वार्षिक प्रतिवेदन
Annual Report
2011-12

राष्ट्रीय डेरी अनुसंधान संस्थान
(मान्य विश्वविद्यालय) (भा.कृ.अ.प.) करनाल - 132 001 भारत

NATIONAL DAIRY RESEARCH INSTITUTE
(Deemed University) (ICAR) Karnal - 132 001 India

MILESTONES

1923	Established in Bangalore as Imperial Institute of Animal Husbandry and Dairying.
1936	Renamed "Imperial Dairy Institute".
1955	National Dairy Research Institute came into existence at Karnal, at the former Central Cattle Breeding Farm.
	Bangalore facilities became Southern Regional Station of the Institute.
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.
1983	IDD (DH) started at Bangalore.
1985	"Farm Advisory Bureau" and "Industrial Consultancy Cell" set up. The Institute recognised as Centre of Excellence in Animal Biotechnology.
1987	Embryo Biotechnology Centre established.
1989	The Institute granted "Deemed to be University" status.
	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.
	National Agricultural Research Project (NARP) funded through World Bank.
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 60,000 lit./ day commissioned for providing practical training to the students of NDRI University and to serve as an interface between Institute and Industry.
1998	A Modern Cafeteria with a seating capacity of 150 constructed in front of the Institute Hostels at the cost of 29 lakhs.
1999	Total no. of 9 NATP Projects with financial outlay of 266.25 lakhs initiated.
2000	NDRI bagged the Best Annual Report Award second time in succession for the years 1996-97 and 1997-98 in the category of large ICAR Institutes.
	A Guest House with two suites named as "Kamdhenu" was constructed at SRS, Bangalore.
	Platinum Jubilee of the Institute celebrated on 7th - 8th April 2000 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 at NDRI made functional.
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 introduction of comprehensive exam. for Ph.D. programme introduced.
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.
	National Academy of Dairy Sciences Launched at NDRI, Karnal.
	Centre of Excellence in Milk Safety established at NDRI, Karnal
	NDRI Recognised 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.

THE 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 contribute towards manpower development programmes.

THE MANDATE

- Conducting research in the areas of Dairy Production, Processing and Marketing.
- Demand driven "Human Resource Development" to meet the requirements of Dairy Industry & R&D Institutions.
- Dissemination of innovative dairy production and processing technologies for socio-economic transformations.

CONTENTS

July 2012

Publisher | **Dr. A. K. Srivastava,** Director, NDRI

Chief Editor | **Dr. G.R. Patil,** Joint Director (Res.), NDRI

Editors | **Dr. (Mrs.) Meena Malik,** Associate Prof. (Eng.)
Mr. Braj Kishor, Tech. Officer

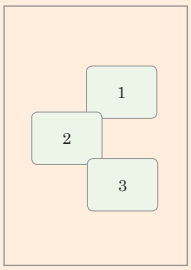
Layout Design and Word Processing | **Mr. Sunil Sharma,** T-4

Hindi Translation | **Mr. Ram Shankar Gautam,** Deputy Dir. (OL)
Mrs. Kanchan Chaudhary, Tech. Officer

Secretarial Operations | **Mr. Ram Dhari,** Assistant
Mrs. Ranjana, P.A.

Cover Design | **Mr. Chiranjee Aggarwal,** Assistant

Photography | **Mr. G. D. Joshi,** Tech. Officer



Cover Page Photos:

1. *'Holi'- Sahiwal calf born through OPU-IVF technique*
2. *Test for detection of detergent in milk*
3. *Equipment developed for in-line production of indigenous milk products*

प्राक्कथन

PREFACE

राष्ट्रीय डेरी अनुसंधान संस्थान के वर्ष 2011–12 की वार्षिक प्रतिवेदन में गत एक वर्ष के दौरान अनुसंधान, शिक्षण, एवं प्रसार तथा मानव संसाधन विकास एवं संरचनात्मक विकास के क्षेत्र में संस्थान की अति महत्वपूर्ण उपलब्धियां प्रस्तुत की जा रही है।

राष्ट्रीय डेरी अनुसंधान संस्थान के अनुसंधान एवं विकास कार्यक्रमों को अधिदेशानुकूल तथा सुव्यवस्थित अनुसंधान कार्यक्रमों के द्वारा और प्रोत्साहन मिला है। इन अनुसंधान कार्यक्रमों में 71 अन्तःसंस्थानीय एवं 46 बाह्य वित्तीय सहायता प्राप्त अनुसंधान परियोजनाएं सम्मिलित है। जिसमें 20 एन.ए.आई.पी. परियोजनाए हैं जिनके लिए लगभग 34 करोड़ रूपये की वित्तीय सहायता प्राप्त कर ली है। अतिरिक्त परियोजनाओं में जलवायुवीय प्रतिस्कंदन कृषि पर राष्ट्रीय प्राथमिकता (एन.आई.सी.आर.ए.) पर एक महापरियोजना भी सम्मिलित है जिसके लिए पशुधन द्वारा जलवायुवीय परिवर्तनों को अपनाने के मामलों का पता लगाने के लिए 20.86 करोड़ रूपए की वित्तीय सहायता प्राप्त है, इसके अतिरिक्त जैवप्रौद्योगिकी विभाग (डी.बी.टी.) तथा कृषि में मूल, अनुकूल तथा अग्रणी अनुप्रयोग अनुसंधान (एन.एफ.बी.एस.एफ.ए.आर.ए.) के लिए राष्ट्रीय फंड द्वारा अग्रणी एवं प्रमुख क्षेत्रों पर कई परियोजनाओं के लिए फंड प्रदान किया गया है। अगस्त 2011 से अन्तर्राष्ट्रीय पशुधन अनुसंधान संस्थान (आई.एल.आर.आई.) के साथ समन्वित प्रस्ताव के अन्तर्गत एक परियोजना भी प्रारम्भ की गई।

NDRI Annual Report 2011-12 is being presented as an all-inclusive account of the most significant achievements of the Institute in the areas of Research, Education and Extension, and the activities related to Human Resource Development and Infrastructure Development during the last one year.

The research and development activities of NDRI got further fillip through its mandate oriented and well-structured research programmes comprising 71 in-house and 46 externally funded research projects, which included 20 NAIP projects in consortium mode having the financial outlay of about ₹ 34 crores. The extra-mural projects also included a mega project on National Initiative on Climate Resilient Agriculture (NICRA) with financial outlay of ₹20.86 crores to address the issue of adaptation of livestock to climate changes, besides a few projects on frontal and upcoming areas funded by Dept. of Biotechnology (DBT) and National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA). A project has also been initiated under collaborative approach with International Livestock Research Institute (ILRI) since Aug 2011.

After the breakthrough in the history of NDRI i.e. the production of three cloned

राष्ट्रीय डेरी अनुसंधान संस्थान के इतिहास में महत्वपूर्ण उपलब्धि अर्थात् तीन क्लोन्ड भैंस के कटड़े/कटड़ी – 'गरिमा','गरिमा–II' तथा श्रेष्ठ के जन्म के बाद संस्थान ने वर्ष 2011–12 में आई.वी.एफ. प्रौद्योगिकी में और अधिक प्रगति की है। रिपोर्टाधीन अवधि के दौरान, साहीवाल गाय से एकत्रित डिम्बाणुजन–कोशिकाओं का प्रयोग करके दिनांक 7 मार्च 2012 को 'होली' नामक एक प्रथम गाय की बछड़ी को जन्म दिया।

