वार्षिक प्रतिवेदन
ANNUAL REPORT
2022

Serving the Nation through Innovative Dairying since 1923

1923–2023
शतवर्षोत्कर्षोत्सवम्
ndri
CELEBRATING
100 Years of Excellence
in Dairy Science

भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान
(मानद् विश्वविद्यालय) करनाल - 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

To 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 milch 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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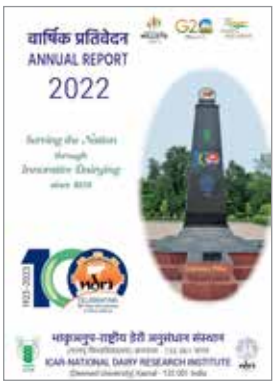

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MILESTONES

Milestones in Institutional Growth

1923 Established as Imperial Institute of Animal Husbandry and Dairying in Bangalore.
1936 Renamed as "Imperial Dairy Institute".
1955 Established as National Dairy Research Institute (NDRI) at Karnal with Southern Regional Station of the Institute at Bangalore
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.
1962 Western Regional Station established at Bombay.
1964 Eastern Regional Station established at Kalyani (W.B.).
1966 Institute brought under the aegis of ICAR.
1975 Operational Research Project initiated.
1976 Department of Human Nutrition and Dietetics established at NDRI, Karnal.
1979 M.Sc., Ph.D. Programme in Dairy Engineering commenced at Karnal.
1980 Karan Swiss cattle breed developed
1982 Karan Fries cattle breed developed
1983 IDD (DH) started at Bangalore.
1985 "Farm Advisory Bureau" and "Industrial Consultancy Cell" set up.
NDRI recognized as Centre of Excellence in Animal Biotechnology.
1987 Embryo Biotechnology Centre established.
1989 The Institute granted "Deemed to be University" status.
National Library of Dairy Science established
M.Sc. in Biotechnology started.
1990 Birth of Pratham, first IVF buffalo calf of the world.
1991 20 bedded Hospital Complex set up and made functional.
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.
The ICAR award (1993-94) for outstanding KVK conferred on the KVK located at NDRI.
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 over one lakh litres/ day commissioned for providing practical training to the students of NDRI University and to serve as an interface between Institute and Industry.
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 23rd December 2000.
2001 Foundation stone of the Agricultural Technology Information Centre laid on 1st 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.
2003 State-of-the-art milking parlour system introduced in cattle section.
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.
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 comprehensive exam for Ph.D. programme introduced.
A new extension programme "Dairy Education at Farmers' Door" started.
2010 8th Convocation of NDRI, Deemed University held in presence of Dr. A. P. J. Abdul Kalam, Former President of India.
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.
2012 Sahiwal Calf "Holi" through Ovum Pick up (OPU-IVF) technique born on 7th March, 2012.
NRC on Milk Quality and Safety established at NDRI, Karnal.
Business Planning and Development (BPD) Unit established at NDRI, Karnal.
2013 First female calf named 'Mahima' was born to a cloned buffalo on 25th January 2013.
A male cloned buffalo calf named 'Swarn' was born on 18th 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.
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 12th December, 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.
2016 Two service centres established at Lalukheri, Muzzafarnagar (UP) and Piprakothi East Champaran (Bihar).
2017 Additional KVK established at Eastern Campus, Kalyani.
One month Foundation Course for newly admitted students of 2017-18 batch introduced.
Automation of the 'Academic Management System' implemented
2018 A mega world-bank funded Institutional Development Plan (IDP) of National Agricultural Higher Education Project initiated.
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.
2019 Three cloned calves produced using donor cells of elite bulls.
2020 Twenty three Faculty members and fifty five students successfully completed their International training in 25 Overseas Universities located in 8 different countries under NAHEP.
2022 ICAR - NDRI ranked first among all Agricultural Universities and four Deemed Universities of ICAR consecutively for five times (2016-2017, 2017-2018, 2018-2019, 2019-2020 and 2020-2021).
Service center of ICAR-NDRI established at Goras, Sheopur, Madhya Pradesh.
Centenary year celebrations of the Institute inaugurated.

प्रस्तावना

PREFACE

भाकृअनुप–एनडीआरआई वार्षिक रिपोर्ट 2022 आपके समक्ष प्रस्तुत करते हुए मुझे अत्यंत प्रसन्नता हो रही है। रिपोर्ट में वर्ष 2022, जो का शताब्दी वर्ष है, के दौरान इन कार्यक्रमों को मजबूत करने के लिए किए गए डेयरी अनुसंधान, शिक्षा, विस्तार और संबंधित गतिविधियों के क्षेत्रों में संस्थान की महत्वपूर्ण उपलब्धियों का वर्णन किया गया है। जानकारी को इस तरह से व्यवस्थित किया गया है कि यह देश के इस प्रमुख डेयरी संस्थान और इसके कामकाज का एक संपूर्ण समग्र दृष्टिकोण प्रदान करता है। डेयरी विज्ञान में 100 वर्षों की उत्कृष्टता का जश्न मनाना और गुणवत्तापूर्ण जनशक्ति विकसित करके डेयरी के उद्देश्य को पूरा करने के हमारे मिशन को अपनाना; उत्पादन से संबंधित तकनीकी जानकारी उत्पन्न करना और उसका प्रसार करना; कृषक समुदाय के लाभ के लिए दूध और दूध उत्पादों का प्रसंस्करण और विपणन; दूध प्रसंस्करण उद्योग और देश के उपभोक्ताओं के लिए, इस वार्षिक रिपोर्ट की जानकारी इस प्रमुख डेयरी संस्थान के समग्र दृष्टिकोण को दर्शाती है।

एनडीआरआई की अनुसंधान और विकास गतिविधियों को अपने अधिदेश–उन्मुख और अच्छी तरह से संरचित अनुसंधान कार्यक्रमों के माध्यम से और गति मिली, जिसमें 89 इन–हाउस और 65 बाहरी वित्त पोषित अनुसंधान परियोजनाएं जिसमें चार अंतर्राष्ट्रीय सहयोगी अनुसंधान परियोजनाएं भी शामिल थी। एनडीआरआई प्रमुख अंतर्राष्ट्रीय/राष्ट्रीय वित्तपोषण एजेंसियों से बाह्य वित्तपोषण प्राप्त करने में सफल रहा है। बिल मिलिंडा गेट फाउंडेशन (बीएमजीएफ), विश्व बैंक, राष्ट्रीय पशुधन मिशन (एनएलएम),

It gives me immense pleasure to present before you the ICAR-NDRI Annual Report 2022. 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 2022, which is the ICAR-NDRI's centennial year. Celebrating 100 years of excellence in Dairy Science and embracing our mission to serve the cause of dairying by developing quality manpower; generating and disseminating technological knowhow relating to production; processing and marketing milk and milk products for the benefit of farming community; milk processing industry and consumers of the nation, the information in this annual report depicts a holistic view of this premier dairy Institute.

The research and development activities of NDRI got further momentum through its mandate-oriented and well-structured research programmes comprising 89 in-house and 65 externally funded research projects, which also included four international collaborative research projects. NDRI has been successful in getting external funding from leading International/ national funding agencies i.e. Bill & Melinda Gates Foundation (BMGF), World Bank, National Livestock Mission (NLM), Department of Biotechnology (DBT), Department of Science and Technology (DST), Indian Council of Medical Research (ICMR), Indian Council of Social Science Research (ICSSR), National Agricultural Science Fund (NASF), Ministry of Food Processing

जैव प्रौद्योगिकी विभाग (डीबीटी), विज्ञान और प्रौद्योगिकी विभाग (डीएसटी), भारतीय चिकित्सा अनुसंधान परिषद (आईसीएमआर), भारतीय सामाजिक विज्ञान अनुसंधान परिषद, राष्ट्रीय कृषि विज्ञान कोष (एनएएसएफ), खाद्य प्रसंस्करण उद्योग मंत्रालय (एमओएफपीआई), और पशुपालन और डेयरी विभाग (डीएएचडी)।

एनडीआरआई ने जमीनी स्तर पर हितधारकों के बीच प्रौद्योगिकियों और सूचनाओं का प्रसार करने के लिए ठोस प्रयास किए। संस्थान कई आउटरीच गतिविधियों के माध्यम से 1,83,517 हितधारकों, विशेष रूप से किसानों तक पहुंचने में गर्व महसूस करता है। आईसीएआर–एनडीआरआई के कृषि विज्ञान केंद्र ने 219 ऑफ–लाइन और ऑन–लाइन प्रशिक्षण पाठ्यक्रमों और दौरों के माध्यम से 8676 किसानों को सशक्त बनाया। इसने 18 राष्ट्रीय कार्यक्रमों का आयोजन किया जिसमें 2148 प्रतिभागी शामिल थे। एनईएच के तहत, 2022 के दौरान भारत के पूर्वोत्तर राज्यों अर्थात् अरुणाचल प्रदेश, त्रिपुरा और असम में चार पशुधन विकास शिविरों का आयोजन किया गया। किसानों के बीच डेयरी पशु, पोल्ट्री चूजे, बतख और अन्य कृषि–इनपुट वितरित किए गए। बतख पालन और मुर्गी पालन, मधुमक्खी पालन, मशरूम की खेती और कट फ्लावर उत्पादन पर 49 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिससे 1263 किसान लाभान्वित हुए।

संस्थान एक के बाद एक कई क्लोन बछड़ों का उत्पादन कर क्लोनिंग के क्षेत्र में अपनी विशिष्टता स्थापित करने में लगातार सफल रहा है। भाकृअनुप–एनडीआरआई भैंस क्लोनिंग पर मौलिक कार्य कर रहा है, जिसका विस्तार स्वदेशी मवेशियों तक किया जा रहा है। वर्ष 2022 के दौरान, एनडीआरआई में दो विशिष्ट भैंस नर क्लोन बछड़ों का उत्पादन किया गया। स्वदेशी मवेशियों के क्लोन भ्रूण का उत्पादन करने के प्रोटोकॉल को निपुणता की और स्वदेशी गायों के क्लोन भ्रूण का उत्पादन किया गया। जीनोमिक मूल्यांकन के लिए दो मॉडल बहु–नस्ल संयुक्त भविष्यवाणी मॉडल और उथले वंशावली डेटा के लिए एकल–चरण मॉडल को जीनोमिक मूल्यांकन के लिए मानकीकृत किया गया था ताकि जीनोमिक प्रजनन मूल्यों के निष्पक्ष और सटीक अनुमान प्राप्त किए जा सकें। इसी तरह, इंट्रा–सेलुलर रोगजनकों के कारण थनैला के खिलाफ एक नया दूध एक्सोसोम आधारित चिकित्सीय भी विकसित किया गया था। इसके अलावा, लार फर्न पैटर्न के आधार पर एस्ट्रस की पहचान करने के लिए महिषी मित्र (बीटा संस्करण) नामक एक कंप्यूटर दृष्टि आधारित ऐप विकसित किया गया था।

संस्थान डेयरी प्रसंस्करण के क्षेत्र में उत्पादों और प्रक्रियाओं को वितरित करने में जीवंत रहा है। इस क्षेत्र में प्रमुख नवाचारों में शामिल हैं: बायोएक्टिव प्रोटीन और पेप्टाइड्स के साथ तैयार

Industries (MoFPI), and Department of Animal Husbandry and Dairying (DAHD).

NDRI made concerted efforts to disseminate the technologies and dairying related information and translate them among the stakeholders at the grass root level. The Institute takes pride in reaching out to 1,83,517 stakeholders especially farmers through multiple outreach activities. Krishi Vigyan Kendra of ICAR-NDRI empowered 8676 farmers through 219 off-line and on-line training courses and visits. It organized 18 National events involving 2148 participants. Under the NEH, four livestock developmental camps were organized in North Eastern states of India namely, Arunachal Pradesh, Tripura and Assam during 2022. Dairy animals, poultry chicks, ducks and different agri-inputs were distributed among farmers. Forty nine training programmes were conducted on duckery and poultry rearing, beekeeping, mushroom cultivation, and cut flower production benefitting 1263 farmers.

The Institute has been continuously successful in establishing its forte in the area of cloning by producing many cloned calves one after the other. ICAR-NDRI has been crafting seminal work on buffalo cloning, which is being extended to indigenous cattle. During the year 2022, Gantantra and Basant, two elite buffalo male cloned calves were produced in NDRI. The protocol to produce cloned embryos of indigenous cattle was perfected and cloned embryos of indigenous cows were produced. Two models, namely Multi-breed joint prediction model and Single-Step model for shallow pedigree data typical to Indian dairy breeding structure were standardized for genomic evaluation so that unbiased and accurate estimates of genomic breeding values can be obtained. Likewise, a novel milk exosomes based therapeutic was also developed against mastits causing intra-cellular pathogens. Further, a computer vision based app named as Mahishi Mitr (beta version) was developed to identify estrus based on salivary fern patterns. At Southern Regional Station of ICAR-NDRI, a novel gene was identified in conserved genomic region of Malnad Gidda Cattle, which was not reported in any of the cattle breed data in the public repositories.

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: A formulation prepared with bioactive proteins and peptides showing anti-diarrhoeagenic activity against *E. coli*; Preparation of bio-functional lactic-yeast fermented milk with a combination of lactic

एक फॉर्मूलेशन जो ई कोलाई के खिलाफ एंटी–डायरिया जेनिक गतिविधि दिखाता है; लैक्टिक एसिड बैक्टीरिया और खमीर संस्कृतियों के संयोजन के साथ जैव–कार्यात्मक लैक्टिक–खमीर किण्वित दूध की तैयारी जिसमें एंटीऑक्सिडेंट, रोगाणुरोधी और एसीई–निरोधात्मक गतिविधि होती है; फ्लेवर्ड मिल्क फॉर्मूलेशन मोरिंगा आधारित पौधे घटक की तैयारी; पोषक अनाज के विकास में प्रोबायोटिक मिश्रित डेयरी प्रसार शामिल है; घी के अवशेषों का विकास शामिल डेयरी प्रसार; अल्ट्रा फिल्ट्रेशन तकनीक और एल प्लांटारम के माइक्रोएनकैप्सुलेशन का उपयोग करके बकरी के दूध आधारित उच्च प्रोटीन मिठाई का विकास। उपभोक्ताओं द्वारा में दही की शेल्फ लाइफ जानने के लिए किण्वित डेयरी उत्पादों जैसे दही और मिष्टी दही के लिए ताजगी संकेतक तैयार किए गए। इसके अलावा, दूध और दूध उत्पादों में बैक्टीरिया की गिनती की सटीक जांच के लिए एक पीएएनआई–पीईसी पेपर स्ट्रिप सेंसर विकसित किया गया।

संस्थान द्वारा विकसित प्रौद्योगिकियों का क्षेत्र स्तर पर एक बोधगम्य प्रभाव पड़ा। आयनिक खनिज मिश्रण पूरकता दूध उत्पादन में 14 प्रतिशत की वृद्धि और दूध उत्पादन की औसत लागत में 3 प्रतिशत की कमी पाई गई। एनडीआरआई के उच्च वंशावली वाले बैलों के वीर्य का उपयोग करके एआई को अपनाने के मामले में एफ 1 संतति की दूध उत्पादकता में 12.31 प्रतिशत की वृद्धि देखी गई। इसके परिणामस्वरूप किसानों की आय में वृद्धि हुई।

सौर ऊर्जा के साथ–साथ विद्युत ऊर्जा का उपयोग करने के लिए किण्वित डेयरी उत्पादों के लिए एक स्वचालित एकीकृत हाइब्रिड सौर प्रणाली विकसित की गई थी। पनीर और ग्रीक दही के उत्पादन के लिए एक बहुउद्देशीय स्वचालित नियंत्रित दर हीटिंग सिस्टम विकसित किया गया, जिसमें एक समान हीटिंग के लिए सिस्टम में शामिल किया गया था। संस्थान ने 10 डिग्री से 90 डिग्री सेल्सियस तक चुंबकीय प्रेरण आधारित दूध हीटिंग प्रणाली भी विकसित की।

डेयरी प्रबंधन के क्षेत्र में, पश्चिम बंगाल के डेयरी फार्म परिवारों पर कोविड–19 महामारी के सामाजिक–आर्थिक प्रभाव का आंकलन कर एक समग्र 'आजीविका सुरक्षा सूचकांक' विकसित किया गया। पूर्वोत्तर क्षेत्र के टीएसपी के तहत अनुसूचित जाति के किसानों (एससीएसपी के तहत) और जनजातीय समुदाय की सामाजिक–आर्थिक स्थिति में पशुधन आधारित एकीकृत कृषि हस्तक्षेपों के माध्यम से सुधार किया गया था।

डेयरी शिक्षा के क्षेत्र में, एनडीआरआई मानद् विश्वविद्यालय अपनी गतिविधियों को भारत सरकार की नई शिक्षा नीति (एनईपी–2020)

acid bacteria and yeast cultures that possessed antioxidant, antimicrobial and ACE-inhibitory activity; Development of a PMA-qPCR assay for the quantification of viable probiotic bacteria from fermented milk; Preparation of Moringa based plant ingredient for use in flavoured milk formulation to augment its functional benefits; Development of Nutri-cereals incorporated probiotic composite dairy spread; Development of ghee residue incorporated dairy spread; Development of goat milk based high protein dessert using ultra filtration technique and Microencapsulation of *L. plantarum* by spray and freeze drying. On-package freshness indicators of set type fermented dairy products namely dahi and misti dahi were fabricated for knowing the shelf life of dahi at consumers' end. Besides, a PANI-PEC paper strip sensor was developed for checking the raw milk quality, final product quality of the ice cream, pasteurized milk, powder, and butter. This test also works in the presence of antibiotics, urea like chemical agents, and not affected by any bacteria present in the milk except spore formers. Evaluation and validation of PANI-PEC paper strip found 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.

In the area of mechanization and engineering, automatic integrated hybrid solar system for fermented dairy products was developed with advanced controller unit integrated with the system to utilize solar energy as well as electrical energy in absence of sunlight with evaporative cooling technology. Likewise, a multipurpose automatic controlled rate heating system was developed for production of *paneer* and Greek yoghurt, incorporating agitator in the system for uniform heating for 20 and 50 kg capacity. The Institute also developed a magnetic induction based milk heating system for heating of milk from 10° to 90°C and also an Inline milk coagulation cum coagulum pressing unit for *paneer* manufacturing at small scale.

In the area of dairy management, socio-economic impact of COVID-19 pandemic on dairy farm households of West Bengal was assessed. A composite 'Livelihood Security Index' was developed. Socio-economic condition of scheduled caste farmers (under SCSP) and tribal community under TSP of NEH region was improved through livestock based integrated farming interventions.

In the area of Dairy Education, NDRI Deemed University is marching ahead to bring in new reforms to keep its

के साथ–साथ उच्च शिक्षा के वैश्विक संस्थानों के रुझानों के अनुरूप रखने के लिए नए सुधार लाने के लिए आगे बढ़ रही है। एनएएचईपी की संस्थागत विकास योजना (आईडीपी) के तहत शैक्षणिक कार्यक्रमों को मजबूत करने, पूर्व छात्रों के नेटवर्क का लाभ उठाने, छात्रों के सॉफ्ट स्किल बढ़ाने और इक्विटी एक्शन प्लान प्लस ग्रीन कैंपस के लिए विभिन्न पहल की गईं।

इसके अलावा, विभिन्न उद्योगों और शैक्षणिक संस्थानों के साथ संबंध स्थापित किए गए थे। दयालबाग शैक्षिक संस्थान (मानद् विश्वविद्यालय) दयालबाग आगरा के साथ सात समझौता ज्ञापनों पर हस्ताक्षर किए गए; ओ.एस. बाल कुमदान फाउंडेशन– काशी (गडौली धाम), वाराणसी (यूपी); गौमुख डेयरी वेलफेयर सोसाइटी ग्राम गढ़खाल, पौड़ी, गढ़वाल (यूके); आईसीएआर–एनएएआरएम, हैदराबाद के कृषि–नवाचार के लिए कृषि केंद्र में उद्यमिता के लिए नवाचार विकास संघ; लवली प्रोफेशनल यूनिवर्सिटी, पंजाब; ऑलटेक बायोटेक्नोलॉजी प्राइवेट लिमिटेड इंडिया, बेंगलुरु और बीएआईएफ डेवलपमेंट रिसर्च फाउंडेशन, पुणे। वर्ष 2022 के दौरान, आठ पेटेंट दिए गए और पांच पेटेंट दायर किए गए। संस्थान में विकसित पंद्रह प्रौद्योगिकियों को वाणिज्यिक घरानों को हस्तांतरित किया गया था और 19 प्रौद्योगिकियों को व्यावसायीकरण के लिए अनुमोदित किया गया था। अब तक, संस्थान की ओर से कुल 84 पेटेंट दाखिल किए गए हैं और 43 (51%) स्वीकृत किए गए हैं, जो एक उल्लेखनीय उपलब्धि है।

यह सब संस्थान द्वारा एनडीआरआई भ्रातत्व के समर्पण, कड़ी मेहनत, सहयोग और समझ के साथ हासिल किया जा सकता है। संस्थान डेयरी अनुसंधान, शिक्षा और आउटरीच को बढ़ावा देने के लिए एक विश्व स्तरीय मॉडल परिसर बनने के लिए प्रतिबद्ध है क्योंकि डेयरी लाखों किसानों के सामाजिक–आर्थिक जीवन को बदलने के लिए एक प्रमुख गेम चेंजर के रूप में उभर रही है।

मुझे पूरी उम्मीद है कि एनडीआरआई वार्षिक रिपोर्ट 2022 देश के अन्य उच्च शिक्षा संस्थानों और डेयरी विकास संगठनों की सूचना के लिए मूल्यवान स्रोत के रूप में काम करेगी।

(धीर सिंह)
निदेशक, भाकृअनुप–राडेअनुसं

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) of NAHEP.

Furthermore, linkages were established with different industries and academic institutions. Seven MoUs were signed with Dayalbagh Educational Institute (Deemed University) Dayalbagh Agra; O. S. Bal Kumdan Foundation- Kashi(Gadauli Dham), Varanasi (UP); Gaumukh Dairy Welfare Society Village Garhkhal, Pauri, Garhwal (UK); Association of Innovation Development for Entrepreneurship in Agriculture Centre for Agri- Innovation of ICAR- NAARM, Hyderabad; Lovely Professional University, Punjab; Alltech Biotechnology Pvt. Ltd. India, Bengaluru and BAIF Development Research Foundation, Pune. During the year 2022, eight patents were granted and five patents filed. Fifteen technologies developed at the Institute were transferred to the commercial houses and 19 technologies were approved for commercialization. So far, a total of 84 patents have been filed from the institute and 43 (51%) have been granted, which is a remarkable achievement.

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 2022 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

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल देश में 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 बेंगलुरु 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 बेंगलुरु 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 मानद् 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 मानद् विश्वविद्यालयों सहित भारत के सभी कृषि विश्वविद्यालयों में प्रथम स्थान दिया गया है।

संगठनात्मक संरचना

भाकृअनुप की मानद् 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 जैवरसायन, 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 मुजफ्फरनगर, उत्तर प्रदेश के लालूखेड़ी 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

EXECUTIVE SUMMARY

ICAR-National Dairy Research Institute, Karnal is a premier research organization of the nation 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, consecutively for the five times in the year 206-17, 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 Muzzafarnagar, U.P. The Institute has infrastructure consisting of central facilities such as Livestock Research Centre, Forage Research and Management Centre, 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

नियंत्रण में है। संस्थान में वर्तमान में 140 वैज्ञानिक, 165 तकनीशियन, 119 प्रशासनिक कर्मचारी और 248 कुशल सहायक कर्मचारी हैं।

बजट परिव्यय

वर्ष 2022–23 के दौरान वास्तविक व्यय के रूप में संस्थान का वित्तीय परिव्यय 25218.86 लाख रु. था एवं वर्ष 2022–23 के लिए स्वीकृत बजट 25218.86 लाख रु. था। इन आंकड़ों में क्षेत्रीय परिसरों के सुदृढ़ीकरण के लिए वित्तीय परिव्यय भी शामिल है। 2022–23 के दौरान क्षेत्रीय परिसरों सहित संस्थान की राजस्व प्राप्तियां 1034.36 लाख रु. थी।

अनुसंधान

- भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान में दो श्रेष्ठ नर भैंस के क्लोन से गणतंत्र एवं बसंत कटडे उत्पन्न किए गए।
- स्वदेशी गोपशु के क्लोन्ड भ्रूण को उत्पन्न करने वाले प्रोटोकॉल को सटीक बनाया गया और स्वदेशी गायों के क्लोन्ड भ्रूण उत्पन्न किए गए।
- भैंस की प्राइमरी कायिक कोशिकाओं में एमएसटीएन–जीन को सफलतापूर्वक सम्पादित किया गया और एमटीएन–जीन केओ भ्रूण उत्पन्न किए गए।
- बीटा–लैक्टलबुमिन नॉकआउट स्तनग्रंथि कोशिकाओं का उत्पादन किया गया।
- स्तनधारी कोशिकाओं के लिए स्वदेशी प्रयोगशाला में तैयार अभिकर्मक बफर विकसित किया गया।
- भैंस के क्लोन भ्रूण के उत्पादन पर अनुक्रमीजनन संशोधक के प्रभाव का विश्लेषण किया गया।
- विशिष्ट प्रजनन क्षमता वाले नर भैंसो के शुक्राणु का प्रोटीन मानचित्र विकसित किया गया और नर भैंसे की प्रजनन क्षमता से संबंधित आशाजनक प्रोटीन कैण्डीडेट्स की पहचान की गई।
- एक माह की अवधि के भीतर ही कैंसर रोग से पीड़ित चूहों को एमएससी उपचार कर ठीक किया गया।
- मानव एवं पशु संक्रमण के लिए विस्तारित स्पेक्ट्रम बीटी लैक्टामेज (ESBL) प्रतिरोधिता के CTX-M-types के वैश्विक महामारी विज्ञान पैटर्न का विश्लेशण किया गया।
- ई. कोलाई के विरूद्ध एक सक्षम एंडोलिसिस की पहचान की गई, उसकी क्लोनिंग की गई और उसे प्रकटित किया गया।
- एल. हेलवेटिकस की एस–लेयर प्रोटीन की क्लोनिंग की गई, उसे प्रकटित किया गया जो कि आंत कोशिका वंशक्रमों में साल्मोनेला तथा ई. कोलाई को जोड़ने में प्रभावी पाया गया।
- गोमूत्र से उत्पन्न सूक्ष्मजीव रोधी पेप्टाइड्स को रोगजनकों के कारण होने वाले रोगों के विरूद्ध प्रभावी पाया गया।
- गोपशु तथा भैंस में गर्भावस्था का जल्दी पता लगाने के लिए BuPAG1 के विरूद्ध एलाइजा तथा BuPAG2 के विरूद्ध लेटरल फ्लो इम्यूनो एसे (LFIA) विकसित किए गए।

administrative control of Comptroller (Finance). The Institute presently has strength of 140 scientists, 165 technicians, 119 administrative staff and 248 skilled supporting staff.

BUDGET OUTLAY

The financial outlays of the Institute in terms of actual expenditure during the year 2022-23 was Rs. 25218.86 lakhs and budget sanctioned for the year 2022-23 was Rs. 25218.86 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. 1034.36 lakhs during 2022-23.

Research:

- Gantantra and Basant, two elite buffalo male cloned calves produced in NDRI.
- The protocol to produce cloned embryos of indigenous cattle was perfected and cloned embryos of indigenous cows were produced.
- MSTN-gene was successfully edited in primary somatic cells of buffalo, and MTN-gene KO embryos were produced.
- Production of beta-lactalbumin gene knockout mammary gland cells.
- Indigenous lab-made transfection buffer was developed for mammalian cells.
- Effect of epigenetic modifiers on production of buffalo cloned embryos was analyzed.
- Protein map of spermatozoa of distinct fertility buffalo bulls was developed and promising protein candidates related to bull fertility identified.
- Cancer affected mice cured with MSCs within the period of one month.
- Global epidemiology pattern of CTX-M-types of Extended Spectrum Beta Lactamase (ESBL) resistance was analyzed for human and animal infections.
- A potent endolysis against *Escherichia coli* was identified, cloned and expressed.
- S-layer protein of *L. helveticus* cloned, expressed and shown effective in excluding binding of *Salmonella* and *E. coli* to enteric cell lines.
- Antimicrobial peptides derived from cow urine were found effective against disease causing pathogens.
- ELISA against BuPAG1 and Lateral Flow Immuno-Assay (LFIA) against BuPAG2 were developed for early pregnancy diagnosis in cattle and buffaloes.

- गोपशु में X तथा Y गुणसूत्र धारण करने वाले शुक्राणु के एप्टामर आधारित संवर्धन के लिए कार्यप्रणाली विकसित की गई और यथार्थ समय पीसीआर और स्वः पात्रे निषेचन अथवा गर्भाधान का उपयोग करके इसका प्रमाणन किया गया।
- लद्दाखी याक के खीस अथवा पीयूष, परिवर्तनकाल तथा अति व्यस्त दुग्धस्रवण की पेप्टीडोम प्रोफाइल उत्पन्न की गई।
- क्रॉस–लिंकर के रूप में एल्गीनेज डायलडिहाइड के साथ तैयार बकरी दूध कैजीन बायोफिल्म की भौतिक विशेषताओं (जल का अवशोषण, नमी पारगम्यता तथा ऑक्सीजन पारगम्यता) को गाय कैजीन एल्गीनेट फिल्मों की तुलना में उल्लेखनीय रूप से अच्छा पाया गया। हालांकि, दोनों बायोफिल्म में एक समान तन्यता मजबूती और फिल्म विस्तार है। बकरी कैजीन फिल्मों में घाव को भरने के लिए जरूरी वांछनीय विशेषताएं प्रदर्शित हुई।
- विभिन्न लिमोसीलैक्टोबैसिलस फर्मेन्टम स्ट्रेन पर किए गए तुलनात्मक जीनोम विश्लेषण और बीटा–कॉम्पलेक्स विटामिन को संश्लेषित करने वाले जीनों के प्रकटन का अध्ययन करने पर यह निष्कर्ष निकला कि थियामिन, पायरीडॉक्सिन तथा फोलेट जैसे विटामिन को क्षमताशील प्रोबायोटिक स्ट्रेन फर्मेन्टम एमटीसीसी 5898 का उपयोग करके उत्पन्न किया जाए।
- प्रोबायोटिक लैक्टोबैसिलाई किण्वित बकरी दूध के सूजन रोधी गुणों को मूषक मॉडल में प्रमाणित किया गया।
- मोरिंगा ऑलिफेरा से भरपूर चीज़ स्प्रेड से चूहों में मधुमेह के कारण उत्पन्न विसंगतियों को दूर किया गया।
- अंतरा–सेलुलर रोगजनकों के कारण होने वाले थनैला रोग के लिए एक नवीन दूध एक्सोसोम आधारित चिकित्सा विकसित की गई।
- महिषि मित्र (बीटा वर्जन) नाम से एक कम्प्यूटर विजन आधारित ऐप विकसित किया गया ताकि लार फर्न पैटर्न के आधार पर मदकाल की पहचान की जा सके।
- मुर्राह भैंस में प्रसव के उपरान्त अमदकाल से सम्बद्ध LAMA2 जीन के अंतिम एक्सॉन में एक एसएनपी पाया गया जिसका कार्यात्मक रूप से प्रमाणन किया गया।
- बकरी कॉडा एपिडीडिमल द्रव के 80 kDa शुक्राणु गतिशीलता निरोधक प्रोटीन के शुद्धिकरण किया गया और मास स्पेक्ट्रोमीट्रि द्वारा पहचान की गई जिसका कि कैप्रीन लैक्टोफेरिन के रूप में पता चला।
- न्यूक्लियर जीनोम से उत्पन्न OXPHOS कॉम्पलेक्स I के माइटोकॉण्ड्रियल प्रोटीन जीन के प्रकटन पर ऊतक विशिष्ट भिन्नताओं की पहचान की गई।
- 50—मा.ग्रा./मिलि से 300 —मा.ग्रा./मिलि की सान्द्रता सीमा में बकरी दूध कैजीन प्रोटीन पीटीसी हाइड्रोलाइसेट तथा छाछ प्रोटीन पीटीसी हाइड्रोलाइसेट (WPH) में 3T3-L1 कोशिकावंशक्रम में वसाजनक रोधी प्रभाव देखने को मिले।
- कंगनी श्री अन्न तथा लस्सी के रूप में प्रोबायोटिक्स लिमोसीलैक्टोबैसिलस फर्मेन्टम का स्वः जीवे मूल्यांकन करने

- Methodology for aptamer based enrichment of X and Y chromosome bearing spermatozoa in cattle was developed and validation using real time PCR and *in vitro* fertilization.
- Peptidome profile of Ladakhi Yak colostrum, transition and peak lactation milk were generated.
- Physical characteristics (water absorption, moisture permeation, oxygen permeability) of goat milk casein biofilms prepared with alginate dialdehyde as cross-linker are significantly greater than cow casein alginate films. However, both biofilms have same tensile strength and film expansion. Goat casein films had shown desirable properties required to support wound healing.
- Comparative genome analysis on various Lm. fermentum strains and studying the gene expression of B-complex vitamins synthesizing genes concluded that vitamins such as thiamine, pyridoxin and folate may be produced using potential probiotic strain Lm. Fermentum MTCC 5898
- Anti-inflammatory attributes of probiotic Lactobacilli fermented goat milk established in rat model.
- *Moringa oleifera* enriched cheese spread ameliorated diabetic induced complications in rats.
- A novel milk exosomes based therapeutic was developed mastitis causing intra-cellular pathogens.
- A computer vision based app named as Mahishi Mitr (beta version) was developed to identify estrus based on salivary fern patterns.
- An SNP in the last exon of LAMA2 gene found associated with postpartum anestrus in Murrah buffaloes and functionally validated .
- Purification of 80 kDa sperm motility-inhibitory protein of goat cauda epididymal fluid was optimized and identified by mass spectrometry which revealed it as caprine lactoferrin.
- Tissue-specific variations were identified on the expression of nuclear genome derived mitochondrial protein genes of OXPHOS complex I.
- Goat milk casein protein PTC hydrolysate and whey protein PTC hydrolysate (WPH) at the concentration ranging from 50µg/ml-300 µg/ml exhibited antiadipogenic effect in 3T3-L1 cell line.
- *In-vivo* assessment of Foxtail Millet and Probiotics *Limosilactobacillus fermentum* in the form of Lassi showed a synergistic ameliorative effect against

पर मोटापे और टाइप–2 मधुमेह के विरूद्ध एक सहक्रियाशील सुधारात्मक प्रभाव देखने को मिला। लस्सी को प्रौद्योगिकीय रूप से आगे प्रसंस्कृत किया जा सकता है और एक बाजार योग्य प्रबलित डेयरी पेय के तौर पर विकसित किया जा सकता है।

- भारतीय डेयरी प्रजनन संरचना के लिए विशिष्ट वंशावली डाटा हेतु दो मॉडल, पहला बहु नस्ल संयुक्त पूर्वानुमान मॉडल एवं दूसरा सिंगल स्टेप मॉडल का मानकीकरण जीनोमिक मूल्यांकन हेतु किया गया ताकि जीनोमिक प्रजनन मानों के निष्पक्ष एवं सटीक अनुमान हासिल किए जा सके।
- उत्पादन (305DMY) एवं प्रमुख रेखीय टाइप गुणों (आकार अथवा डील डौल, वक्ष परिधि अथवा घेरा, तथा शरीर लंबाई) का उपयोग करते हुए बहु–गुण नरपशु मूल्यांकन कार्यप्रणाली विकसित की गई जिसे दीर्घावधि लाभों के लिए डेयरी पशुओं का संतुलित एवं मूल्यकारी चयन करने के लिए भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान के झुण्ड में शामिल किया जाए।
- करण फ्रीज़ गोपशु में जीनोमिक विविधता एवं संख्या संरचना का मूल्यांकन किया गया जिसमें पर्याप्त आनुवंशिक भिन्नता का पता चला। केएफ (करण फ्रीज़) संकर नस्ल वाले गोपशुओं में 61.7 प्रतिशत की विदेशज पैतृकता और 38.3 प्रतिशत की थारपारकर पैतृकता पर संख्या को स्थिर किया गया। यह पहला जीनोम अध्ययन है और इसमें आगे का कार्य प्रगति पर है।
- करण फ्रीज़ तथा थारपारकर में सम्पूर्ण ट्रांसक्रिप्टोम विश्लेश्षण करने पर ऊर्जा उपापचय से संबंधित पाथवे का और 5508 miRSNPs का पता चला जिनमें 1103 थारपारकर गोपशु के लिए अद्वितीय थे। पुनः कुल बीस जीन को ताप सहिष्णुता के क्विंटल के साथ सम्बद्ध पाया गया।
- साहीवाल और करण फ्रीज़ संकर नस्ल के वंशावली डाटा पर अंतः प्रजनन गुणांक का अनुमान लगाने के लिए विचार किया गया और साहीवाल (37.66%) के साथ साथ करण फ्रीज़ (63.03%) गोपशु दोनों में अधिकांश संख्या गैर अंतः प्रजात पाई गई। साहीवाल के साथ साथ करण फ्रीज़ गोपशु दोनों में दुग्ध संयोजन गुणों के लिए क्यूटीएल समृद्ध हैं।
- भैंस की ल्यूटियल कोशिकाओं का CRISPR-CAS 9 आधारित सम्पादन किया गया और यह पाया गया कि COX-2 जीन के लक्षित सम्पादन से स्वः पात्रे संवर्धित भैंस ल्यूटियल कोशिकाओं में COX-2 जीन के उत्छ। प्रकटन में उल्लेखनीय रूप से कमी आई।
- मलनाड़ गिद्दा गोपशु के संरक्षित जीनोम रीजन में एक नवीन जीन 14234460:250-2,626 (SRS-MG-001 के रूप में कोड नाम) की पहचान की गई जिसकी सूचना सार्वजनिक रिपोजिट्रीज में किसी भी गोपशु नस्ल डाटा में नहीं की गई थी।
- शुक्राणु तथा सेमीनल प्लाज्मा की मात्रात्मक प्रोटियोमिक्स प्रोफाइलिंग का उपयोग करते हुए बॉस इण्डिकस हल्लीकर सांड में वीर्य गुणवत्ता से सम्बद्ध प्रोटीनों की पहचान की गई।
- पौधों में पोषक तत्वों की उपलब्धता को बढ़ाने के लिए उपयुक्त नाइट्रोजन का निर्धारण करने वाली एजोटोबैक्टर प्रजाति;

Obesity and type-2 diabetes (diabesity). The Lassi can further be technologically processed and can be developed as a marketable fortified dairy beverage.

- Two models, first Multi-breed joint prediction model and second Single-Step model for shallow pedigree data typical to Indian dairy breeding structure were standardized for genomic evaluation so that unbiased and accurate estimates of genomic breeding values can be obtained.
- Multi-trait sire evaluation methodology using production (305DMY) and major linear type traits (Stature, chest girth, and body length), which may be introduced in the ICAR-NDRI herd for balanced and valuable selection of dairy animals for long-term benefits.
- The genomic diversity and population structure were assessed in Karan Fries cattle suggesting sufficient genetic variability. The population was stabilized at exotic inheritance of 61.7% and Tharparkar of 38.3% in KF crossbred cattle. This is the first genomic study and further work is in progress.
- Whole transcriptome analysis in Karan Fries and Tharparkar indicated pathways related to energy metabolism and 5508 miRSNPs of which 1103 were unique to Tharparkar cattle. Further, a total of 20 genes were found to be associated with QTLs of thermotolerance.
- The pedigree data of Sahiwal and Karan Fries crossbred were considered for estimating inbreeding coefficient and found most of the population is non-inbred in both Sahiwal (37.66%) as well as Karan Fries cattle (63.03%). The QTL are enriched for milk composition traits in both Sahiwal as well as Karan Fries cattle.
- CRISPR-CAS9 based editing of cox-2 gene in luteal cells of buffalo was carried out and found that the targeted editing of COX-2 gene significantly declined the mRNA expression of COX-2 gene in in-vitro cultured buffalo luteal cells.
- A novel gene 14234460:250-2,626 (code-named as SRS-MG-001) was identified in conserved genomic region of Malnad Gidda Cattle, which was not reported in any of the cattle breed data in the public repositories.
- Using quantitative proteomics profiling of spermatozoa and seminal plasma, identified proteins associated with semen quality in Bos indicus Hallikar bulls.

फॉस्फोरस घुलनशील स्यूडोमोनास प्रजाति तथा पोटेसियम घुलनशील बैसिलस प्रजाति को शामिल करके गाय के गोबर पर आधारित जैव प्रबलित उर्वरक तैयार किया गया।

- एकीकृत बहु–ऑमिक्स विश्लेषण का उपयोग करते हुए पता चला कि वीर्य उपापचय को नियंत्रित करने वाले अणुओं द्वारा सांड की प्रजनन क्षमता को प्रभावित किया गया।
- सांड शुक्राणु के ट्रांसक्रिप्टोमिक तथा प्रोटियोमिक संयोजन में हिम परिरक्षण से उत्प्रेरित बदलावों की पहचान की गई।
- किसी दिए गए वीर्य नमूने में शुक्राणु धारण करने वाले X-गुणसूत्रों को समृद्ध करने वाले Y-गुणसूत्रों वाले शुक्राणु को फंसाने के लिए एक लक्षित स्थिरीकरण प्रणाली तैयार की गई। इस विकसित विधि का उपयोग करते हुए गोपशुओं में लिंगानुपात को 1:1 से 3.2:1 (मादा: नर) तक किया जा सकेगा।
- कार्यात्मक गुणों का आनुवंशिक मूल्यांकन करने और संकर नस्ल वाले गोपशुओं के उत्पादन एवं प्रजनन गुणों पर इनके प्रभावों पर कार्य किया गया।
- संक्रमणकाल व रिपीट प्रजनक गायों में बायपास वसा अनुपूर्ति करके डेयरी गायों में प्रजनन प्रबंधन किया गया।
- संवर्धन मीडिया में एक अनुपूरक के तौर पर ल्यूकेमिया निरोधक कारक के साथ अनुपूर्ति करते हुए अपरिपक्व ऊसाइट्स की विकासपरक क्षमता को बढ़ाया गया।
- संकर नस्ल वाली गायों में गर्भावस्था के विभिन्न दिवसों तथा तिमाही, फॉलीकुलर द्रव तथा डिम्बग्रंथि अथवा अण्डाशय कोशिकाओं के दौरान PNX-SMIM20 की गतिशीलता पर अध्ययन किए गए।
- भारत के पूर्वी क्षेत्र में ब्लैक बंगाल बकरी की उत्पादकता को बढ़ाया गया।
- गर्मियों के मौसम के दौरान परिधीय गायों में सूक्ष्म पोशक तत्वों की आपूर्ति करने पर उनकी उत्पादकता और नवजात बछड़ों–बछड़ियों के स्वास्थ्य में सुधार देखने को मिला।
- गाय की खीस/दुग्ध से इम्यूनोमाडुलेशन से संबंधित मैक्रोफेज सक्रिय कारक को अलग किया गया ।
- जहां स्वस्थ गायों (n = 506) में दूध की एससीसी सीमा 0.9 से 2.7 x 10^5 सेल्स/मिलि. थी जबकि स्वस्थ भैंस (n = 239) में दूध के एससीसी मान की सीमा 0.5 से 2.0 x 10^5 सेल्स/मिलि पाई गई। उच्चतर दूध एससीसी मान दर्शाने वाले पशुओं में दूध कॉर्टीसोल स्तर को उल्लेखनीय रूप से कहीं उच्चतर ($P < 0.05$) पाया गया।
- ताप दबाव, शीत दबाव तथा ताप निरपेक्ष परिस्थितियों के दौरान बकरी के दूध में उपापचय की पहचान की गई और इसका उपयोग तापीय दबाव के क्षमताशील जैव मार्करों के तौर पर किया जा सकता है।
- कंट्रोल तथा जिंक से अनुपूरित बकरी समूहों के दूध उपापचय कंट्रोल एवं उपचारित समूह में भिन्नात्मक रूप से नियंत्रित पाए

- Developed cow dung based biofortified fertilizer with the addition of suitable Nitrogen fixing Azotobacter sp., Phosphorus solubilizing Pseudomonas sp. and Potassium solubilizing *Bacillus sp*. to enhance the availability of nutrients to the plants.
- Using integrated multi-omics analyses identified that the molecules governing sperm metabolism potentially influence bull fertility.
- Identified cryopreservation-induced alterations in transcriptomic and proteomic composition of bull spermatozoa.
- Developed a targeted immobilization method to trap Y-Chromosome bearing spermatozoa to enrich X-chromosome bearing spermatozoa in a given semen sample. By using the developed method, the sex ratio could be skewed from 1: 1 to 3.2:1 (female: male) in cattle.
- Genetic evaluation of functional traits and their effect on production and reproductive traits of crossbred cattle was performed.
- Reproductive management in dairy cows was done through there bypass fat supplementation in transition and repeat breeder cows.
- Developmental competence of immature oocytes was enhanced by supplementing with Leukemia Inhibitory Factor as a supplement in culture media.
- Studies were carried out on dynamics of PNX-SMIM20 during different days and trimester of pregnancy, follicular fluid and ovarian cells in crossbred cows.
- Productivity of Black Bengal goats was enhanced in eastern region of India.
- Micronutrient supplementation to peripartum cows during summer season improved their productivity and calf health.
- Macrophage activating factor related to immunomodulation was isolated from cow colostrums.
- Milk SCC ranged between 0.9 and 2.7x10^5 cells/ml of milk in healthy cows (n=506), whereas the values of milk SCC ranged from 0.5 to 2.0 x 105 cells/ml of milk in healthy buffaloes (n=239). Milk cortisol levels were found to be significantly ($P<0.05$) higher in animals exhibiting higher milk SCC.
- Metabolites in goat milk were identified during heat stress, cold stress and thermoneutral condition and can be used as potential biomarkers of thermal stress.

गए जो कि कार्बोहाइड्रेट, लिपिड़ तथा अमीनों अम्ल उपापचय में शामिल थे।

- वृद्धिशील भैंस में जीरा, मोलस्क अथवा शीरा तथा इनके संयोजन को खिलाने पर उनकी बढ़वार में सुधार देखने को मिला और जैविक दबाव मार्कर के स्तरों में कमी होकर तापीय दबाव में सुधार आया।
- थारपारकर सांडों की तुलना में करण फ्रीज़ नस्ल के सांडों में कम अंडकोशीय तापमान प्रवणता ने वीर्य की गुणवत्ता को नकारात्मक रूप से प्रभावित किया जिससे थारपारकर सांडों के मुकाबले में करण फ्रीज़ नस्ल के सांडों में ताप दबाव के प्रति संवेदनशीलता को दर्शाता है।
- अप्रैल, 2021 के मुकाबले में अप्रैल, 2022 के दौरान संकर नस्ल की गायों की दुग्ध उपज में उल्लेखनीय रूप से कमी देखने को मिली। दुधारू संकर नस्ल गायों पर उल्लेखनीय प्रभाव दुग्धस्रवण की अवस्था के अनुसार पाए गए। अप्रैल, 2021 की तुलना में अप्रैल, 2022 के माह की अवधि के दौरान, 0 से 100 दिनों की दुधारू गायों में दूध उपज में नुकसान जहां 8.11 प्रतिशत पाया गया वहीं 100 से 150 दिनों में यह 17.8 प्रतिशत, 150 से 200 दिनों में 14.8 प्रतिशत और 200 से अधिक दिनों में 13.26 प्रतिशत दर्ज किया गया।
- स्वदेशी गोपशु की उत्पादकता को बढ़ाने के लिए एक नया रीति पैकेज तैयार किया गया।
- डेयरी पशुधन पर प्रतिकूल मौसम घटनाओं के प्रभाव मूल्यांकन और जोखिम संवेदनशीलता का अध्ययन करने के लिए एक उच्च पवन वेग प्रणाली की डिजाइन तैयार की गई, उसका विकास करके उसका निर्माण किया गया और निक्रा परिसर में उसे स्थापित किया गया। यह प्रणाली विभिन्न प्रतिकूल घटनाओं और शरीरक्रिया विज्ञान, उत्पादन, वृद्धि प्रजनन, जैव–रासायनिक तथा उपापचय पैरामीटरों पर इनके प्रभाव से जुड़ी जानकारी का सृजन करने में मददगार होगी।
- प्रोटीन से भरपूर और जलवायु अनुकूल रैमी (बोहमेरिया निविया) चारा को करनाल में शामिल करके उसे सफलतापूर्वक उगाया गया। यह भारत के पूर्वोत्तर क्षेत्र की एक देशज फसल है। इससे पशुधन में उत्पादकता को बढ़ाने के लिए विभिन्न क्षेत्रों के पशुधन के लिए वर्षभर हरे चारे की आपूर्ति हो सकेगी।
- गोपशुओं में जनन समय का पूर्वानुमान करने के लिए एक टूल के तौर पर व्यावहारिक बायोमीट्रिक्स तथा इन्फ्रारेड थर्मल इमेजिंग का उपयोग किया जा सकता है और नवजात जनने का पूर्वानुमान लगाने के लिए एक जीपीएस संचार प्रणाली तथा एक बजर अलॉर्म आधारित टूल का विकास किया गया।
- गिर गाय के दूध से उत्पन्न DPP-IV निरोधक पेप्टाइड्स की गोलियां तैयार की गई जिनका प्रयोग करने पर प्रयोगात्मक पशुओं में रक्त ग्लूकोज के स्तर में प्रभावी रूप से कमी आई।
- भारत में, वर्ष 2012 से 2019 की अवधि के दौरान पशुधन संख्या लगभग समान बनी रही इसलिए इस अवधि के दौरान आंत मीथेन, शुष्क पदार्थ इनटेक, गोबर मीथेन तथा नाइट्रस

- Goat milk metabolites of control and zinc supplemented groups were found to be differentially regulated in control and treatment groups and were involved in carbohydrate, lipid and amino acid metabolism.
- Supplementation of cumin, molasses and their combination to the growing buffaloes improved their growth rate by ameliorating the thermal stress through reducing the levels of biological stress markers.
- Lower scrotal temperature gradient in Karan Fries compared to Tharparkar bulls affected semen quality negatively, indicating susceptibility of Karan Fries bulls to heat stress compared to Tharparkar bulls.
- The milk yield of crossbred cows decreased significantly during April 2022 as compared to April 2021. The significant effects on milking cross bred cows were according to the stage of lactation. The loss in milk yield in 0-100 days lactating cows was found to be 8.11%, 100-150 days was 17.8%, 150-200 days was 14.8% & above 200 was days 13.26% during the month of April 2022 as compared to April 2021.
- A new package of practices was developed for increasing the productivity of indigenous cattle.
- To study the risk vulnerability and impact assessment of extreme weather events on dairy livestock, a high wind velocity system was designed, developed, fabricated and installed at NICRA complex. The system may be helpful in generating information related to different extreme events and their effect on physiological, production, growth reproduction, biochemical and metabolic parameters.
- Protein-rich and climate-resilient ramie (Boehmeria nivea) fodder was introduced & grown successfully at the Karnal location, which is a native crop of the Northeast region of India. This may supply round-the-year green fodder to the livestock of different regions for increasing productivity.
- Behavioral biometrics and Infrared Thermal Imaging could be used as a tool to predict calving time in cattle and developed a GPS communication system and a buzzer alarm-based tool for calving prediction.
- Developed encapsulates of DPP-IV inhibitory peptides derived from milk of Gir cattle, which effectively reduce the blood glucose level in experimental animals.

ऑक्साइड् उत्सर्जन भी समान मात्रा में हुआ। भारतीय पशुधन से वर्ष 2019 में लगभग 325Tg CO2e उत्पन्न हुआ।

- एल. प्लाण्टेरम सीआरडी 7 तथा एल. रैम्नोसस सीआरडी 11 आंतों की उपकला कोशिकाओं के लिए सुरक्षित एवं गैर विशाक्त हैं और इसलिए ये नवजात पशुओं में चारे के रूप में उपयुक्त हो सकते हैं।
- गोपशु के नवजात बछड़ों–बछड़ियों से अलग किए गए लिगिलैक्टोबैसिलस सैलिवैरियस की क्षमताशील प्रोबायोटिक विशेषताओं के लिए स्वः पात्रे स्क्रीनिंग की गई।
- साहीवाल नस्ल के वृद्धिशील नवजात बछड़ों–बछड़ियों के राशन में 50 पीपीएम तथा 100 पीपीएम की दर पर आर्टीमीजिया एनुआ के तेल को मिलाने पर आंतों से होने वाले मीथेन उत्सर्जन में 10 से 13 प्रतिशत तक की कमी देखने को मिली।
- प्रतिदिन लगभग 10 किलोग्राम दूध देने वाली संकर नस्ल की गायों के आहार में डीएमआई का सोडियम बाइकार्बोनेट /1.50% शामिल करने पर 4 प्रतिशत वसा दूध में 10 से 12 प्रतिशत की बढ़ोतरी हुई।
- निकल की अनुपूर्ति 10 पीपीएम स्तर पर करने से एचबी, आरबीसी संख्या, एचसीटी तथा ग्लूकोज के स्तर में बढ़ोतरी हुई जबकि कुल कॉलेस्ट्रॉल, एलडीएल तथा एनईएफए सांद्रता में कमी आई।
- दूध देने वाली करण फ्रीज़ गायों में सुधारकों (मैनानो ऑलिगोसैकराइड/15 ग्राम/पशु/दिवस) के साथ अथवा उसके बिना जिससे उनमें आहार ग्रहण करने, दूध उपज तथा दूध संयोजन पर किसी प्रकार का प्रभाव नहीं पडा, में 35–55 पीपीबी AFLB 1 वाले 8.38 पीपीएम कॉपर राशन के साथ आधारीय आहार प्राप्त करने वाले करण फ्रीज़ नवजात बछड़ों–बछड़ियों के आहार में 10 पीपीएम स्तर के अनुपूरक अजैविक कॉपर को 5 पीपीएम स्तर पर बदला जा सकता है और इससे इनके आहार ग्रहण करने, पोषक तत्व उपयोगिता तथा रूधिरविज्ञान पैरामीटरों पर किसी प्रकार का प्रभाव नहीं पड़ा।
- ब्लैक बंगाल बकरी के मेमनों में पोषक तत्व उपलब्धता और वृद्धि प्रदर्शन पर बहिर्जात फाइब्रोलाइटिक एंजायम अनुपूरक का मूल्यांकन किया गया।
- जर्सी संकर नस्ल के नवजात बछ़डों–बछड़ियों में आहार ग्रहण करने और पोषक तत्वों की पाचनीयता पर बहिर्जात फाइब्रोलाइटिक एंजायमों के साथ अथवा इनके बिना पोषक तत्वों से भरपूर चावल पुआल आधारित टीएमआर को आहार रूप में ग्रहण करने के प्रभाव का मूल्यांकन किया गया।
- प्रोबायोटिक्स तथा रसोई जड़ी–बूटियों का रोगनिरोधी उपयोग करने पर नवजात बछड़ों–बछड़ियों के स्वास्थ्य और वृद्धि पैरामीटरों में सुधार देखने को मिला।
- मॉडल घोल में सभी बी विटामिन का साथ–साथ पता लगाने के लिए एचपीएलसी विधि का विकास किया गया।

- Population of livestock remained the almost same during 2012 to 2019 in India, so the enteric methane, dry matter intake, dung methane and nitrous oxide emission during the period. Around 325Tg CO_2e were produced during the year 2019 from Indian livestock.
- *L. plantarum* CRD7 and *L. rhamnosus CRD11* are safe, non-toxic to intestinal epithelial cells, and thus may be potentially suitable for feed applications in calves.
- *In vitro* screening for potential probiotic properties of *Ligilactobacillus salivarius* isolated from cattle calves was undertaken.
- *Artimesia annua* oil incorporation @ 50ppm and 100ppm to the ration of growing Sahiwal calves decreased enteric methane emission by 10-13%.
- Incorporation of sodium bicarbonate @1.50% of DMI to the lactating crossbred cows of around 10 kg milk per day increased 10-12% of the 4% fat corrected milk.
- Nickel supplementation at 10 ppm level increased the levels of Hb, RBC count, HCT and glucose while decreasing total cholesterol, LDL and NEFA concentration.
- Supplementary inorganic copper (Cu) at 10 ppm level could be replaced by 5ppm of nano-Cu without affecting feed intake, nutrient utilization and haemaotological parameters in Karan Fries calves receiving basal diet containing 8.38 ppm Cu ration containing 35-55 ppb AFLB 1 given to lactating Karan Fries cows with or without ameliorant (mannano oligosaccahraide @ 15 g/animal/d) did not affect feed intake, milk yield and milk composition.
- Exogenous fibrolytic enzymes supplementation on nutrient availability and growth performance in Black Bengal kids was assessed.
- Impact of feeding nutrient enriched rice straw based TMR with or without Exogenous fibrolytic enzymes on intake and Nutrient digestibility in Jersey crossbred calves.
- Prophylactic use of Probiotics and Kitchen herbs improved the health and growth performance in calves.
- HPLC method for simultaneous detection of all B vitamins in model solution was developed.
- Methodology for detection of adulteration of vanaspati and goat body fat in ghee was developed using ATR-FTIR coupled with chemometrics.

- कीमोमैट्रिक्स के साथ जुड़कर ATR–FTIR का उपयोग करते हुए घी में वनस्पति तथा बकरी शरीर वसा की मिलावट का पता लगाने के लिए कार्यप्रणाली विकसित की गई।
- डेयरी उत्पादों के लिए उपयोग की गई पैकेजिंग सामग्री से निकले रसायनों का मूल्यांकन करने के लिए विधि तैयार की गई।
- जीसी–एमएस का उपयोग करते हुए दूध उपापचय की पहचान करने में विभिन्न संजात एजेन्टों के बीच तुलना की गई।
- दूध में सर्बिटोल का पता लगाने के लिए टीएलसी एवं एचपीएलसी विधियों का मानकीकरण किया गया।
- एक स्थिरीकरण तकनीक विकसित की गई जिसका उपयोग बीटा–गैलेक्टोसाइडेज़ एंजायम की गैलेक्टो ऑलिगोसैकराइड्स उत्पादन क्षमता को बढ़ाने के लिए किया जा सकेगा।
- जैव सक्रिय प्रोटीनों तथा पेप्टाइड्स के साथ एक फार्मुलेशन तैयार किया गया जिसमें वीनिंग मूषक मॉडल में ई. कोलाई एमटीसीसी 723 के विरूद्ध डायरिया–रोधी गतिविधि प्रदर्शित हुई।
- क्लूविरोमॉयसीज मार्क्सीयानस एमटीसीसी 1389 को छाछ से उच्चतर इथानॉल उत्पादन के लिए 12 प्रतिशत इथानॉल तक अनुकूलित किया गया।
- सूक्ष्मजीव किण्वन द्वारा दुग्ध अथवा खीस छाछ प्रोटीनों से उत्पन्न जैव सक्रिय पेप्टाइड्स में सूक्ष्मजीव–रोधी, इम्यूनोमाड्यूलेटरी तथा प्रति–ऑक्सीकारक गतिविधि पाई गई।
- गैर किण्वित खीस अथवा दुग्ध छाछ में पेप्टाइड की 1.305 –मा.ग्रा./मिलि. की तुलना में 48 घंटे के उपरान्त उच्च प्रोटीन किण्वित खीस अथवा दुग्ध छाछ में पेप्टाइड की मात्रा 16.314 –मा.ग्रा./मिलि. तक बढ़ी।
- बी. सेरियस एटीसीसी 13061, ई. कोलाई एटीसीसी 2592, ई. फेकैलिस एटीसीसी 27736, एस. ऑरियस के विरूद्ध किण्वित खीस अथवा दुग्ध छाछ के <10 kDa पेप्टाइड विखण्डन का अधिकतम निरोध देखा गया।
- पाश्च्युरीकृत दूध के जीवनकाल को बढ़ाने हेतु किण्वित खीस अथवा दुग्ध के सूक्ष्मजीव रोधी पेप्टाइड्स विखण्डनों का उपयोग संघटकों के तौर पर किया गया।
- पृथक किए गए सूक्ष्मजीव रोधी पेप्टाइड्स (<10kDa विखण्ड) में जैविक रोधी प्रतिरोधी ई. कोलाई (ESBL) (विस्तारित स्पेक्ट्रम बीटा–लैक्टामेजिज) (16.6 मिमी.) तथा एसीनिटोबैक्टर 1379 (7.4 मिमी.) के क्लीनिकल पृथक्क के विरूद्ध अधिकतम सूक्ष्मजीव रोधी गतिविधि देखने को मिली जबकि इसे एमआरएसए के विरूद्ध नहीं पाया गया।
- बी. सेरियस एटीसीसी 13061 (26.13 मिमी.), ई. कोलाई एटीसीसी 2592 (24.66 मिमी.), ई. फेकैलिस एटीसीसी 27736 (23.56 मिमी.), एस. ऑरियस (21.66 मिमी.) और ए. बॉमेनाई (23.11 मिमी.) के विरूद्ध संश्लेषित पेप्टाइड P1 का अधिकतम निरोधक जोन पाया गया।

- Methods to assess the chemicals migration from the packaging used for dairy products were developed.
- A comparison among different derivatizing reagents was done in identification of milk metabolites using GC-MS.
- TLC & HPLC methods were standardized to detect sorbitol in milk.
- Developed an immobilization technique, which could be used for enhancing galacto oligosaccharides production ability of the β-galactosidase enzyme.
- A formulation was prepared with bioactive proteins and peptides showed anti-diarrhoeagenic activity against *E. coli* MTCC 723 in weaning mice model.
- *Kluyveromyces marxia*nus MTCC1389 was adapted up to 12% of ethanol for higher ethanol production from whey.
- Bioactive peptides derived from colostrum whey proteins by microbial fermentation were found to have antimicrobial, immunomodulatory and antioxidant activity.
- The peptide content in high protein fermented colostrum whey increased up to 16.314 µg/mL after 48 hours compared to 1.305 µg/mL of unfermented colostrum whey.
- The highest inhibition of <10 kDa peptide fraction of fermented colostrum whey was against *B. cereus* ATCC 13061, *E. coli* ATCC 2592, *E. faec*alis ATCC 27736, *S. aureus*.
- Antimicrobial peptides fractions of fermented colostrum whey were used as ingredients to enhance the shelf life of pasteurized milk.
- Isolated anti microbial peptides (in <10kDa fractions) exhibited the highest antimicrobial activity against clinical isolate of antibiotic-resistant E. coli (ESBL) (Extended-spectrum beta-lactamases) (16.6 mm), and Acinetobacter 1379 (7.4mm) and not against MRSA.
- The highest inhibitory zone of synthesized peptide P1 was against *B. ce*reus ATCC 13061 (26.13mm), *E. coli* ATCC 2592 (24.66mm), E. *faecalis* ATCC 27736 (23.56mm), S. *aureus* (21.66mm) and A. *baumannii* (23.11mm).
- Conjugated AMPs-CuNPs prepared exhibited the highest antimicrobial activity against clinical isolate of antibiotic-resistant *E. coli* (ESBL), *S. aureus* (MRSA) and Acinetobacter 1379.

- तैयार किए गए संयुग्मित AMPs-CuNPs में प्रति–जैविक प्रतिरोधी ई. कोलाई (ESBL), एस.ऑरियस (MRSA) तथा एसीनिटोबैक्टर 1379 के क्लीनिकल पृथक्क के विरूद्ध अधिकतम सूक्ष्मजीव–रोधी गतिविधि देखने को मिली।
- ऊंटनी के किण्वित दूध का स्वः जीवे अध्ययन करने पर टाइप–2 मधुमेह नर विस्टार चूहों में रक्त ग्लूकोज की मात्रा में उल्लेखनीय कमी देखने को मिली।
- लैक्टिक अम्ल तथा जीवाणु एवं खमीर अथवा यीस्ट संवर्धन के संयोजन के साथ जैव कार्यात्मक लैक्टिक–खमीर किण्वित दूध तैयार किया गया जिसमें प्रति–ऑक्सीकारक, प्रति–सूक्ष्मजीव तथा एसीई–निरोधक गतिविधि थी।
- तीन पृथक्कों आरएल 4 (लैक्टीकैजीबैसिलस रैम्नोसस), आरजेड 18 (लैक्टीप्लाण्टीबैसिलस अर्जेन्टोराटेन्सिस), एलजी 12 (लैक्टीकैजीबैसिलस रैम्नोसस) की पहचान 16s rRNA द्वारा की गई और इन्हें एनसीबीआई जीनबैंक में जमा कराया गया। इसके अलावा, स्ट्रेन को पर्याप्त अम्ल विकास (1.224 प्रतिशत तक) के साथ ऊंटनी के किण्वित दूध के लिए उपयुक्त पाया गया।
- खीस अथवा दुग्ध छाछ से उत्पन्न सूक्ष्मजीव रोधी प्रोटीन और पेप्टाइड्स फार्मुलशन का उपयोग जैव कार्यात्मक स्वादिष्ट दूध तैयार करने में संघटकों के तौर पर किया गया। इस पेय में उच्चतर सूक्ष्मजीव रोधी, उच्च तनाव रोधी तथा ऑक्सीकारक रोधी विशेषताएं देखने को मिलीं।
- जामुन की पत्तियों में लिस्टेरिया मोनोसाइटोजीन्स के विरूद्ध सूक्ष्मजीव रोधी गतिविधि प्रदर्शित हुई। जामुन पत्तियों के सत् से हरे नैनो पार्टिकल्स को सूक्ष्मजीव रोधी एजेन्ट के तौर पर प्रयोग करने के लिए तैयार किया गया।
- ऊंटनी के दूध से अलग किए गए लैक्टिक अम्ल जीवाणु में मधुमेह रोधी विशेषताएं हैं जिनका उपयोग श्री अन्न आधारित दही (लस्सी) को तैयार करने में किया गया।
- देशज जीवाण्विक स्ट्रेन लैक्टीकैजीबैसिलस रैम्नोसस NCDC 400 से उत्पन्न एक्सोपॉलीसैकराइड "EPSRam12' में पशु मॉडल में प्रति–ऑक्सीकारक, सूजन रोधी क्षमता और माइक्रोबियोटा माडुलेशन देखने को मिला।
- विकसित EPSKar1 आयरन कॉम्पलेक्स में आयरन की कहीं अधिक जैव उपलब्धता प्रदर्शित हुई और मूषक मॉडल में एनीमिक रोधी प्रभाव देखने को मिला।
- लिमोसीलैक्टोबैसिलस फर्मेन्टम एनसीडीसी 400 जो कि एक घरेलू प्रोबायोटिक पृथक है, को स्वः पात्रे अध्ययनों में सुरक्षित पाया गया और इसमें प्रतिरक्षा समझौता मूषक मॉडल पर किसी प्रकार का प्रतिकूल प्रभाव नहीं पड़ा।
- किण्वित दूध से जीवनक्षम प्रोबायोटिक जीवाणु का परिमाणन करने के लिए एक PMA-qPCR आमाप विकसित किया गया।
- डेयरी उत्पादन प्रणाली से अलग किए गए एएमआर जीवाणु में टेट्रासाइक्लिन प्रतिरोधिता को सर्वाधिक प्रचलित प्रतिरोधिता

- *In-vivo* study of the fermented camel milk showed a significant decrease in blood glucose in Type-II diabetic male wistar rats.
- Bio-functional lactic-yeast fermented milk was prepared with a combination of lactic acid bacteria and yeast cultures that possessed antioxidant, antimicrobial and ACE-inhibitory activity.
- Three isolates RL4 (*Lacticaseibacillus rhamnosus*), RZ18 (Lactiplantibacillus *argentoratensis*), LG12 (*Lacticaseibacillus rhamnosus*) were identified by 16s rRNA and submitted in NCBI Gene Bank. In addition, the strains were suitable for camel milk fermentation with sufficient acid development (up to 1.224%).
- Colostrum whey derived antimicrobial proteins and peptides formulation were used as ingredients for preparation of bio-functional flavoured milk. The beverage exhibited higher antimicrobial, antihypertensive and antioxidative properties.
- The Jamun leaves exhibited antimicrobial activity against *Listeria monocytogenes*. The jamun leaves extract green nanoparticles were formed for their application as antimicrobial agents.
- Lactic acid bacteria isolated from camel milk having anti-diabetic properties were used for the development of Millet based Dahi (Lassi).
- Exopolysaccharide "EPSRam12" derived from native bacterial strain *Lacticaseibacillus rhamnosus* Ram12 exhibited anti-oxidative, anti-inflammatory potential and microbiota modulation in animal model.
- The developed EPSKar1-iron complex showed more bioavailability of iron and showed anti-anaemic effect in rat model.
- *Limosilactobacillus fermentum* NCDC 400, an in-house probiotic isolate found safe in *in vitro* studies and did not show any adverse effects on immunocompromised mice model.
- Developed a PMA-qPCR assay for the quantification of viable probiotic bacteria from fermented milk.
- Tetracycline resistance was found to be the most common resistance in AMR bacteria isolated from the dairy production system. Besides, the bacterial isolates from soil were commonly resistant to piperacillin and tazobactam.
- An integrated omics (metagenomics and culturomics) approach revealed the bacterial diversity of Dahi collected from various regions of India, with *Lactobacilli* and *Streptococci* as the major thermophilic bacteria groups.

पाया गया। इसके अलावा, मृदा से अलग किए गए जीवाणु पाइपरासिलिन तथा टैजोबैक्टम के प्रचलित प्रतिरोधी थे।

- एक एकीकृत ऑमिक्स (मेटाजीनोमिक्स तथा कल्चरोमिक्स) दृष्टिकोण में भारत के विभिन्न क्षेत्रों से संकलित दही की जैविक विविधता का पता चला और इसमें लैक्टोबैसिली तथा स्ट्रेप्टोकॉक्सी प्रमुख थर्मोफिलिक जीवाणु समूह थे।
- PANI-PEC पेपर स्ट्रिप का मूल्यांकन एवं प्रमाणन करने पर पाया गया कि पेपर स्ट्रिप कच्चे दूध, पाश्च्युरीकृत दूध, आइसक्रीम, मक्खन और पाउडर में कुल प्लेट गणना का निर्धारण करने के लिए सटीक, त्वरित तथा एक वैकल्पिक स्रोत था।
- PANI-PEC पेपर स्ट्रिप सेंसर प्रति–जैविक, यूरिया जैसे रासायनिक एजेन्टों की मौजूदगी में भी कार्य करता है और यह बीजाणु फॉर्मर्स को छोड़कर दूध में उपस्थित किसी भी जीवाणु द्वारा प्रभावित नहीं हुआ।
- PANI-PEC पेपर स्ट्रिप को एमबीआरटी के लिए एक वैकल्पिक जांच के तौर पर भी पाया गया। PANI-PEC पेपर स्ट्रिप का उपयोग कच्चे दूध की गुणवत्ता, आइसक्रीम, पाश्च्युरीकृत दूध, पाउडर और मक्खन के अंतिम उत्पाद की गुणवत्ता की जांच करने के लिए रिसेप्शन डॉक पर भी किया जाता है।
- डेयरी से इण्टेरोकोकस प्रजातियों की सूक्ष्मजीव रोधी प्रतिरोधिता (AMR) जांच में सेफुरोक्साइम, रिफैम्पीसिन, सिफेपाइम, इरीथ्रोमायसिन, फॉस्फोमायसीन तथा सिफोटैक्साइम के विरूद्ध उच्चतर प्रतिरोधिता का पता चला। जीनप्ररूपी लक्षणवर्णन में पृथक्कों में मल्टी ड्रग ट्रांसपोर्टर जीन (emeA), ट्रांसपोसन्स तथा इन्टेग्रॉन्स के साथ–साथ बहु प्रतिरोधिता की मौजूदगी का पता चला।
- सर्वाधिक प्रतिरोधी पृथक्क, ई. फेकैलिस B1(C) का सम्पूर्ण जीनोम अनुक्रमण करने पर सूक्ष्मजीव रोधी की व्यापक किस्म के विरूद्ध बहु प्रतिरोधिता के लिए 20 एएमआर जीन कोडिंग की मौजूदगी का पता चला।
- H1NMR मेटाबॉलिक प्रोफाइलिंग में लैक्टोबैसिलस तथा बाइफिडोबैक्टीरम के स्ट्रेन द्वारा जॉयलन के समान जॉयलन की किण्वन प्रोफाइल प्रदर्शित हुई।
- एनएमआर मेटाबोलोमिक डाटा का कीमोमेट्रिक विश्लेषण करने पर प्रमुख उपापचय जैसे कि आइसोबुटाइरेट, लैक्टेट, एसिटेट, इथानॉल आदि प्रदर्शित हुए जो कि निश्चित कार्बोहाइड्रेट्स से किण्वन प्रोफाइल में उल्लेखनीय रूप से उर्ध्व निगमित थे।
- नकली खीर पाउडर बनाने के लिए मीठी क्रीम छाछ को घी–अवशेष पाउडर के साथ मिलाया गया था। एसकेपी नमूनों की समग्र स्वीकार्यता 'मामूली पसंद' से 'बहुत ज्यादा पसंद' के बीच भिन्न थी। विकसित पाउडर का उपयोग विभिन्न खाद्य पदार्थों में खाद्य सामग्री के रूप में किया जा सकता है।
- बिस्कुट और मफिन में मौजूद वसा को घी के अवशेष पाउडर में मौजूद वसा से सफलतापूर्वक बदल दिया गया। संवेदी मूल्यांकन के आधार पर, घी अवशेष पाउडर के साथ 25% डब्ल्यूपीसी प्रतिस्थापन वाला मफिन स्वीकार्य था।

- Evaluation and validation of PANI-PEC paper strip found 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.
- 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 was also found to be an alternative test for MBRT. PANI-PEC paper strip is also used at the reception dock for checking the raw milk quality, final product quality of the ice cream, pasteurized milk, powder, and butter.
- Antimicrobial resistance (AMR) testing of *Enterococcus* species from dairy niches detected higher resistances against Cefuroxime, Rifampicin, Cefepime, Erythromycin, Fosfomycin and Cefotaxime. Genotypic characterization revealed presence of multiple resistance genes along with multi-drug transporter gene (emeA), transposons and integrons in the isolates.
- Whole Genome Sequencing of the most resistant isolate, E. *faecalis* B1(C) detected the presence of 20 AMR genes coding for multiple resistances against a wide variety of antimicrobials.
- H1NMR metabolomic profiling showed fermentation profile of xylan similar to xylan by strains of *Lactobacillus* and *Bifidobacteirum*.
- Chemometric analysis of the NMR metabolomic data showed important metabolites such as isobutyrate, lactate, acetate, ethanol etc. to be significantly up regulated in the fermentation profile from certain carbohydrates.
- Sweet cream butter milk was added with ghee-residue powder to manufacture simulated khee powder. The overall acceptability of SKP samples varied between 'liked moderately' to 'liked very much'. The developed powder could be used as a food ingredient in different food formulations.
- Fat in the Biscuits and muffins was successfully replaced with fat present in the ghee residue powder. Based on sensory evaluation, muffin with 25 % WPC substitution with ghee residue powder was acceptable.
- Goat milk based high protein dessert was developed using ultrafiltration technique and incorporated with blueberry crush at certain level. Under refrigerated storage, the non-thermized and thermized optimized samples were sensory acceptable till 14th and 28th day, respectively.

- बकरी–दूध आधारित उच्च प्रोटीन मिठाई को अल्ट्राफिल्ट्रेशन तकनीक का उपयोग करके विकसित किया गया था और निश्चित स्तर पर ब्लूबेरी क्रश के साथ शामिल किया गया था। प्रशीतित भंडारण के तहत, गैर–थर्माइज्ड और थर्माइज्ड अनुकूलित नमूने क्रमशः 14वें और 28वें दिन तक संवेदी रूप से स्वीकार्य थे।
- सेट–प्रकार के किण्वित डेयरी उत्पादों अर्थात् दही और मिष्टी दही पैकेज ताजगी संकेतक तैयार किए गए थे जो लेबल पर मुद्रित समाप्ति तिथियों को पूरक या पूरक करने और उपभोक्ताओं के अंत में दही के शेल्फ जीवन को जानने में सहायता कर सकते थे।
- पनीर के लिए जैविक (माइक्रोबियल) स्मार्ट टाइम–टेम्परेचर इंडिकेटर (TTI) चार आइसोलेट्स (S2, M5111, M5114, और M61211) के आधार पर विकसित किया गया था।
- अलसी से भरपूर प्रोबायोटिक डेयरी खाद्य के विकास के लिए दही मिश्रण संस्कृति के साथ–साथ लैक्टिप्लांटिबैसिलस प्लांटारम के विभिन्न उपभेदों की जांच की गई।
- चारे के लिए विश्राम कोण और घर्षण के गुणांक को मापने के लिए उपकरण विकसित किए गए और चयनित पशु आहार सामग्री (हरी जई, गेहूं पुआल तथा सांद्र मिश्रण) की भौतिक तथा अभियांत्रिकी विशेषताओं का निर्धारण किया गया।
- किण्वित डेयरी उत्पादों के लिए स्वचालित एकीकृत हाइब्रिड सोलर प्रणाली को एकीकृत उन्नत कंट्रोलर इकाई के साथ विकसित किया गया ताकि वाष्पन कूलिंग तकनीक के साथ धूप की अनुपस्थिति में सौर ऊर्जा के साथ साथ विद्युत ऊर्जा का उपयोग किया जा सके।
- बीस तथा पचास किलोग्राम क्षमता के लिए एकसमान तापन हेतु प्रणाली में एजीटेटर को शामिल करते हुए पनीर और ग्रीक योगार्ट का उत्पादन करने के लिए बहुद्देश्यीय स्वचालित नियंत्रित दर तापन प्रणाली को विकसित किया गया।
- संगणनात्मक द्रव गतिशीलता (CFD) मॉडलिंग और बायोरियेक्टर प्रोटोटाइप के अनुकरण हेतु ANSYS 3D डिजाइन सॉफ्टवेयर का उपयोग करते हुए गोपशु अपशिष्ट प्रबंधन के लिए उन्नत बायोरियेक्टर प्रोटोटाइप विकसित किया गया। यह विकसित प्रणाली उत्तेजना के साथ एवं उसके बिना क्रमशः 0.3 घन मीटर और 0.24 घन मीटर की बायोगैस उत्पन्न करने में समर्थ थी।
- रसगुल्ला पकाने के लिए तापीय द्रव आधारित लघु स्तरीय यांत्रिकीकृत प्रसंस्करण इकाई की डिजाइन तैयार की गई और लघु स्तरीय डेयरी उद्यमियों के लिए इसका निर्माण किया गया। विकसित प्रणाली के लिए संभाव्यता अध्ययनों को तापन पैटर्न अध्ययनों के साथ साथ सफलतापूर्वक किया गया।
- चुम्बकीय इन्डक्शन आधारित दूध को गरम करने की प्रणाली विकसित की गई। इसका उपयोग 10 से 90° सेल्सियस तापमान पर दूध को गरम करने के लिए डेयरी एवं खाद्य प्रसंस्करण उद्योगों में किया जाए और यह पाया गया कि चुम्बकीय ताप से

- On-package freshness indicators of set-type fermented dairy products namely *dahi* and *misti dahi* were fabricated which could assist in supplementing or complementing the printed expiry dates on the label and for knowing the shelf life of dahi at consumers' end.
- Biological (microbial) smart time-temperature indicator (TTI) for paneer was developed based on the four isolates (S2, M5111, M5114, and M61211).
- Different strains of *Lactiplantibacillus plantarum* along with yoghurt mix culture were investigated for the development of flaxseed-rich probiotic dairy food.
- Equipments for measuring of angle of repose and coefficient of friction for fodder were developed and the physical and engineering properties of selected animal feed materials (oats green, wheat straw and concentrate mixture) were determined.
- Automatic integrated hybrid solar system for fermented dairy products was developed with advanced controller unit integrated with the system to utilize solar energy as well as electrical energy in absence of sunlight with evaporative cooling technology.
- Multipurpose automatic controlled rate heating system, for production of *paneer* and Greek yoghurt, incorporating agitator in the system for uniform heating for 20 and 50 kg capacity was developed.
- Improved bioreactor prototype for cattle waste management was developed utilizing ANSYS 3D design software for computational fluid dynamics (CFD) modeling and simulation of bioreactor prototype.The developed system was able to generate total biogas yield of 0.3 m^3 and 0.24 m^3 with and without agitation, respectively.
- Thermic fluid based small scale mechanized process unit for *rasogolla* cooking was designed and fabricated for small scale dairy entrepreneurs. Feasibility studies for the developed system were successfully done along with heating pattern studies.
- Magnetic induction based milk heating system was developed to be utilized in dairy and food processing for heating of milk from 10 to 90°C and it was observed that fat, SNF, and protein of magnetically heated milk were statistically at par before and after heating.
- Inlinemilk coagulation cum coagulum pressing unit for *paneer* manufacturing at small scale was developed with the provision of temperature

गरम किए गए दूध की वसा, एसएनएफ और प्रोटीन के मान दूध को गरम करने से पहले एवं गरम करने के उपरान्त हासिल किए गए मान के समतुल्य थे।

- लघु स्तर पर पनीर तैयार करने के लिए इनलाइन दूध क्लाटन–सह–क्लाट दबाने वाली इकाई को तापमान नियंत्रण के प्रावधान के साथ विकसित किया गया ताकि दूध को 10° सेल्सियस तापमान की सीमा के भीतर निर्धारित तापमान तक गरम और ठंडा किया जा सके।
- घी अपशिष्ट से फॉस्फोलिपिड्स निकालने के लिए माइक्रोवेव सहायता प्राप्त निष्कर्षण और सपंदित विद्युत क्षेत्र सहायता प्राप्त तकनीक के लिए परिस्थितियों को अनुकूलित किया गया।
- मोरिंगा आधारित पादप संघटक तैयार किया गया और इसका उपयोग स्वादयुक्त दूध फार्मुलेशन में किया गया ताकि इसके कार्यात्मक लाभों को बढ़ाया जा सके।
- न्यूट्रि–सीरियल्स को शामिल करके प्रोबायोटिक कम्पोजिट डेयरी स्प्रेड का विकास किया गया।
- घी अपशिष्ट को शामिल कर डेरी स्प्रेड विकसित किया गया।
- तापीय बफरिंग अनुप्रयोग के लिए फैज चेंज सामग्री का सूक्ष्म सम्पुटीकरण किया गया।
- स्प्रे तथा फ्रिज शुष्कन द्वारा एल. प्लाण्टेरम का सूक्ष्म सम्पुटीकरण किया गया।
- पश्चिम बंगाल के डेरी फार्म परिवारों पर कोविड–19 महामारी के सामाजिक–आर्थिक प्रभाव का आकलन किया गया।
- एक समग्र 'आजीविका सुरक्षा सूचकांक' विकसित किया गया।
- पशुधन आधारित एकीकृत खेती के माध्यम से एनईएच क्षेत्र के टीएसपी के तहत अनुसूचित जाति के किसानों (एसएसपी के तहत) और आदिवासी समुदाय की सामाजिक–आर्थिक स्थिति में सुधार किया गया।

शिक्षा

- सोलह संकाय सदस्यों को संयुक्त राज्य अमेरिका और नीदरलैंड में स्थित 6 विभिन्न विश्वविद्यालयों में अंतर्राष्ट्रीय प्रशिक्षण के लिए प्रतिनियुक्त किया गया था। चौबीस छात्रों ने 4 अलग–अलग देशों के 11 विश्वविद्यालयों में अपनी विदेशी इंटर्नशिप पूरी की।
- नए छात्रों के लिए उनकी प्रतिभा को निखारने के लिए फाउंडेशन कोर्स का आयोजन किया गया, जिसके दौरान साहित्यिक गतिविधियों, संचार कौशल, नेतृत्व कौशल, थिएटर कला, सांस्कृतिक नृत्य, संगीत, योग, मूल्यों, नैतिकता और सामाजिक जागरूकता सहित शारीरिक और खेल गतिविधियों पर सत्र आयोजित किए गए।
- कौशल विकास कार्यक्रम यानि एन रीच का संचालन नेस्ले इंडिया प्राइवेट लिमिटेड द्वारा किया गया। बी.टेक. के लिए लिमिटेड. अंतिम वर्ष के छात्रों को अपने संचार कौशल में सुधार करने के लिए।

control so as to heat and cool the milk to the set temperature within the range of ±1°C.

- Optimized conditions for microwave assisted extraction and pulsed electric field assisted technique for extracting the phospholipids from ghee residue.
- Moringa based plant ingredient was prepared and used in flavoured milk formulation to augment its functional benefits.
- Nutri-cereals incorporated probiotic composite dairy spread was developed.
- Developed ghee residue incorporated dairy spread.
- Microencapsulation of Phase Change Materials for thermal buffering applications was carried out.
- Microencapsulation of *L. plantarum* was done by spray and freeze drying.
- Socio-economic impact of COVID-19 pandemic on dairy farm households of West Bengal was assessed.
- A composite 'Livelihood Security Index' was developed.
- Socio-economic condition of scheduled caste farmers (under SSP) and tribal community under TSP of NEH region was improved through livestock based integrated farming

Education:

- Sixteen faculty members were deputed for international training in 6 different universities located in USA and Netherlands. Twenty-four students completed their overseas internship at 11 different universities in 4 different countries.
- Foundation course was organized for fresher students to nurture their innate talents during which sessions on literary activities, communication skills, leadership skills, theatre art, cultural dance, music, physical and sports activities including yoga, values, ethics and social awareness were conducted.
- Skill development programme i.e. N Reach was conducted by Nestle India Pvt. Ltd. for B. Tech. final year students to improve their communication skills.
- Six workshops on various topics viz. women empowerment, leadership and social entrepreneurship; sensory evaluation techniques; mammalian genome editing; advances in starter culture technology; textural analysis of dairy & food products and computer vision applications

- विभिन्न विषयों पर छह कार्यशालाएँ– महिला सशक्तिकरण, नेतृत्व और सामाजिक उद्यमिता; संवेदी मूल्यांकन तकनीकें; स्तनधारी जीनोम संपादन; स्टार्टर कल्चर प्रौद्योगिकी में प्रगति; संकाय और छात्रों के लाभ के लिए डेयरी और खाद्य उत्पादों का पाठ्य विश्लेषण और डेयरी में कंप्यूटर विज़न अनुप्रयोगों का आयोजन किया गया। इन कार्यशालाओं में व्याख्यान देने के लिए संयुक्त राज्य अमेरिका, ब्रिटेन और आयरलैंड के चार विदेशी प्रोफेसरों सहित विषय विशेषज्ञों को आमंत्रित किया गया था।
- डेयरी उत्पादों की सूक्ष्मजीवविज्ञानी गुणवत्ता और सुरक्षा विश्लेषण पर एक कौशल विकास कार्यक्रम और स्टार्टर कल्चर और किण्वित दूध उत्पादों पर एक प्रमाणपत्र पाठ्यक्रम भी आयोजित किया गया।
- विभिन्न उद्योगों, शैक्षणिक संस्थानों के साथ प्रतिष्ठान शुरू किए गए। प्रशासनिक क्षमताओं वाले मानव संसाधन की तलाश कर रहे डेयरी उद्योग की जरूरतों को पूरा करने के लिए डेयरी प्रबंधन पाठ्यक्रम में स्नातकोत्तर डिप्लोमा शुरू करने के लिए इंस्टीट्यूट ऑफ रूरल मैनेजमेंट आनंद (आईआरएमए), आनंद, भारत के साथ एक समझौता ज्ञापन पर हस्ताक्षर किए गए।
- वैश्विक छात्र नेटवर्क को मजबूत करने के लिए पूर्व छात्रों के डेटा बेस को अद्यतन किया गया।
- स्नातक छात्रों के व्यावसायिक विचारों को पोषित करने के लिए संभावित उद्यमियों के लिए ग्यारह उद्यमशीलता विकास कार्यक्रम और एक अभिनव विचार प्रतियोगिता और यूजी छात्रों के लिए एक अनुभवात्मक शिक्षण कार्यक्रम भी आयोजित किया गया था।
- आउटरीच गतिविधि के एक भाग के रूप में ICAR-NAARM, हैदराबाद की मदद से डेयरी उत्पादन और प्रसंस्करण के क्षेत्र में कुल 61 MOOC विकसित किए गए।
- बीटेक छात्रों ने छात्रों को पढ़ाने के लिए आसपास के गांवों का दौरा किया और आम जनता के बीच पर्यावरण और स्वच्छता के बारे में जागरूकता पैदा की।
- देशभर के सिस्टर डेयरी साइंस कॉलेजों के बीस मेधावी छात्रों को एनडीआरआई की प्रयोगशालाओं और अन्य सुविधाओं में दो महीने की अवधि के लिए इंटर्नशिप (लाइव अनुसंधान परियोजनाएं) प्रदान की गईं।
- सामाजिक समानता और पर्यावरणीय स्थिरता पहल के एक भाग के रूप में महिला छात्रों को आत्मरक्षा प्रशिक्षण दिया गया; शैक्षणिक रूप से कमजोर छात्रों के लिए उपचारात्मक कक्षाएं आयोजित की गईं।

विस्तार

- डेरी पशुओं में उत्पादन और प्रजनन से संबंधित विभिन्न मुद्दों को संबोधित करते हुए, अंगीकृत किए गए गांवों में उन्नीस पशु–चिकित्सा अभियान आयोजित किए गए।
- करनाल जिले के जौहर माजरा गांव के बीस किसानों को एक साल के किसान फार्म स्कूल में भाग लेने के बाद प्रमाण–पत्र प्राप्त हुआ।

in dairying were organised for the benefit of the faculty and students. Subject experts including four overseas professors from USA, UK and Ireland were invited to deliver the lectures in these workshops.

- A skill development programme on microbiological quality and safety analysis of dairy products and a certificate course on starter culture and fermented milk products were also organized.
- Linkage establishments with different industry, academic institutions were initiated. A MoU was signed with Institute of Rural Management Anand (IRMA), Anand, India for initiation of Post Graduate Diploma in Dairy Management Course to cater the needs of dairy industry looking for human resource having administrative capabilities.
- Alumni data base was updated to strengthen Global Alumni network.
- Eleven entrepreneurial development programmes for prospective entrepreneurs and one innovative idea contest and an experiential learning programme for UG students were also conducted to nurture business ideas of undergraduate students.
- As a part of outreach activity a total of 61 MOOCs were developed in the field of dairy production and processing with the help of ICAR-NAARM, Hyderabad.
- B.Tech. students visited surrounding villages to teach students and created awareness about the environment and cleanliness among the rural households.
- Twenty meritorious students from sister Dairy Science Colleges across the country were imparted internship (live research projects) for two months duration in laboratories and other facilities at NDRI.
- As a part of social equity and environmental sustainability initiative, women students were given self-defence training; remedial classes were conducted for academically weak students.

Extension:

- Nineteen veterinary and campaigns were organized in adopted villages, addressing various issues related to production and reproduction in dairy animals.
- Twenty farmers of Johar Majra village in Karnal district received certificate after attending one year Farmers Farm School.

- शैक्षिक दौरे और भ्रमण के तहत 143 संस्थानों के लगभग 7795 छात्रों और शिक्षकों ने एनडीआरआई, करनाल का भ्रमण किया।
- कृषि विज्ञान केन्द्र, एनडीआरआई, करनाल ने 219 ऑफ–लाइन और ऑन–लाइन प्रशिक्षण पाठ्यक्रम और दौरों का आयोजन किया, जिससे 8676 किसान लाभान्वित हुए। इसने 18 राष्ट्रीय कार्यक्रम आयोजित किए गए जिसमें 2148 प्रतिभागी शामिल हुए।
- एनईएच के तहत 2022 के दौरान अरुणाचल प्रदेश, त्रिपुरा और असम में कुल चार पशुधन विकास शिविर आयोजित किए गए। किसानों के बीच पशुधन, पोल्ट्री चूजों, बत्तखों और विभिन्न कृषि–इनपुट वितरित किए गए।
- बत्तख पालन और मुर्गी पालन, मधुमक्खी पालन, मशरूम की खेती और कट फ्लावर उत्पादन जैसे विभिन्न विषयों पर उन्तालीस प्रशिक्षण कार्यक्रम आयोजित किए गए, जिससे 1263 (591 पुरुष और 664 महिला प्रतिभागी) लाभान्वित हुए।

आधारभूत संरचना

- कार्यालय के तीन कक्ष अर्थात लेखापरीक्षा अनुभाग, क्रय अनुभाग और E-II/E-III अनुभागों को मॉड्यूलर फर्नीचर और भंडारण कैबिनेट प्रदान किए गए।
- सीपीडब्ल्यूडी के माध्यम से परिसर में शैक्षिक संग्रहालय भवन का निर्माण किया गया।
- एनडीआरआई परिसर में कृष्णा हॉस्टल में वायर मेश शटर दरवाजे प्रदान किए गए।
- संयुक्त निदेशक कार्यालय एवं पीएमई सेल का नवीनीकरण किया गया।
- छात्रों के देर रात तक पढ़ने के लिए लाइब्रेरी में बाहरी सीढ़ी और एक वॉशरूम सुविधा का निर्माण किया गया।
- संस्थागत विकास योजना परियोजना (एनएचईपी) के तहत जैविक कचने के उपचार के लिए बायोहाज़र्ड कचरे के लिए भस्मक खरीदा गया था; छात्रावास सुविधाओं को मजबूत करने के लिए रसोई स्वचालन उपकरण, सीसीटीवी कैमरे स्थापित किए गए और लॉन मूवर्स खरीदे गए।

- About 7795 students and faculty from 143 institutions visited NDRI, Karnal under Educational Visit and Tour.
- KVK, NDRI, Karnal organized 219 off-line and on-line training courses and visits benefitting 8676 farmers. It organized 18 National events involving 2148 participants.
- Under the NEH total four livestock developmental camps were organized in Arunachal Pradesh, Tripura and Assam during 2022. Livestock animals, poultry chicks, ducks and different agri-inputs were distributed among farmers.
- Forty nine training programmes were conducted on different topics like duckery and poultry rearing beekeeping, mushroom cultivation, and cut flower production benefitting 1263 (591 male and 664 female participants.

Infrastructure:

- Three office rooms viz Audit Section, Purchase Section and E-II/E-III Sections were provided with modular Furniture and Storage Cabinets.
- Educational Museum Building was constructed in campus through CPWD.
- Wire Mesh Shutter Doors were provided in Krishna Hostel at NDRI Campus.
- Joint Director (Reseaerch) Office and PME Cell were renovated.
- External staircase and one Washroom Facility was constructed in Library for use of Students in late hours.
- Under Institutional Development Plan Project (NAHEP) incinerator for biohazard waste was procured to treat biological waste; kitchen automation equipment, CCTV cameras were installed and lawn mowers procured to strengthen the student hostel amenities.

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. ICAR-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. This centre was the first to initiate training in artificial insemination in cattle in the country and has the honour of imparting training to Mahatma Gandhi and Pandit Madan Mohan Malviya. 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.

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.

