominence in the interaction meetings, often other stakeholders were also invited for responding to the queries of farmers to their satisfaction. In addition, linkages were developed with 22 organisations from the various streams of rural development.

Activities Organized under MGMG

Sl. No.	Name of activity	No. of activities conducted	No. of farmers benefitted
1	Visit to village by all teams	60	1500
2	Interface meeting/ Goshthies	55	1200
3	Training organized	20	800
4	Demonstrations conducted	25	1250
5	Mobile based advisories	750	750
6	Literature support provided	200	800
7	Awareness programmes	25	800
	Total	1135	7100

Facilitation under MGMT

Facilitation			2020-21		2021-22				
i) Seeds	Crop	Variety	Seeds provided in qtls/ Nos.	Farmers Benefitted (No)	Crop	Variety	Seeds provided in qtls/ Nos.	Farmers Benefitted (No)	
	Wheat		200 kg	50	Wheat	HD 187	50 Q	20	
						HD 2967	20 Q	15	
						PBW 222	45 Q	25	
	Berseem	BL-42	500 kg	100	Paddy	PB 1509	60 Q	18	
						PB 1718	40 Q	12	
					Vegetable kits	Packets of multiple crops	4 kg	200	
ii) Seedlings	Nirgundi Seedlings	Raised seedlings	4000 No	600	Fodder crop	Bajra Napier cuttings	500 No	150	
	Neem	Seedlings	300	150					
iii) Nutrient management	Crop	Quantity (quintal/ Kg)		Farmers Benefitted (No)	Crop	Quantity (quintal/ Kg)		Farmers Benefitted (No)	
a) Fertilizer	Paddy	500 kg		100					
b) Bio-fertilizer	Paddy	50 kg		100	Paddy	Azospirillum		50	
iv) Technology (No)	Numbers	Name of Technology	Area (ha)	Farmers Benefitted (No)	Numbers	Name of technology	Area (ha)	Farmers Benefitted (No)	
	5	Silage, mineral mix., vaccination, deworming, AI, PD, First Aid		2500	50	Storage bin,		50	
						20	Rubber mat,		20
						900	Dewormer,		500
						800 kg	mineral mix.,		800
						50 kg	Cal. powder,		50
						800	Albendazole		500
v) Livestock/ poultry/ fisheries	Numbers	Farmers Benefitted (No)		Numbers	Farmers Benefitted (No)				
a) Livestock	10	400		15	2000				
b) Poultry chicks	20	12		10 Kadaknath	5				
c) Fingerlings					5				



Farmers expressing their views in a MGMT meeting at Rambah village in Karnal district

Faculty of ICAR-NDRI visited following villages in different teams under Mera Gaon Mera Gaurav (MGMG) programme and sensitised the farmers about various farming technologies, packages of practice, awareness for hygiene, and so on:

Sl. No.	Name of Village	Date of Visit
1)	Bajidpur	August 6, 2021
2)	Bijna, Gharaunda (Karnal)	August 18, 2021
3)	Baragaon	September 29, 2021
4)	Kharajpur (distributed mineral mixture and dewormer)	December 3, 2021



“ KARNIKA, a clone of high milk-producing elite buffalo yielding 6089 kg milk, in her fifth lactation and 4810 kg milk in standard 305 days of lactation, was born on 20th December 2021 at ICAR-National Dairy Research Institute, Karnal (somatic cell from ICAR-CIRB, Hissar).

Buffalo cloning technology will help in enhancing the productivity of animals which will lead to sustainable milk production in the country. ”



हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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