डेरी प्रसंस्करण के क्षेत्र में कुछ महत्वपूर्ण अनुसंधान उपलब्धियों में निम्नलिखित उपलब्धियां सम्मिलित हैं– क्रियात्मक डेरी एवं गैर डेरी अवयवों का प्रयोग करके वसा चाकलेट स्प्रेड (एम.एफ.सी.एस.) के निर्माण की विधि विकसित करना, अतिसूक्ष्म छानन (यू.एफ.) तकनीक का प्रयोग करके भैंस के दूध से उच्च कोटि की सैट 'दही' तैयार करने की तैयारी के लिए प्रक्रिया मानकित करना, लौह पुष्टिकारक व्हे प्रोटीन से भरपूर बाजरे के बिस्किट बनाने की प्रौद्योगिकी तैयार की गई तथा पशु माडल में लौह की जैव उपलब्धता के लिए मान्य ठहराई गई, मधुमेह के रोगियों के लिए तुरन्त पकाने योग्य जौ आधारित खीर मिश्रण तैयार करने की एक प्रक्रिया विकसित की गई। करक्यूमिन पुष्टिकृत लस्सी बनाने की प्रौद्योगिकी विकसित की गई। जिसमें ऐलजहमेर रोग के प्रतिकूल प्रोफाइलेक्टिक गुण विद्यमान हैं। शुष्क किस्म की छैना मुर्की की शैल्फ–लाइफ 10° से0ग्रेड पर पाँच सप्ताह पाई गई जबकि क्रियात्मक छैना मुर्की की शैल्फ लाइफ नाइट्रोजन से भरपूर पैकेजों में 10° से0ग्रेड पर 15 दिन प्रदर्शित हुई।

मिलावटी दूध के बढ़ते कारोबार का पता लगाने के लिए एक प्लेटफार्म परीक्षण विकसित किया गया जिसके द्वारा दो मिनट के भीतर दूध में प्रक्षालक (डिटर्जेन्ट) की मिलावट की जांच की जा सकती है। यह परीक्षण विश्व बैंक द्वारा वित्तीय सहायता प्राप्त राष्ट्रीय कृषि प्रवर्तन परियोजना (एन.ए.आई.पी.) नामक अनुसंधान परियोजना से सामने आया है। विकसित परीक्षण सरल है तथा बाजार में उपलब्ध सभी व्यावसायिक प्रक्षालकों (डिटर्जेन्टों) की न्यूनतम स्तर 20 मि.ग्रा./100 मि.ली. दूध में जांच करता है। इस विधि के लिए किसी विशिष्ट उपकरण की आवश्यकता नही होती तथा इस विश्लेषण की लागत प्रति दुग्ध नमूना केवल 3.10 रूपए है।

संस्थान की अन्य महत्वपूर्ण उपलब्धि राष्ट्रीय डेरी अनुसंधान संस्थान पर विकसित मिश्रित डेरी खाद्यों की प्रौद्योगिकियां हस्तांतरित करने के लिए उद्यमशीलता

buffalo calves- 'Garima' , 'Garima-II' and 'Shresth', the Institute made further advances in the IVF technology in the year 2011-2012. During the period under report, using oocytes collected from live cow by Ovum-Pick-up in Sahiwal cattle, the first cattle calf named "Holi" was produced on 7th March 2012.

In the area of dairy processing, some of the significant research achievements included development of the technology to manufacture the Mixed-Fat Chocolate Spread (MFCS) using functional dairy and non-dairy ingredients, standardisation of process for the preparation of good quality set dahi from buffalo milk using ultrafiltration (UF) technique, optimization of the technology to manufacture the iron fortified whey protein-enriched pearl millet biscuits and its validation for bioavailability of iron in animal model, development of a process for the production of ready-to-cook barley based vermicelli (kheer) mix for diabetic persons, optimization of a technology to manufacture curcumin fortified lassi having prophylactic attributes against Alzheimer's disease, and studies on dry type channa murki packed in modified atmospheric packaging showing shelf life of 5 weeks at 10°C while functional chhana-murki exhibiting 15 days shelf life in nitrogen flushed packages at 10°C.

To address the growing concern for adulterated milk, a platform test was developed for the detection of detergent in milk within 2 minutes. This test has come out from World Bank funded National Agricultural Innovation Project (NAIP) research project. The developed test is simple and detects all commercial detergents available in the market at a minimum level 20 mg/ 100 ml (in milk). This method doesn't require any specific instrument and the cost of analysis is only ₹ 3.10 per milk sample.

Another significant achievement was the launching of entrepreneurship development campaign for transferring the technologies of Composite Dairy Foods developed at

विकास शिविर का प्रारम्भ किया जाना था। करनाल के समीप अमृतपुर में संसाधनहीन निर्धन ग्रामीण महिलाओं का समूह जिनकी औसत आय केवल 4500/–रूपये प्रतिमाह थी, गठित किया गया तथा उन्हें मूल्य सवंर्धित डेरी उत्पाद तैयार करने के लिए प्रशिक्षित किया गया। इन महिलाओं ने इन उत्पादों की बिक्री से 65000/– रूपये मासिक का व्यवसाय किया तथा प्रतिव्यक्ति प्रति माह 2000/–रूपए का लाभ अपने गांव मे एक लघु प्रसंस्करण यूनिट संस्थापित करके कमाया। ऐसा ही एक अन्य यूनिट शिमला के समीप शोंगी गाँव में भी संस्थापित किया गया। राष्ट्रीय डेरी अनुसंधान संस्थान डेरी फार्मिंग के क्षेत्र में ग्रामीण महिलाओं के सशक्तिकरण का कार्य करनाल जिले के कुलवेहड़ी ग्राम में विश्वास स्वयं सेवी वर्ग के माध्यम से कर रहा है। यह स्वयं सेवी समूह अगस्त 2011 से कार्य कर रहा है।

राष्ट्रीय डेरी अनुसंधान संस्थान डेयरिंग के क्षेत्र में मानव संसाधन विकास के लिए अग्रणी संस्थान रहा है, उच्च कोटि के शिक्षण मानक कायम रखे गए। डेरी शिक्षण के क्षेत्र में एक महत्वपूर्ण उपलब्धि एन.ए.आई.पी. संघटक के अन्तर्गत बी.टैक (डेरी प्रौद्योगिकी) उपाधि कार्यक्रम के लिए ई0–पाठ्यक्रम का विकास था। अन्य शैक्षणिक सुधारों में (i) ई0 लर्निंग (ii) वैब आधारित पारस्परिक मापदंड तथा (iii) शिक्षण पुस्तिका का विकास सम्मिलित हैं। 'प्री रिसर्च सुग्राह्मता (सेन्सिटाइजेशन) की संकल्पना को विकसित किया गया तथा छात्रों को एक प्रयोगशाला के साथ अथवा एक वरिष्ठ छात्र के साथ उनके अनुसंधान के लिए प्रयुक्त की जाने वाली तकनीकियों पर प्रारम्भिक प्रदर्शन के लिए जोड़ा गया। छात्रों के मन में बैठाने के लिए यह अनुसंधान प्रभावकारी पाया गया। वर्ष 2011–12 के दौरान, राष्ट्रीय डेरी अनुसंधान संस्थान ने रवांडा, ईरान, इथोपिया, श्रीलंका आदि से काफी संख्या में अन्तर्राष्ट्रीय छात्रों को आकर्षित किया है। इस समय राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय द्वारा चलाए जा रहे विभिन्न कार्यक्रमों में 19 विदेशी छात्र अध्ययनरत है। उच्च कोटि के अनुसंधान कार्य के लिए प्रतिस्पर्द्धा की भावना एवं प्रेरणा के लिए प्रोत्साहित करने हेतु मास्टर एवं डॉक्टरेट छात्रों के लिए श्रेष्ठ शोध प्रबन्ध पुरस्कार जारी रहा।

राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय का दसवां दीक्षान्त समारोह दिनांक 21 फरवरी, 2012 को संपन्न हुआ। पदम विभूषण, डा0 एम.एस. स्वामीनाथन सांसद (राज्यसभा) एवं अध्यक्ष एम.एस. NDRI. A group of resource poor village women at Amritpur Kalan located near Karnal, with an average monthly income of ₹ 4500/- only, was formed and they were trained for manufacturing the value added dairy products. These women have earned a monthly turnover of ₹ 65000/- through sale of these products and generated a profit of ₹ 2000 per person per month with the help of a small processing unit established at their village. Another such unit was established at Village Shongi near Shimla. NDRI has also been also working towards empowerment of farm Women in Dairy Farming through Vishwas Self Help Group in village Kulwehri, Dist Karnal functioning since August, 2011.