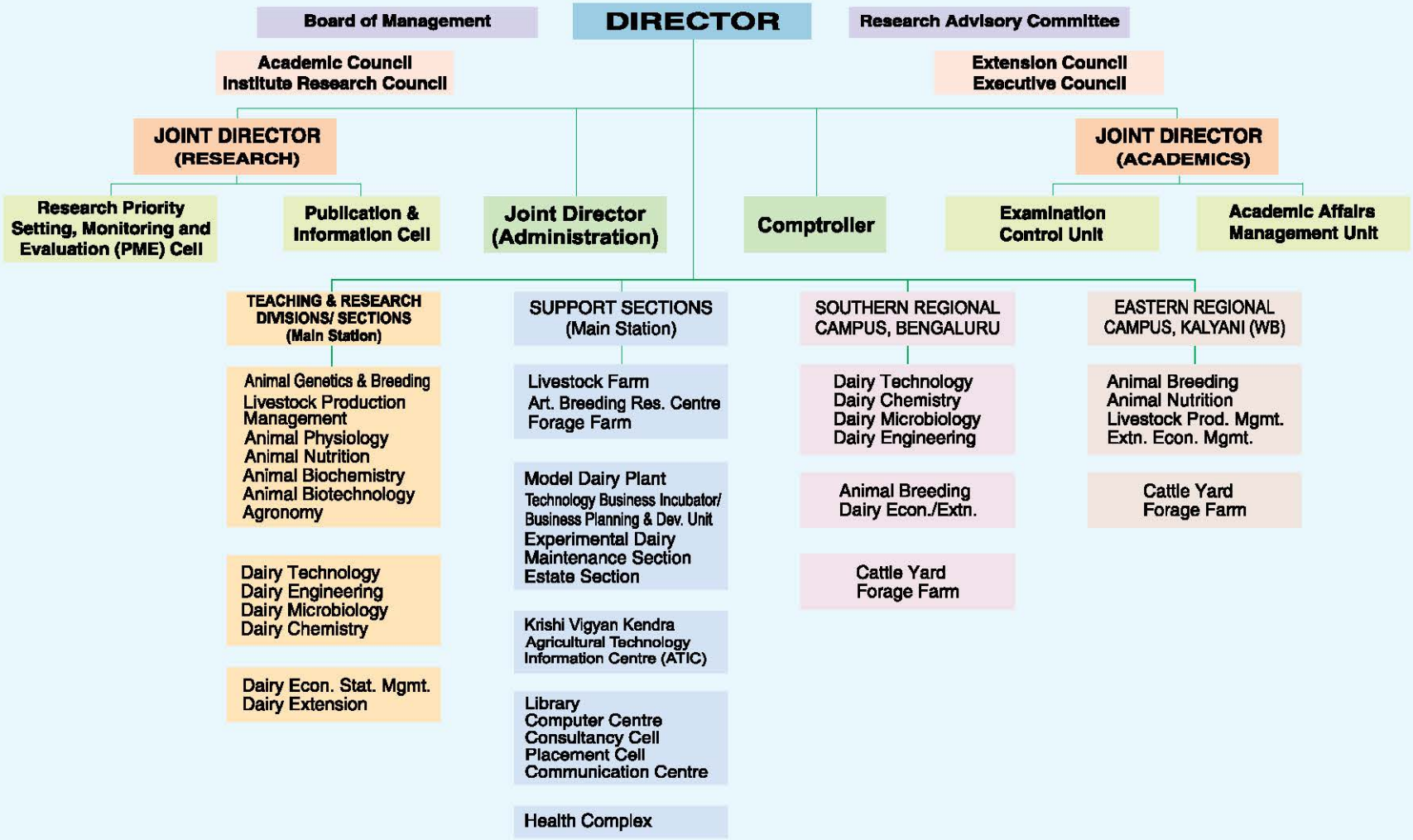
Krishi and Dairy Vikas Kendra, Piprakothi-Motihari

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	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. Pannu,** 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, Agronomy, 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 Wadhera,** Sr. F&AO, Krishi Bhawan, New Delhi

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, AGRA Road Near Chandrmahal Garden Hotel & Poultry Farm, 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, Administrative Office, Dr. YSR Bhawan, 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
Sh. Mukesh Anand, Keshav Gaushala, Anand Ashram, Vill New Gothra, Khetri, Jhunjhunu, Rajasthan	**Sh. Rajumor**, VPO-Ludana, Jind, Haryana

ACADEMIC COUNCIL

Chairman	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

EXTENSION COUNCIL

Director, NDRI, Karnal	Chairman
Joint Director (Extension)	Vice-Chairman
Joint Director (Research)	Member
Joint Director (Academic)	-do-
DDG (Extn. Education), ICAR, New Delhi or his Nominee	-do-

Three Scientists in Management position of the Institute	-do-	**Dr. A.K. Mishra**, I/C, LPM **Dr. Vivek Sharma**, Dairy Chemistry **Dr. R. Malhotra**, Head, DESM
Five Scientists of the Institute (to be nominated by the Board of Management on a two year tenure basis)	-do-	**Dr. Suneel Onteru**, PS, ABC **Dr. Pawan Singh**, I/C, ABRC **Dr. S. De**, I/C, ABTC **Dr. A.K. Dang**, Head, Physiology **Dr. Kaushik Khamrui**, DT Division
One Scientist from Regional Station to be nominated by the Board of Management on a two year tenure basis)	-do-	Head, ERS, Kalyani
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

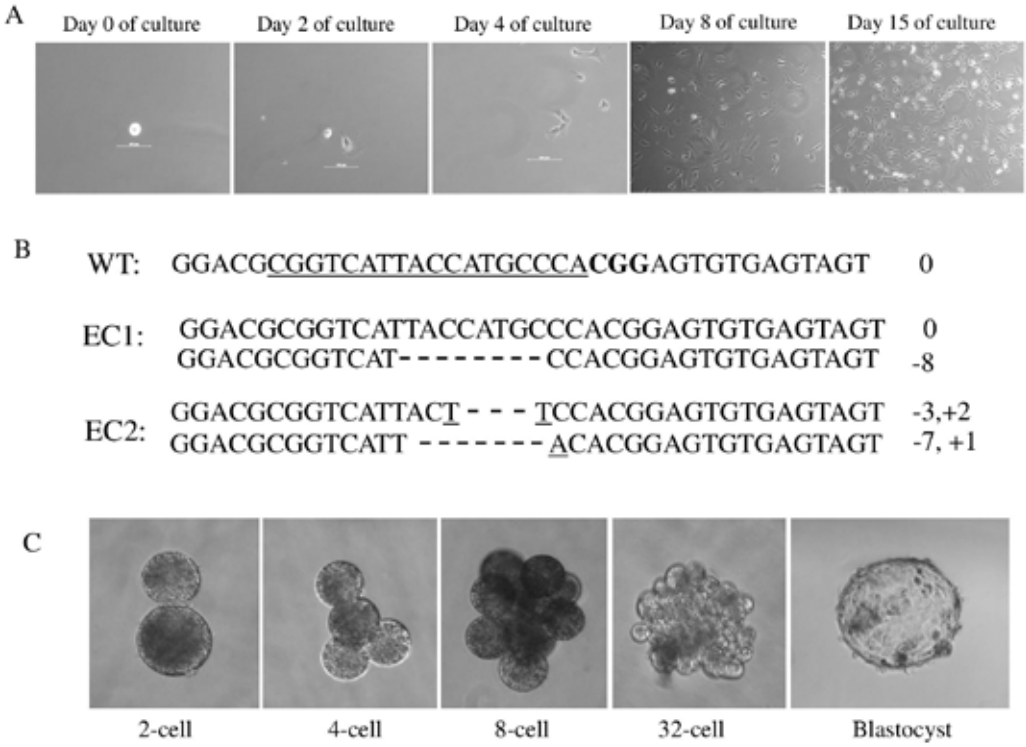
Gantantra and Basant: buffalo male cloned calves produced

Buffalo is the mainstay farm animal in India's agricultural economy. Buffalo contributes approximately 50% of the total milk production, despite its population being half that of cattle; thus, playing important role in farmers' livelihood. For the faster multiplication of elite germplasm, NDRI has developed a simple, economical, and efficient animal cloning technology, called handmade cloning, that used to produce over 30 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. Therefore, there is a huge requirement of semen from high genetic merit bulls to breed 55 million breedable female buffaloes. In India, due to a severe shortage of elite bulls, semen available from progeny-tested bulls is not sufficient to cover even 5% of the breedable population of livestock. In view of this, during the reporting period, two cloned male calves of a superior breeding bull (MU-2501), named Gantantra (January 26, 2022) and Basant (February 07, 2022) were born. Trials carried out at the NDRI will certainly help to reach technology at farmer's doors for enhancing the productivity of their animals which will lead to future sustainable milk production in the country.

Cloned buffalo Gantantra (Left) and Basant (Right) produced in NDRI

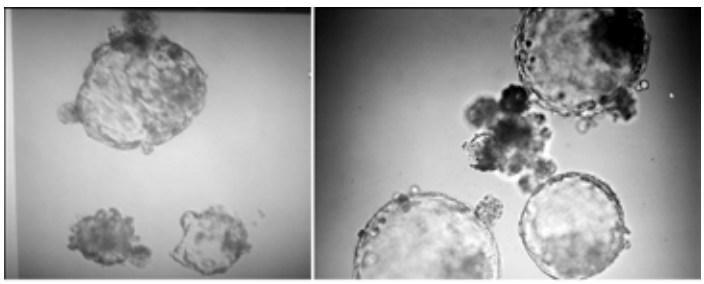
Production of MSTN-gene KO cloned embryos of buffalo

The study aimed to produce myostatin (MSTN) gene edited embryos of the Murrah buffalo using the CRISPR/Cas9 system and SCNT. Fibroblast cells were electroporated with sgRNAs carrying all-in-one CRISPR/Cas9 plasmids targeting the first exon of the MSTN gene. Following puromycin selection, single-cell clonal populations were established and screened using the TA cloning and Sanger sequencing methods. Out of eight single-cell clonal populations, one with a mono-allelic and another with a bi-allelic heterozygous gene editing event were identified. These two gene-edited clonal cell populations were successfully used to produce blastocyst-stage embryos using the handmade cloning method. This work establishes the technical foundation for generation of genome-edited cloned embryos in the buffalo. In addition to plasmid approach, the RNPs were also used to produce MSTN-gene KO embryos.



Generation and screening of single cell clonal populations and development of MSTN-gene edited cloned embryos. A) The growth of a single cell during different days in culture, B) Editing detection in clonal cell populations by TA cloning and Sanger sequencing. EC1 represents a clonal cell culture with a mono-allelic deletion of 8 nucleotides; CE2 represents a bi-allelic edited cell culture, one allele carries a 7 nucleotide deletion and a one base addition, and the other allele carries a 3 nucleotide deletion and a 2 nucleotide addition. WT, wild type sequence is shown on top; deletions '–', insertions are underlined. C) In-vitro developmental stages of a cloned buffalo embryo produced from the bi-allelic edited cell population.

Production of cloned embryos of indigenous cows using handmade cloning



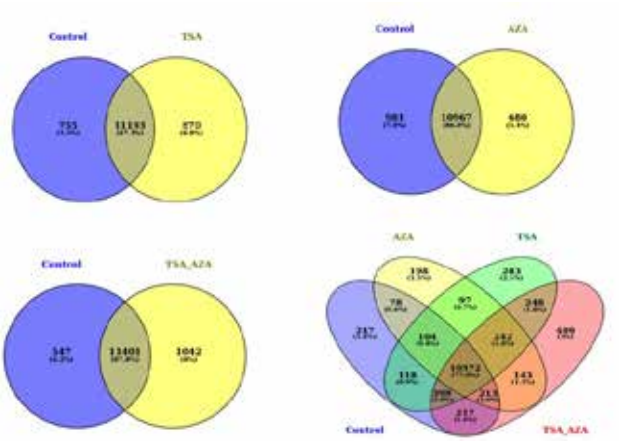
Cloned blastocysts of Sahiwal and Gir cows

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. The generated HMC embryos were cultured to develop them to the pre-implantation transferable stage embryos (morula or blastocyst). A total of five OPU experiments were performed for the production of cloned embryos. For HMC experiments, we used donor cells from Sahiwal and Gir. Eighty embryos were produced of indigenous cows using enucleated oocytes of Sahiwal/ Red-Sindhi, of which 15 blastocysts were developed. The produced blastocysts were transfer into Red-Sindhi and cross-bred cows. Two pregnancies of Sahiwal cows and three pregnancies of Gir were established, of which both Sahiwal pregnancies were aborted, and one Gir pregnancy was aborted. As on Dec 2022, two pregnancies

of Gir were ongoing. Further attempts are continuing to improve blastocyst production rate, and produced blastocysts will be transferred to recipient animals for the production of cloned cows.

Transcriptomic profile of buffalo cloned embryos using epigenetic modifiers

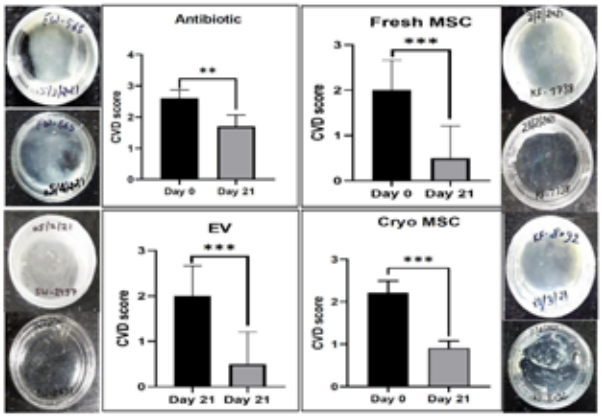
Trichostatin-A (TSA) and/or, 5-aza-2'-deoxycytidine (5-aza-dC) used in buffalo cloned embryo production and found that cleavage rate was significantly higher (P<0.05) when reconstructs were supplemented with 5-Aza-dC (87.15±2.73%) or, TSA + 5-Aza-dC (92.98±3.69%) compared to the controls (80.97±2.92%). During blastocyst production rate, the trend was not similar as for TSA (46.69±1.08%) alone or, in combination (47.60±3.19%) it was significantly higher (P<0.05) than that of 5-za-dC (42.46±1.10%) alone or, control (38.04±1.70%). Transcriptomic data showed that at ≥2-folds change, a total of 12,818 transcripts were differentially expressed among which 755 were unique to the control cloned embryos, 870 were unique to TSA-treated embryos and 11,193 were commonly expressed in both types of embryos. Out of 11,193 commonly expressed transcripts only 497 transcripts were found to be up-regulated and 183 transcripts were down-regulated in TSA treated embryos relative to control cloned embryos at FC ≥2 and (P<0.05),. For 5-Aza-dC treated sample, at ≥2-folds change a total of 12,628 transcripts were differentially expressed among which 981 were unique to the control cloned embryos, 680 were unique to 5-Aza-dC treated embryos and 10,967 were commonly expressed in both types of embryos. At FC ≥2 and significance level of P (P<0.05), out of commonly expressed transcripts i-e, 10,967 only 284 transcripts were found to be up-regulated and 336 transcripts were down-regulated in 5-Aza-dC treated embryo relative to control cloned embryos. In the case of combined treatment group (TSA+5-aza-dC), a total of 12,990 transcripts were differentially expressed among which 547 were unique to the control cloned embryos, 1042 were unique to combined treated embryos and 11,401 were commonly expressed in both types of embryos and out of which 652 were up- and 150 were down-regulated at FC ≥2 and significance level of P (P<0.05). Venn diagram showed all the groups together also commonly expressed transcripts are very high in number (10,572) compared to all other groups. Among top 15 up- and down-regulated transcripts in TSA+5-aza-2'-deoxycytidine treated embryos were Liprin-alpha-1-like, Mucin-16, *FREM1, MMP2* etc. and play roles in embryonic development, cleavage, cell proliferation etc. Differentially expressed transcripts among control cloned and treated embryos affect the various biological processes, cellular components, molecular functions, protein class categories and pathways.



Commonly and uniquely expressed transcripts in cloned embryos.

Use of mesenchymal stem cells for the treatment of metritis in cows

Mesenchymal stem cells (MSCs) are one of the most studied and new heralded stem cells to treat animal diseases in the world. The present studies are to isolate and characterize umbilical cord blood-derived mesenchymal cells and stem cells for the treatment of mastitis and metritis in cattle. MSCs were isolated from umbilical cord blood samples and cultured in DMEM media in laboratory. The MSCs were characterized as per the International Society for Cellular Therapy RT-PCR analysis of stem cell markers and differentiation into lineages. The cDNA was found to be positive for CD73, CD90, and CD105 and negative for CD34, CD45. The MSCs were differentiated into adipogenic, chondrogenic, neurogenic, and osteogenic lineages showed positive



Cervical vaginal discharge score treated with MSCs in cows

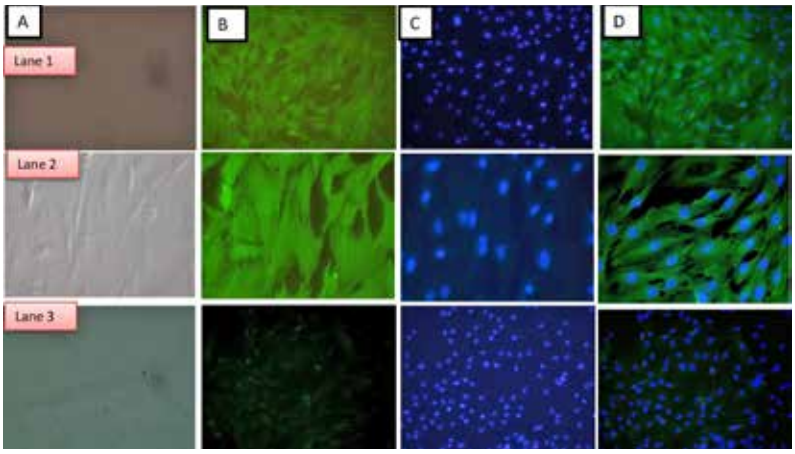
results. Along with antibiotics group as control, treatment groups include fresh MSCs, cryopreserved MSCs and extracellular vesicles (EVs) for cows in each group in mastitis and metritis diseases. In all the 3 MSCs treated groups, somatic cell count (SCC) decreased significantly than that of antibiotic control group.

MSC treated metritis cows delivered healthy calves at NDRI

Similarly, polymorphonuclear (PMN) count was significantly ($p>0.05$) decreased in MSCs and MSCs-EV treated cows compared with the antibiotics group. Gene expression studies also observed a significant ($P<0.05$) increase in anti-microbial peptide (Cathelicidin, Lipocalin 2), anti-inflammatory factors (IL-10, Cystatin), angiopoietin and a decrease in the Pro-inflammatory cytokine (IL-6) in metritis treatment group compared to the antibiotic group cows. In conclusion, UCB-MSCs treated metritis cows were cured successfully within a month and it was observed MSCs are an important regenerative therapy for diseased animals. The UCB-MSCs has a capacity to cure metritis-infected cows.

Exploring the use of mesenchymal stem cells and Panchagavya for the treatment of diabetes and cancer in rats

Mammary cancer is the second most common cancer in women after skin cancer. The animals are also suffering from cancer as per the published research work. The aim of the study is to control diabetes and cancer with panchagavya and mesenchymal stem cells (MSCs). Adipose tissue-derived MSCs were isolated from the omental fat of a mouse and cultured in vitro condition and characterized as per the International Society for Cellular Therapy (ISCT). The MSCs were successfully isolated and characterized and cryopreserved for further use. Six mice were injected with MSCs, and all the mice were monitored, taking weight and examining their health condition. Induction of cancer chemical carcinogen DMBA @ dose of 5 mg/100 g BW in 1 ml almond oil was given by oral intubation IN 10 mice. Every alternate day was palpating the mice for the appearance of tumors in the mammary region of the mice. Cancerous cells



Immunostaining characterization of MSCs derived from mouse adipose tissue

MCF7 were injected @ 10^6 to 10^7 cells per injection into the mammary fat pad in the mice and taking the body weight observing all mice every day.

Cancer induced (left) and MSCs treated mouse (right) cured the cancer

The induction of diabetes was initiated by Streptozotocin in mice through IP injection of 1g/1g dose of Streptozotocin in adult Wistar mice, treated with MSCs. Panchagavya was prepared and used for the in vitro study of cancerous cells MCF7 and observed cell growth was significantly inhibited in cancerous cells. Similarly, diabetic cells were also shown significant inhibition with panchagavya. Diabetes was treated with MSCs and all the mice were cured within a month.

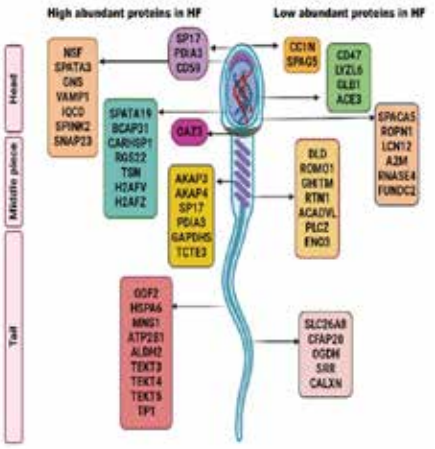
Knockout of β-lactoglobulin gene in buffalo mammary epithelial cells by CRISPR/Cas9

The different sets of β-lactoglobulin specific CRISPR sgRNAs were used for knockout of the buffalo β-lactoglobulin gene. CRISPR sgRNAs were cloned in pSpCas9 (BB)-2A-Puro (pX459_Puromycin/Cas9) vector and transformed in *E.coli* cells. The recombinant vector carrying each sgRNA was isolated. Sequencing results showed that the sgRNA2 and sgRNA4 were inserted into the backbone of the vector. Buffalo mammary epithelial cells (BuMECs) were seeded at a density of $2x10^5$ cells/well. CRISPR gene constructs were transfected in BuMECs. The genomic DNA from transfected BuMECs were isolated and amplified using βLG gene (exon 1) specific primers. The purified PCR product were treated with T7/E1 nuclease. The sgRNA2 and sgRNA4 showed the editing event in βLG gene in transfected BuMECs. Sequencing results confirmed that the sgRNA2 and sgRNA4 mediated transfected BuMECs showed 3 bp deletion in exon 1 of the βLG gene**.** qPCR analysis revealed that the βLG mRNA transcript were significantly decreased ($p < 0.001$) in knockout BuMECs (sgRNA2 and sgRNA4) as compared to wild type (naïve) BuMECs; however, no significant difference was found between knockout BuMECs and wild type (naïve) except the expression of *CSN1S1 mRNA* transcript. The expression of other milk associated genes viz. *LALBA, CSN2, CSN3, LTF, CSN1S1* and *CSN1S2* were not significantly different between knockout (sg2 and g4) and wild type (naïve) BuMECs.

Deletion of the 3bp in exon 1 of the buffalo βLG gene in BuMECs transfected with pX459_Puro/ Cas9 vector carrying sgRNA4.

Development of protein map of spermatozoa of distinct fertility buffalo bulls

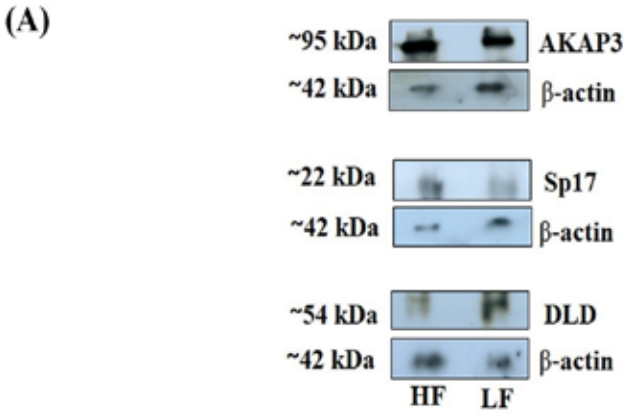
Whole proteome profile of high and low fertile buffalo bull spermatozoa was generated by using label free LC-MS/MS to identify the fertility regulating proteins. Based on data analysis were identified a total of 1064 (85.2%) and 968 (77.5%) proteins in high (HF) and low fertile (LF) bull spermatozoa, respectively. Out of the total identified proteins, 782 (62.6%) proteins were common to both groups and 349 proteins were differentially-expressed between the high and low fertility spermatozoa. While comparing the differently abundant proteins in high *vis a vis* low fertile bull spermatozoon, expression of 194 proteins were up regulated in HF group and 155 proteins were down regulated at log2 fold change. Out of 349 proteins 20 proteins that have shown role in the fertilization were shortlisted. The proteins like AKAP4, AKAP3, SP17, PDIA3, Testis specific 10, GLIPR1-like protein and cylicin-1 etc were highly expressed in high fertile bull whereas Angiotensin-converting enzyme, Acrosin-binding protein, Calmodulin, Cilia and flagella associated protein 52, Dihydrolipoyl dehydrogenase, Growth hormone inducible transmembrane protein were highly upregulated in low fertility bulls. Based on the gene ontology analysis, molecular and cellular functions of identified proteins, a protein map of buffalo sperm proteins was developed.



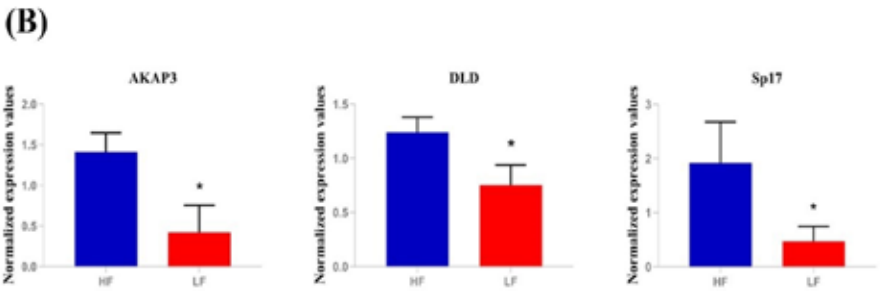
High and low abundance of key proteins in buffalo spermatozoa of distinct fertility

Confirmation of promising protein candidates in buffalo spermatozoa related to bull fertility

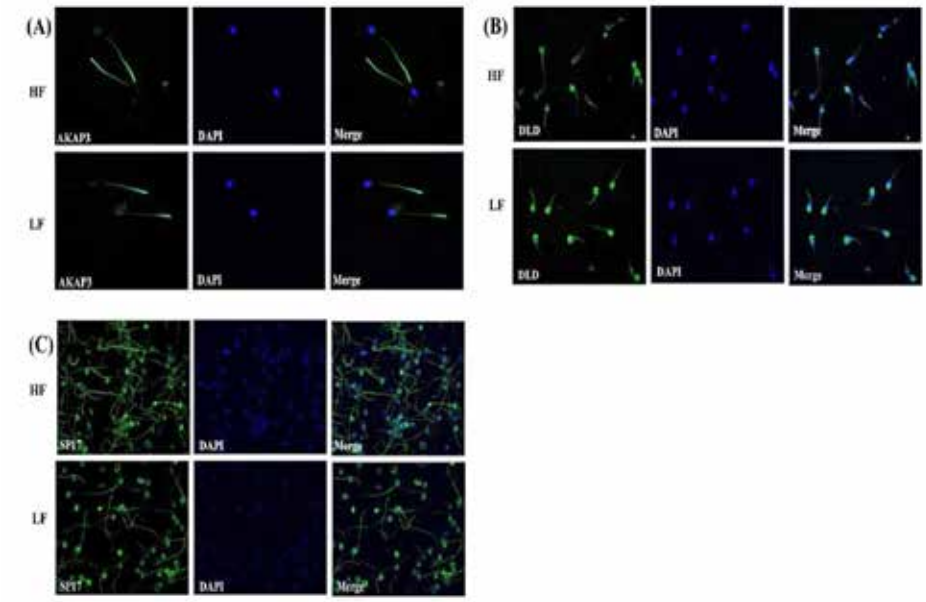
Out of 20 shortlisted proteins, three differentially abundant proteins (DAPs) obtained from the mass spectrometry were further validated and quantified through Western blotting in HF and LF bull spermatozoa. The criteria of selection of DAPs were based on their roles in sperm functions and gene ontology. The DAPs namely; AKAP3, Sp17 and DLD were subjected to Western blotting. AKAP3 (3.68 log fold change) and Sp17 (2.47 log fold change) showed significantly ($p < 0.05$) higher abundance in HF spermatozoa, whereas abundance of DLD (-1.6 log fold change) was significantly lower in HF group when compared to the LF group. The relative abundance of Sp17, DLD and AKAP3 were normalized with ß-actin.



Fold change in abundance of APA3, Sp17 and DLD proteins in HF and LF buffalo bull spermatozoa.



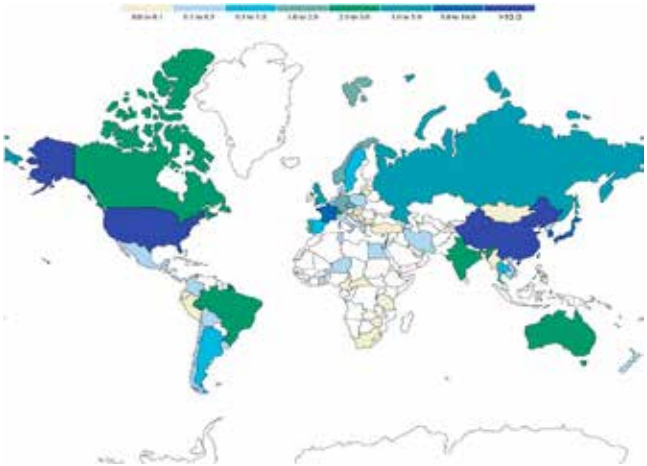
Further, AKAP3, SP17 and DLD proteins were subjected to fluorescence immunocytochemistry (ICC) to localize these proteins in different regions of sperm. Sp17 was specifically localized to the middle piece and in scattered patches all throughout the head area, whereas AKAP3 was predominantly localized in the middle piece and scattered patches in the lower tail of the spermatozoa of both the groups HF and LF. Dihydrolipoamide dehydrogenase (DLD) has lower abundance in the HF group and was localized in the acrosome along with the principal piece of flagella. The multiple line of evidences clearly demonstrates that APA3, Sp17 and DLD are promising protein candidate for assessing bull fertility.



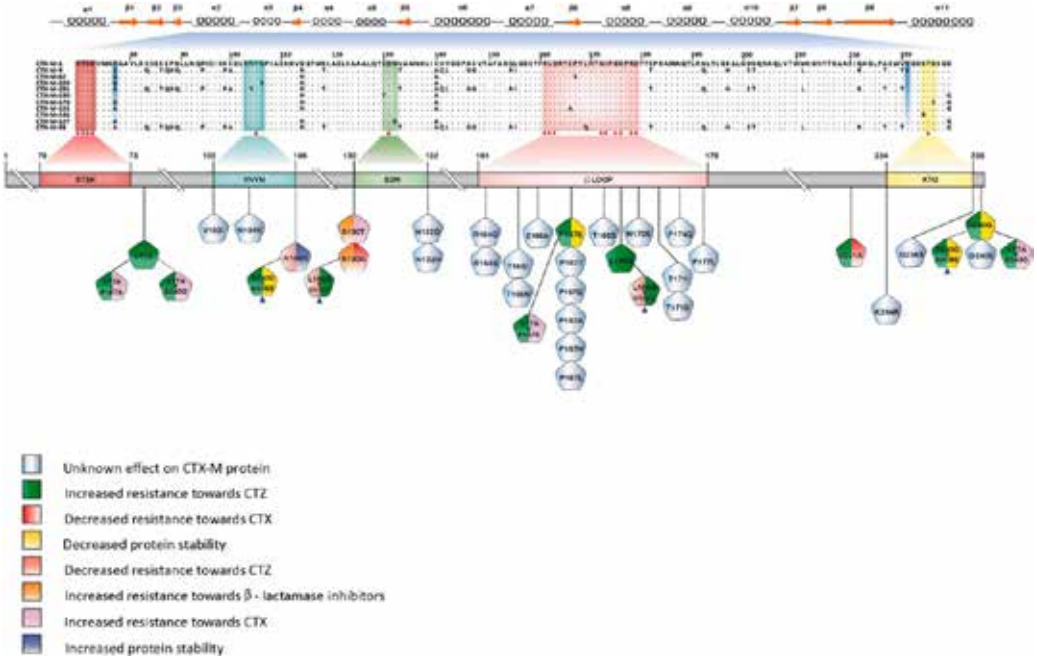
Immunolocalization of APA3, Sp17 and DLD proteins in in HF and LF buffalo bull spermatozoa.

Global epidemiology pattern of CTX-M-types of Extended Spectrum Beta Lactamase (ESBL) resistance was analyzed for human and animal infections.

CTX-M ESBL are widely found in animal and human infections. For better understanding of CTX-M variations and epidemiology, a total of 2210 CTX-M sequences were retrieved from NCBI as at 20 December 2020. The maximum incidences of CTX-M were reported in China (n = 508), USA (n = 354) and Japan (n = 180). Single amino acid substitution in the domain region of CTX-M ESBL lead to survival benefits to the bacteria. A total of 31 different variations were found of which D240G was the most common followed by A77V and V103I substitutions. The variations in CTX-M enzymes were explained continent-wise revealing the maximum variation reported in America followed by Asia and Europe of which D240G substitution was the most prevalent. India contained only three variations (E166A, P167S D240G) found in New Delhi, Karnataka, West Bengal and Tamil Nadu. The P167 and D240 were under strong positive selection.



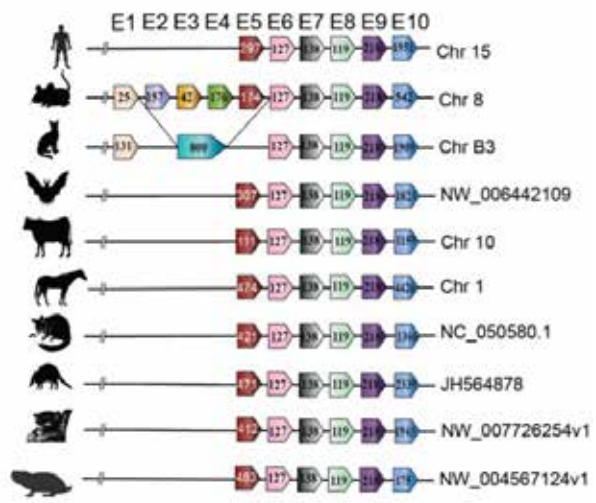
Distribution of CTX-M worldwide (n = 2210). Scale represents highest to lowest number of CTX-M cases reported. Most of the sequences were obtained from China (n=508), USA (n=354) and Japan (n=180) in a descending order of frequency.



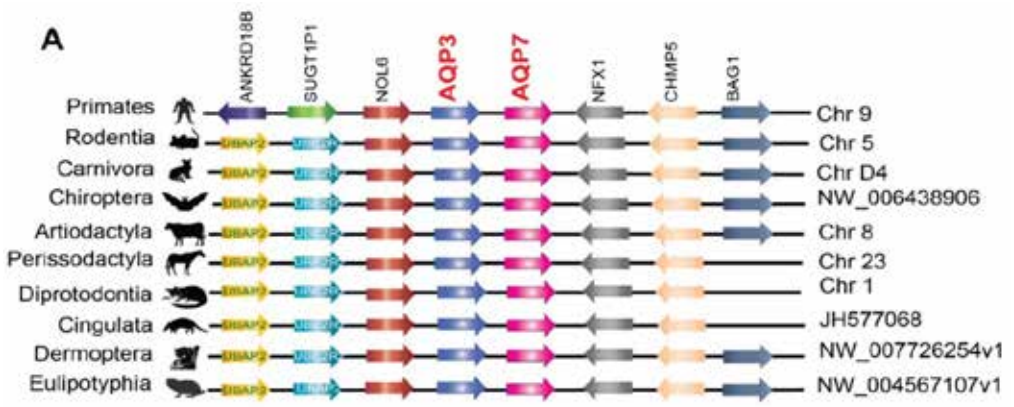
Multiple sequence alignment of CTX-M sequences (n = 2210) showing detailed amino acid substitution. The red, blue, green and yellow boxes represent 70STSK73, 103VNYN106, 130SDN132 and 235KTG237 motif region respectively. The omega loop is indicated by pink box. The red star below the alignment represents the conserved amino acid residues. The mutations are represented in pentagonal-shaped polygon. The blue triangle below the pentagon indicates the in-vitro studied mutations. The effect of the mutations on CTX-M protein studied from the literature is represented by different colors. The plus sign in the pentagon indicates the combined mutations.

Evolutionary pattern of Aquaglyceroporins in Mammalian species

Aquaporins (AQPs), also known as Membrane Intrinsic Proteins (MIPs), are tetrameric channel proteins that facilitate the transport of water and other small solutes across cellular membranes, which is a crucial aspect of cell and tissue metabolism. Thirteen water channel proteins have been identified in mammals and classified into three groups based on their structure and function: (i) Classical aquaporins (AQP0, 1, 2, 4, 5, 6, and 8) which selectively transport water; (ii) Aquaglyceroporins (AQGPs) (AQP3, 7, 9, and 10) which are permeable to small solutes, glycerol, and urea in addition to water; and (iii) S-aquaporins (AQP11 and 12). In mammals AQPs have evolved to enable the penetration of water, solutes, gases, and other chemicals that regulate the fundamental cellular processes, such as energy metabolism, osmolarity, cell growth, cell migration, cell adhesion, exocrine gland secretion, and lacrimation. AQPs also play a crucial role in pathophysiology and physiological processes, including regeneration, organogenesis, lipid metabolism, osmoregulation, and vascular and cancer biology, which can lead to severe diseases.



Chromosomal syntenic location of AQP3 and AQP7 genes in mammals.



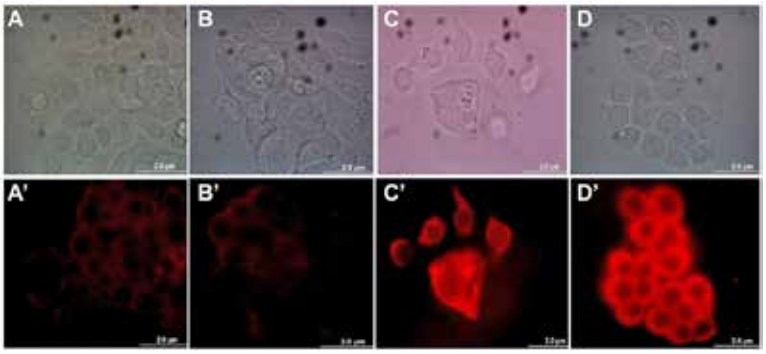
Comparative gene organisation of the AQP9 shows the conservation of exon (represented by different coloured blocks) regions in different orthologous species. The number in each block represents the length of an exon. The direction of the arrowheads represents transcript orientation predicted in the annotated genome assembly of UCSC browser and NCBI genome database.

Recombinant expression of a potent endolysin against *Escherichia coli*

As the world enters a post-antibiotic era due to increase in antibiotic resistance in microbes, alternate therapeutics are needed which would provide the advantages of antibiotics as well as overcome its limitations. Endolysin, a phage peptidoglycan hydrolase enzyme, is a potential biomolecule which cleaves the cell wall of the host bacteria to release the progeny phage. Research on endolysins is in its early phase and has gained interest in past decade. Recently, this killing attribute of endolysins has been exploited against pathogenic resistant bacteria. We have successfully cloned and expressed *E. coli* endolysin. It has expressed in an active form and is catalytically active against various strains of *E. coli* including mastitogenic isolates. Its antibacterial activity via CFU reduction assay against six *E. coli* strains (4 MDR strains) has been tested.

Host-microbe interaction and pathogen exclusion mediated by an aggregation-prone surface layer protein of *Lactobacillus helveticus*

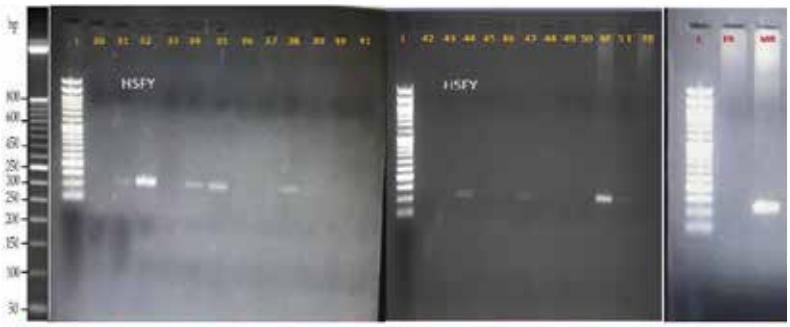
Host-microbe interaction is a complex process where multiple types of surface molecules of host and microbes are involved. The adhesion potential of lactobacilli is linked with their surface architectural proteins. S-layer protein (Slp) of lactobacilli has been implicated in the adhesion of probiotic bacteria in the mammalian gastrointestinal tract. Probiotic surface layer proteins (Slps) have multiple functions and bacterial adhesion to host cells is one of them. The precise role of Slps in cellular adhesion is not well understood due to its low native protein yield and self-aggregative nature. *Lactobacillus helveticus* NCDC 288 (SlpH) is a highly basic protein (p*I* = 9.4), having a molecular weight of 45 kDa. Circular Dichroism showed a prevalence of beta-strands in SlpH structure and resistance to low pH. SlpH showed binding to human intestinal tissue, enteric Caco-2 cell line, and porcine gastric mucin, but not with fibronectin, collagen type IV and laminin. SlpH inhibited the binding of the enterotoxigenic *E. coli* by 70% and 76% and that of *Salmonella* Typhimurium SL1344 by 71% and 75% to enteric Caco-2 cell line in the exclusion and competition assays, respectively. The pathogen exclusion and competition activity and tolerance to harsh gastrointestinal conditions show the potential for developing SlpH as a prophylactic or therapeutic agent against enteric pathogens.



Immunofluorescence microscopy showing binding of MBP-SlpH to human intestinal cell line, Caco-2. Images A, B, C and D show bright fields, and A', B', C' and D' show the respective immunofluorescence signal. (A) and (A') – PBS - no protein (control), (B) and (B') 50 µg ml^{-1} MBP (Tag) protein, taken as control, (C) and (C') 100 µg ml^{-1} MBP-SlpH, (D) and (D) 150 µg ml^{-1} MBP-SlpH.

Aptamer based enrichment of X and Y chromosome bearing spermatozoa in cattle and their validation using real time PCR and IVF

Aptamers have been generated through SELEX and 5 aptamers have shown specific interaction with either X or Y sperm. The Y sperm specific aptamer (1Y) and the enrichment was validated by real time PCR, IVF and embryo sexing. Commercial bull semen available at Artificial Breeding Research Institute at NDRI was used in the experiments for sperm separation. Biotinylated aptamers (1Y) bound Y sperms and the fraction was called bound fraction and remaining unbound fraction was X sperm. Both fractions were analyzed for enrichment by PCR and qPCR. The bound fraction was found to be Y- enriched as only male specific SRY gene bands were observed while in the unbound fraction female specific MOA gene bands were found. It shows that successful selective enrichment of Y-sperms was done using these Y-specific aptamers. The unbound fraction was used to generate the embryos by IVF followed by assessment of sex of the individual embryo. It was observed that more than 70% of female embryos were generated.



GENE	Product length
MAOA (X-SPECIFIC)	126 bp
HSFY (Y-SPECIFIC)	111 bp

Embryo type	Total embryo produced	Phenotypic sex after PCR	% of female embryo produced
Aptamer Treated	51	13 Male (XY)	25.49
	51	38 Female(XX)	74.51

PCR amplification of HSFY gene of single embryo to confirm sex of the embryo

Antimicrobial potential of urine-derived peptides from Murrah buffalo against bacterial pathogens

Antimicrobial peptides hold promising activities against disease causing pathogens. The antimicrobial peptides were isolated from urine of Murrah Buffalo from three physiological states i.e. heifer, pregnant and lactating animals. Peptides were isolated by ultrafiltration, Solid Phase Extraction and LC-MS/MS. Mass Spectrometry identified 1778, 1509 and 1898 peptides from heifer, pregnant and lactating group respectively. The most common peptide length was spanned across 37 to 45 amino acid length. The common amino acid residues found in these peptide sequences were Alanine, Glycine, Proline, Serine and Leucine. The crude peptide extract was used to check for their killing activity for *Escherichia coli* and *Staphylococcus aureus*. The preliminary confirmation of antimicrobial activity was done by disc diffusion assay where 30 µl of the test peptide was coated on the sterile disc from a stock solution of 10 mg/ml. Development of zone of inhibition confirms the antimicrobial activity of the test peptide. The peptide sequences were checked and compared with the sequences in antimicrobial peptide databases. After making suitable mutations the peptides were synthesized and their activity was checked for the bacteria mentioned. The peptides were not effective for *S. aureus* at a low concentration. MIC of IV-18, GL-19 and GV-20 was 62.5, 15.62 and 500 µg/ml for *E.coli*. MBC values were same as that of MIC for all the three peptides.

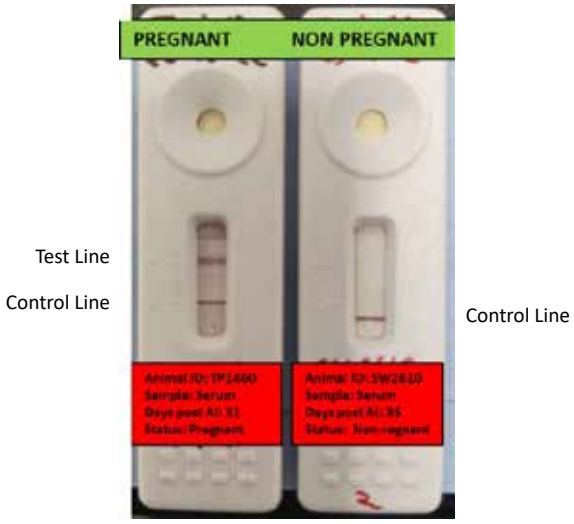
Antimicrobial susceptibility test of peptides against S. aureus

Serum based diagnostics using pregnancy associated Glycoproteins (PAGs) and development of ELISA against BuPAG1

The ELISA was developed, optimised and validated against Buffalo PAG1 (BuPAG1). The final optimization of standards ranging from 0-320 ng/mL of volume 50 µl per well was chosen for developing BuPAG-1 based standard curve. Serum samples from 38 animals including 35 days pregnant, 35 days non pregnant, 1 day after AI (artificial insemination) and heifers were tested in this ELISA. All the samples were diluted in1:8 ratio (optimized dilution) in PBST and were used for the analysis. The 35 days pregnant animals were confirmed by ultrasonography and per rectal palpation. The samples were screened along with standards and the mean OD of the samples were obtained. The mean concentration of the samples were calculated by equation y = mx + b; where m= slope of the line and b=y intercept. The sensitivity, specificity and accuracy of the BuPAG-1 ELISA test are 80%, 91.6% and 86.36% respectively.

Lateral Flow Immunoassay (LFIA) against PAGs

Lateral Flow immunoassay was developed, tested and validated against BuPAG-1, BuPAG-2 and BuPAG-18. Detection of PAG was done using sandwich LFIA format. Sensitivity, specificity and accuracy of the assay were also calculated. The sensitivity, specificity and accuracy using BuPAG-1 based LFIA are 75%, 75% and 78.9% respectively while sensitivity, specificity and accuracy using BuPAG-2 based LFIA are 95.55%, 66.6 % and 85.50%, respectively.



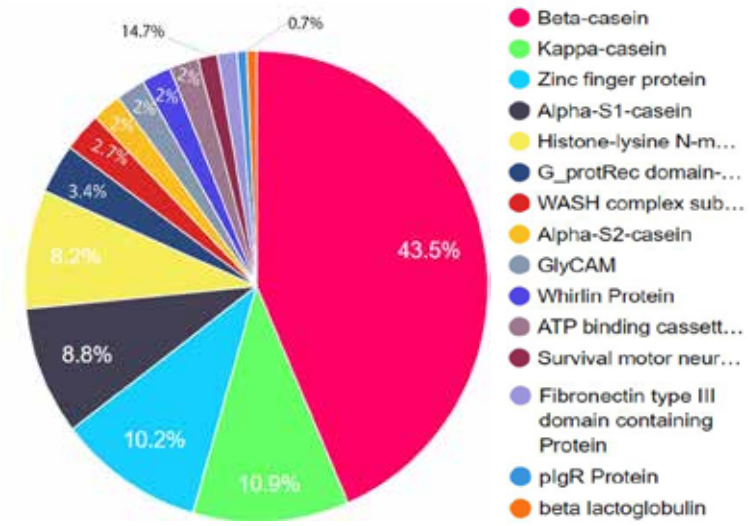
LFIA rapid test cards showing results in pregnant and non-pregnant cattle Lateral Flow Immunoassay Development against Sex Hormone Binding Globulin (SHBG)

A sandwich format LFIA was developed against urinary protein marker Sex Hormone Binding Globulin (SHBG). Two polyclonal antibodies generated against SHBG were used for LFIA- one for conjugation with gold nanoparticles while another used at test line. Anti-rabbit secondary antibody was used at control lines. Various parameters like sample pad, nitrocellulose membrane, conjugation pad were optimized for urine samples.

Characterizing milk colostrum of Ladakhi cows and yak for identification of biomolecules with therapeutic potential

ladakhi Yak colostrum samples which were collected within 24 h of parturition, 4th and 5th day after parturition and at peak lactation were subjected to peptide extraction. After the extraction, the peptides samples were analyzed by LC-MS/MS and raw files generated through mass spectrometry have been analyzed and the peptidome profile has been generated from colostrum. The identified sequences were predicted for the various bioactivities through bioinformatics tools and 2 sequences showing high score for immunomodulatory activity were selected and synthesized. Cytotoxic effect of the synthesized sequences has also been determined on the RAW264.7 cell lines by MTT cell viability test. RAW264.7 cell lines showed the enhanced viability of the cells after the peptide treatment at different concentration. Concentration of major milk proteins like IgG1, IgG2, Lactoferrin, Lysozyme, Albumin, IGF1 and EGF present in colostrum of Ladakhi Yak and trend in their

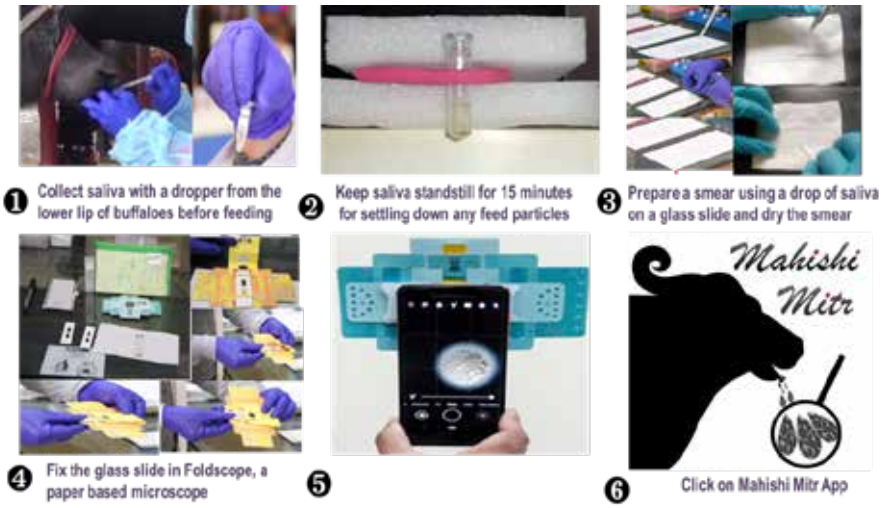
concentration as colostrum proceed towards maturity was quantitatively determined by ELISA with 4 different stages i.e., 0 day, 2, 4 and mature milk. All of these were highest on 0 day colostrum and concentration was found to be higher than reported concentration in bovines. *In Vitro* simulated digestion of LY whey proteins have been performed using simulated enzymatic digestion using pepsin and trypsin enzymes and digestion was confirmed on Tricine-SDS-PAGE. These digested peptide samples will be analyzed for their anti-cancerous activity.



Pie chart showing major protein sources of the identified peptides from Ladakhi Yak colostrum

A computer vision based App named as Mahishi Mitr (beta version) developed to identify estrus based on salivary fern patterns.

Over a decade of research work, it has been established that dried saliva smear showing typical fern-leave like patterns is associated with either with proestrus or early estrus of buffaloes, such as 8-10 hours before the exhibition of overtestrous signs.In order to visualize the typical fern-like patterns, either a traditional simple microscope or the modern paper based microscope called Foldscope are required. Particularly, the Foldscope isportable, afforbable, and can be attached to a smart phone for visualizing the fern patterns. However, to distingush the typical and a typical fern patterns and to determine the estrus stage of the buffaloes, Animal Biocehmistry Division in collaboration with School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, developed a computer vision based appcalled Mahishi Mitr (Female buffalo friend) beta version. The app can guide farmers for easy heat detection in buffaloes at their doorsteps.

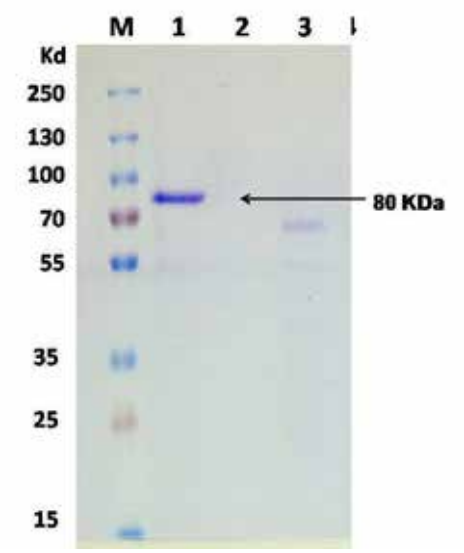


An SNP in the last exon of LAMA2 gene found associated with postpartum anestrus in Murrah buffaloes and functionally validated

Study focused on the identification of possible genetic markers by targeting 9 candidate genes selected from the transcriptome networks of the adipose tissue at early postpartum. Among the identified 24 SNPs, 6 functional SNPs from the *AKR1C3*, *PLG*, *MYF5*, *SEC14L2*, *TPM1*, and *LAMA2*genes were selected for association analysis. The analysis found a SNP in the *Lama2* (g.36417726C>A) significantly (*P < 0.05*) associated with postpartum anestrus in a population of Murrah buffaloes (n = 412). Particularly, the buffaloes with CC genotypes had greater postpartum anestrus interval days (12.71 ± 3.21 days) than that of AA and CA genotypes. Functional analysis also showed that adipose tissues from CC genotypes had significantly higher LAMA2 gene expression (> 8 fold) andfat percentage (48.78 ± 1.87%) than AA genotypes (33.59 ± 4.5%). Likewise, further gene expression analysis revealed that *PPARG* mediated pathway plays a major role for both the adipogenesis and lipolysis in CC genotypes.

Purification of 80 kDa sperm motility-inhibitory protein of goat cauda epididymal plasma

Presence of several sperm quiescent factors has been reported in cauda epididymal plasma (CEP) of goat, sheep and pig and few of these were purified and characterized. The reversible inhibition of sperm motility caused by these proteins has potential application in minimizing sperm damage during semen preservation which could lower the production of toxic metabolites and oxidative damage to sperm membrane. The 80 kDa sperm-quiescent protein of goat CEP was purified by a combination of Hydroxyapatite (HT) gel adsorption and DEAE-agarose anion exchange chromatography techniques. The protein demonstrated strong inhibition of sperm motility at micro molar concentration and reduced protein tyrosine phosphorylation during in-vitro capacitation of sperm.



SDS-PAGE analysis of DEAE-agarose anion exchange chromatography fractions of goat CEP. 1M HT gel adsorption chromatography fraction of goat CEP was further subjected to DEAE-agarose anion exchange chromatography. M: protein marker; 1,2 ,3 : 50, 100, 200 mM potassium phosphate buffer (pH 7.5) elutes

CRISPR-CAS9 based editing of cox-2 gene on expression profiling of cox-2 mRNAs in luteal cells of buffalo

Based on the concept of occurrence of early embryonic mortality due to luteal insufficiency, the present study was designed to examine the mRNA expression of edited COX-2 gene in the luteal cells of buffalo. Two single guide RNAs against exon 1 were designed for COX-2 gene located at chromosome 5.The sgRNAs were successfully cloned into CRISPR/Cas9 plasmid vector separately and validated by PCR amplification using U6 primers. Analysis of sequence confirmed the cloning of sgRNAs into the vector. The resultant CRISPR/Cas9-sgRNA constructs were subsequently used for Lipofectamine mediated transfection into in-vitro cultured buffalo luteal cells. The cells transfected without CRISPR/Cas9-sgRNA construct was used as control. Puromycin was used for screening of the transfected cells. CRISPR/Cas9 tool was used for editing COX-2 gene using each sgRNA separately. Total RNA was isolated from the puromycin selected cells to investigate the effect of CRISPR/Cas9 mediated editing of COX-2 gene on its mRNA expression. The qRT-PCR results revealed the significant

decline in COX-2 mRNA expression in the edited samples in comparison to the control. Genomic DNA extracted from the edited cell samples transfected with CRISPR/Cas9-sgRNA 1 construct along with control samples were subjected to PCR amplification using COX-2 gene specific primers. PCR amplified product was cloned using Topo TA cloning vector and the E. coli (DH5α strain) transformants were screened by ampicillin resistance. A total of 2 colonies were observed and plasmid DNA was isolated from these colonies. PCR amplification of plasmid DNA was performed using M13 primers. Out of the two colonies observed one was found to be positive clone. On the basis of above findings, it is concluded that the targeted editing of COX-2 gene significantly declined the mRNA expression of COX-2 gene in in-vitro cultured buffalo luteal cells.

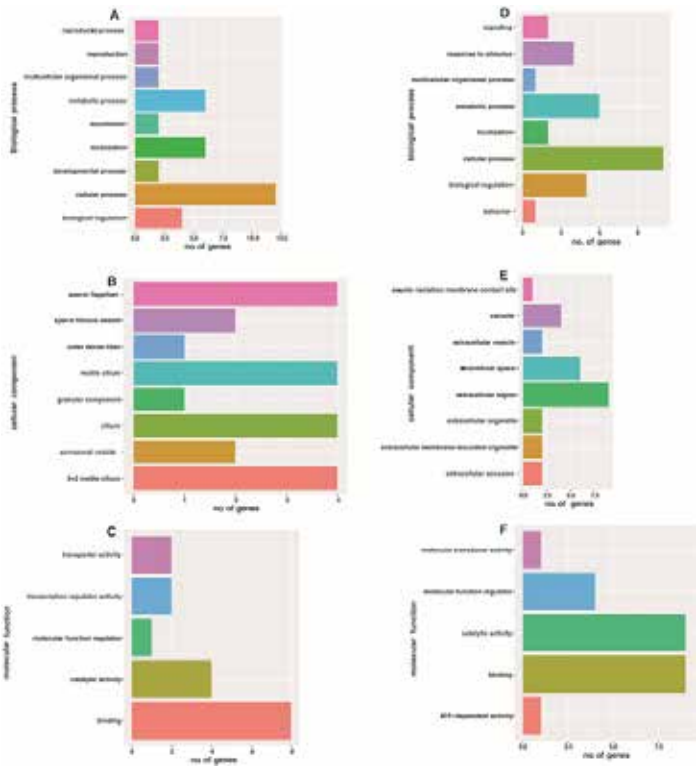
Proteo-Genomic approach to elucidate productive and reproductive performance of MalnadGidda, Deoni and Hallikar breeds of cattle and field performance recording of Malnad Gidda cattle

Integrating with proteogenomic annotation pipeline, the genome annotations of Malnad Gidda cattle was refined and reported a novel gene in conserved genomic region 14234460:250-2,626, which is code-named as SRS-MG-001. Exome sequencing in Hallikar and Holstein Friesian bulls revealed genetic variants in the conserved protein-coding regions of the genome related to semen quality. Genetic variations were observed in genes viz. UCP2, PANK2, GPD2, PTPRG, LARP7, EZH1, DENND1B and TDRD9 with a role in determining the semen quality. Differential proteomics revealed that the expression of haptoglobin protein was highly significant in indigenous Deoni (*Bos indicus*) and Holstein Friesian (*Bos taurus*) crossbred cows during heat stress condition, thus, haptoglobin could act as a potential biomarker associated with thermo-tolerance ability of the animal. Using proteomic profiling of semen of Hallikar bulls with varying Ejaculate Rejection Rate (ERR), the differentially expressed proteins in spermatozoa and seminal plasma were identified. Some of the differentially expressed spermatozoal proteins are involved in SLC-mediated transmembrane transport and glycolysis pathway which are involved in the production of energy to the spermatozoa, supporting motility. Adrenomedullin, which regulates the osmolarity of seminal plasma has a negative correlation with sperm motility, which was downregulated in seminal plasma of bulls with low ERR.

Molecular dynamics indicators associated with reproductive performance of *Bos indicus* cattle in blood plasma samples through data-independent acquisition mass spectrometry

Whole Exome Sequencing (WES) and comparative proteomics profiling in Deoni cows with differing reproductive performance was performed to identify genes and protein related to reproductive performance. The Deoni cows of 6 to 9 years of age were selected based on the basis of days open and inter-calving period. In high reproductive performance (HRP) group cows mean days open and inter-calving period were 113±23.98 days and 398±24.85 days respectively. Likewise, in low reproductive performance (LRP) group cows mean days open and inter-calving period were 292±60.82 days and 576±58.90 days respectively. Using exome sequencing, identified 312 and 301 SNPs in HRP and LRP cow groups respectively. A total of 221 genes from 312 SNPs in HRP cows group and 244 genes from 302 SNPs in LRP cows group were identified in the gene annotation. Gene Ontology revealed binding and catalytic activity in molecular functions while cellular, metabolic and biological processes in biological function were found to be enriched with genes identified in both groups. From pathway analysis 12 different pathways enriched with genes involved in reproductive process were identified. In HRP cattle group ADAMTS19, TRPV4, HDGF, RANGAP1, ROR2, CNOT1, CELSR3, PTPRS, NFAM1, CTRC1, PLA2G4F, SHANK2, and SLIT3 while in LRP cattle group THBS4, SLC37A2, BRWD1, RABEP2, DGKI, ANKH, SCARF1, EPAS1, EIF4G3, and RABEP2 genes were found to be associated with reproduction related traits like calving ease, days open, implantation, calving interval and length of productivity. Using data independent acquisition (DIA) based LC-MS/MS, a total of 430 plasma proteins were identified in all biological replicate samples. In cyclical Deoni cows, a total of 20 proteins were differentially expressed ($P<0.05$) between high and low reproductive performance group; 15 upregulated while 5 downregulated. In pregnant Deoni cows, total of 35 proteins were differentially expressed ($P<0.05$) between high and low reproductive performance group; 23 upregulated while 12 downregulated. All these differentially expressed proteins were involved in oxidative stress control, autophagy, cell differentiation, cell migration, immune response, which are required for successful establishment of pregnancy. It is concluded that there is significant difference between Deoni cattle with differing reproductive performance at genome and proteome level.

Quantitative proteomics profiling of spermatozoa and seminal plasma reveals proteins associated with semen quality in Bos indicus Hallikar bulls



Through the Tandem mass spectrometry approach, quantitative proteomics profiling of the spermatozoa and seminal plasma proteome of *Bos indicus* Hallikar bulls with low (n=3) and high (n=3) Ejaculate Rejection Rate (ERR), A total of 2409 proteins were identified, in which 828 proteins were common in both the semen components, whereas 375 and 378 proteins were unique to spermatozoa and seminal plasma respectively. Tandem mass tags (TMT) based protein quantification resulted in 75 spermatozoal, and 42 seminal plasma proteins being differentially regulated between high and low ERR bulls. Proteins such as SPADH2, TIMP-2, and PLA2G7 which are negative regulators of motility were upregulated in the seminal plasma of high ERR bulls. Proteins such as OAZ3, GPx4, and GSTM3 whose upregulation leads to reduced motility were upregulated in the spermatozoa of high ERR bulls. Caltrin and ADM proteins that enhance sperm motility were downregulated in the seminal plasma of high ERR bulls. The regulation of ACE, a negative regulator of sperm motility was upregulated in both the spermatozoa and seminal plasma of high ERR bulls. The study showed significant differences in spermatozoal and seminal plasma protein profiles between bulls with varying ejaculate rejection rates. Therefore, varying concentrations of spermatozoal and seminal plasma proteins in high and low ERR bulls were likely related to differences in semen quality. This study can further be used to develop molecular tools associated with semen quality and to select bulls for the improvement and conservation of indigenous cattle breeds.

Enhancement of developmental competence of immature oocytes supplementing with Leukemia Inhibitory Factor as a supplement in culture media

The study was conducted to improve the developmental competence of cattle embryos by supplementing culture media with Leukemia Inhibitory Factor (LIF). Cumulus-oocyte complexes were collected from slaughterhouse ovaries and cultured in maturation media after washing for 24 h in a 5% CO_2 incubator at 38.5°C with maximum humidity. Matured oocytes were co-incubated with *in vitro* capacitated sperms for fertilization FBO medium. After co-incubation, presumptive zygotes were cultured in mCR2aa medium. After 40 to 42 h, cleavage was observed and embryos were cultured for 7-9 days. Culture media used to replace with fresh media after every 24 h. Leukemia inhibitory factor was supplemented (*i.e.*15, 30, 45 ng/ml) in culture media. Total 542 cumulus oocyte complexes were used. Four replicates were analysed by one-way ANOVA. There was significant effect of LIF supplementation on maturation rate, cleavage rate (in control group 71.9±0.6 and 72.2±0.8, 78.1±0.8 and 76.7±0.0 in 15ng/ml, 30 ng/ml and 45 ng/ml respectively). However, addition of LIF during culture increased ($P<0.05$) blastocyst development (in control group 7.0±1.3 and 7.1±1.2, 12.9±0.4, 10.2±1.5 in 15ng/ml, 30 ng/ml and 45 ng/ml respectively) for *in vitro* cattle embryo production.

GENETIC IMPROVEMENT OF DAIRY ANIMALS

Genetic relationship among production, functional and linear type traits for selection of elite sires in indigenous and Crossbred Dairy Cattle

Balanced selection of sires/animal will be very important for further propagation of these elite sires in the field for overall well-being of animals with better feet and udder traits and more economic return due to less involuntary culling. Least square means and genetic parameters of 17 linear type traits of Sahiwal and KF cattle were estimated. Stature, one of important dairy type trait has a high positive genetic correlation with 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. Multi-trait sire evaluation was carried out and Sahiwal and KF sires were ranked. Among linear type traits, stature, chest girth, body length and body depth were found to be more favourable towards milk production traits in both Sahiwal and KF cattle. The selection index constructed using production and three linear dairy type traits was having 81% accuracy, which was appropriate. Multi-trait sire evaluation methodology using production (305DMY) and major linear type traits (Stature, chest girth, and body length) was developed, which may be introduced for balanced and valuable selection of dairy animals for long-term benefits.

Indigenous breed programme (Sahiwal)

The female herd strength was 406 including 173 breedable females. A total of 38 growing males and breeding bulls were available at the Germplasm Unit. A total of 116 normal calving out of which 57 males and 59 females were born. For bull selection 10 out of 48 males were selected. EPD % of the selected males was 5.97% and average of Dam's best Lactation Yield was 3967 kg against herd average of 2363 kg. A total of 37 out of 173 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 Best 305-LY, average LY and average EPA were 4424 kg., 2651 kg and 2363 kg against herd average of 1925 kg and average EPA of 1892 kg.

The average age at first calving was (1355.55 ± 34.64days), FLMY (1938.04 ± 52.26 kg), Total Lactation milk yield (1886.84 ± 112.93 kg) peak yield (9.43 ± 0.43 kg) lactation length (233.07±24.11days) dry period (125.21 ± 13.51days) and calving interval (433.29 ± 23.53 days) and service period (112.76 ± 1.79 days) was observed with wet average (7.9 kg) and ry average (4.3 kg).

A total of 259012 semen doses has been produced since inception of project and out of these 114169 doses were utilized for insemination by the germplasm unit and data recording unit and a balance of 144843 frozen semen doses is available for distribution to NGO, Progressive farmers and for germplasm conservation. Semen doses were supplied to DRU units at GADVASU, Ludhiana, GBPUA&T, Pantnagar and LUVAS, Hissar for AI at those centres.

Field progeny testing program on Murrah buffalo

A total of 4844AI were performed in Murrah Buffaloes under field conditions during 2022-23 and as a result an overall conception rate of 48.14% was obtained. The highest conception rate was achieved in the month of August 2022 (49.86%) and the lowest was found for the month of December 2022 (45.28%). Across the 20 villages and five centres, the highest conception rate was observed in Kherimann Singh (52.15%) centre and lowest in Kamalpur (41.66%). A total of 1866 (1063 Male and 803 Female) Murrah buffalo calves were born in the farmers' herds and performance data on milk recording of 86 daughters have been recorded for evaluation of bulls under field conditions. The average lactation yield in the field was recorded as 2282.20 ± 36.99 kg daily milk yield in the recorded daughter were 7.76 kg/day. The total herd strength of registered females and the breedable females at different centers was 6302 and 5004 respectively. As many as 16 breeding bulls 20th Set were tested for progeny testing program.

Network project on buffalo improvement (NDRI Unit)

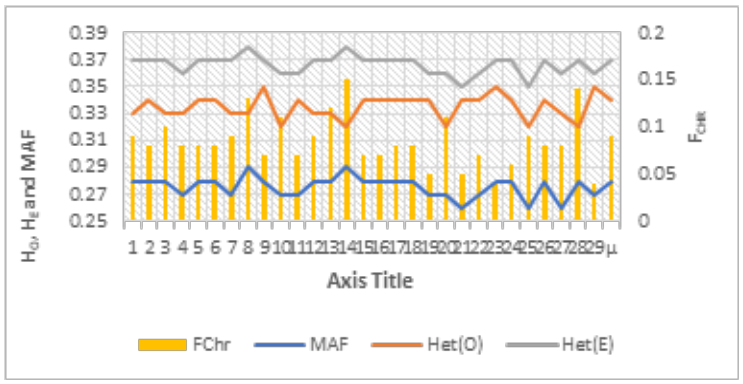
The herd strength of breedable buffaloes was 217. Average age at first calving of buffaloes was 42.4 months. The average service period of buffaloes has been estimated as 118.50 days. The overall female conception rate in the herd was 48.46%. The overall mortality (0-3 months) during the year was 3.77%. The wet and herd average was 7.80 and 4.70 kg, respectively. The average Milk Fat, SNF, Total Solid, Protein and Lactose were estimated as 8.46±0.11, 10.06±0.04, 18.53, 3.2 and 5.61%, respectively. Total 04 elite Murrah male calves were reserved during the period on the basis of Expected Predicted Difference and dam's best 305day or less lactation milk yield, breed characteristics and physical conformity for selection of young male calves for future breeding. Finally, four young bull with their dam's best 305 days lactation milk yield of ranged from 3188 kg in first lactation to 3991 158 kg were reserved. On the basis of 15th set evaluation out of three top ranking bulls, the Bull no. 6007 from NDRI ranked second and was declared as proven bull and selected for nominated mating. The NDRI Centre has produced a total 51432 doses of frozen semen, out of which 21807 doses from the bulls of 20th set were procured / produced during the period. The germplasm of genetically superior progeny tested proven bulls are being used on elite buffaloes in organized herds for production of high-pedigreed bulls for further multiplication and production of superior germplasm and establishment of elite herds. Semen of proven and high-pedigreed bulls of NDRI center is being used by various dairy development agencies and dairy farmers for bringing genetic improvement of Murrah buffaloes. The breeding programme in the herd was followed for nominated mating using semen of four proven Murrah Bulls. About 07 Murrah buffaloes were identified as elite animals. The average best lactation milk yield of elite Murrah buffaloes was 2936 kg which was 24.72% higher than the herd average.

De-novo assembly, annotation and comparative genomics of Bhadawari buffalo

High thoroughput sequencing data generated from of Bhadawari buffalo blood collected from the breeding tract was obtained for assembling the genome de-novo. The buffalo assembly was done using the Illumina short read sequences. Results showed comparable assembly statistics to that of the current reference assembly of Bhadawari. The draft assembly has N50 value of 20 Mb and a coverage of 86% in comparison to the reference assembly. The genome assembly of Bhadawari will contribute to improve the accuracy of buffalo pangenome at global level.

Genomic architecture and breed composition of Karan Fries cattle using High Density SNP Array

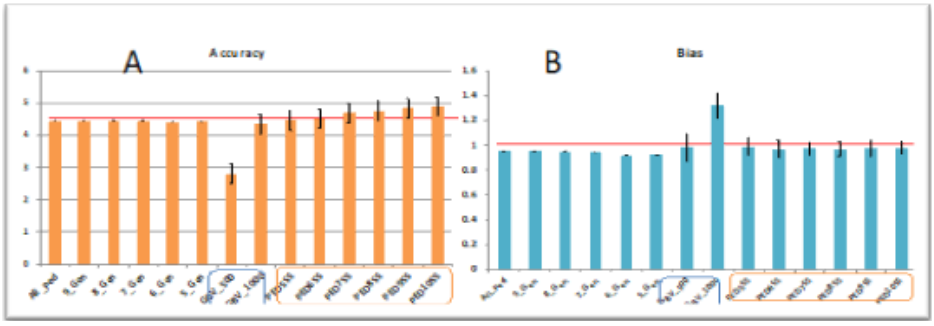
The project has been undertaken to assess the genomic diversity and population structure in Karan Fries cattle as well as to find out stabilization of exotic inheritance in this cattle population using genomic data. Analysis was carried out using SNP genotype data (n=44). The observed and expected heterozygosity of the KF herd was 0.34±0.05 and 0.36±0.05, respectively suggesting sufficient genetic variability in the population. It was found that the overall the KF cattle population was stabilized at exotic inheritance of 61.7%, while TP inheritance was 38.3%.



Strategic modelling of reference population for effective implementation of advanced selection strategies

Development of the genomic analytical models for implementation of genomic selection. Two models typical to Indian dairy breeding structure have been standardised for genomic evaluation so that unbiased and accurate estimates of genomic breeding values can be obtained.

1. Multi-breed joint prediction model: This model is typically useful for Indian dairy scenario where pedigree information is mostly not available in numerically small breeds. Here using only genomic data of low to medium density, random or two-tailed selective genotyping in multiple breeds followed by GBLUP in joint-breed prediction model yields unbiased and accurate estimates of GEBV.



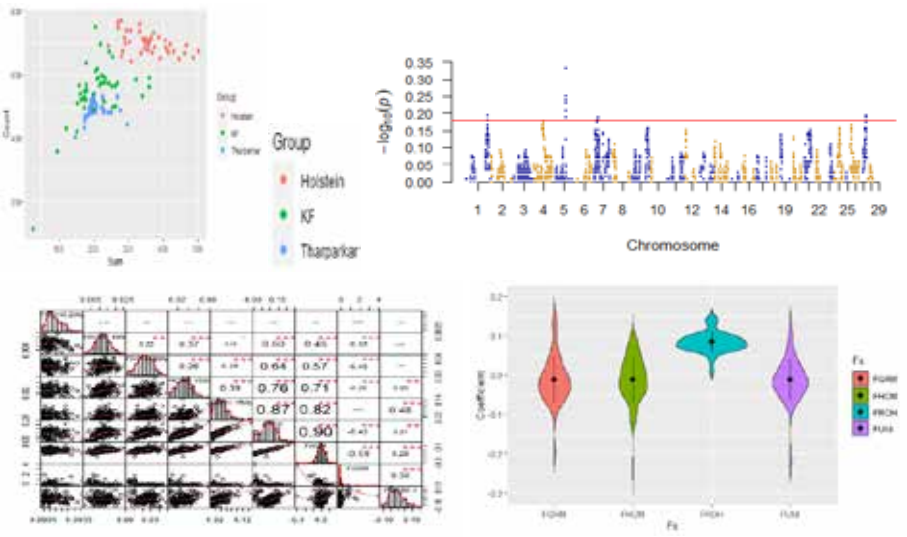
2. Single-Step model for shallow pedigree data: In the case of shallow pedigree or holes with pedigree data in numerically small breeds, pedigree of at least 1 generation can be used in ssGBLUP along with selective (two-tailed) genotyping, which can result in most accurate and unbiased estimates of GEBV.

Deciphering the modifications in miRNA binding region of DNA repair genes in concurrence with thermal stress in Tharparkar and Karan Fries cattle

Whole transcriptome analysis was used for variant calling from three samples of Karan Fries and Tharparkar animals exposed to heat stress. A total of 6,28,879 SNPs, which passed QC, were selected for further analysis and 28107 and 134704 were identified as unique SNPs for Karan Fries and Tharparkar, respectively. A total of 9853 SNPs were found to be fixed in Tharparkar cattle. Functional annotation of genes with unique /fixed SNPs in Tharparkar cattle indicated pathways related to energy metabolism such as regulation of triglyceride catabolic process, inositol phosphate-mediated signaling, regulation of cellular response to insulin stimulus and regulation of triglyceride metabolic process. A total of 5508 miRSNPs were identified, of which 1103 were unique to Tharparkar cattle. Further, a total of 20 genes including PIGM, SLAMF9, IGSF9, TAGLN2,CFAP45, VSIG8, ACKR1, CADM3,NFYA, TREM2, TREML1,TREML2were found to be associated with QTLs of thermotolerance. The SNPs in the bta-mir-1584 and bta-miR-2335 were also associated with QTLs of heat tolerance.

Genome–wide scan for autozygosity, selection signature and genomic inbreeding in Karan Fries and Sahiwal cows

The pedigree data of Sahiwal and Karan Fries crossbred was considered for estimating inbreeding coefficient and found most of the population is non-inbred both in Sahiwal (37.66%) as well as Karan Fries cattle (63.03%). The genomic inbreeding measures based on ROH indicated that the number and size of ROH was maximum for ROH ranging from 2-16Mb in Sahiwal cattle whereas it is 0.5 to 4 Mb in KF. The correlation among the various inbreeding measures showed that the correlation of ROH based approach is better than pedigree based both in Sahiwal as well as Karan Fries cattle. The ROH pattern in KF indicated a greater number of short segments due to ancient inbreeding. The ROH islands were explored to identify the selection signature in both the category. The ROH based selection signature indicated that there are QTL enriched



are associated with host immunity, milk composition traits in Sahiwal, whereas in KF hub genes are identified related to immunity, milk composition traits and fertility.

Genetic evaluation of functional traits and their effect on production and reproductive traits of crossbred cattle

Data on herd life traits of Jersey crossbred cattle, maintained at the ERS, ICAR-NDRi, Kalyani over a period of 39 years (1980-2018) were collected. The least-squares means of herd life (HL), productive herd life (PHL), total milk production (TMP), number of days in lactation (NDL) and number of lactations (NLC) were 2964.83 days, 1879.55 days, 10709.56 Kg, 1164.08 days and 3.42, respectively. The present findings showed highly significant ($P<0.01$) effect of calving period on herd life of animals. Animals calved in later period (period 7) had higher herd life as compared to animals calved at earlier periods. Season of calving had non-significant effect on all considered herd life traits. All herd life traits except NDL were significantly affected by genetic groups of animals. Parity of animals showed significant effect on HL, PHL and TMP of animals. Estimates of heritabilities for HL, PHL, TMP, NDL and NLC were 0.06, 0.07, 0.12, 0.05 and 0.18, respectively. Genetic correlations of herd life traits with productive traits ranged from 0.37 to 0.71 which were much stronger than their phenotypic correlations. Among the herd life traits, number of days in lactation had highest positive genetic correlation (0.71) with FL305DMY and first lactation total milk production had highest positive genetic correlation (0.56) with FLTMY. In this study phenotypic correlation of herd life traits with productive traits ranging from 0.09 to 0.42. Further, low to medium positive relationships of herd life traits with reproductive traits (except NLC-AFC) existed at genetic level. Genetic correlation of herd life traits with reproductive traits ranging from 0.04 to 0.55.

INNOVATIVE APPROACHES IN MANAGEMENT OF DAIRY ANIMALS

Molecular basis of seasonal variation on seminal attributes buffalo bulls

Seasonal effect on bulls' physiological responses, hormonal profile and semen quality was assessed. Sperm kinetics data was generated for frozen semen samples of all 26 Murrah buffalo bulls (two ejaculates/bull) using Computer Assisted Semen Analyzer (CASA). Across the seasons, the semen quality parameters, including sperm motility, acrosomal integrity, viability, and HOST, were lower during hot-dry season, while total sperm abnormality was found to be higher, indicating higher THI effect on semen quality. Cortisol, T3, T4 and TSH was higher during the winter compared to summer months, whereas testosterone concentrations were found to be higher in hot-dry and hot-humid seasons compared to spring and winter seasons. The ROS +ve and apoptosis percentage in semen sample was higher during the hot-dry season, whereas acrosome integrity (live intact) was higher during the spring and winter seasons.

Buffaloes produced from semen provided through Lalukheri Centre

To further expand the AI network through the ICAR-NDRI's Lalukheri centre a project of Rs 8.5 crores is sanctioned under Rashtriya Gokul Mission, Ministry of Fisheries, Animal Husbandry & Dairying in 2022 to provide door step artificial insemination services in dairy animals in 100 villages of district Muzaffarnagar (UP).

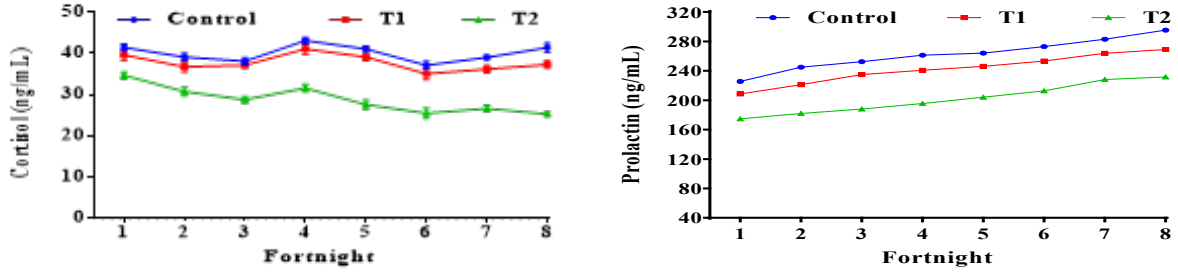
Effect of biostimulation in overcoming seasonal sub-fertility and infertility in buffaloes

Buffaloes have poor reproduction efficiency attributed mainly to poor expression of estrus symptoms especially during summer months and during severe winters. Strategies like hormonal therapy, nutritional management and environmental modification have been tried to improve the reproductive performance with limited success. Biostimulation by bull exposure represents one of the possible management tools to improve reproductive efficiency in this species. Keeping this in view an effort was made to study the effect of biostimulation on reproductive performance of postpartum buffaloes during heat and cold stress and its effect on anestrus and repeat breeding in buffalo heifer and postpartum buffaloes.

Buffalo mothers and calves in fenceline contact

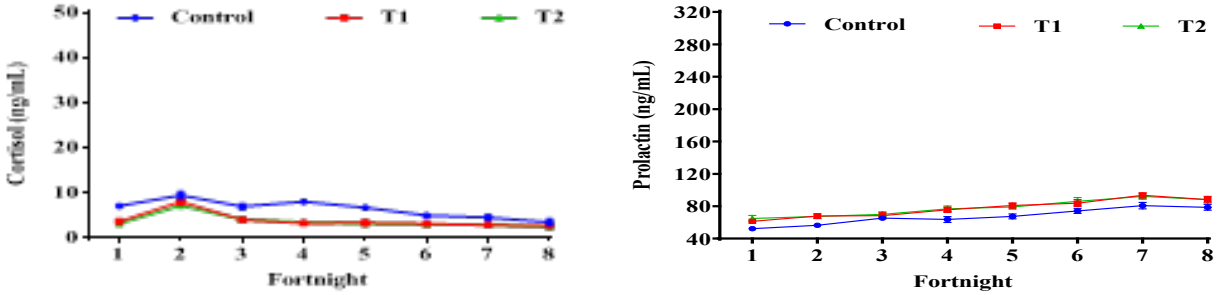
Direct bull exposure for biostimulation

During summer season, a total of 21 freshly calved buffaloes were divided into 3 groups of 7 animals each and were subjected to 3 treatments. In T1, the buffaloes with a fenceline calf contact were exposed to bulls through direct contact twice daily for 6. In T2, the buffaloes in fenceline contact with their calves were exposed to bull through direct contact twice daily for 6 hours as in T1 and were provided with heat stress amelioration measures and in control (T0), the buffaloes were not be exposed to the bull and were allowed restricted calf contact only during morning and evening milking. The onset of estrus in both bull exposed buffalo groups was significantly earlier (T1= 84.4 and T2 =74.8 days post-partum) as compared to control (132.2 days). Daily milk yield was significantly greater in calf contact and bull exposed groups (T1= 10.3±0.30 and T2= 10.9±0.31 kg) in comparison to control (8.20.41kg). Average cortisol levels, rectal temperature, respiration rate and pulse rates were significantly (*P< 0.05*) higher in control buffaloes as compared to both treatment groups whereas dry matter intake, prolactin levels, the time spent on eating, resting and rumination were significantly (*P< 0.05*) higher in both treatments groups than control group of buffaloes.



Blood Cortisol (ng/mL) and prolactin concentrations (ng/mL) in three groups of buffaloes during summer season

During winters, all these treatments were repeated on another set of 21 buffaloes with cold stress amelioration measures in T2. The days from postpartum to first heat were significantly lower in T1 (69.14±6.16) as well as in T2 (66.14±2.32) as compared to T0 (95.33±8.62). The average daily milk yield was significantly higher in both treatment groups of buffaloes (T1=10.28±0.22 kg and T2= 10.35±0.18 kg) in comparison to T0 (7.88±0.46 kg). Average cortisol levels, were significantly (*P< 0.05*) higher in control buffaloes and compared to both treatment groups whereas dry matter intake, the time spent on eating, resting and rumination were significantly (*P< 0.05*) higher in both treatments groups than control group of buffaloes.



Blood Cortisol (ng/mL) and prolactin concentrations (ng/mL) in three groups of buffaloes during winter season

Effect of biostimulation on anestrus buffalo heifers

Twenty-four anestrous heifers (body weights = 330 kg; age = 25.5 m) were selected and allotted to 2 treatments. In T1, heifers were exposed to bull directly in heifer pen for 6 hours daily whereas the T2 heifers were not exposed to the bull. It was observed that 10 heifers out of 12 in the bull exposed group came into estrus while only 2 from the control group were observed in estrus. The average age at first estrus in control and bull exposed heifer was 28.04±0.01 and 27.58±0.33 months, respectively. The average frequencies of estrus behaviuor including sniffing and licking on the day of estrus were higher in T1 heifers.

It was concluded that bull exposure along with summer and winter protection measures elicited normal reproductive performance of buffaloes besides improving their productive performance. The biostimulation of

anestrus buffalo heifers through direct bull exposure was effective in bringing the most of the heifers into estrus with normal expression of estrus behaviour and improved reproductive performance. The findings from the study shall help in designing better management practices for improving the performance of buffaloes during heat and cold stress periods and overcoming the problem of anestrus in buffalo heifers.

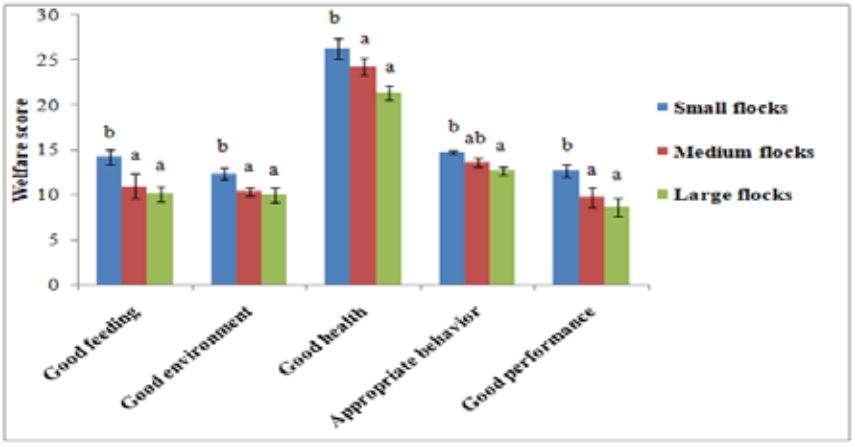
Development of welfare assessment protocol and assessment of welfare of Gaddi goats

Gaddi (White Himalayan) goats, reared by nomadic pastoralists, migrate from foothills of Himalayas in winters to high altitude Alpine ranges during summers on four migratory routes covering a distance of 400-500 km over an elevation gradient of 13000 ft. These goats face welfare challenges of uncertain pasture availability, harsh climate, inadequate housing and healthcare; predation and infrequent supervision. The aim of study was to develop a welfare assessment protocol for migratory goats and to assess the welfare of different flock sizes. The assessment protocol was adapted from AWIN framework for goats (AWIN, 2015). It was categorized into five welfare domains (feeding, environment/facility around camping, health, behaviour and performance) with 32 welfare indicators (5, 6, 9, 5 and 7 from each domain respectively) and domains were assigned a welfare score (WS) of 25,15,30,15 and 15 respectively aggregating into 100. The adapted protocol was tested for its validity (by expert judgment) and reliability by Cronbach's alpha. It was found valid (91.3 per cent of experts agreement) and reliable with the value of Cronbach's α as 0.90.

Typical adult female Gaddi goat

Typical adult female Gaddi goat Typical adult male Gaddi goat

Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small (100 goats), medium (100-200 goats) and large (>200 goats) with eight flocks each. Data was analyzed using one-way analysis of variance (ANOVA) in SSPS.



Average welfare scores in different domains

Small flocks scored higher (P<0.05) than medium and large flocks in feeding (14.25±0.8 vs. 11.00±1.3 and 10.12±0.8), health (26.25±1.1 vs. 24.25±.9 and 21.37±0.8) and environmental domains (12.3±0.2 vs. 8.37±0.5 and 9.00±0.8). Welfare scores of behavioural domain in small flocks (14.75±0.2) were higher (P<0.05) than large flocks (12.75±0.4) but were not different from medium flocks (13.62±0.5) whereas scores of performance were

higher (P<0.05) in small (12.75±0.7) and medium (9.75±1.0) than large flocks (8.62±1.0). Overall welfare scores in smallflocks (80.62±2.4) were higher (P<0.05) than in large (62.87±3.3) and medium (69.00±3.7) flocks. Welfare was found acceptable (welfare score >60) at all small flocks, 75% of medium flocks, 50% of large flocks and 75% of all studied flocks. Body condition score, environmental protection to kids, animal losses, hair coat condition, healthcare practices, familiar human approach test and abortions were most compromised welfare indicators at large and medium flocks. In conclusion, welfare of most of Gaddi goat flocks was acceptable (75 per cent) and small flocks performed better than medium and large flocks.

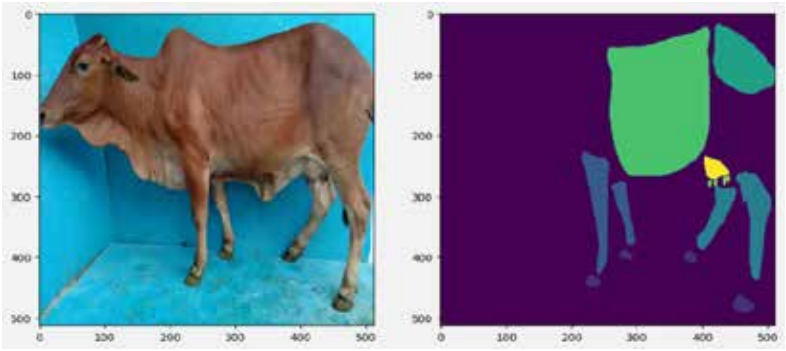
Need based interventions for improving the productivity of indigenous breeds of cattle at Goras, Sheopur (Madhya Pradesh)

Indigenous cattle genetic improvement has been a great challenge due to several inherent problems of the dairy cattle husbandry in India. The Goras village and nearby areas in Sheopur district of Madhya Pradesh, harbours thousands of Gir and Gir type cattle, which are reared by the pastoralists. The proposed project was undertaken to survey and analyze the dairy cattle production system, their breeding, feeding and management practices at surrounding areas of Goras and to undertake need-based interventions in addressing prioritized problems of farmers in the field of dairying. Nearby villages including Goras accounts for more than 80,000 cattle population. Two interactive meetings were conducted with dairy farmers in different villages in study area for taking their opinion on project interventions. Initially, 14 villages of surrounding area of Goras were selected for implementation of interventions in farmers herd. The interview schedule developed for taking the socio-economic profile of the farmers with their different categories of livestock. The four skilled persons are recruited for data collection and implementation of interventions. One animal fertility camp also was organized (in Sep. 2022) at Goras for creating the awareness about scientific dairy cattle management practices among the different stakeholders.

Animal fertility camp and Kisan Gosthi organised at Gorus on 05-09-2022

Automated evaluation by using image processing of linear conformation traits of indigenous dairy cattle herd

Linear traits are associated with dairy performance, longevity and strongly contributes to lifetime milk production of cows. In this study, manual measurement and appraisal of standard linear traits (18+5) on a scale of 1-9 was done for elite multiparous Sahiwal cows (n=150). Average values for most of the linear traits fall in intermediate class that comes under desirable category for a good lactating cattle breed. Some traits *viz.* stature, body depth, chest width, rump width, central ligament, rear udder height and rear udder width, showed scope for further improvement. The main objective of the study was to develop image-processing methodology for automated evaluation of linear traits. The cow images were captured using 3D depth camera from the side, front, and back using a Python GUI with blue background. The captured images were saved in PNG format and labelling was done to locate particular cow body part using an open-source software called *Label-studio*. The depth images provided information about the 3D structure of the cow and used to estimate the real-world measurements of different traits. Three deep learning models such as *VGG19*, *ResNet34*, and *Inceptionv3* were used as backbones for cow image segmentation, and transfer learning was used to train the models. During



A sample of original and annotated images

training, data augmentation technique was used to increase dataset size and robustness of the models. The developed CNN model was able to accurately identify the pixels that correspond to a trait, which is important for the measurement of different traits. The segmented images obtained were then used to extract the relevant linear traits of cows.

The image processing technique can be used for automated for appraisal of linear traits of cattle and it is animal as well as user friendly and having reasonable accuracy.The accuracy of developed computer vision model for stature: 96%; Chest width: 87.46%, body depth: 91.38%; rump angle: 82.19%; Rump width: 84.02%; Rear leg view: 89.11%; Rear leg set: 88.60%; Foot angle: 81.33%; Teat length: 86.03%; Udder depth: 84.19%; Rear udder height: 83.89%; Rear teat placement: 71.48%; Rear udder width: 79.87%; Teat thickness: 83.72% and muscularity: 79.38%.

Effect of *Moringa oleifera* leaf meal and flaxseed on productivity of goat kids

The effect of *Moringa oleifera* leaf meal (MOLM) and flaxseed as replacements for concentrate mixture on growth performance, intake and nutrient digestibility and blood biochemical and immunological parameters of goat kids. The concentrate was taken as basal feed while Moringa oleifera Leaf Meal and Flaxseed were administrated as replacement to cover the concentrate portion of the total mixed ration consisting of fodder and concentrate mixture in the ratio of 60:40 as per ICAR, 2013 standard. Total 32 Alpine x Beetal (AxB) female goat kids of similar age and body weight for a period of 120 days were divided into four groups (C, T1-MOLM replaced @ 20%, T2-Flaxseed @20% and T3-MOLM @10% and Flaxseed @ 10%) with 08 kids in each group. The body weight (kg), ADG and FCR values was found higher ($P<0.05$) in T_1, T_2, T_3 groups than control group indicating a positive effect of MOLM, flaxseed and their combination on growth of kids. Further metabolic trial revealed DMI, crude protein and digestibility of nutrients (DM, OM, CP, EE, NDF and ADF) was significantly higher in T_1, T_2 and T_3 groups than control group. The values for plasma IgG1 and total antioxidant level were significantly higher in T_1 group. The cortisol concentration was non-significant differedamong all the groups.The total antioxidant activity was higher ($P<0.05$) in the treatment groups than control.

Benefit-cost ratio was calculated and the feed cost per kg of live body weight gain was found lowest in T_1 group followed by control, T_3 and T_2. The inclusion of flaxseed increased the cost of feeds for T_2 and T_3, while MOLM reduced the feeding cost as compared to control. The net return (Rs) per kg live body weight gain was 26.57, 39.73, 28.97 and 28.87 for control, T_1, T_2 and T_3, respectively. The income and net return per kg live body weight gain was highest in group T_1 followed by T_2, T_3 and control. The benefit: cost ratio for group T_1, T_2, T_3 and control were 4.88, 3.14, 3.41 and 3.68, respectively. The lowest feed cost/kg gain and highest return was found in group T_1 followed by control, T_3 and T_2. Thus, results indicate lowest feed cost per kg of live body weight gain and highest profit per kg of live body weight gain of goat kids when 20% of concentrate feed was replaced by Moringa oleifera leaf meal. Therefore, T_1 proved to be more economical than control.

CRP on biofortification: suitability of incorporating biofortified cereal straw in animal studies

The influence of feeding biofortified wheat (WB 2) straw-based ration on feed intake, nutrient digestibility, milk production, its composition and blood plasma mineral profile of lactating Murrah buffaloes was assessed. Twelve Murrah buffaloes were divided into two groups i.e. Control (T0) and Treatment (T1) based on body weight, parity and previous milk record. Feeding was done as per ICAR (2013) standard for a period of 90 days. Animals of control group were fed conventional wheat straw, oats fodder and concentrate mixture in the ratio 50:15:35 (on DM basis), respectively, whereas, animals of treatment group were fed biofortified wheat straw, oats fodder and concentrate mixture in the same ratio. Nutrient analysis showed minor differences between biofortified and conventional wheat straw. Even though the iron and zinc content were reportedly higher in grain of biofortified variety than the conventional varieties, its straw showed no significant differences in zinc and iron concentrations.

There was no significant difference ($P>0.05$) among both the groups when means were compared for daily dry matter intake (T0: 15.70±0.17 Kg/day/animal versus T1:15.75±0.12 Kg/day/animal). Digestibility of DM, CP, EE, NDF, ADF, OM did not differ ($P>0.05$) between groups. There was no significant difference ($P>0.05$) in milk yield between the two groups (T0: 7.65±0.1 Kg/day/animal vs T1: 7.75±0.08Kg/day/animal). Similarly, there was no significant difference ($P>0.05$) found in SCC and milk composition (Fat, SNF, Lactose, Protein) when analysed at

weekly interval. Haematological analysis (Hb, PCV, TEC, TLC an d DLC) carried out at monthly interval revealed no significant difference (P>0.05) among two groups. Similarly, there was no difference in SOD, Catalase and IgG1 concentration in both the groups. It can be concluded that even though the wheat variety WB 2 was biofortified, the zinc and iron concentrations in the straw were similar to conventional wheat straw. Replacement of conventional straw based ration with biofortified wheat straw (WB 2) did not have any significant influences on milk yield, milk composition and, blood profile of lactating Murrah buffaloes.

Livestock-crop based technological interventions for empowerment of scheduled caste farmers in selected districts of Himachal Pradesh, Uttarakhand and Haryana

Focused group discussions (FGD) were conducted 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 their problems. Two studies on "Effect of multi-nutrient block supplementation on productive and reproductive performance of dairy animals" and "Effect of rubber mat bedding on production and welfare of dairy animals" were conducted. Results showed significant ($p<0.05$) increase in milk yield (Kg/head/litre), milk fat% and blood urea (mg/dl) and milk SNF% due to MNB supplementation in crossbred cattle, whereas it was non-significant in buffaloes. Significant ($p<0.05$) decreased in service period (days), days of first post-partum oestrus and number of services per conception in crossbred cattle, whereas number of service per conception decreased in all three group of crossbred cattle and buffaloes. Similarly use of rubber mat as bedding, significant ($p<0.05$) increased milk yield (Kg/head/litre), BCS, cow cleanliness score in crossbred cattle and buffaloes. Supplementation of mineral mixture after deworming increased milk yield from 17-21% in dairy animals with improvement in reproductive parameters. Improved varieties of wheat increased the yield from 19.71 to 29.78% over control (Traditional cultivars) in wheat and 15.89 to 24.89%) in paddy over traditional variety used by the farmers.