NDRI being the front ranking Institute for Human Resource Development in the field of Dairying, high quality education standards were maintained. An important milestone in the field of Dairy Education was development of e-course for B. Tech (Dairy Technology) degree programme under NAIP Component-I. Other educational reforms included i) E-learning, ii) Web-based Interactive Modules and iii) Development of Teaching Manuals. Concept of "Pre-research sensitization" was evolved and students were attached to a laboratory or to a senior student to get first hand exposure on the techniques to be used for his research. This was found to be effective in inculcating research acumen among the students. During the year 2011-12, NDRI attracted a number of International students from Rwanda, Iran, Ethiopia, Sri Lanka, etc. A total no. of 19 International students is currently on rolls in different programmes being offered by NDRI Deemed University. Best Thesis Award for Master's and Doctoral students was continued to encourage the spirit of competition and motivation for quality research work.

Tenth Convocation of NDRI Deemed University was held on 21st February, 2012. Padam Vibhushan Dr. M. S. Swaminathan, M.P. (Rajya Sabha) & Chairman M. S. Swaminathan Foundation delivered the convocation address and gave away the

स्वामीनाथन फाउंडेशन ने अपना दीक्षान्त भाषण प्रस्तुत किया। तथा छात्रों को उपाधियां, स्वर्णपदक, मेरिट प्रमाणपत्र एवं पुरस्कार प्रदान किए। राष्ट्रीय डेरी अनुसंधान संस्थान के संर्वागीण विकास के लिए स्वर्गीय डा. डी.सुन्दरेसन के बहुमूल्य योगदान को स्मरण करने के लिए डा. डी.सुन्दरेसन स्मारक व्याख्यान पुरस्कार पदम विभूषण डा. आर.एस.परोदा, भूतपूर्व सचिव डेयर एवं महानिदेशक भारतीय कृषि अनुसंधान परिषद नई दिल्ली तथा अध्यक्ष हरियाणा कृषक आयोग को प्रदान किया गया। राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय की शैक्षणिक उपलब्धियों का पुनरावलोकन करने तथा ध्यान केन्द्रित करने के लिए फरवरी 2012 के द्वितीय सप्ताह में शैक्षणिक सप्ताह मनाया गया। वर्ष 2012 में राष्ट्रीय डेरी अनुसंधान संस्थान में पहली बार डा.के.के.अइया व्याख्यान पुरस्कार एवं डा. एन.एन.दस्तूर व्याख्यान पुरस्कार प्रारम्भ किया गया।

डेरी उद्योग एवं प्रगतिशील डेरी कृषकों की स्टेकहोल्डरों के साथ परस्पर बैठक 12वीं पंचवर्षीय योजना के प्रस्तावों को अन्तिम रूप देने के लिए राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल के अनुसंधान शिक्षण एवं विस्तार गतिविधियों का मार्गदर्शन रूपरेखा तैयार करने के लिए आयोजित की गई। 12वीं पंचवर्षीय योजना के नवीन अनुसंधान कार्यक्रमों को विकसित करने के लिए ब्रेन स्ट्रोमिंग सत्र भी आयोजित किए गए। 12वीं पंचवर्षीय योजना के दौरान 'गाय तथा भैंसों में एकीकृत जनन क्षमता प्रबंधन' तथा दुग्ध एवं दुग्ध उत्पादों की पौषणिकमान एवं शेल्फ लाइफ में वृद्धि पर दो नए फलैगशिप कार्यक्रम तथा परिवर्तित परिस्थितियों के अन्तर्गत गायों तथा भैंसों की प्रतिरूपण पौषणिक आवश्यकताओं पर नेटवर्क परियोजनाऐं प्रस्तावित हैं। अनुसंधान प्लेटफार्म पद्धति के अन्तर्गत राष्ट्रीय डेरी अनुसंधान संस्थान पर अनुसंधान परियोजनाएं विकसित करने की पहल की गई है।

अनुसंधान एवं विकास प्रयासों को और गति देने के लिए राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल पर एक श्रेष्ठ दुग्ध सुरक्षा केन्द्र संस्थापित किया गया। आई. एस.ओः 22000: 2005 (खाद्य सुरक्षा प्रबन्धन प्रणाली) मॉडल डेरी प्लांट के लिए लागू किया तथा एक नई दुग्ध पैकिंग मशीन संस्थापित की गई। उच्च उत्पादन वाली स्वदेशी, संकर गायों तथा भैंसों के लिए तीन अत्याधुनिक आवास प्रणालियां निर्मित की तथा पशुकल्याण एवं आराम के लिए चालू की गई। पशुओं

degrees, gold medals, merit certificates and awards to the students. Dr. D. Sundaresan Memorial Lecture Award to commemorate the valuable contributions of Late Dr. D. Sundaresan for all round development of NDRI was given to Dr. R. S. Paroda, Former Secretary DARE & DG, ICAR and Chairman Haryana Farmers Commission. Academic Week was celebrated in the second week of February, 2012 to lay focus and review the academic achievements of NDRI Deemed University. For the first time NDRI instituted Dr. K.K. Iya Oration Award and Dr. N. N. Dastur Oration Award In the year 2012.

Interactive meeting with stakeholders from Dairy Industry and progressive Dairy Farmers was organized to finalise the 12th Five Year Plan proposals and to prepare the roadmap of research, teaching and extension activities of NDRI, Karnal. Brain-storming sessions were also held for developing new research programmes for 12th Five Year Plan. Two new Flagship Programs on "Integrated Fertility Management in Cattle and Buffaloes" and "Enhancement of Nutritive Value & Shelf-life of Milk & Milk Products" and a Network Project on Modeling Nutrient Requirements of Cattle & Buffaloes under Changing Conditions, have been proposed to be taken up during XII five year plan. Initiatives were taken to develop research projects at NDRI under Research Platform Mode.

To give further thrust to research & development efforts, a Centre of Excellence in Milk Safety was established at NDRI Karnal. ISO: 22000: 2005 (food Safety Management System) was implemented for Model Dairy Plant and a New Milk Packaging Machine (Mechanical Type) was installed. Three state-of-the-art housing systems for high yielding indigenous, crossbred cattle and buffaloes got constructed and commissioned for effective animal welfare and comfort. Wireless sensor based climate control room was developed for animal experiments and Behaviour monitoring system was installed in cattle yard for different behavioural studies in dairy animals. Eastern Regional

पर प्रयोग के लिए वायरलैस संवेदी आधारित जलवायु नियंत्रण कक्ष विकसित किया गया। डेरी पशुओं में विभिन्न व्यवहार्य अध्ययनों के लिए पशुशाला में एक व्यवहार्य मानीटरिंग प्रणाली संस्थापित की गई। राष्ट्रीय डेरी अनुसंधान संस्थान के पूर्वी क्षेत्रीय केन्द्र ने आई.वी. आर.आई. के पूर्वी क्षेत्रीय केन्द्र कल्याणी की 30 एकड़ जमीन विकसित की। बंजर एवं अनुप्रयोगी भूमि को खेती के लिए प्रयोग किया गया तथा पशु आहार के लिए फसलें उगाई गई। इसी प्रकार एन.आई.सी.आर.ए. परियोजना के अन्तर्गत जलवायुवीय संचार पशुधन अनुसंधान केन्द्र के भवन निर्माण तथा छात्रों के लिए एक नए छात्रावास एवं संस्थान परिसर में एक नए खेल परिसर के निर्माण के लिए पहल की गई।

यह सब राष्ट्रीय डेरी अनुसंधान संस्थान के परिवार के सभी सदस्यों के सतत प्रयासों द्वारा ही प्राप्त किया जा सका है। यह मेरा परम सौभाग्य है कि मैं इस कार्य से जुड़े संयुक्त निदेशकों, प्रभागाध्यक्षों, संकाय अधिकारियों एवं कर्मचारियों के योगदान की यहां चर्चा करूं। मुझे आशा ही नहीं पूर्ण विश्वास है कि उनके सहयोग से मैं संस्थान के लक्ष्यों को प्राप्त करने के लिए पूर्ण समर्पण एवं उत्तरदायित्व की भावना से कार्य करूंगा ताकि संस्थान आगामी वर्षो में गौरव एवं सफलताओं की चरमसीमा तक पहुंच सके।

मैं आशा करता हूँ कि यह प्रकाशन वैज्ञानिक/शैक्षणिक संस्थानों के विद्वानों तथा डेरी विकास संगठनों से जुड़े व्यवसायियों के लिए सूचना का अमूल्य स्त्रोत होगा जो कि रिपोर्टाधीन अवधि के दौरान हमारी कुछ गतिविधियों एवं उपलब्धियों को हमारे साथ बांटने के इच्छुक है।

Station of NDRI developed 30 acres land owned by Eastern Regional Station of IVRI at Kalyani. The barren and unutilized land was brought under cultivation and fodder crops were grown for animals feeding. Similarly, initiatives were taken for creating a building of Climatic Resilient Livestock Research Centre under NICRA Project and construction of a new hostel for boys and a new sports complex at NDRI.

All this could be achieved with the persistent efforts of all the esteemed members of the NDRI fraternity. Here I feel privileged to acknowledge and place on record the contributions made by Joint Directors, Heads of Divisions, Faculty, Administrative/ Finance Officers and the Staff in the growth of NDRI. I am sure that with their unrelenting support and efforts, we would be able to march ahead in fulfilling the mandate and objectives of NDRI with earnest zeal and responsibility and bring success and glory to the Institute in the years to come.

I sincerely hope that this Annual Report would serve as a valuable source of information to the professionals of the Scientific/Academic Institutions and would be of interest to all those who are keen to share some of our activities and achievements made during the period under report.

Srivastava

(A. K. Srivastava)

EXECUTIVE SUMMARY

National Dairy Research Institute is the premier research organization of the Nation dedicated for providing Research & 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 were moved to the present location at Karnal in 1955. It has two regional stations, one at Bangalore and the other at Kalyani for providing region-specific support suited to their agro-climatic conditions. The Institute has the distinction of being a Deemed University for implementing its educational programmes.

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 twelve Research Divisions/Sections, namely, Dairy Cattle Breeding, Livestock Production and Management, Dairy Cattle Nutrition, Dairy Cattle Physiology, Animal Biochemistry, Animal Biotechnology, Dairy Technology, Dairy Engineering, Dairy Chemistry, Dairy Microbiology, Dairy Extension and Dairy Economics, Statistics and Management at the main station and its two regional stations. The Institute also has a Agricultural Technology Information Centre (ATIC), Krishi Vigyan Kendra & Dairy Training Centre and Animal Breeding Research Centre. The Institute has infrastructure consisting of central facilities such as Livestock Farm, Forage Research & Management Centre, Animal Health Complex, Model Dairy Plant, Technology Business Incubator, Experimental Dairy Plant, Consultancy Unit, Library and National Bio-informatic Centre, Computer Centre, Estate Section and Maintenance Engineering Section. The administrative functions viz. finance, purchase, stores, establishment and security are under the administrative control of the Joint Director (Admn.) & Registrar. The Institute presently has strength of 154 scientists, 300 technicians, 130 administrative and 618 skilled supporting staff.

BUDGET OUTLAY

The financial outlays of the Institute in terms of actual expenditure for Plan and Non-plan for the year 2011-2012 was ₹ 12576.42 lakhs and budget sanctioned for the year 2011-2012 was ₹ 12578.23 lakhs, respectively. These figures include the financial outlays for the strengthening of Deemed University/KVK and Regional Stations.

RESEARCH

A total number of 70 in-house research projects were in operation during the year 2011. In order to strengthen basic and strategic research, World Bank through NAIP has funded several research projects in consortium mode wherein NDRI is either the Lead Institute or consortium partner. Under NAIP, twenty projects with an outlay of approximately ₹ 34 crores continued during the year 2011-12. Many of the research programmes have Inter-institutional linkages with Dept. of Biotechnology (DBT), National Bureau of Agriculturally Important Microorganisms (NBAIM), National Communication to United Nations Framework Convention on Climate Change (NATCOM-UNFCC), Ministry of Food Processing Industries, State Agricultural Universities (SAUs) and State Development Departments at the National level.

RESEARCH

- Pregnancy was established using oocytes collected from live cow by Ovum-Pick-up in Sahiwal cattle and the first cattle calf named "Holi" was produced on 7th March 2012.

OPU-IVF, Calf 'Holi'

- Cloned buffalo embryos by using somatic cells isolated from milk as donor cells were produced. A protocol was established in goat for production of embryonic stem cells

from blastocysts produced by handmade cloning. Buffalo embryonic stem cells were produced using embryos produced by hand-guided cloning and parthenogenesis.

- Buffalo embryonic stem cells derived from blastocysts produced by IVF, handmade cloning and parthenogenesis were shown to exhibit equivalency in terms of their pluripotent marker expression.
- Buffalo *NANOG* and OCT4 genes were cloned and characterized in buffalo embryonic stem cells.
- Lowering the O_2 concentration during IVM, IVF and IVC from 20% to 5% or supplementation of IVM and IVC media with cysteamine, an antioxidant, was shown to improve blastocyst yield, increase the expression of anti-apoptotic genes and decrease that of pro-apoptotic genes.
- Cattle embryos through *in vitro* technique were produced at Eastern Regional Station, Kalyani.
- A spontaneously transformed buffalo mammary epithelial cell line was achieved and established.
- MGP-40, a mammary gland protein can be treated as a biomarker for mastitis.
- A PCR-based method for differentiating A1 and A2 β-casein containing milk was developed.
- For prediction of first lactation 305-day milk yield, Multiple Linear Regression (MLR) and Artificial Neural Network (ANN) models were developed using body weights at different ages as independent variables and FL305DMY as dependent variable and the accuracy of fitting both the models was compared.
- A total of 119 KF, 78 Sahiwal and 80 Murrah young males were reserved for progeny testing during (2007-2011). The ranges for the expected predicted difference (EPD %) and dam's best 305-day milk yields for the three breeds were 1.57-18.44, 0.24-23.10 and 1.69-18.63% and 4546-8648, 1906-3811 and 2330-4341 kg, respectively.
- The proportion of the elite herd had a range of 23-41% in Karan Fries, 21-26% in Sahiwal and 34-38% in Murrah buffaloes during 2007-2011. Average EPA of elite KF and Sahiwal cows and Murrah buffaloes ranged between 4492 and 5520 kg; between 2199 and 2440 kg and between 2339 and 2371 kg, respectively.
- Two sets each of Sahiwal (11 bulls) and KF (17 bulls) and three sets of Murrah bulls (43 bulls) were evaluated during the period. Out of these bulls, 4 Sahiwal, 5 KF and 3 Murrah bulls were selected as proven bulls with their EBVs ranging from 1641-1917 kg, 3228-4144 kg and 1972-2116 kg, respectively; while their superiority over herd average ranged from 9.33-27.73%, 12.00-16.70% and 8.41-17.26%, respectively. During 2007-2011, as a result, total of 2152 KF and 2325 Murrah female progeny were born from bulls under field conditions.
- During the period, a total of 3,72,770 doses of frozen semen of Karan Fries, Sahiwal and Murrah bulls were produced and 4,70,134 doses of frozen semen of three breeds were disseminated (sold and supplied) through ABRC, NDRI to various dairy development agencies / institutes and farmers.
- The lactation curve parameters of Quadratic cum log model (QCLM), Gamma function (GF), Cobby Le Du model (CLDM), Polynomial regression function (PRF) and Multiphasic logistic function (MLF) were estimated using weekly test day milk yields during first lactation in Karan Fries cows for developing the best model of lactation curve.
- First lactation monthly test day milk yields were used to predict 305-day or less milk yield using different sampling methods viz., centering date method (CDM), test interval method (TIM) and sample day production method (SPM).
- The sample day production method was found to be the best method for predicting 305-day or less milk yield in Karan Fries cattle and can be used under field conditions.
- Forebrain embryonic zinc finger-like gene (FEZL) affected the host disease resistance. RFLP analysis of FEZL gene in Murrah buffaloes revealed polymorphism in exon 3, which was significantly associated with incidence of mastitis.
- PCR-SSCP analysis of Heat Shock Protein 90AA1 (HSP90AA1) gene in Deoni cattle showed three unique SSCP patterns with a genotypic frequency of 0.250, 0.638 and 0.111,

respectively in exon 8. Two SSCP patterns with a genotypic frequency of 0.153 and 0.847 were observed in exon 9 of HSP90AA1 gene and two unique SSCP patterns in exon 10 with a genotypic frequency of 0.236 and 0.764, respectively were observed.