Strengthening dairy based integrated farming system for optimal resource utilization

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). 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 693.8 q/ha with dry matter yield of 149.2 q/ha was recorded from the system. 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 5870 liters from cattle, 6300 liters from buffaloes and 1235 liters from goats is recorded with C: B ratio of 1.53, 1.77 and 1.82, respectively. The net return of Rs. 3,95,605/- was generated during the period under report from the dairy based IFS. The contribution of dairy enterprise was 57.8 %, whereas food/fodder crops and subsidiary enterprises contributed 35.2 and 7.0 %, respectively to the net income. Energy budgeting was more efficient for farmer's system with energy use efficiency of 1.97 while for on-station system it was 1.37. Net energy gain of 201168.52 MJ at on-station and it was 259762.10 MJ for farmer's field. Direct and indirect energy input in on-station system and farmer's field were 29214.91 MJ, 248208.30 MJ and 35872.02 MJ, 232955.20 MJ, respectively. On-station IFS system utilized more renewable energy than farmer's field (88.62% vs 83.72%) while non-renewable energy consumption was more for farmer's field (16.28%) than the on-station system (11.38%). Based on above results it can be concluded that dairy based on-station IFS system was efficient in productivity, profitability and employment generation, whereas energy budgeting was better at farmer's field than on-station IFS system. However, on-station IFS model utilized more renewable energy.

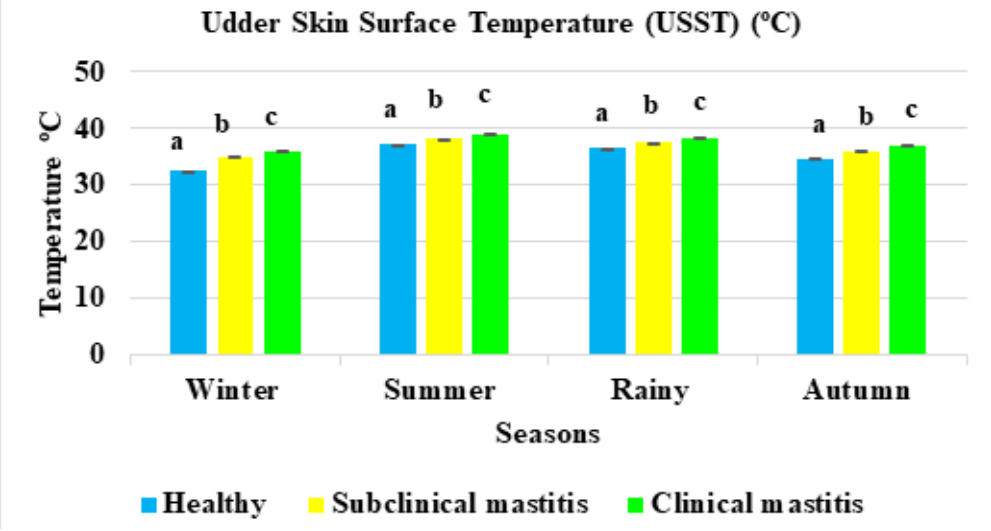
Effect of supplementation of *Moringa oleifera* leaf meal and herbal galactogogues on production, reproduction and immunity of Sahiwal cows

The twenty four lactating Sahiwal cows were selected for the study period of 150 days post-partum. Experimental cows were randomly divided in four treatments consisting of six cows each. Tc considered as control (without any supplementation), TM supplemented with Moringa oleifera leaf meal (MOLM) @12% of concentrate, THG

supplemented with @60g/day/cow herbal galactogogues mixture containing shatavari, fenugreek and jivanti in the ratio of 1:1:1 and TMIX 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≤0.05) improvements were recorded on nutrients utilization in TM, THG, TMIX than Tc. Whereas, DM intake, body weight and metabolic body weight of experimental animals were not affected following supplementation. Significant (P≤0.05) improvements were also noted on daily milk yield, total solids, fat per cent, 4% FCM and ECM yield in TM, THG, TMIX than Tc. Furthermore, milk SCC reduced significantly (P≤0.05) in TM than Tc. As well as, SFA's in milk were significantly (P≤0.05) reduced while UFA's were significantly (P≤0.05) improved in TMIX and TM than TC. Blood plasma profile including total plasma immunoglobulins, albumin, glucose were improved significantly (P≤0.05) in TM, THG, TMIX than Tc. Besides, reproductive parameters were significantly (P≤0.05) better in TM, THG, TMIX than Tc. In addition reproductive disease incidence reduced better in TM, THG, TMIX than Tc. At last, higher net return (`) was noted in TM (301.18), TMIX (268.70), THG (231.04) than Tc (213.06). The benefit: cost ratio was also higher in TM (3.31), and TMIX (2.87) than Tc (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 TM, THG, TMIX than Tc. Dietary inclusion of M. oleifera and herbal galactogogue alone and combination improved production and reproduction performance 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.

Seasonal assessment of mastitis using thermogram analysis in Sahiwal cows

The current study focuses on thermal imaging of the udder and teat quarters of Sahiwal cows in various seasons to detect subclinical (SCM) and clinical mastitis (CM) cases using the Darvi DTL007 camera. Throughout the year, IRT was consistently used to screen out 35–40 lactating Sahiwal cows. CMT was used to confirm the IMI once more. The thermogram study showed a significant difference ($p<0.01$) between healthy, SCM, and CM Sahiwal cows in the mean values of the udder and teat surface temperature over various seasons. In healthy, SCM-affected, and CM-affected quarters, the mean values of the udder skin surface temperature (USST) ranged from 29.07 to 36.91°C, 31.51 to 37.88°C and 32.42 to 38.79°C respectively. The mean values of teat skin surface temperature (TSST) were 28.28 to 36.77°C, 30.68 to 37.88°C and 31.70 to 38.73°C, respectively. A significant increase ($p<0.01$) in mean values of USST during winter, summer, rainy, and autumn were 2.44, 3.35; 0.97, 1.88; 1.06, 1.83; 1.29, 2.39°C and TSST were 2.4, 3.42; 1.11, 1.96; 1.21, 2.19, 1.3, 2.4°C of SCM, CM-affected quarters to healthy quarters, respectively. Thermograms of SCM, CM, and healthy samples revealed a significant positive correlation with CMT scores. IRT is now an effective, helpful technique for the early detection of subclinical mastitis, regardless of the seasons evaluated in the current work.

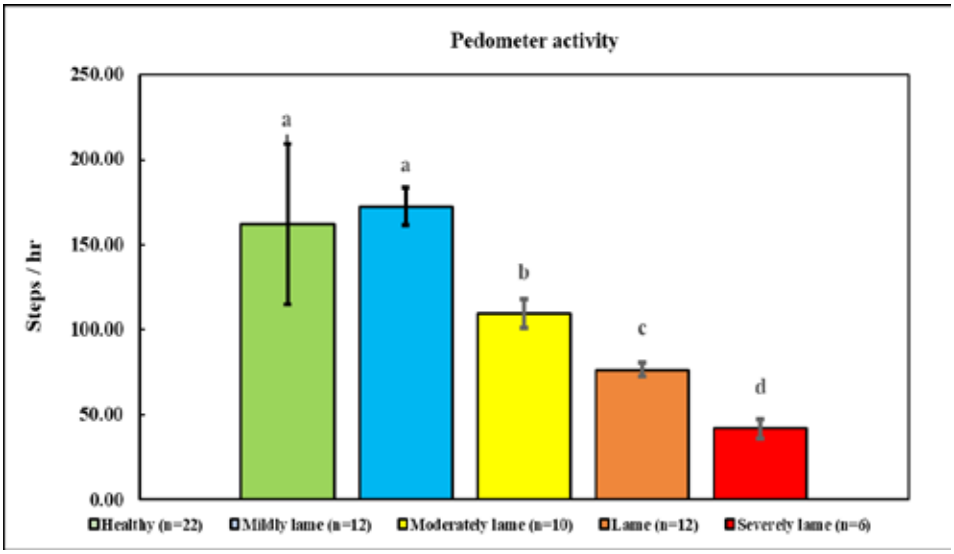


Means bearing different superscript differ significantly ($p<0.05$)

Assessment of lameness in dairy animals using infrared thermography and activity meter

Lameness is the third most costly disease after mastitis and reproductive problem. The early identification of lameness has immense importance. Therefore, the present study aimed to assess lameness in crossbred cattle using infrared thermography (DarviDTL007 camera, TAK Technologies, Pvt. Ltd) and activity meter (Developed by IIT, Delhi, in collaboration with ICAR-NDRI). An assessment of temperature change and activity of dairy animals with different degrees of lameness was conducted. Blood samples were collected from all five groups of animals to estimate the Haptoglobin, Serum Amyloid A, Cortisol, and haematological parameter. A significant increase ($p<0.05$) was observed in the IRT temperature (°C) of the R1 region of lameness-affected animals as compared to healthy animals. A rise of 1.46 °C, 2.78 °C, 3.18 °C, and 3.48 °C was observed in the R1 region of mildly lame, moderately lame, lame, and severely lame animals as compared to that of healthy animals, respectively.

A significant increase ($p<0.05$) was observed in the IRT temperature (°C) of the R2 region of lameness-affected animals as compared to healthy animals, except mildly lame animals. Hb (gm/dl), PCV (%), and TEC ($x10^6$ /µL) were significantly ($p<0.05$) decreased in the case of lame and severely lame animals as compared to healthy animals. Neutrophils (%) and Monocytes (%) were significantly ($p<0.05$) increased in the case of lame and severely lame animals as compared to healthy animals. Cortisol, Haptoglobin and SAA levels increased significantly in the case of mildly lame, moderately lame, lame, and severely lame animals, compared to healthy animals. In another experiment, 22 healthy and 40 lameness-affected animals' activity (number of steps/hr.) was recorded using a pedometer for eight hours daily. Pedometer activity (no. of steps/hr) decreased significantly ($p<0.05$) in the case of moderately lame; lame and severely lame animals as compared to healthy animals. IRT and activity meters can be used as an efficient tool to identify moderately lame, lame, and severely lame crossbred animals.



Activity of healthy and lame animals

Photobiomodulation of sperm for improving post-thaw semen quality

Photobiomodulation therapy over the sperm is efficient as it increases aerobic metabolism, energy production, and kinematic parameters of the sperm. The study determines the impact of various light spectra with different exposure timings on critical sperm function. It was found that motility was significantly higher ($p\leq0.05$) after light exposure at 600 nm for 2 min and 650 nm for 3 min. Both groups had significantly higher ($p\leq0.05$) initial motility than the control 60 min after light exposure. At the post-thaw stage, membrane-intact spermatozoa, intact acrosomes, and the proportion of spermatozoa with higher MMP and sperm kinematic parameters were improved compared to control, but substantially reduced cryocapacitation and lipid peroxidation of spermatozoa. Selected wavelength and time exposure are improving sperm quality due to light irradiation preventing mitochondrial calcium uptake and encouraging calcium to connect to the vesicles of the plasma membrane, thus improving cell viability. The plausible rationale for our finding may be the activation of photoreceptors in the mitochondria, which serve as the main energy source for sperm motility. A higher

proportion of sperm with higher mitochondrial membrane potential (MMP) was present in post-thaw samples from the treatment group compared to the control group, as evidenced in our investigation. These wavelengths can be used for angular light spectral analysis to find the spectral difference between X and Y-bearing sperm.

Seasonal variations, vaccination and age on functional sperm parameters and ameliorative strategies for thermal and vaccination stress in Sahiwal breeding bulls

The ameliorative effect of heat stress was studied in the Sahiwal breeding bulls. The cooling system efficiency was significantly higher ($p<0.05$) in Sprinkler+Fan (Sr+F) followed by the Splashing (Sp) and Sprinkler (Sr) groups. The short treatment (15 min) of Sprinkler+Fan (Sr+F) provides a cooling effect for a more extended period (120 min.) and efficiently combats the thermal stress in Sahiwal breeding bulls. The PTM%, live sperm, acrosome integrity, HOST positive, and CASA parameters were significantly higher ($p<0.05$) in adult (4-8 years) and older (8–11 years) group bulls compared to younger age (<4 years) group bulls. However, dead, apoptotic, moribund, and abnormal sperms were significantly higher ($p<0.05$) in younger bulls compared to adult and older bulls. Sahiwal bull can be used for quality semen production up to 11 years of age without compromising semen quality. The summer and rainy season in the subtropical Karnal climate was unsuitable for optimum quality low dose (15M and 10M) of semen straw production from low fertile bulls. High- and low-fertility bull spermatozoa can be easily differentiated by assessing Mitosox at 0.5 mMol H_2O_2 concentrations during the challenge treatment. Vaccination stress can be ameliorated in breeding bulls for return to normal semen production early for successful cryopreservation by combining levamisole and antipyretic treatment before and at vaccination, respectively.

Elucidating the efficacy of sodium alginate as an antibacterial alternative in cryopreservation of Sahiwal bull semen

Concern about antimicrobial resistance and spermicidal effects of antimicrobials forces the search for new alternative strategies to the use of antimicrobials in semen cryopreservation. Present study was conducted to investigate the efficacy of sodium alginate (S.A.) as an antimicrobial alternative in cryopreservation of Sahiwal bull semen. Initially each of the pre-dominant Gram –ve (*Proteus* spp.) & Gram +ve (*Bacillus* spp.) bacterial isolates from bulls were collected and antibacterial potency of S.A. was determined. It was found that Minimum Inhibitory Concentration (MIC) of S.A. against *Proteus* spp. & *Bacillus* spp. was 0.625 and 1.25 mg/ml, respectively. Thereafter, effect of S.A. as an antimicrobial alternative on microbial load and freezability of Sahiwal bull semen was studied. In this experiment, ejaculates were split into 3 groups; one was kept as control having conventional antibiotics (Penicillin-1000IU/ml; Streptomycin-1mg/ml), T1 (0.625 mg/ml S.A., no antibiotics) and T2 (0.625 mg/ml S.A. + antibiotics) groups. It was found that progressive motility, viability, HOST and acrosomal integrity of spermatozoa in post-thaw stages was found to be significantly higher ($p<0.05$) in T2 group as compared to control and T1 group. Bacterial load (CFU/ml) across cryopreservation stages was found to be lower ($p<0.05$) in T2 group as compared to control. It can be concluded that sodium alginate in combination with antibiotics, enhances motility, viability, membrane integrity and acrosomal integrity of the sperm, as it protects the sperm from the adverse effects of cryopreservation.

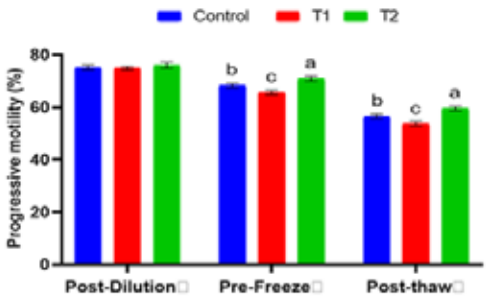


Fig. 4.2.3.2 Effect of standardized dose of sodium alginate on progressive motility (%) in different stages of cryopreservation of Sahiwal bull semen (Mean ± SE, n=24)

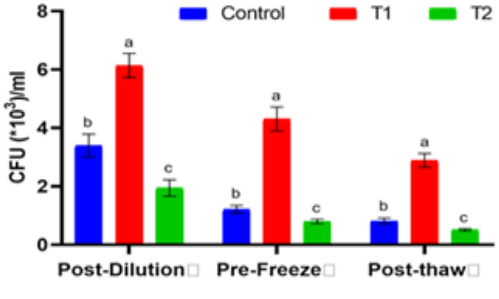
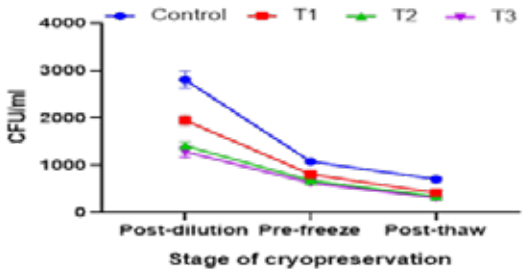


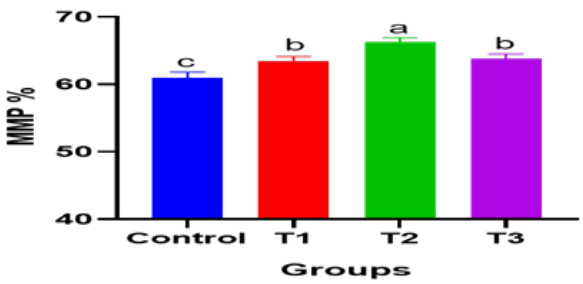
Fig. 4.2.3.1 Effect of standardized dose of sodium alginate on CFU/ml ($\times 10^3$) in different stages of cryopreservation of Sahiwal bull semen (Mean ± SE, n=24)

Selective use of nanoparticles and antimicrobial peptide as anti-microbial alternative in semen cryopreservation of Sahiwal bulls

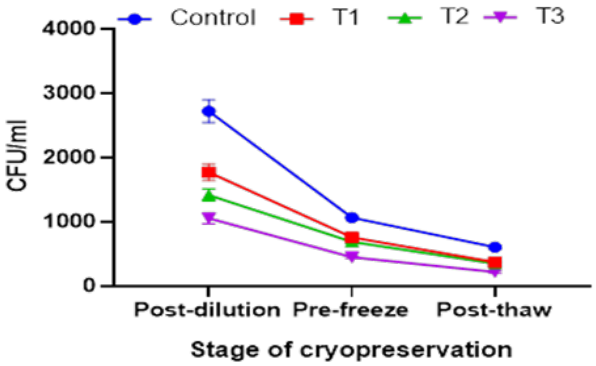
Efficacy of zinc oxide nanoparticles (ZnO NPs) and cyclic hexapeptide (c-WFW) antimicrobial peptide as antimicrobial alternatives in cryopreservation of Sahiwal bull semen was investigated. Initially, bacteria were isolated and identified from Sahiwal bull semen, with Gram -ve Proteus *spp*. and Gram +ve Bacillus *spp*. as predominant bacteria. It was found that minimum inhibitory concentration (MIC) of ZnO NPs against both Bacillus *spp*. and Proteus *spp*. was 60 µg/ml. MIC of c-WFW AMP against Bacillus *spp*. and Proteus *spp*. was found to be 4µg/ml and 6µg/ml, respectively. Thereafter, effect of ZnO NPs and c-WFW AMP as an antimicrobial alternative on microbial load and freezability of Sahiwal bull semen was studied. Control group was having conventional antibiotics and treated groups were having 80 (T1), 100 (T2) and 120 (T3) µg/ml ZnO NPs as replacement of conventional antibiotics.Sperm progressive motility, viability, HOS response, acrosomal integrity, MMP, SOD and TAC were significantly ($p<0.05$) higher in T2 group at post-thaw stage of cryopreservation, while microbial load (CFU/ml) was significantly ($p<0.05$) lower in T2 and T3 as compared to control at post-dilution, pre-freeze and post-thaw stages of cryopreservation. Post-thaw sperm kinematic (CASA) parameters were found to be significantly higher ($p<0.05$) in T2 group than control. In experiment of cyclic hexapeptide antimicrobial peptide, control group was having conventional antibiotics and treated groups were having 4 (T1), 6 (T2) and 8 (T3) µg/ml c-WFW AMP as replacement of conventional antibiotics. Sperm progressive motility, viability, HOS response, acrosome integrity, MMP, SOD and TAC were significantly ($p<0.05$) higher in T3 group as compared to control at post-thaw stage of cryopreservation, while microbial load (CFU/ml) was significantly ($p<0.05$) lower in T3 group than control at post-dilution, pre-freeze and post-thaw stages of cryopreservation. Sperm kinematic parameters after thawing (CASA) were significantly higher ($p<0.05$) in T3 group.



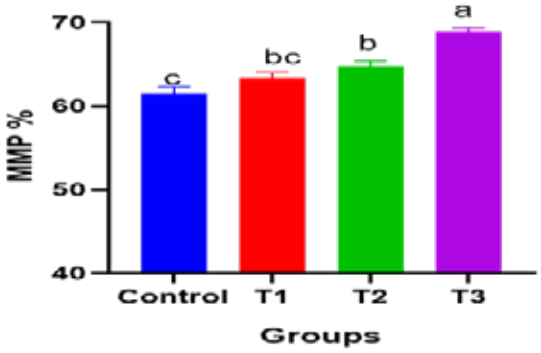
Effect of ZnO NPs on Mitochondrial membrane potential (MMP) of Sahiwal bull semen (Mean ± SE, n=12)



Effect of ZnO NPs on Microbial load (CFU/ml) of Sahiwal bull semen (Mean ± SE, n=12)



Effect of c-WFW on Mitochondrial membrane potential (MMP) of Sahiwal bull semen (Mean ± SE, n=12)

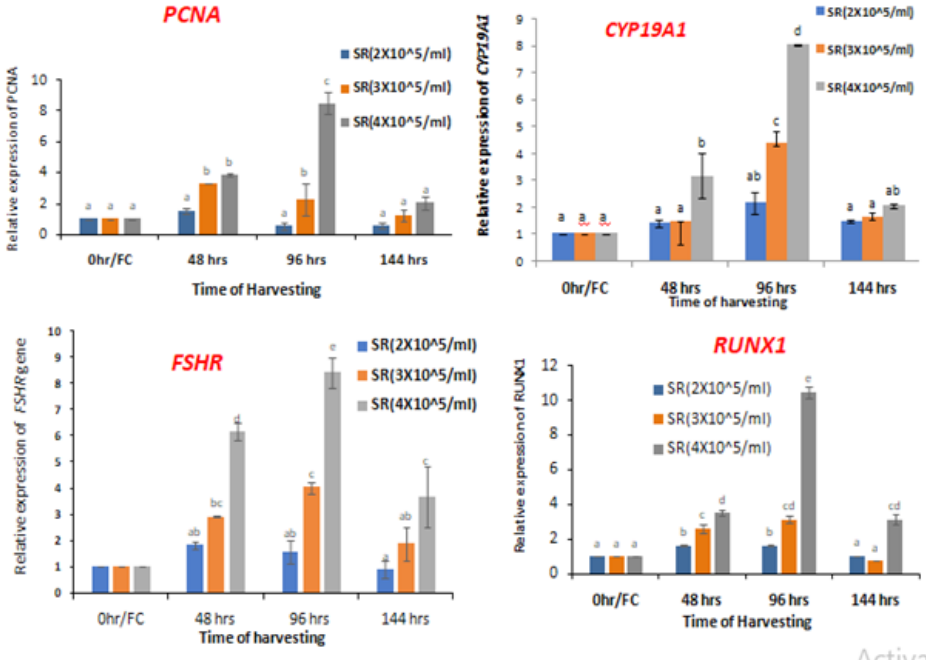


Effect of c-WFW on microbial load (CFU/ml) of Sahiwal bull semen (Mean ± SE, n=12

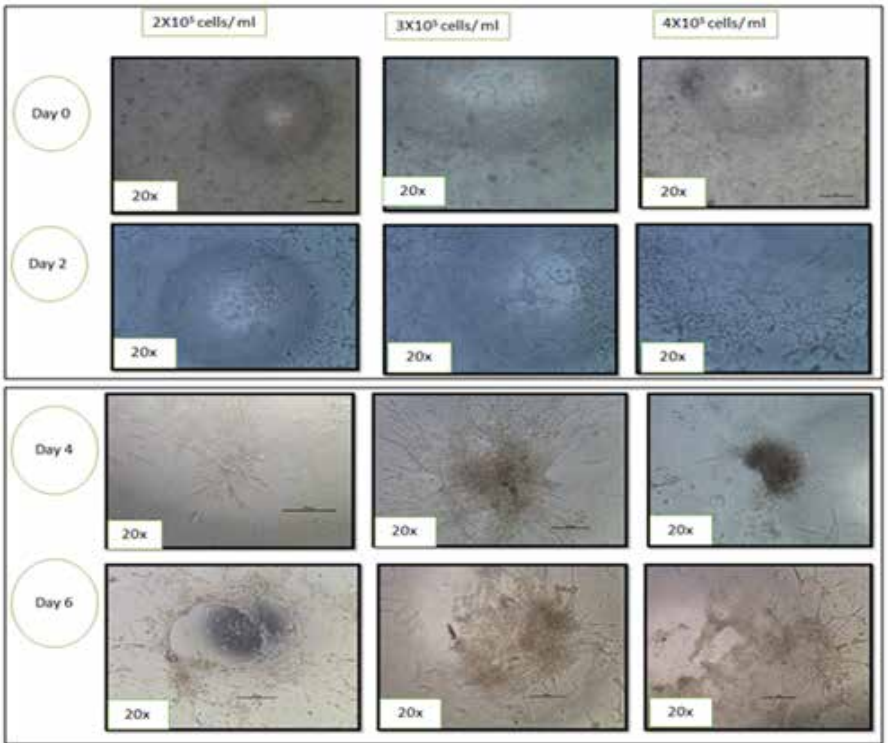
Development of structurally and functionally competent 3D-granulosa cell culture model in buffalo

Summer-induced heat stress impairs the follicular development, cyclicity and resulting poor reproductive efficiency in buffaloes during the low-breeding summer season. Since GCs play a key role in regulating ovarian functions, hence understanding the buffalo granulosa cell's physiology at the cellular and molecular level under heat stress conditions *vis-a-vis* control conditions is important to devise a new therapeutic strategy for improving

the ovarian function of buffaloes during the low-breeding summer season. Therefore, to develop a granulosa cell culture model that can mimic follicular environment, granulosa cells (GCs) were isolated from healthy small follicles (2-4 mm) from the buffalo ovaries collected from slaughter house. Three-dimensional (3D) culture of GCs was carried out in hanging drop method @ seeding density of 2 to 4X10^5 cellsper mL using DMEM/Ham's F-12 medium at 37˚C in an atmosphere of 5% CO_2 and 95% humidified air for a period of 6 days. Gene expression data revealed, significantly higher (P<0.05) expression of *PCNA, CYP19* and *FSHR* in GCs cultured at a higher seeding density (4X10^5/mL vs. 2X10^5/ mL). Further, highest expression of *FSHR* and *CYP19* was observed after 96 hrs of culture which was reduced after 144 hrs of culture indicating GCs in culture attained the preovulatory phenotype after 96 hrs of culture mimicking the preovulatory follicle stage.



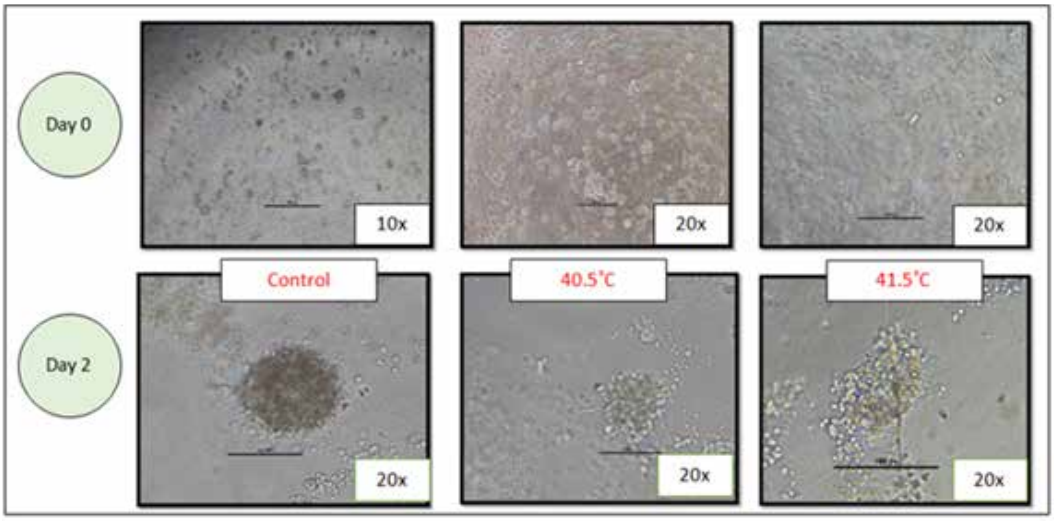
D-culture of granulosa cells using hanging drop method



Functional characterization of GCs under 3-D culture using Hanging drop method

Effect of heat stress on granulosa cells morphology, growth characteristics, and function in a 3D granulosa cell culture model

Granulosa cells in the 3Dgranulosa cell culture model using the hanging drop method were exposed to heat stress (40.5°C and 41.5°C) conditions for a period of 24-120 hrs in order to study the effect of heat stress on GCs morphology and function. Results showed that GCs exposed to 40.5°C and 41.5°C exhibited a significant difference in the growth characteristics. Transcript expression analysis revealed alteration of key genes associated with GCs function upon exposure to heat stress.



Modulating cellular immunity of cow colostrum and milk

Peripartum crossbred cows were selected and divided into control and experimental cows. Supplementation of antioxidant micronutrients (vitamin A, vitamin E, zinc etc) to the experimental cows reduced the level of stress (low cortisol) and enhanced their health status (low milk SCC, increased total Immunoglobulins (Ig), and Phagocytic activity (PA) of neutrophils). Lower cortisol concentration, higher total Ig, increased body weights and PA of neutrophils in the blood of calves indicate the improved quality of colostrum of the supplemented dams which thus may subsequently improve the calf health and their survivability. Further, intramuscular injections were more effective for maintaining the health and immunity of the cows and their calves as compared to the oral supplementations. Exosomes isolated from the colostrum samples highlighted the enrichment of proteins implicated in immune response and growth. Macrophage activation factor (MAF) was synthesized from bovine colostrums and it increased the *in vitro* phagocytic activity (PA) of healthy Mφ (mice peritoneal and cow colostrum) and healthy neutrophils (blood calf) significantly ($P<0.05$). MAF also significantly ($P<0.05$) increased the PA of neutrophils and Mφ obtained from sick calves and immunocompromised mice.

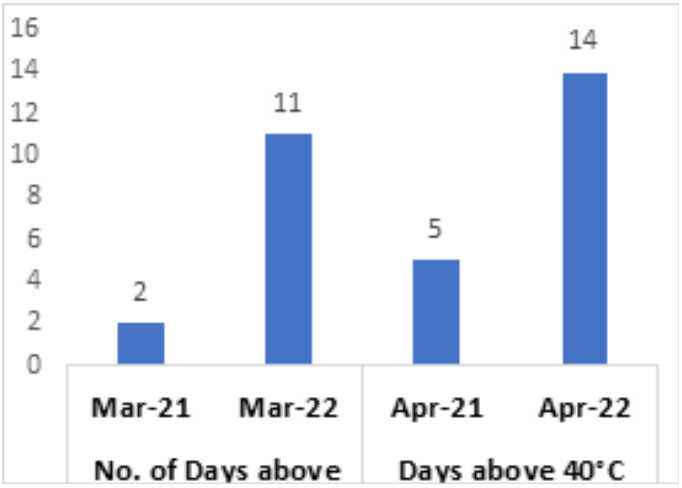
Generation of milk somatic cell reference values and intelligent predictive modelling for monitoring mammary profile and milk quality of indigenous dairy animals

Milk samples were collected from 1810 dairy animals (464: Sahiwal cows, 445: Karan Fries cows, 48: Gir, 55: Tharparkar, 478: buffaloes and 320: goats). Milk somatic cells were counted to check the total number of milk cells present in the healthy, subclinical and clinical mastitis cows. Differential milk cell counting was done. There was a positive correlation between milk SCC and neutrophils (%) whereas macrophages (%) and lymphocytes (%) were negatively correlated with milk SCC in both Sahiwal and Karan Fries cows. A highly significant correlation of milk SCC with milk protein, EC, and pH was found. Milk enzymes along with sodium and chloride showed a positive correlation with milk SCC whereas potassium was negatively correlated.

Impact of heat wave on milk production

The average temperatures observed pan-India for April was 35.5°C, which was the fourth highest in 122 years. During the period, March and April 2022 data was collected from the Livestock related to milk

production from organized farm as well as from rural areas. The significant effects on milking crossbred cows were according to stage of lactation. The loss in milk yield in 0-100 days lactating cows was found to be 8.11%, 100-150 days was 17.8%, 150-200 days was 14.8% & above 200 days was 13.26% during the month of April 2022 as compared to April 2021. The overall losses irrespective of stage of lactation due to sudden rise in maximum temperature in cross bred milking cows were reported as 13.49 %. During hot dry summer (April & May) months temperature between 35-39°C is well tolerable by the lactating animals particularly cross bred cows without any significant losses. The temperature above 40°C for a period of more than 7-10 days continuously affects the milk yield of cross bred animals significantly. The buffaloes and indigenous breeds of cattle were also affected non significantly and able to sustain the milk productivity throughout the month of April, 2022.

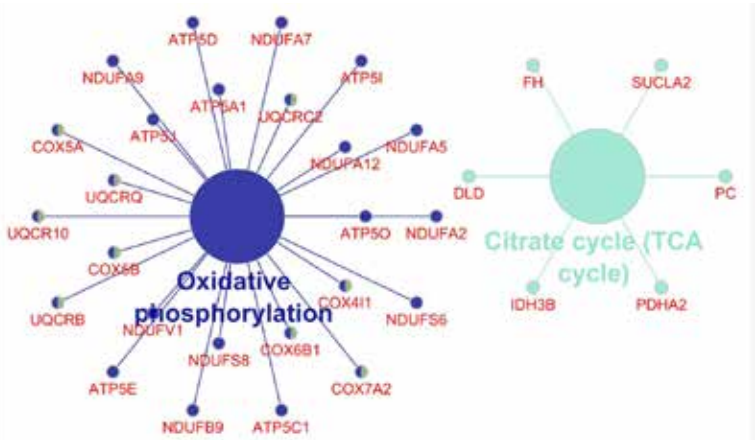


No of days with high temperature increased during March and April (2021 and 2022)

ANIMAL REPRODUCTION AND FERTILITY

Scrotal infrared digital thermography as an indicator of seasonal effect on seminal attributes and physio-biochemical parameters of Tharparkar and Karan Fries bulls

Tharparkar and Karan Fries bulls, semen samples were collected at weekly interval during winter, spring and summer season and analyzed for physical (semen volume, sperm concentration, mass motility, progressive motility, live sperm percent, HOST, acrosomal integrity and sperm abnormalities) and biochemical (seminal plasma malondialdehyde and reactive oxygen species) parameters. Infrared thermography of different anatomical sites i.e. scrotum, ocular and muzzle temperature were recorded at weekly in both the breeds. The temperature gradient (TG) was found to be significantly ($P < 0.05$) higher in Tharparkar than Karan Fries bulls during summer season. The mass motility, progressive motility, live sperm %, hypoosmotic swelling test and acrosomal integrity was found to be significantly ($P< 0.05$) higher during spring season than summer season in Karan Fries bulls. Significantly ($P < 0.05$) higher sperm concentration and lower sperm abnormalies were observed in Tharparkar than Karan Fries bulls during all three seasons. Further the levels of MDA showed significantly ($P < 0.05$) lower levels in Tharparkar than Karan Fries bulls during all three seasons. The ROS positive sperm cells were observed to be significantly ($P < 0.05$) lower during spring season compared to winter and summer in both the breeds. The rectal temperature and respiration rate were significantly ($P < 0.05$) higher in Karan Fries bulls than Tharparkar bulls during all the seasons. The blood plasma testosterone levels were found significantly ($P < 0.05$) higher during all the three seasons in Tharparkar compared to Karan Fries bulls. The blood plasma heat shock protein 70 showed significantly higher ($P <0.05$) levels during summer compared to spring and winter season. Among the breeds, the levels of HSP70 were found to be significantly higher ($P < 0.05$) in Karan Fries than Tharparkar bulls during different season. The scrotal temperature gradient showed significant ($P<0.05$) positive correlation with mass motility, progressive motility, live sperms %, HOST, acrosomal integrity and significant ($P<0.05$) negative correlation with sperm abnormality and level of testosterone. The THI was found to be inversely correlated with TG and positively correlated with testosterone and HSP 70.



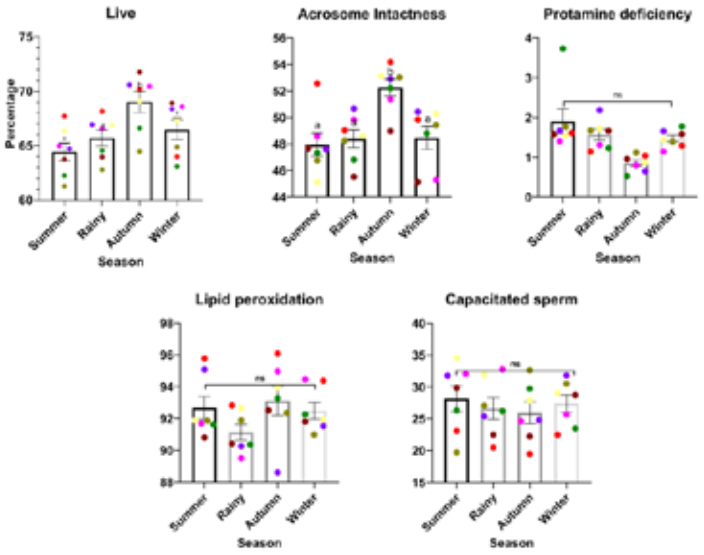
Identification of fertility associated sperm-membrane proteins in bulls

The sperm membrane protein composition assumes significance in male fertility and in-depth knowledge of protein composition of plasma membrane is essential for understanding possible differences among bulls in terms of sperm functionality and fertility. Sperm membrane proteins from high- and low-fertile Holstein Friesian crossbred bulls (n=3 each) were subjected to high-throughput liquid chromatography-mass spectrometry (LC-M/MS) for comparative proteomic analysis. Proteomic profiling identified a total of 456 proteins in crossbred bull spermatozoa; it was found that 108 proteins were up regulated while 26 proteins were down regulated (>1.5-folds) in spermatozoa from low- compared to high-fertile bulls. Gene ontology classification revealed that upregulated proteins in low-fertile bulls were involved in biological process such as oxidation-reduction process (P= 3.14E-06),fusion of sperm to egg plasma membrane (P= 7.51E-04), sperm motility (P= 0.03) and capacitation (P= 0.09), while down regulated proteins were associated with transport (P= 6.94E-04), superoxide metabolic process (P= 0.02) and tricarboxylic acid cycle (P= 0.04). KEGG Pathway analysis revealed that oxidative phosphorylation and tricarboxylic acid cycle pathways are the most significantly affected pathway in low-fertile bulls. It was concluded that expression of proteins associated with oxidative phosphorylation and tricarboxylic acid cycle pathways were altered in low-fertile crossbred bulls, and expression levels of SPATA19, ELSPBP1, ACRBP, CLU, SUCLA2 and SPATC1 could aid in assessing potential fertility of crossbred bulls.

Molecules governing sperm metabolism potentially influence bull fertility

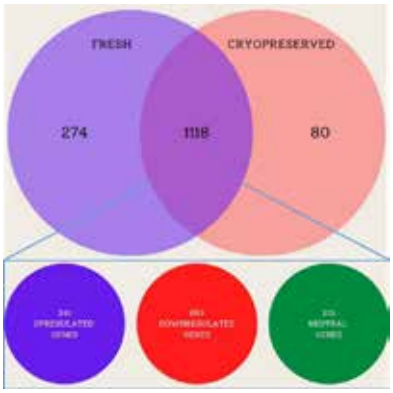
Spermatozoa from high- and low-fertile bulls were subjected to high-throughput transcriptomic, proteomic and metabolomic analysis. Using an integrated multi-omics approach the molecular differences between high- and low-fertile bulls were identified. A total of 18,068 transcripts, 5041 proteins and 3704 metabolites in bull spermatozoa are of which the expression of 4766 transcripts, 785 proteins and 33 metabolites were dysregulated between high- and low-fertile bulls. At transcript level, several genes involved in oxidative phosphorylation pathway were found to be downregulated, while at protein level genes involved in metabolic pathways were significantly downregulated in low-fertile bulls. Metabolites involved in taurine and hypotaurine metabolism were significantly downregulated in low-fertile bulls. Integrated multi-omics analysis revealed the interaction of dysregulated transcripts, proteins and metabolites in major metabolic pathways, including Butanoate metabolism, Glycolysis and gluconeogenesis, Methionine and cysteine metabolism, Phosphatidyl inositol phosphate, pyrimidine metabolism and saturated fatty acid beta oxidation. These findings collectively indicate that molecules governing sperm metabolism potentially influence bull fertility.

Seasonal and climatic factors influence fertility associated sperm phenomic attributes in bulls



Sperm functional competency has not been understood in detail. Weanalysed the sperm functional parameters in breeding bulls over a period of one year were analysed and the effect of climatic variables on the fertility associated sperm parameters were assessed. Seasons were categorized based on the meteorological data into four viz. summer, rainy, autumn and winter. Semen was collected from crossbred bulls across the seasons and evaluated for functional membrane integrity, acrosome reaction status, protamine deficiency, capacitation and lipid peroxidation status using specific fluorescent probes. Bulls produced higher ($p<0.05$) viable and acrosome intact spermatozoa during the autumn. The proportion of uncapacitated spermatozoa was also higher ($p<0.05$) during autumn. Further, correlation of sperm functional attributes with environmental variables revealed that sperm viability was significantly ($p<0.05$) and negatively correlated with daylength and temperature; acrosomal integrity was significantly ($p<0.05$) and negatively correlated with day length; and protamine deficiency had significant ($p<0.05$) positive correlation with day length, average temperature and relative humidity. It was concluded that semen produced during autumn was superior to the semen produced during other seasons in terms of sperm functional competencies required for bull fertility.

Cryopreservation process induced alterations in sperm transcriptomic composition

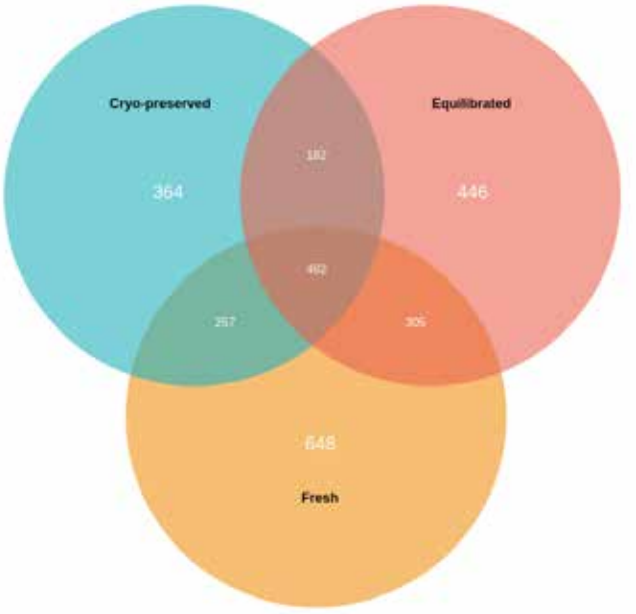


Although cryopreservation has been shown to alter sperm phenotypic characteristics, its effect on sperm molecular health is not thoroughly understood. The present study, using Next Generation Sequencing method, investigated the effect of cryopreservation on sperm transcriptomic composition of bull spermatozoa. In freshly ejaculated bull spermatozoa, 14280 transcripts were detected; on the other hand, only 12375 transcripts were detected in cryopreserved spermatozoa. Comparative analysis found that 241 genes were up-regulated, 662 genes were down-regulated and 215 genes were found to be neutral in expression in cryopreserved spermatozoa compared to fresh spermatozoa. Gene ontology analysis indicated involment of dysregulated transcripts in nucleic acid binding, transcription specific

activity, protein kinase binding involving protein autophosphorylation, ventricular septum morphogenesis and organ development process. Moreover, the dysregulated genes in cryopreserved spermatozoa were found to involve in pathways associated with glycogen metabolism, MAPK signalling, embryonic organ morphogenesis, ectodermal placode formation and regulation of protein auto-phosphorylation. It is inferred that cryopreservation process induced alterations in the abundance of sperm transcripts associated with potential fertility associated functions and pathways, which might partly explain the reduced fertility observed with cryopreserved bull spermatozoa.

Cryopreservation process induces alterations in proteins associated with bull sperm quality

High-throughput comparative global proteomic profiling of freshly ejaculated (before cryopreservation), equilibrated (refrigerated storage; during cryopreservation) and frozen (ultra-low temperature; after cryopreservation) bull spermatozoa. Using liquid chromatography- mass spectrometry (LC-MS/MS) technique, a total of 1692, 1415 and 1286 proteins were identified in fresh, equilibrated and cryopreserved spermatozoa, respectively. Among these proteins, the abundance of 105 proteins were lowered during the equilibration process itself while the abundance of 43 proteins were lowered during ultralow temperature preservation. Remarkably, the equilibration process lowered the abundance of sperm proteins involved in energy metabolism, structural integrity and DNA repair, and increased the abundance of proteins associated with proteolysis and protein degradation. The abundance of sperm proteins associated with metabolism, cGMP-PKG (Cyclic guanosine 3',5'-monophosphate-dependent protein kinase G) signalling and regulation of actin cytoskeleton were also altered during the equilibration process. These findings may be used for developing efficient protocols to minimise the protein damage and to improve the quality and fertility of cryopreserved bull spermatozoa.



Proteomic profiling of an indigenous zebu (*Bos indicus*) cattle spermatozoa

Zebu bulls are known for their uniqueness in terms of high fertility even under low-input production system; hence, investigating sperm proteomic profile would help in better understanding of sperm proteins and male fertility. Therefore, was undertaken a study to characterize and quantify zebu (Deoni breed) bull sperm proteome using a high throughput mass spectrometry technique. Identified 1441 proteins in spermatozoa; 12% (n=173) of proteins were observed to contain signal peptides indicating their secretory nature. The most abundant proteins in zebu bull spermatozoa included A-kinase anchoring protein 4, Seminal plasma protein A3, Cationic trypsin, C-type natriuretic peptide, Outer dense fiber protein 2, Spermadhesin-1, Seminal ribonuclease, Seminal plasma protein PDC-109, Metalloproteinase inhibitor 2 and C-C motif chemokine 2; all these proteins have a prominent role in fertility. Gene Ontology analysis of identified proteins revealed that most of proteins were involved in spermatogenesis, sperm motility, capacitation, sperm-egg recognition and sperm binding to zona pellucida. The proteins significantly enriched in spermatozoa were found to be involved in metabolic pathway and Oxidative phosphorylation. Collectively, the study provides a comprehensive description of zebu bull sperm proteome and their functional association, which could be used as a reference for further studies on fertility of zebu cattle.

Behavioral biometrics associated with calving process in Deoni (*Bos indicus*) and Holstein Friesian crossbred cows

Behavioural biometrics associated with calving process was studied in Deoni and crossbred cattle with the aim to find out if these changes could be used to predict parturition timing. It was observed that 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. Frequency of lying Bouts was found to increase 2 ± 0.26 and 1.17 ± 0.17 times/hr 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. It was concluded that the behavioural parameters viz. lying time, lying bouts and rumination time can be potential behavioural indicators for prediction of calving within 6 to 12 hours.An electronic wireless sensor device prototype for calving prediction in cattle was developed. The 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. The device developed needs future modifications to overcome the bottlenecks. Complete details of the device development and its components were presented and Patent has been filed (Patentfiled:Ref. no: 202111045493, TEMP/E1/51475/2021-DEL).

Infrared Thermal Imaging: a non-invasive technology for monitoring temperature changes associated with calving process in Deoni (*Bos indicus*) and Holstein Friesian crossbred cows

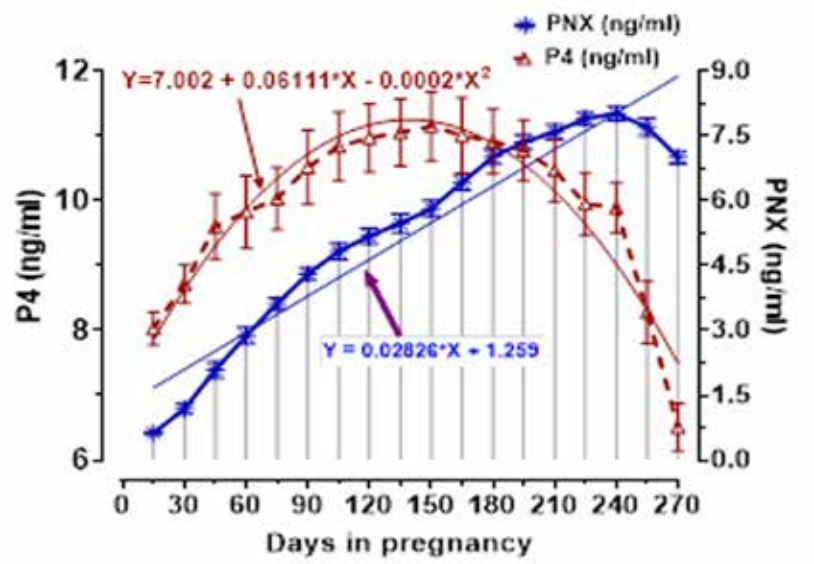
A study was undertaken to assess the utility of Infrared Thermal Imaging profile to identify the changes associated with calving process in Deoni (Bos indicus) and Holstein Friesian crossbred cows. Data on eye and vulval temperature revealed that there was significant ($P<0.005$) and sharp reduction in both eye and vulval skin 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. Similarly, HF crossbred cows also showed significant decrease in eye and vulval skin temperature at 12 hours and thereafter eye temperature further reduced at 6 hours prior to calving. Temperature difference for eye at 12 hours and 6 hours was 0.39 and 0.32 and Temperature difference of 0.55 for vulval region. In both the breeds the eye temperature significantly started increasing till the completion calving process. Interestingly, in both breeds the vulval skin surface temperature increased six hours prior to calving. Therefore, 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.

Development and characterization of progesterone -loaded nanofibre for controlled breeding in Dairy Cattle

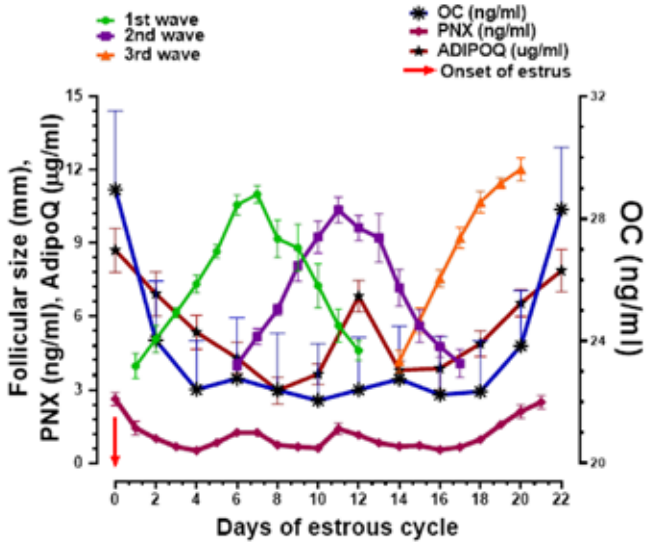
In an attempt to develop Progesterone -Loaded Nanofibre for Controlled Breeding in Dairy Cattle, standardized the optimal polymer-solvent-drug solubility for each select polymer (Zein, Cellulose acetate, Pullulan and Polycaprolactone), followed by solution properties (Electrical conductivity, Density, Surface tension and Viscosity) for Zein-P4, Cellulose acetate-P4, Pullulan-P4 and Polycaprolactone-P4 solutions at three different concentrations. FESEM characterization and EDS analysis of progesterone incorporated select polymer nanofibers: Zein-P4, Cellulose acetate-P4, Pullulan-P4 solutions at three different concentrations. Meanwhile, estrus synchronization of Deoni (n=6) and HF (n=11) cattle by CIDR and Progesterone sponge (control) for controlled animals has been completed. For this study, the following parameters has been assessed including 1) Device retention rate, 2) Discomfort exhibited if any, 3) Time to oestrus after removal, 4) Vaginal discharge scoring, 5) Uterine tonicity on observed oestrus, 6) Ultrasonographic characterization of the follicle, 7) Conception rate by Luteal blood flow analysis (day 19 post AI), ELISA for detection of Pregnancy associated glycoproteins in plasma (day 30) and per rectal palpation (Day 60 post insemination) 8) Serum progesterone concentration for 5-7 days (0 h, 2 h, 4 h, 6 h, 24 h and on alternative days) has been completed.

Dynamics of PNX-SMIM20 during different days and trimester of pregnancy, follicular fluid and ovarian cells in crossbred cows

Plasma concentrations of phoenixin (PNX), a potent secretagogue of endogenous GnRH and Kisspeptin, increased (P<0.01) linearly (Y=0.02826*X+1.259) with the advancement of pregnancy. Estrous and pregnant animals were found have 9 and 31 times more plasma PNX than anestrous cows. Definite pattern of expressions of transcript encoding SMIM20 and KiSS1 genes do occur during different stages of follicular and luteal development Exogenous KP-10 improved the libido & sexual activities; and enhancing seminal attributes in bucks. Phoenixin, adiponectin and osteocalcin were shown to be most abundant during the onset of estrus and the follicular phase has greater concentrations of these peptides than the luteal phase. This proves that aforesaid peptides have a positive effect on follicular growth and maintenance. Additionally, each peptide has a unique impact on pregnancy at certain stages. The highest concentrations of osteocalcin, adiponectin and phoenixin were obtained during early, mid and late stages of pregnancy, respectively.



*Mean (±SEM) plasma phoenixin and progesterone concentrations (ng/ml) during different days of pregnancy in crossbred cows. Concentration of Phoenixin was found to increase linearly with the advancement of pregnancy (Y=0.02826*X+1.259) and progesterone concentrations followed the quadratic polynomial second order equation (Y=7.002+0.06111*X-0.0002*X²) during the entire gestation*



Dynamics of plasma concentrations of adiponectin (µg/ml), phoenixin and osteocalcin (ng/ml) with three waved follicular cycle

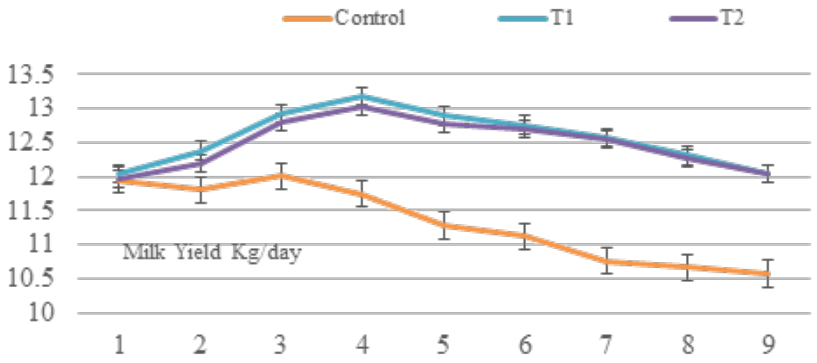
Reproductive management in dairy cows- bypass fat supplementation in transition and repeat breeder cows

Supplementation of palm oil based bypass fat (BPF-PO) to the ration of dairy cows in transition period resulted in significantly higher weight of calves born (27.57±4.05 vs 18.85±0.99 Kg), lower incidence of uterine prolapse (0.0 vs 28.57%), retention of foetal membranes (14.29 vs 42.86%) and postpartum metritis (14.29 vs 42.86%) than the control group cows. The levels of blood NEFA on the day of calving, day 15, 60 and 75 postpartum were significantly ($P<0.05$) lower in supplemented group. Bypass fat supplemented cows had earlier onset of postpartum estrus (28.62±2.40 vs. 36.71±1.20 days) and lesser days to first insemination (46.32±2.60 vs. 56.75±2.40 days). To study the effect of omega 3 fatty acid on reproductive performance of repeat breeder (RB) cows, ration of cows was supplemented with bypass fat of palm oil @ 100g/cow/day and additionally bypass fat of fish oil @ 100g/cow twice weekly over a period of 42 days. Out of 10 cows supplemented 6 cows (60%) conceived while only 4 cows (40%) in control group conceived. Bypass fat supplemented pregnant cows had significantly higher levels of progesterone than the control cows on Day 5, Day 10 and Day 20. Therefore, bypass fat supplementation helps in improvement of reproductive performance in dairy cows.

FEED, FODDER AND ANIMAL PRODUCTIVITY

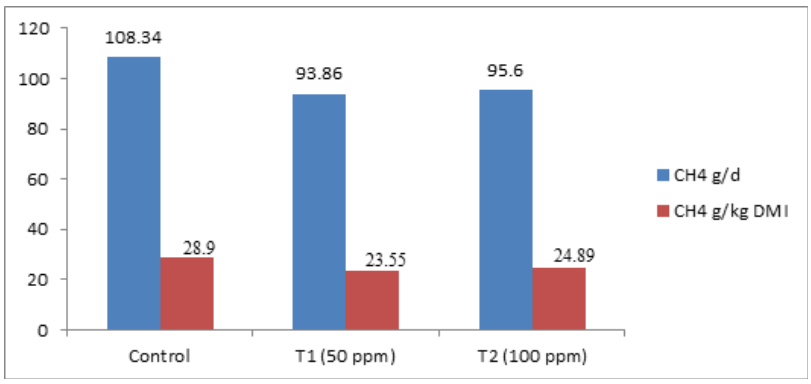
Use of buffers in early lactating crossbred cows

Most of the parturient animals face issues of low feed intake due to stress. Commonly, more concentrate mixture is offered to compensate the situation, however, resulting in development of acidosis and associated metabolic disorders. The current study was conducted to analyze the effect of sodium bicarbonate and magnesium oxide on production performance of early lactating crossbred cows. Eighteen lactating crossbred cows were divided into three groups i.e., control, T_1 and T_2. where additional supplementation of sodium bicarbonate (1.5% dry matter); and sodium bicarbonate and magnesium oxide (1% dry matter), respectively was done. Results revealed that blood biochemical parameters were similar in all groups, however, milk yield and 4% FCM yield and milk fat percentage were higher (p<0.05) due to dietary buffer treatments but milk protein, SNF and lactose percentage remain same. Saturated fatty acids like myristic, pentadecanoic, palmitic acid and overall saturated fatty percentage also increased (p<0.05) in treated groups than control. Palmitoleic acid and overall mono unsaturated percentage decreased significantly in treated groups. However,cis-9Oleic acid ($C_{18:1}$) significantly decreased in T_1 group only not in T_2. It was concluded that incorporation of sodium bicarbonate @1.5% of dry matted intake, may be beneficial in improving milk yield and milk fat without affecting blood biochemicals and nutrient digestibility.



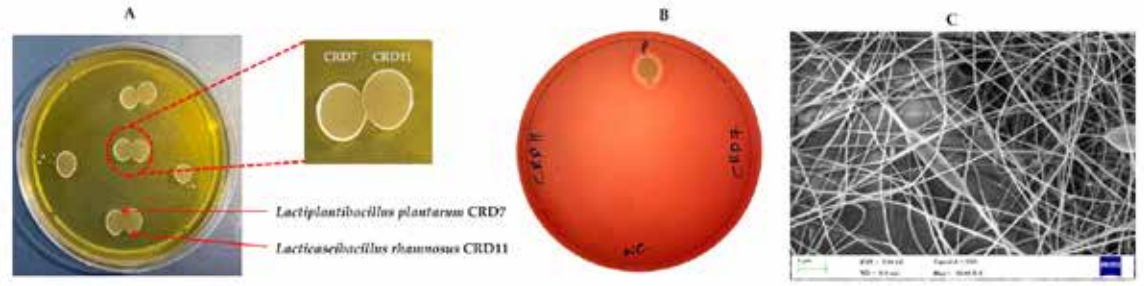
Effect of Artemisia oil in enteric methane emission

Livestock contributes livelihood and nutritional security to millions of farmers but also emits greenhouse gases (methane and nitrous oxide) resulting in global warming. This study was conducted to evaluate the effect of *Artemisia annua* essential oil in reducing enteric methane emission in growing Sahiwal calves. Fifteen male Sahiwal calves (divided into 3 groups: control, T1(50 ppm) and T2 (100 ppm)) were selected for the period of 70 days trial in which at the end of the trial, 7 days of metabolic trial and 7 days of SF_6 trial were conducted with 5 successful collections. The body weight, average daily gain, DMI and feed conversion efficiency, nutrient digestibility and nitrogen balance was similar in all groups. Methane (g/d) was reduced (P<0.005) in T1 (by 13.36%) and 95.60±1.57 in T2 (by 10.83%) than control group. Methane (g/kg DMI) was lower (P<0.05) in T1 and T2 (23.55 ±0.33 and 24.89±0.35) as compared to the C (28.90±0.87) and were decreased by 18.52 % in T1 and 14.18% in T2 as compared to control group. Thus, this study indicates that the different inclusion level of the *Artemisia annua* EO @50 ppm and 100 ppm shown to decrease enteric methane emission without changing nutrient utilization and body weight changes/gain in Sahiwal calves.



Safety assessment of electrohydrodynamic encapsulated probiotics and their effects on gut health and growth performance in indigenous cattle calves

the present study aimed to assess the safety of novel electrohydrodynamic encapsulated probiotics and their appraisal on gut health and immune response in calves. The results revealed that both the probiotic strains *L. plantarum* CRD7 and *L. rhamnosus* CRD11 were compatible. CRD7 and CRD11 were neither hemolytic nor mucinolytic, showed negative for gelatinase, urease, and DNase activities. They didn't not produce ammonia or four major biogenic amines (putrescine, cadaverine, histamine, and tyramine) through HPLC analysis. Moreover, CRD7 and CRD11 showed higher resistance to gentamycin and kanamycin than the EFSA cut-off values and are safe, non-toxic to human epithelial cells (Caco2 cell lines). forty indigenous calves (5–10 days old; 24.86±0.22) were randomly allocated to five groups (n=8) based on age and body weight. The calves were fed the basal diet with respective supplementation as follows: Group I (CT)- no supplementation; Group II (AT)- supplemented with antibiotic chlortetracycline (55 mg/kg of calf starter); Group III (FP)- supplemented with milk fermented with probiotics (*L. plantarum* CRD7 and *L. rhamnosus* CRD11) @ 100 ml/d/calf; Group IV (LP)- supplemented with lyophilized probiotics (1 g/d/calf); Group V (EP) - supplemented with encapsulated probiotics (1 g/d/calf) having $1x10^9$ CFU/g of both *L. plantarum* CRD7 and *L. rhamnosus* CRD11, respectively. After 120 days of administering the probiotics, results revealed significantly increased ($P<0.05$) final body weight and average daily gain in all the supplemented groups compared to the control. The apparent digestibility and nutrient intake did not vary among different groups on probiotic supplementation, but the neutral detergent fibre digestibility was significantly improved in FP, LP and EP ($P<0.05$) group. Moreover, cell mediated immunity, humoral immunity, lymphocyte proliferation was significantly ($P<0.05$) improved in the supplemented group and reduced diarrheal incidence. RT-qPCR analysis of calves' faecal samples showed that lactobacilli and bifidobacteria populations were higher in probiotic supplemented groups with a concomitant reduction in *E. coli* and *Clostridium perfringens*. Overall, the study suggests that *L. plantarum* CRD7 and *L. rhamnosus CRD11* are safe, non-toxic to intestinal epithelial cells, and thus may be potentially suitable for food/feed applications.



(A) Compatibility assay. (B) Hemolytic assay. (C) Scanning electron microscopy picture of encapsulated probiotic containing L. plantarum CRD7 and L. rhamnosus CRD11

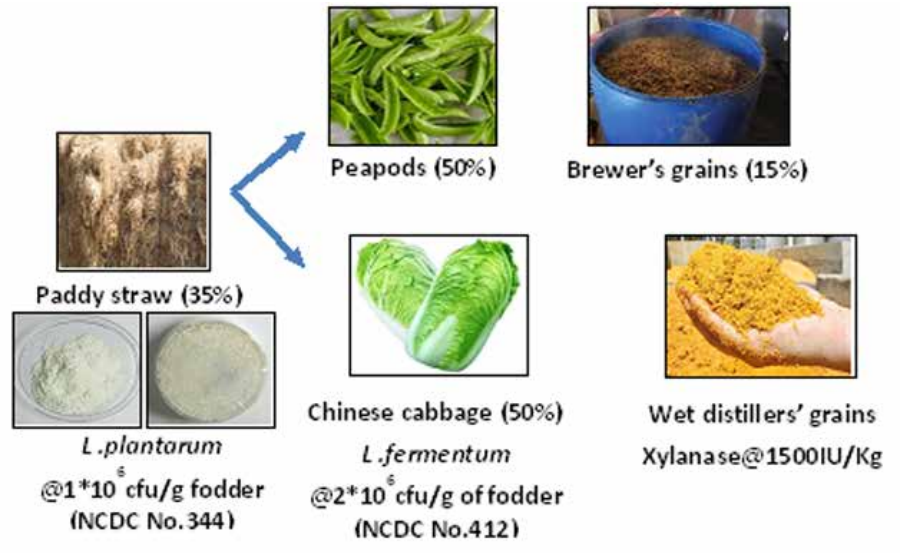
Different forms of L. plantarum CRD7 and L. rhamnosus CRD11 probiotics fed to calves

Utilisation of sugarcane top silage in growing animals

Singh et al. (2021) conducted an in-vitro study to evaluate the quality parameters of sugarcane tops silage wherein a mixture of xylanase plus cellulase and *L. fermentum* along with urea and molasses were used as additive. Exogenous enzymes and LAB inoculants improved fermentation quality, fleig point and nutritive value of sugarcane top silage. The small-scale silage prepared from maize and sugar cane tops, after necessary additive treatment, was used as part of total mixed ration for feeding trials on growing animals based on previous studies to enhance the utility and quality of sugarcane tops. Chauhan et al. (2021)ensiled sugarcane tops, using additives such as exogenous enzymes (Cellulase, C and Xylanase X) with LAB (*Lactobacillus plantarum*: LP and *Lactobacillus fermentum*; LF). Consequently, among all treatments, exogenous enzymes (EFE) and LAB treated silages (C+X+LF and C+X+LP+LF) were the best combinations based on LAB count, yeast and mould counts and LA:AA ratio at days 15 and 25 of ensiling. Combined effect of LAB and enzymes reduced the ensiling period, and improved the SCT silage quality.

Value enhancement of paddy straw with suitable feed ingredients and additives

The paddy straw was ensiled in two combinations: combination 1 (paddy straw, peapods and brewer's grain in ratio 35:50:15) and combination 2 (paddy straw, chinese cabbage and brewer's grain in ratio 35:50:15). Combination 1 was ensiled in two different trials. In trial 1 the strawlage ingredients (paddy straw, peapods and brewer's grain) were supplemented with exogenous fibrolytic enzyme, homofermentor bacteria (Pediococcus acidolactici NCDC 609) and heterofermentor bacteria (Leuconostoc mesenteroides NCDC 421). In trail 2 the strawlage ingredients were ensiled with exogenous fibrolytic enzyme, homofermentor bacteria (Lactobacillus plantarum NCDC 221) and heterofermentor bacteria (Lactobacillus fermentum NCDC 412). The strawlage ingredients in both the trials were ensiled for different time duration, i.e., 30, 40, 50 days. Combination 2 was also ensiled in two different trials. In trial 1 the strawlage ingredients (paddy straw, chinese cabbage and brewer's grain) were supplemented with exogenous fibrolytic enzyme, homofermentor bacteria (Pediococcus acidolactici NCDC 609) and heterofermentor bacteria (Leuconostoc mesenteroides NCDC 421). In trail 2 the strawlage ingredients were ensiled with exogenous fibrolytic enzyme, homofermentor bacteria (Lactobacillus plantarum NCDC 221) and heterofermentor bacteria (Lactobacillus fermentum NCDC 412). In both trials, the strawlage materials were ensiled for 30, 40, and 50 days, respectively. The ensiled combinations in both the trials showed a reduction in pH, ammonia-N, butyric acid and fibre contents and increased the protein content of treatment in which ingredients were supplemented in combination of both bacteria and exogenous enzyme at all ensiling duration i.e., 30, 40 and 50-day. The best combination was determined on the basis of Flieg point and energy recovery. The highest Flieg point and energy recovery was observed in trial 2 of combination 1 in which ingredients were supplemented with both the bacteria and enzyme. The same result was observed in trail 2 of combination 2 as the ingredients ensiled with both the bacteria had higher Flieg point and energy recovery. The present study results suggest that ensiling of combination 1 and combination 2 along with additives can be used as an alternate feed resource for ruminants.

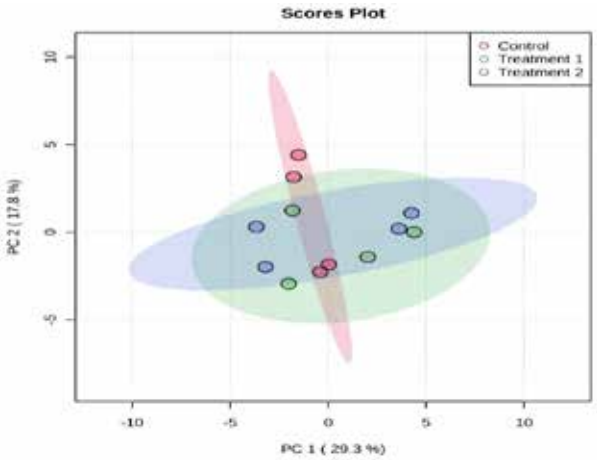


Assessment of milk metabolomics in zinc supplemented dairy goats during winter and summer seasons

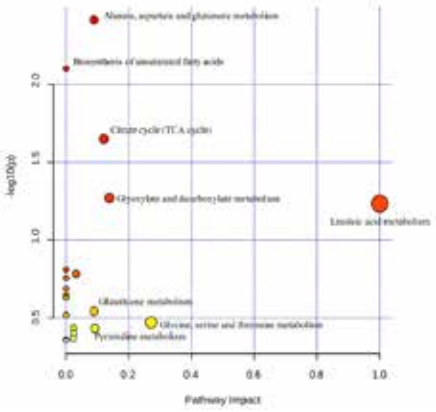
Crossbred lactating goat were supplemented with zinc to study on milk metabolites during winter and summer seasons. PLS-DA analysis revealed twenty-five (25) metabolites found in control (without zinc supplementation), T1 (30ppm of zinc supplementation) and T2 (50 ppm of zinc supplementation) groups of milk samples were having VIP score ≥ 1.

Among different metabolites, arachidic acid and lignoceric acid showed VIP scores of more than 2.5 in the control group compared to the T1 and T2 groups.

The metabolites were found to be higher concentrations in the control group in comparison to treatment groups were arachidic acid, lignoceric acid, 9,12-Octadecadienoic acid, 4-Aminobutanoic acid, fumaric acid, oleic acid, citric acid and hexanoic acid.



Scores plot between the selected PCs



Summary of pathway analysis

The metabolites were found to be in higher concentrations in the treatment groups as compared to control group were serine, D-Talopyranose, heneicosanoic acid, glycine, uracil, D-Tagatofuranose and L-Glutamic acid.

A total of twenty pathways were obtained.Based on -log10(p) and impact values, pathways such as alanine, aspartate and glutamate metabolism, biosynthesis of unsaturated fatty acid, TCA cycle, linoleic acid metabolism, glyoxylate and dicarboxylate metabolism, glutathione metabolism, and glycine, serine and threonine metabolism were found to be differentially regulated in control, T1 and T2 groups and these were involved in carbohydrate, lipid, amino acid and nucleotide metabolism.

Complete Feed Briquettes: a novel livestock feeding approach as an alternative for stubble burning and value addition to crop residues

On the onset of winters around October- November, the Northern farmlands of India burn in the fire of stubble (*parali*). *Parali* burning is a dominant method of crop residue disposal, majorly in Haryana & Punjab, where farmers burn the stubble left off as a residue, to prepare the lands for sowing for next season that tremendously add to

the air pollution and deterioration of air quality. It also leads to thrashing of crop residues that could otherwise be used as a feed resource in the regions which suffer fodder shortage. But the transportation and storage of these crop residues becomes troublesome and economically draining. Therefore, densification of straws can be done to suffice these shortcomings. Newer emerging densification technique like BRIQUETTING was explored by the experimental study carried out by combining this with another precedent technology known as 'complete feed technology'. Briquetting is a process that uses piston/hydraulic/screw press for compaction of agricultural/industrial/forest residues into higher density products, known as biomass briquettes that are generally used for combustible purposes, for domestic households as well as agro-industrial operations, as replacement of fossil-fuels. Complete feed densification in form of briquettes is an innovative technology to provide balanced ration, in form of ready-to-eat meal for livestock eliminating selective-feeding.

The main objectives for the study were to optimise manufacturing protocol for production of complete feed briquettes and conducting a preferential feeding trial for Sahiwal calves. Four types of paddy-straw based complete feeds, similar in energy and protein content but differing in dietary fibre level were prepared according to body weight requirements (as per standards of Indian Council of Agricultural Research-ICAR, 2013) for growth of calves (10-11 months). Optimisation and processing of these complete feed into briquettes was done in collaboration with a local briquette manufacturing unit using molasses as a binder at varied levels and varying speeds of the piston determing the hardness of the briquette. An *in-vitro* trial along with a preferential feeding trial was conducted on 24 Sahiwal calves for a period of 35 days in the institutional cattle yard to check palatability and acceptance response of calves to the four briquettes. Along with an in-depth statistical assessment of results obtained from both the trials (*in-vitro* and feeding trial), a thorough evaluation of physical parameters including briquette profiling, bulk density, post-compression expansion (PCE), durability and briquette efficiency of the four briquettes was conducted. Based on the observations, one briquette out of the four will be selected for another *in-vivo* feeding trial (150 days) on the same calves for comparative evaluation of feeding TMR in mash form or as briquette, with conventional feeding.

Expected outcomes of the experiment revolve around development of feasible alternative technology by optimising briquette manufacturing for replacement of conventional feed and TMR in mash form with complete feed briquettes, which may lead to improved palatability with comparable animal performance with sustainable livestock production. This can act as a secondary application of biofuel briquette industry. Complete feed briquettes, would be a novel feed product that could eliminate stubble burning and will aid in proper agri-waste disposal. It would give impetus to farmers for getting extra remuneration through better sale price of paddy-straw or through utilising the same for feeding own livestock in scientific manner (precision nutrition, minimum wastage).

Effect of nickel supplementation on haematology and blood metabolites in Karan Fries male calves

For this 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- National Dairy Research Institute, Karnal, Haryana, India 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. The haematology parameters such as Hb, RBC count and haematocrit increased ($P<0.05$) with Ni supplementation and highest value were recorded in T_4 group, however,WBC count was not affected by Ni addition in diet. The values of blood metabolites like plasma total protein, albumin, globulin, triglycerides, HDL, creatinine and plasma urea nitrogen were similar in all the groups, however, plasma glucose concentration was the highest ($P<0.05$) and that of total cholesterol, LDL and NEFA lowest ($P<0.05$) in group T_4 as compared to other groups.

Effect of supplementation of nano copper on nutrient utilization, growth and certain blood parameters in Karan fries calves

Twenty-five Karan Fries calves were divided into 5 groups of 5 animals each based on their body weight and age in a randomized block design to study feed intake, nutrient utilization and blood profile. All the animals were fed a basal diet as per nutrient requirements (ICAR, 2013). However, the animals in groups T_1, T_2, T_3, T_4 and T_5 were supplemented with 0, 10 ($CuSO_4$), 1, 5 and 10 ppm (nano Cu), respectively. Concentrate mixture and maize fodder were supplied in the ration in ratio of 40:60 (DM basis) to all the animals. The dietary concentration of Cu was 8.38, 20.07, 9.62, 13.92 and 18.86 ppm of DM in groups T_1, T_2, T_3, T_4 and T_5, respectively. Supplementation with Cu at different levels had no effect on DM intake, the digestibility of nutrients (DM, CP, NDF and ADF), average daily gain and feed conversion ratio. Supplementation of nano Cu improved ($P<0.05$) the Hb, RBC and PCV levels when fed at the level of 5 and 10 ppm. The ALT and AST activities were similar in all groups.

Effects of ameliorant in rations with different levels of aflatoxin B_1 on feed intake, milk yield and composition

For this experiment, 25 lactating Karan Fries (KF) cows were selected from Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal and divided into 5 groups of 5 animals each based on milk yield, body weight and days in milk (30-50 d). In group T_1, the animals were given basal diet while in groups T_2 and T_3 were also added with $AFLB_1$ to simulate practical situation. The animals in groups T_4 and T_5 were given mannano oligosaccahraide (Nutrivet-MOS) @ 15g/animal/d for amelioration of probable ill effects of $AFLB_1$. The $AFLB_1$ level in groups T_1, T_2, T_3, T_4 and T5 was about 15, 35, 55, 35 and 55 ppb, respectively. The body weights of the animals, feed intake (kg/d; kg/kg BW), milk yield and milk composition were found to be similar in all the experimental groups.

Effect of sewage water on Berseem-Maize cropping system under different nutrient management practices

Use of recycled wastewater assumes importance in view of dwindling water resources.An experiment was carried out on a berseem-maize cropping system with three levels of water (tube well water, Treated Sewage water and mixing of TW and TSW) 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 and maize with application of treated sewage with 75% of fertilizer dose, which was at par with 100% recommended dose of fertilizer and mixed application of tube well and sewage water. Higher number of nodules, root length, root volume and dry root weight of berseem were recorded with treated sewage water application and 50% application of fertilizer, which was at par with a higher dose of fertilizer and mixed application of tube well and sewage water. However, the better seed yield of berseem was recorded with the application of treated sewage water and 50% dose of recommended fertilizers. Based on the findings, it can be concluded that judicious use of treated sewage can save a substantial amount of chemical fertilizer upto 25% in fodder berseem and maize and for seed production, it can save about 50% of chemical fertilizers.

Effect of nitrification inhibitor, slow-release fertilizer and ortho silicic acid on performance of wheat-fodder maize cropping sequence

Wheat–fodder maize cropping sequence performed well when fertilized with recommended dose of nitrogen with S–Coating of urea (5% of urea) and Nitrification Inhibitor (DCD@ 10% of urea) with better growth, yield (grain and straw), nutrient content (N and S) and improved straw quality besides improved soil fertility and nutrient availability in terms of available NH_4^+–N, NO_3^-–N, remaining urea and available N and S. Highest system productivity and economic returns were also fetched by this treatment. Wheat–fodder maize cropping sequence performed well with application of ortho silicic acid (@ 0.25%) as foliar spray at vegetative and reproductive stage along with recommended dose of fertilizer in terms of better growth, yield (grain and straw), nutrient content (NPK and Ca), and superior straw quality. However, soil fertility remained unaffected by the treatment. This treatment also proved economically sound with higher system productivity.

Efficacy of nitrogen and zinc nano-fertilizers under wheat-fodder maize cropping sequence

Application of 50% recommended dose of nitrogen through urea and 50% through nano ureawith two foliar sprays of $ZnSO_4$@ 0.5% found to be equally productive as the full recommended dose of nitrogen along with two foliar sprays of $ZnSO_4$@ 0.5% in terms of yield, quality (grain and fodder), profitability for wheat-fodder maize cropping sequence. With respect to soil fertility full recommended dose of nitrogen along with two foliar sprays of $ZnSO_4$@ 0.5% was most effective. So, further long-term study is needed on different soil, agroclimatic zone and cropping sequence for validation of nano fertilizers.

Fodder crop assessment for the dairy industry and potential areas of intensification at state level

The Ground Truth Data of fodder/grain crops has been collected at NDRI Farm during rabi season 2022. Fodder crop area and classification were estimated. The quality assessment of fodder/grain crops (rabi season) has been estimated in the laboratory. Based on these results, forecasting the fodder production would help the farmers to plan the need based fodder production. and maintain stability in the market price of fodder. Fallow land also identified from the satellite data can be utilized for the cultivation of fodder crops with advanced planning and the availability of farm resources. These findings would be helpful in the dairy sector for decision support in fodder development and also fit with drought management in fodder deficit areas. Fodder quality like DM, Protein, ADF and NDF were estimated in rabi fodder/wheat to correlate with remote sensing/drone data for quality estimation in next rabi season.

Development of climate resilient and sustainable agri-based systems for better food, feed, nutritional and livelihood security options to farming community of cold arid region-Ladakh

Three varieties of forage maize (African tall, J-1006 and J-1007), two varieties of sorghum (CSH 24 and CSH 32) were grown in Leh and the three varieties of maize produced 19.9, 16.6 and 14.5 t of green fodder ha^1, respectively while sorghum varieties did not show any promise at Leh. Silage was prepared for the lean season. The pH of water samples collected from different fields of Ladakh ranged between 7.05 nd 7.98.

Among the limited number of milk samples analysed for crossbred cattle (Ladakh), the fat and SNF level was observed to be ranging 3.2-4.4% and 8.3-8.5 %, respectively, however, the Pashmina goat milk samples showed relatively higher content of SNF while lower content of fat. Out of 13 samples of cow milk, 9 showed A1-A2 characteristic peak of beta casein. Higher long chain fatty acids and lower medium chain fatty acids were found in comparison to Karan fries cattle. The saturated fatty acids were also lower in these samples. Milk fat in Pashmina goat milk contained higher capric acid and palmitic acid compared to Alpinex Beetle goat maintained at NDRI. The short chain fatty acids (C4-C8) were also higher.

Evaluation of *Moringa oleifera L.* cultivars for quality fodder production under differential plant geometry in eastern Haryana

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 three cuttings, plant height, stem girth, leaf biomass and green fodder yield were observed to be superior in the PKM-2 variety over others, which were found at par with PKM-1 variety. PKM-2 recorded the highest green

fodder yield (78.1 t/ha) which remained statistically significant compared to other varieties except PKM-1. 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. The proximate components (DM, CP, EE, and Ash content) were also significantly influenced and observed highest with PKM-2. The fire fractions (NDF, ADF and ADL) were reported stastically lower with PKM-1 and vice versa with MOMAX. The crop geometry had not influenced on fiber fractions. Dry matter intake, DMD, TDN and RFQ were also superior with PKM-1. Hence, the PKM-2 variety of moringa gave maximum growth, biomass yield and quality fodder at 45×30 cm^2 plant geometry rather as compaired to other combinations.

Comparative efficacy of inorganic and nano forms of trace minerals (Cu, Zn and Mn) supplementation on recovery of subclinical mastitis (SCM) in lactating dairy cows

Nano minerals were synthesized by chemical reduction method and hydrodynamic diameter (HDD) and zeta potential were characterized by Dynamic Light Scattering spectrometry techniques. The average HDD was found to be <100 nm. About 22 apparently healthy lactating HF crossbred cows were screened for three days using CMT and SCC methods and diagnosed as SCM (SCC ≥ 2 lakh cells/ml) or healthy (SCC ≤ 2 lakh cells/ml). SCM affected cows were additionally supplemented with 100% recommended levels of inorganic trace minerals (Cu: 13 ppm, Zn: 60 ppm, Mn: 17.5 ppm; N=7) or 50% of recommended levels of nanominerals (i.e., Cu: 6.5 ppm, Zn: 30 ppm, Mn: 8.75 ppm; N=7) for 45 days. The data was analysed by linear mixed model using "R"-software. It is observed that supplementation of nanoforms of trace minerals resulted in more significant reduction of SCC and CMT score than inorganic minerals supplemented group, with no significant alterations on plasma Cu, Zn and Mn levels. Supplementation of nano minerals resulted in significant reduction of intra-mammary infection (IMI) rate particularly against *Staphylococcus* spp. TLR-2, TLR-4, TNF-α, IL-8, and SAA3 genes were up-regulated more in inorganic minerals supplemented cows,which is an indicative of more IMIs than nanominerals supplemented cows. It is concluded that supplementation of 50% recommended levels of nano minerals had better efficacy on recovery of SCM affected cows through significant reduction of udder inflammatory markers (CMT and SCC score), lesser IMI rate and inflammatory genes expression profiles than inorganic minerals supplemented cows at 100% recommended level.

Improvement of Black Bengal goats for enhancement of productivity in eastern region of India

Growth performance of Black Bengal weaner kids were assessed under intensive feeding. Kids consumed more DM with an increase in dietary energy levels in their diets. The DM and OM digestibility was influenced by the energy level of the diets and DM intake. On an average Black Bengal kids consumed 66.5 g DM, 5.1 g DCP and 35.4 g TDN per $kgW^{0.75}$/d and had an average daily body weight gain of 31.1 g, respectively under intensive feeding. Black Bengal Kids were dietary supplemented with 2nd grade *Trigonella foenum* seed at 0, 2 and 4% of concentrate mixture under intensive feeding to improve their productive performances. Digestibility of DM, CP, EE and total carbohydrate as well as average daily body weight gain and feed conversion efficiency become higher due to dietary supplementation of *Trigonella foenum* seed in growing kids. Kids showed early estrous due to dietary supplementation of *Trigonella foenum* seed. 2nd grade *Trigonella foenum* seeds supplementation @ 2-4% of concentrate DM improves growth and reproductive performances in Black Bengal goats. Preference for side (outward side vs inward side) and floor (concrete vs slatted wooden floor) in goat barn was tested. Goats preferred outward open side as compared to inward closed side of the goat barn. With advancement of pregnancy the preference for outward side concrete floor was gradually decreased. Animals' preference for wooden slatted floor increased, but preference for concrete floor below showed a decreasing trend. During lactation phase, no clear trend like that of pregnancy was observed. The dirtiness over wooden slatted floor was very less.

Effect of exogenous fibrolytic enzymes supplementation on nutrient availability and growth performance in Black Bengal kids

The study was carried out to evaluate the effect of supplementing exogenous fibrolytic enzymes (EFE) on voluntary feed intake, availability of different nutrients, growth performance and certain blood parameters in Black Bengal kids fed with Total Mixed Ration (TMR). Animals under control (T_0) group was fed *ad libitum* TMR prepared from concentrate mixture and green fodder @ 40:60 (DM basis). Kids under T_1 and T_2 groups were supplemented with two levels of EFE (T_1 with cellulase and xylanase @8000 and 16000 IU/kg TMR DM and T_2 with 12000 and 24000 IU/kg TMR DM). The average intake of DM, CP, TDN (g/d/kid) were significantly ($P<0.05$) higher in both enzymes supplemented groups. Intake of TDN, DCP, digestible NDF, DE and ME per kg $W^{0.75}$also

significantly increased (P<0.001) due to supplementation of EFE. The differences in all the blood biochemical parameters and enzymes (glucose, total protein, globulin, albumin, urea, AST and ALT) were non-significant (P>0.05) among groups. Average daily gain (g/d/kid) increased (P<0.05) by 7.00% in T_1 and 7.19% in T_2 over the control group. The FCE was also significantly higher (P<0.05) in both enzymes supplemented groups; but the variation between T_1 and T_2 was similar. Therefore, it may be concluded that the supplementation of EFE @ cellulase 8000 and xylanase 16000 IU/kg diet DM improved the nutrient intake, growth performanceand feed conversion efficiency in Black Bengal kids without any adverse effect on parameters.

Impact of feeding nutrient enriched rice straw based TMR with or without exogenous fibrolytic enzymes on intake and Nutrient digestibility in Jersey crossbred calves

A feeding trial of 105 days was conducted on 15 crossbred calves (5-7 months of age) divided in three groups of five animals each, to which fed untreated rice straw (RS) based TMR (T0) or with urea-lime-molasses treated RS based TMR (T1) and T1 diet supplemented with EFE mixture @ cellulase 6,000 and xylanase 18,000 IU/kg TMR DM basis (T2). For T1 and T2 diet, RS was pre-treated with Urea, Lime and Molasses maintaining moisture level at 40 percent, which were incubated for 18 days. The TMR was prepared in the ratio of 40:40:20 where 40 parts Concentrates, 40 parts untreated RS/ Pre-treated RS and 20 parts green fodder for all three groups on DM basis. The TMR for all groups made isonitrogenous by adjusting concentrate mixture and untreated/ treated RS proportion. Adigestion trial was conducted to assess the voluntary intake and digestibility of nutrients. DMI (kg/d/animal) was significantly lower in T0 as compared to T1 and T2. However, T1 and T2 differed non significantly. Similar trends were found for OMI and CPI (kg/d/animal). DM digestibility (DMD), found to be significantly higher in T2 followed by T1 and T0. Parallel trends were observed for all other nutrients. However, EE and CP digestibility showed no significant difference (P>0.05) among the three groups. Feeding of nutrient enriched rice straw based TMR with or without EFE supplementation could increase voluntary intake and nutrient digestibility in crossbred calves.

Influence of bio-active compound of 2nd grade *Trigonella foenum* seed supplementation on reproductive performances of Black Bengal goat at lower Gangetic regions

Investigation of field practices revealed that goat keepers (33.51%) had supplemented 2nd grade *Trigonella foenum* seeds to their animals as indigenous practice (ITK) for growth/ vigour, easy birth/ kidding, digestion, milk production and to solve many reproductive problems etc. Therefore, in-vivo experiment with 2nd grade *Trigonella foenum* seeds supplementation (@2-4%) revealed that reproductive parameters like occurrence of first estrus and associated signs were recorded earlier as well as significantly (P>0.05) higher number of animals showed first estrus signs in treatment as compared to control group. No deviation from normal and no significant differences (P>0.05) were observed with respect to feeding and general behavior among goats of three groups. The faecal egg counts EPG, faecal DM% and faecal score were found to be non-significant (P>0.05) among three groups. The bioactive compound of 2nd grade *Trigonella foenum seeds* supplementation to Black Bengal goats improves reproductive performances without showing any deleterious effect. Methanolic extraction of total phenolics and flavonoids andethanolic extraction of saponins and alkaloids revealed satisfactory concentration of bio-active compounds in 2nd grade *Trigonella foenum seeds* which was safe to supplement.

Prophylactic use of Probiotics and Kitchen herbs improved the health and growth performance in calves

The non antibiotic prophylactic use of probiotics (*L fermentum NCDC605 and L rhamnosus NCDC610* @10^{10}cfu/ml) and kitchen herbs (Cinnamon, Turmeric and Carom seeds) were fed to young calves from 4 days upto 2 months age. The study was undertaken for a period of 3 months. Feeding Herb Probiotic mix increased (p<0.05) the final body weight, weight gain, growth rate, dry matter intake and heart girth of the young calves. Also the fecal *E. coli* was significantly higher (p<0.01) in the control groups while *Lactobacillus* sp. were higher (p<0.05) when herb probiotics mix and probiotics were fed. Days of illness were shorter for the Herb probiotic fed groups with reduced incidence of Dirrhoea (25%).

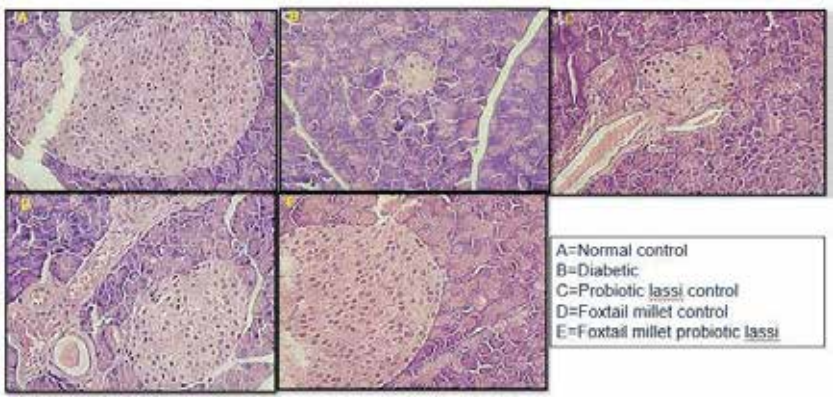
NOVEL APPROACHES IN VALUE ADDITION AND FUNCTIONAL FOODS

Evaluation of casein derived bio-degradable films for wound dressing

Casein-based antibacterial films are attractive materials for wound dressing application because they possess chemical, mechanical, exudate absorption, drug delivery, antibacterial, and biocompatible properties required to support wound healing. Generally, gauze, lint and cotton wool are often used as wound dressings. However, the major drawback of such materials is painful removal which can cause damage to healed tissue. Their opaqueness also becomes a crucial issue for sensitive wound applications that requires visualization-based diagnosis and treatment methods. So, proteins like casein can be formulated into films, hydrogels and electro spun fibers for topical antibacterial therapy. The aim of this study was to compare the properties of casein derived biodegradable films obtained from cow, buffalo and goat along with the *in vivo* wound healing trials on rats. For this study casein protein was isolated from cow, buffalo, goat milk and used for preparation of casein films using different crosslinking agents. The different cross-linkers used were aldehyde (glutaraldehyde), polysaccharide (alginate dialdehyde) and enzyme (tyrosinase). Films were made with and without glycerol. Preparation of milk casein films using cross-linking agents (glutaraldehyde, alginate dialdehyde and tyrosinase) significantly ($p<0.01$) increased the water absorption, film expansion and tensile strength respectively. Use of alginate dialdehyde in preparation of goat casein films significantly ($p<0.01$) increased the water absorption, oxygen permeabilityand moisture permeation properties. There is no major difference in film expansion ratio of casein films prepared from cow and goat milk using glycerol irrespective of the cross-linking agent used. Biofilms prepared with buffalo casein have least water absorption and high moisture permeation in comparison to cow and goat films. Drug release property had revealed that there is slow and sustainable release of drug observed in case of alginate and tyrosinase cross-linked casein films. The prepared films were smooth, flexible, and transparent, which can aid in inspecting wounds without removing the dressing. The Goat casein cross linked with alginate dialdehyde had shown better properties and selected for *in vivo* trials. Herein, films fabricated composed of casein and alginate dialdehyde (AD) loaded with gentamicin sulfate (GS) for application as a wound healing aid. In disk diffusion assay, the alginate cross-linked goat casein films demonstrated excellent antibacterial effect against *E. coli*, *S. aureus*. Overall, the findings suggest that GS-loaded goat casein alginate dialdehyde (CAD) films hold potential for further development as antibacterial wound dressing material.

Effects of foxtail millet fortified lassi on histopathology of mice pancreas

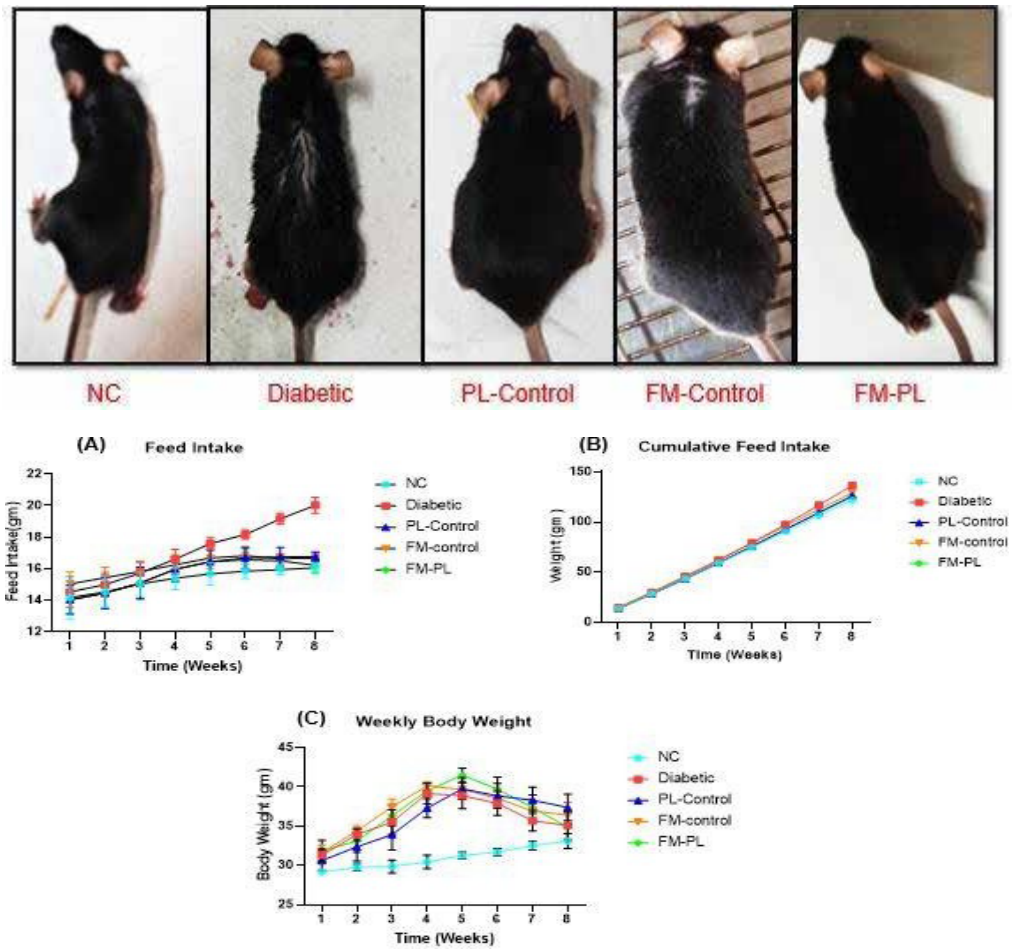
Histopathological examination of the Pancreas indicated that the mice in diabetic groups displayed marked necrosis of pancreatic beta cells as compared to normal control. There was significant increase in beta cell mass in the treatment groups, especially in FM-PL group as compared to the diabetic group.



Representative ultra-thin histopathological images (Hematoxylin and Eosin Stain) of different treatment mice groups Pancreas. The different treatment groups were fed their respective diet for 8 weeks (400×magnification).