- The average proliferation index with inactivated FMD virus reached 3.7 in Deoni and 5.7 in Malnad Gidda native cattle indicating Malnad Gidda showed higher cellular response to FMDV antigen and sub viral practices than Deoni breed. BoLA typing studies showed that locus DRB3.* 11, 15, and 9 were more prevalent in Malnad Gidda cattle than Deoni. Malnad Gidda cattle were found to be more resistant than other genotypes.
- Estrus induction was achieved in non-cyclic buffalo heifers. Conditioning (deworming, mineral and vitamin supplementation) the buffalo heifers before application of exogenous hormones improved the estrus response and fertility.
- Vocalization pattern was identified in buffaloes under stress conditions, isolation, delayed milking and estrus.
- A new method, using flow cytometry, was developed for simultaneous determination of cAMP and tyrosine phosphorylation levels in spermatozoa.
- A specific pattern of tyrosine phosphorylation in spermatozoa related to fertility of a male was identified.
- For the first time, kinetics of intra cellular calcium and tyrosine phosphorylation in live spermatozoa was studied during cryopreservation.
- Technique of fine needle aspiration cytology was standardized in crossbred bulls.
- Resonance frequency was proved to be the best suited acoustic feature which might be utilized in pattern recognition system for the identification of the stage of dairy animals.
- A few pre-partum bio-markers (behavioural and biochemical) were identified for prediction of post-partum metritis in crossbred cattle.
- Four quadrant strain cells based weighing system with wireless sensor based auto identification and data acquiring system were designed and developed and validated for early detection of lameness in dairy cattle.
- Wireless sensor based automatic mist, fan and exhaust fan operation in closed animal house was developed with THI as base algorithm.
- A "Pre-conditioning" protocol for buffalo heifers was developed to improve the treatment response and fertility after application of Ovsynch protocol.
- Buffalo dummy calf model was developed and found successful in milk let down in buffaloes.
- Herd status of mineral and metabolic profile was validated for primary risk factors for high producing crossbred animal and herd health management in tropical climate animal management system.
- Micronutrient supplementation during peri-partum period reduced the number of services per conception and improved milk production
- A protocol was standardized for advancing age at sexual maturity in Sahiwal heifers.
- Elevation of NEFA, BHBA and NEFA: Total cholesterol ratio and low concentration of glucose and total cholesterol during last 2-3 weeks of gestation was associated with post-partum metritis development.
- Among the three milk parameters (pH, EC and SCC) studied, SCC is the best indicator for subclinical mastitis. Supplementation of micronutrients improved the udder health by reducing milk SCC and percent neutrophils of milk.
- Heavy metals (lead and cadmium) exposure to animal increased oxidative stress.
- Administration of 50 ppm Pb to goat kids did not cause any significant adverse effect on blood parameters. Supplementation of Zn had beneficial effect in lowering the adverse effects of Pb.
- Pentasulphate mixture @ 9g/100 kg body weight and Arsenic @ 40ppm of diet were effective in alleviating chronic selenosis in buffaloes.
- Vitamin E @ 1000 IU/d, Zn (80 ppm) and Cu (20 ppm) supplementation during transition

period was found to be beneficial to reduce oxidative stress, improve immune status, reduce the incidence of mastitis and improve milk production as well as reproductive performance of crossbred cows.

- Addition of sulphur @ 0.22% in the diet of buffalo calves fed wheat straw based complete feed blocks containing fungal zoospores of Neocallimastix sp. GR-1 improved the growth rate, digestibility of proximate principles and rumen fermentation.
- *In vitro* studies showed positive response to high synchronous diets in terms of higher microbial protein synthesis and rumen fermentation pattern.
- On farm trials of feeding tannins from babul pods @ 4.5% in concentrate mixture proved beneficial in reducing the number of gastro-intestinal nematodes in grazing sheep.
- Cows of medium and high body condition score (BCS) showed variation of oxidative status during periparturient period as indicated by levels of SOD and catalase enzymes.
- A sensitive EIA for oxytocin in milk of cows was developed. Cows administered 25 I.U. or 50 I.U. (250 to 500 times the dose required for milk ejection) of oxytocin showed minimal increase in milk oxytocin (0.3-0.6% of the dose administered). Milk oxytocin was stable to the tune of 43% at pasteurization and heat treatment conditions up to 130°C.
- A new protocol "Heatsynch Protocol" for estrus synchronization and fixed time insemination was evaluated in terms of endocrine changes, timing of ovulation and conception rates in both summer and winter seasons.
- Phagocyting ability of the milk neutrophils was lowest during early lactation, followed by late and mid lactation. Measurement of lymphocyte proliferation and NO production could be used to indicate functional status of cell mediated immunity in the Murrah buffaloes.
- Feeding of mineral mixture and good quality ration to lactating buffalo resulted in reduction of environmental stress during the month of July, August and September.
- Supplementation of skim milk with Aloe vera resulted in enhancement of ACE inhibitory activity in fermented milk, and also found effective in increasing the viable counts of probiotics in fermented milk.
- Autoclaving of cow and buffalo milk reduced the total and protein specific IgE levels considerably ($P < 0.01$) as compared to raw milk proteins sensitized mice. Methodology for differentiation of bone marrow cells into mast cells was standardized for studying allergic reaction.
- cAMP, Erk and PI cycle dependent and independent signaling pathways were involved during protein tyrosine phosphorylation in the cryopreserved buffalo spermatozoa.
- The soya milk extender (new) significantly protected the buffalo spermatozoa against oxidative stress and protein tyrosine phosphorylation on cryopreservation compared to the conventional egg yolk extender.
- The isozymic forms of the enzymes like Glutathione-s-transferase and dihydrolipoyl dehydrogenase were differentially tyrosine phosphorylated during capacitation and on cryopreservation of buffalo spermatozoa.
- Immunolocalization patterns of the enzymes viz like Glycerol-3-Phosphate dehydrogenase, Glutathione-s-transferase and Dihydrolipoyl dehydrogenase were translocated on different sperm organelles in fresh buffalo spermatozoa compared to the cryopreserved buffalo spermatozoa.
- Scanning electron microscopy revealed attachment of nano-particles on the surface of buffalo sperms. There was dose dependent increase in DNA damaged for TiO_2 nanoparticles (NPs). Eu_2O_2 NPs did not cause DNA damage in sperm. Transmission electron microscopy of sperm showed attached and internalized NPs into the head and tail of spermatozoa.
- After application of nano- TiO_2 formulation on mice, NPs were observed in the skin and testis sections by transmission electron microscopy.
- Mesenchymal stem cells (MSC) from mouse adipose were isolated, proliferated and differentiated into mature adipocyte,

osteocytes and chondrocytes. Colony forming capacity of MSCs was established.

- During proliferation of MSCs from subcutaneous and visceral adipose depots, expression of CD 34, CD 73, CD 81, CD 90, CD 105 and CD 146 surface markers and stem cell antigen-1 (sca 1) and preadipocyte factor 1 (pref 1) marker was established. However, CD 5 was not expressed.
- Proliferation and differentiation of brown adipocytes from mouse was established. Differentiation process resulted in accumulation of numerous multilocular lipid droplets. During proliferation Hox A1, HoxA5, Hox C4, HoxC8, Gpc4, Sfrp2, Shox2, Thbd, En1, Tbx15, Nr2f1 developmental gene and pref1 marker were expressed. However, HoxB1 and HoxA2 developmental genes were not expressed.
- Gene silencing using RNAi in cultured buffalo granulosa cells validated.
- *In vitro* cell culture model to understand buffalo granulosa cell terminal differentiation from FSH-to LH-responsive phenotype was developed.
- A novel regulatory pathway of regulation of buffalo Cyp19 (fertility gene) during folliculogenesis and luteinisation was elucidated.
- A technology was developed for manufacture of Mixed-Fat Chocolate Spread (MFCS) using functional dairy and non-dairy ingredients.
- A process was standardized for the preparation of good quality set dahi from buffalo milk using ultrafiltration (UF) technique.
- A process was developed for the production of ready-to-cook barley based vermicelli (kheer) mix for diabetic persons.
- Technology for manufacture of iron fortified whey protein-enriched pearl millet biscuits was optimized and validated for bioavailability of iron in animal model. Similarly, high fiber, low fat and protein-enriched extruded snacks from pearl millet and barley flour with milk proteins and coarse cereal flours were developed.
- Technology for Pearl millet (Bajra lassi) and Barley lassi with novel starter bacteria having amylolytic, proteolytic and phytase activity was developed. The shelf-life of the developed lassi was also enhanced.
- Technology for low cost composite nutrimix was developed.
- Technology of khoa jalebi preparation using khoa, arrowroot powder and toukir was developed at Southern Regional Station, Bangalore. Shelf life of khoa Jalebi was enhanced to more than a month by active packaging.
- A method was developed for utilization of whey in jaggery, bread, bun and soup sticks.
- An ergogenic drink from hydrolysed whey was developed.
- Ready to reconstitute foxtail millet – milks solids dry mixes with long shelf-life was developed.
- High Hydrostatic Pressure (HHP) treated samples both cow and buffalo milks showed enhanced shelf life of 20 days under refrigeration.
- Technology to manufacture curcumin fortified lassi having prophylactic attributes against Alzheimer's disease was optimized.
- Dry type channa murki packed in modified atmospheric packaging showed shelf life of 5 weeks at 10°C.
- Funcional chhana-murki exhibited 15 days shelf life in nitrogen flushed packages at 10°C.
- There was no significant decrease in immunomodulatory activity of Aloe vera upon heat treatment.
- Protocols were standardized for preparation and characterization of nutraceutical components from selected Indian herbs.
- Delivery systems were developed for herbal nutraceuticals in milk products.
- Lactic cultures with antagonistic activity against pathogenic strains of *E.coli* and *Staphylococcus aureus* were isolated from dahi.
- The kinetics of colour changes in gulabjamun during frying was modeled using fractional conversion first order reaction kinetics and Arrhenius relationship.

- The moisture sorption characteristics of kunda and four commercially available gulabjamun mixes were established at 10, 25 and 40°C using gravimetric method.
- Continuous butter melter machine was developed. Technology for continuous manufacture of ghee using three stage SSHE was also developed.
- Inline production system was developed for manufacture of burfi and process mechanization for in-line production of Rabri.
- Kinematic half turn nut pressing mechanism for paneer was designed and developed.
- Conveyor system for viscous dairy product was developed.
- An indigenous probiotic strain Lf1 was found to exhibit a protective role in DSS induced colitis in mice based.
- A new simple test was developed for qualitative as well as quantitative estimation of detergent in milk. The method could be used as platform test for ensuring quality of milk.
- A spore based bioassay for monitoring aflatoxin M1 was developed. The test could be used for monitoring of milk quality.
- Technology of low cholesterol ghee was transferred to M/s Kwality Dairy India Ltd. New Delhi through NRDC, New Delhi. The product is available in market.
- Addition of herb extracts of *Withania somnifera* (Ashwagandha), *asparagus racemosus* (Shatavari), *Pueraria tuberosa* (Vidarikand) to ghee had a significant effect on oxidative stability of ghee. Antioxidative behaviour of herbs was found to be more effective than green tea extract and comparable with rosemary extract but less effective than BHA and TBHQ.
- *In-vivo* studies showed that the antioxidative enzymes viz, catalase, superoxide dismutase and glutathione peroxidase activities in RBC lysates and liver homogenates were increased significantly in the whey protein hydrolysates fed group as compared to control after 15 and 30 days.
- Two antioxidative peptides produced from action of proteinase from *L. helvetics* NCDC 288 on casein were identified. First peptide GVSKVKEAMAPK matched with sequence ß-Casein (94-105) and the second peptide RPKHPIKHQGLPQ matched with sequence -CN (1 – 13).
- A process was optimized for production of caseinophosphopeptides viz. αs1 -CN(37-58), αs_1 -CN (35-58), αs_1 -CN (43-58), αs_2-CN(2-21), β-CN(2-27) by hydrolyzing buffalo casein with digestive enzyme.
- An indigenous probiotic strain Lf1 was found to exhibit a protective role in DSS induced colitis in mice based on improvement in DAI, histological scores, decrease in MDA levels and increase in the expression of SOD2 and TrxR-I.
- Probiotic Lp91 fed to LPS mouse model resulted into significant down regulation of adhesion molecules 'VCAM-1' and ICAM-1' to -3.135 and 2.279 folds, respectively.
- Lp9, Lp78, Lp91 and NCFM were able to bring about a significant ($P<0.001$) level of down regulation of 'TNF-α' expression by -1.34, -1.34, -1.45 and -1.21 fold, respectively.
- Cost effective whey based agar medium was formulated for enumeration of *Lactobacillus* spp.
- Two species of anaerobic fungi *Orpinomyces* i.e. O. intercalaris and *O. joyonii* could be differentiated on the basis of PCR-RFLP using D1/D2 domain of large-subunit (LSU) ribosomal DNA as a taxonomic marker.
- A variation of G/T created an extra restriction site for *AluI* in *O. intercalaris*, which resulted in cleavage of 212 bp regions in *O. joyonii* into two regions of 138 and 74 bp in *O. intercalaris* and hence, *AluI* was used as a biomarker for species level differentiation in *Orpinomyces* spp.
- Probiotic *Lactobacillus delbrueckii* ssp. *bulgaricus* LB-2 exhibited cholesterol reduction, antioxidant and anticancer potentials.
- Probiotic strains of *Lactobacillus delbrueckii* ssp. *bulgaricus* LB-2 and *Streptococcus salivarius* ssp. *thermophilus* ST-1 exhibited inhibition of *L. monocytogenes* ATCC 15303, *E. coli* ATCC 25922, *B. cereus*, ATCC 13061 *S. typhi* NCDC 113, *C. pseudotropicalis* NCDC 44 and *G. candidum* NCDC 228.

- Supplementation with inulin and *O. sanctum* essential oils showed synergistic effect on inhibitory and antioxidant activity of synbiotic yoghurt.
- A test was developed for detection of *Enterococci* in different types of milk system within 5-12 hrs as per standards recommended by the BIS as well as a selective medium for isolation and differentiation of *Enterococci*.
- Whey fermentate peptide fractions of Lactobacilli isolated from cheese were more inhibitory to *L. monocytogenes*, *E. coli, S. typhii, S. aureus, E. faecalis* and *Pseudomonas* spp.
- Different strains of *lactococci* and *Leuconostoc* spp. isolated from the mixed strain starter cultures of O-type and LD – type were characterised by phenotypic and genotypic methods and evaluated for their technological properties. These strains are available in the NCDC culture collection.
- Performance appraisal of dairy manufacturing enterprises was studied. There was decline in number of unorganized dairy manufacturing units after 2000-01, which suggested the rising trend towards organized milk processing and dairy product manufacturing. The unorganized manufacturing units were highly concentrated in W. Bengal and U.P. (more than 70% share in India). There was positive growth in employment generation but share in gross value added was not commensurate to share in number of units suggestive of low productivity in the states.
- Urea-ammonia treated straw and mineral mixture supplementation maintained the level of milk production even in the summer season. The feeding of the common salt to their dairy animals helped in prevention of diarrhea.
- Extension strategies were developed for promoting value addition in milk among farming community.

EDUCATION

- Initiatives were taken for development of e-course for B.Tech (Dairy Technology) degree programme under NAIP Component-I. Other educational reforms included i) E-learning, ii) Knowledge and Management and Dissemination through ICT, iii) Web-based Interactive Module and iv) Teaching mannuals.
- Concept of "Pre-research sensitization" was evolved and students were attached to a laboratory or to a senior student to get first hand exposure on the techniques to be used for his research. This was found to be effective in inculcating research acumen among the students.
- During the year 2011-12, NDRI attracted a large number of International students from Rwanda, Iran, Ethiopia, Sri Lanka, etc. A total no. of 19 foreign students is currently on rolls in different programmes being offered by NDRI Deemed University.
- Best Thesis Award for Master's and Doctoral students was continued to encourage spirit of competition and motivation for quality research work.
- Tenth Convocation of NDRI Deemed University was held on 21st February, 2012. Padam Vibhushan Dr. M. S. Swaminathan, M.P. (Rajya Sabha) & Chairman M. S. Swaminathan Foundation delivered the convocation address and gave away the degrees, gold medals, merit certificates and awards to the students.
- Third Dr. D. Sundaresan Memorial Lecture Award to commemorate the valuable contributions of Late Dr. D. Sundaresan for all round development of NDRI was given to Dr. R. S. Paroda, Former Secretary DARE & DG, ICAR on 21st February, 2012.
- Academic Week was celebrated in the second week of February, 2012 to lay focus and review the academic achievements of NDRI Deemed University.
- In the year 2012, Dr. K.K. Iya Oration Award and Dr. N. N. Dastur Oration Award have been instituted. In the First Dr. K.K. Iya Oration Award was given to Dr. V. K. Taneja, VC, GADVASU and Dr. N. N. Dastur Oration Award was given to Dr. Tej Partap Singh, VC, Shere Kashmir University of Agriculture Science & Technology, Kashmir.
- Under the aegis of ASRB, infrastructure was also created at NDRI Deemed University for on-line examination system for the admission of students.