In-vivo evaluation of probiotic fermented fortified lassi on hfd/stz induced type-2 diabetes

The animal experiment was performed using the five groups. The average body weight for the randomly divided experimental animals was 25.7 grams. Groupwise combinational diets resulted in the alteration in body weight. Weekly feed intake was also significantly increased ($p < 0.0001$) in diabetic group as compared to NC and was significantly decreased when compared to the treated groups (PL-Control, FM-Control, FM-PL).



(A) Representative images of mice with different treatment groups and fed them respective diet. (B) Feed intake change (in weeks) Cumulative feed intake of mice for 8 weeks fed ad libitum (C) Weekly body weight (for 8 weeks) on different dietary groups such as CD, diabetic, PL-Control, FM-Control, FM-PL. Statistical significance was evaluated by Two Way Anova followed by Bonferroni post hoc test for comparison of all pairs of multiple groups to each other. Values are mean ± SEM, n=6, columns with different letter differ significantly (P< 0.001).

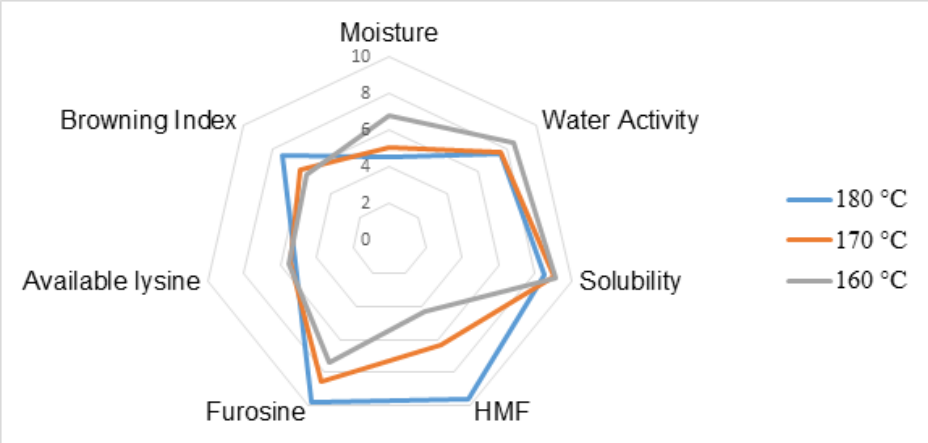
In silico presence of B-complex vitamins biosynthesis in *Limosilactobacillus fermentum* (MTCC 5898)

Vitamins are typically categorized as fat-soluble vitamins, and water-soluble vitamins which include series of B-vitamins thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin (B7), folic acid (B9), and cobalamin (B12). These vitamins serve as coenzymes that typically transport specific chemical groups to many biochemical reactions. Bacterially synthesized B-vitamins could supplement the expensive chemical production of these vitamins to enrich food or to do improved *in situ* fortification of fermented foods. As *Limosiactobacillus fermentum* (MTCC 5898) is safe and non-toxic and may be considered for functional food application. Hence present study was undertaken to evaluate presence of B-complex vitamins Biosynthesis genes in *Limosilactobacillus fermentum* (MTCC 5898) based upon its whole genome sequence data which was annotated using RAST (Rapid Annotation Subsystem Technology) tool. Later genes associated with vitamins biosynthesis in candidate genome were found out after downloading complete available genome sequence data of other *Lm. fermentum* strains from NCBI data base after annotation. Finally, all sequences data was subjected to multiple sequence alignment and predicted the presence of three important B-complex vitamins

(Thiamine, Folate and Pyridoxin) genes related to committed step in their biosynthetic pathway in candidate genome. The proteins structures of these enzymes were either searched in protein data bank (PDB) or predicted with SWISS-MODEL server followed by homology modeling. Later expression of these key enzymes by the potential probiotic strain *Limosilactobacillus fermentum* MTCC 5898 were confirmed by RT-PCR.

Effect of inlet air temperature of spray dryer on interrelation between various parameters for the manufacture of LHMP (lactose hydrolysed milk powder)

The multi enzyme-based LHMP (P3) prepared using different inlet air temperatures resulted in a powder which was comparable with skim milk powder (P1) in terms of moisture content, water activity, solubility and available lysine. Further, the powder P3 displayed lower value of Maillard reaction indicators (HMF, furosine and browning index) and hence was superior in quality than single enzyme based LHMP (P2). It is evident from figure that powder P3 prepared using inlet air temperature of 170 and 180°C resulted in a powder with comparable moisture content and water activity**.** According to FSSAI (2017) the moisture content of powder samples must be below 5%. Powder P3 prepared using an inlet air temperature of 170 and 180°C were able to meet these specifications, whereas, powder prepared at 160°C failed to do so. On the other hand, Maillard reaction indicators such as HMF, furosine and browning index of powder P3 prepared using an inlet air temperature of 160 and 170°C were comparable and lower in values than the powder prepared at 180°C. Moreover, the solubility and available lysine content of powder P3 prepared using an inlet air temperature of 160 and 170°C were almost similar and superior to the powder prepared at 180°C. Hence, an inlet air temperature of 170°C was ultimately finalised for preparation of powder P3. Moreover, figure depicts the milk powders P1, P2 and P3 prepared using an inlet air temperature of 170°C. It can be safely inferred from figure that the use of multi enzyme approach to produce LHMP resulted in a powder, which resembles skim milk powder in appearance and undergoes lower browning compared to single enzyme-based LHMP.



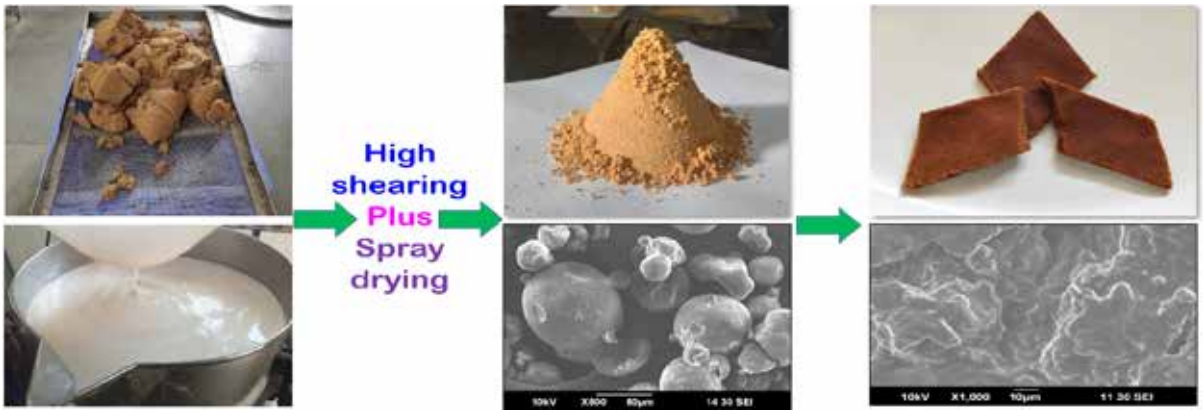
Inter-relation between various physico-chemical parameters of LHMP based on multi enzyme approach (P3) produced at different inlet air temperatures

P3 *P1* *P2*

Milk powders P1 (skim milk powder), P2 (single enzyme-based LHMP) and P3 (multi enzyme-based LHMP) prepared using an inlet air temperature of 170°C

Production of dairy powder from by-products (ghee residue and butter milk): Characterization and application in heat desiccated products/ convenience formulations

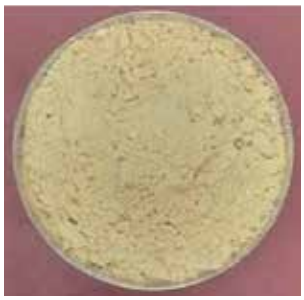
Research on *"Process Standardization of Sweet Cream Buttermilk admixed Ghee-residue Powder for Convenience Foods: Burfi and Gulab Jamun"* was conducted. This study was aimed to manufacture simulated khoa powder (SKP) using SCBM and ghee-residue. Developed SKP was characterized for various powder parameters and also explored to formulate *burfi* and *gulab jamun*. SEM micrograph revealed presence of variable particle size, clustering and particle infusion responsible for poor dispersibility and solubility. The overall acceptability of SKP samples varied between 'liked moderately' to 'liked very much', but overall acceptability of burfi samples made from them varied from 'liked slightly' to 'liked moderately' on 9-point hedonic scale. SEM micrograph revealed close knit texture and compact body in burfi samples. The use of SKP in preparation of *gulab jamun* was not feasible due to crust formation that hindered the penetration of sugar syrup *inside gulab jamun* samples. Developed SKP powders were stored at 4±1^{0}C and 25±1^{0}C. Storage induced changes in different properties of SKP samples are in progress. The developed powder could be used as a food ingredient in different food formulations.



Conversion of ghee-residue and sweet cream buttermilk into simulated khoa powder and burfi

Production and shelf-life enhancement of phospholipids enriched instant Lassi powder from *Desi Chhaach*

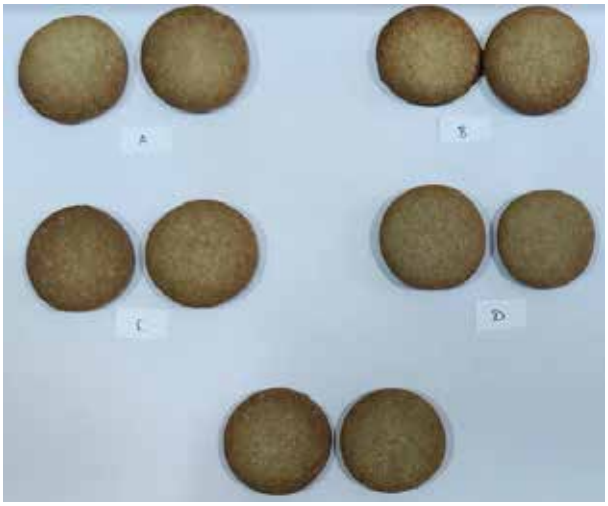
For each trail fresh *desi chhaach* samples were procured from various farmers located in the vicinity of ICAR-NDRI, Karnal, Haryana. Such farmers routinely produce *desi chhaach* using traditional method via churning of curd. Samples meeting the organoleptic criteria were collected in early morning, pooled and brought to ICAR-NDRI, Karnal in pre-sterilized SS cans (40 Kg) at the earliest. For each trail 120-140 Kg sample was used. Just after receiving the pooled sample at ICAR-NDRI, Karnal, it was immediately subjected to physico-chemical analysis. The total solids (TS), fat, protein, ash contents and pH values were determined. Thereafter, it was concentrated, spray dried and the obtained powder was subjected to its detailed characterization.



Manufactured desi buttermilk powder

Technology development for the production of ghee-residue powder

Work on replacement of bakery fat with the fat present in ghee residue powder during preparation of biscuits and muffins was investigated. Ghee residue utilization lowered dough hardness whereas ghee residue powder addition increased the dough hardness value. Sensory evaluation indicated that bakery fat can be replaced up to the 20 % ghee residue and it was rated best in overall acceptability. However biscuit sample containing 25 % ghee residue powder, resulted in biscuits with maximum overall acceptability score. An attempt was made to prepare eggless muffins by substituting whey protein concentrate with ghee residue powder. Increasing the level of Ghee residue powder caused lowering in protein but increase in fat and ash content. Among the physical parameters' redness, specific volume and hardness of muffins increased, whereas lightness value decreased. Based on sensory evaluation, muffin with 25 % WPC substitution with ghee residue powder was acceptable.



Biscuits prepared with incorporation of ghee residue powder

Technology of blueberry incorporated goat milk based high protein dessert

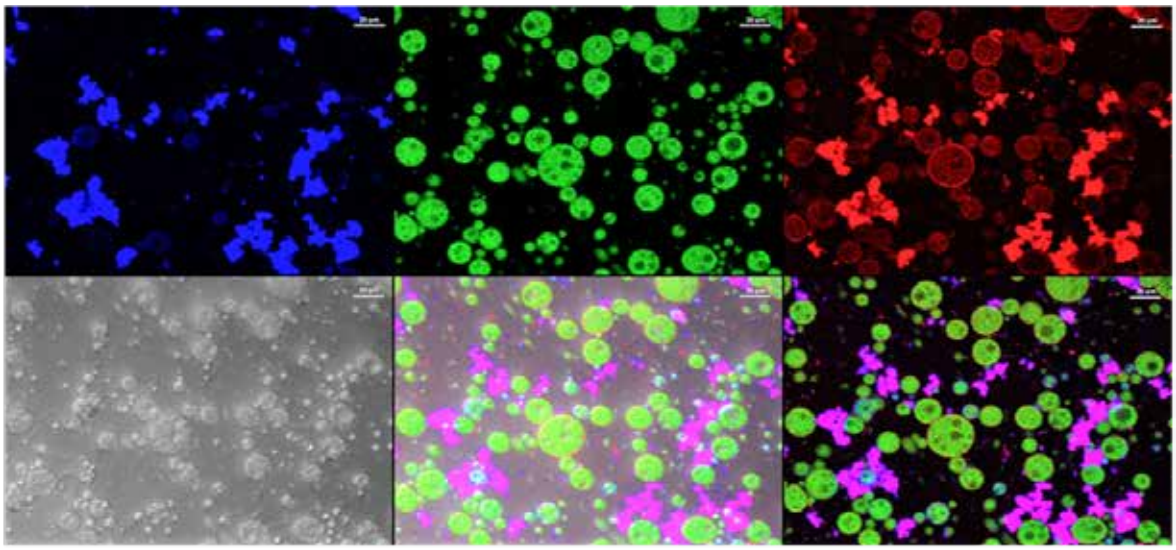
Goat milk based high protein dessert was developed using ultrafiltration at different concentration and optimizing its formulation using blueberry, sugar and inulin. Ultrafiltered goat skim milk 3X was used for preparation of blueberry dessert owing to the higher protein and total solids (%) than 1X and 2X. Protein curd mass (PCM) obtained after fermentation was further optimized for the incorporation of blueberry crush (BC) (PCM: BC::70:30, 80:20, 90:10), sugar (5%,10%,15%) and inulin (2%, 3%, 4%). Based on sensory analysis and rheological characteristics, PCM: BC with 80:20 ratio, 10% sugar and 4% inulin was optimized. Color values of high protein blueberry dessert were significantly ($p < 0.05$) affected with the addition of blueberry crush. The antioxidant activity (DPPH, FRAP) and total phenolic content of optimized blueberry dessert (OBD) were significantly higher ($p<0.05$) than control. OBD was subjected to in-package thermization. Under refrigerated storage, the non-thermized and thermized OBD were sensory acceptable till 14th and 28th day respectively.

Methodology for preparation of goat milk based high protein blue berry dessert

Process development for production of dipeptidyl peptidase-IV (DPP-IV) inhibitory peptides from milk of Gir cows and their encapsulation through double emulsification technique

Whey proteins were separated and its major protein fractions were isolated, the molecular weight of the fractions was confirmed through SDS-PAGE. Among the whey proteins (α-lactalbumin and β-lactoglobulin), pepsin-treated α-lactalbumin hydrolysates showed maximum DPP-IV inhibition of 87.81±0.84% (IC50 =0.78 mg/mL). The 3 kDa permeate, which exhibited 84.47±2.29% DPP-IV inhibition was fractionated through RP-

HPLC. All fractions were analysed for DPP-IV inhibition activity. One novel peptide [LKDLKGYGG (f31-39)] was identified through LC-MS/MS, which showed adequate DPP-IV inhibition (IC50 =4.93 mM). Among the caseins, kappa casein showed maximum DPP-IV inhibition (IC50 = 0.06 mg/mL). The double emulsion matrix was optimized and it was stable upto 25 days at 37°C. The confocal microscopy structure of the optimized double emulsion is given as figure. The animal bioassay revealed that the developed encapsulates of DPP-IV inhibitory peptides have effectively reduced the blood glucose level. Encapsulated hydrolysates (SDEH and EEH) and non-encapsulated hydrolysates (NEH) were found to decrease blood glucose levels significantly ($p < 0.05$) as compared to diabetic control rats.



1. Blue- Calcofluor White- Carbohydrates; 2. Green- Nile blue A- Inner water phase ; 3. Red- Nile Red- Oil Phase; 4. Simple microscopic Image; 5.. Mixed Channel Image (1X2X3X4); 6. Mixed Channel image (1X2X3). Magnification- 60X, Bar scale- 20 µm

Isolation of proline-rich polypeptides from colostrum of select indigenous cattle breed and evaluation of their nutraceutical potential

Colostrum was collected from 6 animals of Sahiwal, Gir, Deoni, Tharparkar, Holstein Friesian (HF), Karan Fries, HF cross breed in time-based manner and their compositional analysis has been completed. Holstein Friesan colostrum has higher total solids (30.07±0.71%) and protein (19.19±0.7) in the first colostrum, however, it rapidly reduces during subsequent milking. After 36 h of parturition (4th milking), the indigenous cattle breeds colostrum has higher TS and protein compared to HF. Proline-rich polypeptides (PRP) were isolated from 4 breeds (Sahiwal, Gir, Tharparkar and Karan Fries), among them Gir colostrum has maximum PRP content. The first milking colostrum has higher PRP content and it decreases with the subsequent milking, ~20% reduction was observed after 12 h of parturition. All other compositional parameters except lactose showed decreasing trend with increasing duration after parturition. The isolated PRP has been profiled through SDS-PAGE and RP-HPLC. PRP has molecular weight fractions of less than 10 kDa.

Application of nano-immobilized β-galactosidase for production of galactooligosaccharides from dairy by-product

The galactooligosaccharides (GOS) production ability of the β-galactosidase immobilized on mesoporous silicon dioxide nanoparticles functionalized by glutaraldehyde was assessed. The immobilization technique was developed by optimizing the conditions such as functionalization time (2h), immobilization time (1h) and concentration of enzyme (1mg). The immobilized enzyme showed better stability over broad range of pH (5-8) and temperature (30-70 °C). A decrease in Vmax and Km values (affinity towards substrate) of immobilized β-galactosidase for lactose was observed compared to free enzyme. The immobilized enzyme was characterized using FTIR and SEM analysis. The conditions such as concentration of enzyme (1%) and hydrolysis time (12h) were optimized for maximum GOS yield (20.16%). Overall, the immobilized β-galactosidase showed 5.5 times higher GOS production ability than free enzyme. The developed immobilization technique also enhanced GOS production ability of commercially available β-galactosidase enzymes by 2-15 times. It indicates that developed immobilization technique is widely useful for enhancing GOS production ability of the β-galactosidase enzyme

Extraction of phospholipids from ghee residue

Optimization of microwave assisted extraction conditions for extracting the phospholipids from ghee residue was carried out. The distilled water was used as solvent; microwave power, time and solvent to solid ratio were optimized for yield of phospholipids. Through Taguchi designed T9 orthogonal array, parameters were optimized to 540 W power, 60s of treatment time and 10 solvents to solid ratio for phospholipids yield. Whereas, 180W power, 40s treatment time and 10 solvents to solid ratio were optimal parameters for highest antioxidant activity. At optimal operating conditions, phospholipids yield was 21.84%. Optimization trials reported R^2 value of 97.04% with time and power playing significant effect on phospholipids extraction ($p<0.01$). With short extraction time, the study proved that microwave is having potential to assist in extraction of phospholipids from ghee residue. Scanning electron micrograph images of microwave treated samples showed significant damage to the surface of ghee residue with flaky features indicating mechanical action during assisted extraction. The extract contained phosphatidylcholine, phosphatidylinositol, phosphatidylethanolamine, phosphatidylserine and phosphatidylglycerol classes of phospholipids as obtained by liquid chromatography mass spectrometry. This technique has advantage of being an eco-friendly technique for extracting this valuable compound.

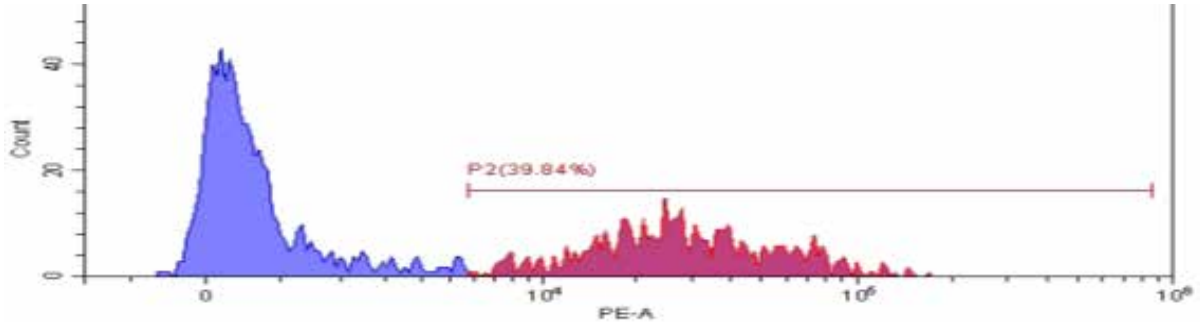
Extraction of phospholipids from ghee residue using pulsed electric field

The extraction conditions for phospholipids from ghee residue using pulsed electric field assisted technique were optimized using Taguchi L9 orthogonal array. The one factor at a time approach was used; levels of treatment were set at voltage (40, 50 and 60 kV/cm), time (3, 4 and 5 min.) and solvent to solid ratio (7.5, 10 and 12.5). Optimization study was carried in a concentric treatment chamber. Phospholipids yield was maximum at 60 kV/cm for 5 min. at 7.5 solvent solid ratio. The phospholipids reported at optimal treatment was 18.14% on dry fraction basis. Extract optimized for antioxidant activity indicated 37% radical scavenging activity by DPPH assay. At optimal level of factors, voltage and time significantly ($p<0.05$) contributed for phospholipids yield. Observation of treated ghee residue sample through scanning electron microscopy indicated partial destruction of surface structure. Detailed analysis of extract for phospholipids classes indicated presence of phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol by liquid chromatography and mass spectrometry.

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 solvent to solid ratio (5, 7.5 and 10 w/v). Using Taguchi optimization technique parameters were optimized to 540 W power, 60s of treatment time and 7.5 solvent to solid ratio for phospholipids yield. At optimized level of operation, the phospholipids yield was reported as 21.84% on dry fraction basis.

Antidiabetic effect of the β-casein hydrolysates: An *in vitro* assay

MIN6 cells were treated with β-casein hydrolysates of 3 kDa permeate at 0, 10, 20 and 30 mg/mL concentrations in presence of low (2.8 mM) and high glucose (16.7 mM). There was a significant ($p<0.05$) increase in insulin concentration with increase in peptide concentration in cells treated in presence of high glucose concentration (16.7 mM) But in presence of low glucose concentration (2.8 mM) there was non-significant ($p>0.05$) increase in insulin concentration with increase in peptide concentration. Pancreatic β-cells experienced more stress and stop functioning at higher glucose concentration, resulting in loss of ~33% cells due to apoptosis, however, DPP-IV inhibitory peptides rich hydrolysates treatment prevents the apoptosis in cells and only ~5% cells were apoptotic in presence of high glucose. This demonstrates the ability of the hydrolysates to protect the β-cells of the pancreas.



Nanoimmobilisation of β- galactosidase and evaluation of its effect on production of galacto-oligosaccharides

Generally, β-galactosidase suffers from loss of catalytic activity at high substrate concentration, instability to severe environmental conditions and no subsequent reuse. It can be overcome by immobilizing the enzyme on proper support materials. The enzyme immobilized on nanoparticles may have better activity and stability in a wide range of temperature and pH compared to free and micro-immobilized enzymes. In this regard, the present study was aimed to immobilize β-galactosidase on zinc oxide nanoparticles (ZnO NPs) and evaluate its effect on production of galactooligosaccharides. The glutaraldehyde, epichlorohydrin and aminosilane were used for activation of ZnO NPs before immobilization of enzyme. The parameters such as activation time, immobilization time and concentration of enzyme were optimized based on highest enzyme activity. The activation times of 1, 2 and 1 h were found optimum for glutaraldehyde, epichlorohydrin and aminosilane activators, respectively for activation of ZnO NPs. The immobilization times of 3, 1 and 2 h were found optimum for immobilization of β-galactosidase on ZnO NPs activated with glutaraldehyde, epichlorohydrin and aminosilane, respectively. The β-galactosidase concentration of 2, 2 and 6 mg was found optimum for immobilization on ZnO NPs activated with glutaraldehyde, epichlorohydrin and aminosilane, respectively. The optimized conditions were validated and compared between different activators; the epichlorohydrin method was found most suitable for activation of ZnO NPs as it showed highest enzyme activity and immobilization yield. The enzyme immobilization on ZnO NPs was confirmed and characterized through FTIR and SEM analysis. In FTIR analysis, protein bands were observed at 1350-1391, 1543-1565, 1635-1638 and 3280-3326 cm^{-1}. The intensity of bands increased with increase in the immobilization yield. The SEM analysis indicated that immobilization of enzyme increased the size of the ZnO NPs. The stability of free and nano-immobilized enzyme at various temperatures (30-70°C) and pH (5-8) with varying time (0-18 min) combination was determined. The activity of both free and nano-immobilized enzymes decreased with increase in the temperature and incubation time. However, the nano-immobilized enzyme showed more stability in comparison with free enzyme at all temperatures. At pH minima and maxima, the activity of both free and nano-immobilized enzyme was drastically reduced. The production GOS at different enzyme concentration (0.05-0.6%) and incubation time (0-8 h) was evaluated. The production of GOS was observed above 0.1% concentration of enzyme and samples treated with immobilized enzyme (at lower concentration) showed thicker GOS bands indicates higher efficiency of GOS production.

Fotification of flavoured milk with Moringa pod pulp powder

Added nutrients in the flavoured milk make it as a functional dairy beverage. Since the demand for functional food in the market is increasing, hence, in the present work Moringa based plant ingredient is prepared and used in flavoured milk formulation to augment its functional benefits. *Moringa oleifera* is a medicinal plant; every part of Moringa is shown to be significant importance towards human health and nutrition. In this study, Moringa pod (fruit)pulp powder wasprepared using four different drying techniques like freeze drying, micro-ovendrying, hot air oven tray drying and sun drying. The prepared ingredient was analyzed for both physicochemical and bio functional properties. Further, prepared functional ingredient was used in the formulation of flavoured milk. Among all the colour and flavor combinations, the chocolate flavor was found to be more sensorily acceptable. Fortification of Moringa pod pulp powder to milk did not affect the composition and sensory properties. The prepared product found stable for three months, and exhibited enhanced antioxidant, antihypertensive properties along with fibre enrichment. As a value-added dairy beverage, developed flavoured milk can serve as a promising fortificant for delivery of Moringa ingredients for improved bioavailability and functionality.

DEVELOPMENT AND VALIDATION OF HEALTH PROMOTING DAIRY FOODS

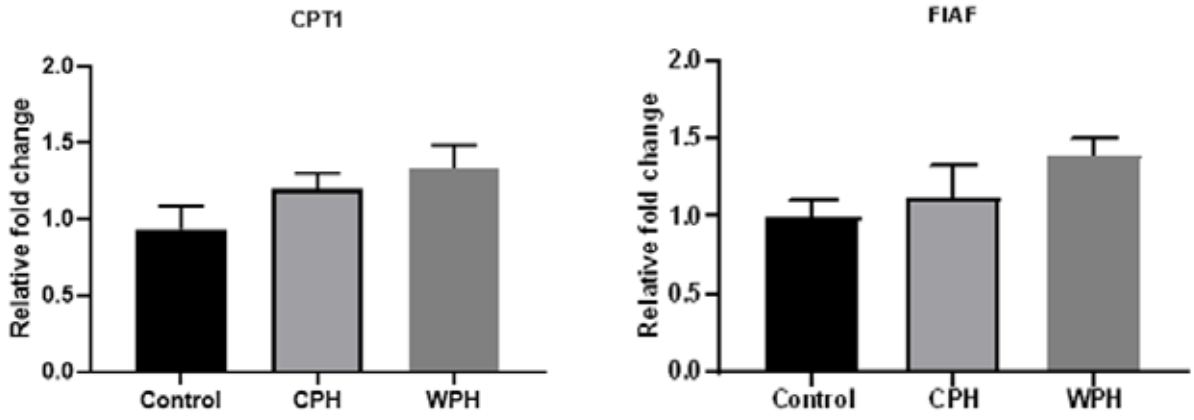
Anti-inflammaging attributes of probiotic *Lactobacilli* fermented goat milk

The aim was to assess the anti-immunosenescence/inflammaging effects of consumption of goat milk fermented with probiotic viz *Lactobacillus rhamnosus* 5957, *Lactobacillus rhamnosus* 5897 and *Lactobacillus fermentum*5898 in aging and inflammatory rats. In the inflammatory DSS model study, It was observed that when given a basal diet, DSS-induced colitis rats lost considerably more body weight than animal groups given probiotic fermented goat milk. While, compared to control (DSS) animals, the percentage phagocytosis, the phagocytic index and myeloperoxidase activity (neutrophils) of the peritoneal macrophages and blood neutrophils of probiotic treated rats exhibited considerably decreased activity. Along with this the relative mRNA expression levels for TLR-2, TLR-4, and CD-14 respectively, were significantly lower in peritoneal macrophages isolated from probiotic-supplemented rats than in DSS treated rats. The levels of the pro-inflammatory markers were markedly decreased by feeding either probiotic *Lactobacillus* fermented goat milk with *L. rhamnosus* or *L. fermentum*. As opposed to DSS-induced colitis animals, probiotic fermented goat milk consumption resulted in a significant decrease in *E. coli* levels in faeces.

In the rats (8 and 16 months old) administered with probiotic fermented goat milk demonstrated a substantial reduction in body weight compared to the animal groups fed a basal diet (BD). On the contrary, rats fed probiotic fermented goat milk showed significantly higher levels of phagocytosis and phagocytic index by peritoneal macrophages than did control (BD) aged rats in all the age groups. Similarly, rats fed probiotic fermented goat milk showed significantly higher levels of phagocytosis and phagocytic index by blood neutrophils than did control(BD) aged rats in all the age groups. The feeding of probiotic *Lactobacillus* fermented goat milk with *L. rhamnosus* and *L. fermentum* significantly increased the levels of IFN-γ while a concurrent significantly decreased in IL-4 level was observed as compared to BD (control) with ageing, suggesting a gradual shift towards Th1 response and weakened Th2 response. These pro-inflammatory markers, such as IL-4, IL-6, TNF-α, and MCP-1 together with IFN-γ, were considerably reduced in the intestines of all the age groups after receiving probiotic fermented goat milk. The results clearly depict the anti-inflammatory and anti-immunosenescence potential of probiotic fermented goat milk.

Antiadipogenic effect of goat milk casein and whey protein hydrolysate

Goat milk casein protein PTC hydrolysate (CPH) and whey protein PTC hydrolysate (WPH) at the concentration ranging from 50µg/ml-300 µg/ml exhibited antiadipogenic effect in 3T3-L1 cell line. WPH was significantly more effective in increasing the expression of *cpt1* and *fiaf* genes (genes involved in fatty acid transport and its oxidation) as compared to CPH and control.



Gene expression of CPT1 and FIAF in 3T3-L1 cell line

Development of direct vat set (DVS) probiotics for preparation of fermented milk products

Direct vat set (DVS) starters are concentrated form (10^{11}-10^{14} CFU/g), available in freeze-dried and frozen state used for preparation of fermented dairy foods. Investigations on compatibility of eight probiotic *Lactobacillus* strains, revealed best combinations of *Lactiplantibacillus plantarum* CRD7, *Lp. plantarum* HD48, *Lp. plantarum* HD51 with each other w.r.t. techno-functional, total probiotic counts, sensory and textural parameters for probiotic *dahi*. Significance difference (p<0.05) was observed in quality parameters of probiotic *dahi* prepared from mixed cultures as compared to single strain. Curd setting time (h), pH and titratable acidity (% LA) were found to be 14.33±0.02, 4.26±0.0, 0.72±0.00 and 8.71±0.01, respectively. Based on better compatibility of listed three *Lactobacillus* strains were selected for optimization of lyophilization conditions for probiotic DVS powder preparation. Six cryoprotective agents *i.e.* lactose, dextrose, mannitol, sorbitol, whey protein concentrate (WPC) and horse serum albumin (HSA) were assessed for their cryoprotectant ability to improve survivability of probiotic lactobacilli. Evaluation of probiotic DVS prepared with sugars at varied concentrations showed better techno-functional performance as compared to WPC and HSA. The cell survivability of probiotic selected *Lactobacillus* strains was found to be affected by the type and concentration of the cryoprotective agents. Inoculum level @0.002% (w/v) of three different lyophilized probiotic DVS was optimized for preparation of *dahi*. Observations on storage stability of probiotic DVS stored at -20°C and -4°C showed no significant difference in techno-functional performance upto six months. It is concluded that optimized lyophilized conditions for preparation of probiotic DVS starters using *Lactobacillus* strains *Lp. plantarum* CRD7, *Lp. plantarum* HD48 and *Lp. plantarum* HD51 could be utilized for preparation of health promoting fermented dairy foods such as *dahi*, *lassi* etc.

Production of EPSKar1-iron complex for enhancing iron bioavailability

L. rhamnosus Kar1 VTCCDM 314B derived EPSKar1-iron complex was investigated for stability, bioaccessibility and bioavailability of iron. EPSKar1-iron complex comprised of 53.65±0.04 mg EPSKar1, 44.26±0.14 mg iron and 2.02±0.02 mg moisture. The stability of EPSKar1-iron complex was above 90% between 4-7 pH which observed to be decreased to 63.44% at pH 2. At a temperature range of 50-70°C, the stability of the complex remained above 88%. In gastric simulated conditions, 49.45±1.20% of the iron was found to be bioaccessible as compared to control (34.99±0.52%). EPSKar1-iron showed significantly higher uptake of iron (61.27±1.96%) from the complex by Caco2 cells. EPSKar1-iron complex fed to anaemia induced rats for 20 days indicated that the iron from the complex was more bioavailability. Further, EPSKar1-iron fed rats exhibited higher levels of serum transferrin and organ ferritin than the control group.

Unveiling the microbial diversity of traditional Indian fermented milk product 'Dahi' through culturomic and metagenomic approaches

Integrated Omic approaches are widely used to understand the microbiome (microbial composition) of various econiches including gut and fermented milk products. These advanced techniques have been employed in the present investigation to study the bacterial profile of the traditional Indian fermented milk product '*Dahi*,' *widely* prepared by the traditional back slopping method. To decipher the bacterial profile of Dahi collected from different regions of India (Northern, Southern, Eastern and Western), metagenomics (16S Amplicon sequencing using the Oxford Nanopore technology platform) and culturomics (60 culturomics conditions using ten different media, three different atmospheric conditions and different temperatures) approaches were used. Dahi samples from the eastern region displayed the highest species richness compared to the samples collected from other regions of India. From the metagenomic data, a total of 10 bacterial phyla, viz., Firmicutes, Proteobacteria, Bacteroidetes, Actinobacteria, Cyanobacteria, Tenericutes, Deinococcus, Thermus,

Ignavibacteriae, Spirochetes and Fusobacteria, were selected for the comparative analysis. Firmicutes (most of which have a Gram-positive cell wall structure) appeared as major phyla in all the *Dahi* samples collected from different regions. However, a higher abundance of proteobacteria was recorded in *Dahi* samples collected from southern India. At comparative analysis at genus level, Limosilactobacillus, the genera associated with the production of exopolysaccharides from sucrose, were found comparatively higher in the *Dahi* samples collected from Eastern India. In the culturomics approach, again, Limosilactobacillus emerged as the major genera associated with EPS production in Dahi samples. Both culturomics and metagenomics approaches revealed the prevalence of lactic acid bacterial genera such as Lactobacillus, Streptococcus, Lactococcus and Leuconostoc in Dahi samples, besides recording Enterococcus, Aerococcus, Staphylococcus and Bacillus as major environmental contaminants. From the data that emerged from the study, it is quite clear that both metagenomics and culturomics are highly complementary approaches and both can push forward the field of microbiota research in the field of traditional fermented milk products.

Propidiummonoazide assisted real time PCR-based assay for rapid quantification of probiotic *Lactobacillus spp.*

Molecular techniques, particularly quantitative real-time PCR (qPCR), have significantly overcome the limitations of traditional methods and can now be used in a wide variety of dietary matrixes, including fermented probiotic dairy products. However, the differentiation of dead and live cell DNA is not possible with qPCR, which can be overcome by coupling it with propidiummonoazide (PMA). Hence, in the current study, a PMA-qPCR assay has been developed for the quantification of probiotic lactobacilli. The developed assay was able to quantify the viable cells of probiotic *Lactobacillus* spp. from the assortment of live and dead probiotic bacteria. With the standardized DNA extraction procedure, the developed assay was able to yield very similar results with that of conventional method. On comparison, the developed PMA–qPCR-based assay was found sensitive, less biased, repeatable, reproducible, user-friendly with accuracy of 86-91% and precision of 2-3% for the quantification of probiotic *Lactobacillus* spp. in probiotic dairy products. Hence, the developed PMA assisted q-PCR based assay could be an appropriate alternative to the existing time-consuming and laborious conventional methods for routine monitoring of probiotic count in probiotic dairy products at the designated threshold level prescribed by Food Safety and Standards Regulation (FSSR).

NMR (H1) Spectroscopy based metabolomics of the prebiotic fermentation by *Lactobacillus* and *Bifidobacterium* strains

Initially, the Gut media was standardized for optimal growth of both the bacterial types (*Lactobacillus* and *Bifidobacterium*). The growth curve was then plotted to finalize the sampling point (12 hours- early stationary phase) for the cultures. The six cultures were then grown in test carbohydrate (xylan) with two standard prebiotics (inulin and FOS). All the strains (along with their co-culture) utilized xylan efficiently (pH drop and counts increase at par with inulin). For the NMR metabolomics, the NMR machine and the D_2O buffer were initially standardized with only the carbohydrates. The samples were then run in NMR and the obtained spectra were then corrected by topspin and quantified by AMIX. The AMIX files were then processed for Chemometric analysis by Metaboanalyst. It was observed that the metabolomic profile of xylan fermentation was similar to inulin but different to FOS. In the PCA and ANOVA analysis (from Metaboanalyst) *L. gasseri* showed 12 significantly up-regulated phase bins [3 metabolites at CS 2.185, 1.175 (isobutyrate) and 1.345 (lactate)]. *L. paracasei* showed 9 significantly up-regulated phase bins [3 metabolites at CS 1.175 (isobutyrate), 2.185 and 0.175]. *L. plantarum, B. animalis*, *B. bifidum* and *B. longum* showed 21, 37, 17 and 54 significantly up-regulated phase bins. In the co-culture experiment, 57 significantly up-regulated phase bins were detected corresponding to lactate, acetate, ethanol and an unknown metabolite at CS 2.185.

Buffalo colostrum proteins derived formulation for diarrhoea treatment in weaning mice

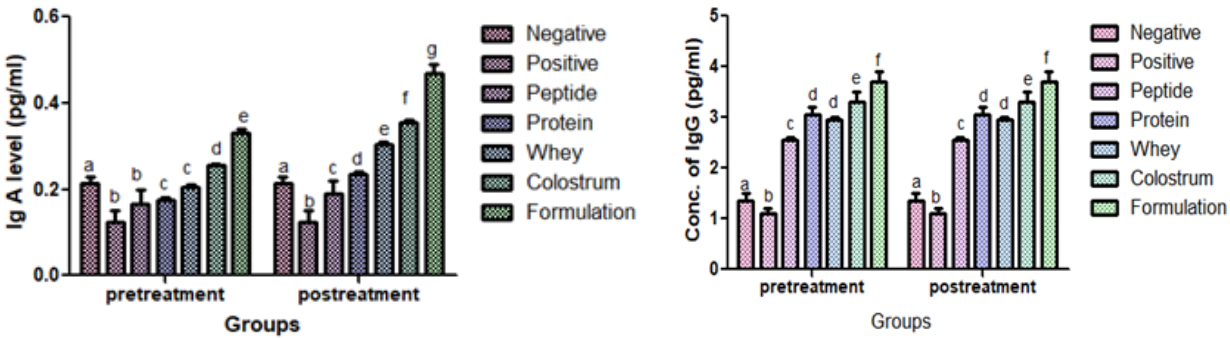
colostrum whey fermentation by proteolytic lactobacillus cultures generated peptide fractions (10 kDa, 5 kDa and 3 kDa) of 8.5 mg/ml. Smaller than 100 kDa protein fractions showed a significantly ($p<0.05$) immunomodulatory effect i.e., % phagocytosis activity (55.02±0.07). Whereas, smaller than 10 kDa peptide fraction showed maximum antimicrobial activity against all pathogenic *E. coli* strains with the MIC concentration of 4.06 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 that 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 and histopathological examination showed recovery of villi in the formulation feeding group. IgA and IgG were also significantly higher 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 were helpful in managing diarrhoea caused by diarrheagenic *E. coli* in immunocompromised mice.

a. Colostrum

b. Bioactive proteins

c. bioactive peptides

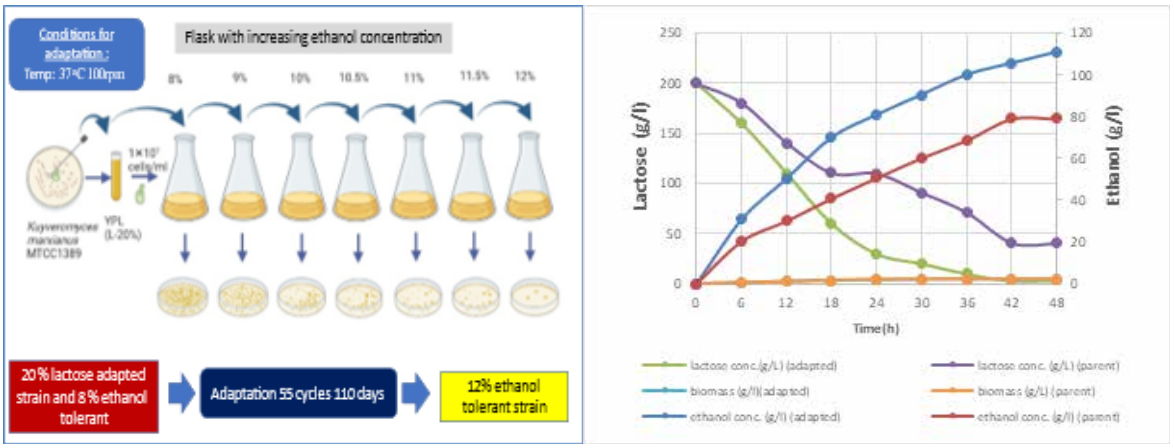


IgG and IgA level

Adaptive evolutionary engineering of *Kluyveromycesmarxianus* for high ethanol tolerance

Kluyveromyces marxianus has several benefits over *Saccharomyces cerevisiae* with respect to thermotolerance and the capacity to convert lactose to ethanol and several sugars. Currently, *K. marxianus*'s weak ethanol tolerance makes it unsuitable for industrial use and more research is needed to increase its ethanol resistance and understand the underlying systematically mechanisms. Therefore, the adaptive evolutionary engineering technique was used to increase ethanol tolerance of *Kluyvkromyces marxianus* MTCC1388. The lactose adapted strain was able to produce 78.33±0.88 g/L in 46 hr of fermentation with residual lactose 41±0.28 g/L, its ethanol tolerance was 8% (v/v). Adaptive evolution, a sequential transfer with increase in ethanol stress, was done for 110 days to improved ethanol tolerance to 12% (v/v). Ethanol production in this adapted strain was 110.51±0.87 g/L in 46 h which was 42.9% higher from parent strain. Specific growth rate was also enhanced from 0.043 h^{-1}, 0.049 h^{-1} in adapted strain. In serial re-pitching of strain there was no significant reduction of ethanol production up-to 5 cycles. The strain was found stable up-to 10 cycles of subculturing in low sugar medium. The yeast strain was multi-stress tolerance for oxidative, thermal, osmotic, ethanol stress as compared to parent strain. Relative gene expression of ethanol tolerance gene was upregulated in ETP1 (2.5 folds) and ADH6 expressed (1fold), osmotic stress Gene were upregulated SLN1 (3 folds) and thermal stress responsive gene HSF1 and MSN2 were upregulated under ethanol stress condition. Ergosterol concentration under ethanol stress was

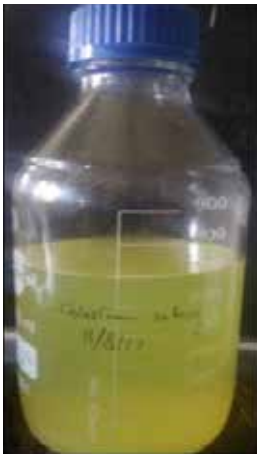
significantly higher in adapted strain while Heat shock protein and Trehalose concentration decreased under ethanol stress condition. The adaptation of *K. marxianus* MTCC1389 to high ethanol concentration enhanced its ethanol tolerance to 12% (v/v) that yielded 42.9% higher ethanol than lactose adapted strain. Its pre-adaptation to multiple stresses made it suitable for economical ethanol production.



Ethanol production by ethanol adapted strain of K. marxianus MTCC1389

Evaluation of immunomodulatory effects of bioactive peptides rich whey drink in animal model

Colostrum whey was fermented with *Lacticaseibacillus rhamnosus* C-25 to produce bioactive peptides. Bioactive peptide ingredient (BAPI) showed good antimicrobial activity against pathogens. Lowest MIC of 4.4±0.29 mg/ml was observed against *B. cereus* and highest MIC of 66.5±0.17 mg/ml against *S. enterica*. Two types of fermented whey drinks- Paneer-whey drink (PWD) with added BAPI (*L. acidophilus* 195 @ 2%, 37°C/ 24h) and Colostrum-whey drink (CWD) with in-situ production of BAPI (195+C-25, 2:1, 37°C/ 48 h) was prepared. All the whey drinks showed good antioxidant activity. Among which CWD showed highest % scavenging of 85.5±90.4. 10KDa BAPI and prepared whey drinks (PWD1(10% BAPI), PWD2 (20% BAPI), CWD 1(10 times MIC), CWD 2(20 times MIC), were checked for immuno modulatory activities in mice models against one normal control and infected model group. Mice were given treatments for a period of 7 days via oral gavage. The mice were challenged with *E. coli* ATTC 723 for 3 days and sacrificed on 15th day. Both CWD showed good phagocytotic activity of 46.88% and 46.89%. Blood serum collected from animals of each group were analysed for ALT/ AST, Blood cholesterol, Triglycerides, IgA, IL-10 and TNF-α. CWD groups increased anti-inflamatory cytokines such as IgA (534.5±1.00 µg/ml) and IL-10 (968±0.01 pg/ml) levels and decreased pro-inflamatory TNF- α levels compared with model group. CWD2 fed mice group significantly reduced ALT/AST levels in serum (12.80±0.64 & 4.66±0.58 U/L respectively. CWD2 showed good lactobacillus translocation in large intestine and significantly decreased *E. coli* levels in the same. Protein-rich fermented colostrum whey drink with in-situ production of BAP as well as BAP ingredients may be used for immune modulation.



Fermented colostrum ingredient

Whey 10 kDa permeate

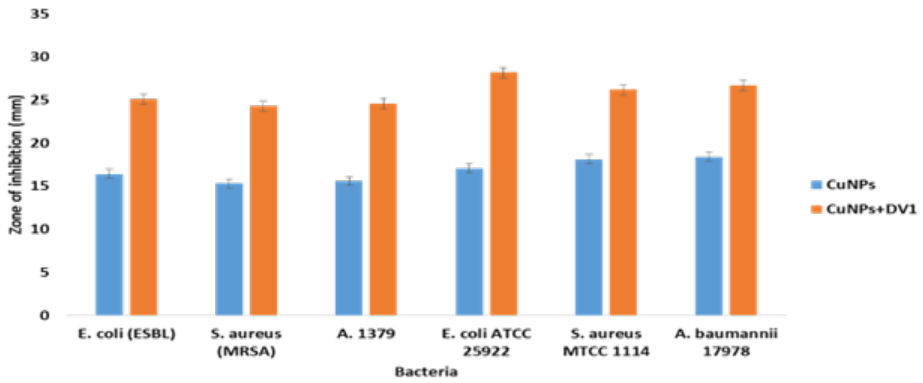
Bioactive peptide

Shelf-life enhancement of pasteurized milk using whey derived antimicrobial bioactive peptides

Proteolytic *Lacticaseibacillus rhamnosus* C25 was used for fermentation to generate the whey proteins-derived bioactive peptides. Colostrum whey and WPC mixture were fermented with the C25 culture @ 2% inoculum levels for 48 hours and 10 kDa bioactive peptides were separated. Upon fermentation, the protein content of colostrum whey and WPC decreased from 6.97±0.50 mg/ml and 9.19±0.09 mg/ml to 5.33±0.64 mg/ml and 4.80±0.15 mg/ml, respectively. The peptides content increased from 0.95±0.04 mg/ml and 0.56±0.04 mg/ml to a range of 1.23±0.06 mg/ml and 1.08±0.04 mg/ml for colostrum whey and WPC, respectively. The 10kDa bioactive peptides showed antimicrobial activity against a wide range of organisms. The peptide content of 10kDa fractions of colostrum whey and WPC was found to be 0.86±0.02 mg/ml and 0.70±0.06 mg/ml, respectively. Both the 10kDa fractions of colostrum whey and WPC showed antimicrobial activity against all tested spoilage and pathogenic organisms with MIC of highest 66.6±0.18 µg/ml for *B. licheniformis* and 27.3±0.3 µg/ml for *B. megaterium,* respectively. The peptides were stable at heat treatment of 80°C for 10 mins. Bio-preservation of pasteurized milk was done by adding the peptide at a rate of 400µg/ml which is 6 times the MIC of most resistant organisms. The bioactive peptide added at a rate of 400µg/ml of milk showed good sensory values and overall acceptability above 8. The shelf-life of pasteurized milk was enhanced to 9 days and 8 days at 7°C by Colostrum whey peptides and WPC peptides, respectively, while the control milk was spoiled on the 6th day. Hence, it may be concluded that whey-derived antimicrobial bioactive peptides may be used to enhance the shelf-life of milk. Furthermore, there is a need to explore the bio functionality of milk supplemented with antimicrobial peptides.

Role of colostrum whey-derived potent functionalized antimicrobial peptide against antibiotics resistant pathogens

Resistant bacteria can develop a resistance to antibiotics due to overuse or misuse. They can cause serious infections that are difficult to treat and may even be resistant to all available antibiotics. Food grade peptides and copper nanoparticles show promise in fighting these bacteria as they can attack a wide range of bacteria and have a lower risk of causing resistance. In recent studies, conjugated peptide-copper nanoparticle combinations were prepared to combat antibiotic-resistant bacteria. These hybrid materials showed synergistic effects, with the copper nanoparticles enhancing the antimicrobial properties of the peptides. The highest inhibitory zone of synthesized peptide fraction was against *B. cereus* ATCC 13061 (26.13 mm), *E. coli* ATCC 2592 (24.66 mm), *E. faecalis* ATCC 27736 (23.56 mm), *S. aureus* (21.66 mm) and *A. baumannii* (23.11 mm). Isolated conjugated AMPs-CuNPs exhibited the highest antimicrobial activity against clinical isolate of antibiotic-resistant *E. coli* (ESBL) (Extended-spectrum beta-lactamases) (27.63 mm) *S. aureus* (MRSA) (26.54 mm) and *Acinetobacter* 1379 (24.73 mm). It was found that a conjugation of a colostrum whey-derived peptide and copper nanoparticles was effective against a range of drug-resistant bacteria, including MRSA (methicillin-resistant *Staphylococcus aureus*).

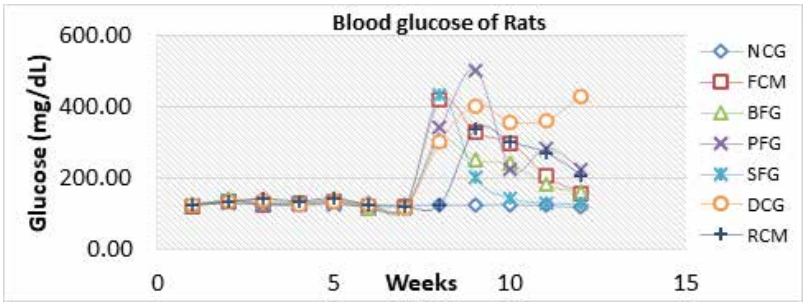


Colostrum whey-derived potent Antimicrobial peptide conjugated-copper nanoparticle against antibiotics resistant pathogens

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. Total 188 strains of lactic acid bacteria have been isolated from camel milk.

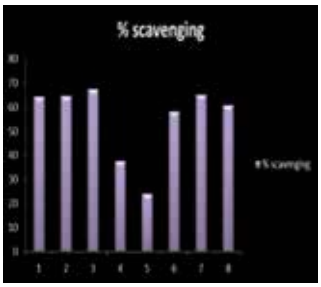
Among them, only 23 were selected on the basis of primary screening and proteolytic activity. Three isolates RL4 (*Lacticaseibacillus rhamnosus*), RZ18 (*Lactiplantibacillus argentoratensis*), LG12 (*Lacticaseibacillus rhamnosus*) were identified by 16s rRNA and submitted in NCBI GeneBank. These strains also have good antioxidative, α-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*). In-vivo study has been done which shows significant decrease in blood glucose in type-II diabetic male wistar rats. [CG=Negative Control Group, FCM=Fermented Camel Milk, BFG=Bacteria Fed Group, PFG=Peptide Fed Group, SFG=Sitagliptin Fed Group, DCG=Diabetic Control Group and RCM=Raw Camel Milk].



Preparation of bio-functional 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 were 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.

Fermented Product

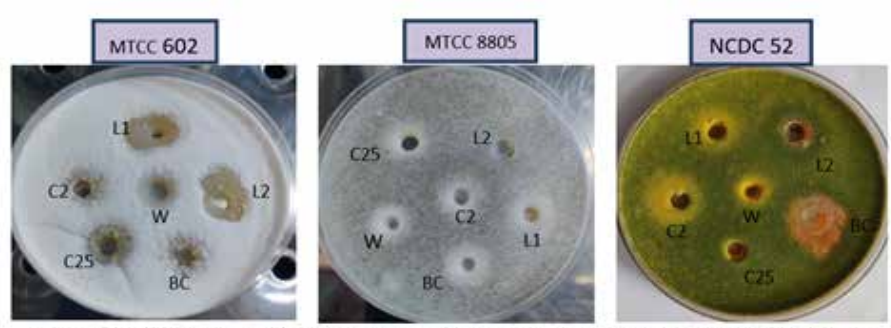


Anti-oxidative Activity

Anti-microbial Activity

Antifungal potentials of cow colostrum whey-derived lactoferrin rich fermentate preparations against mucormycosis causing molds

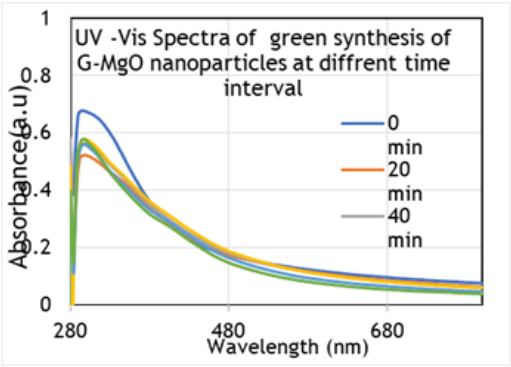
Gir cow colostrum was collected from the Cattle Research center on the first day of calving and defatted. Lactoferrin was isolated using cation exchange chromatography. The colostrum whey was heated at 55^{0}C for 30 min and fermented with *Lactiplantibacillus plantarum* C2 and *Lacticaseibacillus rhamnosus* C25 @ 2% for 48 hours at 37 C and >50 KDa and <50kDa fractions were separated using molecular ultra-filtration. Some convenient and efficient *in silico* tools were used to identify and predict peptides from LC-MS/MS data as an antifungal peptide sequences in *Lactiplantibacillus plantarum C2* and *Lacticaseibacillus rhamnosus* (C25) in 50kDa fractions. The peptide sequences SSGFLSIEWQNPR, QIYQTYGFLPSR, MPCAEDYLSLILNR, VEIIANDQGNR, EPVLGPVRGPFP were predicted to possessantifungal activity. The isolated lactoferrin and lactoferrin-rich fermentate 50kD aretentate showed antifungal activity of mucormycosis strains i.e., *Rhizopusoryzae* NCDC 52, *Rhizopus homothalicus* MTCC 602, *Apophysomyces elegans* MTCC 8805, *Mucor microspores* MTCC 10574, *Rhizopus microspores* MTCCC 10711 by agar well diffusion assay in which *Mucor microspores* MTCC 10574 and *Rhizopus homothalicus* MTCC 602 were most susceptible and *Apophysomyces elegans* MTCC 8805 was least susceptible.

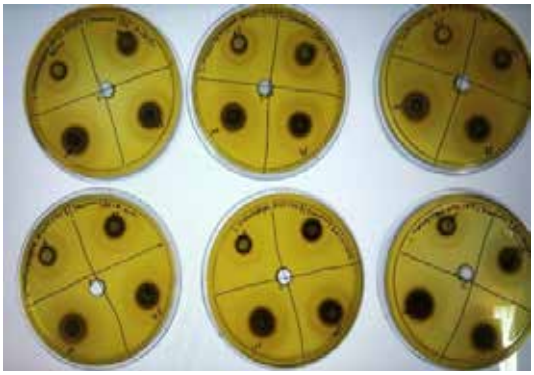


Zone of inhibition by antifungal agents agaisnt test mold cultures (C25- C25 fermentate prepration 50 kDa, C2-C2 Fermentate prepration 50 kDa, L1 &L2- Isolated lactoferrin, W-whey 50 kDa R, BC- buffalo colostrum fermentate prepration 50 kDa)

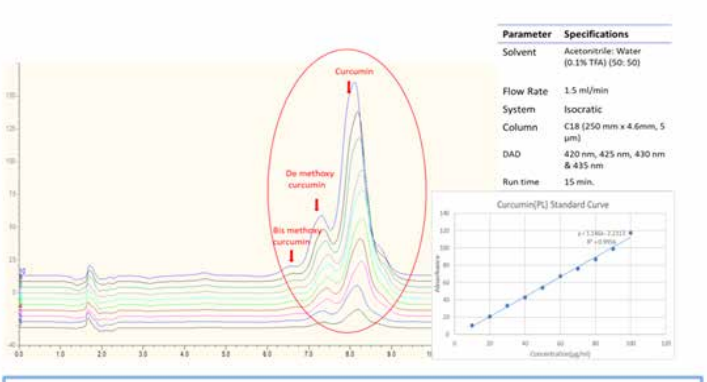
Quorum quenching potential of green nanoparticles to inhibit biofilm formation by *Listeria monocytogenes* on food contact surface

Dairy industries face a problem of pathogenic bacteria biofilm development on food contact surfaces. The biofilm development is controlled by chemical singling and strong signals make it very robust for the chemical to remove from surfaces. The project was initiated with the idea to target this signal molecule with help of green synthesis nanoparticles. Hence, local plant leaves were selected for research. The plant leaves were authenticated and jamun leaves were selected on basis of their antimicrobial activity (*L. monocytogenes* ATCC 19118 at 100 mg/ mL-25 mm; *L. monocytogenes* ATCC 35152 at 100 mg/ mL-24 mm), phenolic content (201.72 mg/GAE g) and flavonoid content (115.63 mg/ QUE g) which found high among the selected plant leaves. The green synthesis of nanoparticles with jamun leaves was performed and nanoparticles were formed in 2 hours. The formation was confirmed by UV-Visible spectroscopy range of 290-320 nm and further validated by a published literature.





Standardization of a HPLC based method for estimation of Curcumin in milk matrix



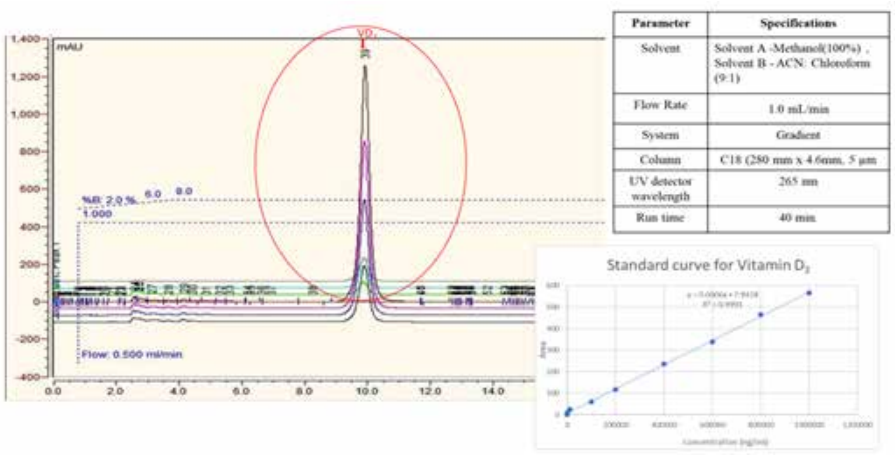
RP-HPLC chromatogram of **Curcumin** standard at different concentrations

Optimization of a method for estimation of Curcumin in milk matrix using RP-HPLC was standardized. The separation of curcumin was achieved using RP-HPLC under isocratic conditions using acetonitrile and water - 0.1%TFA (1:1ratio) at 1.5 ml/min flow rate over run time of 15 min on C18 column. The elution of peaks

corresponding to curcumin and its derivatives were observed in chromatogram between 6.8 to 8.4 min. The retention time of major peak corresponding to curcumin was found at 8.2 min.

Standardization of a HPLC based method for estimation of Vitamin D3 in milk

A HPLC based method was optimized for estimation of Vitamin D3 in milk using RP-HPLC. HPLC conditions for the estimation of VD_3 have been optimized. Cholecalciferol (Sigma) was optimised by using solvent gradient (Methanol—Solvent A and Acetonitrile—chloroform [9:1]—Solvent B) at a flow rate of 1.0 ml/min at 265nm using C18 column over 40min run time. The major peak of VD_3 was observed at 10 min of retention time.



Parameter	Specifications
Solvent	Solvent A -Methanol(100%) , Solvent B - ACN: Chloroform (9:1)
Flow Rate	1.0 mL/min
System	Gradient
Column	C18 (250 mm x 4.6mm, 5 µm
UV detector wavelength	265 nm
Run time	40 min

RP-HPLC chromatogram of **Vitamin D_3** standard of different concentrations

Preparation of whey protein-maltodextrin Conjugate based nanoemulsion for Vitamin D3 and Curcumin

The process for the preparation of whey protein—maltodextrin (WP-MD) conjugate was optimized. The whey protein concentrates and maltodextrin in the ratio of 1:2 was heated at 60°C for 60 min at pH 7.0 to get the WP-MD complex. The degree of glycation corresponded to 25.83 ±3.19% and the formation of conjugate was confirmed by the SDS—PAGE, FTIR and RP-HPLC analysis. The prepared complex showed excellent emulsifying properties. Further, the conjugate will be evaluated as coating material for the encapsulation of bioactive components.

New Initiatives (during 2022) – NASF Project *"Development of nano-micro matrices for the delivery of bioactives, micronutrients and therapeutics".*

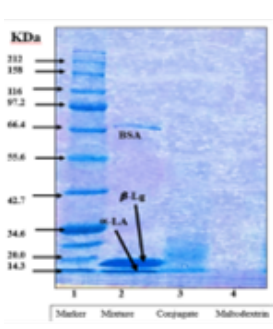


Fig no. 1 SDS-PAGE

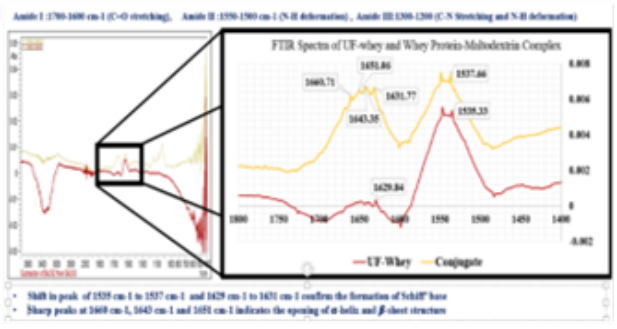


Fig no. 2 FTIR spectra

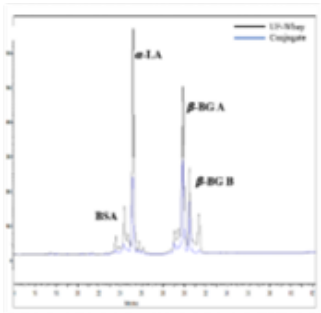


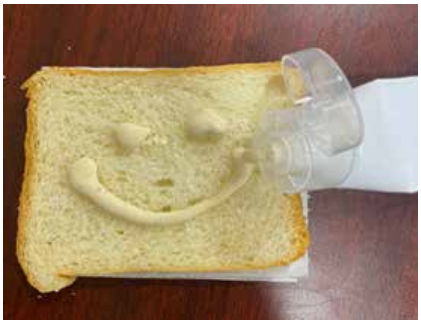
Fig no. 3 RP-HPLC

Characterization of whey protein-maltodextrin conjugate

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. Storage study was conducted for the sorghum incorporated probiotic dairy spread packed in two different packaging materials viz. PS cups and laminated flexi tubes (PE/AL/PE) and stored at 5±1°C. The scores for overall

acceptability of the product packed in flexi tubes remained above 8 on 9-point hedonic scale even after 60 days of storage period. Whereas, the product packed in PS cups secured the overall acceptability score of 7.4 on 60th day of storage. The viable probiotic count of the product packed in PS cups and flexi tube decreased significantly ($P<0.05$) to 8.24 and 9.16 log10 cfu/g on 60th day of storage at 5±1°C, respectively. Consumer acceptability study was done by using questionnaire. It was evident from the consumer acceptability study that, 99 per cent of the total respondents liked the product with 54 per cent rated the product as excellent. Majority (74 %) of the respondents showed their willingness to buy the product if available in the market. Hence, the product can have a very good market potential.



Development of ghee residue incorporated dairy spread

A study was conducted to optimize the formulation and processing conditions of ghee residue incorporated dairy spread. Levels of ghee residue (10-20%), chhana (10-15%), butter (15-25%), whey powder (8-12%) and sodium tripolyphosphate (STPP) (0.5-1.5%) were optimized using I- optimal mixture design. Sensory scores, pH, acidity, total solids and textural parameters of the spread were recorded. The polynomial models fitted well to sensory and textural parameters with R2 values in the range 0.70 – 0.86. The optimized formulation of the developed dairy spread has a desirability of 0.89. After formulation optimization, the processing parameters were optimized using response surface methodology. Cooking time, homogenization speed and mixing time varied from 2-5 min, 10000-20000 rpm and 1-5 minutes, respectively during optimization. The overall sensory acceptability increased with increasing speed of high shear mixer. Upon optimization, the desirability for the obtained solution was 0.91, which was further validated by comparing the predicted and actual values. The optimized product recorded 52.34% moisture, 22.49% fat, 5.86% protein and 2.1% ash content with a storage life of 30 days at refrigeration temperature. Further, the study revealed wider acceptance at consumers for this product. Thus, it can be concluded that a sensorially acceptable dairy spread could be successfully developed using ghee residue as an ingredient.

MECHANIZATION AND PROCESS ENGINEERING

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 (Oat straw, Wheat straw and concentrate mixture, 455.03±11.52, 40.42±1.76, 504.25±1.82, respectively) and moisture content (Oat straw, Wheat straw and concentrate mixture, 64.27±11.45, 12.07±0.88, 11.74±0.71, respectively) for all three selected feed material were determined.

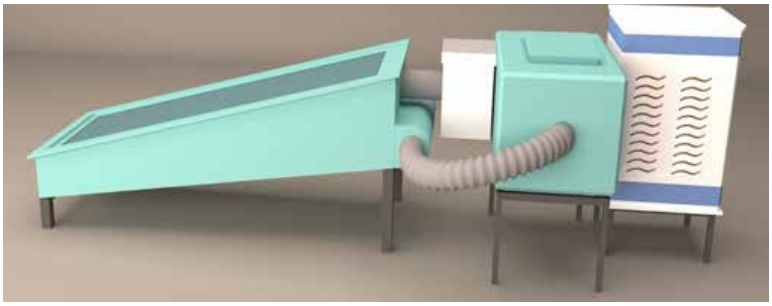
Equipment for measuring angle of repose and coefficient of friction of fodder

Two green fodder wagons and one grain wagon were selected for centre of gravity determination. Centre of gravity was determined at empty feed condition. The position of centre of gravity behind front wheel axle (X_{CG}), above the ground level and midway between the wheels (Y_{CG}) and height of centre of gravity from the line joining the front and rear axles (Z_{CG}) were determined.

Development of automatic integrated hybrid solar system for fermented dairy products

Advanced controller unit was integrated with the system to utilize solar energy as well as electrical energy in absence of sunlight. Evaporative cooling technology was employed for pre-cooling after incubation. Performance evaluation trials were conducted using solar convective heating, electrical heating and with or without pre-cooling of curd cups. Temperature profiles with time during the day were found inside the solar collector unit and the incubation cabinet without temperature controller and found that a maximum of 70 °C and 48 °C could be achieved inside the collector unit and thermal cabinet. Temperature difference between collector plate and hot inlet air to the cabinet and also the temperature gradient between trays were plotted w.r.t. time. Almost similar desired temperatures could be maintained in the curd cups placed in different trays. For performance enhancement of unit in terms of getting a suitable air velocity field and air temperature distribution inside the cabinet, CFD analysis was done in the ANSYS software. A detailed thermal analysis became possible with the CFD analysis and simulation.

3D - CAD drawing of automatic integrated hybrid solar system



Automatic integrated hybrid solar system & 3D Diagram of Complete Setup

Development of multipurpose automatic controlled rate heating system for production of paneer and Greek yoghurt

The fabrication work of prototype multipurpose automatic controlled rate heating unit (20 and 50 kg capacity) was accomplished. Agitator was integrated in the system for more uniform heating. Heating and cooling pattern of milk (20 - 50 kg) was studied for 3 paired and 5 paired heaters.

Multipurpose automatic controlled rate heating unit

Milk was heated to 90°C by using 3 paired and 5 paired heaters and cooled to 37°C using air and tap water as a cooling medium. The heating and cooling patterns of milk were found linear trend. Heating time and cooling time was observed to be increased for 20-50 one capacity for 3 paired heaters and 5 paired heaters. Proportional increment is observed in Heating Rate for 3 paired heaters and 5 paired heaters i.e. 1.32-0.57°C/min for 20-50 one capacity. Inverse relation between Cooling Rate and different pairings for different capacities is observed 0.88- 0.61°C/min for 20 to 50.

Uniformity in heating and cooling of milk was observed with low average temperature gradient values. There was no tinge of the fouling in the milk by using the agitator. Localized heating on the surface of the vessel was reduced because agitator helped in proper mixing and better distribution of heat in the complete vessel. Performance coefficient of the system was found to be low for lower capacity and increase towards higher capacity and further it can be increased by providing proper insulation. The controlled heating rate and agitator speed had significant effect on temperature profile during heating and cooling of milk and reduces the fouling problem.

Development of improved bioreactor prototype for cattle waste management

aNSYS 3D design software was successfully applied for computational fluid dynamics (CFD) modeling and simulation of bioreactor prototype. The step by step approach was used to formulate the flow problem, model the geometry, explore flow domain and to establish the boundary and initial conditions. Mesh grid was generated and on the basis of inputs, CFD simulation was carried out. Bioreactor setup was designed and fabricated. After preliminary trials, necessary modifications were made in the water circulation system. An induction motor was connected to the rotor assembly using a coupling. The motor speed was effectively controlled using solid state

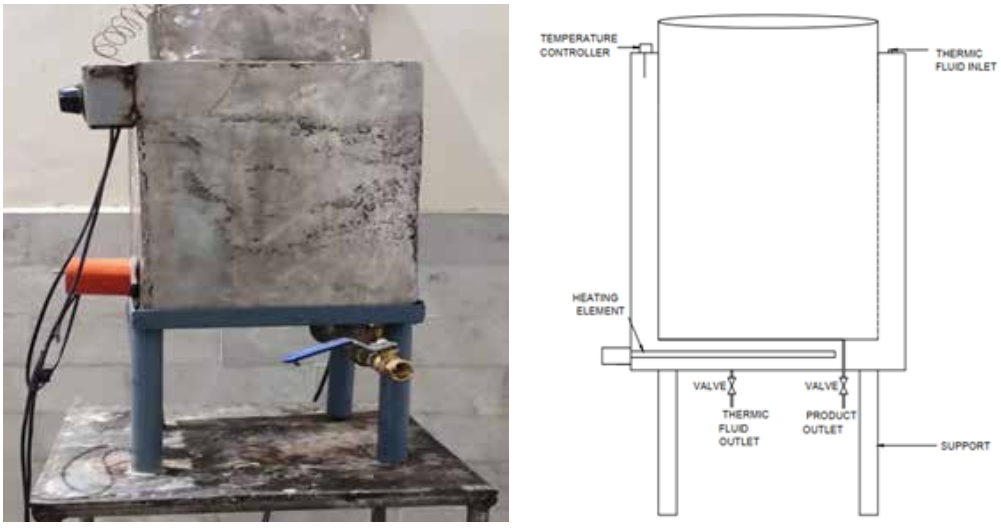
variable speed controller. During preliminary trial need was felt to set the shaft alignment. Modifications were made for proper alignment and smooth operation of the rotor blade assembly. The rotor blade assembly was redesigned to reduce the total weight of the assembly, making use of low horse power (hp) motor possible.

Bioreactor prototype

During performance evaluation manure: water ratio was kept as 1:1. The slurry pH was in the range of 6.9-7.4 with agitation. While in the control without agitation pH varied from 6.8-7.3. Maximum daily biogas yield was 0.017-0.022 m^3. Total biogas generated was 0.3 m^3 and 0.24 m^3 with and without agitation, respectively. Periodic agitation helped to improve methane content of the biogas from 61.3 to 65.3%.

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 thermic 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.



Fabricated prototype for studying heating pattern of thermic fluid

Development of magnetic induction based milk heating system for Paneer

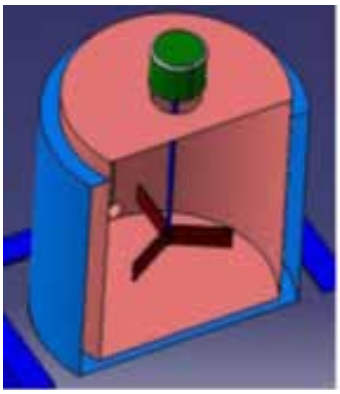
Magnetic induction heating (MIH) is an electromagnetic heating method which can be efficiently utilized in dairy and food processing. The quality of milk, heated in a laboratory-scale batch-type MIH system, was evaluated. The MIH unit mainly consisted of an electrical circuit, an induction coil and a sample holder.

Laboratory scale batch-type MIH unit

Each trial was conducted with 400 ml milk. Milk was heated to temperatures ranging from 10°C to 90°C using seven different adjustable induction powers such as 500 W, 800 W, 1000 W, 1300 W, 1600 W, 1800 W, and 2000 W. Effect of induction powers on total heating time was analyzed. Heating time showed a gradual decrease with the increase of induction power. The chemical (acidity, fat, SNF, protein, phosphatase test) and microbiological tests (MBRT, SPC, coliform, yeast, and mould count) were performed after heating the milk to 90°C. It was observed that fat, SNF, and protein were statistically at par before and after heating, whereas other parameters varied significantly ($p<0.05$) depending on the applied induction power.

Development of inline milk coagulation cum coagulum pressing unit for paneer manufacturing at small scale

An inline milk coagulation cum coagulum pressing unit consists of different components i.e. milk coagulation unit (heating cum coagulation tank), whey separation unit, milk coagulum pressing unit (pneumatic pressing unit), an automatic control unit, accessories and supporting frame. The heating cum coagulation tank was designed based on the principles of a batch mixing tank with provision for heat exchange through external jacket and fabricated. The unit was comprised of an inner cylindrical vessel, jacket vessel, insulated outer cylinder, agitator and heating elements.



Cut section view

Solid model view

Milk coagulation unit (heating cum coagulation tank)

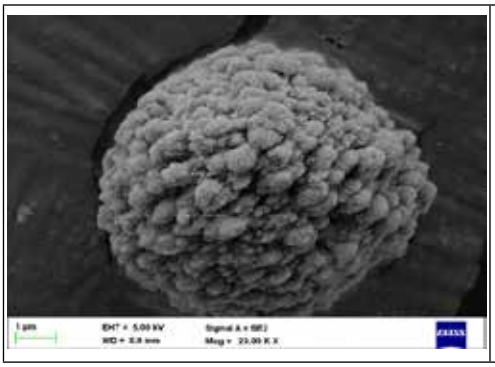
Water was selected as heating and cooling medium in the jacket space and heated to the desired temperature through a heater placed in the jacket. The regulation of the milk temperature in the inner vessel during heating

and cooling processes would be achieved using suitable thermocouple attached to temperature controller so as to heat and cool the milk to the set temperature within the range of ±1°C. For cooling process, externally normal tap water could be added in the jacket space. The milk coagulum pressing unit (pneumatic pressing unit) was fabricated. It consists of a jacketed rectangular shaped module having whey drainage facility, pressure gauge, solenoid valve and pneumatic cylinder for automatic pressing and its process was controlled by automation.

In order to drain the whey from coagulum of milk coagulation unit prior to the milk coagulum pressing unit, a whey separation unit was under fabrication.

Microencapsulation of phase change materials for thermal buffering applications

A major concern while employing PCMs directly, is the potential risk of leakage that could occur during the phase change, leading to contamination and induction of certain undesirable reactions. To eliminate this risk, microencapsulation of the PCM in a suitable stable shell material using self-assembly technique was employed. The process protocol used calcium carbonate at the shell material to contain the phase change within the shell.



	Total 100	C	O	Ca
ME-PCM	Weight %	45.28	33.62	21.10
	Atomic %	58.93	32.84	8.23

SEM analysis of the obtained encapsulates confirmed the spherical morphology formed during the process and EDX data from the XRD peaks at 26.9° confirmed the presence of Vaterite structure of the formed calcium carbonate shell and 29.2° confirmed the Calcite structure of the shell material formed during the process. FTIR characterization studies revealed peaks at 718 cm^{-1} (In-plane bending vibration of O–C–O in $CaCO_3$ lattice), 853 cm^{-1} (carbonate out–of–plane bending vibration), 1440 cm^{-1} (asymmetric stretch of carbonate), which confirmed the presence of Calcium carbonate shell material. It also showed peaks at 2923 cm^{-1} (CH_3 stretch), 2854 cm^{-1} (CH_2 stretch) and 1464 cm^{-1}(CH_2 bending) which showed that fatty acid compositions are present inside the structure. Characterization studies confirmed the proper microencapsulation of the PCM inside the outer shell material.

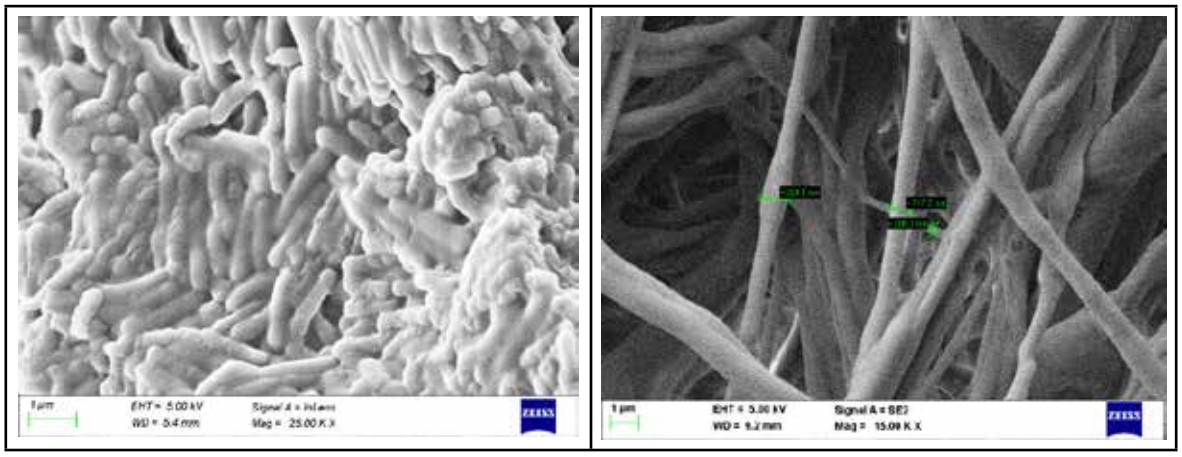
Utilization of Therminol 55 based alumina-doped zinc oxide nanofluid in tubular heat exchanger

Zinc oxide (ZnO) NPs were biogenically synthesised from cow urine. ZnO NPs are in best amalgamation with Therminol 55. The Therminol 55 based ZnO and alumina-doped zinc oxide (AZO) NFs were prepared using stearic acid (1:1) as surfactant. AZO NFs showed higher thermal conductivity than ZnO NFs. The AZO NFs showed a maximum increase of 30, 19.98 and 22.63% for convective heat transfer coefficient, overall heat transfer and energy efficiency, respectively when compared with Therminol 55. Additionally, the maximum reduction in energy consumption after utilizing ZnO and AZO NFs was 3.26 and 5.40%, respectively. It is concluded that AZO NFs possess better heat transfer properties resulting in reduction in energy consumption than ZnO NFs and Therminol 55 for heating milk in a tubular heat exchanger.

Microencapsulation of *L. plantarum* by spray and freeze drying

In this study spray and freeze drying were used for encapsulation of *L. plantarum* CRD7. Trehalose, sucrose and whey protein isolate (WPI) were used as thermal protectants during spray drying. For freeze drying, trehalose, maltodextrin and myo-inositol were used as cryoprotectants. In both cases, isomalto-oligosaccharides (IMO) and pullulan was used as prebiotic and wall material, respectively. Pullulan at 14% concentration, IMO at 30% concentration and myo-inositol at 20% rate were the optimized conditions for freeze drying. Spray drying parameters were optimized as 14% concentration of pullulan, 30% concentration IMO and 20% concentration of WPI. The highest survival rates of 88.71 and 89.15% were observed for *L. plantarum* after freeze and spray

drying, respectively. FESEM images revealed the fibrous morphology of encapsulates obtained from the spray dryer along with some embedded bacteria. In contrast, the probiotic-loaded encapsulates from the freeze-dryer had flake-like structure. The freeze-dried plantarum-loaded encapsulate had high BET specific surface area of 0.40 m^2/g and mean pore diameter of 32.78 nm. DSC thermogram showed shifting of melting point peaks to lower temperature due to interaction between the probiotic and wall materials. IMO at 30% (w/w) along with WPI and myo-inositol at 20% concentrations provided the highest storage stability and the lowest rate of cell death of *L. plantarum* after encapsulation by spray and freeze drying, respectively. Acid and bile salt tolerance study revealed that after encapsulation, *L. plantarum* could sustain the harsh GI conditions with more than 7.5 log CFU/g viability after 3 h interval for both freeze- and spray-dried probiotic. It was also observed that after 12 h of incubation at 37°C, skim milk inoculated with encapsulates made using WPI and myo-inositol as thermal and cryoprotectants could reduce the pH below 4.8 and make curd.

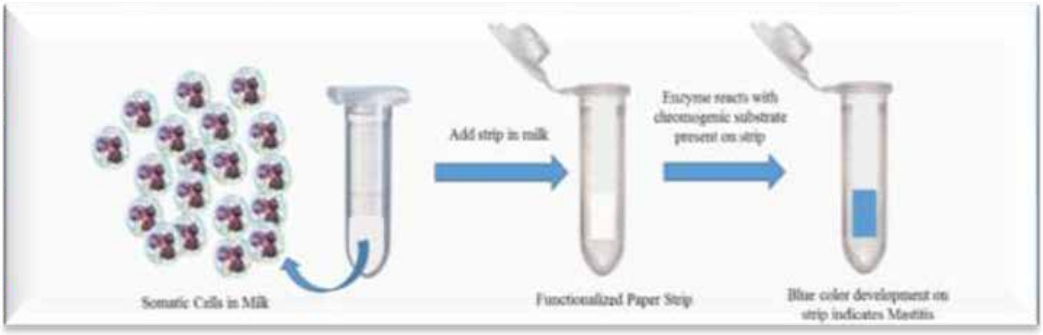


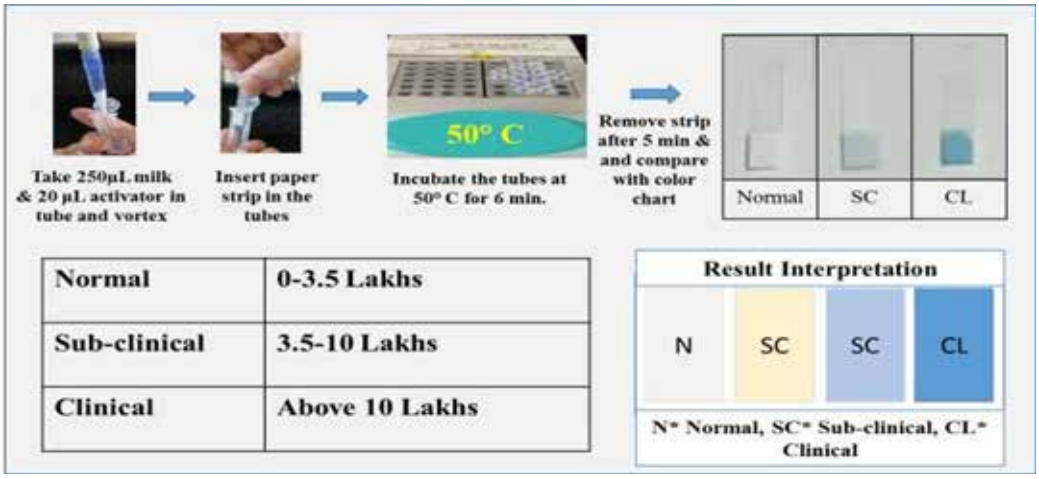
SEM micrographs of (a) free L. plantarum cells and (b) those encapsulated by spray drying

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 clinical and sub-clinical mastitis in milk

Strip based test was further refined for detecting mastitis in milk in 6 min by optimizing incubation temperature at 50°C, substrate concentration on strip and marker enzyme intervention. Test can be performed using single strip for detection of clinical and sub-clinical mastitis based on color chart. Test also provide information on somatic cell count (upto 3.5 lakhs for healthy animal; 3.5-10 lakhs for sub clinical and >10 lakhs for clinical mastitis).

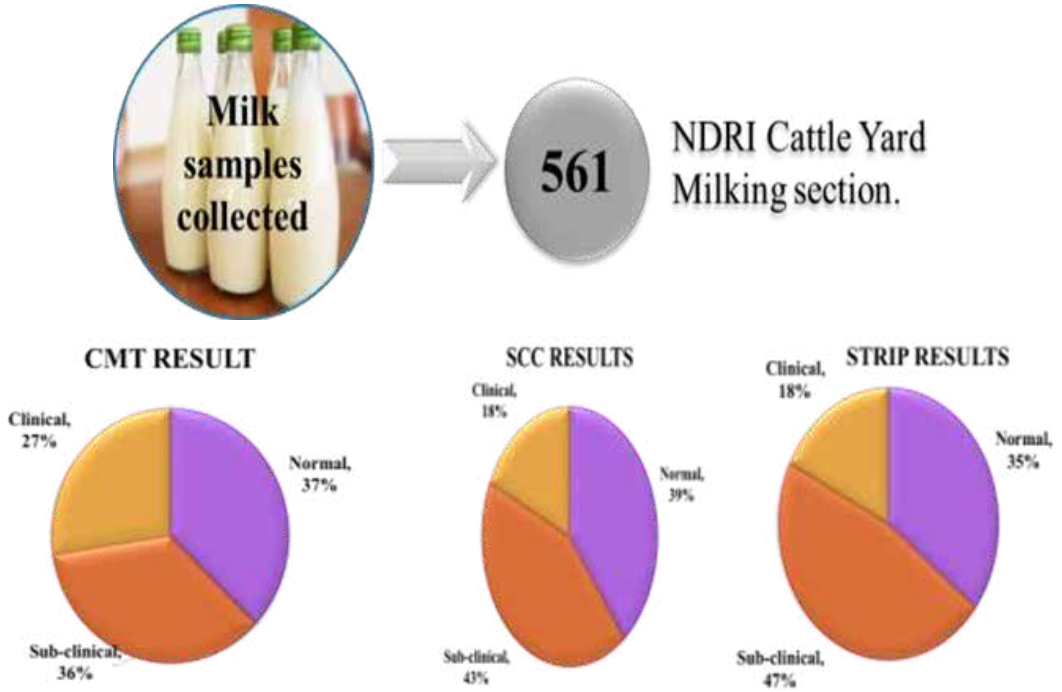




Novel features of technology

- Test can detect subclinical and clinical mastitis based on identified novel marker(s) in somatic cell within 6 min.
- Test is cost effective (Rs 5/- test), robust, reproducible, sensitive, selective with no false positive/ negative results.
- Semi-quantitative test with information on somatic cell counts in milk.
- Test has been validated with CMT, Somatic cell counter.
- Technology can be used for monitoring of mastitis in dairy animals under field conditions. Stability of strip is upto 6-7 months at ambient storage in vacuum packed conditions.
- Strips can be manufactured within 40 min and require one incubator for assay running under field conditions.
- Technology on mastitis strip was released during AGM Meeting at ICAR on 26th March, 2022.

After refinement, test was evaluated in laboratory by screening 561 milk samples. Strip test showed 18% clinical case, 47% sub clinical and 35% normal milk. Good correlation was established with Somatic cell counter (18% clinical case, 43% sub clinical and 39% normal milk) and CMT (27% clinical case, 36% sub clinical and 37% normal milk).



Field trial of strip based test for early detection of mastitis in cow and buffalo was also carried out with 140 animals (120 cows and 20 buffalos). A very high correlation in terms of diagnosis was achieved in the field wherein sub-clinical and clinical status was 45% and 28.33%, respectively. Perceived effectiveness of diagnosis of Clinical and sub clinical mastitis using strip based test was also evaluated. The percentage frequency of sub-clinical mastitis before testing was almost negligible in comparison to 45% after testing while in case of clinical mastitis prevalence was 5% against 28.33%.

Field trial results of strip based test for early detection of mastitis in cow and buffalo

S. No.	Particulars	No. of Animals Screened	Subclinical mastitis		Clinical mastitis	
			Number Positive	Prevalence (%)	Number Positive	Prevalence (%)
1.	Cows	120	54	45	34	28.33
2.	Buffaloes	20	5	25	4	20

Strip based test after its refinement was evaluated for sub-clinical (47%) and clinical (18%) mastitis. Similar evaluation was done in field conditions with 140 (120 cow and 20 buffalo) animals and sub-clinical and clinical status was 45% and 28.33%, respectively indicating very high correlation in terms of diagnosis.

Perceived effectiveness of diagnosis of clinical and subclinical mastitis using strip based technology

Diagnosis of clinical and sub clinical mastitis using strip		No. of animals found to be affected			
		Before		After	
		Frequency	%	Frequency	%
Sub clinical mastitis	Cows (n=120)	0	0	54	45
	Buffalo (n=20)	0	0	5	25
Clinical mastitis	Cows (n=120)	6	5	34	28.33
	Buffalo (n=20)	2	10	4	20

Paper Strip test for rapid detection of β-lactam group in milk

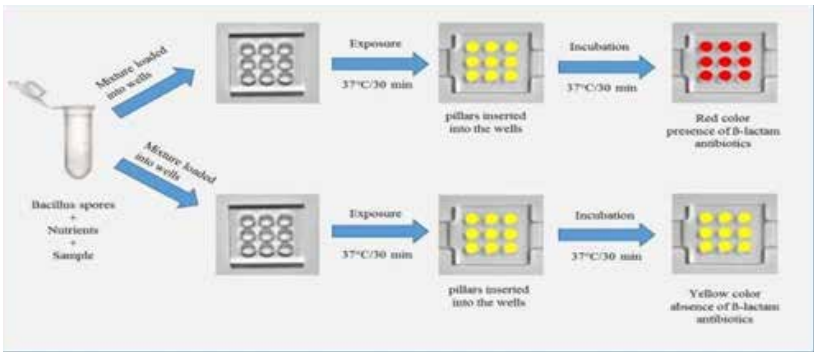
Developed paper strip assay was transformed on pillar based analytical device for rapid detection of β-lactam group in milk for high throughput analysis. Pillar based analytical device was designed with 9 Pillars of 4 mm diameter were micro-milled on a Poly-Methyl Methacrylate (PMMA) surface (1 mm height). The dimensions of the chip were 20x20x3 mm (width x length x height). Filter paper (Whatman Grade 3) was cut into 4 mm diameter and anchored on the pillar via a double sided tape. On the other hand, sample container consisting of 9 wells of 4.5 mm wide and 2.4 mm deep which are complimentary to the pillars present on the top part of the chip were fabricated in UK.

Operating parameters of pillar based analytical device such as sample volume 15µL, substrate volume 3µL and incubation temperature 37°C were optimized for high throughput analysis of β-lactam group in milk.

Transformation of Paper strip assay on Microfluidics Pillar Array Device for the rapid detection of β-lactam group in milk:

Microfluidics pillar array device

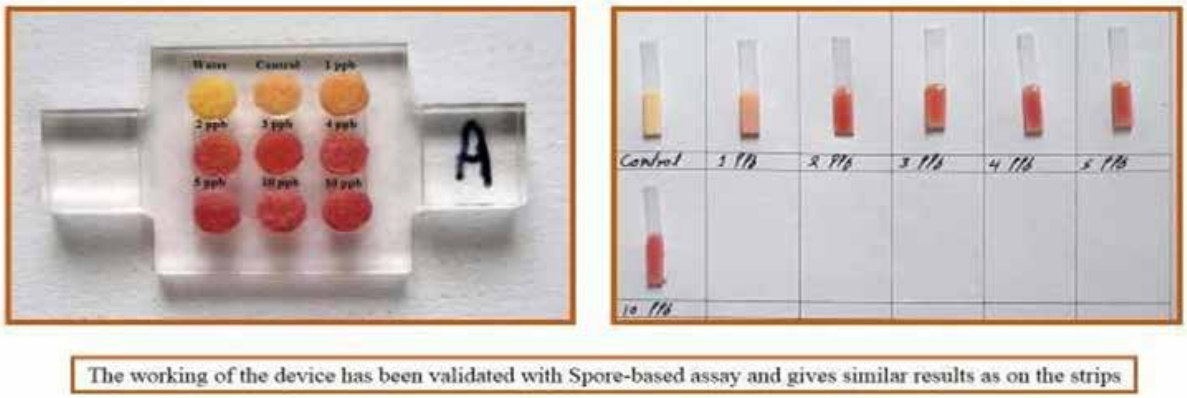
Developed Paper Strip Assay has been transformed on Microfluidics Pillar Array Device for the rapid detection of β-lactam group in milk for high throughput analysis. Microfluidics Pillar Array Device was fabricated at the University of Southampton in collaboration of ICAR-NDRI. The device consists of pillar array chip with attached paper on the pillar and sample container for enzymatic reaction on the paper. Briefly, filter paper was attached onto the pillar and a chromogenic substrate was loaded on the paper and dried. Samples were loaded on to micro-well after mixing with specific spores + germinant and incubated at 37°C/30 min. for induction of marker enzyme. The pillar chip is then inserted into the containers and incubated again at 37°C/30 min. to allow enzyme substrate reaction on the paper. The pillar chip is removed from the container and smartphone is used to analyse the results. Presence of antibiotic in sample induce the production of beta-lactamase enzyme in the germinating spores and react with substrate and color on paper will change from yellow to red.



Step Wise Protocol for the Detection of Beta-Lactam Group in Milk

Validation of microfluidics pillar array device with paper strip assay

Microfluidics Pillar Array Device has been tested for the induction of beta-lactamase in the germinating spores and found suitable for the detection of beta-lactam antibiotic in milk and validation has been done with the paper strip assay.



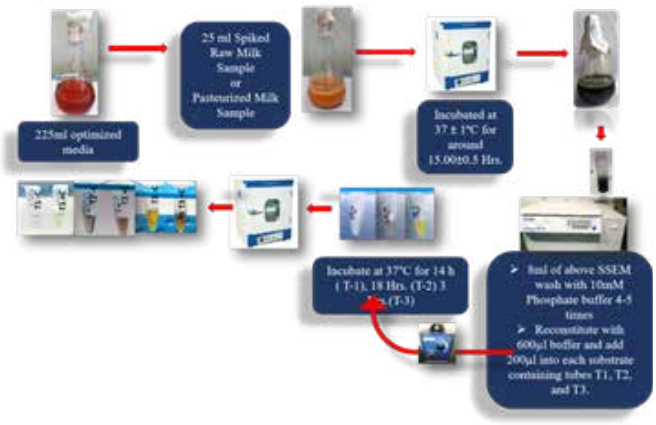
Validation of Microfluidics Pillar Array Device with Paper StripAssay

Significant findings:

- Semi-quantitative detection of β-lactam group.
- Assay is cost effective, rapid, robust, reproducible, selective and sensitive to β-lactam group.
- Minimal false positive/ negative results.
- Consistency in color development within 1 hr.
- No interference of non- β-lactam antibiotics and other inhibitors has been observed.
- Stability of test kits up to 9 months under refrigeration storage.
- Field application for routine monitoring of antibiotic residues in raw milk, pasteurized milk and dried milk.
- Evaluation & Validation has been done with AOAC approved CHARM ROSA strip test.