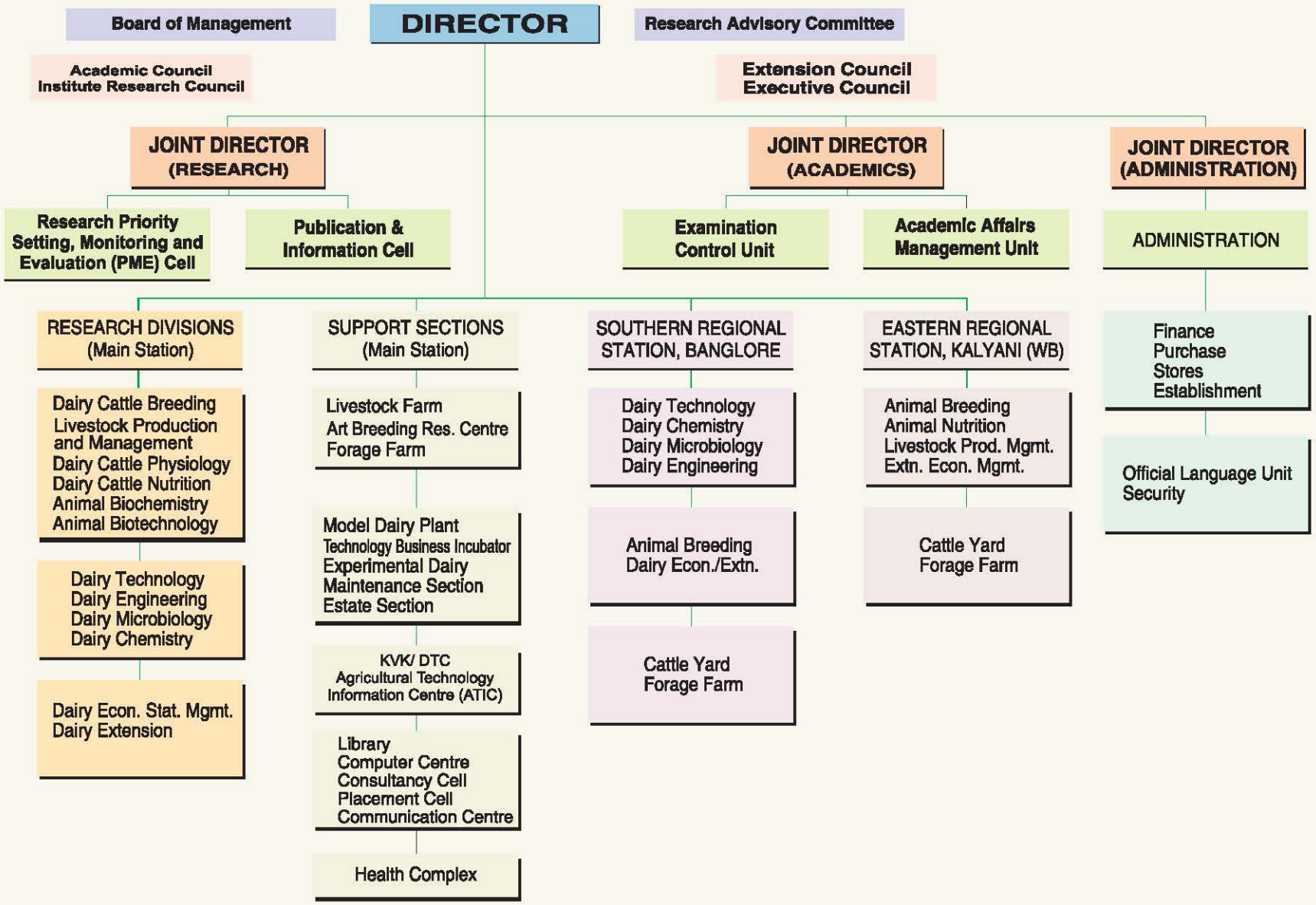
EXTENSION

- A total no. of 56 Kisan Sangoshties were organised in the adopted villages for transfer of technologies developed by the Institute. A total no. of 856 farmers were made aware about the reproductive management practices, mastitis control, disease preventive measures and fodder production.
- Cross breeding programme was continued in cows and selective breeding in local buffaloes through AI. The conception rate of AI was observed as 46.20% in cows and 35% in buffaloes.
- A total of 60 veterinary aid campaigns were organized in adopted villages. A total of 1210 no. animals were diagnosed with late maturity, anestrous and repeat breeding and were given adequate treatment.
- The Extension Education Programme "Dairy Education at Farmers' Door" was continued to strengthen the effective dissemination of dairy production and processing technologies among farming community.
- During the year, KVK/DTC organised 293 training programmes (both on and off campus) participated by 26367 trainees on different aspects of dairy production, dairy processing, agriculture, vermicompost, bee-keeping, fisheries and home science.
- Agriculture Technology Centre (ATIC) was further strengthened. During the period under report, 23200 farmers visited ATIC for obtaining technical information and advisory services. ATIC was involved in providing helpline services, sale of publications, sale of seeds, biofertilizers & vermicompost, exhibition, filmshows and face to face interactions.
- Several foreign delegates from Bhutan, Denmark, Nepal, USA, Finland, Kajakistan, etc. visited ATIC. They were explained about the objectives, working, linkages with other research and development agencies/institutes, role of information and transfer of technologies and impact of single window system approach adopted by ATIC to enhance productivity and income of stakeholders.
- Several farmers, across the country, visited the facilities and production practices of the cattle yard and were sensitized about the package of practices for optimizing production and reproduction in dairy animals.
- Organized training programs on commercial dairy farming, dairy animal reproduction management and artificial insemination in goats for the farmers and veterinarians from different states in collaboration with TBI.

INFRASTRUCTURE

- Three state-of-the-art housing systems for high yielding indigenous, crossbred cattle and buffaloes were got constructed and commissioned for effective animal welfare and comfort.
- Wireless sensor based climate control room was developed for animal experiment.
- Behaviour monitoring system installed in cattle yard for different behavioural studies in dairy animals in tropical climatic conditions.
- Construction of sheds for heifers; milking animals and dry & pregnant animals at Cattle Yard.
- Renovation of animal breeding laboratory; lipid analysis laboratory; precision nutrition & nutrition biochemistry laboratory; feed processing & quality control laboratory; stress and environmental physiology laboratory and cell culture laboratory.
- Renovation of guest house/administrative block.
- Renovation of reference section of library.
- Renovation of security section.
- Renovation of electric works at sport ground/sutlej hostel/krishna hostel.
- ERS of NDRI developed 30 acres land owned by Eastern Regional Station of IVRI, Kolkata at Kalyani. The land was kept barren and unutilized for long time. The land was brought under cultivation and fodder crops were grown for animals feeding.

Organizational Structure of NDRI



1 INTRODUCTION

Historical Perspective

The National Dairy Research Institute is the premier organisation that provides R&D support for Dairy Development programmes of the Nation. Over the years, it has gained prominence as the front ranking research organisation on global basis. The Institute works in close liaison with various National and International developmental agencies. Scientific achievements, development of human resource at multi-tier level and infusion of science in various sectors of the dairy industry have been the hallmarks of the Institute. The Institute catalyses close interaction among scientists, students, farmers and dairy industry for orchestrating dairy development process in a harmonious manner.