Two-stage enzyme(s) assay for detection of *Salmonella*

The growth pattern of Salmonella was examined in four different commercial media: RappaportVassialadius broth, Tetrathionate broth, Selenite Cysteine broth and lactose-sulphite broth sowed greater selectivity and inhibitory activity towards potential contaminants frequently encountered as background microflora, as well as higher log counts reduction, when compared to R.V., S.C. and T.T. Broth. After choosing the lactose-sulphite broth, the growth supplements were further improved based on H_2S generation activity. In order to have higher selectivity towards background micro-flora and better sensitivity towards the target organism, namely Salmonella, it was additionally supplemented with/or modified with novel selective agents. The newly created medium, known as Salmonella Selective Enrichment Medium (SSEM), was successfully used to grow Salmonella selectively and was later converted into an assay for the detection of Salmonella using various novel marker enzymes. The developed assay provides presumptive Salmonella identification in its first stage based on the medium turning black during the test organism's selective enrichment. Further Salmonella was confirmed in stage II of the assay based on the production of a green and yellow coloured product in 'Enzyme Substrate Mixtures' following its selective enrichment in SSEM. Gram +ve (Salmonella, Staphylococcus, Bacillus and Enterococci) and Gram -ve (*E. coli*, Klebsiella, Citrobacter and Proteus) pollutants were used to test the devised assay and none of the contaminants displayed a black colour at any stage of the experiment. Using spiked milk samples, raw milk and pasteurized milk in comparison with IS 5887: Part 3 for the identification of Salmonella, the new technique was further verified internally. When our assay's results were compared to those from IS 5887's methodologies for the detection of Salmonella, there was a perfect correlation.



Two stage enzyme substrate assay for detection of Salmonella

Isolation and characterization of bacteriophages against MDR pathogens

From 172 samples collected in various locations, three phages against MDR *E. faecalis* were identified. A double layer agar assay was used to purify isolated phages. Purified phages with phage concentrations between 10^7 and 10^8 PFU/ml were multiplied to produce high titer phage stocks. All of the separated phages were discovered to be entirely lytic because they created a distinct zone of total lyses varying in size from 0.40 mm to 1.04 mm on the lawn of each of their unique host bacteria. Isolated bacteriophages demonstrated a wide host range spectrum, proving their polyvalent nature. Three phages, designated PEF1, PEF2 and PEF3, were discovered against the strains of *E. faecium* CYK-47, CYK-24 and ATCC 19434 19434, respectively. Also displaying lytic activity against MDR *S. aureus* was PEF1 and PEF2. The average PFU/ml values for the phages PEF1, PEF2 and PEF3 were $2.15x10^8$, $1.7x10^7$ and $2.5x10^8$, respectively. The average plaque size for the PEF1, PEF2 and PEF3 phages was 1.049 mm, 0.454 mm and 1.076 mm, respectively, with a plaque size range of 0.40

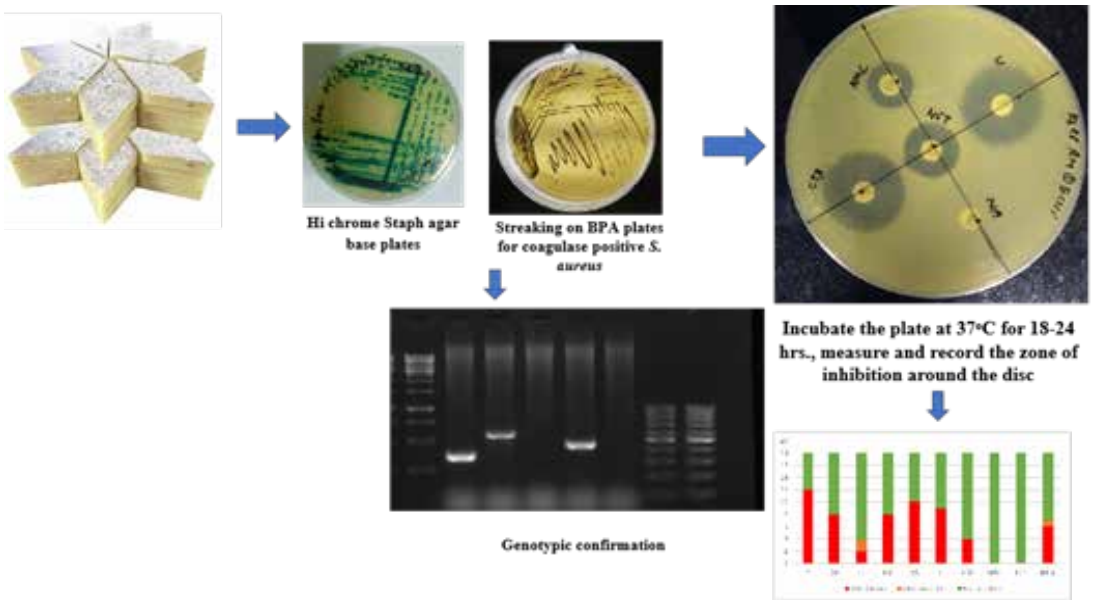
mm to 1.07 mm. PEF1 was identified as a member of the Siphoviridae family by morphological analysis of TEM images, which revealed that it had an icosahedral head, a lengthy non-contractile tail and no head that contained the capsid protein. The lengths of the head and tail were 68.57 and 264.44nm, respectively. PEF2 appears to be a member of the Myoviridae family because of its icosahedral head, long contractile tail, lack of an envelope and heads and tails that are, respectively, 103.81nm and 128.60 nm in length. With a head and tail length of 63.04nm and 233.31nm, respectively, PEF3 shared the same morphology as PEF1 and is from the Siphoviridae family.

Surveillance of heat desiccated and acid coagulated dairy products for antibiotic resistant bacterial pathogens

Out of 100 samples, *E. coli* was found using the usual approach in 19 samples of paneer and Chhana-based sweets and 45 samples of Khoa and Khoa-based sweets. Following genotypic analysis on all *E. coli* samples, it was discovered that 7 isolates, one from heat-desiccated dairy products and the other from heat-acid coagulated dairy products, were *E. coli*. In the case of *Enterococcus* spp., 26 samples were found to be positive using traditional based methods and 13 isolates were further verified as *Enterococcus* spp. using PCR based methods. A total of 59 samples for *S. aureus* tested positive, of which 18, also tested positive for coagulase. After genotypic identification, coagulase-positive *S. aureus* was only found in 6 isolates. The disc diffusion assay was employed to evaluate each validated isolate's antibiotic sensitivity in accordance with CLSI guidelines. Penicillin, oxacillin, clindamycin and erythromycin resistance was present in all 45 *E. coli* isolates; however, ampicillin and trimethoprim resistance was only present in 12 and 10 isolates, respectively. In the ESBL antibiotic instance, three isolates showed resistance to cefotaxime and ceftriaxone and were classified as belonging to the ESBL group of antibiotic resistant bacteria. The same three isolates exhibited resistance to carbapenamase-class antibiotics. Penicillin resistance was present in 12 coagulases +ve *S. aureus* isolates, while resistance to oxacillin and rifampicin was present in 8 isolates. There were six methicillin-resistant isolates, one to intermediate and eleven sensitivities to methicillin. All *S. aureus* isolates showed susceptibility to meropenem and ertapenem, but only four *S. aureus* isolates showed resistance to imipenem. In the case of *Enterococcus*, 26 isolates showed resistance to penicillin and erythromycin, 22 isolates to nitrofurantoin and rifampicin and 4 isolates to vancomycin.

Isolation, identification and characterization of lactic acid bacteria (VTCC)

A total of twenty-five LAB isolates were obtained from different homemade curd samples collected from Haryana. Based on the phenotypic and genotypic tests, these isolates were belonged to the genera of *Lactobacillus*, *Streptococcus* and *Enterococcus*. The identified cultures were deposited to VTCC repository under Dairy Microbes components with an accession numbers VTCC DM0000678B to VTCC DM0000702B.

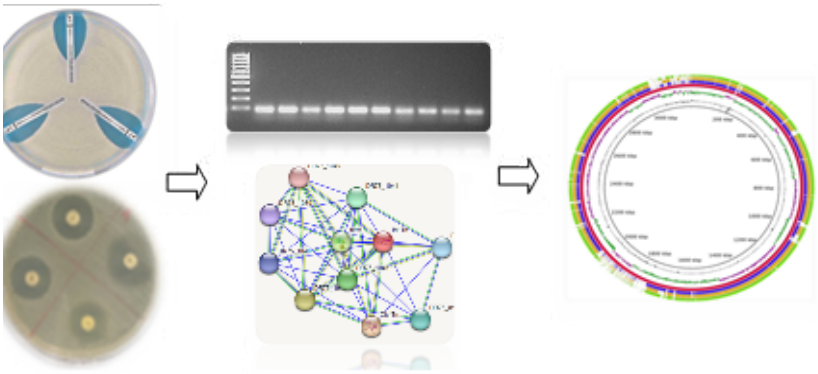


Isolation and characterization of antibiotic resistant bacteria from organized dairy production system

Antibiotic resistance a seemingly harmless process has evolved on to as a dreaded pandemic by ensuring its presence in every nook and corner across the globe. The food chain is one of the major sources for spreading of antibiotic resistance. Samples of milk, faeces, waste water and soil and hand swab were collected from dairy production system. Samples on nutrient agar, plate count agar and violet red bile agar and found that higher bacteria were enumerated against amoxicillin, cefotaxime, tetracycline, with high prevalence in samples of soil and waste water and isolated 295 suspected antibiotic resistant bacteria for samples. Two hundred and two bacterial isolates were identified by 16S rRNA gene sequencing of which *Escherichia* were highest. Further antibiotic resistance profiling was carried for the identified World Health Organization (WHO) critical and high priority pathogens. *Staphylococcus* spp. isolates 100% resistant to oxacillin, 60% isolates of *Escherichia* spp. were resistant to tetracycline, 100% of *Enterococcus* spp. isolates were resistant to ampicillin, norfloxacin and tetracycline, 66.67% of shigella isolates and 21.4% Pseudomonas isolates were resistant to piperacillin/ tazobactam, 22.22% Acinetobacter isolates were resistant to piperacillin and tazobactam. Tetracycline resistance was found to be the most common resistance in AMR bacteria isolated from the dairy production system. Besides, the bacterial isolates from soil were commonly resistant to piperacillin and tazobactam.

Phenotypic and genotypic characterization of antibiotic resistant *Enterococcus* species from dairy niches

A total of 64 dairy samples collected from the different regions of Haryana were used for enterococci isolation. From the preliminarily identified 235 enterococci isolates a total of 140 isolates were confirmed as enterococci out of which a total of 84 *Enterococcus* isolates were further tested for antimicrobial susceptibility testing. The highest resistances in the isolates were observed against Cefuroxime (50%), Rifampicin (21.43%), Cefepime (19.05%), Erythromycin (15.48%), Fosfomycin (9.52%), Cefotaxime (8.33%), as well certain isolates showing resistance against Tetracycline, High Level Streptomycin, Gentamycin, Norfloxacin, Chloramphenicol and Levofloxacin. Extended Spectrum β Lactamases production was confirmed in 9/24 isolates. PCR for resistance genes in the resistant isolates showed the presence of resistance genes against aminoglycoside, tetracycline, chloramphenicol and macrolides. Among the resistant isolates, 69.76% of isolates were positive for multi-drug transporter gene (*emeA*), while 25.58% and 30.23% were positive for Transposons family (Tn-5397 and Tn-916/ Tn-1545), respectively. Presence of class-1 and class-2 Integron gene were also detected in 4 and 12 isolates, respectively. Whole Genome Sequencing of the most resistant isolate, *E. faecalis* B1(C) detected the presence of 20 AMR genes coding for multiple resistances against peptide antibiotic, aminoglycoside, macrolide, tetracycline, diaminopyrimidine, lincosamide, phenicol, streptogramin, acridine dye, disinfecting agents and intercalating dyes, elfamycin, fluoroquinolone, nucleoside, oxazolidinone, pleuromutilin and rifamycin antibiotic.

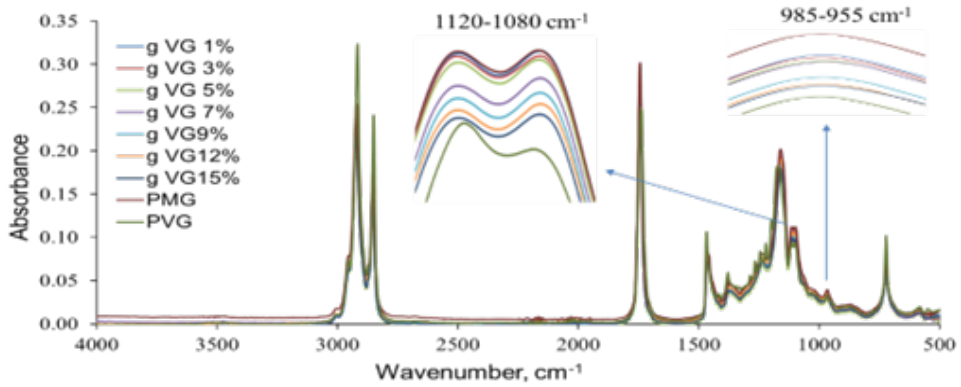


Phenotypic and Genotypic Characterization of Enterococcus from Dairy Niches

Attenuated total reflectance-fourier transform infrared spectroscopy coupled with chemometrics to detect mineral and coconut oil in ghee

Attenuated total reflectance-Fourier transform infrared spectroscopy coupled with chemometrics was applied to detect Vanaspati (VG), Palm olein (PO), Goat Body Fat (GBF), Pig Body Fat (PBF) and their admixture in ghee. Wavenumber regions found useful for detecting adulteration of ghee with different adulterants were 1120-

1080 and 985-955 cm^{-1} for VG, 1167-1137 cm^{-1} for PO, 1760-1730 cm^{-1} for GBF, and 1190-1140 and 1100-970 cm^{-1} for PBF. Principal Component Analysis (PCA) showed separate clusters for pure mixed ghee even at low levels of adulteration, and as adulterant levels increased, the clusters shifted towards the pure adulterants. Partial Least Squares (PLS) and Principal Component Regression (PCR) models were equally efficient in detecting adulterants in ghee based on selected FTIR spectra regions. SIMCA approach combined with established PLS models showed 100% classification efficiency for pure mixed ghee, pure body fats, and pure vegetable oils in the selected wavenumber regions. Classification efficiencies for ghee samples containing individual adulterants and their admixture never fell below 86% and 73%, respectively. ATR-FTIR and chemometrics can detect up to 1% of vanaspati, palmolein oil, goat body fat, pig body fat, and 3.3% of their admixture in ghee.

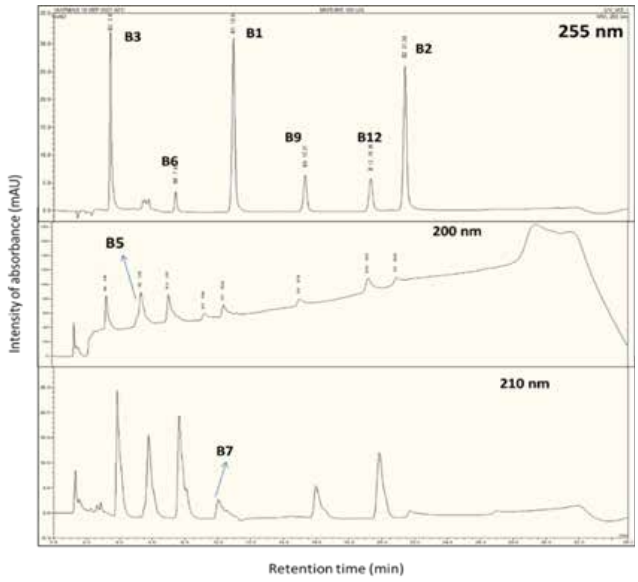


Detection of non-milk proteins in whey protein based health supplements

In the market, various types of protein-based health supplements are available. Among these, whey protein-based supplements are being marketed aggressively in health fitness centres across India and are often sold at premium rate. Quality of such protein-based products is seldomly checked. There are no particular quality parameters for marketing such products. RP-HPLC based analytical methods have been developed for the detection of soy-proteins and egg-proteins in whey protein based health supplements. Methodology involved solubilizing sample in denaturing buffer (6 M guanidine HCl, 20 mM dithiothreitol, 5 mM trisodium citrate, pH 7) followed by the resolution of the proteins using C8 column in RP-HPLC. Separation was achieved using linear gradient consisting of Solvent A (Water + 0.1%TCA) and Solvent B (Acetonitrile + 0.1% TCA) and monitored at 215 nm. The detection of soy proteins in whey protein concentrate is achieved by monitoring extra peak appearing at 42 min. Limit of detection was around 1%. Similarly, the presence of egg-protein in whey protein based supplements can be detected by appearance of additional peaks at retention time of 41 min.

Quantification of all B vitamins in a single run using ion-pair modified liquid chromatography with UV detection

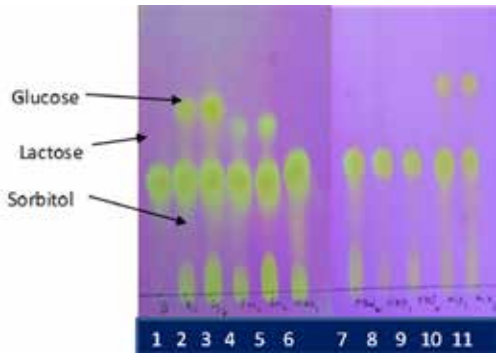
A rapid and simple approach based on ion-pair liquid chromatography for the estimation of all B vitamins in a single run of 35 min using UV detector is developed. The estimation is based on the separation of all B vitamins on the C18 column using gradient elution comprising mobile phase A (65 % methanol) and B (sodium dihydrogen phosphate, pH 3.05 containing 5 mM hexane sulphonic acid as an ion-pair reagent). Vitamins B1, B2, B3, B6, B9, and B12 were detected at 255 nm, while vitamins B5 and B7 were best detected at 200 and 210 nm, respectively. The standardized protocol was validated in buffer and milk permeate. The correlation coefficient for all B vitamins determined using a linear regression equation in the range of 1-30 µg mL^{-1} was >0.99. The relative standard deviation for intra-day and inter-day repeatability of vitamins (10 µg mL^{-1}) was less than 6 %, and recoveries were in the 75-120 % range. The applicability of the developed method has also been demonstrated for the quantification of B vitamins (B2, B3, B5, B6) in fortified commercial energy drinks.



Separation of B vitamins on RP-HPLC using gradient elution. Mobile phase A: methanol 65 % and mobile phase B: sodium dihydrogen phosphate (0.05 M, pH 3.05) containing 5 mM hexane sulphonic acid. Vitamins were detected using a DAD detector at 3 different wavelengths (i) 255 nm (B1, B2, B3, B6, B9, B12) (ii) 200 nm (B5) (iii) 210 nm (B7)

Thin layer chromatography based method for the detection of sorbitol in milk

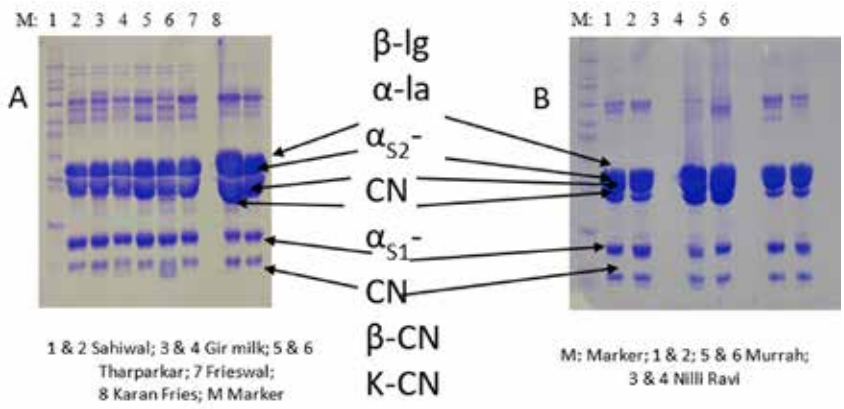
The standardised TLC conditions which were capable of separating the sorbitol in the aqueous system in the presence of other sugars and sugar alcohols were; i) the use of Silica gel 60F TLC plates after Cu-impregnation for 1.5 min. ii) Sample application volume 2.0 µl. iii) Solvent system consisting of n-propanol: ethyl acetate: water (7:1:2) proportion. iv) 0.5% of potassium permanganate in 0.1M NaOH as colour developing reagent.v) Drying temperature (65 °C/ 10 min.) after spraying the colour developing reagent.The limit of detection was 0.2% of added sorbitol in milk.



1 blank; 2 & 3 Sorbitol+Glucose; 4 & 5 sorbitol+sucrose; 6 & 7 Sorbitol and mannitol, 8 & 9 Sorbitol and maltitol; 10 & 11 All the sugars

Chemical and microbial analysis of milk from selected indigenous breeds of cattle and buffalo

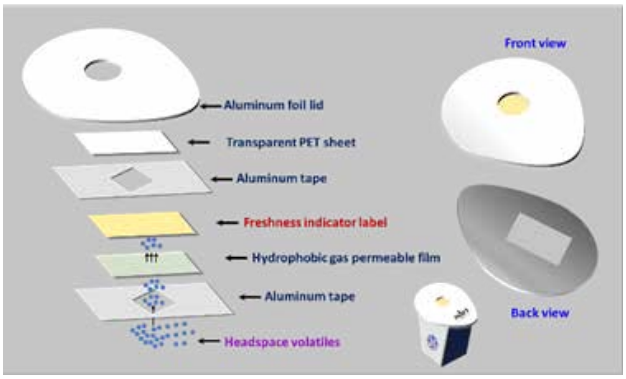
Total 172 milk samples (77 cow milk and 95 buffalo milk) were collected from LRC NDRI, CIRB, Hisar & Nabha and assessed for somatic cell count and compositional analysis. On analysis of milk samples (with SCC count below 2.5 lakh), the level of average fat & SNF content was observed to be 3.90±1.75% & 8.56±0.36% for Sahiwal breed cattle, 4.01±0.69% & 8.6±1.02% for Tharparkar breed cattle and 4.13±0.51% & 8.50±0.65% for Gir breed cattle, respectively. The average fat and SNF content of Murrah buffalo corresponded to 6.78±2.61% and 9.98±1.09%, respectively. Significant difference was observed in SNF content between breeds of Murrah and Nili Ravi. SDS-PAGE analysis of skim milk from different breeds of cattle and buffalo (murrah and Nilli Ravi) showed similar pattern of bands corresponding to casein and whey proteins. For genotyping, milk from cattle (including three from Gir and four from Tharparkar) and five from Murrah breed were studied. Three different forms of variants exist in CSN1S1: gene alternative splicing, amino acid substitution, amino acid deletion, etc. Milk from indigenous cow was observed to have significantly higher unsaturated fatty acids content than crossbred (Karan Fries). Among unsaturated fatty acids, the essential fatty acids were significantly higher in milk of Sahiwal (2.73%±0.11) and Tharparkar (2.67%±0.07) than Karan Fries (2.47%±0.08). Based on total bacterial counts, raw milk samples were of very good quality (< 2 lakh CFU/ml). However, the comparative microbial analysis indicated the higher abundance of spores, Yeasts & Molds and coliforms in milk of Gir cattle in comparison to Tharparker and Karan Fries.



SDS-PAGE profile of milk from different breeds of Cattle (A) and Buffalo (B)

On-package smart sensor as freshness indicator for set-type fermented dairy products

In this project, based on selected target metabolite groups, on-package freshness indicators of set-type fermented dairy products namely *dahi* and *misti dahi* were fabricated. As a result of several preliminary trials, smart ink components were selected and the indicator label (smart sensor) was successfully integrated with aluminum foil and used as a closure for polystyrene cups. One smart indicator label each for *dahi* prepared using NCDC-74 (**S16-10**), NCDC-146 (**U-50**), and NCDC-167 (**U-40**) was selected, and their performance was tested against different types of aldehydes (C_5-C_9) in the vapor phase and at different concentrations (0.5-6 µL) at 45°C. The real-time performance of the smart indicator labels of *dahi* (**S16-10**, **U-50,** and **U-40**) carried out at 5±2°C for 21 days, revealed that the indicator label response in terms of *ΔE* and *Yellowness index* was found to have a non-linear relationship with the biochemical quality attributes (titratable acidity, pH, FFA) of *dahi*. It is concluded that the freshness indicator labels namely **S16-10**, **U-50,** and **U-40** could be successfully developed for *dahi* prepared with NCDC-74, NCDC-146, and NCDC-167 starter cultures, respectively which could assist in supplementing or complementing the printed expiry dates on the label and for knowing the shelf life of *dahi* at consumers' end.



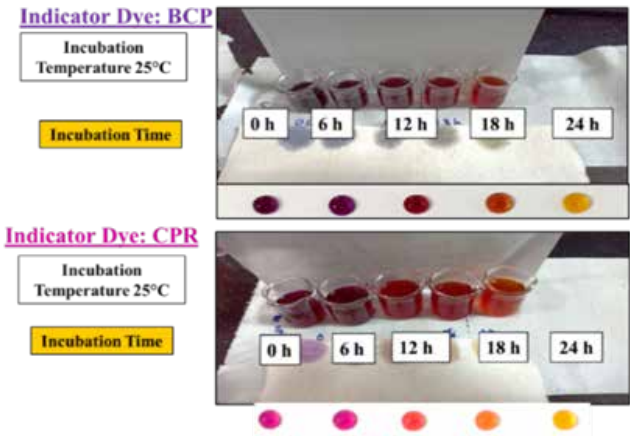
Structural arrangement of freshness indicator of dahi

Physical appearance of freshness indicator of dahi integrated with aluminum Foil Lid

Biological smart time temperature indicator for monitoring thermal abuse and quality of *Paneer*

For the development of a biological (microbial) smart time-temperature indicator (TTI) for *paneer*, 14 isolates were obtained from the spoiled vacuum-packaged *paneer*. Out of these, four isolates (S2, M5111, M5114, and M61211) were selected based on their different phenotypic attributes and changes in pH of skim milk at 25°C/ 4 days and 10°C/ 20 days. The 16s rRNA gene sequencing revealed these four isolates as *Enterococcus casseliflavus* (S2), *Bacillus cereus* (M5111), *Atlantibacter hermannii* (M5114), and *Enterococcus faecium* (M61211). Based on preliminary trials, the substrate media comprising BHI broth with added glucose (1%) and two dyes bromocresol purple (BCP) and chlorophenol red (CPR) with pH adjusted to 7.0 was selected for the TTI development. Isolates S2 and M61211 were able to drastically decrease the pH of substrate media from 7.0 to 4.71 and 4.43, respectively. The working of TTI at different storage temperatures (5, 15, and 25°C) was assessed

using 10^3-10^4 cfu/mL inoculum of culture isolates. No significant changes in pH and the microbial counts were observed at a storage temperature of 5°C. While at 15°C, the pH of media decreased gradually to around 4.52-4.89 after 5 days with a concomitant increase in microbial load to 7 log cfu/mL from an initial pH value of 6.92-7.02 and microbial count of 3 log cfu/mL at 0th and 2nd day. Likewise, endpoint pH at 25°C reached after 30 h of incubation at 25°C. Microbial count at this temperature increased to 8 log cfu/mL from 3 log cfu/mL during this time frame. The association analysis of the colorimetric changes in the biological TTI was carried out with the quality attributes of the *paneer*.



Proof of Concept of Microbial TTI at smart ink formulation stage

Development of flaxseed-rich probiotic dairy foods to address menopause symptoms

The lignan from milled defatted flaxseed flour was extracted using direct alkaline hydrolysis coupled with different methods such as magnetic stirring (MS), microwave-assisted extraction (MAE) and ultrasound-assisted extraction (UAE). Identification and quantification of lignan was done by using Fourier transform infrared spectroscopy (FTIR) and high-pressure liquid chromatography (HPLC) techniques. It was found that among different methods, MS method resulted in maximum secoisolariciresinol diglucoside (SDG), (predominant lignan) extraction from defatted flaxseed flour. The quantity of SDG in the extract was estimated to be in the range of 11.74-13.00 mg/g flaxseed. The extracted lignan was used for further studies. Qualitative and quantitative analysis of different strains of *Lactiplantibacillus plantarum* (A1, Lp9, A5) along with yoghurt mix culture (NCDC 146), *Streptococcus thermophilus* (NCDC 74) and *Lactobacillus bulgaricus* (NCDC 253) were done in their respective broths and accordingly the most compatible cultures were selected for further analysis. The compatibility study of the selected co-cultures was again carried out to analyze their growth in in double toned milk medium. Different concentrations of extracted flaxseed lignan (0-400 mg of SDG/100 mL) were further inoculated to double-toned milk for fermentation and were analyzed for acidity, pH and fermentation dynamics of the selected co-cultures for 12 hours. Qualitative and quantitative analysis of *Lactiplantibacillus plantarum* strains with the NCDC cultures in respective broth showed that all the selected bacterial cultures are compatible with each other. However, NCDC74/A1, NCDC74/A5, NCDC146/A1 and NCDC146/A5 were the most compatible co-cultures and were analyzed for 12 hours in double toned milk medium for their fermentation dynamics. There observed no significant difference in the fermentation dynamics between any of the four co-cultures, although, NCDC74/A5 and NCDC146/A5 were selected for the further studies in presence of different concentrations of SDG. The fermentation study in presence of SDG revealed that there is no significant effect of SDG on the growth or fermentation dynamics of the co-cultures.

Standardized Protocol for the Extraction of Flaxseed Lignan

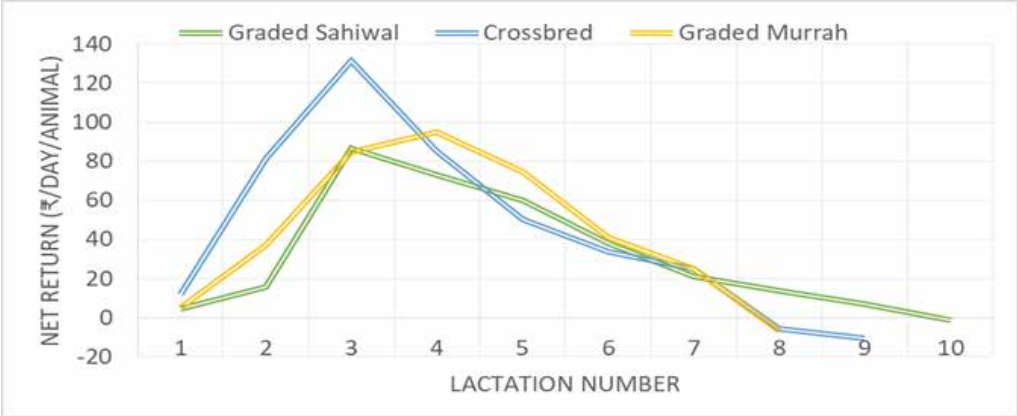
DAIRY DEVELOPMENT: POLICY ANALYSIS, STRENGTHENING DATABASE AND IMPACT ASSESSMENT

Impact assessment of high pedigree bull semen

Field survey of 304 households (encompassing 1129 dairy animals) revealed that NDRI semen accounts for 30 per cent of breedable population of dairy animals in Karnal district of Haryana. Positive transitional heterogeneity (TH) establishes a positive income impact of adoption of NDRI semen. The adoption of NDRI semen led to increase in milk productivity of F1 progeny by 12.31 per cent. Moreover, conception rate improved (approx. 5.5%) as compared to other semen sources. The simulated gain (in economic surplus and surplus distribution) of NDRI semen was to the tune of ₹ 2154 crores at 30 per cent adoption in North India and 10 per cent in remaining parts of the country.

Lifetime economics of selected dairy breeds at field level

Under field conditions, the net returns per day were highest in crossbred upto third lactation, whereas, it was highest for Sahiwal after seventh lactation. Eighth lactation onwards, the net returns of Murrah and Crossbred animals turn out to be negative. The maintenance cost was estimated to be lowest for Sahiwal cow followed by crossbred cow and Murrah buffalo.



Comparative net returns among different breeds of dairy animals (₹/day/animal)

Economic impact of public research investment on livestock productivity

A unique panel data set of 15 states for the period from 1991-92 to 2017-18 was developed and divided into four zones (North, East, West and South) to carry out regional analysis. Using fixed effects panel regression model, it was found that investment on livestock research and education bears significant positive impact on livestock total factor productivity (TFP). The TFP rises by almost 20 per cent with per unit rise in research stock. Regionally, the impact was higher in North zone (64%) followed by South (19%), East (10%) and West (7%) zones. Overall, a high marginal internal rate of return (MIRR) to research investment (40.9%) indicates substantial economic gains of livestock research investment. The North zone experienced the largest economic gain in terms of return on research investment, with an estimated MIRR of 49.5 per cent, followed by the East (38.2%), West (37.3%), and South (36.7%). The findings reiterate the support for additional allocation to livestock research especially in the economically backward regions.

Climate change-induced production risk and adaptation strategies in dairy farm households of Odisha

The study estimated the extent of climate change-induced risk in Odisha and to assess the climate change-induced risk among dairy households of selected districts. A composite risk index was developed using 46

indicators across all the districts of Odisha, which consists of risk as hazards, exposure, and vulnerability (sensitivity and adaptive capacity) components. Intriguingly, 36.96 per cent of the total geographical area is highly vulnerable to climate change-induced risk, covering 6 coastal and 6 non-coastal districts. All the districts of the North Central Plateau, the North Eastern Coastal Plain, and most of the districts of the East and South Eastern Coastal Plain and the North Eastern Ghats fall under the high-risk category. Comparing risk index value across all the districts, it was found to be highest for Bhadrak district (1.69) and lowest for Sambalpur district (1.21).

A household level risk index (HLRI) was developed using 42 indicators under different components of hazard, exposure, and vulnerability using a sample of 360 dairy households selected from six districts covering 6 agro-climatic zones. Herd sizes, education, MGNREGA beneficiaries, sources of climate information, and climate understanding have a positive and significant relationship with climate adaptation strategies, while family size has a negative and significant relationship. The results obtained from endogenous switching regression reveal that high adapters have a net income of about 1240 ₹/day, compared to low adapter (530 ₹/day). The treatment of the untreated reveals that farm households with low adapter would have gained 68 per cent more if they become high adapter. It was found that keeping local breeds (83.03%), regular vaccination (68.33%), and providing healthcare through veterinary officers (68.33%) are the most common general adaptation strategies, while providing frequent water to animals (60.28%) during the dry season and deworming (70%) of animals during the rainy season are the most particular adaptation strategies in the study area.

Perception and preferences of urban consumers for liquid milk in North India

Primary data were collected from 270 consumer households of New Delhi, Ludhiana and Karnal. The average daily household milk consumption was found to be 2.6 l/day. Liquid milk accounted for 69 per cent of total household monthly expenditure on milk and milk products. Monthly household consumption expenditure on milk increased by ₹ 975/month with presence of a pregnant/nursing mother in the family. Freshness was the most important factor considered by the households before buying milk. Around 56 per cent of the sample households were buying processed milk. Buffalo milk was consumed by 41.48 per cent of the sample households, whereas mixed milk and cow milk was consumed by 32.96 per cent and 25.56 per cent sample households, respectively. Consumers were willing to pay ₹ 9.94 more for indigenous (desi) cow milk and ₹5.75 more for buffalo milk over cow milk. The sample households had a positive perception on nutrition and health benefits of milk but they rated milk and dairy farming relatively lower on ethical (0.57) and safety related (0.535) aspects. Raw milk received, comparatively, higher scores for taste and nutritional quality; whereas processed milk received higher scores for safety, availability and affordability. Desi cow milk was preferred for its taste but it scored low on availability and affordability. Among processed milk, full cream scored highest.

Evaluation and impact of dairy farmer collectives in Saurashtra and Kutchh regions of Gujarat

Two major farmer collective organizations, namely, Rajkot Milk Union (under AMUL) and Maahi Milk Producer Company (Maahi MPC) operational in the study area were considered for the study. The analysis of determinants of membership of dairy farmer collectives reveals that both age and size of the household have negative and significant effect on the probability of membership. If livestock is the main source of income for the household, the probability of membership increases significantly by 12.5 percentage points. Access to mass media also positively and significantly affects the chances of membership – when a household has access to mass media, the probability of its becoming a member of farmer collective increases by 27.4 percentage points. Contact with extension also has a positive and significant effect on membership – it increases the chances of membership by 75.5 percentage points. Looking at the impact of membership on household income, the annual net returns from local cow increased significantly by ₹ 3,714/- for the member households. The annual net returns from buffalo increase significantly by ₹ 6,430/-, thereby increasing the total annual net returns from dairy by ₹ 10,144/- for the members. After membership, the share of dairy in total household income increases significantly by 14 percentage points. Share of milk sold captures the impact of membership on commercialization. It increases significantly by 1.4 percentage points after membership. There are no significant effects of membership on milk yield.

An economic analysis of dairy-integrated farming systems in Terai region of West Bengal

The major farming systems identified in Terai Region were Dairy (D), Dairy+Crop (D+C), Dairy+Crop+Goat (D+C+G), Dairy+Crop+Poultry (D+C+P), Dairy+Crop+Mushroom (D+C+M) and Dairy+Crop+Fish (D+C+F) farming system. The estimated input-output coefficient revealed that the backward linkage, i.e., the link from dairy to crop, was stronger than the forward linkage, i.e., the link from crop to dairy, in each farming system. The farming system with the strongest connection between dairy to crop was in D+C+P(0.44) and the weakest linkage was found in D+C (0.31) farming system. It was estimated that 81 to 96 per cent variation in actual profit from maximum profit (profit frontier) among households under these farming systems was mainly due to the differences in farmers' practices. There was wide range of variation in profit efficiency in overall farming system. The levels of education, farming experience, age and herd size were the important determinants of profit inefficiency of the farmers. The result regarding resource use efficiency in milk production revealed that green fodder was used efficiently in D and D + C + G farming system but it was underutilized in D + C + M farming system, whereas dry fodder was used efficiently in all the farming systems. Concentrate was used efficiently in D+C,D+C+P farming system but was over utilized in D + C + M and D + C + F farming system. Concentrate was over utilized in overall farming system for indigenous cow, whereas green fodder and dry fodder in case of crossbred and dry fodder in case of indigenous cow were used efficiently.

Socio-economic impact of COVID-19 pandemic on dairy farm households of West Bengal

The dairy sector is one of the most affected sectors during the COVID-19 pandemic as dairy products are highly perishable and depend on interspersed and time-sensitive supply chains. Against this backdrop, the present study was carried out assess the socio-economic impact of the COVID-19 pandemic on COVID-19-infected and uninfected dairy farm households in West Bengal state. The Dairy Economic Performance Index (DEPI) consisting of the number of milch animals, milk yield, marketed milk, milk procurement price, concentrate price, and the veterinary cost was developed using Principal Component Analysis. DEPI index value ranges from 0 to 1. A higher index value indicates better dairy economic performance. DEPI value was lesser by 7 per cent ($P<0.01$)) for the infected group (DEPI) than that of the uninfected group. As infected dairy farmers incurred more losses during the COVID-19 pandemic additional cash and kind support may be extended to them.

EXTENSION APPROACHES FOR SOCIO-ECONOMIC UPLIFTMENT THROUGH DAIRYING

Perception and utilization behaviour of the new age digital advisory services among dairy farmers in Eastern Haryana

Perception and utilization behaviour towards the new age digital advisory services was appraised among the commercial and smallholder dairy farmers of Haryana. Majority (93.75%) of the smallholder dairy farmers had low to medium level of perception towards the new age digital advisory services whereas 98.75 percent of the commercial dairy farmers had medium to high level of perception. Perception of both categories of farmers differs significantly at 5 percent level of significance. Utilization behaviour has been studied as the way in which dairy farmer seek, process and share the information received through digital advisory services. Both the smallholder and commercial farmers were having preferences towards App and web based services for seeking information than the SMS based services. In case of App based services, both types of farmers accessed information for feeding and breeding management than the healthcare management.

Development of THI based climate services and its impact on Murrah Buffalo farmers of Haryana

Weekly module on the climate information and THI based climate services on Murrah buffalo rearing were prepared and disseminated to 360 farmers across the 24 villages of Hisar, Jind and Rohtak districts of Haryana through mobile application, text SMS and WhatsApp group. The study indicated that climate services had a positive effect on the number of farmers adopting the practices like improved fodder varieties, use of oil cakes, minerals and feed additives in the animal diet. Treatment effect was found to be significant on quantity of oilcakes (0.39, 0.45 and 0.51 kg/animal/day); concentrates during both summer (0.48, 0.56, 0.59 kg/animal/day) and in winter (0.35, 0.40 and 0.42 kg/animal/day); and mineral mixture (9.47, 12.34 and 13.08 gm/animal/day) in Text SMS, WhatsApp and MobileApp group respectively. Treatment effect of climate services was also found to be significant on milk yield during summer (0.38, 0.44 and 0.50 litre/animal) from Text SMS, WhatsApp and MobileApp, respectively. Hence, the exclusive climate services developed for Murrah buffalo farmers was found to an effective adaptive mechanism to cope up with changing climatic scenario.

Comparatives study on effectiveness of extension service providers in Animal Husbandry Sector of Karnataka

A study was carried out in Karnataka during 2019-2022 with a randomly drawn sample size of 325 comprising 200 livestock farmers and 125 extension personnel using semi-structured interview schedule and observation method. Cost of extension service delivered by public organizations was perceived as reasonable (64%) with medium level of timeliness (52%). Fifty four per cent respondents expressed medium level of willingness to pay for extension service. Public extension service providers exhibited the higher level of effectiveness with mean index value of 0.50 in comparison to private and cooperative extension service providers. Amongst the five study districts, Dharwad district in Karnataka was found to be the most effective in public extension service delivery with a mean index value of 0.62. Bengaluru Rural district was found to be most effective with mean index value of 0.53 in private extension service providers. Time utilization, job satisfaction, job performance, service orientation and service commitment were positive and significant with extension effectiveness at 5 per cent level. The study suggests moving away from a system of stationary veterinary dispensaries and hospitals to providing services at farmers' doorsteps, convergence with other agencies and individuals including cooperatives, NGOs and private entrepreneurs to provide seamless services to farmers.

Prioritizing extension interventions for resource poor dairy farming households in Haryana

A study was conducted in three districts of Haryana state namely Karnal, Jind and Jhajjhar representing three different Agro climatic zones in Haryana during 2021-2022 with a sample size of 120. Majority of the respondents possessed medium level of overall knowledge (57.50%) and medium level of overall adoption (47.50%) under improved dairy farming practices. Education, land holding and social participation were positively correlated

with knowledge level of farmers on improved dairy farming practices. Extension interventions were prioritized as per the expert opinion by using Analytical Hierarchy Process methodology which indicated that training has acquired the highest rank with a value of 0.35 followed by demonstration with value 0.34. Among policy interventions, subsidy has acquired the highest rank with a value of 0.37 and then incentive acquired 2nd rank with value 0.25. Among technological interventions, Artificial Insemination has obtained the highest rank with a value of 0.41 followed by mineral mixture with value 0.26. Among input services interventions, milking equipment has acquired the highest rank with a value of 0.45 and then medicine and veterinarian drug acquired 2nd rank with value 0.25. The study suggests the importance of intensive training, demonstration and exposure visit to research institution and progressive farmers for gradually empowering the resources poor farmers.

Empowerment of tribal farmers through dairy interventions in Rajasthan

Majority of farmers were having substandard sheds adjacent to their houses (59%) and a considerable percentage keeping animals tied within their homes (40%). Limited availability of green fodder was observed, with green grasses (28.5%) and fodder trees (71.5%) being the main sources and no one provide mineral mixture to their animals. Artificial insemination was adopted by a significant proportion of respondents (45.5%), while a both AI and natural service was used by 27.5% of respondents, mainly for animals with repeat breeding cases. Vaccination against diseases like FMD, HS, and BQ was neglected by a considerable portion of respondents (44.5%). Other prevailing practices included knuckling for (79.5%), lack of record-keeping (84%), leaving the naval cord left as such (47%) and occasional deworming (69%), with a small percentage practicing regular deworming (8%). It was calculated that considerable percentage, 38.50 per cent of household, falls under moderate quality of life but also a sizeable percentage i.e., 37 per cent, were under low quality of life.

An appraisal of natural farming practices in different climatic zone of North India

For the respondent selection, Participatory Guarantee System for India (PGSI), website was searched, which show the state-wise individual farmer and farmers groups, who are registered for organic, Jaivik and Natural farming. PGSI website showed that till Sept.2022 at all India level there are 66 Regional Council for organic, Jaivik and Natural farming are working. In the project area: Haryana (1), Uttarakhand (5) and Rajasthan (2) Active regional council are working. On the basis of PGSI website respondents were selected for the study and interviewed for the collection of required information as per the objectives of the study. The farmers registered on the PGSI were not specifed as per the farming practices i.e. Organic, Jaivik and natural farming, hence data from the mix group were collected and then specifed as per agriculture practices followed by the farmers. Primary data from 45 respondents indicated that 40.00 percent of the respondents were practicing natural farming, followed by 31.11 per cent organic farming, whereas 24.44 per cent were practicing mixed farming. It was surprised to note that few registered farmers were still using chemical fertilizers and insecticide.

Nutritional status of farm women in aspirational districts of Kerala and Tamil Nadu

The present study focused on the nutritional status of farm women in aspirational districts of Kerala and Tamil Nadu. The study was conducted in Wayanad, Virudhunagar and Ramanathapuram districts, which were listed as aspirational districts by NITI Aayog. Majority of the households (67%) experienced various levels of food insecurity (moderate [35.83%] –mild [25.83%]-extreme level [5.28%]) and only 33 percent of the households were food secure. Majority of the respondents (59-95%) did not experience severe food insecurity. There is a significant but weak relationship between food security and nutritional status. All the three identified factors had significant influence in the nutritional status of farm women in both the states and cumulatively explained the variance in BMI upto 59 percentage. In both the states majority of the respondents had medium intention to consume nutritious food, followed by high intention. The model fit indicators shows that theory of planned behavior adequately predicts behavioral intention. The effectiveness of the module was perceived as high by the respondents in general. Hence the study reinforces the need for nutrition sensitive extension approaches.

Crop residue management in trans-gangetic plains: stakeholders perspective

Punjab and Haryana states were purposively selected for investigation due to highest crop residue burning in last three years. Finding revealed that the majority (68.75%) of respondents were using Basmati paddy straw for dairy animal without any treatment. Nearly one third (75.62%) of respondents were using normal paddy straw

for feed after treatment with 4% urea and 45-50% moisture improve the nutritive value by never digestibility palatability and Crude Protein Content. Majority (71.25%) of respondents perceived that Paddy straw can be used as manures after bedding for animal with urine and dung. Majority (69.37 %) of respondents were aware with the fine imposed to farmers between Rs 2,500 and Rs 15,000 by the National Green Tribunal (NGT) for burning their paddy fields. Majority of respondents (75.60 %) agreed that customs hiring centres and straw bale units can also help farmers recover their operational costs. In case of use of paddy stubble as mulch, initially (2017-18) only (11.25%) of respondents were practicing this but in year 2021-22 it increased to 30.62%. In year 2017-18, 58.75 per cent of respondents were practicing burning of stubble which increased by 5 per cent in year 2018-19 but again it showed declined in burning of crop residue by almost (4.5%) in year 2019-20. Happy seeder was identified as CRMT with highest adoption index (0.73), followed by Rotavator (0.63). Effectiveness index score of soil health improvement is having highest mean index value (0.85). "Lack of appropriate farm machinery for stubble management suitable for field preparation to grow vegetables" has emerged as most important technological constraint.

Digital agro-animal farming technology in Haryana: farmers perspective

MoU's with different digital technology service providers and established INDO-ISRAELI centres. The study was conducted Karnal and Sonipat districts with 120 respondents. The criteria for selection of respondents was dairy farmers should have at least 10 animals and crop farmers should have at least 2 acres of land and both type of respondents should be using 2 digital technologies at the time of investigation. *Perception scale* was developed to measure the farmers perception regarding digital farming technology. Data were collected through semi-structured and structured interview schedule. In case of digital agriculture technologies, majority (55.00%) of agriculture farmers used laser land leveler. While automated machineries and humidity sensors were adopted by only 10.00 per cent of respondents. In case of dairy farmers, Cent percent respondents had yellow QR code tags for their animals. This was followed by adoption of Bulk milk coolers by 30.00 percent of respondents. Among digital service technologies, most (99.17%) of farmers were using online resources for obtaining updates to related to crop/dairy farming. The respondents strongly agreed that digital farming technologies improves the decision-making capability of the farmer with mean value of 4.08. About 45.00 percent of the respondents agreed that digital technology aids in knowing pH, temperature, and weather information instantly. Majority of the farmers were less confident to use digital technologies. However, they are ready to learn new skills and upgrade themselves. So, necessary interventions should be taken to train the farmers and strengthen the adoption of digital farming technologies.

Development of dairy business school model for farmers: an action research

The present study was designed to develop a "Dairy Business School" model for the farmers of Haryana with 180 dairy farmers. The results showed, 61.11 per cent of dairy farmers had medium level of entrepreneurial behaviour followed by 20.00 per cent farmers in high level. Based on the entrepreneurial behaviour score, thirty dairy farmers were selected for Dairy Business School (DBS). The DBS was organized at Expert Institute with developed curriculum for capacity building of aspiring dairypreneurs in the areas of dairy production, processing and marketing. After the completion of school, the Dairy Business School model was developed by using interpretive structural modeling with 13 leading factors for dairy entrepreneurship development. It was found that an impact of 71.43 per cent change was observed in knowledge level of DBS participants regarding dairy marketing practices followed by 52.64 per cent change in processing practices and 48.07 per cent change in dairy production practices. Collectively, more than 92. 00 per cent of the farmer participants had favorable attitude towards Dairy Business School model. The farmer participants' involvement and support for Dairy Business School model highlighted the positive impact of this model in dairy entrepreneurship development and improving the knowledge and adoption levels on dairy production, processing and marketing practices.

Farmers' participatory appraisal of cation-based mineral supplement on performance of dairy animals in Karnal district of Haryana

The rate of milk let down in high yielding dairy animals in the first six weeks of lactation, is so high that the secretion of nutrients into the milk exceeds the rate of uptake of nutrients from the digestive tract. The appetite of the animal during the early lactation (upto 8 weeks) is reduced by 2 to 3 kg per day. Usually, all such cows and

buffaloes will remain under negative energy balance during first five months of lactation. The sudden change in diet and feeding high concentrate diet to fulfil their demand impose the risk of rumen acidosis. Findings from experimental research stations suggest that feeding cationic diet post-partum improves rumen pH and reduces SARA while improving productive and reproductive performance of dairy animals. With this background, the effectiveness of 'cation-based mineral supplement' for controlling SARA, increasing the milk production, milk fat and service period was evaluated. The randomized controlled trial design was used with 212 dairy animals (106 cows and 106 buffaloes). The study revealed that C-bMS was highly effective in preventing SARA as after feeding C-bMS, cases were not found in treatment group. The overall cost of production reduced by (2.87%), improvements in milk yield (13.02%) and farmer's profits (28.65%) with C-bMS supplementation. The peak adoption rate for C-bMS is predicted to be 96 per cent after a period of 8 years. Majority of the dairy farmers have responded that C-bMS is effective to control the ruminal acidosis, increase in dry matter intake, improvement in BCS and increase in milk production of dairy animals.

Capacity building of resource poor farmers in paddy-wheat cum dairy production systems through farmer FIRST (farm, innovation, resources, science and technology) programme under irrigated agro-eco. Region of Haryana

About 25 technologies/package of practices pertaining to the crop, dairy husbandry and horticultural enterprises under FFP research projects were demonstrated in 7 villages of Karnal with more than 1500 households. It was found that milk fever was controlled after experimentation of feeding of Anionic Mineral Mixture with 200 animals in the field (from 21% to 2%) and improvements in milk yield (14%) and farmer's profit was found to be 35 per cent. Similarly: Cation-based Mineral Supplement to 212 animals in the field was also highly effective in preventing Sub Acute Ruminal Acidosis; cases decreased from 23 per cent to 2 per cent and increases milk production by 13.47% and profits by 28.65%. Early detection of mastitis using the Strip based technology, which confirms subclinical mastitis incidences in 45 per cent and 25 per cent of Cows and Buffaloes, respectively. Whereas, clinical mastitis were confirmed in 28.33 per cent and 20 per cent of Cows and Buffaloes, respectively. The major positive feedback about the dairy-based intervention was increase in milk yield (94.44%), reproductive efficiency and improvement in health (83.33%). The major constraints in case of dairy intervention were observed as "inadequate availability of bypass fat supplements (33.33%), preference over purchase of balanced feed from the market (33.33%), difficulty in purchasing of 300 doses vaccine container and management and filling of liquid nitrogen in the container by a single or small group of farmers (100%).

Livelihood augmentation of resource poor scheduled caste farm households in western dry region of Rajasthan

Interventions are being implemented based on the identified problems to enhance production and income of the Scheduled caste farmers in Bikaner and Hanumangarh district of Rajasthan. It was found that Yield of Oat (Variety Kent) was recorded as 318 quintal per hectare while yield of Chinese cabbage was recorded as 175 quintals per hectare which is first time introduced in this area. Increase in yield of Chick Pea (GNG-1958) in Bikaner 26.28per cent than the farmer practice was observedand cost benefit ratio (3.04) was also calculated as compared to 2.57 of local varieties. Capacity building of SC farmers for establishing enterprise based on their interest and need and six training programmes were organised. Awareness messages on Lumpy skin disease were circulated in 9 WhatsApp groups. Ayurveda treatment of Lumpy skin disease messages were also conveyed in WhatsApp groups.

Sustainable livelihood development of scheduled caste farmers through livestock based technological interventions in kolar district of Karnataka

Four villages viz. Karisandra, Hunasikote, Thoralakki and Jinagathimmanahalli in Kolar District were identified for implementing the project interventions. A total of 84 SC dairy farm families from the four villages were identified as the beneficiaries. 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 impact of overall

institute's interventions resulted in increased milk yield of 10-20% and improved knowledge and adoption of level on dairy farming practices.

Enriching knowledge-integrating technology and institutions for holistic village development in horticulture based farming system

The interventions included on-farm interactive sessions, Animal Health care, On-Farm Demonstrations and On-Campus Training programme. Animal Infertility & Health camp was organised, in the project villages, ChikkelegowdanaDoddi, KebbeDoddi, Yeremgere and Vasappanadoddi of Ramanagara District Karnataka, for the health care of the dairy cattle of the beneficiary farm families. The animals health camp attracted dairy cattle, 50 calves, 53 Sheep and 20 goats of 132 beneficiary farm families. On-farm demonstrations on mastitis management were organised in the project villages for sensitising the importance of early detection of clinical and sub-clinical mastitis with CMT kits, preventive measures with teat dips and follow-up activities. On-farm demonstrations on clean milk production were organised to sensitise the farm families on adoption of clean milk production practices for quality milk production. An on-campus training programme on 'Scientific Dairy Management Practices' was organised on 27.07.2022.

Agri-Startups in national capital region of Delhi: an exploratory study

The research study was conducted in the National Capital Region of Delhi in the districts of Delhi, Gurugram, Noida, Ghaziabad and Faridabad with fifty Agri Start-ups selected from a total of 133 Agri Start-ups, using purposive sampling method. The significant findings of the study revealed that, 38% of the Agri Start-ups were present in the 'early traction' stage, followed by, 'validation stage' (30%), 'scaling stage' (24%) and 'ideation stage' (8%). Majority (74%) of the Agri- Start-ups were established during the period 2017 to 2020. Only 28% of the Agri Start-ups were acquainted with incubator programme and 40% of the entrepreneurs of the start-ups under study had received training related to their Start-ups. The identified factors of the influence revealed that most of the respondents belonged to category of medium level of influence, in case of entrepreneurialbehaviour factors (70%), economic factors (56%), demographics factors (56%), environmental factors (60%), and business factors (62%). With regard to internal factors (66%) and sociocultural factors (68.18%) the levels of influence were low and medium respectively. The major constraints faced by Agri Start-up entrepreneurs were, low price for the products (49.44), high cost of technologies (47.44), lack of government support (48.14), non-cooperation of family members (54.56) and limited market access during covid-19 pandemic (59.48).

Analysis of livelihood security of dairy farmers in aspirational districts of Karnataka

A study on role of dairying in securing the livelihood of farmers in the Aspirational Districts of Karnataka State viz. Raichur and Yadgir districts, was carried out among the equal number of dairy and non-dairy farmers (n=200). To analyse the livelihood security of dairy farmers in aspirational districts a composite 'Livelihood Security Index' (LSI) was developed consisting of seven indicators. Propensity Score Matching (PSM) method was used to statistically compare dairy and non-dairy farmers. The salient findings of the study revealed that majority (52%) of the dairy farmers belonged to medium level of livelihood security, whereas, most of the non-dairy farmers (43%) had low livelihood security. The composite index score of dairy farmers was found to be 0.68, which was higher than the non-dairy farmers (0.59). PSM technique revealed that the livelihood security of dairy farmers is significantly higher than non-dairy farmers by 14.10 per cent.

Analysis of livelihood security of dairy farmers in aspirational districts of Andhra Pradesh

The research study was carried out in the aspirational districts of Andhra Pradesh namely Kadapa Vizianagaram and Visakhapatnam with180 respondents comprising equal number of dairy farmers and non-dairy farmers. The salient findings of the study revealed that most of the respondents belonged to medium level of livelihood security, whereas, most of the non-dairy farmers (48%) had low level of livelihood security. The composite index score of dairy farmers was found to be 0.72 which was higher than the non-dairy farmers (0.56). PSM technique (Propensity Score Matching) revealed that the livelihood security of dairy farmers was significantly higher than non-dairy farmers by 23.61 per cent. Food and nutritional security was found to be highest among dairy farmers (0.86) and non-dairy farmers (0.72) while economic security was the lowest for both dairy (0.51) and non-dairy farmers (0.40).

Fodder crop management interventions through bio-fertilizers and bio-pesticide for sustainable dairy farming

Demonstrations of maize and sorghum fodder crops were carried out at farmers' fields and the data pertaining to the demonstration were collected and analyzed. Nutritional quality parameters of fodder crops produced through the application of bio-fertilizers and bio-pesticides were analyzed. CP content of demonstrated maize produced in Chakdaha block was 8.92±0.47, Ranaghat-1 block was 8.75±0.20 and in Santipur block was 8.84±0.42 whereas the CP content in the sorghum fodder crop produced in Chakdaha block was 7.64±0.14, in Ranaghat-1 block was 7.61±0.21 and in Santipur block was 7.71±0.19. In the milk produced by feeding demonstrated maize fodder crop, the overall Fat (%) was 4.12±0.11, SNF (%) was 9.10±0.12, Total Solid (%) was 13.23±0.16, Protein (%) was 3.76±0.12 and FPR was 1.11±0.03. On the other hand, in the milk produced by feeding sorghum fodder crop, overall Fat (%) was 4.14±0.11, SNF (%) was 8.88±0.11, Total Solid (%) was 13.02±0.17, Protein (%) was 3.62±0.10 and FPR was 1.15±0.03. One multimedia CD was developed under the project to popularize fodder production technology by using bio-fertilizers and bio-pesticides. One YouTube channel was also created for wider promotion of the fodder production technology by using bio-fertilizer and bio-pesticide.

Upliftment of socio-economic condition of tribal people through integrated livestock farming in North Eastern Hill Region/ Eastern part of India (TSP)

The developmental works were continued in tribal dominated villages/ clusters of Birbhum, Bardhaman and Nadia districts in West Bengal during January-December, 2022. Tribal farmers were motivated to rear livestock scientifically for strengthening livestock farming with integrated approach for enhancing the family income and improving the nutritional status of their family members. Total of 105 goats and 11650 kg goat feed were distributed among 70 and 299 needy tribal farmers, respectively; 60 piglets along with 1450 kg of pig feed were also distributed to 30 beneficiary farmers; 2000 chicks and 4400 ducklings along with 12000kg chick/ duckling feed were distributed to 240 and 515 resource poor beneficiary farmers, respectively along with other inputs, like feeders, waterers etc. Off-farm Interaction-cum-Training sessions were also conducted to train 1174 Tribal farmers on different aspects of dairy farming, goat husbandry, pig farming, poultry and duck farming. Several onsite health-cum-vaccination camps were also organized to treat diseased animals reared by tribal farmers. Cattle, goats and poultry birds were also vaccinated against dreaded diseases. FLDs on oilseed (mustard) and pulses (green gram, black gram) were done based on the focused areas of the government. The benefit to cost ratios (B:C) of oilseed (Bullet variety), green gram (Virat IMP-205/07 variety) and black gram (PU 31 variety) were estimated 1.83, 1.90 and 1.91. The benefit to cost ratios (B:C) of fodder sorghum (MFSH 4 variety) and maize (J1006 variety) were evaluated as 1.68 and 1.60. Therefore, it may be interpreted that farmers can easily go for fodder production in their own cultivated land to increase the production potential of their livestock economically.

Improving the livelihood through dairy farming in North Eastern region of India

Different livestock based developmental works were continued in some villages/ clusters of north eastern hill states (Namsai district in Arunachal Pradesh, Dhalai and Udaypur districts in Tripura, Dhubri and Morigaon district in Assam, East Sikkim district in Sikkim). Farmers 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. Total of 257 goats and 13650 kg goat feed; 104 piglets along with 13100 kg of pig feed; 2000 chicks were distributed to 343 beneficiary farmers along with other inputs. Cattle feed (10800 kg) along with mineral mixture were also provided to the beneficiary farmers for enhancing the milk production potential of dairy animals reared by NEH farmers. Off-farm Interaction-cum-Training sessions were also conducted to train 625 farmers on different aspects of dairy farming, goat husbandry, pig farming, poultry and duck farming.

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. 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 beneficiary farmers of different NEH states (Sikkim, Tripura and Arunachal Pradesh) under the NDRI-NEH component adopted and increased their income through 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. On the basis of technological needs of the farmers in 6 villages under this project, a total of 218 pure Bengal goats were distributed among the SC farmers' in different districts. A total of 2000 chicks of 28 days of old were also distributed among the beneficiaries. Other inputs like supply of goat feed (3750kg), mineral mixture, dewormer, vaccine, medicines etc. were also distributed among the farmers' in the project area. One livestock mela was organized in the Birbhum district of West Bengal. A total of 40`0 beneficiaries from the Scheduled Caste community had benefited during the various interventions.

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 14, 2022 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 April 23, 26 & 28 and May 2, 13 & 20, 2022 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 October 8, 2022 at SRS, Bengaluru, November 9, 2022 and December 22&28, 2022 and January 4, 5 & 10, 2023 at ICAR-NDRI, Karnal and February 7, 2023 at ERS, Kalyani. 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. Ten PMC Meetings PMC Meetings were conducted on 24.01.2022, 04.02.2022, 25.02.2022, 30.03.2022, 16.04.2022, 27.04.2022, 21.05.2022, 25.05.2022, 25.06.2022, 27.07.2022 to consider and screen 83 No Externally Funded / Contract / Consultancy research proposals. In addition, proposals for external funding grants for research as well as training were also screened online by seeking expert comments of members of PMC through mails for submission 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 New Delhi , DST SERB Power Grant, National Livestock Mission, ICMR, FSSAI, BMGF, ICSSR, Pradhan Mantri Kisan Sampada and Alltech Biotechnology Pvt.Ltd., Bangalore. The Proceedings of the above PMC meetings were also documented and accordingly proposals were modified and aligned with priorities of the Institute.

PME also coordinated with scientists of the divisions and regional stations and facilitated submission of research proposals after proper documentation. The cell also handled all the correspondence and maintained liaison with SMD, ICAR for smooth implementation of research and training proposals.

Formulation of Guidelines

In order to provide robust mechanism for developing and strengthening the research ecosystem, PME Unit formulated guidelines related to submission of Project Proposals for External Funding / Consultancy / Contract Research. PME Cell also prepared 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 Dayalbagh Educational Institute (Deemed University) Dayalbagh agra on 03.01.2022.
- MoU signed with The O. S. Bal Kumdan Foundation- Kashi(Gadauli Dham), Office at B- 41, Virat Apartment, Mahmoorganj, Varanasi (UP) on 29.06.2022.
- MoU signed with Gaumukh Dairy Welfare Society Village Garhkhal, Talla Banas, PO, Kimsar, Block Yamkshwar, Pauri, Garhwal (UK) on 06.07.2022.
- MoU signed with Association of Innovation Development for Entrepreneurship in Agriculture Centre for Agri- Innovation of ICAR- NAARM, Hyderabad on 08.07.2022.
- MoU signed with Lovely Professional University, Punjab on 18.05.2022.
- MoU signed with DBT Project on development of polarized angular light scattering and microfluidics Technology for bovine sperm sexing on 22.04.2022.
- MoU signed with Alltech Biotechnology Pvt. Ltd. India, Bengaluru on 15.12.2022.
- MoU signed with BAIF Development Research Foundation, Pune on 02.11.2022.

Agricultural Research Management System (ARMS)

The PME Unit implemented on-line database / computerization of research projects under ARMS introduced in 2022. A Nodal Officer (ARMS) was appointed to manage the ARMS data base.

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, evaluated and allotted publication numbers of ICAR-NDRI:

- Hundred Glorious years of NDRI
- Innovative Dairy Technologies Commercialized
- Economic Impact of Research and Development of Indian Dairy Sector
- Comparative Study of Indigenous v/s Crossbred and Buffalo
- Starter Cultures and Fermented Milk Products
- Karan Fries Cattle –Pride of ICAR-NDRI
- Compendium on Basics of Electrical Engineering for B.Tech (Dairy Technology) Students

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 -2021.
- ICAR-NDRI News Letter-a quarterly newsletter in English.
- Director's Report for the 19th Convocation.
- Research Projects (2022).
- 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 2022-2023.

XIII Plan EFC Memo Document (2021-26)

- Formulation of EFC plan document under the theme No. 17: "Dairy Production &Technology Development" amounting to Rs. 420.97 Crores comprising Sub-scheme 17(i): ICAR-NDRI, Karnal with total outlay of (Rs.238.27) Crores: 17(ii): ICAR-CIRB, Hisar with total outlay of (Rs.54.19) Crores; 17(iii): ICAR-CIRB, Network Project on Buffalo Improvement, Hisar with total outlay of (Rs.32.31) Crores; 17(iv): ICAR-CIRC, Meerut with total outlay of (Rs.33.08) Crores; 17(v): ICAR-CIRC, All India Co-ordinated Research Project, Meerut with total outlay of (Rs.30.37) Crores, 17(vi): ICAR-NRC on Camel, Bikaner with total outlay of (Rs.32.76) 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 / Weekly/ Monthly Reports

- PME unit consolidated the half yearly / Quarterly / Weekly/Monthly 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 July & August, 2022.

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.

- Thirty Eight Report of Standing Committee on Agriculture, Animal Husbandry and Food Processing on Demands for Grants (2022-23) of the Ministry of Agricultural and Farmers Welfare (DARE).
- PM Announcements for the period (April, 2022 to March, 2023).
- Observation (s)/suggestion (s) made during the interactive of Director General ICAR- meeting held on October 28, 2022.
- SOC meeting held on 7th march, 2022 held at ICAR, New Delhi.
- SOC meeting held on 6th July, 2022 held at ICAR, New Delhi.
- Action plan for 2022-23 for organization of skill development training programmes during 2022-23 under Agriculture Skill Council of India.
- eSamikSha status on the important observation(s)/suggestion(s) with respect to Department of Agriculture Research and Education (DARE) as on June 25, 2022
- PMO Reference- Urgent Inputs regarding success stories for doubling farmers' income.
- Minutes of 93 Annual General meeting of ICAR Society held in 2022 through video conferencing.
- ICAR Directors' Annual Conference held during 2022.
- 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.
- Annual Conference of VCs of Agricultural Universities held during 2022.
- Plan of action and time frame applicable at Institute level on QRT recommendations (2013-2018).
- Minutes of the meeting held under the Chairmanship of Additional Secretary, DARE & Secretary, ICAR to review the preparedness for ICAR Foundation Day celebrated on 16th June, 2022.
- Consolidated information sought by PMO office for making Atmanirbhar Bharat by providing scientific interventions to the dairy farmers.
- Ministry wise actionable points derived from various PPTs in respect of ICAR- NDRI, Karnal.
- Research targets for the year 2021- 2022 for implementation of TSP / NEH / SCSP Programmes.

Besides, PME Cell also collated information towards agenda and nine 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 publication 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 44 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	:	89
•	New Research Projects	:	12
•	Externally Funded Projects (National)	:	61
•	Externally Funded Projects (International)	:	04
•	Externally Funded Projects Proposals Screened	:	117
•	Contract / Consultancy Projects	:	03
•	MoUs Screened / Signed	:	08
•	IRC Meetings Convened and Co-ordinated	:	02
•	Manuscripts of Technical Bulletins / Books Scrutinized / Evaluated	:	07
•	NDRI-Annual Report (2021)	:	01
•	Quarterly NDRI News Letter (4 Issues)	:	04
•	Proceedings of IRC	:	02
•	Proceedings of RAC	:	01
•	Reports Collated	:	65
•	Action Taken Reports / Status Reports	:	21
•	Half Yearly Reports	:	02
•	Parliament Questions Attended	:	44
•	Monthly Reports	:	12
•	Quarterly Reports	:	04
•	Assessment Cases of Scientists Handled	:	45

Research Projects 2022 (In-House)

S. No.	Name of Project	Name of 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)	Dhruba 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)	Ajay Mondal
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 regin 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.	Monitoring various physio-pathological conditions by Infra Red Thermography (IRT) in dairy animals for efficient management decision.(B-54)	Mukesh Bhakat
16.	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 Mishra
17.	Improvement of Black Bengal goats for enhancement of productivity in eastern region of India products. (B-56)	A. Santra
18.	Augmentation of fertility in jersey crossbred cows through nutritional and hormonal interventions. (B-57)	M. Karunakaran
19.	Enhancement of socio-economic condition of Scheduled Caste farmers through livestock based integrated farming in Eastern India interventions. (B-58)	Ajay Mondal
20.	Faster multiplication of Sahiwal germplasm through OPU-IVF-Assisted Reproductive Technology. (B-59)	T.K. Mohanty
21.	Strengthening dairy based integrated farming system and optimization of resource utilization.(B-60)	Arun Kumar Mishra
22.	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
23.	Selective use of antimicrobial alternatives in cryopreservation of crossbred bull semen. (B-62)	Nishant Kumar
24.	Development and Characterization of progesterone loaded nanofibre for controlled breeding in dairy cattle.(B-63)	Vedamurthy G.V.
25.	Evaluation of recycled manure solids as a potential cow bedding material.(B-64)	MukundA.Kataktalware
26.	Effect of of biostimulation in overcoming seasonal sub-fertility and infertility in buffaloes.(B-65)	M.L. Kamboj
27.	Therapeutic efficacy and immunomodulatory role of trisoidum citrate and nano-minerals supplementation of subclinical mastitis in dairy cows (Lead Station. (C-57)	A. Manimaran
28.	Evaluation of Moringa oleifera L. cultivars for quality fodder production under differential plant geometry in eastern Haryana. (C-58)	Rajesh Kumar Meena
29.	Supplementation of micronutrients on attaining early sexual maturity of males. (C-59)	Goutam Mondal
30.	Priobiotics, Prebiotics and phytogenic medicinal extracts exploration of their role in augmenting neonatal calf gut health and growth performance.(C-60)	Sachin Kumar

31.	Flavour and taste ingredient as feed additives and their effect on feed intake and growth performance of cattle calves. (C-61)	Raman Malik
32.	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
33.	Utilisation of paddy straw as strawlage: a complete feed solution for dairy animals. (C-63)	Nitin Tyagi
34.	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
35.	Nutritional enrichment of rice straw: evaluation and utilization in crossbred cattle Ration. (C-67)	A. Chatterjee
36.	Effect of sewage water on seed production of Maize-Berseem cropping system under differential nutrient management practices. (C-68)	Hardev Ram
37.	Protein profiling of milk from native indigenous breeds (cow and buffalo) in relation to their bioactive potential. (D-56)	Rajesh Kumar
38.	Unveiling the microbial diversity of traditional Indian fermented milk product 'Dahi' through culturomic and metagenomic approaches.(D-58)	Rashmi H.M
39.	Development of nutria-cereal based protein rich probiotic dairy spreads and dips. (D-59)	Devaraja H.C
40.	Development of direct vat set (DVS) probiotics for preparation of fermented milk products. (D-60)	Chand Ram
41.	Development of colostrum whey-derived bioactive peptide ingredients and preparation of protein-rich fermented whey beverage. (D-61)	Shilpa Vij
42.	Profiling of milk constituents from indigenous breeds of cattle and buffalo. (D-62)	Rajesh Kumar
43.	Development of processed cheese from milk protein ingredients. (E-45)	Yogesh Khetra
44.	Development of mechanised feed and fodder distribution and feeding system. (E-47)	Ankit Deep
45.	Technology for Moringa oleifera enriched cheese spread (Lead Division: Dairy. (E-48)	Neelam Upadhaya
46.	Technology Development for the Production of Ghee Residue Powder. (E-49)	G.S Meena
47.	Development of automatic integrated hybrid solar yogurt making system. (E-50)	Chitranayak
48.	On-package smart sensor as freshness indicator for set-type fermented dairy products. (E-51)	Narendar Raju Panjagari
49.	Development of Convective-Electrohydrodynamic Drying System for Paneer. (E-52)	F.Magdaline Eljeeva Emerald
50.	Valorization of ghee residue as a source of phospholipids for application in select food products. (E-53)	Monika Sharma
51.	Development of multipurpose automatic controlled rate heating system for production of paneer and Greek yogurt. (E-54)	Vairat Amita Dinkar
52.	Development of improved bioreactor prototype for cattle waste management. (E-55)	P.S. Minz
53.	Metabolomics-assisted elucidation of compositional and technological variations among milks of different goat breeds. (E-56)	Heena Sharma
54.	Development of an energy efficient method for ghee preparation from butteroil. (E-57)	Writhdama Prasad
55.	Development of thermic fluid based small scale mechanized process unit for rasogolla cooking.(E-58)	Priyanka
56.	Development of Magnetic Induction based milk heating System for Paneer. (E-59)	Hima John
57.	Development of Integrated Milk Coagulation cum Coagulum pressing unit for Paneer manufacturing at small scale. (E-60)	P. Barnwal
58.	Functional analysis of urine of indigenous vis-à-vis crossbred cows. (F-28)	Mamta
59.	Biological smart time temperature indicator for monitoring thermal abuse and quality of paneer. (F-29)	Gourav Kumar Deshwal
60.	Detection of Sorbitol as an adulterant in milk. (F-30)	Vivek Sharma
61.	Development of lateral flow immunoassay to detect buffalo milk in cow milk. (F-31)	Kamal Gandhi
62.	Isolation & screening of bacteriophages for removal of Bacillus & Geobacillus biofilm from dairy surfaces. (F-32)	Pradip Behare

63.	"Development of analytical strategy for estimation of endogenous water-soluble vitamins in milk".(F-33)	Richa singh
64.	Attenuated total reflectance-fourier transform infrared spectroscopy coupled with chemometrics to detect foreign fats in ghee. (F-34)	Kamal Gandhi
65.	Exploring the anti-obesity potential of protein hydrolysates derived from goat, camel, cow and buffalo milk. (F-35)	Sunita Meena
66.	Fodder crop management interventions through bio-fertilizers and Bio-pesticide for sustainable dairy farming. (G-68)	Asif Mohammad
67.	Impact assessment of COVID-19 pandemic on Indian dairy sector. (G-69)	Gunjan Bhandari
68.	Impact assessment of selected technologies of NDRI. (G-70)	Anil K. Dixit
69.	Development of climate services for Murrah buffalo farmers of Haryana. (G-71)	Sanjit Maiti
70.	Sustainable Livelihood Development of Scheduled Caste Farmers through Livestock based Technological Interventions in Kolar District of Karnataka. (G-72)	S. Subhash Scientist
71.	Improving adaptive capacity of women farmers of Haryana through climate resilient Dairy farming practices. (G-73)	Sanchita Garai
72.	Promotion of dairy farming for upliftment of socio-economic status of tribal farmers through technological interventions in Meghalaya. (G-74)	B. S. Meena
73.	Estimation of life time economics of selected breeds of dairy animals in field conditions. (G-76)	B. S. Chandel
74.	Dairy startups in Karnataka State: An ecosystem analysis. (G-77)	S. Subhash
75.	Breed-wise economics of milk production in Gujarat- A Comparative analysis. (G-78)	Udita Choudhary
76.	Livelihood augmentation of resource poor Scheduled Caste farm households in Western Dry Region of Rajasthan. (G-79)	Gopal Shankhala
77.	Explore the use of mesenchymel stem cells for early puberty of cattle and buffalo heifers	D.Malakar ABTC
78.	Enhancing economy of livestock farmers of SC communities of Uttrakhand state through artificial insemination using cloned buffalo bull semen.	M. K. Singh
79.	Exploring the potential of OPU-IVF in buffaloes.	Naresh L. Selokar
80.	To Elucidate the genomic architecture and breed composition of Karan F cattle	Sabya Sachi Mukherjee
81.	Need based intervention for improving the productivity of indigenous breeds of cattle at Goras, Sheopur (Madhya Pradesh)	S.S.Lathwal
82.	Determination of sample size and covariance structure for animal studies involving linear mixed-effects models	M. Sivaram
83.	Development of organic nutrient management practices on fodder- food based cropping systems.	Sanjeev Kumar
84.	Effect of residue management on soil microbial activities under salt affected soils in rice-wheat system	Rakesh Kumar
85.	Utilization of paneer whey towards sustainable production of bioactive lactose-derived oligosaccharides	Priyanka Singh Rao
86.	Development of modular humidity controlling device for enhancing shelf stability during refrigerated storage for selected dairy products.	Ankit Deep
87.	Empowerment of tribal farmers through dairy interventions in Rajasthan.	B. S. Meena
88.	Farmers participatory assessment of saliva scope for estrus detection method in Buffalo	Sanjit Maiti
89.	An appraisal of natural farming practices in different climatic zone of north India	H. R. Meena

New Externally Funded Projects Sanctioned-2022

S. No.	Title	PI/CC PI	Co-PI	Funding Agency	Duration	Budget Rs. in Lakhs
1.	Antimicrobial resistance surveillance in view of one health concept	Lead Centre-KCGMCH Karnal S. De	Anupam Berwal	ICMR-New Delhi	2022-24	57.34

2.	Utilization of paddy straw as complete fodder block by treating with goumutra (Indigenous cow urine)	CIRC Meerut NDRI, Karnal: (Nitin Tyagi)	Sanjeev Kumar Verma, Naimi Chand, Ahmad Fahim, CCPI: CCCo-PI: Sachin Kumar	DST	2022-2025	70.68
3.	Evaluation of bio functional attributes of extracellular components derived from probiotic lactobacilli as postbiotics.	Rajeev Kapila	Suman Kapila	SERB	2022-2025	40.00
4.	Isolation of pro-rich poly peptides from colostrum of select indigenous cattle breed and evaluation of their neutraceutical potential.	Sathish Kumar, M.H.	Shaik Abdul Husain	NASF	2022-2025	100.55
5.	In-situ production of active vitamin B12 rich ready to use therapeutic composite dairy food and evaluation of its bioavailability and safety	Devraja H.C., SRS	Monika Sharma, Rashmi H.M., Ruchika M. S.	ICMR- New Delhi	2022-2025	99.92
6.	Unique innate-immunity genomic signatures identification in Sahiwal Gir, Tharparkar, Kangeyamm Karan Fries and Holstein Friesian cattle using immune informatics	Suneel Kumar Onteru	Ragothaman M.Yennamalli, Sastra Deemed to be University, Thanjavur	NASF	2022-2025	95.40
7.	Comparative functional analysis of human bovine and goat milk based on modulation in the gut bacterial and metabolite composition.	Rashmi H M	Diwas Pradhan, Suman Kapila, Rajesh Kumar, Heena Sharma	ICMR (Collaboration: Dr. B. R. Ambedkar State Instt. of Medical Science	2022-2025	90.00
8.	Evaluation of semen characteristics and fertility parameters of cloned bulls and performance of clones progenies-phase-II	Lead Centre-ICAR-CIRB, Hisar-125001 M.K. Singh	ICAR-NDRI, Karnal-132001	NASF	2022-2025	450.58

9.	Development of Nano-Micro Matrices for the Delivery of Bioactives, Micro-nutrients and Therapeutics	Bimlesh Mann	Naveen K Navani, IIT Roorkee, Rajendran D., ICAR-NIANP, Bengaluru, P.Senthil Kumar, TANUVAS, Orathanadu, P.Heartwin Amaladhas	NASF	2022-2025	401.63
10.	Characterization of native livestock and spoultry population of West Bengal State.	Main center NBAGR CC-PI Ajoy Mandal (ERS)	S. M .Deb. M. Karunakaran & C. Bhakat	ICAR under Network Project on Characterization & Documentation of ANGR of NBAGR Karnal	2022-2024	27.50
11.	Electronic Platform to monitor catle health and milk quality	CCPI: S.M.Deb (ERS)	A. Mandal, M. Karunakaran & C. Bhakat	Ministry of Electronics & Information Technology	2022-2024	60.88
12.	Development of climate resilient and sustainable agri-based systems for better food, feed, nutritional and livelihood security options to farming community of Cold arid region-Ladakh	Anurag Saxena	Sanjeev Kumar, Hardev Ram,A. K.Mishra, Ashutosh, P.N.Raju, Richa Singh	DST	2022-2025	272.00
13.	Unraveling the genomic diversity and identifying Putative SNPs for Milk quality and production in Bilahi and crossberd population in Haryana State	G. R. Gowane	Vikas Vohra,Rani Alex	DST(HSCSI&T)	2022-25	40.00
14.	Genome editing for improved lactation traits in Indian Buffalo	Naresh Selokar Bhanu	Chi-hun- Park, Ravikant Reddy Ponnuru	BMGF	2022-27	98.53
15.	Development and functional characterization of spray-dried lactose-free milk powder using high molecular weight polysaccharide as adjunct	Richa Singh	Sumit Arora	DST	2022-25	21.00
16.	Controlling subclinical mastitis through NIFs indigenous medication farmers field in region of Haryana	K. Ponnusamy	A.K. Mishra, T.K. Mohanty, Chand Ram Grover	NIF	2022 -23	10.45
17.	Establishment of AI network in Muzaffarnagar	Pawan Singh	-	DADF	2022-23	859.10

5. EXTRA-MURAL FUNDING AND COLLABORATIONS

Externally Funded Projects

S. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration	Cost (Lakhs)
1.	Network project on buffalo Improvement-Institute herd-ICAR (CIRB Hisar-125001)	Vikas Vohra	Pawan Singh, G.R. Gowane, T.K. Mohanty and Mukesh Bhakat	ICAR	2017-2026	15.60
2.	Network project on buffalo Improvement-Field Unit (CIRB Hisar-125001)	Vikas Vohra	G.R. Gowane, Sabyasachi Mukherjee and S.K. Rathi	ICAR	2017-2026	30.70
3.	Monitoring of drug residues and other environmental pollutants-outreach project of ICAR	N. K. Goel	Raghu H. V	ICAR	2017-2022	19.87
4.	Indigenous breed program (Sahiwal Cattle).	Anupama Mukherjee	Vikas Vohra, T. K. Mohanty, S.S. Lathwal, Mukesh Bhakat	ICAR	2015-2026	8.35
5.	National Innovations in climate resilient Agriculture (NICRA)	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 and Biswa Bhaskar	CRIDA (ICAR)	2021-2025	91.50
6.	Network programme on veterinary type culture (VTC)-Rumen Microbes.	Sachin Kumar	Nitin Tyagi	ICAR	2009-2023	13.80
7.	Scheme on Dairy Microbes under Network Mode	P.V. Behare	A.K. Puniya	ICAR Network Project	2019-2024	95.00
8.	Upliftment of socio-economic condition of tribal people through integrated livestock farming in north eastern hill region/eastern part of India – ICAR	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 and R. Behera	ICAR	2020-2026	50.00
9.	Water budgeting and improving water productivity livestock based farming.	Ashutosh	Mahendra Singh, Sunita Meena and Satish Kumar	ICAR	2020-2025	90.00
10.	Study of fodder crop assessment for dairy industry and potential areas of intensification of state level.	Magan Singh	V. K. Meena and Sanjiv Kumar	Space App. Centre, Ahmedabad	2016-2023	34.00
11.	Preparation of inventory of GHG emissions from Indian Livestok for the year 2019	Goutam Mandal	Nitin Tyagi	MoE&F Th. Inspire Network for Environment.	2016-2022	75.80
12.	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 and (S. Bandopadhyay, Samiran Bandopadhyay, S. Naskar & P. Dandapat=IVRI-ERS-Kolkata)	ICAR	2017-2026	20.00

13.	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 and Omvir Singh	ICAR	2016-2023	33.62
14.	Proteo-Genomic Approach to Elucidate Productive and Reproductive Performance of Malnad Gidda, Deoni, and Hallikar Breeds of Cattle.	K. P. Ramesha	M. A. Kataktalware, S.Jeyakumar, A. Manimaran and D. N. Dass	KLDA-MoEF	2017-2022	296.50
15.	Enriching knowledge-integrating technology and institutions for holistic village development in horticulture based farming system.	B. Balakrishna, IIHR, Bengaluru	M. C. A. Devi and S. Subhash	ICAR	2016-2022	31.80
16.	Incentivizing Research in Agriculture Project-V Semen sexing in cattle.	A. K. Mohanty	Sudarshan Kumar	ICAR	2017-2023	239.50
17.	Incentivizing research in agriculture Project-V Semen Sexing in cattle.	T. K. Mohanty	Mukesh Bhagat, A. Kumaresan, Pawan Singh and Rubina K. Baithalu	ICAR	2017-2023	549.84
18.	DOSA- Diagnostics for one health and user driven solutions for AMR.	Naresh Kumar	-	Indo-UK DBT	2018-2022	88.09
19.	CRISPR/CAS9 guided functional analysis of genes regulation early embryonic in buffalo.	D. Malakar	Satish Kumar	NASF	2018-2022	62.44
20.	Modulating the immune-cellular components and their signaling molecules in bovine colostrum and milk after micronutrient interventions and their functional validation under ex-vivo and in vivo animal models.	A.K. Dang	Sujata Pandita, S. S. Lathwal and Rajeev Kapila	DBT	2019-2022	76.39
21.	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 and K. Ponnusamy	ICMR	2019-2022	59.19
22.	Empowering farmers through selective interventions in salt affected agroecosystems of Ghaghar Plains(Farmers FIRST Programme, Funded by ICAR	Sohanvir Singh	K. Ponnusamy	ICAR	2018-2023	169.80
23.	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	2019-2023	28.80
24.	The mechanism behind formation of coocable milk gels (GELCOOK)	Yogesh Khetra	S. A. Hussain	University of Copenhagen, Denmark	2019-2022	64.90
25.	Explaining the biogenesis and interaction of Pirnas and PIWI proteins in buffalo testes in relation to bull fertility	Rakesh Kumar	T.K. Datta	SERB Funded, ASEAN –INDO Collaboration	2020-2022	16.8

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 and Pardeep Kumar	DBT	2020-2023	193.00
27.	Development of flaxseed-rich probiotic dairy foods to address menopause symptoms	Sangita Ganguly	Neelam Upadhyay	DST	2020-2023	35.06
28.	Elecrohydrodynamic encapsulation of probiotics in prebiotic nanofibres for food applications	P.Heartwin Amaladhas	Sachin Kumar and Nitin Tyagi	DST	2020-2023	25.07
29.	Prevalence of Antimicrobial resistance in dairy starter bacteria in Haryana region	Diwas Pradhan	Rashmi HM and Saurabh Kadyan	ICMR	2019-2022	41.66
30.	Differential carriage of extracellular vesicles (EVs) in seminal plasma of cattle and buffalo bulls as a novel fertility indicator	Rakesh Kumar	T.K.Datta and Mukesh Bhakat	DBT	2021-2023	85.32
31.	Genomic based approaches for characterization of the microbial antibiotic resistance and resistome in Dairy production system	Rashi H.M.	Diwas Pradhan, Saurab Kadyan and Sunita Grover	ICMR	2021-2024	49.32
32.	Development of phyto-immunobiotic for reduction of bovine intra mammary infections: comparative studies on bioactive compounds and whole extract effects	A. Manimaran	-	SERB	25.03.2021 to 24.03.2024	46.20
33.	Process for the preparation of lactose free skim milk powder with approaches to minimize maillard reaction	Sumit Arora	Vivek Sharma, Ashish Kumar Priyanka Singh Rao and Richa Singh	DBT	2021-2024	44.45
34.	Application of nano-immobilized β-Galactosidase for production of galactooligosaccharides from dairy by-product	Manoj Kumar C.T.	Latha Sabiki, Abdul Hussain and Rajan Sharma	MOFPI	2021-2023	43.94
35.	Development of polarized angular scattering and microfluidics technology for bovine sperm sexing	Sharad Gupta	T.K. Mohanty and Mukesh Bhakat	DBT	2021-2023	157.0376
36.	Production of dairy powder from by-products (ghee residue and butter milk); characterization and application in heat desiceated products/ convenience formulations.	G.S. Meena	A.K. Singh, Sumit Arora and Yogesh Khetra	MOFPI	2021-2023	4352
37.	Characterizing milk colostrum of ladakhi Cows and Yak for identification of Biomolecules with therapeutic potential	Sudarshan Kumar	Jai Kumar Kaushik	SERB-DST	2020-2023	349.42
38.	Production of Double Muscled-Mass Farm Animal using CRISPR	Naresh Selokar	S. De, S. Lathwal, M.K. Singh and M.S. Chauhan	NASF	2021-2023	165.92
39.	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
40.	CRP on biofortification: suitability of incorporating biofortified cereal straw in animal studies	Arun Kumar Misra	Chander Datt and Rajan Sharma	ICAR-NIANP	2021-2023	10.00

41.	Development of quantitative molecular assays for rapid enumeration of viable probiotics from probiotic food products	Rashmi H.M.	Diwas Pradhan	ICMR	2021-2024	43.90
42..	Utilization of paddy straw as complete fodder block by treating with Gomutra (Indigenous cow urine)	Ajayvir Singh Sirohi	Sanjeev Kumar Verma, Naimi Chand, Ahmad Fahim, Nitin Tyagi and Sachin Kumar	DST-SEED-SUTRA	2022-2024	70.68
43.	Antimicrobial resistance surveillance in view of one health concept	Prerna Aggarwal KCGMCH	Anupam Berwal and Sachinandan De	ICMR	2022-2024	57.34
44.	Electronic platform to monitor cattle health and milk quality	S.M. Deb	Ajoy Mandal, Chamapak Bhakat and M. Karunakaran	MEIT	2022-2024	60.88
45.	Characterization of native livestock and poultry population of West Bengal State.	Ajoy Mandal	S.M. Deb, M. Karunakaran and Mohan Mandal	ICAR	2022-2027	27.50
46.	ICAR Network programme on precision agriculture.	T.K. Mohanty	A.K. Mishra, S.S. Lathwal and Mukesh Bhakat	ICAR-NEPPA	2021-2026	332.00
47.	Development of climate resilient and sustainable agri based systems for better food, feed, nutritional and livelihood security potions to farming community of cold arid region-Ladakh.	Anurag Saxena	Nirmal Kumar Ravindra Kashinath Naitam, Shiraj Saleem Bhatt, Sandeep Saran and Goutam Kolluri	DST	2022-2025	272.00
48.	Evaluation of bio functional attributes of extracellular components derived from probiotic lactobacilli as postbiotics.	Rajeev Kapila	Suman Kapila	SERB	2022-2025	40.00
49.	Isolation of pro-rich poly peptides from colostrum of select indigenous cattle breed and evaluation of their neutraceutical potential.	Sathish Kumar, M.H.	Shaik Abdul Husain	NASF	2022-2025	100.55
50.	Generation of milk somatic cell reference values and intelligent and predictive modelling for monitoring mammry profile and milk quality of indigenous dairy animals.	A.K. Dang	Gourav Kr. Deshwal, and Adesh K. Sharma	DBT	2021-2024	73.06
51.	Protein Based Optical sensors for detection of listeria monocytogenes in milk.	Raghu H.V.	Rashmi H.M. and Naresh Kumar	ICMR	2021-2024	43.30
52.	Dairy entrepreneurship development among rural youth and women in aspirational districts of Karnataka State	S. Subash	K.P. Ramesha, S. Jeyakumar and H.C. Devaraja	RKVY	2021-2024	232.00
53.	In-situ production of active vitamin B12 rich ready to use therapeutic composite dairy food and evaluation of its bioavailability and safety	Devraja H.C.	Monika Sharma, Rashmi H.M. and Ruchika M.S.	ICMR	2023-2026	44.89
54.	Unique innate-immunity genomic signatures identification in Sahiwal Gir, Tharparkar, Kangeyamm Karan Fries and Holstein Friesian cattle using immune informatics	Suneel Kumar Onteru	Ragothaman M. Yennamalli, Thanjavur	NASF	2022-2025	95.40

55.	Comparative functional analysis of human bovine and goat milk based on modulation in the gut bacterial and metabolite composition	Rashmi H M	Diwas Pradhan, Suman Kapila, Rajesh Kumar and Heena Sharma	ICMR (Collaboration with Dr. B. R. Ambedkar State Inst. of Medical Science)	2022-2025	90.00
56.	Evaluation of semen characteristics and fertility parameters of cloned bulls and performance of clones progenies-phase II.	Prem Singh Yadav, ICAR-CIRB, Hisar	Manoj K. Singh	NASF	2022-2025	450.58
57.	Development of Nano-Micro Matrices for the Delivery of Bioactives, Micro-nutrients and Therapeutics	Bimlesh Mann	Naveen K Navani, IIT Roorke, Rajendran D., ICAR-NIANP, Bengaluru P. Senthil Kumar, TANUVAS, Orathanad and P. Heartwin Amaladhas	NASF	2022-2025	401.63
58.	Unraveling the genomic diversity and identifying Putative SNPs for Milk quality and production in Bilahi and crossberd population in Haryana State	G.R. Gowane	Vikas Vohra and Rani Alex	DST (HSCSI&T)	3 Years	40.00
59.	Development and functional characterization of spray-dried lactose-free milk powder using high molecular weight polysaccharide as adjunct	Richa Singh	Sumit Arora	DST under SYST	3 Years	21.00
60.	Controlling subclinical mastitis through NIFs indigenous medication farmers field in region of Haryana	K. Ponnusamy	A.K. Mishra, T.K. Mohanty and Chand Ram Grover	NIF (DST)	2022-2023	10.45
61.	Establishment of AI network in Muzaffarnagar	Pawan Singh		DADF	2022-2023	859.10
62.	Molecular markers for improving reproduction of cattle and buffaloes (MMIRCB).	Rakesh Kumar	Dheer Singh, Suneel Onteru, Rubina K. Baithalu, A. K. Mohanty, Sudarshan Kumar, T. K. Mohanty, J. K. Kaushik and Mukesh Bhakat	Bill & Melinda Gates Foundation, USA	2018-2023	648.38
63.	Molecular markers for improving reproduction of cattle and buffaloes (MMIRCB)-Bill & Melinda Gates Foundation, USA	A.Kumaresan	A. Manimaran and K.P. Ramesha	Bill & Melinda Gates Foundation, USA	2018-2023	127.13
64.	Development of probiotic fermented food for prevention of childhood diarrhea against Indian diarrheal pathotypes	Suman Kapila	-	Indo-Spain Project	2020-2023	10.20
65.	Genome editing for improved lactation traits in Indian Buffalo	Naresh Selokar Bhanu	Chi-Hun- Park, Ravikant Reddy Ponnuru	IAEA/BMGF	5 Years	98.53

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 decisis 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. During the year from Jan 2022 – Dec 2022, two ITMC meetings were held as per follows

- 54th ITMC Meeting was held on 16.03.2023
- 55th ITMC Meeting was held on 06.08.2022
- 56th ITMC Meeting was held on 22.12.2022

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, a total of 15 technologies developed at the Institute were transferred to 06 commercial houses through 06 different License agreements thereby earning a total of Rs. 40.50 Lakhs (excluding Service Tax) for the Institute through technology transfer fee. The lists of technologies transferred and other activities are as follows:

Technologies Developed-2022 (19)

S. No.	Name of Technology	Approved on	Inventors
1.	"Dual technique Rumen protected B-complex enzymes"	16.03.2022 (54th ITMC)	Bandla Srinivas and R. Dhinesh Kumar
2.	"Area-specific mineral mixture (ALMIN-ERS) for livestock in the lower Genetic region of West Bengal".	16.03.2022 (54th ITMC)	Ajoy Mandal, A. Chatterjee and M. Karunakaran
3.	"Kid life-milk supplement to enhance the survivability and growth of kids".	16.03.2022 (54th ITMC)	Ajoy Mandal, M. Karunakaran and T.K. Dutta
4.	"Extender for preservation of Black Bengal buck semen".	16.03.2022 (54th ITMC)	M. Karunakaran, Ajoy Mandal and S.K. Das
5.	"Post-partum reproduction augmenting polyherbal mixture for dairy cattle and buffaloes"	16.03.2022 (54th ITMC)	A. Kumaresan, Phule Japheth, P.S. Oberoi and A. Manimaran
6.	"Encapsulation of DPP-IV inhibitory peptides in double emulsion matrix"	16.03.2022 (54th ITMC)	Shaik Abdul Hussain, Swapnil Ramrao Patange, Latha Sabikhi, Prashant Shelke, Yogesh Khetra, Sunita Meena and Sathish Kumar, M.H.
7.	"Low-Cost natural Chromogenic media to distinguish between *E. Coli* and *Klebsiella* Species"	16.03.2022 (54th ITMC)	Sachinandan De, Parul Chaudhary, Rajib Deb and Manisha Behera
8.	"Sperm function-based bull fertility assessment technology" (Inventor: A. Kumaresan), LPM Section, ICAR-SRS-NDRI, Bengaluru.	16.03.2022 (54th ITMC)	A. Kumaresan
9.	"Technology for reduced energy consumption during clarification step of Ghee preparation"	16.03.2022 (54th ITMC)	Writdhama G Prasad, Shubham Kumbhare, Kaushik Khamrui and Shaik Abdul Hussain
10.	"A process for preparation of milk protein fortified eggless muffins"	16.03.2022 (54th ITMC)	Kaushik Khamrui, Rishi Puri and Writdhama G Prasad
11.	"Rapid AST assay for detection of EBSL, Amp-C β-Lactamase and Carbapenem resistance in *E. coli*"	16.03.2022 (54th ITMC)	Naresh Kumar, Avinash Jaswal and Raghu H.V.

12.	Technology of low-fat Shrikhand by using exopolysaccharides (EPS) producing lactic cultures"	16.03.2022 (54th ITMC)	Pradip Vishnu Behare, Harisha M. R., S. K. Tomar and Sanket Borad
13.	Technology of making universal control line in lateral flow assay	06.08.2022 (55th ITMC)	Y.S. Rajput, Dhiraj Nanda and Rajan Sharma
14.	Ghee –Residue Powder and Process of Preparing the same	06.08.2022 (55th ITMC)	Ganga Sahay Meena, Akash Gill, Yogesh Khetra, Ashish Kumar Singh and Sumit Arora
15.	An energy efficient method for Ghee flavour simulation in butteroil	22.12.2022 56th ITMC	Writdhama G Prasad, Piyush Poharkar, Kaushik Khamurai, Shaik Abdul Hussain and Ankit Deep
16.	On-Package Smart Indicator for Khoa	22.12.2022 56th ITMC	Narender Raju Panjagari, Rakesh Kumar Raman, Gautam Kumar and Ashish Kumar Singh
17.	On-Package Smart Indicator for Sandesh, A Chhana-based Confection	22.12.2022 56th ITMC	Narender Raju Panjagari, Karpurapu Uma, Sangita Ganguly and Ashish Kumar Singh
18.	On-Package Smart Indicator for Nutrimix	22.12.2022 56th ITMC	Narender Raju Panjagari, Lal Chand Sharma and Ashish Kumar Singh
19.	Ghee residue incorporated chocolate dairy spread.	22.12.2022 56th ITMC	Monika Sharma, Abhishek Singh Kanwar, Devaraja HC and Menon Rekha Ravindra

Technologies Commercialized-2022 (15)

S. No.	Name of technology	Inventor (s)	Technologies commercialize date	Price Fix (in Rupees)	Buyer
1.	Paper strip assay for rapid detection of pesticide residues	Naresh Kumar, N. Tehri, R. Gopaul Sharma, Morab S. & Raghu H.V.	09.05.2022 (through Agrinnovate)	7.50 Lakh	Delmos Research Pvt. Ltd
2.	A PCR based method differentiating for A1 and A2 milk	Sachinandan De & Kailash Jaishwal	06.05.2022 (through Agrinnovate)	2.00 Lakhs	Manorama Agrobiotech Pvt. Ltd. Gujarat
3.	Technology for preparation of shelf-stable, nutritionally richsmoothies using dairy and non– dairy ingredients	Sathish Kumar M.H., Latha Sabikhi, D.K. Thompkinson, Devarja H.C. & Sumit Arora	21.05.2022	2.00 Lakhs	KMF Karnataka
4.	Technology for preparation of rich cheese squeeze	Devaraja, H.C., Jayaraj Rao, K., Sathish protein Kumar M.H., Monika Sharma & Manoj Kumar C.T.)	21.05.2022	2.50 Lakhs	KMF Karnataka
5.	Technology for preparation of rich cheese squeeze	Devaraja, H.C., Jayaraj Rao, K., Sathish protein Kumar M.H., Monika Sharma & Manoj Kumar C.T.)	21.05.2022	2.50 Lakhs	2S Dairy Deli Products (OPC)
6.	Cow ghee enriched with natural polyphones for enhanced shelf-life	Laxmana Naik N., Shivli Jha, Priyanka Singh Rao, K. Jayaraj Rao, Sathish Kumar M.H., Rekha R. Menon & F. Magdalene	21.05.2022	3.00 Lakhs	KMF Karnataka
7.	Milk millet-based protein richdairy dip	Devaraja, H.C., Jayaraj Rao, K., Monika Sharma, Sathish Kumar M.H. & Gopal Gadewar	21.05.2022	3.00 Lakhs	KMF Karnataka

8.	Ghee residue incorporated energybar	Monika Sharma, Amanchi A. Sangma, KJayaraj Rao, Menon Rekha Ravindra & Laxmana Naik N.	21.05.2022	4.00 Lakhs	KMF Karnataka
9.	Functional butter with hypocholesterolemic attributes	Devaraja H.C., Kaushik Khamrui, SatishKumar, Suman Kapila & Rajan Sharma	21.05.2022	2.00 Lakhs	KMF Karnataka
10.	Dry crystalized kheer mix	Menon Rekha Ravindra, Monika Sharma& Devaraja, H.C.	21.05.2022	4.00 Lakhs	KMF Karnataka
11.	Flavored milk and curd fortifiedwith plant source of omega 3 fatty acid	Monika Sharma, Devaraja H.C., Pramod Bhivasen Tambade, B.C. Ghosh & Laxmana Naik N	21.05.2022	1.50 Lakhs	KMF Karnataka
12.	Spray dried milk malted milletbeverage mix	P. Heartwin Amaladhas, F. Magdaline Eljeeva Emerald, B. Surendra Nath, H.V.Vikram Simha & P. Arun Kumar	21.05.2022	2.00 Lakhs	KMF Karnataka
13.	Spreadable butter fortified with vegetarian source of omega-3-fattyacid	(Monika Sharma, Devaraja H.C. & PanduleVishal Shrirang	21.05.2022	2.00 Lakhs	KMF Karnataka
14.	Technology for preparation of Curcumin enriched ghee	Kaushik Khamrui, Jui Lodh & Writdhama Prasad	07.07.2022	2.00 Lakh	Brahmins Foods India Pvt. Ltd. vengalloor - Kolani Bypass Road, Manakkad P.O., Thodupuzha, Kerala
15.	Total Mixed Ration	S.S. Kundu	29.08.2022	Rs. 1.00 Lakh+Tax (18.0%) without royalty	Digi Vet Care PVT. LTD.

Patents Filed-2022 (5)

S. No.	Title of Patent	Inventors	Date of Filing	Patent Application No.
1.	Ghee-Residue powder and process of preparing the same	Ganga Sahay Meena, Aakash Gill, Yogesh Khetra, Ashish Kumar Singh, Sumit Arora	30.03.2022	202211019096
2.	BullTraMin"-Formulation of a bull-specific trace mineral mixture and method of its preparation	Goutam Mondal, Rashika Srivastava, Mukesh Bhakat and Veena Mani	20.04.2022	202211023368
3.	Process for semi-hard ripened cheese from camel milk	Yogesh Khetra	16.06.2022	202211034642
4.	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 Haldar	25.08.2022	202111038528 (Provisional)
5.	A novel method for Ghee preparation with lesser energy requirement".	Writdhama G Prasad, Shubham Kumbhare, Kaushik Khamrui and Shaik Abdul Hussain	23.12.2022	202111060140

Patents Granted-2022 (8)

S. No.	Title of Patent	Inventor (s)	Grant No. and date
1.	A milk-protein based nutritive antacid and a process for its preparation (574/DEL/2014)	Amit Kumar Jaylal bhai, Patel Ashok Kumar Ambalal Patel & Ram Ran Bijoy Singh	402839 on 02.08.2022
2.	Antimicrobial nanoemulsion of clove oil stabilized with milk protein and a process thereof (913/DEL/2015)	Bimlesh Mann, Minaxi, Rajan Sharma & Rajesh Kumar	401941on 25.07.2022
3.	Aptamers specific for cefquinome (1775/DEL/2015)	Rajan Sharma, Amit Kumar Barui, Y.S. Rajput, & Bimlesh Mann	395869 on 29.04.2022
4.	A process for manufacture of low-fat chakka and shrikhand by using exopolysaccharides producing bacteria (201811033236)	Pradip V. Behare, Sanket Borad, Harisha, & SK Tomar	388158 on 31.01.2022
5.	Stabilization of non-ionic surfactant based nanovesicles loaded wtih resveratrol using stearic acid and method of preparation thereof (201811004766)	Battula Surendra Nath, Vankayala Jaya Sravani, Kandasamy Ruckmani, Mariya Antoniraj Gover Antoniraj, Pushpadass Heartwin Amaladhas, Naik Lakshmana Naik, & Franklin Magdaline Eljeeva Emerald	404471 on 25.08.2022
6.	A peptide with osteoanabolic and antiresorptive activity (2778/DEL/2013)	Venkatesa Perumal Shanmugam, Suman Kapila, Rajeev Kapila	405144 on 30.08.2022
7.	Mangiferaindica flower panicles' extract stabilized gold nanoparticles and method for making the same (807/DEL/2015)	VarijNayan, Suneel Kumar Onteru, and Dheer Singh	408952 on 12.10.2022
8.	Two Stage Enzyme Assay for Detection of *Listeria Monocytogenes* in Milk Products (1357/DEL/2013)	Mandeep Balhara, Naresh Kumar, Geetika Thakur, Hirikyathanahalli Raghu, Vinay Kumar, RamakantLawaniya, Alia Khan, Shabnam	410633 on 31.10.2022

Filing of Reply of First Examination Report (FERs) of Patents Filed

Name of Institute	Application/ Registration No.	Inventors of the Patent	Name of Innovation/ Technology/ Product/ Variety	Date of Filing/ Registration	Remarks
ICAR-NDRI	202111007461	Pradip Vishnu Behare, Rallapalli Vembar Rajanikar, Sudhir Kumar tomar, Diwas Pradhan, Rajan Sharma and Sanket Borad	A process for production of antimicrobial coagulant formulation for making extended shelf-life paneer	15.12.2022	FER Issued

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 organization, individuals, industries and entrepreneurs. The services include contract research, consultancy services, contract service and training programmes. Contract research comprises all research activities undertaken through specific contractual agreements with external agencies for the purpose. Consultancy shall mean 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 would 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 2022, four contract research projects were received. The details of contract research projects are given below:

Project Name	Name of the bilateral/ multilateral organisation	Name of consultant
Estimation of productions & Utilization pattern of milk & milk products in India	National Accounts Division, National Statistical Office, Ministry of Statistics & Plan Implement, Sardar Patel Bhawan, Parliament Street, New Delhi	Dr. Ajmer Singh Dairy Economics Statistics & Management Division
Supplemental effect of Alkakarb and Alkakarb plus on rumen parameters and production performance in lactating dairy animals	Tata Chemicals Pvt. Ltd. Mumbai	Dr. Gautam Mondal Animal Nutrition Division
Efficacy of rumen protected choline and methionine in crossbred cows on health and milk yield	Indian Herbs Specialities, Chandigarh	Dr. Bandla Srinivas Animal Nutrition Division, SRS Bengaluru
The effect of slow release nitrogen feeding on nutrient utilization, microbial protein synthesis and milking performance in lactating cows.	M/S Alltech Biotechnology Pvt. Ltd., Bengaluru	Dr. Sachin Kumar Animal Nutrition Division

Consultancy Projects

Institute is offering both general and advisory consultancy to individuals or organization on various aspects of dairy production, processing and management. The details of consultancy projects are given below:

Project Name	Firm Name	Name of Consultant
Performance evaluation of automated colony counter for Jupiter glass works	M/S Jupiter Glass Works, New Delhi	Dr. Pradip Behare Dairy Microbiology Division
Preparation of Processed cheese on Pilot Scale	Mr. Ganapathy Kuppasamy, General Manager Business development Sanzyme Biologics, Hyderabad	Dr. Yogesh Khetra Dairy Technology Division
Effect of presence of antibiotics in milk on fermentation time and quality characteristics of yoghurt	M/S Chr. Hansen A/S Boege Alle 10-12 2970 Hoersholm, Denmark	Dr. Yogesh Khetra 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 49 services of analysis, 15 supplies of kit and culture to different organization, individuals and industries.

Training Programmes

A total number of 91 students from other universities and educational organization were imparted training from one to six months duration in various divisions and sections of the Institute.

Professional Service Functions at a glance

S. No.	Services	Number
1.	Contract Research Projects	4
2.	Consultancy Projects	3
3.	Contract Services	64
	Analytical Services	49
	Supply of Kits and Culture	15
4.	Training Programmes	91

SINED-TBI

Five Entrepreneurship Development Programs (EDP) on 'Commercial Dairy Farming', five in 'Processing of Milk and Milk Products' and two in 'Technology of Cheese Making' were undertaken at Society for Innovation & Entrepreneurship in Dairying–Technology Business Incubator (SINED-TBI). Benefited 155 prospective entrepreneurs across the country. Four new entrepreneurs availed the incubation facilities of ICAR-NDRI in 2022.

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 which has been 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 28.3.1989, is well equipped and staffed to meet emerging needs of the 21st Century of the Dairy Industry. The university offers academic programmes at Diploma, 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 2022-23. 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 4 Year 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:

S. No.	Discipline	S. N0.	Discipline
1.	Dairy Microbiology	9.	Animal Nutrition
2.	Dairy Chemistry	10.	Animal Physiology
3.	Dairy Technology	11.	Agricultural Economics
4.	Dairy Engineering	12.	Agricultural Extension Education
5.	Animal Biochemistry	13.	Agronomy
6.	Animal Biotechnology	14.	Animal Reproduction Gynaecology and Obstetrics (ARGO)
7.	Animal Genetics & Breeding		
8.	Livestock Production and Management		

Scholarship and fellowships

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

1.	Master's degree:	Rs. 7,560/- P.M. for two years plus Rs. 6,000/- per annum as contingency.
2.	Ph.D.:	Rs.25,000/- P.M. for first two years, Rs. 28,000/- during third year and Rs. 10,000/- per annum as contingency.
3.	Ph.D. (In-service):	Rs. 3,000/- P.M. for three years and Rs. 10,000/- per annum as contingency.

ICAR Fellowship

1.	Master's degree	Rs. 12,640/- P.M. (For veterinarians) for two years and Rs. 6,000/- per annum as contingency.
2.	Ph.D. degree	Rs. 31,000/- P.M. (For veterinarians), Rs. 35,000/- for two years and Rs. 10,000/- per annum as contingency.

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 in Dairying students were

provided employment in reputed organizations through campus interviews. Passed out students of NDRI are getting employment in Dairy/ Food Industry (Govt./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. Presently the cell is headed by Dr. Yogesh Khetra, Dairy Technology Division. 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 2022-23 for B.Tech. (Dairy Technology), M.Sc./ M.V.Sc./ M.Tech. and Ph.D. programmes were made.

S. No.	Courses	No. of students admitted
1.	B.Tech. (Dairy Technology)	39
2.	Masters' Programme	103
3.	Ph.D. Programme	99

Meetings

- 93rd meeting of the Standing Committee on Course Curricula and Academic Affairs was held on March 17, 2022.
- 81st, 82nd, 83rd meetings of the Standing Committee on Faculty, Students Problems and Discipline were held on March 15, 2022, June 22, 2022 and September 23, 2022 respectively.
- 51st meeting of Academic Council was held on March 28, 2022.

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 2022. A total of 16 faculty members were deputed for international training in 6 different universities located in USA and Netherlands. A total 24 students have completed their overseas internship at 11 different universities in 4 different countries. Foundation course was also organized for fresher students to nurture their innate talents during which sessions on literary activities, communication skills, leadership skills, theatre art, cultural dance, music, physical and sports activities including yoga, values, ethics and social awareness were conducted. Also, skill development programme i.e. N Reach was conducted by Nestle India Pvt. Ltd. for B. Tech. final year students to improve their communication skills. Six workshops on various topics viz. women empowerment, leadership and social entrepreneurship; sensory evaluation techniques; mammalian genome editing; advances in starter culture technology; textural analysis of dairy & food products and computer vision applications in dairying were organised for the benefit of the faculty and students. Subject experts including four overseas professors' from USA, UK and Ireland were invited to deliver the lectures in these workshops. A skill development programme on microbiological quality and safety analysis of dairy products and a certificate course on starter culture and fermented milk products were also organized.

Also, linkage establishments with different industry, academic institutions were initiated. A MoU was signed with Institute of Rural Management Anand (IRMA), Anand, India for initiation of Post Graduate Diploma in Dairy Management Course to cater the needs of dairy industry looking for human resource having administrative capabilities. Alumni data base was updated to strengthen Global Alumni network. Eleven entrepreneurial development programmes for prospective entrepreneurs, and one innovative idea contest and an experiential learning programme for UG students were also conducted to nurture business ideas of undergraduate students.

As a part of outreach activity a total of 61 MOOCs were developed in the field of dairy production and processing with the help of ICAR-NAARM, Hyderabad. Also, B.Tech. students visited surrounding villages to teach students and created awareness about the environment and cleanliness among the common masses. Twenty meritorious students from sister Dairy Science Colleges across the country were imparted internship (live research projects) for two months duration in laboratories and other facilities at NDRI.

As a part of social equity and environmental sustainability initiative women students were given self-defence training; remedial classes were conducted for academically weak students; incinerator for biohazard waste was procured to treat biological waste; kitchen automation equipment, CCTV cameras were installed and lawn movers procured to strengthen the student hostel amenities.

*A workshop on **Entrepreneurship development programme** for the UG students conducted during August 29-30, 2022*

*Glimpses of the workshop on the topic **Cracking an Interview** organized at ICAR-NDRI during Sept. 8-9, 2022 under IDP-NAHEP Project*

*A 15 days National Training Programme on the topic **Microbiological and Chemical quality and Safety Monitoring in Dairy Industry** organized from Sept. 15-29, 2022 for the B. Tech. students*

9. TECHNOLOGY DISSEMINATION AND EXTENSION PROGRAMMES

DAIRY EXTENSION DIVISION

Field/Farm Technician (FFT) Laboratory

The Field/Farm Technician (FFT) Laboratory of Dairy Extension Division provides a base for extension work in the adopted villages around Karnal and keeps the records of all extension activities of the Division. Newly adopted villages are Shahpur, Hemda and Dadupur. The FFT Laboratory is operated through Stockman Centres. The Stockmen are the grass-root level workers through whom a live contact between scientists and farmers is established. The major activities being carried out through these Centers are:

- To organize fertility and veterinary aid campaigns.
- To provide necessary treatment to the animals.
- To provide vaccination against contagious diseases.
- To educate farmers regarding scientific methods of breeding, feeding, improved management practices.

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

S. No.	Activities	No. of Cases
1	A.I. in Cows	912
2	Conception rate	43.60%
3	A.I. in Buffaloes	645
4	Conception Rate	40.00%
5	No. of Crossbred calves born	718
6	No. of buffalo calves born	480
9	General Treatment cases	145

ii) Infertility and Veterinary aid Campaigns

A total of nineteen campaigns were organized in Kulweri, Daniyalpur, Subhri and Jhanjhari villages. During the campaigns, animals were treated for reproductive disorders and various other veterinary 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.

S. No.	Activities	Numbers	Activities	Numbers
1.	Repeat breeding cases	235	Mastitis	98
2.	Anoestrus and late maturity	116	Retained Placenta	40
3.	Metritis & Endometritis	27	Prolapse of Uterus	21
4.	Pyrexia	56	Cystic Ovarian Condition	09
5.	Wound	72	Tick control	538
6.	Indigestion	32	Deworming (Endo-parasite)	397
7.	Diarrhea	162		

iii) Kisan Sangosthies

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

1. Management of animals during unseasonal rainfall
2. Clean milk production practices in rural areas
3. Role of reducing inter-calving period in lactating animals
4. Preparation of value added milk products
5. Preventive measure of H.S. and FMD Disease
6. Awareness on endo & ecto-parasite infestation
7. Cutting management in multi cut fodder crops
8. Role of mineral mixture in animal diet
9. Correct time of breeding of females
10. Management of dairy animals during transition period

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

Farmers Farm School: A new initiative of NDRI for farmers

An ambitious programme has been started to farmers of Haryana State are being provide 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 completed successfully.

Dairy Samachar

Quarterly Hindi Magazine "Dairy Samachar" is published by bringing out 3000 copies in each of four quarters. Each issue highlights important technologies and products for the benefit of the farmers.

Educational Visit and Tour: A total of 7795 visitors (students & Faculty) of 143 colleges/Institutions/Universities visited the Institute. The visiting 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. The details of educational tour is as follows:

Educational Visit and Tour

S. No.	Particulars	Jan-Mar	April-June	July-Sep	Oct-Dec	2022
1	Number of Institutions/ organization/Colleges	12	25	33	73	143
2	Boy students	322	530	807	2069	3728
3	Girl students	301	550	752	1934	3537
4	Male faculty	29	46	60	154	289
5	Female Faculty	22	49	44	126	241
6	Total visitors	674	1175	1663	4283	7795

Advisory Services

Division is providing the regular advisory services through postal, e-mail, phone to individual 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/demonstrations at farmers fileds

Module	Intervention	Village covered	Area Covered (ha)/ animal (No.)	Number Household covered
A. Crop Based	Varietal Trial of Rice (PB-1692)	7	80.93	200
	Varietal Trial of Wheat DBW-327 DBW-332	6	20.00	100
	IPM in Paddy	7	37.41	85
	Weed control in wheat	7	25.91	64
	INM in Wheat	7	23.48	58
	Summer Moong	4	10	50
	Crop diversification of Mustard (PM-32 & Pusa Tarak)	4	19.43	48
	Round the year green fodder	7	15.48	89
	Crop Residue Mgmt.	7	128	285
B. Horticulture based	Vegetable kit	4	1	50
	Fruit Plantation	2	0.20	10
C. Dairy Based	Mineral Mixture Supplementation	7	460	245
	Anionic Mineral Mixture	7	150	120
	Cationic Mineral Mixture	7	210	210
	Ecto parasite	7	1634	1245
	Endo parasite	7	1307	321
	Theilariosis Vaccination & treatment	7	175	43
	Mastitis treatment	7	122	122
	Silage Demonstration	2	--	41
	SMS Portal	7	All households	Full coverage
D. Enterprise based	Processing of milk	2	15	15

Extension Activities under Farmers First Programme 2022

S. No.	Activities	No. of villages	No. of activities	No. of Farmers/ animals
1.	Training programmes	7	11	537
2.	Kissan sanghoshthi	7	04	124
3.	Animal heath camps	7	14	594
4.	Field Visits	7	24	492
5.	Exposure visits	7	4.	77
6.	Institute visits	7	04	124
7.	Mastitis testing	7	7	140
8.	Theileriosis vaccination camps	7	07	175

KRISHI VIGYAN KENDRA

On Campus Training

KVK provides 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 are being organized for farmers, farm-women, rural youth, in-service personnel and rural leaders.

Training Achievements (2022)

Title of the course	Duration (days)	No. of courses	No. of trainees
Dairy Production			
District-Karnal	5	5	280
Other district-Sponsored	5	6	240
Dairy Processing/ Home Science			
District-Karnal	5	5	124
Other district-Sponsored	5	2	25
Crop Production (CRM)	4	5	213
Crop Diversification	1	1	28
RAWE training	42	2	28
Bee-keeping	4	4	247
Fish Farming	4	4	337
Goat Farming	5	3	100
Vermicompost making	4	2	50
Horticulture (Exotic Vegetable production)	4	3	118
Sub-Total (a)		27	1790
Short Visit cum Training Programmes (b)	1-5	60	2507
Total (a+b)		87	4297

Off Campus Training

Off campus training programmes

Title of the course	Duration (days)	No. of courses	No. of trainees
Crop Production	1	9	212
Horticulture	1	4	74
Soil Health and Fertility Management	1	6	198
Live stock Management	1	10	207
Home Science/Women empowerment	1	4	55
Plant Protection	1	5	72
Crop Residue Management	1	28	912
Fisheries	1	3	142
Total		69	1872

Exposure visits cum short training programmes

KVK being located in NDRI premises having live demonstration units that attracts the attention of various State governments, NABARD and NGOs which send various groups of farmers, farm women and youth on exposure and study visits to KVK. In total 61 visits were organized in which 2507 number of farmers and farm women participated from Haryana, Uttar Pradesh, Chhattisgarh, Gujarat, Uttarakhand, Rajasthan, Odisha, Delhi, Jharkhand and Bihar.

On-Farm Testing

OFT : Performance evaluation of capsicum under low tunnel technology

Details of Technology	• Use of improved variety • Nursery: First fort night of November • Tunnel size: Height 45-60 cm, RXR 130 cm • Transplanting: PXP 30 cm • Transparent non-perforated plastic sheet of 100 gauge thickness
Source	ICAR-IARI, New Delhi, 2000
No. Treatment	TO_1 – Low tunnel system TO_2 – Open System (Farmer Practice)
Assessment	Assessment
No. Replication	3
Area (in ha) /unit/ nos.	Total area – 0.25 ha
Farming situation	Irrigated, Soil type-Sandy Loam
Parameters of assessment	i) Average Yield (q/ha) ii) Disease incidence (%) iii) Identify favorable range of temperature iii) B:C ratio

Parameters	Demo.	Farmers Practice
Highest Average Yield (q/ha)	390	295
Lowest Average Yield (q/ha)	310	250
Average Yield (q/ha)	328	272
% increase in yield	20.58	
Gross Cost (Rs)	229100	245420
Gross Return (Rs)	820000	544000
Net Return (Rs)	590900	298580
BCR	1:3.57	1:2.21

FLD: Popularization of coriander variety (Hisar Bhumit DH 228)

Details of Technology	• Use of improved variety Hisar Bhumit DH 228 • Spacing: Row to row 30 cm. Plant to plant 20 cm • Rabi season-2022 (September)
Farming situation	Irrigated, previous crop-Rice, soil type-sandy loam
Source	CCSHAU, Hisar/ IARI, New Delhi
No. of Treatments	TO1 – Hisar Bhumit DH 228 TO2 – Local variety (farmer practice)
No. of farmers	3
Area (in ha) /unit/ nos.	Total area – 1.25 ha Farming situation – Irrigated
Observations	i) Insect and disease incidence % ii) Average Yield (q/ha) iii) B:C ratio

Parameters	Demo.	Farmers Practice
Highest Average Yield (q/ha)	62	-
Lowest Average Yield (q/ha)	42	
Average Yield (q/ha)	48	42.5

% increase in yield		12.94
Gross Cost Rs/ha	23625	25125
Gross Return Rs/ha	67200	59500
Net Return (Rs/ha)	43575	34375
BCR	1:2.84	1:2.36

Cluster front line demonstrations on oilseeds, pulses, cereals and fodder

CHICKPEA: Details of technology demonstration under CFLD

Crop	Thematic area	Variety	Season and year	Area (ha)		No. of farmers/ demonstration		
				Proposed	Actual	SC/ST	Others	Total
Chickpea	Crop diversification	HC-5	Rabi 2021-22	10	5	1	28	29
	Crop diversification	HC-7	Rabi 2021-22		5			

Crop Sequence: - Rice-Chickpea
Sorghum-Chickpea

2. Situation: - Irrigated

3. Soil: - Type- Loam and Sandy Loam
Organic Matter- 0.36 to 0.69 %
Nitrogen- 115 to 193 kg/ha
Phosphorus- 9 to 46 kg/ha
Potassium – 126 to 456 kg/ha

4. Weed Flora: - *Chenopodium album, Chenopodium murale, Asphodelus tenuifolius*

5. Diseases: - Wilt (*Fusarium oxysporum f. sp. ciceris*), Ascochyta blight (*Ascochyta rabiei*)

6. Insect: - Gram Pod borer (*Helicoverpa armigera*), Cut Worm (*Agrotis ipsilon*)

Sowing date: - 15th Oct to 5th Nov Total Rainfall (mm):- 191.1 mm

Source of technology: CCS HAU, Hisar, 2005 and 2019

Variety	No of Demo.	Area (ha.)	Demonstration					Local check (HC-1)			
			Av. Yield (q/ha)	Gross cost (Rs. / ha)	Gross return (Rs. / ha)	BC Ratio	% increase yield	Av. Yield (q/ha)	Gross cost (Rs. / ha)	Gross Return (Rs. / ha)	BC Ratio
HC-5	10	5	15.56	31110	79356	2.5	15	13.53	31284	69003	2.2
HC-7	19	5	17.13	31110	87363	2.8	26.6	13.53	31284	69003	2.2

Field day at village Phurlak 05.04.2022

Field visit conducted at village Uplana

World Pulse Day at KVK 10.02.2022

Field day at village Bheni khurd 08.04.2022

Technical Feedback on the demonstrated technologies

S. No.	Technical points recorded (Feedback)
1.	Chickpea variety HC-5 and HC-7 exhibited better performance.
2.	Chickpea variety HC-5 and HC-7 were found tolerant to Helicoverpa armigera and diseases in demonstrated practice than farmer practice

Farmers' Reactions on specific technologies

S. No.	Technical points recorded (Feedback)
1.	The farmers showed interest in fallow all parameters of crop i.e Optimum seed rate and sowing depth, timely sowing, seed treatment, integrated pest management and integrated diseases management.
2.	Farmers of the district Karnal were found less interested in growing Chickpea crop because of unorganized marketing facilities, less sale price than MSP.

CFLD: Cluster Frontline Demonstration on Summer Moong Variety

Cropping system	Wheat-Summer Moong-Paddy, Mustard-Summer Moong-Paddy
Source of technology	ICAR-IIPR, Kanpur, 2016
Technology to be demonstrated	Use improved variety IPM 205-7 Seed treatment with Trichoderma bio-fungicide @ 5gm/kg seed. Soil treatment with Trichoderma @ 2.5 kg with 100 kg F.Y.M / ha. Seed inoculate with bio-fertilizer Rhizobium 50 ml and P.S.B 50 ml /10 kg seed. Fertilizer application : Nitrogen-15 kg / ha., Phosphorus 40 kg / ha. and Zinc sulphate 25 kg (1% per ha.). Spacing: Row to row 20cm and plant to plant10 cm. Weed management: Use Pendimethalin @ 2.5 lit. /ha. 1-2 D.A.S pre-emergence and followed by one weeding. Insect pest and disease management: For pod borer and hairy caterpillar Emamectin Benzoate 5% SG (220 gm / ha) and for leaf spot Mancozeb (Indofil M-45) @ 3gm / litre water to be used
Observation recorded	Seed Yield, No. of pod per plant, no. of seed per pod, percentage diseases incidence, BC Ratio, congenial weather for better production of crop

Technology Demonstration and Observation under CFLD on Summer Moong

Crop	Thematic area	Variety	Season and year	Area (ha)		No. of farmers/ demonstration		
				Proposed	Actual	SC/ST	Others	Total
Mungbean (*Vigna radiata*)	Crop diversification	IPM 205-7	Zaid 2022	8	8	1	59	60
Mungbean (*Vigna radiata*)	Crop diversification	IPM 205-7	Summer 2022	12	12			

Existing Agro-ecology situation analysis

1. Crop Sequence:- Wheat-Summer Moong
   Mustard-Summer Moong
   Garlic-Summer Moong
2. Irrigation : Tube well Irrigated
3. Soil type & nutrient status:- Type- Loam and Sandy Loam
   Organic Matter- 0.36 to 0.69 %
   Nitrogen- 115 to 193 kg/ha
   Phosphorus- 19 to 46 kg/ha
   Potassium – 250 to 456 kg/ha
4. Weed Flora:- *Cyanodon dactylon, Boerhavia diffusa, Cyprus rotundus*
5. Diseases There is negligible incidence of Yellow Mosaic Virus(YMV).

Source of technology: ICAR-IIPR, Kanpur, 2016

Sowing date:- 4th April to 12th April

Season	Variety	No of Demo.	Area (ha.)	Demonstration					Local check			
				Av. Yield (q/ha)	Gross cost (Rs./ ha)	Gross return (Rs./ ha)	BC Ratio	% increase yield	Av. Yield (q/ha)	Gross cost (Rs./ ha)	Gross Return (Rs./ ha)	BC Ratio
जायद 2022	IPM 205-7	20	8	9	21915	69795	3.18	**83.67**	4.9	19855	38154	1.9
ग्रीष्म कालीन 2022	IPM 205-7	40	12	8.5	21915	62040	2.83	**63.26**	4.9	19855	38154	1.9

IPM 205-7 पकी मुंग के दाने

IPM 205-7 पकाव की अवस्था पर मूंग की फसल

Field Days and Field Visits organized under CFLD 2022

Programme	No. of Activities	No. of farmers
Field Day	3	90
Field visit	3	32

Technical Feedback on the demonstrated technologies

S. No.	Technical Feed Back Points as emerged
1.	Moong variety IPM 205-7 showed better performance over old varieties.
2.	Less incidence of insect, pest and diseases observed in demonstrated fields as compared to farmer practice.
3.	However, long prevailing eastern directional wind caused some what YMV incidences disease and less flowering and poding in month of May

Farmers' Reactions on specific technologies

S. No.	Technical points as emerged
1.	Farmers have shown preference towards adoption of IPM 205-7 (Virat).
2.	Farmers also assured to keep about 20% of the produce as seed to use in next season.

Success points of the technology

S. No.	Success points as emerged
1.	Summer moong short duration variety Virat sown in Mustard cropping sequence registered higher yield wheat cropping sequence
2.	Timely sowing and adoption of recommended practices improved the yield.

Suggested roadmap for horizontal spread and adoption of CFLD Pulse technology

Roadmap to increase productivity in the region:

- Promotion of crop diversification in rabi season with oilseed
- Promotion of climate resilient short duration variety
- Promotion of efficient utilization of natural resources through CRM machineries.

CFLD: Performance evaluation of Mustard under CFLD

Details of Technology	• Use of improved variety Pusa Mustard-32 • Seed treatment with Trichoderma bio-fungicide @ 5gm/kg seed. • Fertilizer application : Nitrogen-80 kg / ha., Phosphorus 30 kg / ha. and sulphur 12.5 kg / ha. (90%) • Spacing: Row to row 30cm and plant to plant 10 cm. • Weed management: One or two hand-hoeings • Insect pest and disease management: For aphid control Neemzal 3ml / lit. water
Source and Year	ICAR-IARI, 2020
No. of Demonstrations	50
Farming situation	Irrigated
Observations	Nos. of tiller/plant Nos. of siliquae/branch No. of seeds/siliquae Insect and Disease incidence (%) Yield/ha BC Ratio Congenial weather for better production of crop

फसल निरीक्षण हेतु नैदानिक प्रक्षेत्र दौरा एवं प्रक्षेत्र दिवस का आयोजन

कार्यक्रम का नाम	संख्या	किसानों की संख्या
प्रक्षेत्र दिवस का आयोजन	3	90
कृषक प्रक्षेत्र भ्रमण	3	32

गांव कैमला व सुलतानपुर फसल निरीक्षण

Front Line Demonstration (FLD) is a National Programme to promote and popularize the production of the oilseeds, pulses and fodder crops in this region. One of the prime mandates of KVK is to conduct FLD in various crops to generate production data and feedback information and to study the factors, which enhance the optimum yield, and also to prove the production potential of newly developed crop production technology.

Performance of Crop Demonstration Unit of KVK

Seed and other bio-products produced

This KVK is maintaining 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 are being sold through ATIC to farmers. The performance of instructional farm (Crops production) including seed production during the year 2022 is given in the following table.

Seed produced during the year 2022

Crop	Area (acre)	Details of production	
		Variety	Qty. in (Qtl.)
Wheat	13.05	HD-3226	240
	13.85	DBW-187	275
Paddy	6.25	PB-1509	110
	5.0	PB-1718	90
	16.35	PR-114	290
	1.0	PB-1692	10
Berseem	3.60	BL-42	6
	0.50	BL-43	2
Dhaincha	0.50	CSD-123	4.00

Production from other demonstration Units

S. No.	Products	Species/Varieties	Quantity
1.	Fish	Rohu, Katla &Mrigal Comman carp, Grass Carp & Bighead Carp	7.5 Qtls.
2.	Fish seed	-do-	507000 (Nos.)
3.	Vermicompost	*Eiseniafoetida*	760 kg
4.	Honey production	*Apismellifera*	95 kg

4.2 Seed and bio-products sold to farmers

The seeds and bioproducts produced from KVK demonstration units were sold not only to farmers of Haryana but also to those from other states. Following seed material of various crops and bio-products was made available to the farmers as given below:

Seed sold during 2022

Crop	Variety	Quantity	No of farmers
Paddy seed	PB-1509	167.40	2
	PB-1718	97.75	200
	PUSA 44	123.20	110
Wheat Seed	DBW-187	275	222
	HD-3226	240	110
Berseem seed	BL 42 BL-43	5.74 1.30	Farm Section

Bio-products sold during 2022

Bio-products	Varieties	Quantity
Fish sold	Rohu, Catla & Mrigal	560 Kg
Fish (fingerlings)	Rohu, Catla&Mrigal	26000 no's
Vermicompost	*Eiseniafoetida*	460 kg
Honey	*Apismellifera*	90 Kg

Projects/ Schemes being implemented

1. Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of NCT Delhi and Haryana.
2. Cluster Front-line Demonstrations (Pulses) under the scheme NFSM.
3. Cluster Front-line Demonstrations (Oilseed) under the scheme NFSM.
4. Frontline Demonstrations(Vegetables)
5. Training for Skill Development in Vermiculture on behalf of ASCI.
6. Establishment of District Agro Meteorology Unit at KVK.
7. Farm Machinery & Equipment under submission on Agricultural mechanization.
8. Out scaling of natural farming to KVKs.

Field Extension Activities:

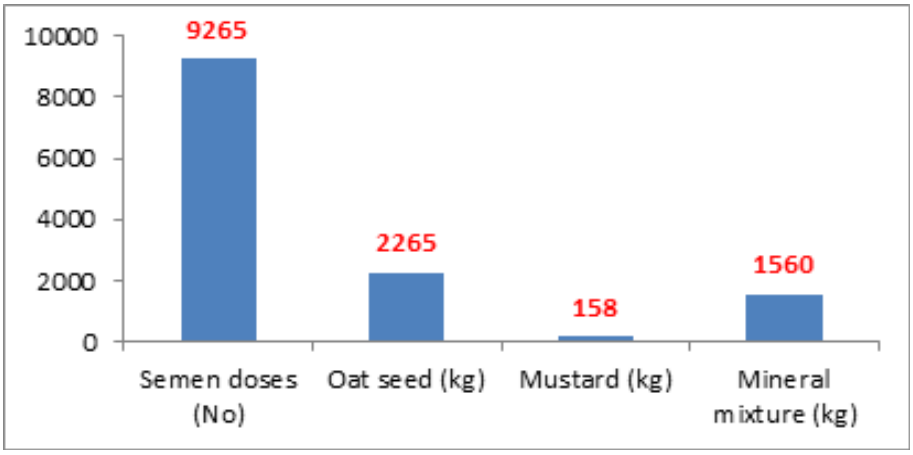
S. No.	Name of the Activity	Date	Participants
1.	Meeting of Scientific Advisory Committee:	02.02.2022	45
2.	National Horticulture Fair	09.02.2022	45
3.	National Science Day	28.02.2022	70
4.	International Women Day	08.03.2022	130

5.	World Water Day	22.03.2022	90
6.	World Bee Day	20.05.2022	45
7.	World Milk Day	01.06.2022	267
8.	World Environment Day	05.06.2022	35
9.	World Zoonoses Day	06.07.2022	23
10.	ICAR 93rd Foundation Day	16.07.2022	70
11.	World Breast Feeding Week	07.08.2022	30
12.	Food and Nutrition for farmers	26.08.2022	91
13.	Poshan Abhiyan cum tree plantation campaign	17.09.2022	45
14.	PM-Kisan interaction program	28.09.2022	152
15.	Mahila Kisan Diwas	15.10.2022	107
16.	World Food Day	16.10.2022	73
17.	World Soil Health Day	05.12.2022	45
18.	Kisas Mela	23.12.2022	785
	Total		2148

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. The demand of fodder crops seed, mineral mixture and frozen semen doses has also increased among the farmers in surrounding villages. In every village 200-300 calves have born in the surrounding villages through the frozen semen doses of high genetic merit bulls provided from Lalukheri centre. There is improvement in milk production of dairy animals in their first lactation itself.

In one village- Bhorakhurd at least there are 10-15 buffaloes produced ~ 14-15 liters of milk in a single day during their lactation.



Inputs supplied through Kisan Seva Kendra, ICAR-NDRI, Karnal at Lalukheri (Muzaffarnagar, UP)

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE

Agricultural Technology Information Centre at NDRI Karnal became operational in November 2004. ATIC NDRI is using following approaches for disseminating agricultural and dairy information to its intended users:

1. Personal interaction with visiting farmers
2. Audio/Video shows
3. Visits to Dairy farm
4. Information through toll free telephone number (1800-180-1199)
5. Selling publications
6. Providing material inputs like improved seed varieties, wheat grain, vermicompost etc.
7. Through emails
8. Through whatsapp Group

Services Rendered for Agricultural Technologies during 2022

S. No.	Details of services	No. of Services	No. of Persons
1.	Dairy/Agriculture related information through Video show and Lecture	27	1063
2.	Personal Discussion with Subject-Matter-Specialist on Dairy Farming	104	110
3.	Information through Dairy/Agriculture Literature	74	74
4.	Information on Agriculture (Seed/Fertilizer/Compost etc)	1207	1490
5.	Information through telephone (Toll-free) on Agriculture & Dairying etc.	909	901
6.	Information through e-mail on Agriculture & Dairying etc.	22	22
7.	Information through what app group on Agriculture & Dairying etc.	100	2320
	Total	2443	5980

Sale of Products/ Books at ATIC during 2022

S. No.	Item	Amount (Rs.)
1.	Agriculture Inputs (seeds, fertilizers etc.) obtained from KVK NDRI, Farm Production Section NDRI.	31,66,804.00
2.	Books (NDRI Publications)	32,564.00
3.	Sale in Integrated Farmer System	3,974.00
4.	Sale of NICRA Products like Diyay, Ganesh Murti etc.	15,516.00
	Total	32,18,858.00

10. WOMEN EMPOWERMENT AND MAINSTREAMING OF GENDER ISSUES

A training programme on Role of Women Power in environmental protection was organized on 27.01.2022 under NICRA project in which 55 women participated. Hands-on training was given to participants for preparation of *Ghan-jivaamrit* and *Jivaamrit* at NICRA complex to promote cow based and further all participants visited a vegetable unit developed purely by using *Ghan-jivaamrit*" as an organic manure

Hands-on training for preparation of Ghan-jivaamrit and Jivaamrit at NICRA complex

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.

An Appraisal of Extension and Advisory Services for Farming: A Gender Perspective

Extension and Advisory Services (EAS) play a vital role in bridging productivity and income gap in agriculture and allied sectors. Study was undertaken to assess the access, preferences and impacts of EAS in crop-dairy mixed farming system in a gender perspective. Primary survey was conducted among 400 households from four randomly selected districts in Bihar. Data were collected from both male and female decision makers of the households with the help of interview schedule. Results of the study revealed a better level of access to institutional EAS related to crop farming both for male (73.5 %) and female decision makers (61.75 %) which is mainly sourced through targeted approaches by public agencies such as JEEViKA and Krishi Vigyan Kendras (KVKs).

Considering dairy farming activities, access to EAS was relatively lower among male (9 %) and female decision makers (11.25 %). Major mode of EAS delivery in crop farming was through mobile phone and it covered 58 per cent and 53. 25 per cent of male and female decision makers respectively. Compliance to information received through mobile phones was relatively lower among the respondents and the EAS access-EAS use gap was much wider among females. Though there is limited access to EAS in dairy farming, it was mainly through personal contact, among both male and female decision makers. Elicitation of farmers' preference towards improved EAS provision through choice experiment method indicated that majority of the respondent preferred 'One

system EAS' (Single window delivery of crop and dairy EAS) irrespective of gender with positive and significant willingness to pay (WTP). Gendered heterogeneity was observed in WTP for improved EAS scenario and female decision makers' WTP for EAS was not significant. Male decision makers preferred private agencies and Non-Governmental Organizations over public agencies and doorstep delivery of services for farming with a significant WTP towards them.

To have some evidence on impact of EAS on farm productivity and net income from farming, Inverse Probability Weighted Regression Adjustment (IPWRA) method was used. A significant positive impact of EAS use was found on adoption of improved varieties in wheat crop. Among the households with females having access to use of EAS was found to have 7 per cent higher yield in case of wheat crop. Impact of use of EAS in net income from wheat cultivation ranged between 8 to11 per cent. In case of dairy farming, use of EAS was found to have positive impact only in case of adoption of curative disease management practices among dairy animals and milk productivity of cows. Major conclusions from the study point towards the need for convergence of different stakeholder organizations for demand driven EAS provision. The study also recommended different strategies for gender mainstreaming in EAS provision.

Promoting Gender Equity under GATI

Gender Advancement for Transforming Institutions (GATI) is an innovative Pilot launched the WISE-KIRAN Division under the aegis by the Department of Science and Technology (DST). It is a project sanctioned by the Ministry of Science and Technology, Government of India. It ushers a novel intervention program for promoting gender equity in science and technology and disciplines related to Science, Technology, Engineering, Medicine and Mathematics (STEMM). GATI aims to nudge institutions of higher education and research towards supporting diversity, inclusion and the full spectrum of talent for their own success and progression.

With the initiation of the GATI program in NDRI, the institute undertook initiatives towards the betterment of working environment and empowerment of faculty, staff and students especially women by organizing various gender sensitization events and webinars. For the motivation of women scientists working at the institute, best research paper award was announced for publishing the research in highest impact journal. To this, the entries were received from women scientists working at various levels of their career, i.e. early, mid and senior levels. The first best research paper award was given to Dr. Neelam Upadhyay, Scientist-Senior Scale (Food Technology) for publishing her research work as lead/ corresponding author in 'Waste Management'- an Elsevier journal having impact factor of 7.145, while second best research paper was jointly shared by Dr. Bimlesh Mann, Principal Scientist (Dairy Chemistry) and Dr. Heena Sharma, Scientist (Livestock Products Technology) for publishing their work (separately) as corresponding/ first author in 'Food Research International'- an Elsevier journal having an impact factor of 6.475. The awards were presented during Republic Day Celebrations.

A webinar on 'Environmental Issues and Sustainable Approaches' during National Science Day on 28th February 2022 was organized and speaker of the webinar was Dr. S. Lakshmi Devi, Hony. Director, Centre for Entrepreneurship and Career Oriented Program, University of Delhi. In addition, two-days webinar series on the theme "Gender Equality Today for a Sustainable Tomorrow" was organized by GATI committee on the occasion of International Women's Day-2022. In order to impart knowledge about GATI, Dr. Pratibha Jolly, Principal Investigator, GATI Pilot Academic Consultant, National Assessment and Accreditation Council (NAAC) delivered a talk on 'The GATI Pilot: Leading the Change' in National webinar on 13th April,2022. The launch workshop of GATI Project was conducted on April 30, 2022 under the chairmanship of honorable secretary DARE and DG, Dr. Trilochan Mahapatra. Data was collected regarding Gender Profile of the Institution; Gender Advancement, Career Progression and Leadership; Gender Policies, Processes, Procedures, Practices; Gender Climate and Organizational Culture; Institutional Values, Best Practices, Case Studies and Institutional Strategy for Gender Advancement for self-assessment application.

11. HONOURS AND AWARDS

Team Awards

- The students' team of Sumit Kumar Singh, Rohit Kumar and Anju Nagpal, PhD students (Mentor: Dr. Sudarshan Kumar) was awarded the Biotechnology Industry Research Assistance Council (BIRAC)'s award at National Bio Entrepreneurship Competition 2022. The team got the top position and earned a cash prize of Rs. 3.0 lakhs and a certificate.
- The students' team of Dasriya V, Dhillon HS and Chaudhary V (Mentor: Dr. A. K. Puniya) was awarded KRITAGYA (National HACKATHON 2.0) organized by 'National Agricultural Higher Education Project (NAHEP)' and Animal Science Department of Indian Council of Agricultural Research, New Delhi.

- Dr Neelam Upadhayay, Dr Ashish Kumar Singh, Mr. Shailesh Meena, Dr. Ganga Sahay Meena, Dr Ravinder Malhotra: FSSAI EAT RIGHT RESEARCH AWARD AND GRANT Under Team Category Theme: Eat sustainable.

Best Oral Presentation /Best Paper/ Poster Awards

- P. Narender Raju received Best Paper Presentation Award for the paper entitled, "Development of an On-Package Freshness Indicator for Misti Dahi, an Eastern Indian Fermented Dairy Product" at 3 days International Conference on "Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security" held at University of Kashmir, Srinagar, J&K from Sept. 28-30, 2022.
- Dr. Satish Kumar MH received Best Oral Presentation Award (Ist Prize) in International Conference on Advances in Agriculture and Food System Towards Sustainable Development Goals, held at GKVK, Bengaluru during 22-24 Aug., 2022.
- Tiwari, S., Lathwal, S.S. and Dang, A.K. awarded First prize in oral presentation in 1st National Conference of Association of Mastitis on "Implications of Mastitis" held at DUVASU, Mathura on October 19-20, 2022.
- Dr. S.V. Singh received Best Oral Paper Presentation Award on "Effect of supplementation of Cumin and molasses on Physiological, morphological parameters and antioxidants markers under field condition" during "19th Biennial International Conference of Animal Nutrition Society of India on Nutritional Technologies to Augment Livestock, Poultry, Canine, Fish Production for Global Competitiveness" held at GADVASU, Ludhiana from Nov 16-18, 2022.
- Bhavesh B Chavhan, P Barnwal, Ankit Deep, Pooja Bhagat, Vinod K Sharma received First prize in Oral Paper Presentation entitled "Chemical kinetic modelling of in-package microwave treated pindi khoa for shelf life prediction" under theme "Tech-engineering interventions in milk production and processing", in 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India", at Warud, Pusad (Maharastra), 15-16 December 2022.
- Aakash Dadarao Wani, Writdhama Prasad, Ankit Deep, Kaushik Khamrui, Shaik Abdul Hussain received First Prize in Oral Paper Presentation entitled "Evaluation of selected solvents as an alternative for efficient

milk fat extraction from ghee residue" in 10th International Conference on Advancements in Engineering and Technology, ICAET-2022, organised at Bhai Gurdas Institute of Engineering and Technology (BGIET), Sangrur, 11-12 November, 2022 via online mode.

- Dr. Nishant Kumar received Best Oral Presentation award for the research paper entitled "Elucidating the efficacy of Sodium alginate as antimicrobial alternative in cryopreservation of Sahiwal bull semen" in National Conference on "Fostering One Health for Food Safety and Security through Sustainable Animal Husbandry & Aquaculture Practices" organized by Society for Promotion of Farm and Companion Animals at Bihar Veterinary College, Bihar Animal Science University, Patna from 10-11 November 2022
- Dr. Nishant Kumar received Best Oral Presentation award for the research paper entitled "Effect of Boron Supplementation on Physiological and Biochemical attributes of peripartum crossbred cows under heat stress condition" in International Conference on Contemporary Multidisciplinary Issues in Applied Sciences, Humanities, Agriculture, Animal Health and Production (ASHAA-2022) at Rajiv Gandhi South Campus, Banaras Hindu University, Mirzapur, Uttar Pradesh from 14-15 November 2022
- Dr. R. K. Baithalu received Best Oral Presentation award in XIX Annual Convention and National Symposium on "Contemporary Technology for Animal Genetic Resource (AnGR) Management" from 21-22 September 2022 held at ICAR-NBAGR, Karnal.
- Dr. R. K. Baithalu received Best Oral Presentation award in International Conference on "Advances in Agricultural, Veterinary and Allied sciences for Improving Livelihood and Environmental Security" from 28-30 Sep., 2022 held at University of Kashmir, J&K.
- Aakash Dadarao Wani, Writdhama Prasad, Ankit Deep, Kaushik Khamrui, Shaik Abdul Hussain received First prize for oral presentation entitled "Evaluation of low toxicity solvent as an energy efficient alternative for milk fat extraction from Ghee residue" under theme "Emerging technologies in the field of dairy processing and quality control", In: 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India" at Warud, Pusad (Maharastra), 15-16 December 2022.
- Gayathri, S.L. and Bhakat, M. received Young Scientist Award for the paper Assessment of mastitis using thermal image analysis among dairy breeds during autumn and winter season in National Symposium on Contemporary Technology for Animal Genetic Resource (AnGR) Management organized by Society for Conservation of Domestic Animal Biodiversity & ICAR-National Bureau of Animal Genetic Resources, Karnal during September 21- 22, 2022.
- Gupta, V.K., Mohanty, T.K., Dewery, R.K., Nain, D., Aye, S. and Yadav, R. received Young Scientist Award for the poster presentation on "Lessening the negative effect of vaccination stress in Sahiwal breeding bulls with the use of levamisole and antipyretics", in National symposium on optimizing animal reproduction through recent techniques of biotechnology, nutraceuticals and alternative medicine & XXXVII annual convention of ISSAR from November16-18, 2022.
- S. Ragulraj, M. Bhakat, T.K. Mohanty, S. Maiti, A. Fernandas and P.B. Nandhini. received A. Lakshman Rao received Award for the paper entitled "Application of infrared thermography for identification of estrus, calf health and tick infestation in dairy animals in National Livestock Conference UTKARSHA organized by ISAPM in Visakhapatnam, Andhra Pradesh from April11-13, 2022.
- Elizabeth Jose and K.Ponnusamy were awarded best oral presentation award for the topic Efficiency of Farm Diversification in Haryana in 4th National Conference of Society of Veterinary & Animal Husbandry Extension (SVAHE) on the theme "Pluralistic Approaches for Livestock Development – An Extension Call" at the CSK Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh during 06-08 May 2022. ATMA, Dept of Agriculture, Karnal and Panipat and HAMETI, Jind.
- Dr. Nishant Kumar received 2nd Best Oral Presentation award for the presentation entitled "Effect of Vitamin E and Selenium supplementation on performance of crossbred bulls under induced heat stress condition" in 22nd Indian Veterinary Congress, XXIX Annual Conference of IAAVR & National Symposium on

advancement in Veterinary Medical Research contributing to one health for betterment of Animal Health & their Welfare organized at C.V.Sc Udaipur, RAJUVAS, Bikaner from 8-9 April 2022.

- Dr. Nishant Kumar received 2nd Best Oral Presentation award for the presentation entitled "Effect of supplemental Boron on performance of peri-parturient Karan Fries cows under heat stress condition" in International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022) organized by University of Kashmir, Hazratbal, Srinagar, Kashmir from 28—30 September 2022.
- Dr. Monika Sharma received second Prize for oral presentation on Valorization of ghee residue for development of value-added food products in International Conference on "Food Sustainability: Challenges and Opportunities for The Future" 5th AMIFOST – 2022 from 29- 31 March 2022.
- Dr. Monika Sharma received Best Poster award for Malted finger millet -milk based composite probiotic beverage. 28th ICFOST EAT-SAFE organized from 20-22 Jan 2022.
- Dr. Monika Sharma received Best Poster award for Utilization of ghee residue for extraction of phospholipids through pulsed electric field technique. National Dialogue on "Innovations in Reshaping the Indian Dairying" at DUVASU, Mathura on 29 October 2022.
- Gayathri S. L., Bhakat, M. and Mohanty T. K. received Best Poster Presentation (Second Prize) on Short-milking-tube thermograms as mastitis detection tool in dairy animals" in 14th Kerala Veterinary Science Congress on One-health approaches in the management of animal health care- New paradigms organized by Indian Veterinary Association, Kerala, from 12.11.2022 to 13.11.2022.
- Poonam Rani and Rakesh Kumar received Best Poster award in SOCDAB at NBAGR, September 21-22, 2022.
- Gurpreet Kaur, Navkiran Kaur, Neha Sarova, K. Siddharth Singh, Sudershan Kumar, and Jai K. Kaushik won the first Best Poster Award during the 6th Biennial PAi Conference and International Symposium on "Psychobiotics and Gut: Potential in the neurological disorders organized by NDRI during 5-6 Dec 2022.
- Apeksha Ukey, S.V. Singh, A.K. Misra, Gaurav Kumar, Nikita Bhalakiya and Jaskiran Kaur received Best Poster Presentation Award on "Impact of concentrate replacement with Moriga Olifera on stress indicators and metabolic hormones of Barbari goats in different seasons" during National Seminar and Annual Conference on "Prospects and Potential of Small Ruminants Production for Enhancing Income under Changing Scenario" held at ICAR-CSWRI, Avikanagar (Rajasthan) from 10-12 November, 2022.
- Akash, Monica Rose Amarlapudi, Hemlata Singh, Chandrasekhar B., Ganga Gulati, Ngangyola Tuikhar, Amit Yadav, Raghu H. V., Diwas Pradhan, Nishant Kumar, Dhiraj Dhotre, Rashmi H M received Best Poster Award (Second) for poster entitled "Characterization of Antibiotic Resistant Bacteria from Dairy Production System" by in the VII Convocation of National Academy of Dairy Science (India) and National Symposium on Innovation in Reshaping Indian Dairying on October, 29, 2022 at DUVASU, Mathura.
- Rashmi H M, Sree Niharika Erwa, Bidisha Senapati, Saurabh Kadyan, Diwas Pradhan received award for presentation on "Integrated omics (Metagenomics and Culturomics) approach to reveal the microbial signatures of Dahi" in the VII Convocation of National Academy of Dairy Science (India) and National Symposium on Innovation in Reshaping Indian Dairying on October, 29, 2022 at College of Veterinary Science and Animal Husbandry, Mathura.
- Ravikant V Vinchurkar, Heena Parveen, Hogarehalli Mallapa Rashmi and DiwasPradhan received Best Poster Award entitled 'Prevalence of Antibiotic Resistance in Dairy based Enterococcus strains using in vitro and WGS approach' in the 6th Probiotic Association of India Biennial e-Conference and International e-Symposium on 'Psychobiotics and Gut: Potential in Neurological Disorders' on Dec 5-6, 2022.
- Abhinash P, Chitranayak, Minz, P.S., Suresh, D., Sharanabasava, John, H., and Priyanka received First prize for Poster Presentation entitled "Development of Isothermal Bioreactor for the Generation of Biogas from Cow Dung" under theme "Application of Nanotechnology, Artificial Intelligence, Machine Learning and I-O-T and Design of New Processes or Equipment for Mechanisation in the Dairy Industry". in 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India", Warud, Pusad (Maharastra), 15-16 December 2022.

- Swetha Damodharan P.V., Sangita Ganguly, Ashish Kumar Singh, P.N.Raju 2nd Best Paper Presentation Award for paper entitled 'Fermentation Dynamics of selected probiotic organisms in milk-flaxseed based composite substrate' in International Conference on 'Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022) held during September 28-30, 2022 at University of Kashmir, India.
- Rohit, H.K. and Mukul, S received Third Prize for the presentation on 'Development of Ice Slurry Based Milk Cooling System', (Mentor: Dr. Chitranayak) in National Level Hackathon under the IDP-NAHEP Project on "Smart and Remunerative Farming", held at Navsari Agricultural University (NAU), Navsari, on 5th March 2022.
- Dr. R. K. Baithalu received best oral presentation award in International conference on "Contemporary Multidisciplinary issues in Applied Sciences, Humanities, Agriculture, Animal Health and Production" held at Banaras Hindu University from 14-15 Nov. 2022.
- Aakash Wani, Writdhama Prasad, Kaushik Khamrui, Shaik Abdul Hussain and Ankit Deep awarded Best Paper (1st) for the paper 'Evaluation of selected solvents as an alternative for efficient milk fat extraction from ghee residue' presented in 10th International conference compendium on Advancements in Engineering and Technology, held at Bhai Gurdas Institute of Engineering and Technology, Sangrur, Punjab, during 11-12 Nov 2022.
- Aakash Wani, Writdhama Prasad, Kaushik Khamrui, Shaik Abdul Hussain and Ankit Deep awarded best paper (1st) for the paper 'Evaluation of low toxicity solvents as an alternative for efficient milk fat extraction from ghee residue' presented in 12th Convention of IDEA and national seminar on 'Engineering interventions in Dairy Processing for self-reliant India', held at College of Dairy Technology, Warud (Pusad) during 15-16 Dec, 2022.
- Manas Sarkar, Writdhama Prasad and Kaushik Khamrui: Best poster (3rd) presentation award for the paper "Active Food Packaging through Electro hydrodynamic processing with natural fibres" presented in National Seminar on 'Advanced Practices in Dairy Industry and Research', held at West Bengal University of Animal and Fisheries Sciences, Mohanpur Campus, Nadia, West Bengal on 23rd December 2022.
- Sonam Kumari, Shaik Abdul Hussain, Writdhama Prasad and Yogesh Khetra: Best poster (3rd) presentation award for the poster entitled "Uchh koti ice cream ki banawat karyakarta aur sanvedi visheshtao par stabilizer mishran ka prabhav" presented during Hidi Ullas Mahotsava 2022 at ICAR-National Dairy Research Institute, Karnal on 29 Sep., 2022.
- M. Sathiyabarathi received Best Paper Presentation Award under the Session: III Livestock Production and Artificial Intelligence during the National Livestock Conference and 28th Annual Convention of ISAPM held at Vizac between 11 and 13 April, 2022.
- Oral presentation award by Hi-Tech Horticultural Society to Talluri, T.R., Kumaresan, A., Sinha, M.K., Paul, N., Ebenezer Samuel King, J.P. and Datta, T.K for the paper "Integrated multi-omics analyses reveals molecules governing sperm metabolism potentially influence bull fertility" published in Scientific Reports during the seminar on 9th October, 2022
- First Prize for Best Poster Presentation for the paper "Economic impact of COVID-19 pandemic on dairy supply chain" authored by Das, A, Mushi, S,A, Shivaswamy, G,P, Subash, S, Sivaram, M was received during International Conference of Indian Dairying – Sustainability and Nutritional Security held at Coimbatore on 14th October 2022.
- Naveen Jose has secured First prize in poster presentation for presenting poster on "Dry-Crystallization: A Novel Approach for Development of Convenience Mixes" at International Conference on Advances in Agriculture and Food System Towards Sustainable Development Goals (AAFS2022) held at University of Agricultural Sciences, Bangalore between 22nd-24th August, 2022.
- Gajanan P Deshmukh has been awarded Best Poster Award In: 12th convention of Indian Dairy Engineering Association held at Pusad, Maharashtra for the topic "Process optimization of pumpkin powder incorporated lassi" by Sawale P. D., Deshmukh, G. P., Meshram B. D., Patil, P. S., Dhotre, A. V. and Wasnik, P. G.

- Gajanan P Deshmukh was awarded with Best Oral Presentation award (First Prize) at 12th convention of Indian Dairy Engineering Association held at Pusad on December 15-16, 2022 for topic entitled "Design and development of mechanical Unit for dry-crystallisation of PaladaPayasam- Indian Sweet Delicacy".
- Rupesh Datir was awarded second prize in Best Paper award category for the paper entitled "Preparation and optimization of processed cheese spread in a small volume dispenser unit" under the theme Techno-engineering interventions in Milk production and processing, during the 12th Convention of IDEA and National seminar held at the College of Dairy Technology, Warud (Pusad), Maharashtra during December 15,16-2022.
- Das, A, Mushi, S, A, Shivaswamy, G, P, Subash, S, Sivaram, M was awarded First Prize for Best Poster Presentation for the paper "Economic impact of COVID-19 pandemic on dairy supply chain"during International Conference of Indian Dairying – Sustainability and Nutritional Security held at Coimbatore on 14th October 2022.
- Nutan Chauhan won best oral presentation award for her work titled "Effects of Lactic Acid Bacteria and Propionic Acid Additives on the Fermentation Quality and Aerobic Stability of Sugarcane Tops Silage" in 19th Biennial International Conference on Nutritional Technologies to Augment Livestock, Poultry, Canine, and Fish Production for Global Competitiveness.
- Deepesh Misra won best oral presentation at National conference conducted by NAVNAW in 2022 for abstract titled "Ensiling of paddy straw at specific time intervals with agro industrial byproducts and additives for the preparation of straw age".
- Deepesh Misra won best oral presentation at ANSICON 2022 in Ruminant Nutrition session.
- Dr. Nitin Tyagi won Second Best Oral Presentation Award in National Conference conducted by National Academy of Veterinary Nutrition and Animal Welfare in September 2022
- Naliyapara H.B, Raman Malik, Dhaigude V. D., Rana Parul, Chander Datt, Kuldeep Dudi, Harneet Kour and Ojha L. won First Prize for poster presentation on "Inclusion of varying levels of feed aromas in paddy straw based TMR and their effects on feed preference and intake of crossbred calves" during "Nutritional Technologies to Augment Livestock, Poultry, Canine and Fish Production for Global Competitiveness" & 19th Biennial International Conference of Animal Nutrition Society of India, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, from Nov. 16-18, 2022.
- Thamizhan, P, Chander Datt, Shambhvi, Veena Mani and Goutam Mondal received First Prize for poster presentation on "Influence of supplementary nickel on mineral balances, plasma mineral profile and blood metabolites in Murrah buffalo calves" (during "Nutritional Technologies to Augment Livestock, Poultry, Canine and Fish Production for Global Competitiveness" & 19th Biennial International Conference Of Animal Nutrition Society of India organized by Department of Animal Nutrition, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab-141004 from Nov. 16-18, 2022.
- P. Thamizhan, Chander Datt, Shambhavi, A Thakuria, Veena Mani and G. Mondal received Second Prize for poster presentation on "Influence of supplementation of nickel on antioxidant status in Murrah buffalo calves" during "Coordinated nutrition, health and extension approach for sustainable livestock production" organised by College of Veterinary Science and Animal Husbandry, NDVSU, Jabalpur (M.P.) from 21-22 Sept. 2022.
- Richa Singh, Ravali Parvatam, Anusha Kishore received Second Prize in oral presentation (2022). "Effect on environmental temperature in metabolites in milk of Sahiwal cows" during "National Symposium on Contemporary Technology for Animal Genetics Resources management and XIX Annual Convention of Society for Conservation of Domestic Animal Biodiversity (SOCDAB)" September, 21-22 2022 at National Bureau of Animal genetics and Breeding, Karnal.
- Anusha Kishore and Richa Singh received Second best poster award on "Metabolite alterations in whole raw milk of dairy cows with respect to season" by in National Seminar on "Innovations and advances in valorization of functional dairy products" held on 25-26 November 2022 at BHU, Banaras.

- Dr. Dhruba Malakar was awarded the "second-Best Poster Award" in the SOCDAB, NBAGR, Karnal, 2022.
- Swetha Damodharan P.V., Sangita Ganguly, Ashish Kumar Singh, P. N. Raju awarded 3rd Best Poster for paper entitled 'Development of a base model for probiotic formulations in milk-flaxseed- based composite substrate through fermentation kinetics study' in National Dialogue on "Innovations in Reshaping the Indian Dairying" held on October 29, 2022 at Pandit Deen Dayal Upadhyay Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, UP.
- S. Praveen, Ramesh Chandra, Nishant Kumar, Manisha Yadav, Sanchi Kamal, and Ashutosh received "Third Best Poster Presentation Award" for their poster paper entitled "Effect of Boron supplementation on performance of Karan Fries cows during heat stress condition" in Hindi Ullas Mahotsav held at ICAR-National Dairy Research Institute, Karnal on September 29, 2022.
- Diptesh Das, Nikunj Tyagi, Sudarshan Kumar and Jai K. Kaushik won the third Best Poster Award during the 6th Biennial PAi Conference and International Symposium on "Psychobiotics and Gut: Potential in the neurological disorders organized by NDRI during 5-6 Dec 2022.
- Deshmukh, A.K., Talwar, G., Mehta, S., Chandla, N.K. received Second prize for Poster presentation entitled "Effect of ultrasonication on mechanical properties of biodegradable cup" under theme "Emerging Technologies in the Field of Dairy Processing and Quality Control" in 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India", organized by Indian Dairy Engineers' Association (IDEA) at College of Dairy Technology, Warud, Pusad (Maharastra), 15-16 December 2022.
- Mehta, S., Minz, P.S., Deshmukh, A., Rohit, H.K., Chitranayak, Kumari, S. received Third prize for Poster presentation entitled "Energy Benchmarking: A useful tool for energy conservation in dairy processing plant" in "Techno-engineering interventions in milk production and processing" in 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India", organized by Indian Dairy Engineers' Association (IDEA) at College of Dairy Technology, Warud, Pusad (Maharastra), 15-16 December 2022.
- Mehta, S., Minz, P.S., Deshmukh, A., Rohit, H.K., and Chitranayak. Third prize for Poster presentation entitled "Python based simulation tool for prediction of rheological behaviour during bioreactor operation" In: 12th Convention of Indian Dairy Engineers' Association (IDEA) and National Seminar on "Engineering Interventions in Dairy Processing for Self-Reliant India", organized by Indian Dairy Engineers' Association (IDEA) at College of Dairy Technology, Warud (Pusad), Dist-Yavatmal (Maharastra), 15-16 December 2022.
- Third Best poster award for the poster entitled "High yield paneer formulation using buffalo milk protein coprecipitate by Hemant Gawande, Sumit Arora, A.K.Singh, G.S.Meena and Vivek Sharma presented in the third 12th convention of IDEA and National Seminar on "engineering interventions in dairy processing for self reliant India", 15-16 Dec 2022 at CDT, Warud (Pusad), Dist- Yavatmal (Maharashtra).
- Teja Allu, Ph.D student (ARGO) was awarded "Young Scientist Award" during the XXXVII Annual Convention of Indian Society for the Study of Animal Reproduction (ISSAR) – 2022.
- Mani Arul Prakash, Arumugam Kumaresan, Ebenezer Samuel King John Peter, Pradeep Nag, Ankur Sharma, Manish Kumar Sinha, Elango Kamaraj, Tirtha Kumar Datta received Prof. Nils Lagerlof Memorial Award by the Indian Society for Study of Animal Reproduction for the research paper "Comparative Transcriptomic Analysis of Spermatozoa from High- and Low-Fertile Crossbred Bulls: Implications for Fertility Prediction" published in Frontiers in Cell and Developmental Biology during ISSAR conference on 16th November 2022.

Fellows and Other Individual Awards

- Dr. A. Kumaresan was awarded NAAS Fellowship on 4thJune 2022 in New Delhi.
- Dr. A. Kumaresan was awarded with VASVIK Industrial Research Award in the field of Agricultural Science and Technology in Mumbai on 5th May 2022.

- Dr. Dhruba Malakar was awarded the "Rashtriya Shiksha Gaurav Puraskar 2022" by the Centre for Education Growth and Research, New Delhi.
- Dr. Dhruba Malakar was awarded the "Dr. D.S. Balain Memorial Award- 2022" in the SOCDAB, NBAGR, Karnal.
- Dr. Dhruba Malakar was awarded the "Lifetime achievement award-2022" in the Society for Technology, Environment, Science & People, Kozhikode, Kerala, India ICASTESP-2022.
- Dr Sohan Vir Singh was awarded as Fellow of Society for Conservation of Domestic Animal Diversity during XIX Annual Convention and National Symposium on Contemporary Technology for Animal Genetic Resources (AnGR) Management during 22-23 April, 2022 at ICAR-NBAGR, Karnal.
- Dr. Sanjit Maiti was selected as the Associate Fellow of the National Academy of Dairy Science (India).
- Dr. K. Ponnusamy received Distinguished Alumnus Award of Tamil Nadu Agricultural University, Coimbatore.
- Dr. Monika Sharma awarded with Associate Fellowship of National Academy of Dairy Science (India) on October 29, 2022 in the VII Convocation of NADS(I) at DUVASU, Mathura.
- Dr. Sangita Ganguly was awarded Associate Fellowship of National Academy of Dairy Science, India on October 29, 2022.
- Dr. Nishant Kumar received Gaon Gyan Paritoshik Award at 22nd Indian veterinary Congress, XXIX Annual Conference of IAAVR & National Symposium on advancement in Veterinary Medical Research contributing to one health for betterment of Animal Health & their Welfare organized at C.V.Sc Udaipur, RAJUVAS, Bikaner from 8-9 April 2022.
- Dr. R. K. Baithalu received Distinguished Scientist Award on the occasion of International Conference on "Advances in Agricultural, Veterinary and Allied sciences for Improving Livelihood and Environmental Security" from 28-30 Sep., 2022 held at University of Kashmir, J&K.

Recognitions

- Dr. A. K. Puniya nominated as Member, Scientific Panel, Milk and Milk Products, Food Safety and Standards Authority of India, New Delhi.
- Dr. A. K. Puniya nominated as Member National Core Group and Convener of National Level Committee; BSMA (Basic Subject Matter Area) for "Restructuring of Master's & Ph.D. Curriculum & Syllabi" of Dairy Science & Technology; ICAR-Agricultural Education Division, New Delhi.
- Dr. Raghu H V., certified as FSSAI food analyst declared by Food Analyst Board constituted by FSSAI for the year 2022 under the provision of Food safety standards Act., 2006.
- Dr. Naresh Kumar was nominated as member secretary codex committee of ICAR-NDRI to attend international codex meeting on food hygiene in virtual mode in management of biological foodborne outbreaks chaired by Denmark from 28th February -4th March and 9th March 2022.
- Dr. Naresh Kumar contributed in development as FAD-19 Member of IS: 17945:2022 standard on food for special medical purpose intended for infants – Specifications - Standard was approved and released in BIS gazette dated 28th September 2022.

12. PUBLICATIONS

Animal Biotechnology

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Ali Murtaza, Devika Gautam, Sameni Deepika, Amar Singh Meena, Jatinder Chera, Sachinandan De. (2022). The genetic variations in CSN2 gene of Indian sheep breeds affect its protein stability and function. *Small Ruminant Research* 207: 106612.	1.893	7.89
2.	De, A.K., Sawhney, S., Muthiyan, R., Bhattacharya, D., Ponraj, P., Malakar, D., Sunder, J., Sujatha,T., Kumar, A., Mondal, S. and Bera, A.K., (2022). Legacies of domestication, Neolithic diffusion andtrade between Indian subcontinent and Island Southeast Asia shape maternal genetic diversity ofAndamancattle. *Plos one*, *17*(12), p.e0278681.	3.24	9.75
3.	Deb Rajib, Prasanna Pal, Parul Chaudhary, Sanat Bhadsavle, Manisha Behera, Devika Gautam, Mayank Roshan, Ashutosh Vats, Ashutosh Ludri, Vivek Kumar Gupta, Sachinandan De. (2022). Development of gold nanoparticle-based visual assay for rapid detection of *Escherichia coli* specific DNA in milk of cows affected with mastitis. *LWT*, 155: 112901.	6.056	12.06
4.	Dubey, A., Saini, S., Sharma, V., Malik, H., Kumar, D., De, A.K., Bhattacharya, D. and Malakar,D.,(2022).DeducingInsulin-Producing Cells from Goat Adipose Tissue-Derived Mesenchymal Stem Cells. *Cellular Reprogramming*, 24(4), pp.195-203. https://doi.org/10.1089/cell.2022.0029.	2.257	8.26
5.	Ghai, S., Saini, S., Ansari, S., Verma, V., Chopra, S., Sharma, V., Devi, P., Malakar, D., (2022).Allogenic umbilical cord blood-mesenchymal stem cells are more effective than antibiotics inalleviatingsubclinicalmastitisindairycows. *Theriogenology*.187C,141-151.https://doi.org/10.1016/j.*Theriogenology*.2022. 05.001.	2.923	8.9
6.	Jamwal, S., Ansari, S., Malakar; D., Kaushik, J. K., Mohanty, A.K.,Sudarshan Kumar(2022).Production of biologically active recombinant buffalo Leukemia inhibitory factor (BuLIF) in *Escherichia* Coli. *Journal of Genetic Engineering and Biotechnology* 20:47 https://doi.org/10.1186/s43141-022-00328-1.	2.322	8.32
7.	Kues W.A., Kumar D., Selokar N.L., Talluri T.R. (2022). Applications of genome editing tools in stem cells towards regenerative medicine: an update. *Curr Stem Cell Res Ther*. 17(3): 267-279.	3.75	9.7
8.	Kumar Biplab, Pramanik, Subhasis Batabyal, Apratim Maity, Sachinandan De, Saibal Chattopadhyay, Abhijit Barui. (2022). Molecular characterization of buffalo αs1-casein gene. *Buffalo Bulletin* 41(3): 447-454.	0.917	6.20
9.	Kumar S, Chauhan MS. (2022). Relative expression of the developmentally important candidate genes in immature oocytes and in vitro-produced embryos of buffalo (Bubalus bubalis). Zygote. 30 (4):509-515. doi: 10.1017/S0967199421000976.	1.81	7.82
10.	Roshan Mayank, A Parmanand, Arora Devan, Behera Manisha, Vats Ashutosh, Gautam Devika, Deb Rajib, Parkunan Thulasiraman, De Sachinandan, (2022). Virulence and enterotoxin gene profile of methicillin-resistant *Staphylococcus aureus* isolates from bovine mastitis. *Comparative Immunology, Microbiology and Infectious Diseases* 80 101724. doi.org/10.1016/ j.cimid.2021.101724.	2.729	8.73
11.	Mehra, V.K., Malakar D., Kumar S. (2022). Molecular characterization of α-lactalbumin (LALBA) protein in Indian buffalo (*Bubalus bubalis*). *Indian Journal of Dairy Sci.* 75(3): 255-264. https://doi.org/10.33785/IJDS.2022.v75i03.008.	-	5.95
12.	Pratiksha Dubey, Vipul Batra, Parul Sarwalia, Samiksha Nayak, Rubina Baithalu, Rakesh Kumar, Tirtha Kumar. October (2022). miR-1246 is implicated as a possible candidate for endometrium remodeling facilitating implantation in buffalo (*Bubalus bubalis*). *Veterinary Medicine and Science* https://doi.org/10.1002/vms3.968	1.672	7.67
13.	Punetha M., Bajwa K.K., Dua S., Bansal S., Kuotsu V., Parashar A., Selokar N.L., Kumar P., Yadav P.S., Kumar D. (2022). Pluripotent stem cells for livestock health and production. *Curr Stem Cell Res Ther*. 17(3):252-266.	3.7	9.7

14.	Deb Rajib, Chaudhary Parul & De Sachinandan, (2022). CRISPR/cas9 cassette targeting *Escherichia coli* blaCTX-M specific gene of mastitis cow milk origin can alter the antibiotic resistant phenotype for cefotaxime. Animal Biotechnology. doi. org/10.1080/10495398.2022.2053695.	1.42	8.14
15.	Rana Chanchal, Rajput Shiveeli, Behera Manisha, Gautam Devika, Vikas Vaibhav, Vats Ashutosh, Roshan Mayank, Ghorai Soma M., De Sachinandan. (2022). Global epidemiology of CTX-M-type β-lactam resistance in human and animal. *Comparative Immunology, Microbiology and Infectious Diseases* 86: 101815.	2.729	8.73
16.	Saini, S., Ansari, S., Sharma, V., Saugandhika, S., Kumar, S.and Malakar, D., (2022). Folate receptor-1 is vital for developmental competence of goat embryos. *Reproduction in Domestic Animals*. https://doi.org/10.1111/rda.14092.	1.76	7.86
17.	Saini, S., Sharma, V., Ansari, S., Kumar, A., Thakur,A., Malik, H., Kumar,S., Malakar, D., (2022). Folate supplementation during oocyte maturation positively impacts the folate-methionine metabolism in pre-implantation embryos.*Theriogenology* 182:63e70.DOI:10.1016/j.*Theriogenology*.2022.01	2.923	8.92
18.	Singh, M.K., Selokar N.L., Chand S., Patel K., Lathwal S.S., Mohanty T.K.and Chauhan M.S. (2022). Buffalo calves from the semen of cloned bulls. *Current Science*, 123(3): 253-253.	1.169	7.17
19.	Solanki Subhash, Kashyap Poonam, Azmal Ali Syed, Kumar Vijay, Vats Ashutosh, Pukhrambam Martina, Kumar Rakesh, De Sachinandan and Datta Tirtha Kumar (2022). Identification, Amplification and Association of Polymorphisms in the Bovine Beta- Defensin 129 (BBD129) Gene revealed its Function in Bull Fertility. *Scientific Reports* 12, 19042 (2022). https://doi.org/ 10.1038/s41598-022-23654-3.	4.99	11.00
20.	Solanki Subhash, Kumar Vijay, Kashyap Poonam, Kumar Rakesh, De Sachinandan, Datta Tirtha Kumar. (2022). β-defensins as marker for male fertility: a comprehensive review. *Biology of Reproduction*,ioac197, https://doi.org/10.1093/biolre/ioac197.	4.161	10.16
21.	Tiwari M., Rawat N, Sharma A, Bhardwaj P, Roshan M, Nagoorvali D. Singh M.K., Chauhan M.S. (2022). Methylation status of imprinted gene IGF2/ H19 DMR3 region in Goat (*Capra hircus*) blastocysts produced through parthenogenesis and in vitro fertilization. *Small Ruminant Research*, 216: 106796.	1.893	7.89
22.	Verma Mahima, Denis Laloe, Mahesh Shivanand Dige, Sachinandan De, Pramod Kumar Rout. (2022). Landscape and bioclimatic diversity of milk protein variability in tropical goats. *Small Ruminant Research* 207: 106614.	1.893	7.89
23.	Yata, V. K., Singh, S. K., Kumar, S., Mohanty, T. K.and Mohanty, A. K. (2022). Use of sexed semen for genetic improvement of indigenous dairy cattle and buffaloes productivity. *The Indian Journal of Animal Sciences*, 92(7), 797–805.https://doi.org/ 10.56093/ijans.v92i7.105407.	0.294	6.29

Animal Genetics & Breeding

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Dige, M. S., Rout, P. K., Singh, M. K., Bhusan, R. and Gowane, G. R. (2022). Fitting random regression models with Legendre polynomial and B-spline to model the lactation curve for Indian dairy goat of semi-arid tropic. *Journal of Animal Breeding and Genetics*. https://doi.org/10.1111/jbg.12678.	3.271	9.27
2.	Dige, M. S., Rout, P. K., Singh, M. K., Bhusan, R., Kaushik, R. and Gowane, G. R. (2022). Estimates of genetic parameters for linear body measurements and prediction of body weight in goat. *Journal of Animal Breeding and Genetics*. https://doi.org/ 10.1111/jbg.12677.	3.271	9.27
3.	Gowane, G. R., Rani Alex, Mukherjee, A., Vohra, V. (2022). Impact and utility of shallow pedigree using single-step genomic BLUP for prediction of unbiased genomic breeding values. *Tropical Animal Health and Production*. 54:339. https:// doi.org/10.1007/s11250-022-03340-2.	1.893	7.89
4.	Gurao, A., Vasisth, R., Singh, R., Dige, M. S., Vohra, V., Mukesh, M., & Kataria, R. S. (2022). Identification of differential methylome signatures of white pigmented skin patches in Nili Ravi buffalo of India. *Environmental and Molecular Mutagenesis* 63: 408-417.	3.216	9.58

5.	Joshi, P., Gowane, G. R.,Rani Alex, Gupta, I. D., Worku, D., George, L., Ranjan, A. and Verma, A. (2022). Estimation of genetic parameters of growth traits for direct and maternal effects in Murrah buffalo. *Tropical Animal Health and Production* 54:352. https://doi.org/10.1007/s11250-022-03343-z.	1.893	7.89
6.	Kumar M, Vohra V, Ratwan P, Gopal R. Gowane and R. Malhotra (2022): Sustainable multi-trait selection index based on production, reproduction, and health traits for genetic improvement of Murrah buffaloes, *Animal Biotechnology*, DOI: 10.1080/10495398.2022.2101117.	2.14	8.14
7.	Kumar, A., Vohra, V., Verma, U. and Singh, U. (2022). Estimates of genetic parameters for production and reproduction traits in Murrah buffaloes (Riverine buffalo) in India. *Buffalo Bulletin*, 41(1), 135-141.	0.172	6.20
8.	Kumar, M., Vohra, V., Ratwan, P., Gowane, G. R. and Malhotra, R. (2022). Sustainable multi-trait selection index based on production, reproduction, and health traits for genetic improvement of Murrah buffaloes. *Animal Biotechnology*, 1-9.	2.14	8.14
9.	Kumar, S. L., Singh, R., Gurao, A., Mishra, S. K., Kumar, P., Vohra, V. and Kataria, R. S. (2022). Genetic admixture and population structure analysis of Indian water buffaloes (Bubalus bubalis) using STR markers. *Molecular Biology Reports*, 49(7):, 6029-6040.	2.74	8.74
10.	Singh, M. K., Dige, M. S., Pourouchottamane, R., Kumar, A., Gowane, G. R. (2022). Influences of maternal factors on the estimate of genetic parameters for goat feed efficiency traits. *Tropical Animal Health and Production*. 54:376 https://doi.org/10.1007/s11250-022-03355-9.	1.893	7.89
11.	Singh, M. K., Dige, M. S.,Singh, S. P., Kumar, A. and Gowane, G. R. (2022). Genetic studies on the estimates of (Co) variance components for growth traits in Barbari goat. *Small Ruminant Research*. Volume 210, 2022,106668, ISSN 0921-4488, https://doi.org/10.1016/j.smallrumres.2022.106668.	1.893	7.89
12.	Worku D, Gowane G, Alex R, Joshi P, Verma A. (2022) Inputs for optimizing selection platform for milk production traits of dairy Sahiwal cattle. *PLoS ONE* 17(5): e0267800. https://doi.org/10.1371/journal.pone.0267800	3.24	9.75
13.	Worku D, Gowane G, Mukherjee A, Alex R, Joshi P, Verma A (2022) Associations between polymorphisms of LAP3 and SIRT1 genes with clinical mastitis and milk production traits in Sahiwal and Karan Fries dairy cattle. *Veterinary Medicine and Science* : 2593-2604 https://doi.org/10.1002/vms3.924	1.776	7.78

Animal Biochemistry

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Agrawal H, Thakur K, Mitra S, Mitra D, Keswani C, Sircar D, Onteru S, Singh D, Singh SP, Tyagi RK and Roy P. (2022). Evaluation of (anti) androgenic activities of environmental xenobiotics in milk using a human liver cell line and androgen receptor-based promoter-reporter assay. *ACS Omega*.7, 45, 41531–547.	4.132	9.51
2.	Bhawal S., Kumari, A., Kapila, S. and Kapila, R. (2022). Biofunctional Attributes of Surface Layer Protein and Cell-Bound Exopolysaccharide from Probiotic Limosilactobacillus fermentum (MTCC 5898)*Probiotics and Antimicrobial Proteins,* 1-12.	5.26	11.26
3.	Devi, S., Kapila, R. and Kapila, S. (2022).A novel gut inflammatory rat model by laparotomic injection of peptidoglycan from *Staphylococcus aureus*. *Archives of Microbiology* 204 (11): 684.	2.66	8.66
4.	Devi,S., Kapila,R. and Kapila, S. (2022). Gut function restoration by indigenous cow milk in gut inflammation by peptidoglycan from Staphylococcus aureus via regulating NF-kB.*Food and Nutrition Journal* 7, 256.	2.0	--
5.	Iram, D., Sansi, M.S., Zanab, S., Vij, S., Ashutosh and Meena, S. (2022). In silico identification of antidiabetic and hypotensive potential bioactive peptides from the sheep milk proteins—a molecular docking study. *Journal of Food Biochemistry*. DOI: 10.1111/jfbc.14137.	-	9.65

6.	Kaur, H., Kaur, H., Gupta,T., Kapila, S. and Kapila R.(2022). *Lactobacillus fermentum* (MTCC-5898) based fermented whey renders prophylactic action against colitis by strengthening the gut barrier function and maintaining immune homeostasis. *Microbial Pathogenesis* 173, 105887.	3.84	9.84
7.	Kumar L.K., Kapri A, Chandel R, Kumar V, Verma S, Vedamurthy GV, Singh D, Onteru SK. (2022). Digestive propensity of Aflatoxin M1 (4-Hydroxyaflatoxin B1), an indication from in vitro digestion model system. *Journal of Food Processing and Preservation*.e16577.	2.609	8.19
8.	Kumar TV, Verma SK, Sharma D, Kumar LK, Veerappa VG, Singh D, Onteru SK. (2022). Meprin A1 subunit beta gene polymorphism is associated with the length of post-partum anestrus interval in Murrah buffaloes. *Gene*. 827:146456.	3.913	9.69
9.	Kumar, S., Bhadane, R., Shandilya, S.Salo-Ahen, OMH and Kapila, S. (2022). Identification of HPr kinase/phosphorylase inhibitors: novel antimicrobials against resistant Enterococcus *faecalis*. *Journal of computer-aided molecular design* 36 (7): 507-520.	4.179	10.179
10.	Kumari,A., Bhawal S., Kapila, S. and Kapila, R.(2022). Strain-specific effects of probiotic *Lactobacilli* on mRNA expression of epigenetic modifiers in intestinal epithelial cells. *Archives of Microbiology* 204 (7), 411.	2.66	8.66
11.	Kumari,A., Bhawal S., Kapila, S.,Yadav,H.and Kapila, R. (2022). Health-promoting role of dietary bioactive compounds through epigenetic modulations: a novel prophylactic and therapeutic approach. *Critical Reviews in Food Science and Nutrition* 62 (3), 619-639.	11.20	17.20
12.	Sansi, M.S., Iram, D., Zanab, S., Vij, S., Puniya, A.K. Singh, A., Ashutosh and Meena, S. (2022). Antimicrobial bioactive peptides from goat Milk proteins: In silico prediction and analysis. *Journal of Food Biochemistry*. DOI: 10.1111/jfbc.14311.	-	9.65
13.	Surla GN, Kumar LK, Vedamurthy VG, Singh D, Onteru SK. (2022). Salivary TIMP1 and predicted mir-141, possible transcript biomarkers for estrus in the buffalo (*Bubalus bubalis*). *Reproductive Biology*. 22(2): 100641.	2.089	8.38
14.	Thakur K, Goud ESK, Jawa Y, Keswani C, Onteru S, Singh D, Singh SP, Roy P, Tyagi, R.K. (2022). Detection of endocrine and metabolism disrupting xenobiotics in milk-derived fat samples by fluorescent protein-tagged nuclear receptors and live cell imaging. *Toxicology Mechanisms and Methods*, pp.1-14.	4.019	10.19
15.	Verma SK, Chandel R, Mahanandia NC, Kumar TV, Kumar LK, Veerappa VG, Singh D, Onteru SK. (2022). A single nucleotide polymorphism of the thyrotropin releasing hormone degrading ectoenzyme (TRHDE) gene is associated with post-partum anestrus in Murrah buffalo. *Gene*.146580.	3.913	9.69

Animal Physiology

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Biswal, S., Misra, A. K., Ukey, A. K. and Singh S. V. (2022). Effect of replacement of concentrate mixture with *Moringa oleifera* leaf meal on haemato-biochemical parameters in Barbari goats. *The Pharma Innovation Journal* 11(11): 1898-1902.	-	-
2.	Chikkagoudara, K.P., Singh, P., Bhatt, N., Barman, D., Selvaraj, R., Lathwal, S.S., Singh, S.V., Choudhary, S. and Uddin, J. (2022). Effect of heat stress mitigations on physiological, behaviouraland hormonal responses of buffalo calves. *International Journal of Biometeorology* 66(5):995-1003.	-	-
3.	Deb, R., Chaudhary, P., Pal, P., Tomar, R.S., Roshan, M., Ludri, A., Gupta, V.K. and De, S. (2022). Development of an on-site lateral flow immune assay based on mango leaf derived colloidal silver nanoparticles for rapid detection of *Staphylococcus aureus* in milk. *Journal of Food Science and Technology*, 1-15. (IF:3.12).	-	9.12
4.	Grewal, S., Aggarwal, A., Vats, P., Rani, S. Jaiswal, S., Prasanna, P., Senthamilan, S. Arya, A., Mohanty, A.K. and Alhussien, M.N. (2022). Curcumin induces thermotolerance by reducing oxidative stress, apoptosisand inflammation in buffalo mammary epithelial cells under heat shock conditions. *Journal of Reproductive Immunology*, 153, pp 103684	3.99	9.99

5.	Mohammed, S., Alhussien, M.N. and Dang, A.K. (2022). Pregnancy stage-dependent modulation of neutrophil function may impact embryo survivability and pregnancy outcome in crossbred cows. *Theriogenology*, 191, pp.200-206.	-	-
6.	Pandey, Y., Panda, B.S., Kamboj, A., Alhussien, M.N., Kapila, R. and Dang, A.K. (2022). Macrophage- activating factor of bovine colostrum promotes phagocytic activity of murine macrophages and bovine phagocytes. *Journal of Reproductive Immunology*, 153, p.103660.	-	9.99
7.	Praveen, S., Chandra, R., Kumar, N., Fernandes, A. and Dhaarani, C. (2022). Improvement in Reproductive Performance of Boron Supplemented Karan Fries Cows During Hot and Humid Season. *Journal of Animal Research*, *12*(1), pp.87-91.	-	5.43
8.	Somagond, Y.M., Singh, S.V. and Deshpande, A. (2022). Effect of dietary supplementation of astaxanthin, prill fat and combination on stress indicators, milk yield and composition during heat stress in buffaloes. *Biological Rhythm Research 53*(5): 665-675.		
9.	Vaidya, M.M., Donge, V.B., Dhenge, S.A., Kokate, V.N., Khandait, V.N. and S.V. Singh (2022). comparative efficacy of three different heattolerance indices for thermo-adaptability during heat stress in bovines. *Indian Journal of Dairy Science* 75 (5):453-457.	-	5.95

Livestock Production and Management

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Rajput Atul Singh, Bhakat Mukesh, Mohanty Tushar Kumar, Baithalu Rubina Kumari, Mir Asheq Ahmed, Gayathri S Lal, Rajput Manmohan Singh, Dewery Raju Kumar and Shah Nadeem (2022). Identification of estrus using infrared thermography in indigenous dairy animals. *The Pharma Innovation Journal 2022*; SP-11(2): 1571-1575.	-	5.23
2.	Behara, S., Garai, S. Maiti, S., Bhakat, M., Meena, B.S. Behara, J., Dixit, A.K. and Kadian, K.S. (2022). Adaptive capacity to climate change among the Chilika buffalo rearers of Odisha. *Indian Journal of Animal Sciences*, 92 (1): 112–117.	-	6.29
3.	Bhatt, N., Chandra, R., Prasad, C. K., Kandwal D., Mishra, D. B and Tyagi, N (2022). Effects of replacing the protein content of Azolla Pinnata with concentrate on physiological and blood profiles changes in Sahiwal calves. *Turkish Journal of Veterinary and Animal Sciences*. 46(5): 724-733.	-	6.60
4.	Choudhary S, Kamboj ML, Jamwal S, Pal P, Arora D, Ingle V, Singh Pawan and Lathwal SS. (2022). Effect of mother contact and voluntary colostrum suckling on growth, health and stress of neonatal buffalo calves. *Indian Journal of Animal Sciences* 92(1): 89-95.	-	6.29
5.	Choudhary, S. Kamboj, ML, Ungerfeld, R and Singh, Pawan (2022) Calf-cow and bull-cow management in buffaloes: Effects on growth, productive and reproductive performance of mothers and calves. *Reproduction in Domestic Animals. 2022;00:1-12* DOI:10.1111/rda.14219.	1.858	7.86
6.	Dogra, A., Dhehibi, b., Kumawat, R.N., Misra, A.K., Louhaichi, M., Hassan, A.A. and Sarker, A. (2022). Predicted farmer uptake of new agricultural practices: case of silvo-pastoral technologies in Rajasthan, India. *Range Mgmt. & Agroforestry* 43 (1): 161-166.	-	6.58
7.	Devi Indu, Mallick P. K., Mohapatra A. and Kumar A. (2022). Relationship of udder morphology and milk yield of Patanwadi sheep with suckling behaviour of lambs. *Indian Journal of Small Ruminants*. 28 (1): 96-100.	-	5.95
8.	Jamwal, Shwetambri, Pawan Singh and Rajneesh Thakur. (2022). Effect of different rearing systems on behavioural responses to novel stimuli in Murrah buffalo calves *Buffalo Bulletin.* 41, No. 4: 655-667.	-	6.20
9.	Kamboj ML, Kumar C and Mahla V (2022). Development of a welfare assessment protocol and assessment of dairy cattle welfare in Haryana and Punjab states of Northern India. *Animal Welfare,* 31: 545-555, ISSN 0962-7286 Doi: 10.7120/09627286.31.4.008	-	-
10.	Kumawat, R.N., Misra, A.K., Louhaichi, M. and Venkatesan, K. (2022). Vegetation dynamics under different management interventions in arid rangelands of Rajasthan. *Range Mgmt. & Agroforestry*. 43 (1): 11-18.	-	6.58

11.	Singh Laishram Kipjen, Pandey Mamta, Baithalu Rubina Kumari, Fernandes Abhijeet, Ali Syed Azmal, Jaiswal Latika, Pannu Suryaprakash, Neeraj, Mohanty Tushar K., Kumaresan A., Datta Tirtha K., Kumar Sudarshan and Mohanty Ashok K.(2022). Comparative proteome profiling of saliva between estrus and non-estrus stages by employing Label-Free Quantitation (LFQ) and Tandem Mass Tag (TMT)-LC-MS/MS Analysis: An approach for estrus biomarker identification in Bubalus bubalis. *Frontiers in Genetics*. 13: 867909.	4.599	10.60
12.	Leitanthem, V.K., Chaudhary, P., Bhakat, M, Mohini, M. and Mondal, G. (2022). Impact of Moringa oleifera on rumen fermentation and methane emission under in vitro condition. *AMB Express*, 12 (1), 1-10.	3.90	10.13
13.	Lone, S.A., Mohanty, T.K., Bhakat, M., Yadav, H.P. Paray, A.R., Baithalu, R.K., Sinha, R., Dewry, R.K., Kumar, P. (2022). Effect of over dilution of semen with tris extender on motion and functional attributes of bull spermatozoa during cryopreservation. Andrologia e14478.https://doi.org /10.1111/and.14478.	2.775	8.78
14.	Pande M, Tyagi Shrikant, Kumar Suresh , Soni Y.K., Chand N., Sirohi A.S., Sarika, Devi I. and Mahajan S. (2022). Effects of unconjugated gold, silver and titanium dioxide nanoparticles on bovine spermatozoa at various stages of cryopreservation. *CryoLetters* 43(3), 150 – 157.	-	6.89
15.	Mamta, Lathwal S S, Singh Pawan, Devi Indu and Kumar Ajay. (2022). Anthelmintic potency of garlic (*Allium sativum*) and neem (*Azadirachta indica*) combination as herbal anthelmintic in lactating Karan Fries cows. *Indian Journal of Animal Sciences*. 92 (6): 706–710.	-	6.29
16.	Kuri Piyali, Kumar Parveen, Kumar Nishant, Parray Mohsin Ahmad and Aggarwal Anjali (2022) Effect of polyherbal mixture supplementation on milk composition and udder health of post partum Sahiwal Cows. *Haryana Veterinarian* 61 (2): 226-228.	-	5.58
17.	Biswa L Prachurya, Lathwal S S, Baithalu Rubina K, Nag Pradeep and Kumar Susheel. (2022). Total antioxidant capacity, neutrophil profile, in vitro phagocytic activity, myeloperoxidase (MPO) activity and IL-8 status in uterine infected Murrah buffaloes during peripartum period. *Indian Journal of Animal Sciences,*92 (1): 32–37.	-	6.29
18.	Dubey Pratiksha, Batra Vipul, Sarwalia Parul, Nayak Samiksha, Baithalu Rubina K., Kumar Rakesh, Datta Tirtha Kumar. (2022). miR-1246 is implicated as a possible candidate for endometrium remodelling facilitating implantation in buffalo (*Bubalus bubalis*). *Veterinary Medicine and Science*. 1-14.	1.776	7.78
19.	Verma Preeti, Sharma Ankita, Sodhi Monika, Tiwari Manish, Prince Vivek, Kataria Ranjit S., Niranjan Saket K., Bharti Vijay K., Dabbas Pawan S., Lathwal S S., Sharma Vishal and Masharing Nampher and Mukesh Manishi (2022). Identification of Internal Reference Genes in PBMCs of Cattle Populations Adapted to Hot Arid Normoxia and Cold Arid Hypoxia Environments, *Frontiers in Genetics*, doi: 10.3389/fgene.2021.730599.	4.772	10.77
20.	Yadav Preeti, Maiti Sanjit, Jha S K, Meena H R, Bhakat Mukesh and Dixit A K. (2022). Participatory assessment of farmer-led adaptation strategies in livestock rearing to climate change in eastern Uttar Pradesh. *Indian J Dairy Sci*., 75(5): 472-477.	-	5.95
21.	Rajneesh, Misra, A.K., Baithalu, R.K.and Jamwal, S. (2022). Influence of bypass fatty acid and Tinospora cordifolia supplementation on uterine involution, follicular developmentand reproductive performance of Murrah buffaloes. *Indian Journal of Animal Sciences* 92 (6): 757–761.	-	6.29
22.	Ramasamy Arunkumar, Kumaresan Arumugam, Sinha Manish Kumar, Elango Kamaraj, John Peter Ebenezer Samuel King, Nag Pradeep, Karuthadurai Thirumalaisamy, Baithalu Rubina Kumari, Mohanty Tushar, Kumar Rakesh and Datta Tirtha Kumar. (2022). The cryopreservation process induces alterations in proteins associated with bull sperm quality: The equilibration process could be a probable critical control point. *Frontiers in Endocrinology* 13: 1064956. doi: 10.3389/fendo.2022.1064956.	6.055	-
23.	S Praveen, Chandra Ramesh, Kumar Nishant, Fernandes Abhijeet, Dhaarani C (2022) Improvement in Reproductive Performance of Boron Supplemented Karan Fries Cows During Hot and Humid Season. *Journal of Animal Research* 12 (1) :87-91.	-	5.43

24.	Choudhary Sanjay, Kamboj ML, Sahu Dharma, Dutt Sunil, Ankit, Singh Pawan, Kumar Nishant, Ungerfeld Rodolfo, Prasad C Kotresh (2022). Effect of biostimulation on growth rate and reproductive development of Bos indicus dairy heifers.*Tropical Animal Health and Production* 54 (2): 1-8.	1.893	7.89
25.	Sethi, M., Mohanty, T.K., Bhakat, M., Shah, N., Yadav, D.K., Baithalu, R.K. and Swain, D.K. (2022). Trehalose with a modified freezing protocol can be an alternative to improve the sperm motility of poor freezable dairy bulls. *The Pharma Innovation Journal* 11(8): 766-769.	-	5.43
26.	Gupta Shailesh Kumar, Chandra Ramesh, Shinde Kuladip Prakash, Bhakat Mukesh, Lone Shabir Ahmad, Kumarand Nishant , Dey Dipak (2022). Effect of azolla (Azolla *pinnata*) supplementation on puberty, semen characteristics and sexual behaviour in Alpine × Beetal crossbred bucks. Indian Journal of Animal Sciences.92 (7): 881–886.	-	6.29
27.	Singha Shubham, Pandey Mamta, Jaiswal Latika, Dasha Sangram, Fernandesa Abhijeet, Arumugan Kumaresan, Ranjan Maharana Biswa, Lathwal Surender Singh, Thulasiraman, K Tirtha. Dattag, Mohanty Tushar K.and Baithalu Rubina Kumari. (2022). Salivary cell-free HSD17B1and HSPA1A transcripts as potential biomarkers for estrus identification in buffaloes (Bubalus bubalis). *Animal Biotechnology.* 1-11.	2.14	8.28
28.	Shwetambri, Jamwal, Singh Pawan, Sanjay, Choudhary, Kamboj M.L. and Rajneesh (2022). Effect of mother bonded rearing on growth, health and physiological state of Murrah buffalo calves. *Journal of Dairy Research*. DOI: 10.1017/S002202992000747.	2.027	8.03
29.	Srivastava, R., Tiwari, S., Banakar, P. S., Bhakat, M., Mani, V., Mohanty, T. K. and Mondal, G. (2022). Iodine Supplementation Improved Antioxidant Status, Hormonal Status, Sexual Behaviorand Semen Production Performance of Bos indicus Bulls under Tropical Climatic Condition. *Biological Trace Element Research*, DOI: https://doi.org/10.1007/s12011-021-03066-6.	4.081	10.08
30.	Tiwari, S., Srivastava, R., Kulkarni, N.A., Raval, K., Patidar, P., Fernandes, A., Bhakat, M. and Mohanty, T.K. (2022). Filtration techniques are advantageous over colloidal centrifugation in improving freezability of low-quality buffalo bull (*Bubalus bubalis*) ejaculates. *Animal Biotechnology*, DOI:10.1080/ 10495398.2022. 2121715.	4.081	10.08
31.	Vanmathy Kasimanickam, Nishant Kumar and Ramanathan Kasimanickam (2022). Investigation of Sperm and Seminal Plasma Candidate Micro RNAs of Bulls with Differing Fertility and *in Silico* Prediction of miRNA-mRNA Interaction Network of Reproductive Function. *Animals.*12, 2360. https://doi.org/10.3390/ ani12182360.	3.231	9.23
32.	Veenesh R, Pawan S, Prasad K and Kamboj ML. (2022)Welfare status of dairy animals under field conditions in Muzaffarnagar district of Uttar Pradesh (India). *Journal of Applied Animal Welfare Science* https://doi.org/10.1080/10888705.2022.2042297.	1.60	-
33.	Yadav, P., Maiti, S., Meena, H., Bhakat, M. and Dixit, A. (2022). A Study on the Effectiveness of Farmer-LedAdaptation Strategies for Livestock Rearing to Climate Change in Eastern Uttar Pradesh Through a Participatory Approach. *International Journal of Livestock Research*, 12(2): 23-30. doi: 10.5455/ ijlr.20220222020551.	-	-

Animal Nutrition

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Amit Sharma, Veena Mani, Ravi Prakash Pal, Srobana Sarkar, Hunny Sharma, Shimala Yadav and Chander Datt. (2022). Effect of boron supplementation on nutrient utilization and productive performance of peripartum Murrah buffaloes. *Biol Trace Elem Res*. 200(10):4303-4315. doi: 10.1007/s12011-021-03038-w.	-	10.08
2.	Avinesh Sharma, Chander Datt**,** Jitendra Kumar, Kuldeep Dudi, Shambhvi, Veena Mani and S.S. Lathwal (2022). Supplementary effect of *K. alvarezii* baesd seaweed product on milk production, its composition and organoleptic appraisal in crossbred cows. *Indian J. Dairy Sci.* 75 (2): 156-161.	-	5.95
3.	Banakar, P.S., Kumar, S., Varada, V.V., Dixit, S., Tyagi, N. and Tyagi, A.K.,(2022). Dietary supplementation of Aloe vera extract modulates rumen microbes and improves the functional food value of milk by altering phenolic content, antioxidant capacityand fatty acid profile in lactating goats. *Animal Biotechnology,* 1-12.	1.97	8.14

4.	Dixit, S., Kumar, S., Sharma, R., Banakar, P.S., Deb, R. and Tyagi, A.K. (2022). Rumen microbial diversity, enteric methane emission and nutrient utilization of crossbred Karan-Fries cattle (Bos taurus) and Murrah buffalo (Bubalus bubalis) consuming varied roughage concentrate ratio. *Animal Biotechnology*, 1-9.	1.97	8.14
5.	Kumar, S., Banakar, P.S., Tyagi, A.K. and Sharma, H. (2022). Intra-species variation in fatty acid profile and nutritional indices of cattle (Bos indicus), buffalo (Bubalus bubalis) and goat (Capra hircus) ghee deciphered using GC-FID and FT-IR spectroscopy. *International Dairy Journal*, 105342.	3.57	9.57
6.	Kumar, S., Kumar, B., Chouraddi, R., Bhatia, M., Rashmi, H.M., Behare, P.V. and Tyagi, N. (2022). In vitro screening for potential probiotic properties of Ligilactobacillus salivarius isolated from cattle calves. *Current Research in Biotechnology*. https://doi.org/10.1016/j.crbiot.2022.06.001.	5.64	11.64
7.	Kumar, S., Varada, V.V., Banakar, P.S., Tyagi, N., Chouraddi, R., Hogarehalli Mallapa, R. and Tyagi, A.K. (2022). Screening and characterization of Sahiwal cattle calves-origin lactic acid bacteria based on desired probiotic attributes for potential application. *Animal Biotechnology*, 1-14.	1.97	8.14
8.	Leitanthem V K , Parul Chaudhary , Mukesh Bhakat, Madhu Mohini and G Mondal. (2022). Impact of Moringa oleifera on rumen fermentation and methane emission under in vitro condition. 12:141 *AMB Express*. https://doi.org/10.1186/s13568-022-01480-0.	4.13	10.13
9.	Ojha, L., Kumar, S., Kewalramani, N., Sarkar, S. and Tyagi, A.K. (2022). Effect of Milk Fermented with *Lactobacillus acidophilus* NCDC15 on Nutrient Digestibility, Faecal Biomarkers and Immune Response in Murrah calves. *Brazilian Archives of Biology and Technology*, 64.	1.18	7.18
10.	Prusty S , S. S. Kundu , V. K. Sharma and G. Mondal. (2022). Studies on growing Murrah buffalo fed on diverse energy and protein ration and their effect on biochemical parameters. Indian *J. Anim. Nutr.* 39 (1): 12-22. doi: 10.5958/2231-6744.2022.00002.0.	-	5.66
11.	Srivastava R, S Tiwari, P. S. Banakar, M Bhakat, Veena Manl, T. K. Mohanty, G Mondal. (2022). Iodine Supplementation Improved Antioxidant Status, Hormonal Status, Sexual Behaviorand Semen Production Performance of Bos indicus Bulls Under Tropical Climatic Condition. *Biological Trace Element Research*. https://doi.org/10.1007/s12011-021-03066-6.	4.08	10.08
12.	Varada V.V., Kumar S., Chhotaray S. and Tyagi, A.K. (2022). Host-specific probiotics feeding influence growth, gut microbiotaand fecal biomarkers in buffalo calves. *AMB Express*, 12(1):118. doi: 10.1186/s13568-022-01460-4.	3.90	10.13
13.	Varada, V.V., Kumar, S., Tyagi, N. and Tyagi, A.K., (2022). Effects of compound lyophilized probiotics on selected faecal microbiota, immune responseand antioxidant status in newborn buffalo calves. *Current Research in Biotechnology,* 4: 493-502.	5.64	11.64
14.	Venkatesan P, N Sivaramane, B S Sontakki, R Roy Burman, C H Srinivasa Rao, V P Chahal, A K Singh, P Sethuraman, J P Sharma, R N Padaria, S Chakravorty, N Sharma, N Patel, H Choudhary, G Mondal, R Singh, B Kalyani, S Sharma and R Kumar. (2022). Predicting adoption of agricultural technologies in Indo-Gangetic Region. *Indian Journal of Agricultural Sciences* 92 (6): 769–74.	0.37	6.37
15.	Vinay, V.V., Tyagi, A.K., Banakar, P.S., Asit Das, Nitin Tyagi, Rashmi Hogarehalli Mallapaand Kumar, S. (2022). Autochthonous Limosilactobacillus reuteri BFE7 and Ligilactobacillus salivariusBF17 probiotics consortium supplementation improves performance, immunityand selected gut health indices in Murrah buffalo calves. *Veterinary Research Communications*, 1-11.	2.81	8.82

Agronomy

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Akshay Glotra, Singh, Magan and Maneesha (2022). Nano-fertilizers: A Review on the Futuristic Technology of Nutrient Management in Agriculture. *Agricultural Reviews* Doi:10.18805/ag.R-2469, pp: 1-7.	-	4.63
2.	Baral, R., Bhandari, K., Kumar, R.and Min, D. (2022). Yield gap analysis of alfalfa grown under rainfed condition in Kansas. *Agronomy*, 12(9), 2190.	-	9.949

3.	Karwariya, S., Dutta, S., Singh, M., Kumar, H., Kumar, S., Meena, V.K.and Bhattacharya, B. K. (2022). Estimating fodder crops area using multi-date high-resolution satellite data-a case study in Madhya Pradesh, India. *Range Management and Agroforestry*, 43(1), 19-24. [ISSN 0971-2070]	-	6.37
4.	Khapte, P.S., Kumar, P., Singh, A., Wakchaure, G.C., Saxena, Anurag and Sabatino, L. (2022). Integrative Effect of Protective Structures and Irrigation Levels on Tomato Performance in Indian Hot-Arid Region. *Plants*, 11: 2743. DOI: 10.3390/ plants11202743	4.658	9.94
5.	Kumar R., Kumar R., Meena, R.K; Ram, H; Kumar, V; Makarana, G; Kumar, Dinesh; K, Rakesh. (2022). Fodder Quality, Fibre Fractionation and Energy Balances of Oats (*Avena sativa L.*) as Influenced by Nano Urea Application. *Frontiers in crop improvement,10*(6), 2909-13.	-	4.67
6.	Kumar, D., Singh, M., Yadav, M. R., Makarana, G., Kushwaha, M. A. N. I. S. H., Dutta, S., Bhattacharjee, S. and Rajesh, B. (2022). Growth and yield performance of fodder oats (*Avena sativa*) grown under different nutrient management practices. *Indian Journal of Agricultural Sciences*, *92*, 267-272.	0.7	6.37
7.	Kumar, H., Singh, M., Dutta, S., Karwariya, S. K.and Kumar, S. (2022). Fodder crop estimation using Sentinel-2A/B satellite data for West Bengal, India. *Indian Journal of Agricultural Sciences*, 92(6), 716-20.*doi:10.56093/ijas.v92i6.108325*.	0.7	6.37
8.	Kumar, Himanshu, Singh, Magan, Kumar, Sanjeev, Kumar, Brijesh, Meena, V.K. (2022). Fodder Quality Assessment through Remote Sensing: A Review. *Indian Journal of Ecology* 49(6): 2431-2435.	-	5.79
9.	Kumar, R., Ram, H., Meena, R.K., Kumar, M., Verma, A.K., Kumar, S., Makrana, G., Kumar, D. and Jat, P.L. (2022). Effect of nano nitrogen application on yield, nutrient uptake and profitability in fodder oat (*Avena sativa L.*) under north western Haryana condition. *Range Management and Agroforestry*, 43(2), 340-344.	-	6.85
10.	Kumar, R., Ram, H., Tyagi, N., Meena, R.K., Kumar, D., Kumar, R., Singh, K. and Min, D. (2022). Effect of zinc fertilization on nutritional quality of cowpea cultivars. *Legume Research-An International Journal*, 45(8), 974-980.*doi: 10.18805/LR-4669*	-	6.59
11.	Mahanta, R.K., Meena, R.K., Singh, Y.V., Kumar, R., Ram, H. and Kumar, D., (2022). Soil microbial and enzymatic responses to various sources of potassium in fodder maize and sugargraze. *Annals of Plant and Soil Research* 24(1): 167-172.	-	5.22
12.	Praveen, B. R., Lathwal, O. P., Dhaka, A. K., Garhwal, R. S., Singh, M., Rundan, V.and Kumar, R. (2022). Influence of planting geometry and nitrogen levels on nutrient content, uptake and soil fertility status in scented rice (*Oryza sativa L.*). *Indian Journal of Ecology*, 49(3), 752-757.	-	5.79
13.	Ram, H., Kumar, R., Singh, M., Meena, R.K.and Kumar, R. (2022). Effect of rhizobium inoculation and tillage practices on fodder cowpea (*Vigna unguiculata*). *Legume Research-An International Journal*, *45*(5), 608-613.*doi: 10.18805/LR-4373*.	-	6.59
14.	Singh, K., Ram, H., Kumar, R., Meena, R.K.and Kumar, R. (2022). Effect of weed management practices on weed dynamics, nutrient depletion, productivity and profitability of summer mungbean (*Vigna radiata*) under zero tillage condition. *Legume Research-An International Journal*, 45(6), 762-768.*doi: 10.18805/ LR-4497*.	-	6.59
15.	Singh, M., Harika, A. S., Oberoi, P. S.and Dutta, S. (2022). Enhancement of nutrient use efficiency and profitability of teosinte (*Euchlaena mexicana*) fodder production under different nutrient management practices.*The Pharma Innovation*11(7), 995-999.	-	5.23
16.	SK, M., Kumar, R., Ram, H., Meena, R. K., Yadav, M. R., Makarana, G.and Kumar, U. (2022). Growth, yield and economics of fodder maize (*Zea mays*) as influenced by Jeevamrutha formulations under varying nutrient levels. *Indian Journal of Agricultural Sciences*92 (5):607-10.	-	6.37
17.	Soni, M.L., Birbal, Nangia, V, Saxena, Anurag, Yadava, N.D. and Subbulaxmi, V. (2022). Vegetable based inter-cropping system in pomegranate under hot arid region. *Indian Journal of Arid Horticulture*, 2(1&2): 46 – 50.	-	-

18.	Yadav, M. R., Singh, M., Kumar, R., Kumar, D., Kumar Meena, R., Ram, H.and Makarana, G. (2022). Integrated nutrient management in maize-cowpea intercropping system is an attractive option to improve the fodder productivity and quality. *Communications in Soil Science and Plant Analysis*, 53(22), 3045-3059.	1.58	7.33
19.	Yadav, M. R., Singh, M., Kumar, R., Kumar, D., Kumar Meena, R., Ram, H.and Makarana, G. (2022). Integrated nutrient management in maize-cowpea intercropping system is an attractive option to improve the fodder productivity and quality. *Communications in Soil Science and Plant Analysis*, 53(22), 3045-3059.	-	7.61
20.	Yadav, M.R., Singh, M., Kumar, R., Ram, H., Meena, R.K., Makarana, G., Kumar, D. and Dutta, S. (2022). Inclusion of legume and integrated use of organic and inorganic nutrient sources can improve the productivity and qualitative traits of oats straw. *Journal of Plant Nutrition*, 45(13), 1991-2002.*doi:10.1080/01904167.2022.2063137*.	2.277	7.71

Dairy Microbiology

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Anjali, M. K., Bharath, G., Rashmi, H. M., Naresh, K., Raju, P. N.and Raghu, H. V. (2022). Polyaniline-Pectin nanoparticles immobilized paper based colorimetric sensor for detection of Escherichia coli in milk and milk products. *Current Research in Food Science*, 5, 823-834.	6.269	12.269
2.	Brijesh Kumar, Naresh Kumarand Raghu Hirikyathanahalli Vishweswaraiah. (2022). Spore germination-enzyme inhibition assay for rapid detection of Pesticide residue in milk. *Journal of Food Science &Technology*, 7(1), 417.	3.117	8.7
3.	Chaudhary V, Katyal P, Panwar H, Kaur J, Aluko RE, Puniya AK. (2022). Antioxidative, anti-inflammatoryand anticancer properties of the red biopigment extract from Monascuspurpureus (MTCC 369). Journal of Food Biochemistry, 46(9):e14249.	2.72	8.72
4.	Chaudhary V, Katyal P, Panwar H, Puniya AK, Poonia AK. (2022). Evaluating anti-microbial and anti-oxidative potential of red biopigment from Monascuspurpureus. *Environment Conservation Journal,* 23 (12), 83-93	-	5.66
5.	Garima Sharma, Eithne Leahy, Ram Pratim Deka, Bibek R. Shome, Samiran Bandyopadhyay, Tushar K. Dey, Naresh Kumar Goyal, Åke Lundkvist, Delia Graceand Johanna F. Lindahl. (2022). Antibiotic use, knowledgeand practices of milk vendors in India's informal dairy value chain. *Frontiers in Sustainable Food Systems*. Volume 6– 2022.	5.65	12.45
6.	Garima Sharma, Florence Mutua, Ram PratimDeka, Rajeshwari Shome, Samiran Bandyopadhyay, Bibek Ranjan Shome, Naresh Goyal Kumar, Delia Grace, Tushar Kumar Deyand Johanna Lindahl. (2022). Comparing the effectiveness of differentapproaches to raise awareness about antimicrobial resistance infarmers and veterinarians of India. *Frontiers in public Health*, 10(1).	-	9.71
7.	Goel, P., Vishweswaraiah, R.H. & Kumar, N. (2022). Spore-based innovative paper-strip biosensor for the rapid detection of ß-lactam group in milk. *Sci Rep* 12, 21965.	4.996	10.38
8.	Iram D, Kindarle UA, Sansi MS, Meena S, Puniya AK, Vij S. (2022). Peptidomics-based identification of an antimicrobial peptide derived from goat milk fermented by Lactobacillus rhamnosus (C25). *Journal of Food Biochemistry*, e14450-e14450	-	8.72
9.	Iram, D., Sansi, M. S., Zanab, S., Vij, S.and Meena, S. (2022). In silico identification of antidiabetic and hypotensive potential bioactive peptides from the sheep milk proteins-a molecular docking study. *Journal of Food Biochemistry*, e14137.	2.72	8.72
10.	Jena R, Choudhury PK, Puniya AK, Tomar SK. (2022). Applicability of rpoB Gene for PCR-RFLP based Discrimination of Bifidobacterial Species Isolated from Human and Animal sources. *Journal of Pure and Applied Microbiology* 16 (1), 503-514.	-	5.05
11.	Kashyap, R., Narayan, K. S.and Vij, S. (2022). Evaluation of the antimicrobial attribute of bioactive peptides derived from colostrum whey fermented by Lactobacillus against diarrheagenic E. coli strains. *Journal of Food Science and Technology*, 1-11.	3.117	8.7

12.	Kashyap, R., Narayan, K. S.and Vij, S. (2022). Identification of antibacterial and immunomodulatory bioactive peptides generated from buffalo (Bubalus bubalis) colostrum whey fermented by Lactobacillus rhamnosus C25: LC-MS/MS-based analysis. *Journal of Functional Foods*, 95, 105158.	5.223	10.45
13.	Kumar, B., Yadav, G.S., Kumar, N. *et al.* (2022). Magnetic Molecularly Imprinted Polymer (MMIP) Mediated Bacterial Esterase-Based Assay for Captan Detection in Milk. *Food Anal. Methods* 15, 1269–1285.	3.498	9.37
14.	Kumar, C. M., Mondal, S., Prasad, W. G., Rathod, G. S., Raghu, H. V.andKokkiligadda, A. (2022). Evaluation of physicochemical and functional attributes of whey powder incorporated with pomegranate peel extract. *Food Chemistry Advances*, 1, 100088.	-	-
15.	Kumari M, Dasriya VL, Nataraj BH, Nagpal R, Behare PV. (2022). *Lacticasei bacillusrhamnosus*-Derived Exopolysaccharide Attenuates D-Galactose-Induced Oxidative Stress and Inflammatory Brain Injury and Modulates Gut Microbiota in a Mouse Model. *Microorganisms*. 10:2046.	4.926	10.13
16.	M.K. Anjali, G. Bharatha, H.M. Rashmi, JaswalAvinash, Kumar Naresh, P.N. Raju, H.V. Raghu. (2022). Polyaniline-Pectin nanoparticles immobilized paper based colorimetric sensor for detection of Escherichia coli in milk and milk products. *Current Research in Food Science*, (2022), 5, 823.	5.65	11.65
17.	Manju G.and Grover C. R. (2022). Evaluation of synergistic preservative effect of cinnamaldehyde and citral against yeast in milk and *Lassi*. *Indian J Dairy Sci.75(2)*: 133-138.	0.43	5.95
18.	Nimisha Tehri, Geetika Thakur, Namita Ashish Singh, Avinash Yadav, Naresh Kumar and Raghu HV. (2022). Protease activity as a marker of Bacillus spore germination and its utility for spore eradication. *Indian J Dairy Sci* 75 (6): 522-527.	-	5.95
19.	Pal, Upmaand Shilpa Vij (2022) "Adaptive evolution of Kluyveromycesmarxianus MTCC1389 for high ethanol tolerance". *Biocatalysis and Agricultural Biotechnology*: 102533.		
20.	Parveen, H., Tewari, L., Pradhan, D.and Chaudhary, P. (2022). Comparative Study of Diverse Pretreatment Approaches to Degrade Lignin from Bambusabalcooa. *Bio Resources*, 17(4).	1.747	7.61
21.	Prashant Goel, Raghu Hirikyathanahalli Vishweswaraiah & Naresh Kumar.(2022). Spore based innovative paperstrip biosensor for the rapid detection of ßlactam group in milk. *Scientific Reports*, 12:21965.	4.996	10.38
22.	Rai, S., Rao, P. S., Sharma, V., Pradhan, D.and Singh, R. (2022). Antimicrobial potential of panchagavya formulation from Indian cow breeds. *International Journal of Bio-resource and Stress Management*, 13(6), 613-621.	-	5.11
23.	Rani, S; Verma S.; Singh H; and Ram C. (2022). Antibacterial activity and mechanism of essential oils in combination with medium-chain fatty acids against predominant bovine mastitis pathogens. *Letters in Applied Microbiology*. First published: 18 February 2022.	2.78	8.86
24.	Sansi, M. S., Iram, D., Zanab, S., Vij, S., Puniya, A. K., Singh, A.and Meena, S. (2022). Antimicrobial bioactive peptides from goat Milk proteins: In silico prediction and analysis. *Journal of Food Biochemistry*, 46(10), e14311.	2.72	8.72
25.	Singh H; Verma S.; Jaiswal A.; Rani, S; and Ram C. (2022). *In-vitro* evaluation of indigenous probiotic lactobacilli for lead bio-adsorption potential, its tolerance and complex stability. *Journal of Functional Foods,* 95 (2022) 105175.	4.75	10.45
26.	Srivastava U, Nataraj BH, Kumari M, Kadyan S, Puniya AK, Behare PV, Nagpal R. (2022). Antioxidant and immunomodulatory potency of Lacticaseibacillusrhamnosus NCDC24 fermented milk-derived peptides: A computationally guided in-vitro and ex-vivo investigation. Peptides. 155:170843.	3.867	9.75
27.	Tehri, N., Thakur, G., Singh, N. A., yadav, A., Kumar, N.and HV, R. (2022). Protease activity as a marker of Bacillus spore germination and its utility for spore eradication. Indian Journal of Dairy Science, 75(6).	-	5.95

Dairy Chemistry

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Amila, Sumit Arora, Rita, Hemant Gawande, G.S. Meena and A.K. Singh (2022) Process optimization for the preparation of milk protein co-precipitate using calcium lactate as coagulant. *Journal of food processing and preservation* (46)12: 17250.	2.609	8.89
2.	Atbhaiya, Y., Sharma, R., Gandhi, K., Mann, B.and Gautam, P. B. (2022). Methods to differentiate between cotton tract area ghee and cotton seed oil adulterated ghee. *Journal of Food Science and Technology*, 59(12), 4782-4793.	3.117	9.12
3.	Chapke, K., Gandhi, K., Lata, K., Sharma, R., Mann, B.and Singh, N. (2022). Migration study of chemical additives from low density polyethylene (LDPE) into dahi. *Journal of Food Science and Technology*. 59(8), 3283-3295.	3.117	9.12
4.	Deshwal, G. K., Singh, R., Singh, A. K., Kumar, D.and Sharma, H. (2022). Comparative characterisation of ghee from Indian camel breeds using GC-MS and FTIR techniques. *International Journal of Dairy Technology*, *75*(1), 182-193.	4.286	10.29
5.	Gandhi, K., Sharma, R., Seth, R.and Mann, B. (2022). Detection of coconut oil in ghee using ATR-FTIR and chemometrics. *Applied Food Research*, 2(1), 100035.	-	-
6.	Gawande, H., Arora, S., Sharma, V., Meena, G. S.and Singh, A. K. (2022). Functional characterisation of buffalo milk protein co-precipitate. *International Journal of Dairy Technology*, 75(4), 892-901.	4.286	10.29
7.	Gawande, H., Arora, S., Singh, A. K.and Sharma, V. (2022) Process optimization for production of spray-dried buffalo milk protein co-precipitate with enhanced solubility. *Applied Food Research* 2: 100062.	-	-
8.	Parmar, A., Sharma, V., Arora, S.and Raju Panjagari, N. (2022) Activation of lactoperoxidase system in buffalo milk using dual enzyme (lactase & glucose oxidase) and its effect on milk constituents. *International Journal of Dairy Technology*, 75 (2): 348-360.	4.286	10.29
9.	Saha, P., Bajaj, R., Mann, B, Sharma, R. and Mandal, S. (2022) Isolation and characterisation of micellar casein from buffalo milk using microfiltration technique with modified buffer composition. *International Journal of Dairy Technology*. doi: 110.111/1471- 0307.12844)	4.286	10.29
10.	Sharma, M.; Mann, B*.; Pothuraju, R.; Sharma, R. and Kumar, R. (2022) Physico-chemical characterization of ultrasound assisted clove oil-loaded nanoemulsion: As enhanced antimicrobial potential. *Biotechnology Reports,* 34*: e00720*.	-	-
11.	Shilpashree B. G, Sumit Arora, Prince Chawla and Sharma V. (2022) A comparison of zinc interactions with succinylated milk protein concentrate and sodium caseinate.. *LWT - Food Science and Technology,* 157: 113116.	6.056	12.06
12.	Singh, N., Mann, B., Sharma, R., Verma, A., Panjagari, N. R.andGandhi, K. (2022). Identification of polymer additives from multilayer milk packaging materials by liquid-solid extraction coupled with GC-MS. *Food Packaging and Shelf Life*, 34, 100975.	8.75	14.75
13.	Singh, P., Arora, S., Rao, P. S., Kathuria, D., Sharma, V.andSingh, A. K. (2022). Effect of process parameters on the enzymatic hydrolysis and galactooligosaccharide formation in concentrated skim millk. *Food Chemistry,* 393: 133355. 133355	9.53	15.23
14.	Singh, R., Rathod, G., Meletharayil, G. H., Kapoor, R., Sankarlal, V. M.and Amamcharla, J. K. (2022). Invited review: Shelf-stable dairy protein beverages—Scientific and technological aspects. *Journal of Dairy Science*. 105 (12): 9327-9346	4.225	10.23
15.	Sonia Mor, Vivek Sharma, Sumit Arora and P.S.Minz (2022) Physico-chemical and color parameters to distinguish cow ghee from buffalo ghee. *Journal of Food Science and Technology*, 59, 33231- 3236	3.117	9.12
16.	Syama, M. A, Sumit Arora, Chitra Gupta and A. K. Singh. (2022). Loading of vitamin D2 in native and modified sodium caseinate: Delineation of physicochemical and in-vitro bioaccessibility attributes. *LWT - Food Science and Technology* 155: 112992	6.056	12.06
17.	Vasava, H., Singh, R.and Yadav, T. (2022). Characterisation of whey protein–polyphenol conjugates prepared by the noncovalent and covalent methods for their effect on the functional properties of whey proteins. *International Journal of Dairy Technology*, *75*(3), 563-574. (NAAS: 10.37), (IF: 4.286)	4.286	10.29

Dairy Technology

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Anjali MK, Bharath G, Rashmi HM, Kumar N, PN Raju, Raghu HV (2022). Polyaniline-Pectin nanoparticles immobilized paper based colorimetric sensor for detection of Escherichia coli in milk and milk products. *Current Research in Food Science*, 5: 823-834. https://doi.org/10.1016/j.crfs.2022.04.006	6.259	-
2.	Badola, R., Prasad, W., Panjagari, N. R., Singh, R. R. B., Singh, A. K.and Hussain, S. A. (2022). Khoa and khoa based traditional dairy products: preparation, spoilage and shelf life extension. *Journal of Food Science and Technology*, 1-13.	3.31	9.31
3.	Chand, P., Kumar, D., Siingh, A.K., Deshwal, G.K., Rao, P.S. and Sharma, H. (2022). Influence of processing and packaging conditions on probiotic survivability rate, physico-chemical and sensory characteristics of low calorie synbiotic milk beverage. *Journal of Dairy Research*. https://doi.org/10.1017/S0022029922000164	8.03	2.027
4.	Deshwal, G.K., Singh, R., Singh, A.K., Kumar, D. and Sharma, H. (2022). Comparative Characterization of ghee from Indian camel breeds using GC-MS and FTIR techniques. *International Journal of Dairy Technology*. 75(1). doi: 10.1111/1471-0307.12826	10.29	4.286
5.	Kumar, C. M., Mondal, S., Prasad, W. G., Rathod, G. S., Raghu, H. V.and Kokkiligadda, A. (2022). Evaluation of physicochemical and functional attributes of whey powder incorporated with pomegranate peel extract. *Food Chemistry Advances*, 1, 100088.		
6.	Panwar S, Panjagari NR, Singh AK, Deshwal GK, Badola R, Minz PS, Goksen G, Rusu A, Trif M (2022). Electrospun smart oxygen indicating tag for modified atmosphere packaging applications: Fabrication, characterization and storage stability. *Polymers*, 14: 2108 DOI: https://doi.org/10.3390/polym14102108	4.967	10.33
7.	Parmar A, Sharma V, Arora A, Panjagari NR (2022). Activation of lactoperoxidase system in buffalo milk using dual enzyme (lactase & glucose oxidase) and its effect on milk constituents. *International Journal of Dairy Technology*, 75(2): 348-360.	4.286	10.37
8.	Prasad, W., Wani, A. D., Khamrui, K., Hussain, S. A.and Khetra, Y. (2022). Green solvents, potential alternatives for petroleum based products in food processing industries. *Cleaner Chemical Engineering*, 100052.		
9.	Prasad, W., Wani, A. D., Shende, V., Khamrui, K.and Hussain, S. A. (2022). Effect of glucan addition on complexed zinc concentration and physico-chemical attributes of buffalo milk paneer whey. *Food Bioscience*, 49, 101912.	11.32	5.32
10.	Roy, S., Hussain, S. A., Prasad, W. G.and Khetra, Y. (2022). Quality attributes of high protein ice cream prepared by incorporation of whey protein isolate. *Applied Food Research*, 2(1), 100029.	-	-
11.	Roy, S., Hussain, S. A., Prasad, W. G.and Khetra, Y. (2022). Quality attributes of high protein ice cream prepared by incorporation of whey protein isolate. *Applied Food Research*, 2(1), 100029.	-	-
12.	S. Bhagwat, S. Ganguly, N. R. Panjagari and Y. Khetra (2022). In-situ control of spoilage micro organisms in presence of probiotic Lactobacillus acidophilus La 05 in Ricotta cheese. *Indian J Anim Health*, 61(2), 295-304	-	5.25
13.	Shelke, P. A., Sabikhi, L., Khetra, Y., Ganguly, S.and Baig, D. (2022). Effect of skim milk addition and heat treatment on characteristics of cow milk Ricotta cheese manufactured from Cheddar cheese whey. *LWT*, 162, 113405.	6.056	12.056
14.	Shende, V., Khamrui, K., Prasad, W., Wani, A. D.and Hussain, S. A. (2022). Preparation of whey based savory beverage with enhanced bio-accessible zinc. *Journal of Food Science and Technology*, 59(11), 4288-4296.	3.31	9.31
15.	Wani, A. D., Prasad, W., Khamrui, K.and Jamb, S. (2022). A review on quality attributes and utilization of ghee residue, an under-utilized dairy by-product. *Future Foods*, 100131.	-	-

16.	Wani, A. D., Prasad, W., Khamrui, K., Hussain, S. A.and Deep, A. (2022). Evaluation of green solvent as an environment friendly alternative for milk fat extraction from ghee residue (clarified butter sediment waste). *International Journal of Food Science & Technology*.	-	-

Dairy Engineering

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Ammu, V. K., Vairat, A. D., Minz, P. S., Singh, A. K., Chitranayak, Juneja, A. K.and Jayswal, D. (2022). Whey removal characteristics during conventional production of chhana. *Indian J Dairy Sci*, 75(3), 208-214.	-	5.95
2.	Bhagat, P. N., Barnwal, P., Deep, A., Ranveer, S. A., Chavhan, B. B.and Manoj, K. N. (2022). Determination of hold up volume for three stage scraped surface heat exchanger. *The Pharma Innovation Journal,* SP-11(8), 99-102.	-	5.23
3.	Chitranayak, Basava, S., Abhinash, P., Nagaratna, Minz, P. S., John, H., Priyanka, Nagajjanavar, K.and Simha, V. (2022). Application of renewable solar energy for thermal treatment of milk: A review. *International Journal of Bioresource and Stress Management*, *13*(11), 1163-1169.	-	5.11
4.	Kumar, H., Chitranayak, Minz, P.S., Dabas, J.K., Kumari, K. (2022). Estimation of freezing point of ternary coolant mixture. *Material Science Research India*, 19(3),161-169.	-	4.57
5.	Kumari, K., Chakraborty, S. K., Sudhakar, A. and Kishore, A. (2022). Dielectric spectroscopy-based characterisation of different types of paneer (Indian cottage cheese) in terms of texture, microstructure and functional groups. International Journal of Dairy Technology, First published online: 23 October 2022. https://doi.org/10.1111/1471-0307.12913	4.286	10.29
6.	Mahesh Kumar, G., Ravindra, M. R., Nagajjanavar, K., Juvvi, P., Sinha, C., Manjunatha, M.and Basava, S. (2022). Design and development of sub-baric thermal processer for frying of Gulab jamun: A deep-fat fried dairy product. *Journal of Food Process Engineering*, 45(6), e14005. https://doi.org/10.1111/jfpe.14005	2.889	8.89
7.	Mehta, S. Minz, P. S., Chitranayakand Vairat, A.D. (2022). Application of simulation tool for estimation of impeller power requirement in bioreactor. *The Pharma Innovation Journal*, SP-11(2), 1027-1031.	-	5.23
8.	Mehta, S., Minz, P. S., Chitranayak, Raju, P. N.and Behare, P. (2022). Estimation of rheological properties of cow manure slurry using simulation method. *The Pharma Innovation Journal*, SP-11(2), 1023-1026.	-	5.23
9.	Mor, S., Sharma, V., Arora, S.and Minz, P. S. (2022). Physico-chemical and color parameters to distinguish cow ghee from buffalo ghee. *Journal of Food Science and Technology*, 59(8), 3231-3236.	3.117	9.12
10.	Panwar, S., Panjagari, N. R., Singh, A.K., Deshwal, G. K., Badola, R., Minz, P. S., Goksen, G., Rusu, A.and Trif, M. (2022). Electrospun Smart Oxygen Indicating Tag for Modified Atmosphere Packaging Applications: Fabrication, Characterization and Storage Stability. *Polymers*, 14 (10), 2108. https://doi.org/10.3390/polym14102108.	4.967	10.97
11.	Patel, D., Minz, P.S., Chitranayak, Sharma V.and Prajapati, R. (2022). Monitoring of changes in quality parameters during thermal treatment of ghee. *The Pharma Innovation Journal*, 11(10), 1274-1282.	-	5.23

Division of Dairy Economics, Statistics and Management

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Antony, A.V., Verma, A., Chaudhary, U., Sen, B. and Dixit, A.K. (2022). Assessment of clean and safe milk production practices on the profitability of dairy farmers in Kerala. *The Pharma Innovation Journal*, *SP-11*: 811-815.	-	5.23
2.	Antony, A.V., Verma, A., Chaudhary, U., Sen, B. and Dixit, A.K. (2022). Constraints in adoption of clean and safe milking techniques by dairy farmers in Kerala: An assessment. *Journal of Experimental Agriculture International*, *44*:175-180.	-	4.89

3.	Bhandari, G., Chandel. B.S. and Malhotra, R. (2022). Beyond economic motives: Value of indigenous dairy cattle breed for the livestock keepers in India. *Indian Journal of Animal Sciences*, *92*: 630-635.	-	6.32
4.	Cariappa, A.G.A., Chandel, B.S., Sankhala, G., Mani, V., Sendhil, R. and Dixit, A.K. (2022). Anionic mineral mixture prevents milk fever and improves farmer income: Evidence from randomized controlled trail. *Agricultural Economics Research Review, 35*: 19-36.	-	5.84
5.	Cariappa, A.G.A., Chandel, B.S., Sendhil, R., Dixit, A. K., Sankhala, G., Veena, M. and Meena, B.S. (2022). Do the prices of a preventive animal health product affect dairy farmers' willingness to pay and product use? Evidence from an experimental study. *Journal of Behavioral and Experimental Economics*, *100*:1019-25.	-	7.83
6.	Chandel, B.S. and Kumar, B. (2022). How elastic is the profit to prices of output and the variable inputs? Some insights from paddy cultivation in India. *Agricultural Economics Research Review, 35* (Conf. No.), 1-10.	-	5.84
7.	Das, J. and Singh, A. (2022). Export and import of Indian dairy products: An assessment. *Indian Journal of Dairy Science*, *75*: 1-7	-	5.95
8.	Devi, A.S.S. and Chandel, B.S. (2022). What derives the profitability of dairy processing firms in India? The results of decomposition analysis. *Agricultural Economics Research Review, 35*: 81-92.	-	5.84
9.	Dixit, A.K., Sirohi, S., Ravishankar, K.M., Cariappa, A.G.A., Kumar, S., Bhandari, G., Sharma, A.K., Thakur, A., Bhullar, G.K. and Thakur , A. (2022). Understating emerging value chains and business performance: Evidence from dairy industry in India. *Journal of Agribusiness in Developing and Emerging Economies*, https://doi.org/10.1108/JADEE-10-2022-0219. (Ahead-of Print)	-	-
10.	Haritha, K. and Bhandari, G. (2022). Livelihood vulnerability of dairy farming households to impacts of COVID-19 pandemic in Kerala. *Economic Affairs*, *67*: 353-359. https://doi.org/10.46852/0424-2513.3.2022.28.	-	5.08
11.	Haritha, K., Bhandari, G.and Sendhil, R. (2022). Economic impact of COVID-19 pandemic on dairy farmers: A case study of Kozhikode district of Kerala. *Indian Journal of Economics and Development*, *18*: 412-418. https://doi.org/10.35716/IJED/21206.	-	5.15
12.	Kathayat, B., Dixit, A.K., Chandel, B.S., Sendhil, R. and Sharma, A.K. (2022). Economic impact of public research investment on livestock, productivity: Evidence from India. *Agricultural Economics Research Review, 35* (Conf. No.): 27-38.	-	5.84
13.	Kumar, A., Chandel, BS, Dixit, A. K., Singh, A., Sankhala, G., Singh, P. (2022). Milk production in productive life of selected dairy breeds in central region of Bihar: An economic analysis. *Indian Journal of Dairy Science, 75:* 458-464.	-	5.95
14.	Lal, P. and Chandel, B.S. (2022). Spatio-temporal distribution of subsidy on major livestock inputs and services in India. *Agricultural Economics Research Review, 35*: 93-102.	-	5.84
15.	Mondal, I., Bhandari, G., Sen, B. and Panja, A. (2022). Perception of urban consumers on dairy farming and milk consumption in North India. *Indian Journal of Extension Education,58*:139-143.	-	5.95
16.	Naresha, N., Dixit, A.K., Singh, A. and Meena, B.S. (2022). Economic analysis of milk production in southern and north coastal regions of Andhra Pradesh. *Indian Journal of Dairy Science, 76*: 1-7.	-	5.95
17.	Rathore, R., Malhotra, R., Chaudhary, U. and Dixit, A.K. (2022). Determinants of repayment performance of women dairy self-help groups in Rajasthan. *Journal of Community Mobilization and Sustainable Development*, *17*: 260-264.	-	5.67
18.	Singh, A., Das, J. and Godha, G. (2022). Production and utilization pattern of milk and milk products in Rajasthan: An empirical study. *Research & Reviews: Journal of Dairy Science & Technology,11*: 27-35.	-	-
19.	Singh, A., Kamboj, M.L. and Chandel, B.S. (2022). A study on cow welfare vis-à-vis sustainability of Gaushalas (cow orphanages). *Indian Journal of Dairy Science,75*: 265-271. https://doi.org/10.33785/IJDS. 2022.v75i03.009	-	5.95

Dairy Extension

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Behara, S., Garai, S., Maiti, S., Bhakat, M., Meena, B.S., Behara, J., Dixit, A.K. and Kadian, K.S. (2022) Adaptive capacity to climate change among the Chilika buffalo rearers of Odisha. *The Indian Journal of Animal Sciences,* 92(1): 112-117.	0.29	6.29
2.	Cariappa Adeeth.A.G; Chandel , B.S; R. Sendhil , Dixit A.K;, l Sankhala G ;Veena Mani ;and Meena B.S(2022) "Do the prices of a preventive animal health product affect dairy farmers' willingness to pay and product use? Evidence from an experimental study" *Journal of Behavioural and Experimental Economics* 100(2022)101625.	1.831	-
3.	Cariappa Adeeth.A.G; Chandel , B.S; Sankhala G; R. Sendhil ;Veena Mani ; Dixit A.K and Meena, B.S (2022) "Anionic mineral mixture prevents milk fever and improves farmers income: evidence from a randomized controlled trial" *Agricultural Economics Research Review* 2022, 35 (1), 19-36.	-	5.84
4.	Chandran Vani and Chakravarty Ritu. (2022). Extent of Adoption of Available Components in the IFS Units of Kerala. Indian *Journal of Extension Education*. 58(4):130-133.	-	5.95
5.	Das, P.J., Kour, A., Deori, S., Begum, S.S., Pukhrambam, M., Maiti, S., Sivalingam, J., Paul, V and Sarkar, M. (2022) Characterization of Arunachali Yak: A Roadmap for Pastoral Sustainability of Yaks in India. *Sustainability* 14(19): 12655; https://doi.org/10.3390/su141912655.	3.89	9.89
6.	Dixit A and Ponnusamy, K. (2022). Role and motivational factors of vendors in milk marketing system. *Indian Research Journal of Extension Education*. 75 (2): 194–198.	--	5.22
7.	Garai, S., Ghosh, M.K., Maiti, S., Garai, S., Meena, B. S., Dutta, T. K. and Kadian, K. S. (2022) Development and application of dairy-based sustainable livelihood security index in the districts of West Bengal, India: A tool for dairy development planning. *Journal of Rural Studies*. 93: 187-195.	5.16	11.16
8.	H.R. Meena, K.S. Kadian, B.S. Meena, Gunjan Bhandari and Vikash Kumar(2022). Factors Affecting Machinations at Dairy Farms : An Appraisal from Economic Perspective. *Indian Res. J. Ext. Edu*. 22 (1):32-37.		5.22
9.	Mandi Kalyan, Chakravarty Ritu and Ponnusamy K.,Kadian K.S.,Dixit A.K.,Singh M and Mishra A.K. (2022) Impact of Jharkhand State Cooperative Milk Producers'Federation on Socio-economic Status of Dairy Farmers. *Indian Journal of Extension Education*.58(2):47-52.	-	5.95
10.	Mandi Kalyan, Chakravarty Ritu,Ponnusamy K, Kadian K.S., Dixit A.K., Singh Magan and Mishra A.K. (2022).SWOT Analysis of Dairy Processing Supply Chain of JMF using Analytical Hierarchy Process Dairy *Asian Journal of Food Research*.0:1-7.	-	5.75
11.	Mandi Kalyan, Chakravarty Ritu,Ponnusamy K, Kadian K.S., Dixit A.K., Singh Magan, Niva Bara, Jagarnath Oraon and Jha B.K. (2022). A Comparative Analysis of Reproductive and ProducttivePerformance of Jhgarkhand State Cooperative Milk Producers' Federation. *Asian Journal of Dairy and Food Research*. ResearchGate.10.18805/ajdfr.DR-1973.	-	5.75
12.	Manjusree RV, Maiti1 S, Garai S, Manjunath KV, Bhakat M, Dixit AK, Jha SK and Kadian KS (2022). Impact of Agromet Advisory Services on Farmers'Operational Decisions Related to Dairy Farming in Thiruvananthapuram. *Indian Journal of Dairy Sciences*. 75(3): 285-289.	-	5.95
13.	Manjusree RV, Maiti1 S, Garai S, Manjunath KV, Bhakat M, Dixit AK, Jha SK and Kadian KS. Impact of Agromet Advisory Services on Farmers' Operational Decisions Related to Crop Cultivation in Thiruvananthapuram District of Kerala. *Journal of Community Mobilization and Sustainable Development*. 17(1): 87-92.	-	5.67
14.	Manjusree RV, Maiti1 S, Garai S, Manjunath KV, Jha SK and Kadian KS. Farmers' Perception Towards Agromet Advisory Services Disseminated from Agromet Field Unit in Thiruvananthapuram, Kerala. *Indian Research Journal of Extension Education*. 22(2): 34-37.	-	5.22
15.	Manjusree RV, Maiti1 S, Garai S, Manjunath KV, Jha SK and Kadian KS. Farmers' Feedback Associated with Accessibility and Usability of Agromet Advisory Services Disseminated in Thiruvananthapuram District. *Journal of Community Mobilization and Sustainable Development* 17(1): 1-5.	-	5.67

16.	Meena, D. C., Garai, S., Maiti, S., Meena, B. S., Bhat, N., Chadda, A. and Meena, D.K. (2022) Adoption of improved goat husbandry practices among Raika pastoralists of Rajasthan. *Indian Journal of Small Ruminants*, 28(1): 224-228.	-	5.95
17.	Meena, D.C., Meena, B.S., Garai, S., Meena, H.R., Sankhala, G. and Chadda, A. (2022) Crop and Livestock Depredation by Wild Animals: The Case of Ranthambore Tiger Reserve, India. *Indian Journal of Extension Education* 58(4): 38-41.	-	5.95
18.	Meena, D.C., Meena, B.S., Sankhala, G., Garai, S., Meena, H.R., and Madhu Latha, C (2022) Goat Husbandry Practices followed by Farmers in the Vicinity of Ranthambore Tiger Reserve, India. Indian *Research Journal of Extension Education* 22(4):57-63.	-	5.22
19.	Meena, H.R., Kadian,K.S., Meena, B.S., Bhandari, Gunjan and Kumar, Vikash(2022). Factors Affecting Machinations at Dairy Farms :An Appraisal from Economic Perspective. *Indian Res. J. Ext. Edu*., 22 (1):32-37.	-	5.22
20.	Mukherjee, S., Jha, S.K., Maiti, S., Tiwari, S., Kadian, K.S. and Dixit, A.K. (2022). Farmers' Attitude towards ICT-based Extension Services in West Bengal. *Journal of Community Mobilization and Sustainable Development* 17(3): 1001-1005.	-	5.67
21.	Patnaik, Neela Madhav.,Meena, B.S.,Maji, Saikat and Kar, Priyajoy (2022). Strategic framework construction for sustainable livelihood of livestock farmers in drought prone areas: A participatory approach from Odisha. *Indian J. Dairy Sci*.,75(5):465-471.	-	5.95
22.	R Senthil Kumar, B.S.Meena, Ritu Chakravarty, K.S.Kadian and P.Mooventhan(2022). Differential Perception and Logit Analysis of Climate Change Adaptation Strategies among Dairy Farmers in Arid and Semi Arid Regions of Haryana. *Asian Journal of Dairy and Food Research* 41(1):15-21.	-	5.75
23.	Yadav, P., Maiti, S., Jha, S.K., Meena, H.R., Bhakat, M..and Dixit, A.K. (2022) Participatory assessment of farmer-led adaptation strategies in livestock rearing to climate change in eastern Uttar Pradesh. *Indian J Dairy Sci* 75(5): 472-477.	-	5.95

PME Cell

S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Malik Meena. (2022). Language Teaching and Culture. *International Journal of English Literature, Language and Skills* (IJELLS) 10(4):69-73	3.235	-

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S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Aditya Sukumar Pasagadi, Seethu B.G., Vikram Simha H.V., Arun Kumar P., MagdalineEljeeva Emerald Franklin, Heartwin A. Pushpadass. (2022). Shelf-Life prediction of milk-millet powders. *Journal of Food Process Engineering*,e14204.	2.89	8.89
2.	Arunkumar R, Kumaresan A, Sinha MK, Elango K, Ebenezer Samuel King JP, Nag P, Karuthadurai T, Baithalu RK, Mohanty TK, Kumar R and Datta TK (2022) The cryopreservation process induces alterations in proteins associated with bull sperm quality: The equilibration process could be a probable critical control point. Front. *Endocrinol*. 13:1064956. doi: 10.3389/fendo.2022.1064956	6.15	12.1
3.	Ebenezer Samuel King, J.P., Kumaresan, A., Talluri, T.R., Sinha, M.K., Raval, K., Nag, P., Karuthadurai, T. and Aranganathan, V., (2022). Genome wide analysis identifies Single Nucleotide Polymorphism variations and altered pathways associated with poor semen quality in breeding bulls. *Reproduction in Domestic Animals* 57(10):1143-1155.	1.76	7.86
4.	Ebenezer Samuel King, J.P., Sinha, M.K., Kumaresan, A., Nag, P., Dasgupta, M., Arul Prakash, M., Talluri, T. and Datta, T.K., (2022). Cryopreservation process alters the expression of genes involved in pathways associated with fertility of bull spermatozoa. *Frontiers in Genetics*, 13: 1025004.	-	-
5.	Gadapa, S., Battula, S. N., Mor, S., Pushpadass, H. A., Naik, L. N.and Emerald, M. E. (2022). Green tea catechin loaded niosomes: Formulation and their characterization for food fortification. *Journal of Food Science and Technology*, 59(9), 3669-3682.	3.12	9.1

6.	Jose, N., Ravindra, M. R.and Deshmukh, G. P. (2022). Effect of dry-crystallization method on the engineering properties of an instant mix for rice flake-milk pudding. Measurement: *Food*, 7, 100044.	-	-
7.	Jose, N., Ravindra, M. R., Deshmukh, G. P.and Rao, K. J. (2022). Sorption and thermodynamic properties of dry crystallized Paladapayasam mix prepared using manual and mechanical stirring. *Journal of Food Science and Technology*, 59(3), 1075-.	3.117	9.1
8.	Krishnegowda, R., Sharma, M., Ravindra, R. M.and Naik, L. N. (2022). Process optimization and kinetics for ultrasonication assisted extraction of phospholipids from ghee residue. *Journal of Food Process Engineering*, e14260.	2.89	8.89
9.	Krishnegowda, R., Sharma, M.,Ravindra, R. M., Naik,L. N. (2022). Process optimization and kinetics for ultrasonication assisted extraction of phospholipids from ghee residue. *Journal of Food Process Engineering*. http://doi.org/10.1111/jfpe.14260.	2.98	8.89
10.	Kumar, A., Kumar, M.H.S., Rajani, C.S, Sabikhi, L.and Naik, N.L. (2022). Dipeptidyl peptidase-IV inhibitory potential of alpha-lactalbumin extracted from milk of Gir cows: A Bos indicus species. *International Journal of Dairy Technology*, 75(3), 527-537.	4.28	10.29
11.	Kumar, C. M., Mondal, S., Prasad, W. G., Rathod, G. S., Raghu, H. V.andKokkiligadda, A. (2022). Evaluation of physicochemical and functional attributes of whey powder incorporated with pomegranate peel extract. *Food Chemistry Advances*, 1, 100088.	-	-
12.	Kumar, L.K., Kapri, A., Chandel, R., Kumar, V., Verma, S., Vedamurthy, G.V., Singh, D and Onteru, S.K. (2022). Digestive propensity of Aflatoxin M1 (4-Hydroxy aflatoxin B1), an indication from in vitro digestion model system. *Journal of Food Processing and Preservation*. 46 5), e16577.	2.61	8.61
13.	Kumar.T.V.C., Verma S. K., Sharma, D., Kumar, L.K., Vedamurthy G. V., Singh, D and Onteru, S.K. (2022). Meprin A1 subunit beta gene polymorphism is associated with thelength of post-partum anestrus interval in Murrah buffaloes. *Gene*. 827:145456.	3.91	9.91
14.	Lokesh Babu Dyapasandra Siddalingaiah, Sakthivel Jeyakumar, Ayyasamy Manimaran, Heartwin Amaladas Pushpadass, MuniyandiSivaram, Mayilsamy Sathiyabarathi, Arumugam Kumaresan, Mukund Amritrao Kataktalware and Kerekoppa Puttaiah Ramesha. (2022). Digital infrared thermal imaging of body and hoof skin surface temperature profile in murrah buffaloes (*Bubalus bubalis*): a preliminary report. *Bufalo Bulletin*, Vol.41, No.4.	0.27	6.2
15.	Mahesh Kumar, G., Ravindra, M. R., Nagajjanavar, K., Juvvi, P., Sinha, C., Manjunatha, M.andBasava, S. (2022). Design and development of sub-baric thermal processer for frying of Gulab jamun: A deep-fat fried dairy product. *Journal of Food Process Engineering*, 45(6), e14005.	2.89	8.89
16.	Panditrao, D. G., Ravindra, M. R., Jose, N., Nath, B. S.andSivaram, M. (2022). Process optimisation for the mechanised dry crystallisation of rice flake–milk pudding mix. *International Journal of Dairy Technology*, *75*(2), 463-473.	4.3	10.29
17.	Patange, S.R., Sabikhi, L., Shelke, P.A., Rathod, N., Hussain, S.A., Khetra, Y.,& Kumar, M.H.S. (2022). Encapsulation of dipeptidyl peptidase-IV (DPP-IV) inhibitory peptides from alpha-lactalbumin extracted from milk of Gir cows–a Bos indicus species. *International Journal of Dairy Technology*, 75(3), 575-587.	4.28	10.29
18.	Prajapati, S., Kumar, M.H.S., Devaraja, H.C., Rao. K. J., Shaik. A. H., Rajani, C.S.,&Sabikhi, L. (2022). Effect of ionic silver solution on Paneer (Indian cottage cheese) quality and shelf life. *International Journal of Dairy Technology*.	4.28	10.29
19.	Prakash, R., Ravindra, M. R., Pushpadass, H. A., Sivaram, M., Jeyakumar, S.and Rao, K. J. (2022). Milk chilling using nanoparticle enhanced phase change material capsuled inside a jacketed cylindrical module: A numerical and experimental study. *Innovative Food Science & Emerging Technologies*, *81*, 103112.	7.10	13.10
20.	Preeti, B., Ravindra, M. R., Surendra Nath, B.and Gajanan Panditrao, D. (2022). Impact of pulsed electric field treated milk on quality of paneer and khoa. *Food Science and Technology International*, 10820132221102277.	2.64	8.64

21.	Ramesha, K. P., Jeyakumar, S., Mall, S., Vedamurthy, G.V., Kumaresan, A., Devadasn, M. J., Kataktalware, M. A., Arul, D., Das. D. N and Manimaran, A. (2022). Anti-Müllerian hormone as an endocrine biomarker of reproductive longevity and assessment of single nucleotide polymorphisms in AMH gene of Bos indicus breeds of cattle. *Reproduction in Domestic Animals*. 57, (11): 1450-1464 https://doi.org/10.1111/rda.14222.	1.86	7.86
22.	Saraf, K.K., Kumaresan, A., Arathi, B.P., Sundaresan, N.R. and Datta, T.K., (2022). Comparative high-throughput analysis of sperm membrane proteins from crossbred bulls with contrasting fertility. *Andrologia*, p.e14451.	2.53	8.53
23.	Saurabh S. Patel, P. HeartwinAmaladhas, F.MagdalineEljeeva Emerald, B. Surendra Nath and V.Palanimuthu. (2022). Microencapsulation of curcumin by spray drying: Characterization and fortification of milk. *Journal of Food Science and Technology, 59:* 1326-1340.	3.12	9.12
24.	Saxena V.K., Vedamurthy G.V.and Singh R. (2022). A novel concept of Pyridoxal 5'-phosphate permeability in *E.coli* for modulating the heterologous expression of PLP dependent proteins. *Process Biochemistry*. 113, 37-46.	4.78	10.89
25.	Seethu B.G., Aditya Sukumar Pasagadi, Vikram Simha H.V., Arun Kumar P., MagdalineEljeeva Emerald Franklin, Rose PrabinKingsly Ambrose and Heartwin A. Pushpadass. (2022). Effect of moisture content on physical and flow properties of milk-millet powders. *Journal of Food Process Engineering,*e14198.	2.89	8.89
26.	Sinha, M.K., Kumaresan, A., Talluri, T.R., King, J.P.E.S., Prakash, M.A., Nag, P., Paul, N., Raval, K., Kamaraj, E. and Aranganathan, V., (2022). SNPs Cumulating to Genetic Variation for Fertility in Crossbred (*Bos taurus X Bos indicus*) Bull Spermatozoa. Animal Biotechnology, 1-12 (Impact factor- 2.14, NAAS Rating- 8.2)	2.14	8.2
27.	Talluri, T.R., Kumaresan, A., Sinha, M.K., Paul, N., Ebenezer Samuel King, J.P. and Datta, T.K., (2022). Integrated multi-omics analyses reveals molecules governing sperm metabolism potentially influence bull fertility. Scientific Reports, 12(1), pp.1-18	5.0	11
28.	Talluri, T.R., Kumaresan, A., Paul, N., Sinha, M.K., Ebenezer Samuel King, J.P., Elango, K., Sharma, A., Raval, K., Legha, R.A. and Pal, Y. (2022). High throughput deep proteomic analysis of seminal plasma from stallions with contrasting semen quality. Systems Biology in Reproductive Medicine, pp.1-14.	2.95	8.96
29.	Tripathi, U.K., Kumaresan, A., Saraf, K.K., Golher, D.M., Chhillar, S., Nayak, S., Lathika, S., Nag, P. and Mohanty, T.K. (2022). Seasonal and climatic factors have a significant influence on fertility associated sperm phenomic attributes in crossbred breeding bulls (Bos taurus× Bos indicus). *International Journal of Biometeorology*, pp.1-10.	3.79	9.74
30.	Verma S. K., Chandel. R., Mahanandia, N.C., Kumar, T.V.C., Kumar, L.K., Vedamurthy G. V., Singh, D and Onteru, S.K. (2022). A single nucleotide polymorphism of the thyrotropin releasing hormonedegrading ectoenzyme (TRHDE) gene is associated with post-partumanestrus in Murrah buffalo. Gene. 834:146580.	3.91	9.91
31.	Adarsh M Kalla, MagdalineEljeeva Emerald Franklin, Heartwin A Pushpadass, Sathish Kumar MH and Surendra Nath Battula. (2022). Isolation and characterization of cellulose from coconut shell powder and its reinforcement in casein films. *The Pharma Innovation Journal*, 11(10): 1043-1053.	-	5.23
32.	Ammu,V.K., Vairat, A.D., Minz, P.S., Sinha, C., Juneja, A., Jayswal, D. (2022). Whey removal characteristics during conventional production of chhana. Indian *Journal of Dairy Science,* 75(3): 208-214.	-	5.59
33.	Anuja, A, R, Shivaswamy, G, P, Ray, M, Singh, K, N (2022). Pattern of crop diversification and its implications on undernutrition in India. *Current Science* 122:1154-1160.	1.1	7.17
34.	Anupama, M., Devaraja, H.C. & Jayaraj Rao, K. (2022). Evaluation of prebiotic potential of nutria-cereals using different probiotic strains. *Indian Journal of Animal Health*, 61(2): 226-238.		5.25
35.	BP Pushpa, AP Heartwin and HM Jayaprakasha. (2022). Effect of fortification of glycomacropeptides (GMP) on rheological and sensory attributes of probiotic-yoghurt. *Indian Journal of Dairy Science*, 75(5):402-408.	-	5.95
36.	Chaudhary, M.B., Jayaraj Rao, K. & Asha Ashok. (2022). Moisture sorption characteristics of Mohanthal, a chick pea flour (besan) based traditional dairy product. *Indian Journal of Dairy Science*, 75(4): 306-313.	-	5.95

37.	Datir, R. P., Ravindra, M. R., Manjunatha, M.and Sharma, M. (2022). Optimization studies on mixing of curd and ingredients during Lassi (Stirred Curd) manufacturing. *Indian Journal of Dairy Science*, 75(2), 99-106.	-	5.95
38.	DayalNitai Das, Thirumalaisamy Karuthadurai, Dipankar Paul, Reshma Raj S, Mukund AmritraoKataktalware, MuniandySivaram, Mamta Chauhan and Kerekoppa P Ramesha. (2022). Prediction of lifetime milk production on the basis of early economic traits in Deoni cattle. *Indian J Dairy Sci* 75(6): 547-551.	-	5.95
39.	Dipankar Paul, Dayal N. Das, Sukanta Mondal, ShanmugapriyaGnanasekaran, Avantika Mor, Komala Subramanya (2022). Optimization of β-actin gene as a housekeeping gene for quantification of mRNA levels of target genes in endometrium of buffalo cows. *Indian Journal of Physiology and Allied Sciences*, Volume 74 Issue 4.	-	-
40.	Gururaj, M, Sivararm, M, Dixit, P, K (2022). A Status and Performance of Dairy cooperative Societies in Karnataka. I*ndian Journal of Economics and Development*.	-	5.15
41.	Hallolli, A. C., Sharma, D., Sahu, C., Manimaran, A, Kumaresan, A., Sivaram, M., Jeyakumar, S., Rajendran D. and Boopathi, V. (2022). Relationship of indirect diagnostic tests, haematological parameters and milk components with subclinical mastitis in dairy cows. *The Pharma Innovation Journal*; SP-11(9): 3285-3290.	-	5.23
42.	Karthik, D., Devi, M.C.A., Subash, S., Dixit, P. K. and Sivaram, M. (2022). Knowledge on improved dairy farming practices among youth in Telangana state. *The Pharma Innovation Journal*, 11(9): 16-19.	-	5.23
43.	KathanRaval, Nilendu Paul, Pradeep Nag, Elango K, Yash Pal, Legha R A, T R Talluri and Arumugam Kumaresan (2022) Asthenozoospermic stallions tend to have high acrosome reacted spermatozoa as evidenced by dual fluorescent staining assay. *Indian Journal of Animal Sciences* 92 (8): 946–949.	0.33	6.29
44.	Khalandar, S, Sharma, S, Bishist, R, Sivaram, M, Sharma, S, Roy, A, Gautham, K, L (2022) Spatio-temporal analysis of livestock composition and milk production trends in Himachal Pradesh India: a District-wise analysis. *Indian Journal of Animal Sciences*. 92:624–629.	0.33	6.29
45.	Mandi, K., Subash, S. (2022). Adoption of Animal Welfare Practices by Selected Gaushalas (Cow-Shelters) in the State of Karnataka, India. *Asian Journal of Agricultural Extension, Economics & Sociology*, 40(11), 365–372.	-	4.86
46.	Prashant Kumar, Mukund A. Kataktalware, S. Jeyakumar,A. Kumaresan, D.N. Das, Letha Devi, G., K.P. Ramesha. (2022). Seasonal Variation in Sexual Behaviour of Deoni (Bos indicus) Bulls. *Indian Journal of Animal Research*. 10.18805/IJAR.B-4956.	0.4	6.43
47.	Pushpalatha, B., Jabeen, N.M., Chaudhary, M.B. &Jayaraj Rao, K.(2022). Optimization of ingredients for preparation of turmeric milk. *Indian Journal of Nutrition and Dietetics*, 59 (1): 12-27.	-	4.87
48.	R.Saravanan, N. Murali, A.K. Thiruvenkadan, D.N. Das (2022). Comparitive Genome Sequence Analysis of Bovine Lymphocyte Antigen BoLA DRB3.2 Alleles in Deoni and Ongole (Bos indicus) Cattle Breeds of India. *Indian Journal of Animal Research Volume* 56 Issue 7: 783-789.	0.4	6.43
49.	Sahu, C., Manimaran, A, Kumaresan, A., Rajendran, D., Ezhuthupurakkal, P. B., Sharma, D., Dey, D. K. and Sivaram, M. (2022). Supplementation of trisodium citrate improves recovery rate of subclinical mastitis in crossbred cows. *The Pharma Innovation Journal* 2022; SP-11(11): 1023-1030.	-	5.23
50.	Shinde, D., Nath, B.S., Rahila, M.P. and Heartwin A. Pushpadass. (2022). Effect of incorporation of Generally Regarded as Safe (GRAS) carbohydrate derivatives on quality attributes of skim milk. *Indian Journal of Dairy Science*, 75(3):225-235. (Impact factor: NA, NAAS Rating:)	-	5.95
51.	Shivanand, F. MagdalineEljeeva Emerald and Somveer. (2022). Synthesis and characterization of aluminum oxide nanoparticles. *The Pharma Innovation Journal*, 11(6):1068-1072.	-	5.23
52.	Shivaswamy G P, Kishore A, Joshi K, Anuja A, R, Singh K N (2022). Impact evaluation of seed replacement on pulses productivity in India. *Indian Journal of Agricultural Sciences* 92: 90-94.	0.37	6.37

53.	Sutar, P.,Sharma, M., Devaraja, H. C., &Rao, J. (2022). Millet based composite dairy foods– a review. (Invited review article) *Indian Journal of Animal Health*, Kolkata, 61(2): 119-132.	-	5.25
54.	Thejesh, S, Das, A, Gururaj, M, Khalandar, S, Subash, S, Sivaram, M (2022). Economic impact of COVID-19 pandemic on dairy farmers of Karnataka. Indian Journal of Animal Sciences 92: 126–131.	0.33	6.29
55.	Thejesh, S, Das, A, Gururaj, M, Khalandar, S, Subash, S, Sivaram, M (2022). Economic impact of COVID-19 pandemic on dairy farmers of Karnataka. *Indian Journal of Animal Sciences* 92: 126–131.	0.33	6.29
56.	Veeresh, H. B.and Bandla Srinivas (2022) Colostrum quality and the neonatal calf nutrition and growth with or without a source of PUFA supplement. *Indian Journal of Dairy Science*#328979.	-	5.95
57.	Veeresh, H. B.and Bandla Srinivas (2022) PUFA supplements to improve diarrhea, fecal consistencyand disease resilience in calves in neonatal and preweaning age. *Indian Journal of Veterinary Science & Biotechnology* #1950.	-	5.58
58.	Wankhade, P. R., Manimaran, A, Kumaresan, A. and Sivaram M. (2022). Differential adaptation of metabolic inflammation between primiparous and multiparous Zebu cows during transition period. *Indian Journal of Animal Sciences*, 92 (7): 830-836.	0.33	6.29

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S. No.	Research Papers	Impact Factor	NAAS Rating
1.	Anil, Dutta T.K., Chatterjee, A., Singh, A.K., Sushil K. Yadav and A. Mohammad. (2022). Effect of Supplementation of Exogenous Fibrolytic Enzymes on Intake, Nutrient Utilization Pattern and Economics of Feeding in Weaned crossbred Calves. *Biological Forum – An International Journal* 14: 169-176	-	-
2.	Behera, R, A Mandal, S Rai, M Karunakaran, M Mondal, M, K Ghosh. (2022) Genotype x environment interaction on fertility traits of crossbred dairy cows under tropical climatic conditions of India. *Journal of Agrometeorology,*24(2): 146-151.	-	6.55
3.	Behera, R, Ajoy Mandal, Saroj Rai, M Karunakaran, Mohan Mondal, MK Ghosh. (2022). Genotype environment interaction on milk production traits of crossbred dairy cows under tropical climatic condition of India. *Indian Journal of Animal Research*, 56(11):1422-1427.	-	6.43
4.	Bhakat Champak, Singh A.K., Mandal A., Karunakaran, M., Mohammad, A., Mandal, D.K., Rai, S., Chatterjee, A., Mondal, M. and Dutta, T.K. (2022). Udder health maintenance to augment milk production in dairy cattle: A Review. *Indian Journal of Animal Research*. DOI: 10.18805/IJAR.B-4816.	-	6.43
5.	Chaturvedi, Indu, Dutta, T.K., Singh, P. K., Chatterjee, A., Mandal, D.K. Bhakat, C., Mohammad, A. and Das, A. K. (2022). Effect of supplementation of phytogenic feed additives on intake, in vitro fermentation, growth performance and carcass traits in weaned Barbari kids reared under intensive feeding. *Tropical Animal Health and Production*, 54:150-162. https://doi.org/10.1007/ s11250-022-03142-6.	-	7.89
6.	Chauhan JK, Meena BS, Meena HR, Bhakat Champak, Upadhyay AD, Lahiri B, Pal, M.B. Tengli MB, Kumar S, Chandegara AK and Koreti K. (2022). Assessment of livelihood security and diversification of tribal dairy farmers in NEH region of India. *Indian Research Journal of Extension Education.* 22(3): 182-187	-	5.22
7.	Choudhary, S., Santra, A., Muwel, N., Sarkar, S., Mandal, A. and Das, S.K.(2022). Screening of forest tree leaves from North Eastern Himalayan region as feed additives for modulating in vitro rumen fermentation and methanogenesis from total mixed ration. *Agroforestry Systems*, 96(2):359-374.	-	8.42
8.	Choudhary, S., Santra, A., Sarkar, S., Mandal, A. and Das, S.K. (2022). Potential of native forest leaves to modulate in vitro rumen fermentation and methane. *Current Science*, 122(3): 322-327.	-	7.17
9.	Dutta, T. K., Bandii, K., Chatterjee, A., Bhakat, C., Mandal, D. K.and Rai, S. (2022). In-vitro and *In-vivo* evaluation of different leguminous straw based rations on fermentation metabolites, growth and nutrient utilization in barbari kids. *Animal Nutrition and Feed Technology,* 22(2), 353-366.	-	6.23

10.	Gogoi J, M Mondal, P Pal, VR Upadhyay, P Kuri, I Mukherjee, S Tripura (2022). Potential role of Catsper and proton ion channels in bull fertility *J. Pharm. Innov* 11, 313-321.	-	5.23
11.	Kondiba, MA, Vipin, A. Mandal, Karunakaran. M. (2022). Assessment of area specific mineral mixture supplementation on growth and biochemical profile of Jersey crossbred heifers. *Indian Journal Dairy Science,* 75(6): 1-7.	-	5.95
12.	Kumar A and MandalDK. (2022). Order of entry at milking and its relationship with milk yield, udder health and milk composition in jersey crossbred cows. *The Pharma Innovation Journal*.2022; 11(2S): 298-301.	-	5.23
13.	Kumar, A. and Mandal, D.K. (2022). Effect of Seasons on Expressions of Milking Parlour Behaviours and Milk Yield of Crossbred Jersey Cows in Tropical Climate. *Asian Journal of Dairy and Food Research*. 00:1-5, DOI: 10.18805/ajdfr.DR-1816.	-	5.75
14.	Kumar, A. and Mandal, D.K. (2022). Post milking behaviours and influence of different factors on post milking behaviours in jersey crossbred cows under tropical conditions. *The Pharma Innovation Journal*; SP-11(5): 1532-1537.	-	5.23
15.	Lalhriatpuiia M., Chatterjee A., Satapathy D., Mohammad A., Rai S., Bhakat C., Mandal D.K., Dutta T.K., Patra A.K. (2022). Effect of dietary inorganic and organic chromium on nutrient utilization and growth performance in Black Bengal goats (Capra hircus). *Small Ruminant Research*.216:106797.https://doi.org/10.1016/.smallrumres.2022.106797	-	7.61
16.	Lalmuansangi, Ishani Roy, M. Rahman, A. Mandal, R. Behera. (2022) Analysis of Jersey crossbred cows for lactation specific demographic parameters. *Indian Journal of Animal Sciences*, 92(12):1-4.	-	6.29
17.	Mandal D.K., M. Karunakaran, A. Debbarma, S.K. Swain, A. Santra, T.K. Dutta, A. Chatterjee, S. Rai. (2022). Black Bengal goat husbandry-An appraisal of productive and reproductive performance under intensive management system. *Journal of Livestock Science* (ISSN online 2277-6214) 13: 227-233.	-	4.93
18.	Mandal DK, Karunakaran M, Debbarma A, Swain SK, Santra A, Dutta TK, Chatterjee A, Rai S. (2022). Black Bengal goat husbandry-An appraisal of productive and reproductive performance under intensive management system. *Journal of Livestock Science*, 13(4): 227-233.doi.10.33259/JLivestSci.2022.227-233.	-	4.93
19.	Mandal, A, Baneh, H., Rout, P. K., Notter, D. R. (2022). Genetic analysis of sexual dimorphism in growth of Jamunapari goats of India. *Journal of Animal Breeding and Genetics*, 139(4): 462-475.	-	9.27
20.	Mandal, D. K., Kumar, M.and Tyagi, S. (2022). Association of linear type pelvic traits with testicular characteristics and reproductive capability of breeding dairy bulls. *Reproduction in Domestic Animals,* 57(9): 957-966. https://doi.org/10.1111/rda.14162.	-	8.01
21.	Mandal, D. K., Kumar, M.and Tyagi, S. (2022). Effect of seasons and photoperiods on seminal attributes and sperm morphology in Holstein Friesian × Sahiwal crossbred dairy bulls. *International Journal of Biometeorology*, 00, 1-13. https://doi.org/10.1007/ s00484-022-02350-x.	-	9.79
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13. TRAINING AND CAPACITY BUILDING

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(A) Deputations Abroad

The information on training attended by Scientists abroad during 2022 is as under:-

S. No.	Name of Employee and Designation	Name of Training programme attended	
		Under the Project	Duration
1.	Dr. Diwas Pradhan, Scientist	NAHEP Project	21.03.2022 to 20.08.2022
2.	Dr. Rakesh Kumar, PS	BMGF Project at USA	06.06.2022 to 05.08.2022
3.	Dr. M.K. Singh, Sr. Scientist	NAHEP Project at Germany	24.06.2022 to 20.08.2022
4.	Dr. Rakesh Kumar, PS	NAHEP Project at USA	01.07.2022 to 15.07.2022
5.	Dr. K. Ponnusamy, PS	-do-	15.08.2022 to 29.08.2022
6.	Dr. H.R. Meena, PS	-do-	15.08.2022 to 14.10.2022
7.	Dr. Vikas Vohra, PS	-do-	08.08.2022 to 07.10.2022
8.	Dr. A.K. Dixit, PS	-do-	01.09.2022 to 31.10.2022
9.	Dr. A Kumaresan, PS	-do-	15.09.2022 to 14.11.2022
10.	Dr. Gunjan Bhandari, Scientist	NAHEP Project at Canada	22.09.2022 to 18.02.2023
11.	Dr. Asif Mohammad, Sr. Scientist	NAHEP Project at Thailand	25.07.2022 to 21.12.2022
12.	Dr. Naresh Lalaji Selokar, Sr. Scientist	NAHEP Project at Germany	25.09.2022 to 24.02.2023
13.	Dr. Satish Kumar M.H., Sr. Scientist	NAHEP Project at Thailand	01.09.2022 to 31.10.2022
14.	Dr. Nitin Tyagi, PS	NAHEP Project at USA	16.09.2022 to 15.11.2022
15.	Dr. Sangita Ganguly, Scientist	NAHEP Project at New Zealand	18.11.2022 to 31.03.2023
16.	Dr. Gautam Kaul, PS	NAHEP Project at USA	28.11.2022 to 12.12.2022
17.	Dr. Sanchita Garai, Scientist	NAHEP Project at UK	19.09.2022 to 15.02.2023

(B) Trainings (Category-wise)

S. No.	Name and Designation	Training Programme	Organizing Institute	Date/ Duration
		Scientists		
1.	Dr. K. Ponnusamy, PS	Training programme on National Facilitators Development programme	(NFDP) at MANAGE, Hyderabad	January 17-22, 2022
2.	Dr. (Mrs.) Heena Sharma, Scientist	ICAR Winter School (online) on Prescribing Human Health Using Foods of Animal Origin	ICAR-IVRI, Izatnagar	February 8-28, 2022
3.	Dr. Biswajit Sen, Scientist	Training on Computable General Equilibrium (CGE) modelling (Phase I & II)	IFPRI, New Delhi	April, 4-13 May, 10-18, 2022
4.	Dr. Rajan Sharma, PS	Training programme titled MDP on Leadership Development (a pre-RMP programme)	ICAR-NAARM, Hyderabad	June 14-25, 2022
5.	Er. Ankit Deep, Scientist	Training on Computer aided design (online)		July 7 to August 6, 2022

6.	Dr. (Mrs.) Hima John, Scientist	-do-		-do-
7.	Dr. Sangita Ganguly, Scientist	Training programme on Promotion of Biofortification for ensuring Nutritional Security (online)		July 27-29, 2022
8.	Ms. Priyanka, Scientist	The training program on Intellectual Property Rights (IPR)	ITPM, ICAR, New Delhi	August 1-5, 2022
9.	Dr. Sachinandan De, PS	Workshop on Training Workshop for Vigilance Officers of ICAR institutes	NAARM, Hyderabad	August 24-26, 2022
10.	Dr. P. N. Raju, Sr. Scientist	Management Development Programme (MDP) on Market Analytics for Small Business (online)		August 29 to September 2, 2022
11.	Dr. J. K. Kaushik, PS	Training programme on 12th T.P. on Science Technology and Emerging Trends in Governance	New Delhi	November 21-25, 2022
12.	Dr. Shaik Abdul Hussain, Scientist	Training program titled Advances in web and mobile application development	ICAR-NAARM, Hyderabad	December 5-9, 2022
13.	Dr. Rashmi H.M., Sr. Scientist	ICAR-HRD Training Programme (online)	ICAR-IIWBR, Karnal	December 3-15, 2022
		Technical Personnel		
14.	Sh. Sandeep Deswal, ACTO	Refresher Course	NCC Officers Training Academy, Kamptee, Maharastra	March 1-30, 2022
15.	Dr. S Raju, ACTO	Short course on National Animal Disease emergency preparedness: An Animal Health Contingency Plant	ICAR- NIVE&DI, Bangalore	February 14-23, 2022
16.	Sh. Sandeep Deswal, ACTO	NCC Training Camp with NDRI students	NCC Academy, Ropar, Punjab	May 28 to June 6, 2022
17.	Smt. Manju Bala, TO	Training course on computer aided designed (online)	CIAE, Nabibagh, Bhopal	July 7 to August 6, 2022
18.	Sh. Rakesh Raman, TA	Competency Enhancement programme on soft skills and personality development for T1-T4	ICAR- NAARM, Hyderabad	October 17-22, 2022
19.	Sh. Uttam Kumar, CTO	ICAR-HRD Training Program on Emotional and social Intelligence at work place (online)	ICAR- IIW&BR, Karnal	December 13-15, 2022
		Administrative Staff		
20.	Sh. Sukhdev Singh, AAO	Training on Pension and Retirement Benefit for officers and Staff of ICAR (online)	ICAR-NRRI, Cuttack	January 12-14, 2022
21.	Sh. Gurjeet Singh, AAO	-do-	-do-	-do-

(C) Participation in Conferences/ Seminars/ Workshops within India

S. No.	Name & Designation	Title of the Training	Period
1.	Dr. Latha Sabikhi, PS	International conference on Water, Agriculture, Dairy and Food processing for Sustainable Economy held in a hybrid mode by Verghese Kurien Centre of Excellence (VKCoE), Institute of Rural Management Anand (IRMA), Anand (Gujarat)	March 25-26, 2022.
2.	Dr. D. Malakar, PS	National Conference on "Animal Breeding Strategies in the Era of Genomics and Ohenomics at NBAGR, Karnal.	December 17-18, 2022.
3.	Dr. Kamal Gandhi, PS	28th Indian Convention (online) of Food Science & Technologies at Aurangabad Maharashtra.	January 20-22, 2022.
4.	Dr. G. S. Meena, Scientist	-do-	-do-
5.	Dr. T. K. Mohanty, PS	Guest Speaker in the National Livestock Conference "UTKARSHA" at Visakhapatnam.	April 11-13, 2022

6.	Dr. K. Ponnusamy, PS	Lecture in the National Conference at CSK Himachal Pradesh Agricultural University, Palampur Distt Kangra (H.P)	May 6-8, 2022
7.	Dr. Mukesh Bhakat, PS	National Symposium on " Advancement in Veterinary medical research contributing to "One Health" for betterment of Animal and public health and their welfare" at Udaipur	April 8-9, 2022
8.	Dr. Nishant Kumar, Sr. Scientist	-do-	-do-
9.	Dr. Sachin Kumar, Scientist	National Symposium on Self-Reliant Coastal Agriculture at ICAR- CCARI, Ela, Old Goa.	May 11-13, 2022
10.	Dr. Pankaj Saraswat, Scientist	National Conference of KVKs 2022 at YSPH&F, Solan	June 1-2, 2022
11.	Dr. Magan Singh, Sr. Scientist	Seminar/ National Group Meeting Kharif 2022 at SKUAST-Kashmir, Srinagar	June 13-14, 2022
12.	Dr. Sanjeev Kumar, Scientist	-do-	-do-
13.	Dr. Sachin Kumar, Scientist	XX NAVS (I) convocation-cum-scientific convention on "Restructuring veterinary education, research and extension for enhancing livestock and poultry production to boost the GDP at MAFSU, Nagpur	June 20-21, 2022
14.	Dr. Gautam Mondal, PS	International Conference on "Advances in Agriculture and Food System at Bangalore.	August 22-24, 2022
15.	Dr. G. S. Meena, Sr. Scientist	-do-	-do-
16.	Dr. Yogesh Khetra, Sr. Scientist	-do-	-do-
17.	Dr. Kamal Gandhi, Sci	IDF World Dairy Summit 2022 at Greater Noida (UP)	September 12-15, 2022
18.	Dr. G. R. Gowane, Sr. Scientist	XIX Annual Convention (SOCDAB) & National Symposium on Contemporary Technology for Animal Genetics Resources at NBAGR, Karnal .	September 21-22, 2022
19.	Dr. Anupama Mukherjee, PS	-do-	-do-
20.	Dr. D. Malakar, PS	-do-	-do-
21.	Dr. Nitin Tyagi, PS	India Animal Health Summit 2022, NASC Complex, New Delhi.	July 6-7, 2022
22.	Dr. Gopal Gowane, Sr. Scientist	-do-	-do-
23.	Dr. Nishant Kumar, Sr. Scientist	-do-	-do-
24.	Ms. Priyanka, Scientist	Training program on "Intellectual Property Rights (IPR) organized by National Intellectual Property and Technology Management Unit (ITPM) of ICAR	August 1-5, 2022
25.	Ms. Priyanka, Scientist	International Conference on Advances in Agriculture and Food Systems towards Sustainable Development Goals	August 22-24, 2022
26.	Dr. P.S. Minz, Sr. Scientist	-do-	-do-
27.	Dr. Sachin Kumar, Scientist	-do-	-do-
28.	Dr. Sudarshan Kumar, Sr. Scientist	XIX Annual Convention and National Symposium on Contemporary Technology for Animal Genetics Resource (ANGR) Management, NBAGR, Karnal (online)	September 21-22, 2022
29.	Dr. Rani Alex, Sr. Scientist	-do-	-do-
30.	Dr. Rubina K. Baithalu, Scientist	-do-	-do-
31.	Dr. S. Mukherjee, PS	-do-	-do-
32.	Dr. Sohan Vir Singh, PS	-do-	-do-
33.	Dr. P. N. Raju, Sr. Scientist	International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022), University of Kashmir, Hazratbal, Sri Nagar (online)	September 28-30, 2022
34.	Dr. Nishant Kumar, Sr. Scientist	-do-	-do-

35.	Dr. Rubina K. Baithalu, Scientist	-do-	-do-
36.	Dr. Heena Sharma, Sr. Scientist	7th Convocation of NADSI and National Dialogue at DUVASU, Mathura.	October 29, 2022
37.	Dr. G. S. Meena, Sr. Scientist	-do-	-do-
38.	Dr. Yogesh Khetra, Sr. Scientist	-do-	-do-
39.	Dr. A. K. Singh, Joint Director (A)	-do-	-do-
40.	Dr. Heena Sharma, Sr. Scientist	National Seminar-cum Annual Conference on at ICAR-Central Sheep and Wool Research Institute, Avikanagar.	November 10-12, 2022
41.	Dr. G. R. Gowane, Sr. Scientist	-do-	-do-
42.	Dr. Hima John, Sr. Scientist	CAFT training programme on "Innovations in Processing and Packaging of Dairy and Food Products and Opportunities for Entrepreneurship Development and Start-ups at NDRI, Karnal.	November 7-27 2022
43.	Dr. Chitranayak, PS	12th Convention of IDEA & National Seminar on " Engineering Interventions in Dairy Processing for Self Reliant India at Warud (Pusad) Distt.- Yavatmal (M.S.)	December 15-16, 2022
44.	Er. Ankit Deep, Sci	-do-	-do-
45.	-do-	10th International Conference (online) at Bhai Gurdas Institute of Engineering Technology at Sangrur.	November 11-12, 2022
46.	Dr. Vikas Vohra, PS	1st National Convention & National Seminar at DPR, Hyderabad.	December 2-3, 2022
47.	Dr. D. Malakar, PS	National Development Programme at NBAGR, Karnal	December 17-18, 2022
48.	Dr. Arun Kumar Mishra, PS	National Dialogue on "Sustainable growth and Development of Indian Dairy Sector" at DUVASU, Mathura	December 16-17, 2022
49.	Dr. Ashutosh, PS	International Conference on "Reimaging Rainfed Agro-ecosystems at Hyderabad.	December 2-3, 2022
50.	Dr. P.N. Raju, Sr. Scientist	7th Convocation of NADSI and National Dialogue on "Innovation in Reshaping the Indian Dairying" DUVASU Mathura.	October 29, 2022
51.	Dr. P.S. Minz, Sr. Scientist	International Conference on Advancements in Engineering and Technology (online).	November 11-12, 2022
52.	Dr. Nishant Kumar, Sr. Scientist	National Conference on "Contemporary Multidisciplinary Issues in Applied Science, Humanities, Agriculture, Animal Health and Production" (ASHAA-2022), Rajiv Gandhi South Campus, Barkachha, Mirzapur, BHU	November 14-15, 2022
53.	Dr. Sunita Meena, Sr. Scientist	-do-	-do-
54.	Dr. Rubina K. Baithalu, Scientist	National Symposium National Symposium on "Optimizing animal reproduction through recent techniques of biotechnology, nutraceuticals and alternative medicine" & XXXXVII ANNUAL CONVENTION of ISSAR (ISSARCON-2022).	November 16-18, 2022
55.	Dr. S. De, PS	AMR International Seminar & deliver talk on "AMR patterns of E.Coli from fish", ICAR-CIFT, Cochin, Kerala	November 21-22, 2022
56.	Dr. Rakesh Kumar, PS	International Seminar "Interventions for control of AMR: Harnessing One Health Knowledge", Cochin Kerala	November 21-22, 2022
57.	Dr. S. De, PS	XVI Annual Conference of Indian Society of Animal Genetics & Breeding (ISAGBCON2022), ICAR- Directorate of Poultry Research, Hyderabad	December 2-3, 2022
58.	Dr. P.S. Minz, Sr. Scientist	6th Biennial e-Conference of Probioltic Association of India (PAi) and International e-symposium on "Psychobiotics and Gut: Potential in Neurological Disorders" (online).	December 5-6, 2022
59.	Dr. Meena Malik, Professor (English)	16th International and 52nd Annual Conference of ELTAI, New Panvel (W), Navi Mumbai.	December 8-10, 2022
60.	Dr. Pradip Behare, Sr. Scientist	12th Convention and National Seminar, College of Dairy Technology, Warud Pusad, Maharashtra	December 15-16, 2022

14. MAJOR EVENTS

Date	Title of the Event
January 28, 2022 to February 17, 2022	Winter school on Advances in Agricultural Extension Research
February 28, 2022	National Science Day
March 23, 2022	Industry Meet
March 16 to April 29, 2022	NDRI Virtual Training Program on Personality Development and Neuro Linguistic Program
April 15, 2022	Mentor-Mentee Program
April 30, 2022	Launch Workshop of Gender Advancement for Transforming Institutions (GATI)
May 23-28, 2022	Entrepreneurship Development Program on Starter Cultures and Production of Fermented Milk Products
June 1, 2022	World Milk Day
June 20, 2022	International Webinar on Impact of Climate change and heat stress on Dairy Cattle and Mitigation strategies
June 21, 2022	International Yoga Day
June 22, 2022	International Webinar on Extraction of bioactive compounds from food and application of *in vitro* digestion models
July 1, 2022	Centenary Celebrations at ICAR-NDRI, Karnal
August 26, 2022	National Workshop on Patent Drafting and Filing Procedure
September 28, 2022	Training on "Fodder Production and Feed Management" at Hunder, Leh-Ladakh
October 2-31, 2022	Special Swachhta Campaign
October 16, 2022	World Food Day
October 17-21, 2022	Refresher Training Programme on "Capacity building of Artificial Insemination Trainees"
November 30, 2022 to December 2, 2022	Workshop for Technical Personnel
December 1-21, 2022	36th National Training Programme Centre for Advanced Faculty Training (AG&B)
December 5-6, 2022	International symposium on Psychobiotics and Gut: Potential in the neurological disorders
December 16-31, 2022	Swachhta Pakhwada

Inauguration of Centenary Pillar by Hon'ble Minister of Agri. & Farmers Welfare, Sh. Narendra Singh Tomar Ji

Organization of NDRI-Industry Meet on March 23, 2022 at ICAR-NDRI

National Workshop on Patent Drafting and Filing on August 26, 2022 at ICAR-NDRI

15. DISTINGUISHED VISITORS

Date	Name & Designation of the Visitor
March 15, 2022	Dr. D. K. Yadav, ADG (Seed)/ Addl. charge
	Dr. Arun K. Joshi, CIMMYT, Asia Regional Representative & Managing Director (BISA)
April 5-9, 2022	Dr. K. M. Bujarbaruah, Vice Chancellor, Assam Agricultural University, Jorhat, Assam
	Dr. Kusumakar Sharma, Ex-ADG (HRM), Education Division, Krish Anusandhan Bhawan-II, New Delhi
	Dr. D. N. Kamra, ICAR-NAARM, Hyderabad
	Dr. D. C. Rai, Founding Head, Institute of Agril. Sciences, BHU
	Dr. Sameera Qayoom, Professor, Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir
	Dr. M.K. Agnihotri, PS & Controller of Examinations at ICAR, New Delhi
April 9, 2022	Shri Ganesh Joshi, Hon'ble Agriculture Minister & Farmers Welfare of Uttrakhand
April 30, 2022	Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE Govt. of India & Director General, ICAR, New Delhi
	Dr. B. N. Tripathi, DDG (Animal Sciences), ICAR, New Delhi
	Dr. Suresh Kumar Chaudhari, DDG (Natural Resource Management), ICAR, New Delhi
May 2, 2022	Dr. A. K. Gahlot, Ex-VC, RUVAS, Bikaner
May 26-28, 2022	Dr. A. D. Pathak, PC, AICRP (Sugarcane) and Director, ICAR-IISR, Lucknow
June 3, 2022	Sh. G. P. Sharma, Director Finance, ICAR, New Delhi
June 9, 2022	Shri Kapil Moreshwar Patil, Hon'ble Minister of State in the Ministry of Panchayati Raj, Govt. of India
July 1, 2022	Shri Narender Singh Tomar, Hon'ble Agriculture & Farmers Welfare Minister, Govt. of India
July 1, 2022	Dr. Shiv Parsad Kimothi, Member ASRB (AS & FS)
	Dr. B. N. Tripathi, DDG (AS)-ICAR, New Delhi
	Dr. A. K. Tyagi, ADG (ANP), New Delhi
	Sh. Mohinder Kumar, PSO to Secretary (DARE) & DG-ICAR, New Delhi
	Sh. Kuldeep Rawat, PPS to Secretary (DARE) & DG-ICAR, New Delhi
July 19, 2022	Prof. (Dr.) A. K. Srivastava, Hon'ble Vice Chancellor, DUVASU, Mathura
August 6, 2022	Dr. Anil Singh Gosain, J.D. Technical, Srinagar
August 8, 2022	Dr. S. K. Gajmoti, CAO, IIFWC, Dehradun
September 30, 2022	Shri Surya Pratap Shahi, Hon'ble Agriculture Minister, U.P.
November 1, 2022	Ms. Alka N. Arora Joint Secretary, DARE & FA, ICAR, New Delhi
December 5, 2022	Sh. Ashish Bhatgain, Director, Administration and Monitoring, G.B. Pant University of Agriculture & Technology, Pantnagar, U.K.
December 21, 2022	Dr. Trilochan Mohapatra, former Director General, ICAR, New Delhi

16. PERSONNEL

INSTITUTE STAFF

As on December 31, 2022

Director's Cell	
Dheer Singh, PhD	Director
Nirmala Kumari, BA	Private Secretary
Joint Director (Research) Cell	
Dheer Singh, PhD	Joint Director
Shakuntla Rani, BA	Private Secretary
Research Prioritization, Monitoring and Evaluation Unit	
Meena Malik, BA, MPhil, PhD	Professor (English)
Braj Kishor, MA (English)	Assistant Chief Technical Officer
Lakshman, BCom	Technical Officer
Joint Director (Academics) Cell	
A. K. Singh, PhD	Joint Director
Shyam Lama, Matric	Principal Private Secretary
Academic Affairs Management Unit	
Nitin Tyagi, PhD	Academic Coordinator
Ravinder Malhotra, PhD	Controller of Examinations
Sukhdev Singh, BA	Administrative Officer
Bhagwan Dass, BA	Assistant Administrative Officer
Administrative Wing	
B.D. Phansal, M.A	Joint Director (Admn) cum Sr. Registrar
K.L. Meena	Chief Administrative Officer (Sr. Grade)
Dinesh Nagpal, AMIE (Civil Engineering)	Chief Administrative Officer
Gajanand Yadav, M.sc	Senior Administrative Officer
Ravinder, B.E (Mechanical)	Senior Administrative Officer
Ram Niwas Panchal, BA	SeniorAdministrative Officer
Karambir Malik, M.A	Principal Private Secretary
Rajbir, BA	Administrative Officer
Sukhdev Singh, BA	Administrative Officer
S.S. Meena, BA	Assistant Administrative Officer
Bhagwan Dass, BA	Assistant Administrative Officer
Subhash Chand, BA	Assistant Administrative Officer
Ajit Singh, BA	Assistant Administrative Officer
Ram Pal, BA	Assistant Administrative Officer

Gurjeet Singh, B.Pharma	Assistant Administrative Officer
Subhash Chander, BA (First Year)	Assistant Administrative Officer
Ram Dhari Singh, M.A	Assistant Administrative Officer
Raj Kumar, B.Com, Bed, DCOM	Assistant Administrative Officer
Chiranjee Lal, MLISC	Assistant Administrative Officer
B.L. Meena, Senior Secondary	Assistant Administrative Officer
Subhash Kumar, BA	Assistant Administrative Officer
Santosh Kumari, BA	Assistant Administrative Officer
Sonika Yadav, MTech	Assistant Administrative Officer
Dharmendra Singh, B.sc	Assistant Administrative Officer
Meera Rani, Senior Secondary	Assistant Administrative Officer
Anita Behl, BA	Private Secretary

Finance Wing

Avesh Yadav,	Comptroller
Jagdish Chander	Senior Finance & Account Officer
Vishal Acharya, MA	Assistant Finance & Account Officer
Avnish Kumar, B.Com	Private Secretary

Animal Genetics & Breeding Division

Archana Verma, PhD	Principal Scientist & Acting 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	Sr. Scientist
Satish Kumar Rathee, PhD	Scientist
Vinod Kumar, Matric, NTC (Machinist)	Technical Officer
Santra Devi, BA	Principal Private Secretary

Livestock Production & Management Division

Arun Kumar Misra, PhD	Principal Scientist & Acting 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 Kumari Baithalu, Ph.D	Senior Scientist
Indu Devi, Ph.D.	Scientist
Shiv Kumar, MSc (Agriculture)	Assistant Chief Technical Officer

Animal Nutrition Division	
Raman Malik, PhD	Principal Scientist & Acting Head
Ram Singh, PhD	Principal Scientist
Chander Datt, PhD	Principal Scientist
Nitin Tyagi, PhD	Principal Scientist
Goutam Mondal, PhD	Principal Scientist
Sachin Kumar, PhD	Scientist (SS)
Uttam Kumar, PhD (Agronomy)	Chief Technical Officer
Gyan Singh, MSc (Agriculture Economics)	Assistant Chief Technical Officer
Sumit Narayan, MSc (Agriculture)	Senior Technical Officer
Ramesh Kumar, Matric	Technical Officer

Animal Physiology Division	
Sohanvir Singh, PhD	Principal Scientist
A.K. Dang, PhD	Principal Scientist & Acting Head
Anjali Aggarwal, PhD	Principal Scientist
Ashutosh, PhD	Principal Scientist
Sahadev Singh, MSc (Agriculture-Chemistry)	Assistant Chief Technical Officer
Yogender Partap Singh, BSc	Senior Technical Officer
Narender Kumar, BA (Economics)	Technical Officer
Dheeraj Kumar, MSc (Agriculture)	Technical Officer
Ranjana Khurana, BA	Private Secretary

Animal Biotechnology Centre	
S. De, PhD	Principal Scientist & Acting Head
J.K. Kaushik, PhD	Principal Scientist
D. Malakar, PhD	Principal Scientist
Satish Kumar, PhD	Principal Scientist
Rakesh Kumar, PhD	Principal Scientist
M.K. Singh, PhD	Sr. Scientist
Sudarshan Kumar, PhD	Sr. Scientist
Selokar Naresh Lalaji, PhD	Scientist
Bharti Pandey, PhD	Scientist
Ranjeet Verma, MVSc (VGO)	Senior Technical Officer

Animal Biochemistry Division	
Gautam Kaul, PhD	Principal Scientist & Acting Head
Rajeev Kapila, PhD	Principal Scientist
Suman Kapila PhD	Principal Scientist
Suneel Kumar Onteru, PhD	Principal Scientist
Sunita Meena, PhD	Senior Scientist
Sadeesh E. M., PhD	Senior Scientist
Rajani Kumar Paul, PhD	Senior Scientist
Ravi Kant, PhD (Life Science)	Chief Technical Officer
Meenu Rani, M.A, PGDCA	Private Secretary

Dairy Technology Division	
Kaushik Khamuri, PhD	Principal Scientist & Acting Head
P. Narender Raju, PhD	Senior Scientist
G.S. Meena, PhD	Senior Scientist
Yogesh Kehtra, PhD	Senior Scientist
Shaik Abdul Hussain, PhD	Senior Scientist
Gunvantsinh Rathod, MTech	Scientist
Writdhama G. Prasad, PhD	Scientist
Sangita Ganguly, PhD	Scientist
Heena Sharma, PhD	Scientist
Gourav Kumar Deshwal, MTech	Scientist
Sunita Chaudhary, BA	Principal Private Secretary

Dairy Chemistry Division	
Raman Seth, PhD	Principal Scientist
Bimlesh Mann, PhD	Principal Scientist & Acting Head
Sumit Arora, PhD	Principal Scientist
Vivek Sharma, PhD	Principal Scientist
Rajan Sharma, PhD	Principal Scientist
Rajesh Kumar, PhD	Principal Scientist
Richa Singh, PhD	Scientist
Kamal Gandhi, PhD	Scientist
Rajani Bala, BA	Private Secretary

Dairy Microbiology Division	
A. K. Puniya, PhD	Principal Scientist & Acting Head
Naresh Kumar, PhD	Principal Scientist
Shilpa Vij, PhD	Principal Scientist
Chand Ram, PhD	Principal Scientist
P. V. Behare, PhD	Sr. Scientist
Raghu H.V., PhD	Sr. Scientist
Rashmi H. M., PhD	Sr. Scientist
Diwas Pradhan, PhD	Scientist
Saurabh Kadyan, MTech	Scientist
Yogita Sharma, MSc (Chemistry)	Technical Officer

Dairy Engineering Division	
P. Barnwal, PhD	Principal Scientist & Acting Head
Chitranayak, PhD	Principal Scientist
P.S. Minz, PhD	Senior Scientist
Ankit Deep, MTech	Scientist
Khushbu Kumari, MTech	Scientist
Priyanka, MTech	Scientist

Hima John, PhD	Scientist
Sunil Kumar, MTech (EIC)	Assistant Chief Technical Officer
Manju Bala, Senior Secondary, NTC (Draftsman)	Technical Officer
Pardeep, MTech (Mechanical-PT)	Technical Officer

Dairy Economics, Statistics and Management Division

Ravinder Malhotra, PhD	Principal Scientist & Acting Head
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, PhD	Sr.Scientist
Gunjan Bhandari, PhD	Scientist
Biswajit Sen, MTech	Scientist
Santosh, BA	Private Secretary

Dairy Extension Division

K. S. Kadian, PhD	Principal Scientist & Acting 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
Sanjit Maiti, PhD	Senior Scientist
Sanchita Garai, PhD	Senior Scientist

Forage Research and Management Centre

Anurag Saxena, PhD	Principal Scientist & In-charge
Rakesh Kumar, PhD	Principal Scientist
Magan Singh, PhD	Senior Scientist
Hardev Ram, PhD	Senior Scientist
Sanjeev Kumar, PhD	Scientist
Rajesh Kumar Meena, PhD	Scientist
Vijendra Kumar Meena, PhD (Agronomy)	Chief Technical Officer
Anil Kumar Dagar, MSc (Agriculture-Agronomy)	Assistant Chief Technical Officer
Ravi Rawat, MSc (Agriculture-Entomology)	Assistant Chief Technical Officer
Kamal Garg, MSc (Agronomy)	Senior Technical Officer

Agricultural Technology Information Centre (ATIC)

Raj Kumar	Senior Scientist & In-charge
Jitendra Singh Rana, PhD (AH&D)	Assistant Chief Technical Officer

Krishi Vigyan Kendra/ TTC	
Pankaj Kumar Saraswat, PhD	Principal Scientist & Head
Neelam Upadhyay, PhD	Scientist
Kulvir Singh, MSc (Agriculture Economics)	Chief Technical Officer
Raj Kumar, BCom, BEd, DCom	Assistant Administrative Officer
Ashwani Kumar, MSc (Agriculture)	Assistant Chief Technical Officer
Deepa Kumari, MA (Sociology)	Senior Technical Officer
Livestock Research Centre	
S. S. Lathwal PhD	Principal Scientist & In-charge
Nishant Kumar, PhD	Senior Scientist
Rubina Kumari Bithalu, PhD	Senior Scientist
Artificial Breeding Research Centre	
Pawan Singh, PhD	Principal Scientist & In-charge
Mukesh Bhakat, PhD	Principal Scientist
National Library in Dairying	
A.K. Puniya, PhD	Principal Scientist & Head
Bindeshwari Patrap Singh, MLib, MA (AH)	Assistant Chief Technical Officer
Sunil Kumar Sharma, MSc (CS)	Senior Technical Officer
Narendra Singh, MSc (CS), MCA, MLib	Senior Technical Officer
Computer Centre	
Udita Chaudhary, PhD	Sr.Scientist & In-charge
Vivek Kumar, MSc (Agriculture)	Senior Technical Officer
Des Raj, Senior Secondary	Technical Officer
Atul Gupta, MTech (Computer Engineering)	Technical Officer
Communication Centre	
B.S. Meena, PhD	Principal Scientist & In-charge
Paramjeet, Diploma (Electronics-Telecom)	Technical Officer
Sourav Singh, Diploma (Instrumentation)	Technical Officer
Official Language Unit	
Dhiraj Sharma, MA, PGJMC	Dy. Director
Security Section	
Ashutosh, PhD	Principal Scientist & In-charge
Human Health Complex	
Suneel Kumar Onteru, PhD	Principal Scientist & In-charge
Deepak, Matric, Certificate Course	Technical Officer

Anuradha, Senior Secondary, Diploma (GN&M)	Technical Officer
Richa Walia, Matric, Course of Nurses	Technical Officer
Saroj Bala Kathuria, Senior Secondary, Course	Technical Officer
Saroj Bala, BA, Diploma (Pharmacy)	Technical Officer

Guest House

Chiranjee Lal	Assistant Administrator Officer & In-charge

Hospitality Cell

Navdeep Singh, MTech (Computer Engineering)	Technical Officer & In-charge
Ramesh Kumar, LMV/ MCWG/ MCWOG	Technical Officer
Pawan Kumar, Senior Secondary, Diploma (Diesel Mechanic)	Technical Officer
Atam Parkash, LMV/MCWG	Technical Officer
Sudesh Kumar, Senior Secondary, PSVBUS/HVM	Technical Officer
Surinder Pandey, HVM	Technical Officer
Umed Singh, LMV	Technical Officer

Vehicle Maintenance Section

Sanjeev Kumar, MSc (CS)	Assistant Chief Technical Officer

Artificial Breeding Research Center

Subhash Chand, BVSc & AH	Assistant Chief Technical Officer
Ghan Shyam Meena, BSc (Agriculture)	Technical Officer
Kaushal Kumar, BVSc & AH	Technical Officer

Sports Cell

Sandeep Deswal, MPhil (Physical Education)	Assistant Chief Technical Officer

National Referral Lab

Rakesh Kumar, PhD (Zoology)	Assistant Chief Technical Officer

Maintenance Engineer

J.K. Dabas, PhD	Chief Technical Officer & In-charge
Balbir Singh, Matric, ITI (Electrical)	Technical Officer
Mohan Lal, MTech (EE)	Technical Officer
Namo Narayan Meena, Diploma (ME)	Technical Officer
Ravinder Singh, BTech, Diploma (CE)	Technical Officer
Mahender Pal, Matric NTC (Fitter)	Technical Officer

Livestock Research Center	
S. Raju, MVSc	Chief Technical Officer
Rajbir, Senior Secondary	Technical Officer
Dharam Pal, Senior Secondary	Technical Officer
Pramod Kumar, MSc (Agriculture)	Assistant Chief Technical Officer
Parveen Kumar, MVSc	Chief Technical Officer
Amar Pal Singh, PhD	Assistant Chief Technical Officer
Puneet Pal Singh, BVSc & AH	Technical Officer
Neha Gupta, MVSc (VM)	Senior Technical Officer
Santosh Kumar, PhD (LPM)	Assistant Chief Technical Officer
Hari Kishan Meena, Senior Secondary	Technical Officer

Hostel Office	
Hardev Singh, BSc (Botany)	Technical Officer

Experimental Dairy	
Surinder Kumar Gupta, PhD (DT)	Chief Technical Officer
Lehri Singh, MSc (Chemistry)	Chief Technical Officer
Sanjiv Kumar, MA (Economics)	Assistant Chief Technical Officer
Gurpartap Singh, MTech (PT)	Senior Technical Officer
Jagdish Singh, BA (Economics)	Technical Officer

Estate Section	
Pooran Mal Meena, MSc (Agriculture-Horticulture)	Assistant Chief Technical Officer

Consultancy Processing Cell	
Bimlesh Mann, PhD	Principal Scientist & Chairman
Veenu, BSc (CS), MCA	Technical Officer

Southern Regional Station, Bengaluru	
K. P. Ramesha, PhD	Principal Scientist & Acting 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. Kataktalware, PhD	Principal Scientist
F. Magdaline Eljeeva Emerald, PhD	Principal Scientist

Mamta Chauhan, 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 G.V., PhD	Scientist
Priyanka Singh Rao, PhD	Scientist
S. Varalakshmi, M.VSc	Scientist
Laxman Naik. N., PhD	Scientist
Vairat Amita Dinkar, PhD	Scientist
Manoj Kumar C.T., Ph.D	Scientist
B.K. Rajashekaria, BSc (Agriculture)	Chief Technical Officer
P. G.Sathish, BVSc	Chief Technical Officer
P. Murugananthan, BSc, MLib	Chief Technical Officer
V.R.V. Surendranath Naik, MMBS, MD	Chief Technical Officer
Siddaramanna, PhD	Assistant Chief Technical Officer
K. Ningaraju, PhD (LPM)	Assistant Chief Technical Officer
Janakshi, MSc, MCA	Assistant Chief Technical Officer
R. Muthuraju, BCA, MCA	Assistant Chief Technical Officer
Meghanathn, Diploma (Electrical Engineering)	Assistant Chief Technical Officer
M.S. Nagarajaiah, Diploma (Civil Engineering)	Assistant Chief Technical Officer
K. Ramakrishna Prasad, MSc (Microbiology)	Senior Technical Officer
Ahmad Hussain, PhD (Animal Biochemistry)	Senior Technical Officer
S.S. Meena	Assistant Administrative Officer

Eastern Regional Station, Kalyani

S.M. Deb, PhD	Principal Scientist & Acting 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	Senior Scientist
Saroj Rai, PhD	Scientist
Alokes Goswami, MSc (Agriculture)	Chief Technical Officer

Somenath Dutta, MVSc	Chief Technical Officer
Amitava Ghosh, MVSc	Chief Technical Officer
Debabrata Basantia, MS. (Agriculture-Horticulture)	Assistant Chief Technical Officer
Sanjay Kumar Ray, PhD (Agriculture)	Assistant Chief Technical Officer
Parth Pratim Choudhary, MSc (Zoology)	Assistant Chief Technical Officer
Annu Mann, BTech	Assistant Administrative Officer
S. Roy Deb	Principal Private Secretary

Joining/ Appointments/ Promotions

- Dr. M.S. Chauhan, Director was re-employed for the Post of Director, ICAR-NDRI vide office order No. 13/ Dir./2022 dated 1.02.2022(FN).
- Sh. Subhash Kumar, Assistant was promoted to the post of AAO vide office memorandum No. 6-33/20/ DPC/E-I/(S)/Vol.VI/717-19 dated 3.02.2022.
- Smt. Santosh Kumari, Assistant was promoted to the post of AAO vide office memorandum No. 6-33/20/ DPC/E-I/(S)/Vol.VI/717-19 dated 3.02.2022 and she joined as on 3.2.2022(A.N) and posted at E-IV Section.
- Dr. Gopal Ram Das Gowane, Scientist was promoted as Senior Scientist.
- Sh. Vivek Purwar, CAO was promoted to the post of CAO (SG) and he joined at ICAR-NDRI, Karnal on 16.03.2022.
- Dr. Vairat Amita Dinkar, Scientist, Dairy Engineering was transferred from ICAR-NDRI to SRS Bangalore vide office order No. 12-60/11/E-I(S)-Vol.II/897-908 dated23.02.2022.
- Dr. R.R. B. Singh, Joint Director (Academic) retired on 31.03.2022.
- Dr. Dheer Singh, Joint Director (Research) took over the charge of Joint Director (Academic) on 31.03.2022 vide office order No. 1-44/2016/E-I(S)/Vol.II.
- Dr. Indu Devi, Scientist joined at ICAR-NDRI W.E.F. 4.04.2022(FN) vide council order No.11-1/2021/pers-II(IV) dated 16.03.2022
- Ms. Sonika Yadav, Assistant was promoted to the post of AAO vide office order No. F.6-33/20 /LDCE/E-I(S)/276-80 dated 21.04.2022.
- Sh. Dharamendra Singh, Assistant promoted to the Post of AAO vide office order No. F.6-33/20 /LDCE/E-I(S)/281-85 dated 21.04.2022.
- Sh. Abhishek Rana, Senior Administrative Officer relieved from ICAR-NDRI on 22.04.2022 after his transfer to the post of CAO at CSSRI, Karnal.
- Sh. B.D. Phansal, CAO (SG) NAARM Hyderabad joined as Joint Director (Admn.) cum Senior Registrar on 22.08.2022 at ICAR-NDRI, Karnal vide Council office order F.No. Admn./6-1/2019-Estt. dated 2.8.2022
- Sh. Mukesh Kumar Dua, AAO was promoted to the post of Administrative Officer vide office order No. F.6-33/20 /LDCE/E-I(S)/Vol-I/328-348 dated 25.04.2022.
- Sh. Sukhdev Singh, AAO was promoted to the post of Administrative Officer vide office order No. F.6-33/20 /LDCE/E-I(S)/685-96 dated 8.06.2022.
- Sh. Dinesh Nagpal joined as on 15.07.2022(FN) the post of CAO vide Council office order Admn. 6-4/2021-Estt. I dated 28.04.2022
- Smt. Sunita Chaudhary, Private Secretary promoted to the post of PPS vide office order No. F.6-57/20 /E-I(S)/ Vol-IV/184-192 dated 03.08.2022
- Sh. Karambir, Private Secretary joined the post of PPS vide Council office order No. F.Admn./6-1/2022-Estt.I dated 04.08.2022(FN).

- Smt. Santra Devi, Private Secretary joined as PPS vide Council office order No. F.Admn./6-1/2022-Estt.I dated 05.08.2022(FN).
- Smt. Parvesh Lata, Private Secretary was relieved her duty vide office order No. 13-630/1/E.I(S)/194-204 dated 4.08.2022 to join at CSSRI for the post of PPS F.Admn./6-1/2022-Estt.I dated 03.08.2022.
- Sh. Shyam Lama, Private Secretary joined as PPS vide Council office order No. F. Admn./6-1/2022-Estt.I dated 05.08.2022 (AN).
- Sh. Avnish Kumar, PA was promoted to the post of Private Secretary vide office order No. 1-139/90/E.I(S)-Vol.I/175-181 dated 4.08.2022(A.N).
- Dr. Udita Chaudhary, Scientist, Agricultural Statistics was promoted as Senior Scientist in PB-3 w.e.f. 05.11.2021.
- Dr. A. Manimaran, Senior Scientist, Veterinary Pharmacology was promoted as Senior Scientist in PB-4 (Revised Research Pay level-13A)] w.e.f. 07.02.2022.
- Dr. Ashish Kumar Singh, Principal Scientist and Acting Head, Dairy Technology assumed the charge of Joint Director (Academics) ICAR-NDRI, Karnal on 17.11.2022 (AN) vide office order No. 13-502/98/EI(S)/369-379 dated 23.11.2022.
- Dr. Dheer Singh, Director (Acting) assumed the charge of Director, ICAR-NDRI, Karnal in the afternoon of 08.12.2022 vide Council Memorandum No. 39(1)/2022/Per. III dated 08.12.2022
- Dr. Bharti Pandey, Scientist joined ICAR-NDRI, Karnal on 30.12.2022 (FN).
- Dr. Gunjan Bhandari, scientist, Agricultural Economics was promoted to the next higher grade in PB-3 (Revised Research Pay level-11) w.e.f. 05.07.2021.
- Dr. Ranjeet Verma joined as STO (F/FT) on 06.06.2022 at ICAR-NDRI, Karnal.
- Dr. Neha Gupta joined as STO (F/FT) on 08.06.2022 at ICAR-NDRI, Karnal.
- Sh. Sonu K.S. joined as STO (L/T) on 14.06.2022 at SRS of ICAR-NDRI, Bengaluru.
- Dr. Ahmad Hussain joined as STO (LT) on 24.06.2022 at SRS of ICAR-NDRI, Bengaluru.
- Sh. Kamal Garg joined as STO (F/FT) on 08.09.2022 at ICAR-NDRI, Karnal.
- Sh. Vivek Kumar joined as STO (L/T) on 24.08.2022 at ICAR-NDRI, Karnal.

Transfer/ Retirement/ Relieving

- Sh. Vivek Purwar, CAO (SG) was relieved from ICAR-NDRI, Karnal to ICAR-NARRM, Hyderabad vide office order No. 13-741/2019/E-I(S)/694-702 dated 16.09.2022.
- Sh. Mukesh Kumar Dua, Administrative Officer was relieved from ICAR-NDRI, Karnal to join at IIWBR, Karnal vide office order No. 13-661/2012/E-I(S)-917-21 dated 10.10.2022
- Mr. Varinder Hans, Technical Officer, retired from Council's service w.e.f. 31.05.2022.
- Dr. Amita D Vairat, Scientist, Agricultural Structures and Process Engineering transferred to SRS of ICAR-NDRI, Bengaluru w.e.f. 09.03.2022.
- Sh. Debabrata Basantia, ACTO/ SMS (Horticulture) joined at ERS of ICAR-NDRI, Kalyani in the A/N of 01.01.2022.
- Sh. R. Muthuraju, ACTO (L/T) joined at SRS of ICAR-NDRI, Bengaluru on 30.03.2022.
- Sh. Santosh Kumar, ACTO, SMS (Livestock Production) joined at ICAR-NDRI, Karnal on 12.08.2022.
- Sh. Sanjay Kumar Ray, ACTO/ SMS (Soil Science) joined at ERS of ICAR-NDRI, Kalyani on 08.08.2022.
- Dr. Leena Mishra, Senior Technical Assistant joined at SRS of ICAR-NDRI, Bengaluru on 22.08.2022.

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.

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 stakeholders, 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 in 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 Artificial Breeding Research Center of Institute besides supporting the training and extension activities of the institute.

The mandate of the division 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 behaviour lab, Molecular Reproduction lab, ABRC, Andrology and semen preservation lab, milk analysis lab, ARGO lab in LRC and 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 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 has been committed to conduct Research, Teaching, and Extension activities in Environmental and Stress Physiology, Lactation and Immuno Physiology, Growth and Reproductive Physiology, and Endocrinology. 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. It was bifurcated into independent division as Dairy Cattle Nutrition and Dairy Cattle Physiology in 1978. Dairy Cattle Nutrition Division was renamed as Animal Nutrition Division in the year 2016. 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. Milk replacer and calf starter based on locally available sources were developed along with their feeding schedule. 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. Surveys have been carried out to find the prevalence of pesticide and toxic metals as well as essential trace minerals.

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. This division offers Ph.D. and Masters Program in Animal Nutrition discipline.

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, ^{15}N-Analyzer, methane analysis equipment using SF_6 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 sister section of forage production section in 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 master and 4 for doctoral programmes. Section has facilities for quality analysis of forages and about 10-acre land for conducting research experiments of total five scientists and 19 students' trial.

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 researches. The Division is offering Masters and Doctoral degree courses in Animal Biochemistry. The Division has Central Instruments Room that houses expensive equipments and are available to all users. Small Animal House is Central facilities managed by Animal Biochemistry Division. The contributions of the Division have been amply recognized by three Rafi Ahmed Kidwai Memorial Awards, Dr. P. G. Nair Award, two Jawahar Lal Nehru Award, Young Scientist Award, IUIS/FIMSA Travel Bursary Award, Best publication award and several paper presentation awards.

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 on 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 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 accredited 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 on, Electrophoresis, Imaging system, Refrigerated water bath, Dual beam digital Spectrophotometer, Water purification on 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.

DAIRY MICROBIOLOGY

Dairy Microbiology Division is 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; bioactive peptides, microbial metabolites and bio-preservatives; biosensors, quality assurance and food safety; rumen micro-organisms etc. The division has played a leading 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 recently 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 carbonated *lassi*, vitamin B_{12} 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 Division offers M. Tech and Ph. D programmes in Dairy Microbiology. The division 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 the country.

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.

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. 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 under-graduate level also, that is, B. Tech. (DT). 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. Gender mainstreaming 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 main extension programme of the Institute includes Dairy Mela, training, study visit, demonstrations, field days etc. Research-Extension-Industry-Farmer Interface is also organized by the division to provide an opportunity for the convergence of all stakeholders 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 Sanghosthi 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" initiated on 9.02.2009 to strengthen the effective dissemination of dairy production and processing technologies among farming community. A new Extension Approach "Farmers Farm School" in village is initiated on 30.08.2014 for updating farmers knowledge in the field of dairy farming in particular and agriculture in general.

SUPPORT SECTIONS

LIVESTOCK RESEARCH CENTRE

Livestock Farm

The total milk production of the herd during the current year was 778769.4 kg. The production performance of the two crossbred strains developed by the NDRI viz. Karan Swiss and Karan Fries was 10.5 and 9.0 kg per

head per day, respectively. The milking average of Sahiwal cows was 5.8 milking average of Gir Cows and Murrah buffaloes was 3.5 and 7.3 kg per animal per day respectively. One Sahiwal cow (SW-2492) produced best milk yield of 14.5 kg in peak lactation. Best yield in Murrah buffalo (MU-6774) was 19.5 kg per day during the current year. The peak milk yield by the KF and KS crossbred cows was 24.5 kg (KF-8085) and 19.0 kg (KS-4465) respectively.

Month-wise Milking Average (kg.) of Cows, Buffaloes and Goats Maintained at NDRI, Karnal during 2022

Months	Cows										Buffaloes		Goats			
	Sahiwal		Tharparkar		Gir		Karan Swiss		Karan Fries		Murrah		Alpine x Beetal		Sannen x Beetal	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
January	63	7.2	17	4.0	28	5.3	02	15.7	62	12.1	98	8.9	53	1.4	15	1.5
February	67	7.4	22	4.1	32	4.4	02	14.3	66	11.6	99	8.7	43	1.8	14	1.7
March	70	7.1	21	5.6	34	4.2	03	12.8	72	10.7	94	7.9	60	1.9	20	1.8
April	88	6.6	26	4.8	37	4.0	04	11.8	79	11.2	87	7.7	75	2.0	26	1.9
May	93	5.8	21	5.0	35	3.2	03	14.2	65	11.7	83	6.9	75	1.7	25	1.6
June	90	6.2	22	4.3	33	2.9	03	10.9	60	11.3	80	6.7	73	1.5	23	1.6
July	87	5.7	25	3.8	31	2.8	03	10.8	61	9.8	73	6.4	64	1.0	22	1.1
August	90	4.8	25	4.2	31	2.7	03	8.5	57	8.9	74	6.0	29	1.1	16	1.0
September	83	5.3	27	3.7	24	2.9	03	6.4	52	9.0	84	6.2	17	1.0	08	0.9
October	81	5.1	28	2.9	28	2.8	03	5.1	54	8.7	86	6.9	44	1.2	13	1.3
November	78	4.3	19	2.9	26	3.1	01	10.2	54	9.0	96	7.1	86	1.4	27	1.4
December	66	5.5	14	3.2	25	3.6	01	1.8	53	10.1	98	7.7	95	1.4	29	1.5
Average	**80**	**5.8**	**22**	**4.1**	**30**	**3.5**	**03**	**9.0**	**61**	**10.5**	**88**	**7.3**	**59**	**1.5**	20	1.5

(1)= Av. No of animals in milk per day, Milk Yield Av. (kg) per Animal per day

Bovine Strength of Cattle and Buffaloes as on 31-12-2022

Age group	Cattle						Buffaloes	Total Bovines
	Sahiwal	Tharparkar	Gir	Karan Swiss	Karan Fries	Total	Murrah	
Male up to 06 months	20	07	10	-	10	47	36	83
Female up to 06 months	18	11	09	-	08	46	37	83
Heifers	157	67	68	08	91	391	134	525
Cows/ Buff	170	75	71	04	99	429	166	595
Young Male Stock	51	13	13	-	23	100	40	140
Bulls	07	-	-	-	-	07	09	16
Teaser Bull	-	-	-	-	-	-	02	02
Total	**433**	**173**	**171**	**012**	**231**	**1020**	**424**	**1444**

Flock Herd Strength of Goats as on 31-12-2022

Age Group	Alpine x Beetal	Sannen x Beetal	Total
Female			
Kids upto 06 months	74	28	102
Yearling	84	10	94
Goats	106	32	138
Male			
Kids upto 06 months	77	21	98

Bucks	50	16	66
Total	391	107	498

Sale of Livestock during 2022

Mode of Disposal	Cattle	Buffaloes	Goats	Total
Public Auction	307400.00	1389500.00	37500.00	1734400.00
On Book Value	287378.00	220582.00	100746.00	608706.00
Grand Total	594778.00	1610082.00	138246.00	2343106.00

- Auction of animals was conducted on 09,10 and 11.05.2022

Fodder and Concentrate fed to Animals during 2022

Months	Type of Fodder (q.)			Concentrate
	Green	Dry/Hay	G. Total	(kg.)
January	23245.00	252.00	23497.00	125923.00
February	20024.50	365.00	20389.50	116820.00
March	23065.50	221.00	23286.50	125236.00
April	18156.00	253.00	18409.00	130693.00
May	15680.00	285.00	15965.00	116707.00
June	17160.00	55.20	17215.20	118374.00
July	20250.00	190.00	20440.00	116804.00
August	21135.00	230.00	21365.00	116167.00
September	19159.00	180.00	19339.00	118708.00
October	17650.00	155.00	17805.00	111791.00
November	15693.00	506.00	16199.00	125705.00
December	17491.00	411.00	17902.00	125423.00
Total	228709.00	3103.20	231812.20	1448351.00

Total Milk Production and Milk Supplied to Experimental Dairy during 2022

Months	Total Milk Production	To Calves/ Kids	To Other Division	Total Disposal Milk	Total Milk Sent to Expt. Dairy
January	76581.6	17585.1	269.8	17854.9	58460.0
February	71251.4	16283.4	300.0	16583.4	54454.2
March	78310.5	17135.7	373.0	17508.7	60292.5
April	81234.2	19128.9	423.5	19552.4	61449.1
May	72951.7	17297.8	645.8	17943.6	54983.2
June	65704.4	14668.8	971.7	15640.5	50014.1
July	59026.5	13554.5	1090.8	14645.3	44337.3
August	52283.4	11114.0	1022.8	12136.8	40042.8
September	50793.6	10598.0	1061.2	11659.2	38880.4
October	54414.7	12992.4	621.6	13614.0	40290.4
November	54970.6	14626.4	804.0	15430.4	39373.6
December	61246.8	14208.1	831.9	15040.0	45840.9
Total	778769.4	179193.1	8416.1	187609.2	588418.5

Total milk production during the year : 778769.4 kg

Average No. of animals in milk per day cattle : 196

Buffaloes : 88

Goats : 79

Performance of Dairy Animals during 2022

Particulars	Genetic Groups									
	Sahiwal	Tharparkar	Gir	Karan Swiss	Karan Fries	Total cattle	Murrah	AXB Goats	SXB Goats	Total Goats
Av. number of animals in milk per day	80	22	30	03	61	196	88	59	20	79
Av. number of dry animals per day	89	44	40	02	38	213	69	23	05	28
Milking av. (kg) per day	5.8	4.1	3.5	9.0	10.5	6.8	7.3	1.5	1.5	1.5
Overall av. (kg) per day	2.8	1.4	1.5	5.4	6.5	3.2	4.1	1.1	1.2	1.1
Best yield (kg) in a day	14.5	14.0	11.5	19.0	24.5	-	19.5	4.4	4.5	-
Animal Number	2492	1476	96	4465	8085	-	6774	335	291	-

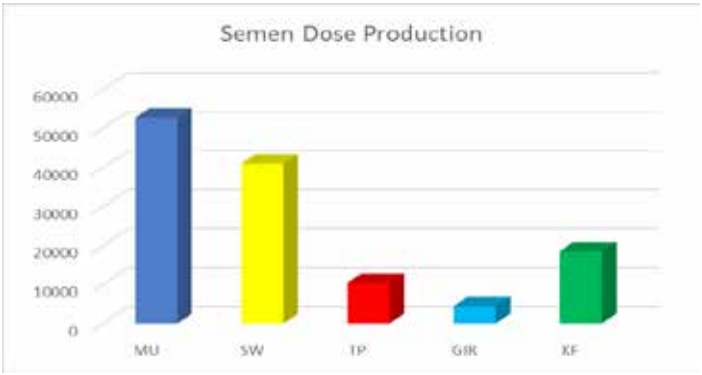
ANIMAL BREEDING RESEARCH CENTRE

The Artificial Breeding Research Centre (ABRC) with 143 breeding bulls (Sahiwal-46, Tharparkar-8, Karan-Fries-25, Karan Swiss -01, Murrah – 60, Gir-3), is engaged in progeny testing programme for Sahiwal and Murrah bulls. This centre is engaged in advanced research on bull management, breeding soundness evaluation, semen cryobiology, sperm sexing; bull fertility assessment and dissemination of quality germplasm to the farmers and developmental agencies. The Artificial Insemination Laboratory under ABRC is also developing strategies for fertility improvement in dairy cows and buffaloes through reproduction management, oestrous synchronization ec.

Production of superior germplasm

The centre is involved in production and conservation of superior male germplasm of cattle and buffaloes. During 2022, a total of 126766 doses of frozen semen were produced.

	MU	SW	TP	GIR	KF	TOTAL
Semen Dose Production	52682	40940	10328	4380	18436	126766



Breed wise production of superior germplasm during 2022

Dissemination of superior germplasm

The centre is disseminating superior male germplasm for genetic improvement programme of cattle and buffaloes. During the year ABRC disseminated 139315 doses of liquid semen of Sahiwal, KF and Murrah bulls to local farmers and also disseminated / supplied 89983 doses frozen semen of Sahiwal, Tharparkar, KF and Murrah bulls to farmers and various Dairy development organizations / Institutes / Gaushalas of 13 states viz., Haryana, Punjab, Uttarakhand, Delhi, U.P, MP, Rajasthan, Bihar, Himachal Pradesh, J&K and Maharashtra.

Month-wise dissemination of semen doses during 2022

Month	Liquid semen doses	Frozen semen doses
January	10735	3848
February	10095	7861
March	11830	9432
April	9215	3138
May	10195	8415
June	11245	1280
July	12410	9355
August	13470	6545
September	13100	10661
October	11450	7352
November	12815	12025
December	12755	10071
Total	139315	89983

Distribution of breeding bulls: The centre distributed 14 surplus breeding bulls (TP-Two, Murrah – Eight, Sw–Three and Gir–one) to government agencies/farmers. A total of Rs. 640919/- revenue generated through the sale of bulls.

Revenue generation

ABRC has generated Rs 2804680.00 as revenue for the institute through the sale of liquid and frozen semen during 2022. The month wise revenue generated is as follows:

Revenue generated through the sale of semen (Rs.)

Month	Frozen semen (Rs.)	Liquid semen (Rs.)	Total (Rs.)
January	58760	107350	166110
February	135720	100950	236670
March	125240	113710	238950
April	30560	92150	122710
May	133640	101950	235590
June	25600	112450	138050
July	157100	124100	281200
August	102900	134700	237600
September	211220	131000	342220
October	91040	114500	205540
November	169320	128150	297470
December	175020	127550	302570
Total	1416120	1388560	2804680

Reproductive Status of NDRI Herd during 2022

Particulars	Breed					
	SW	TP	KS	GIR	KF	MU
	Cow/Buffalo					
No. of Observations	79	35	2	38	31	65
Service Period (days)	153.31	129.6	167.0	155.13	162.77	128.67
No. of Services/Conception	1.27	1.34	2.0	1.39	1.25	1.27

Heifer						
No. of Observations	45	12	-	8	27	42
Average age at Maturity (Month)	32.66	32.41	-	27.25	28.07	30.61
Average age at Conception (Month)	33.68	33.41	-	28.25	29.59	32.64
No. of Services/Conception	1.35	1.25	-	1.25	1.18	1.42
Conception Rate (%)						
Conception Rate 1st Service	61.58	56.89	25.00	44.77	52.94	52.14
Conception Rate 3rd Service	79.26	84.48	75.00	55.22	82.5	89.28
Overall Conception Rate	57.69	50.00	37.5	41.37	49.64	47.23

FORAGE PRODUCTION SECTION

Fodder/Feed Production and Supply

Good quality of, 259751.00 q. Green Fodder, 1571.00 q. dry fodder and 3713.65 q. Straw has been produced from high yielding varieties of fodder crops of Maize, Sorghum, Napier Grass and Cowpea during *Kharif* season and Berseem, Oats, Chinese Cabbage and winter Maize in *Rabi* season. Similarly, seed/grain crops of Maize, Oats, Wheat, Mustard with a total production 5618.55 q. grains was also grown. During the period under report a total of 261322.00 q of fodder including 259751.00 q. green fodder 3713.65 q. Straw and 1571.00 q. dry fodder was supplied to cattle yard and other sections.

Production and Productivity of Forage Crops in terms of Green Fodder and Dry Fodder at Forage Production Section during 2022 (*Rabi* 2021-22 & *Kharif* 2022)

S. No.	Crop	Area (ha.)	Production (q.)	Average Yield (q./ha.)
	***Rabi* Season**			
1.	Berseem + Mustard	49.24	53356.00	1083.59
2.	Oats	69.03	35860.00	519.48
3.	Oats + Mustard C.C.	6.52	2311.00	354.45
4.	Oats dry	0.40	154.00	385.00
5.	Maize	10.26	4329.00	421.93
6.	Mustard C. cabbage	8.08	3046.00	376.98
7.	Lucerne	9.72	6282.00	646.30
8.	Napier Grass Mixture	1.62	905.00	558.64
9.	Napier Grass	20.08	9367.00	466.48
	Total	174.95	115610.00	
	***Kharif* Season**			
1.	Maize	134.55	51332.00	381.51
2.	Maize + Cowpea	25.28	9338.00	369.38
3.	Jowar (Single Cut) Green	42.13	17908.00	425.07
4.	Jowar (Single Cut) Dry	1.01	311.00	307.92
4.	Jowar (Multi Cut) Green	50.02	22490.00	449.62
	Jowar (Multi Cut) Dry	3.24	1106.00	341.36
5.	Bajra	27.00	16347.00	605.44
6.	Jowar (Single Cut) + Cowpea	5.99	4012.00	669.78
7.	Cowpea	3.62	1051.00	290.33
8.	Napier Grass	15.47	6997.00	45.29
9.	Napier grass mixture	17.41	15850.00	910.40
	Total	325.72	146742.00	

1.	Green Fodder	496.02	260935.00	525.16
2.	Dry fodder	4.65	1571.00	337.85
3.	Grand Total	500.67	262352.00	

Production and Productivity of Grain crops during 2022 (*Rabi* 2021-22 and *kharif* 2022)

S. No.	Crop	Area (ha.)	Average Yield (q./ha.)	Total Production (q.)
1.	Wheat	102.65	48.29	4956.75
2.	Mustard (C. cabbage)	8.10	6.20	50.20
3.	Oats (Kent)	39.66	13.53	536.60
4.	Maize (J-1006)	3.24	23.15	75.00

Production and Productivity of Straw during 2022 (Rabi 2021-22)

S. No.	Crop	Area (ha.)	Average Yield (q./ha.)	Production (q.)
1.	Oats Straw	39.66	30.85	1223.55
2.	Wheat Straw	102.65	24.26	2490.10
Total		142.31	55.11	3713.65

Monthly Fodder Supply to LRC during 2022

Month	Green Fodder (q.)	Dry Fodder (q.)	Total (q.)
January	26061.00	-	26061.00
February	22585.00	-	22585.00
March	25631.00	91.00	25722.00
April	20745.00	63.00	20808.00
May	18346.00	-	18346.00
June	19771.00	-	19771.00
July	23025.00	-	23025.00
August	24007.00	-	24007.00
September	21865.00	-	21865.00
October	20462.00	-	20462.00
November	18230.00	-	18230.00
December	19023.00	1417.00	20440.00
Total	**2,59,751.00**	**1571.00**	**2,61,322.00**

Cost of Fodder Supplied to LRC during 2022 (*Rabi* 2021-22 & *Kharif* 2022)

S. No.	Crop Name	Quantity (q.)	Rate (Rs. /q.)	Amount (Rs.)
1.	Green fodder	259751.00	160/-	41560160.00
2.	Dry Fodder	1571.00	120/-	188520.00
3.	Straw	3713.65	550/-	2042507.50
	Total			43791187.50

Revenue generation at Forage Production Section by sale and supply of seeds/saplings/FYM (2022)

S. No.	Kind	Supplied (Kg.)	Sold (Kg.)	Rate per Kg.	Amount (Rs.)
1.	Oats Seed	5184	-	40/-	207360.00
2.	Oats seed	-	80000	40/-	3200000.00
3.	Oats Seed	5600	-	15/-	84000.00
4.	Oats Seed	-	1548.50	40/-	69380.00

5.	Oats seed	6001.00	-	40/-	240040.00
6.	FYM Lose	-	1650.00	1/-	1650.00
7.	Napier Root	-	1775.00	2.00/- Root	3550.00
8.	Fuel wood (below 6" dia)	-	50.00	5.00/-	250.00
10.	Mustard (C. Cabbage)	-	19.90	100/-	1990.00
11.	Mustard (C. Cabbage)	2.00	-	100/-	200.00
		Total			3808420.00

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. During the year under report 4956.75 q. seed of improved varieties of Wheat crop was produced, 41696.00 q. green fodder, 2490.10 q. Bhusa were also produced. Total calculated cost of Green Fodder and Bhusa is Rs. 8040915.00, Seed is Rs. 12986814.00 and revenue generated by sale of seeds is Rs.13061814.00 under Revolving fund scheme on Seed Production during the report as per details given below:

Production and Productivity of Forage Crops in term of Green Fodder and Dry Fodder in Revolving Fund Scheme (Rabi 2021-22 & Kharif 2022)

S. No.	Crop	Area (ha.)	Production (q.)	Average yield (q./ha.)
1.	Jowar (Multi cut)	20.04	10427.00	520.31
2.	Maize	55.43	23977.00	432.56
3.	Jowar (Single cut)	9.86	2837.00	287.73
4.	Maize + Cowpea	9.57	4455.00	465.52
5.	Bhusa	102.65	24901.10	24.25

Production and calculated cost of green fodder and bhusa at RFS, seed production and supplied to LRC by Forage Production Section (Rabi 2021-22 & Kharif 2022)

S. No.	Kind of Fodder	Production (q.)	Rate (Rs./q.)	Calculated cost (Rs.)
1.	Green Fodder	41696.00	160/-	6671360.00
2.	Bhusa	2490.10	550/-	1369555.00
	Grand Total	44186.10	-	**8040915.00**

Total Revenue Generation by sale/ supply of seed under RFS (Seed Production) 2021-22

S. No.	Kind	Quantity (q.)	Rate (Rs./q.)	Amount (Rs.)
1.	Wheat Seed	4956.75	2518.75	12484814.00
2.	Oats seed	14.75	4000/-	59000.00
3.	Mustard C. cabbage	50.00	10000/-	500000.00
4.	Mustard C. cabbage	1.10	10000/-	11000.00
5.	FYM loose	70.0	100/-	7000.00
	Grand Total			**13061814.00**

Total calculated cost of fodder supplied to LRC is Rs. 43791187.50 and total revenue generation by sale/ supply of different item at FRMC is Rs. 3808420.00 and seed under RFS is Rs. 13061814.00. The total revenue generated was Rs. 6,06,61,421.50.

EXPERIMENTAL DAIRY

Experimental Dairy was setup 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 2022. Experimental dairy manufactured and sold Skimmed Milk Powder (Roller)-19772.0 Kg., Pasteurized table butter (200 gm)-1259 Pkt, Ghee 15077.0 kg, Paneer 32477.75 kg, Kalakand-31369.0 kg, Ice–cream (100 ml)-35777 cups, Flavoured Dairy Drink (200 ml)-214764 pkts, Processed Cheese Slices (200 gm)-1017 Pkt, Gulab Jamun Mix 4154.0 kg. Pizza Cheese (200 gm)-1993 Pkt, Cheddar Cheese 17.5 kg, Khoa – 338.0 kg, Mozzarella Cheese-1.5 kg, and Cooking Butter-12.5 kg.

Experimental Dairy provides facilities for practical, 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. Eleven students from several institutions were provided practical training during the year 2022 in the experimental dairy. During the year, initiatives were taken to curtail the use of single use plastic material in packaging of milk products. Accordingly, paper cups were used in place of plastic cups for filling and selling of ice-cream at milk parlour.

This self-sustaining Experimental Dairy has been running under Revolving Fund Scheme since 1989-90. Revenue generated under the scheme is being utilized for development of infrastructure and maintenance of this dairy. The revenue generated from the sale of milk and milk products during the year 2022 was Rs.5,45,35,345.00/-.

COMPUTER CENTRE

The Computer Centre was established in 1982 with the aim to provide scientific data processing facilities to scientists and research scholars of the Institute. Over the years, the Centre has expanded its activities in line with the rapid advancements in ICT field to face the new challenges. The Centre has by now successfully inculcated Computer culture in the Institute by organizing training programmes/ workshops. The activities of Computer Centre are being carried out through three units namely Data Processing Unit; Teaching & Training Unit and Computer maintenance Unit besides AKMU Cell and BTIS Sub Centre. The Centre is enjoying ASRB Lab and PC Lab where more than 130 systems are currently working and well equipped with an i3/i5, heavy duty Line Matrix Printer and software like MATLAB, SYSTAT etc. NKN Connectivity 1 GBPS link with more than 300 Mbps speed is provided at NDRI offices and library. The network is utilized for various official purposes. Apart from this, the library is providing Internet/ Email Services to students, faculty members and other staff members of the institute. For this purpose there are 40 work-stations available in the library, so that they may got current information in the area of their interest and communicate with the researchers of their interest immediately. Server room, web server and mail server for smooth internet functioning of NDRI are also maintained.

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 97,758 volumes which include books, bound journals, theses, standards and annual reports. In addition of that 1491 e-books of different foreign and Indian publishers were made available for perpetual access at NDRI Campus up to December 2022. 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 Computerised 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.

CeRA usage report (2022)

1.	Total Hits	20156
2.	Total Logins/ Sessions	1402
3.	Searches	10558
4.	Full Text / Abstract Views	3348
5.	ILL Requests/ Enquiries	70
6.	TOC Browsing	2722
7.	Profiles Created	28
8.	Others	2027

The Library provides instant Document Delivery Services to users of ICAR sister Institutes, State Agricultural Universities and other participating Institutions on their request. During 2022, Out of 136 no. document delivery requests received from ICAR Institute/ State Agriculture Universities, 101 requests were fulfilled.

The Library is also an active partner of Agricat (a sub-portal under WorldCat). Presently 54,803 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.

Presently the Library has 6650 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

The Communication Centre works as a Central facility of the Institute, which includes audio -video recording & editing, dubbing & mixing for the faculty, students & Staff. Photo & video coverage of 257 events of the Institute consisting of National seminars, Workshops, meetings, conferences, cultural programme, Cattle shows, Kisan Sangoshties, Exhibition & other functions of the institute were carried out.

Number of programmes and Revenue Generation

S. No.	Facilities	No. of programme	Re-venue generated in Rs.
1.	Dr. D. Sundaresan Auditorium	08	236000.00
2.	Dr. N.N. Dastur Auditorium	49	-
3.	Pinaki & Jayanti Hall	31	-

Exhibitions Organized

S. No.	Date	Subject	Place
1.	08.03.2022	Exhibition and Mahila Diwas	Organised by NDRI at Vill. Sanghoi, Karnal, HR
2.	15-17.04.2022	Pashu Arogya Mela	Motihari, Bihar
3.	12-15.09.2022	World Dairy Submitt-2022	India Expo Centre & Mart, Greater Noida (UP), Delhi.
4.	12.10.2022	Kisan Mela	Sugar Cane Institute, Karnal
5.	17-20.10.2022	112th All India Farmers Fair and Agro-Industrial Exhibition-2022	Panth Nagar. U.K.
	05.11.2022	Sthapna Diwas of Shree Lohsidh Hanuma and Kisan Mela	Gomukh Gaushala, Garhkhal Talla banasa, Uttarakhand
6.	11-13.11.2022	Exhibition and Farmers training "Krishi Mela and "Agri Exhibition"	Morena, M.P.
7.	23.12.2022	Kisan Diwas and Krishi Mela	KVK, NDRI, Karnal, HR
8	30.12.2022	Krishi Shiksha Diwas	Organized by NDRI, Karnal at Vill. Sultanpur, Karnal, HR

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 to provide maintenance services of all kinds to the whole institute. The following works/ functions are included in the mandate of Maintenance Engineering Section.

- Operation and Maintenance of the water supply through bore wells and water supply lines throughout campus & 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 Engineering, 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 woks 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.
- IX To process the cases of House Building Advances of the employees & 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 of the inventory by maintaining Civil and Electric stores.
- To monitor solar power generation through 1.0 MW rooftop solar power plant and to keep liaison with solar power producer.

MODEL DAIRY PLANT

A state-of-the-art commercial Dairy Plant was established in 1996 at National Dairy Research Institute (NDRI), Karnal through the financial assistance and installed on turnkey basis by the National Dairy Development Board (NDDB). The Plant has been designed to handle 60,000 liters of milk per day initially and is presently handling 1,40,000-1,50,000 liters per day. Model Dairy Plant (MDP) is presently certified under the Food Safety Management System ISO 22000:2018.

Training to the Students

Model Dairy Plant provides In-plant training to the fourth 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, 632

students were trained at MDP. Students were 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 were 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.

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 1.32 lacs 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 1,45,000 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 45-50 metric tons per month. All the Ghee manufactured at MDP was being sold through the MDP Sale Counter.

Cheese and Paneer

MDP is also engaged in training students in manufacturing of Cottage Cheese, Processed Cheese, and 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 February 14, 2015 and developed by the students of batch 2010-14. Total Sale of Pinni was 55.0 metric tons from January, 2022-March, 2023.

Highlights of the year (2022)

- Self-Cleaning Cream Separator of 10 KL installed.
- High Speed Milk Packing Machine installed.

18. REGIONAL CAMPUSES

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 20221, 51 students registered for their PGDFSQM at SRS.

EXTENSION ACTIVITIES

Events/ Seminar Conducted

- One day Workshop on 'Augmentation of Milk Productivity and Quality in Dairy Cattle' was organized for the benefit of Field Veterinarians and Extension Officers from Karnataka Milk Federation by SRS of ICAR-NDRI in association Indian Dairy Association, South Zone, Bengaluru on March 28, 2022.

- One day Farmers Training Workshop on "Entrepreneurship Development through Profitable Dairying" was organized for progressive dairy farmers from Chamarajnagar, Bellary Districts of Karnataka State by SRS of ICAR-NDRI in association with Bangalore Environmental Trust (BET) on April 27, 2022.

- One day on campus farmers training programme on 'Scientific Dairying and Value addition to Milk' was organized for the benefit of 50 SC farmers under SCSP Project on May, 21, 2022 at SRS of ICAR-NDRI.

- One day training cum demonstration on 'Improving Milk Production, Milk Quality and Clean Milk Production' was organised for the benefit of dairy farmers, Secretaries and milk testers of Dairy Cooperative Societies of Malur Division, Kolar District of Karnataka Cooperative Milk Producer's Federation Ltd (KMF) on July 22, 2022 under SCSP funded IRC project.
- One day on campus farmers training programme on 'Scientific Dairy Farming Practices' was organized for the benefit of 55 farmers from Kanakapura Taluk under Farmers FIRST Project on July 27, 2022 at SRS of ICAR-NDRI.
- One day mid-career orientation training program on 'Dairy Development' was organised for the benefit of Assitant Audit Officers, IA&AD, Bengaluru at SRS of ICAR-NDRI on September 23, 2022.

- One day Farmers Training programme on 'Quality Milk Production Practices' was organised under SCSP project for the benefit of 105 SC farmers on the occasion of 'Farmers Day' on December 23, 2022 at Malur Camp Office of Kolar Milk Union Ltd, Kolar District of Karnataka State.
- Advisory services rendered during the period under report, comprised the information needs of the 188 dairy farmers/ progressive farmers/entrepreneurs, who sought technical advice for their proposed initiatives in dairying and the on-going dairy farming activities, in the areas of Management of dairy cows, Improved fodder varieties, Preparation of new milk products, Information on market access for milk products, Information on dairy start-ups, Indigenous breeds of the region, Technical advice on scientific dairy farming, Management of indigenous dairy cattle, Hydroponic green fodder production, Preparation of milk & milk products, Indigenous cattle management for organic farming, Commercial dairy farming, Improved green fodder production, Cattle feed formulation for balanced feeding, Milk processing / preparation of indigenous products, Food regulatory issues, Guidelines for export of dairy products, Good management practices for commercial dairy farming and Silage making for green fodder conservation.


- Visits organized - The profile of visitors visited the institute, during the period under report included 1393 numbers in 31 batches, comprising students from various educational institutes, farmers, entrepreneurs, extension officers and government officials from different parts of Karnataka and adjacent States. The visitors were briefed about the on-going institute activities, were taken around the institute as per their needs and were briefed on the research and extension activities.

Empowerment of Women and Mainstreaming of Gender Issues

As part of celebration of 'Azadi-ka-Amrit Mahotsav' (75 years of India's Independence Celebrations), on the occasion of 'International Women's Day', 30 SC women farmers were sensitised about importance of 'Milk and milk products and adoption of 'Nurtigarden' for nutritional security of them and their family members. The event was or ganized in cooperation with the officials of KOMUL, Kolar and Local DCS at Jinagathimmanahalli village, Kolar District on March 25, 2022.

SERB funded training programme "VRITIKA (Training and Skill Internship)"

The Science and Engineering Research Board (SERB) sponsored VRITIKA (training and skill internship) programme on "Nano-immobilization of enzymes for production of lactose free milk and synthesis of functional ingredients" conducted for two PG students for the period of two months under the scheme "ABHYAAS". Ms. Navya Shree Sangam from University College of Technology, Osmania University, Hyderabad and Ms. KorlapuKousalya from Oil


Technological and Pharmaceutical Research Institute, Ananthapuramu, Andhra Pradesh attended the training programme from May 1 to June, 2022.

EASTERN REGIONAL STATION, KALYANI

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.

EXTENSION ACTIVITIES

Celebration of National Girl Child Day

On January 24, 2022, 'National Girl child Day' was celebrated with focus on importance of proper nutrition and balanced diet for young girl child. A total of 63 farm woman inclusive of 20 girl students actively participated in the event.

Celebration of 'Word Pulses Day'

An online training programme was organized by ERS of ICAR-NDRI and KVK (addl.) Nadia on February 10, 2022. In the training programme scope of pulse crop cultivation in the district was discussed. A total of 65 progressive farmer virtually participated from Banamalipara, Sutra, Mahanala, Ichhapur, Jatrapur, Kalibazer and Huda village of Nadia district.

Celebration of 'International Women Day'

International Women Day was organised at Phulia, in Santipur block of Nadia district on March 8, 2022. In the off-campus programme, 65 women farmers participated. In the programme, different issues pertaining to women empowerment, gender equality and importance of farm women in agricultural farm operation were discussed.

Off campus training cum awareness programme on 'off-season vegetables cultivation technique'

Training cum awareness programme on off-season vegetable cultivation was organized on March 21, 2022 at Bishnupur village of Krishnagar -1 Block in Nadia district of West Bengal. The awareness cum training programme helped the farmers to increase their knowledge about cultivation of off-season vegetable for higher profitability. A total of 35 Progressive farmer participated in this training program.

Extension activities organized under TSP and SCSP

The Institute organized Livestock-cum-Agriculture Mela under both TSP and SCSP Project components of NDRI on March 3, 2022 at Hatrusulganj Football ground, Raipur-Supur Gram Panchayet, Near Bolpur, Birbhum in collaboration with Bolpur Manab Jamin (NGO), Bolpur, Birbhum. Several Direct Benefit Transfers (DBTs) like goats, poultry chicks and ducklings were distributed to large group of ST farmers for boosting the farming system and to enhance the livelihood security, family income and nutritional status of family members. Total of 70 goats, 2400 chicks, 2400 ducklings of elite breeds were distributed to 275 Tribal farmers along with other inputs.



Different extension activities under NEH project

Organization of camp at Arunachal Pradesh under NEH project

Scientists of ERS-NDRI, Kalyani trained 66 needy beneficiary farmers of Arunachal Pradesh on "Scientific pig farming" in a programme organized on 7th September 2022 at KVK complex, Namsai. 23 farmers were also distributed with piglets (one each), pig feed (76 kg/ farmer), feeders and waterers, mineral mixture, medicines and first aid kit etc. to boost the farming. Old beneficiary pig farmers (43) were also provided with pig feed (76 kg/farmer), feeders and waterers to improve the growth performance of their pigs.

Earlier beneficiary farmers adopted by ERS-NDRI 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 transfers and they increased profit by 131.3%.

Organization of camp at Assam under NEH project

ICAR-NDRI, ERS, Kalyani, West Bengal organized programmes on "Livelihood improvement through livestock interventions" at Chapar, Dhubri, in collaboration with KVK, Dhubri, Assam on 8th March, 2022. A total of 47 Beetal crossbred Male goats were distributed to 47 goat keepers and 51 piglets (Hampshire and Ghungroo) to 51 pig farmers. Goat feed, minerals mixture, medicines, vitamins and veterinary first aid kit etc. were also distributed to the beneficiary farmers. A total of 101 dairy farmers were given cattle feed, minerals mixture, medicines, vitamins etc. to enhance the productivity of dairy animals. Goat feed, minerals mixture, medicines, vitamins, veterinary first aid kit etc are distributed. A total of 68 dairy farmers were given cattle feed minerals mixture, vitamins, medicines etc.

Livestock Development Programme at Tripura for adopting goat farming in scientific way to increase livelihood security

Two programme were organized at Tripura during the year. The first programme was organized by ICAR-NDRI, ERS, Kalyani, West Bengal on "Livelihood Improvement NEH Farmers through Livestock Interventions" at the Grampanchayet of South Bagma, Udaipur district, Tripura on 15.03.2022 under NDRI-NEH Project Component in collaboration with Bagma Agri Producers Company Ltd, Udaipur, Tripura. A *Scientists-Farmers' Interaction-cum-*

Training (off-campus) programme on livestock rearing at the area was conducted where more than 150 NEH farmers participated. Animal husbandry inputs viz. live goats (30 nos, 10-12 kg body weight), piglets (30 nos, 10-12 kg body weight), chicks (1000 nos, 35 days old), feed for goat (1500 kg), pig feed (1500 kg), poultry feed (2500kg) and cattle feed (2500kg) were distributed among the farmers.



The second programme was organized by ICAR-NDRI, ERS, Kalyani, West Bengal on "Livelihood Improvement NEH Farmers through Livestock Interventions" on 28.09.2022 at the KVK Dhalai district, Tripura in collaboration with KVK Dhalai, Tripura. During the programme Scientist-farmer's interaction meet cum training programme of tribal farmers. Animal husbandry inputs viz. live goats (55 nos), feed for goat (2750 kg), Feeder, Waterer, supplements and mineral mixure were distributed among 55 farmers.

ICAR-KVK (ADDITIONAL), NADIA, NDRI-ERS, KALYANI

Training

In total, 1192 farmers, 131 rural youth, and 40 extension personnel were trained in scientific cultivation practices for cereal, oilseed, pulse, vegetables, fruits, tubers, floriculture, plantation, and fodder crops. Training programme on livestock farming, such as scientific dairy and goatery farming, was also imparted for livelihood security. Capacity building programme was also conducted for tribal women's for duckery and poultry rearing. Training on secondary agricultural interventions such as beekeeping, mushroom cultivation, and cut flower production were also organized.

Table: Training programmes for farmers, rural youth and extension personnel

Target group	No. of training	Male	Female	Total
Farmers	42	430	554	1192
Youth	6	41	90	131
Extension personnel	1	20	20	40
Total	49	591	664	1263

On farm testing (OFT)

Three trials were conducted on fodder sorghum (NFSH-4), late seasonal tomato performance, and leaf curl tolerant chilli cultivars. In total 40 numbers of farmers were involved in the trails.

Title of OFT	Technology options (TO)	Participants	Results
Cultivation of Fodder sorghum for augmenting milk production	TO 1: Cultivation of MFSH-4 + Bio pesticide treatment TO 2:Cultivation of PC-23+treatment of bio pesticides	20	MFSH-4 was found superior with fodder yield of 45.3 t/ha with B:C ratio of 1.34:1
Evaluation of late season tomato cultivation under Nadia climatic condition.	TO-1: ArkaRashask TO-2: ArkaAbhed TO-3: Himsekhar (F1 seed) TO-4: Saaho (F1 seed)	10	Saaho (F1 seed) was found superior among all other varieties for late seasonal cultivation with yield of 26.35 t/ha with B:C ratio of 1.89:1

Evaluation of leaf curl virus tolerant Chilies	CLV tolerant chilies variety TO-1: Arkasweta TO-2: ArkaTejaswi TO-3: ArkaMeghana TO-4:ArkaSanvi	10	Arkasweta was found superior among all other varieties (yield 9.2 t/ha B:C ratio 1.74:1) in terms tolerance of leaf curl virus

OFTs were conducted in farmers fields in various locations in Nadia district based on various identified problems. The OFT on green fodder sorghum cultivation was successfully evaluated in 20 farmers field. Sorghum variety-MFSH-4 was found to be superior, with a fodder yield of 45.3 t/ha, and it has a positive effect on increasing milk production and improving milk quality parameters. The evaluation of late seasonal tomato cultivation was conducted with four tomato varieties and only two varieties, Himsekhar and Saaho (26.35 t/ha), performed well during the late season.TheOFT on cultivation leaf curl virus (CLV) free chilli was conducted in five different locations with CLV tolerant varieties of IIHR-Bangalore. Among these, Arkasweta (9.2 t/ha) and Arka Tejaswi performed well and significantly more tolerant on leaf curl virus disease.

Front line Demonstration (FLD)

A total of 8 FLD programmes were carried out in order to popularize proven technology among the farming community.

Title of FLD	Technology demonstrated	Benefited farmers	Results
Cultivation of Maize fodder crop through improved package of Practices	Variety J-1006	60	Yield (35.1 t/ha)
Popularization of Indian mustard variety NRCHB-101 for enhancing oilseed production	Improved practices (NRCHB 101)	80	Ongoing
Popularization of Elephant foot Yam	Variety: Bidhan Kusum	40	Yield (37.5 t/ha)
Popularization of Bio-fortified Sweet Potato	Variety: Bhu-Krishna	120	Ongoing
Popularization of short duration Green gram variety	Variety: Virat	75	Yield (0.9 t/ha)
Scientific cultivation practice of Blackgram	Variety: PU-31	90	Yield (1.115 t/ha)
Promotion of bio-fortified rice variety	CR dhan 310 and CR dhan-311	42	Ongoing
Popularization of Nanourea use in *kharif rice* cultivation for improving nitrogen use efficiency	Spraying Nano urea by replacing top dressing granular urea use	57	Yield 4.95 t/ha

In total eight (08) numbers of FLD programmes were conducted to popularize proven technology among the farming community. The FLD on fodder maize, elephant foot yam, nano urea use in rice and scientific black gram cultivation was the most popular. Other FLDs, such as high yielding mustard, bio-fortified rice (CR dhan 310 and CR dhan-311) and sweet potato (Bhu-krishna), are performing well and are in high demand among local growers. Farmers also liked the FLD on short-duration green gram (Virat).

Cluster Frontline Demonstration (CFLD) Programme on Pulse (Lentil)

A cluster frontine demonstration programme was conducted in Chakdah, Ranaghat, Krishnanagar, and Nakashipara blocks, involving 81 farmers and covered an area of 14.66 ha. The objective of the programme was to popularize high yielding fortified lentil variety (L 4717) among the farming community of Nadia district. Seeds, liquid fertilizers, herbicides, and pesticides were also distributed to selected farmers through the CFLD programme.

Special Events Organized

Special events and flagship programmes such as Swachha Bharat Abhiyan, Mahila Kisan Diwas, PM Kisan Samman Sammelan, World Soil Day Celebration, Kisan Samman Diwas, and Krishi Mela under Jal Shakti Abhiyan were also organized time to time.

Livestock Farm

Annual performance of ERS-NDRI, Kalyani Herd

Production & Reproductive Performance of Cattle at ERS- NDRI Herd during 2022

Particulars	Jersey Cross
Herd Strength as on 31-12-2022	200
Total Milk Production (Kg)	173595
Average number of Cows in Milk/Day	63
Average number of Cows Dry/Day	20
Wet Average (Kg)/Day	7.65
Herd Average (Kg)/Day	5.83
Age at First Calving (Month)	37.60
No. of Inseminations	233
No. of Pregnant Cows	78
Conception Rate (%)	33.50
Service Period (Days)	113
Inter-Calving Period (Days)	466
Mortality (%)	5.50

Milk Production Performance at ERS-NDRI, Kalyani herd during 2022

Months	Milk Production (Kg.)	Wet Average (Kg.)	Herd Average (Kg.)	Average FAT %	Average SNF %
January	14492.5	6.63	5.00	5.00	9.04
February	13547.5	7.27	5.51	5.01	9.02
March	14494.5	7.65	5.88	4.70	9.06
April	13556.0	7.55	5.50	4.73	8.88
May	14781.5	7.54	5.62	4.60	8.77
June	14872.5	7.76	5.74	4.53	8.78
July	15989.0	8.00	5.86	4.61	8.84
August	15498.5	7.60	5.62	4.67	8.84
September	15335.0	7.93	6.32	4.88	8.78
October	13770.0	8.29	6.48	4.76	8.81
November	13247.5	7.83	6.22	4.78	8.87
December	14010.5	7.71	6.23	5.10	9.03
Total Milk	**173595.0**	-	-	-	-
Overall Average	**14466.250**	**7.65**	**5.83**	**4.78**	**8.89**

Forage Farm

Forage Farm section is engaged in cultivation of quality fodder crops in 30 hectares area and manages harvesting and supply of fodder crops either chaffed or unchaffed to the Cattle Yard. 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. 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.

Fodder production and supply to the Institute Farm, ICAR-NDRI-ERS, Kalyani, during 2022

Particulars of fodders	Quantity (Qtl.)
Maize/ Maize + Cowpea/ Maize + Guinea	2108.25
Sorghum/ Sorghum + Cowpea/ Sorghum + Rice bean/ Sorghum + Guinea	3614.80
Oats/ Oats + Mustard/ Oats + Guinea	3230.50
Berseem/ Berseem + Mustard	1159.85
Cowpea/ Cowpea + Guinea, Bajra	2422.90
Hybrid Napier Grass/ Guinea Grass/ Para Grass/Hybrid Napier Grass + Guinea	442.50
Total	**12978.80**

Library

The Library of ERS contains 1818 books, 4078 volumes of bound journals and other periodicals in the field of Dairying.

Academic Cell

M.Sc./ M.V. Sc. and Ph. D. students of different disciplenes like Animal Nutrition, Livestock Production & Management, Animal Physiology, Animal Reproduction, Animal Biotechnology, Animal Genetics & Breeding and Dairy Extension are alloted to pusue ther disseration/ research work at Eastern Regional station, Kalyani. During the year 2022, ten Master degree students and two Ph.D. students have successfully completed their thesis works and awarded the respective degrees. Presently,six Master degree students and twenty Ph.D. students are pursuing their research work. Other than academics, some sports and literary acivities were organized in which students took keen interest.

Resource Generation during 2022

S. No.	Heads	Amount (Rs.)
1.	Sale of Milk	3389829.00
2.	Sale of seed	11487.00
3.	Rent of guest house	32100.00
4.	Sale of Semen straws	72232.00
5.	Sale of goat	70480.00
6.	Sale of cows	701000.00
7.	Training fees	240000.00
8.	Miscellaneous	435696.00
	Total	49,52,824.00

19. BUDGET AND EXPENDITURE

The financial outlays in terms of actual expenditure for Grants for the year 2022-2023 was Rs. 25218.86 lakhs and the sanctioned budget for Grants in 2021-2022 was Rs. 25218.86 lakhs. These figures include the financial outlays for Regional Stations.

Financial Outlays & Expenditure of National Dairy Research Institute, Karnal (including ERS Kalyani and SRS of Bangalore) during 2022-2023

(Rs. in Lakhs)

Particulars	RE/ Budget 2022-23	Expenditure 2022-23
Grant-in-Aid Capital	408.00	408.00
Grant-in-Aid General	3710.00	3710.00
Non Scheme GIA-General	283.82	283.82
Total (Capital + General)	**4401.82**	**4401.82**
Grant-in-Aid Salary	9589.49	9589.49
Grant-in-Aid Pension	11227.55	11227.55
Total (Salary + Pension)	**20817.04**	**20817.04**
Grand Total	**25218.86**	**25218.86**

Revenue Generation

The Revenue Receipts of the Institute and the Regional Stations for the year 2022-23 were Rs.1034.36 lakhs.

(Rs. in Lakhs)

S. No.	Head of Account	Amount
1.	Sale of Farms Produce	270.69
2.	Sale of Livestocks	96.77
3.	Licence Fee	86.75
4.	Interest earned on Loans and Advances	8.69
5.	Leave Salary and Pension Contribution	15.15
6.	Analytical and Testing Fee	6.89
7.	Application fee from candidates	0.63
8.	Interest earned on short term deposits	56.85
9.	Income generated from Internal Resource Generation	22.39
10.	Recoveries of Loans and Advances	36.18
11.	Miscellaneous Receipts	433.37
	Grand Total	1034.36

Position of Manpower at NDRI, Karnal and its Regional Stations as on December 31, 2022

Type of Posts	Sanctioned/ Approved Posts	In-Position Posts	Vacant Posts
Director	1	1	0
Joint Director	2	1	1
Scientific	190	140	50
Administrative (Group: A&B)	50	42	8
Technical	336	165	171
Administrative (Group: Non-Gazetted)	92	77	15
Supporting	384	248	136
Total	1055	674	381

20. राजभाषा गतिविधियां – 2022

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल की विभिन्न राजभाषा गतिविधियां–2022

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। संस्थान के द्वारा वर्ष 2022 में निम्नलिखित गतिविधियों का आयोजन किया गया।

संस्थान राजभाषा कार्यान्वयन समिति की बैठकें

1. संस्थान राजभाषा कार्यान्वयन समिति की 94वीं तिमाही समीक्षा बैठक दिनांक 15.03.2022 को कोविड संबंधी निर्देशों की पालना के साथ संस् थान में आयोजित की गयी। इस बैठक में संस्थान की विभिन्न हिन्दी प्रतियोगिताओं (2021–22) के मूल्यांकन समिति गठन हेतु कार्रवाई करने, प्रभारी, राजभाषा एकक द्वारा प्रभागों/अनुभागों/केन्द्रों का रूटीन/औचक राजभाषा निरीक्षण जारी रखने एवं बेंगलूरू/कल्याणी क्षेत्रीय केन्द्रों की तिमाही प्रगति रिपोर्ट की समीक्षा कर पत्र के माध्यम से उन्हें सूचित करने, आगामी प्रबंध मंडल की बैठक की कार्यसूची (एजेण्डा) का प्रस्तुतीकरण (प्रजेन्टेशन) द्विभाषी/हिन्दी में तैयार करने, विभिन्न परियोजनाओं एवं संस्थान बजट के अंतर्गत की जाने वाली भर्ती परीक्षा के संक्षिप्त विज्ञापन तथा अन्य सभी विज्ञापनों जैसे नीलामी, निविदा आमंत्रण आदि को द्विभाषी तैयार कर समाचार पत्रों/वेबसाइट पर प्रकाशित करने, 2022–23 में संस्थान के द्वारा एक राष्ट्रीय स्तर की हिन्दी तकनीकी वैज्ञानिक संगोष्ठी आयोजित करने एवं मंत्रालयिक कर्मचारियों को हिन्दी नोटिंग में आने वाली समस्याओं के निराकरण के लिए उन्हें यथोचित मात्रा में हिन्दी भाषा में उपलब्ध नियमों की पुस्तकें पर्याप्त संख्या में खरीद कर संबंधितों को जारी करने का निर्णय लिया गया।

2. राजभाषा कार्यान्वयन समिति की 95वीं तिमाही समीक्षा बैठक दिनांक 22.04.2022 को कोविड संबंधी निर्देशों की पालना के साथ संस्थान में आयोजित की गयी। बैठक में राजभाषा हिन्दी के प्रचार, प्रसार एवं कार्यान्वयन संबंधी सभी बिन्दुओं पर चर्चा की गई जिसे कार्यवृत्त के माध्यम से सभी प्रभागाध्यक्षों एवं अनुभागाध्यक्षों को कार्रवाई किए जाने हेतु प्रेषित किया गया।

3. संस्थान राजभाषा कार्यान्वयन समिति की 01 जुलाई से 30 सितंबर, 2022 तक की 96वीं तिमाही समीक्षा बैठक दिनांक 23.07.2022 को आयोजित की गयी। बैठक में संस्थान के 14 पदाधिकारी शामिल हुए।

4. डा. धीर सिंह, निदेशक, भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल की अध्यक्षता में संस्थान राजभाषा कार्यान्वयन समिति की 01 अक्तूबर से 31 दिसंबर, 2022 तक की 97वीं तिमाही समीक्षा बैठक दिनांक 29.12.2022 को पूर्वाह्न 10.30 बजे के साथ संस्थान के पिनाकी सभा कक्ष में आयोजित की गयी। बैठक में संस्थान के 11 पदाधिकारी शामिल हुए। बैठक के दौरान समिति ने उन सभी बिन्दुओं पर चर्चा की जहां हिन्दी के कार्य में गति लाने की आवश्यकता थी।

हिन्दी कार्यशालाएं, संगोष्ठियां एवं प्रशिक्षण

1. राजभाषा हिन्दी: प्रचार–प्रसार एवं कार्यान्वयन विषय पर आयोजित की गई एक दिवसीय हिंदी कार्यशाला में संस्थान के अनेक तकनीक, प्रशासनिक श्रेणी के अधिकारी एवं कर्मचारी सम्मिलित हुए। इस अवसर पर राजभाषा नियम 1976 तथा राजभाषा अधिनियम 1963 के नियमों एवं धाराओं की विस्तार से चर्चा की गई।

2. संस्थान के में हिन्दी में टाइपिंग का प्रारंभिक एवं पुनः चर्चा प्रशिक्षण कार्यक्रम विषय पर दिनांक 25.05.2022 से 27.05.2022 तक 03 दिन का आयोजन किया गया जिसमें 08 कर्मचारियों ने हिन्दी टाइपिंग का प्रशिक्षण लिया।

3. भाकृअनुप के संस्थानों के प्रशासनिक कर्मचारियों हेतु पांच दिवसीय कार्यशाला विषय पर दिनांक 30.05.2022 से 03.06.2022 तक 05 दिन का आयोजन किया गया। इस अवसर पर उप निदेशक (राजभाषा) ने राजभाषा हिन्दी के समग्र प्रचार, प्रसार पर व्याख्यान दिए। इस कार्यशाला में 80 से अधिक प्रतिभागी सम्मिलित हुए।

4. राजभाषा हिन्दी–नीति, नियम, अधिनियम एवं कार्यान्वयन विषय पर तिमाही हिन्दी कार्यशाला का आयोजन किया गया जिसमें 24 अधिकारी एवं कर्मचारी शामिल हुए।

5. संस्थान में दिनांक 27.12.2022 को "यूनिकोड/कंप्यूटर हिन्दी टेबल कार्यशाला" विषय पर तिमाही हिन्दी कार्यशाला का आयोजन किया गया जिसमें 14 अधिकारी एवं कर्मचारी शामिल हुए।

हिन्दी दिवस/हिन्दी उल्लास महोत्सव एवं वार्षिक पुरस्कार वितरण समारोह

संस्थान में हिन्दी दिवस से प्रारंभ कर दिनांक 20.09.2022 से 16.11.2022 तक की अवधि में राजभाषा हिन्दी उल्लास महोत्सव का आयोजन किया गया। इस महोत्सव के दौरान हिन्दी श्रुतलेखन प्रतियोगिता (22.09.2022), हिन्दी निबंध लेखन प्रतियोगिता (24.09.2022), हिन्दी टिप्पण/आलेखन प्रतियोगिता (27.09.2022), वैज्ञानिकों तथा विद्यार्थियों के लिए हिन्दी शोध पत्र पोस्टर प्रदर्शन प्रतियोगिता (29.09.2022), हिन्दी टंकण प्रतियोगिता (06.10.2022), हिन्दी सामान्य ज्ञान एवं शब्दार्थ प्रतियोगिता (07.10.2022), का आयोजन किया गया। सितंबर, 2022 माह में संस्थान के दक्षिणी क्षेत्रीय केन्द्र, बेंगलूरू एवं पूर्वी क्षेत्रीय केन्द्र, कल्याणी के द्वारा भी हिन्दी दिवस/सप्ताह का आयोजन किया गया।

राजभाषा के उत्कृष्ट कार्यान्वयन संबंधी पुरस्कार/उपलब्धियां

1. संस्थान को मिला हिंदी का राजर्षि टंडन पुरस्कार

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल को भारतीय कृषि अनुसंधान परिषद, नई दिल्ली का वर्ष 2020–21 का राजर्षि टंडन राजभाषा (प्रथम पुरस्कार) प्राप्त हुआ है। यह पुरस्कार राष्ट्रीय कृषि विज्ञान अकादमी के ए.पी. शिंदे सभागार में केंद्रीय कृषि एवं किसान कल्याण मंत्री, श्री नरेंद्र सिंह तोमर जी से संस्थान के निदेशक डा. मनमोहन सिंह चौहान ने ग्रहण किया।

2. एनडीआरआई को गृह मंत्रालय, भारत सरकार का उत्तर क्षेत्र का क्षेत्रीय राजभाषा पुरस्कार

भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल, नराकास को उत्तर–1 "क" क्षेत्र के नगर राजभाषा कार्यान्वयन समितियों में भारत सरकार के राजभाषा विभाग द्वारा वर्ष 2020–21 का प्रथम पुरस्कार तथा वर्ष 2021–22 का द्वितीय पुरस्कार प्रदान किया गया है। इन पुरस्कारों को डा. धीर सिंह, निदेशक, भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल एवं अध्यक्ष, करनाल, नराकास तथा श्री धीरज शर्मा, उप निदेशक (राजभाषा) ने भारत सरकार के गृह मंत्रालय के संयुक्त सचिव, राजभाषा विभाग से अमृतसर के गुरूनानक देव विश्वविद्यालय के दशमेश सभागार में प्राप्त किए। इसके अलावा, भारत सरकार के 50 से अधिक स्टाफ संख्या वाले कार्यालयों में भाकृअनुप–राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल को वर्ष 2020–21 के दौरान का द्वितीय पुरस्कार भी प्राप्त हुआ है।

वर्ष 2022 के दौरान संस्थान की राजभाषा संबंधी प्रमुख गतिविधियां:

- संस्थान की हिन्दी की चारों तिमाही बैठकें प्रत्येक तिमाही में एक–एक कर आयोजित की गयी।
- नराकास, करनाल का सचिवालय होने के कारण नगर राजभाषा कार्यान्वयन समिति की जून, 2022 तथा दिसंबर, 2022 में छमाही समीक्षा बैठक आयोजित की गयी।
- संस्थान में वर्ष के दौरान चार हिन्दी कार्यशालाओं का आयोजन किया गया।
- निदेशक महोदय के हस्ताक्षर से संस्थान के सभी प्रभागों एवं अनुभागों में जांच बिन्दु बनाए गए।
- संस्थान की राजभाषा गृह पत्रिका दुग्ध गंगा का प्रकाशन किया गया।

- संस्थान के सभी वैज्ञानिकों, अधिकारियों एवं कर्मचारियों के नाम से निदेशक महोदय के हस्ताक्षर उपरांत व्यक्तिशः आदेश जारी किए गए।
- संस्थान के 100 से अधिक शोधकर्ता विद्यार्थियों के थीसिस एब्सट्रेक्ट का हिन्दी अनुवाद किया गया।
- संस्थान के लगभग 50 विद्यार्थियों को सप्ताह में तीन दिन हिन्दी की कक्षा के माध्य म से हिन्दी संबंधी बुनियादी जानकारी प्रदान की गयी।
- राजभाषा अधिनियम 1963 की धारा 3 (3) के अंतर्गत आने वाले 400 से अधिक दस्तावेजों को राजभाषा एकक द्वारा द्विभाषी किया गया।
- हिन्दी में प्राप्त सभी पत्रों के उत्तर हिन्दी में दिए गए।
- एनडीआरआई नराकास, करनाल का सचिवालय होने के कारण करनाल शहर के भारत सरकार के 47 कार्यालयों को समय–समय पर सुझाव दिए गए। जब कभी भी भारत सरकार के कार्यालयों में कार्यशाला या प्रशिक्षण कार्यक्रम आयोजित किए गए, उन अवसरों पर व्याख्यान एवं मार्गदर्शन के माध्यम से प्रेरित किया।

21. SWACHH BHARAT ABHIYAN: CLEAN & GREEN NDRI

ICAR-NDRI is religiously pursuing robust initiatives to keep its premises clean and green, apart from mobilising the rural farming community to maintain hygienic and healthy environment of their locations under the novel programme, Swachchh Bharat Abhiyan (SBA) led by the Union Government. This encompasses organising cleanliness campaigns, motivational talks, publications, awareness camps, cycle rally, tree plantation 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 involved as participants to make the planned interventions as 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 2022. 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.

Faculty and students of ICAR-NDRI during Cleanliness Campaign on 02.10.2022

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, DAPSC, ICMR, NIF etc); Dairy Education at Farmers' Doors, Farmers' Farm School and Mera Gaaon Mera Gaurav and gave due emphasis about significance of Swachchh Bharat Abhiyan, thereby inculcating a sense of responsibility for cleanliness among them.

Scientists and villagers at a temple premises in Kailash village of Karnal district on 08.10.2022

Celebration of World Food Day and Cleanliness campaign in Pundri village

ICAR-National Dairy Research Institute, Karnal organised a special swatchhta campaign 2.0 and World Food Day in Pundrak village on October 16, 2022. Before starting the campaign, villagers were sensitised about maintaining clean and hygienic environment and leading 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 including temple 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 the farmers' doors and examined the shelter, feeding and health management practices of dairy animals followed by the farmers. Remedial measures were suggested with respect to queries related to reproductive problems of dairy animals, marketing of milk and various health issues of dairy animals. Farmers were also encouraged to form producer companies and link with urban consumers directly to realise the better price for their produces.

A view of celebration of World Food Day in Pundrak village on 16.10.2022

Special Swachhta Campaign

Each Division/ Section/ Unit in main campus Karnal in Haryana and regional stations at Bengaluru in Karnataka and Kalyani in West Bengal carried out the cleaning, rearranging and other innovative practices involving all the faculty, staff and students daily basis. An innovative approach of maintaining an oxygen park at the NDRI premises could inspire many inmates of campus as well as outsiders after thoroughly cleaning the space.

NDRI carried out 15 special Swachhta campaigns with a total participation of 1250 stakeholders. The faculty educated the villagers and farmers 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.

A view of Oxygen park established in NDRI, Karnal, Haryana

Swachhta Pakhwada activities of NDRI

December 16-31, 2022, ICAR-National Dairy Research Institute, Karnal organized Swachhta Pakhwada from 16.12.2022 to 31.12.2022. Various activities were undertaken including taking pledge, organising farmers interaction meets, celebration of Kisan Diwas, competition for school children and college students and 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 were organized on daily basis. Awareness was created about the clean India campaign among the visiting students (86 numbers) of southern Campus of the Institute of Agriculture and Technology, Vedasanthur, Dindigul district, Tamil Nadu (TNAU affiliated college) on December 17, 2022. Apart from Swachhta pledge, the students and faculty were exposed to the technologies and products of ICAR-NDRI, Karnal. They were taught on maintaining cleanliness in their own localities and surrounding areas.

An awareness about Swachh Bharat Abhiyan was conducted for 200 students of Government Senior Secondary School, Bakhli, Pehowa, Kurushetra district in Haryana on December 21, 2022. They were explained about importance of celebrating the Swachhta Pakhwada, maintaining cleanliness among students, school and surroundings, good academic habits, NDRI technologies and other advisories, which are useful for their career and life.

A debate programme was organized by ICAR-National Dairy Research Institute, Karnal-132001, Haryana on 22.12.2022 on the topic "Swachh Bharat is the engine for transforming India's picture at global stage as developed nation". Students from Government Senior Secondary School, Sangoha, Karnal participated in the debate and presented their views for and against the debate motion. The debate provided scope to the students to present their views on the mentioned topic and helped to create awareness among them. Participants highlighted the success of the swachhta program and its larger penetration in the society by changing group attitude which is beneficial for the society. The programme was coordinated by Dr K.Ponnusamy, Nodal Officer, Swachh Bharat Abhiyan.

Villagers Sensitized about Eco-friendly Farming Practices

The cleanliness awareness campaign was organised in Staundi village of Karnal district on December 20, 2022. Villagers were explained about maintaining cleanliness not only in household surroundings, but also the cattle yard and the village environment. They were motivated to be self-sufficient in all respect and including the food, milk and vegetable requirements in the village itself and maintained clean milk production practices. Farmers were advised to practise natural farming and briefed about stable burning management including manure and fodder preparation. The participants were also exposed to video presentation about NDRI technologies, compost making from straw and preparation of compost from Kitchen waste.

Celebration of Kisan Samman Diwas

Farmers' fair, exhibition with farmers-scientist interface on the subject of Annual Crop Residue Management was organized on December 23, 2022, on the occasion of Kisan Samman Diwas at KVK-National Dairy Research Institute, Karnal. On this occasion, a comprehensive exhibition was organized by the Institute for the farmers depicting Crop Residue Management, Improved Livestock Production and Dairy Management, Natural Farming, Integrated Farming System Model, Good and Proven Agricultural Technologies, Pisciculture, Honey Bee Farming, Small and Marginal Women Dimensions of livelihood security of farmers, plans for livestock production and agriculture development, bamboo cultivation for soil conservation, dragon fruit cultivation under vegetable

and horticulture and lectures on entrepreneurship development and green energy production along with lectures on wide ranging topics in scientific farming. Officers of district level departments including farmers, women farmers, self-help groups and students of district Karnal participated in the Kisan Mela. In the program, Director, NDRI exhorted the farmers to adopt farming in entrepreneurial mode to realise higher income. Mr Kanwal Singh Chauhan, a Padma Shri farmer from Aterna village in Sonipat district of Haryana was the chief guest in this function and explained how he adopted baby corn cultivation to harness the market opportunities in Delhi and surrounding areas.

MERA GAON MERA GAURAV (MGMG)

Mera Gaon Mera Gaurav (MGMG) was implemented by ICAR-NDRI as per the guidelines of ICAR since its inception in 2015. At present, twenty two teams comprising of 4 to 5 Scientists each from multiple disciplines of the Institute were 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 420 field activities including messages / advisories were conducted in 120 villages benefitting 6850 farmers.

The approach lies in identifying the key resource persons of the village, facilitation of interaction with the villagers though them and taking the feedback from the interaction meetings to the concerned stakeholders for addressing them. Every MGMG team created a Whastsapp group for regular communication with key resource persons. Meanwhile, the field oriented research projects were also linked with MGMG villages for enhancing the visibility of the activities and the institute. Many farm centric interventions were popularised among the farmers in the MGMG villages. Other stakeholders are also invited for responding to the queries of farmers. In addition, linkages were developed with 22 organisations from the various streams of rural development.

Activities Organised under MGMG

S. No.	Name of activity	No. of activities conducted	No. of farmers benefitted
1.	Visit to village by all teams	70	1500
2.	Interface meeting/ *Goshthies*	30	1550
3.	Training organized	20	750
4.	Demonstrations conducted	18	1100
5.	Mobile based advisories	25	250
6.	Literature support provided	222	750
7.	Awareness programmes	35	950
	Total	420	6850

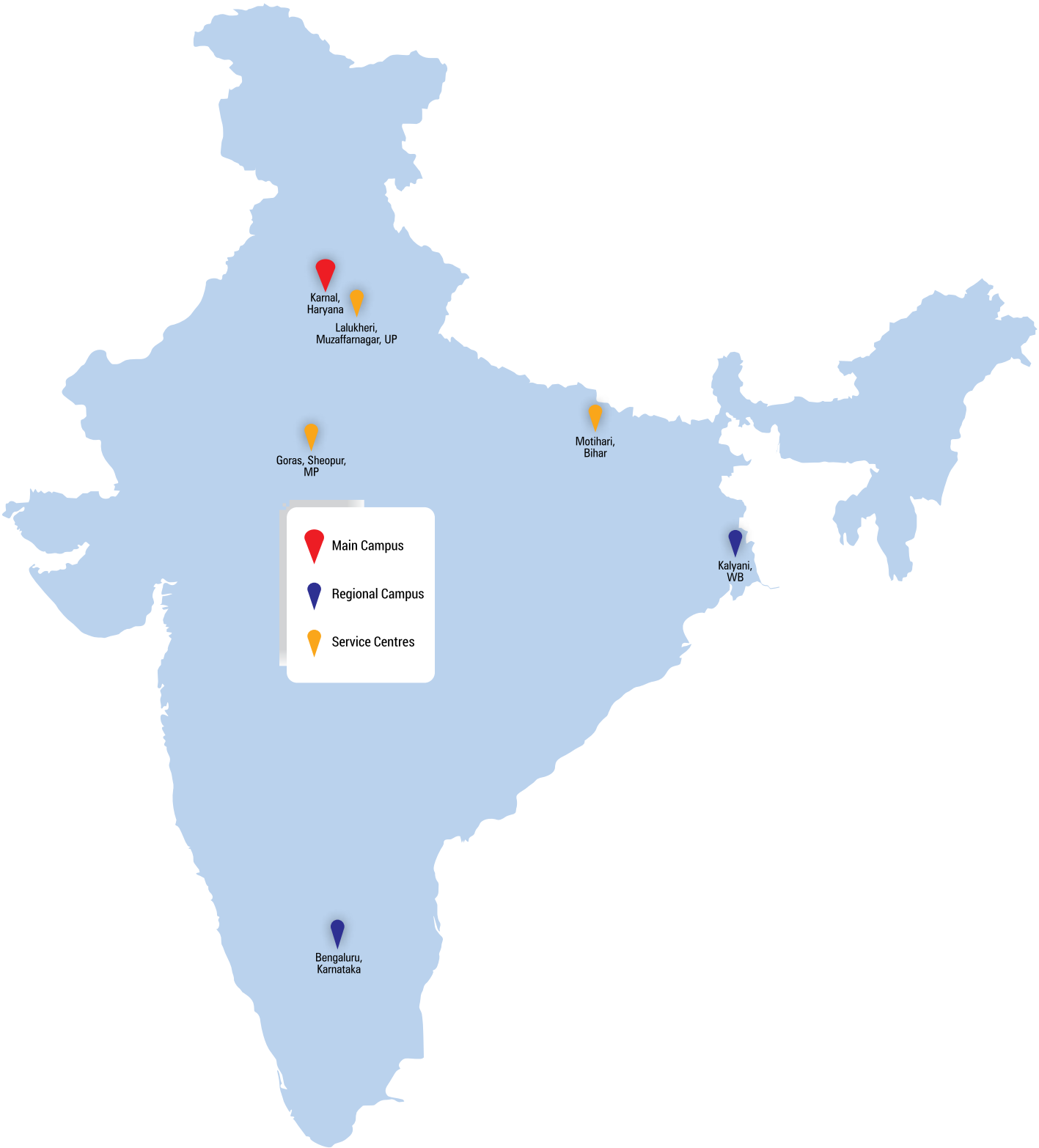
Distribution of mineral block to women farmers in a MGMG village

Facilitation under MGMG

	Crop	Variety	Seeds provided in quintal/ No.	Farmers Benefitted (No)
i) Seeds	Wheat	HD 187 HD 2967 PBW 222 DBW 327 & 332	50 Q 20 Q 45 Q 20 Q	20 15 25 100
	Paddy	PB 1509 PB 1718	60 Q 40 Q	18 12
	Vegetable kits	Packets of multiple crops	4 kg	200
ii) Seedlings	Fodder crop	Bajra Napier cuttings	500 No	150
	Maize	J1006	2.95 Q	33
	Oat	Kent	3 Q	25
iii) Nutrient management Crop		**Quantity (quintal/ kg)**		**Farmers Benefitted (No)**
a) Fertilizer				
b) Bio-fertilizer	Paddy	Azospirillum		50
iv) Technology (No)	**Numbers**	**Name of technology**	**Area (ha)**	**Farmers Benefitted (No.)**
	50 20 900 800 kg 50 kg 800	Storage Bin Rubber Mat Dewormer Mineral Mixture Calcium Powder Albendazole (Tab.)		50 20 500 800 50 500
v) Livestock/ poultry/ fisheries	**Numbers**		**Farmers Benefitted (No)**	
a) Livestock	15		2000	
b) Poultry chicks	10 Kadaknath		5	
c) Fingerlings				

Milk products preparation training in Pinjouri village in Yamunanagar district of Haryana on 29.03.2022

ICAR-NATIONAL DAIRY RESEARCH INSTITUTE



भाकृअनुप
ICAR

हर कदम, हर डगर
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