The National Dairy Research Institute metamorphosed from erstwhile Imperial Institute for Animal Husbandry & Dairying, which was established at Bangalore in 1923. In 1936, it was expanded and renamed as Imperial Dairy Institute. It was in 1955 that its Headquarters were shifted to Karnal at the location formerly called Central Cattle Breeding Farm. With a view to consolidate the impressive infrastructure already developed at Bangalore, the unit was reorganised to serve as the Southern Regional Station of the Institute. In 1962 and 1964, two regional stations were established in Bombay and Kalyani, respectively, to serve as the Western and Eastern regional stations of the Institute. However, the Western Regional Station (WRS) at Bombay was closed down in 1984. The Southern and the Eastern Regional Stations continue to provide region specific R&D support for dairy development in relation to the agro-climatic conditions that exist in those areas. In 1966, the Institute's management was weaned away from the Ministry of Agriculture and brought under the wings of the Indian Council of Agricultural Research with a view to provide greater operational autonomy in research management functions. In 1989, status of Deemed University was conferred to the Institute for further strengthening the academic programmes for human resource development. The Institute provides high quality education in the field of dairying, which has no parallel in Asia. It is noteworthy that NDRI is not only an important contributor of manpower in dairying required in State Agricultural Universities (SAUs) but also plays an important role in enhancing the teaching capabilities of the faculty from SAUs. This is evidenced by recognition of the Institute by the ICAR, as "Centre for Advanced Faculty Training (CAFT)" in Animal Genetics & Breeding and Dairy Processing disciplines to further strengthen the research and training components.

Organisational Setup

The organisational structure of NDRI follows the Deemed University pattern of the ICAR. The policy making functions are managed through five main bodies focused at research, education and extension activities.

- 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. The Director NDRI, is the Chairman of this Board. The Research Advisory Committee is responsible for all round progress of 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 programmes.

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 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 station is conducted through 12 subject-matter Divisions/Sections.

Board Of Management

Chairman	Dr. A. K. Srivastava Director, NDRI
Member	Dr. S. L. Goswami Joint Director (Research), NDRI (upto 20.12.2011)
Member	Dr. G. R. Patil Joint Director (A), NDRI
Members (Head of Divisions/ Principal Scientists nominated By President of ICAR)	Dr. B. S. Prakash (upto 29.12.2011) Dr. S. Kulkarni Dr. A. A. Patel Dr. (Mrs.) B. K. Wadhwa Dr. S. S. Kundu Dr. A. K. Chakravorty Dr. Rameshwar Singh Dr. V. K. Kansal (upto period 30.09.2011)
Members (Two Members of Governing Body Nominated by the President, ICAR)	Dr. (Ms.) Chanda Nimbkar (NARI, Phaltan, Maharashtra) Dr. P. Raghava Reddy (VC, ANGRAU, Hyderabad)
Member (VC of Agril. University Nominated by the President, ICAR)	Dr. K. M. Bujarbaruah VC, AAU, Imphal
Member (Nominee of the DG, ICAR)	Dr. K. M. L. Pathak DDG (AS), ICAR
Member (Director IVRI/IARI)	Dr. M. C. Sharma Director, IVRI
Member (Animal Husbandry Commissioner, Ministry of Agriculture)	Animal Husbandry Commissioner DAH&D, Govt. of India
Member (One Eminent Scientist in the Field of Research done in Institute but not employed by ICAR, Nominated by President, ICAR)	Dr. M. P. Yadav, Ex-VC SVPUAT, Meerut
Member (One Eminent Agril. Educationist Concerned with the Research work of the Institute but not employed by ICAR, Nominated by President, ICAR)	Dr. B. B. Mallik, Ex-VC WBUAFS, Kolkata
Member (One Official Persons Representing Agriculture Interest Nominated by President, ICAR)	Shri. Rajvir Jeeta Ram Shri Dhiraj N. Chauhan
Member (FA, ICAR or his Nominee)	D.D. (F-I), ICAR
Member (Development Commissioner Rohilkhand Division)	Commissioner, Rohtak Division, Rohtak
Member Secretary	Sh. J. K. Kewalramani Joint Director (Admn. & Registrar)

Academic Council

Chairman	Dr. A. K. Srivastava Director, NDRI
Vice-Chairman	Dr. G. R. Patil Joint Director (A)
Member	Dr. S. L. Goswami Joint Director (Research) (upto 20.12.2011)
Members (Four Eminent Scientists from outside the NDRI)	Dr. B. P. Shah Principal & Dean SMC College of Dairy Science AAU, Anand 388 001 (Guj.)
	Dr. B.V. Venkateshaiah Dean Dairy Science College Karnataka Veterinary Animal & Fisheries Sciences University (KVAFSU) Hebbal, Bangalore – 560 024
	Dr. S. R. Singh, Director, Institute of Agriculture Banaras Hiudu University Varanasi - 221005
	Dr. B. Mishra, Vice Chancellor Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu
Member (Representative from the UGC)	UGC Nominee
Member (DDG Education or his nominee)	DDG (Edn.), ICAR
Members (One Senior Scientist from each Division)	Dr. Shiv Prasad Dr. B. S. Prakash (upto 29.12.2011) Dr. A. K. Dodeja Dr. K. K. Datta Dr. Rameshwar Singh Dr. Ram Kumar Dr. A. A. Patel Dr. R. S. Manik Dr. (Mrs.) B. K. Wadhwa Dr. Y. S. Rajput Dr. S. S. Kundu Dr. Satish Kulkarni Dr. I. K. Sawhney Dr. R. S. Gandhi Dr. A. S. Harika Joint Director (Admn. & Registrar)
(Two Representatives from PG Faculty)	Dr. R. C. Upadhyay Dr. B.S. Chandel
Students Member	Mr. Sidhartha Shankar Layek Mr. Lalatendu Keshary Das
Member-Secretary	Registrar (Academic), NDRI Deemed University

Research Advisory Committee

Chairman (An Eminent Scientist from outside ICAR system, nominated by DG, ICAR	Dr. K. Pradhan Vice-Chancellor, OUA&T, Bhubneshwar, Orissa
Members (External experts, nominated by Director General, ICAR)	Dr. N. Balaraman, Ex-Vice-Chancellor, TNVASU, Plot No. 27, Rajalakshmi Nagar, Madipakkam, Chennai - 600091
	Dr. B.S. Bisht, Vice-Chancellor, GBPUA&T, Pantnagar
	Dr. H.N. Mishra, Head, Post Harvest Technology Centre, IIT, Kharagpur – 721302
	Dr. Narpinder Singh, Dean, Applied Sciences and Prof. of Food Sciences, Dept. of Food Sciences & Technology, Guru Nanak Dev University, Amritsar
	Dr. Suresh Pal, Head, Deptt. of Agril, Economics, IARI, Pusa, New Delhi
Member	Dr. K.M.L. Pathak Dy. Director General (AS), ICAR
Member	Dr. A.K. Srivastava Director, NDRI
Member Secretary	Joint Director (Res.), NDRI

Extension Council

Chairman	Dr. A. K. Srivastava Director, NDRI
Vice Chairman	Joint Director (Extension)
Members	Dr. S. L. Goswami Joint Director (Research) (upto period 20.12.2011)
	Dr. G. R. Patil Joint Director (Academic)
	DDG (Extn. Edu.), ICAR
	Dr. S. S. Kundu
	Dr. A. A. Patel
	Dr.(Mrs.) Smita Sirohi
	Dr. R. S.Gandhi
	Dr. R. C. Upadhayay
	Dr. A. K. Chakravarty
	Dr. Shiv Prasad
	Dr. A. K. Singh
Member (Regional Station)	Dr. T. K. Dutta
Members	Director (Crops), Govt. of India, Ministry of Agriculture Director General, Deptt. of Animal Husbandry & Dairying, Govt. of Punjab,
	Director (Farm Information), Directorate of Extension, Govt. of India,
Member Secretary	Dr. Ram Kumar Head Extension NDRI

FINANCE

The financial outlays in terms of actual expenditure for Plan and Non-plan for the year 2011-2012 was ₹ 12576.42 lakhs and the sanctioned budget for Plan and Non-plan in 2011-2012 was ₹ 12578.23 lakhs. These figures include the financial outlays for strengthening of Deemed University/KVK and Regional Stations.

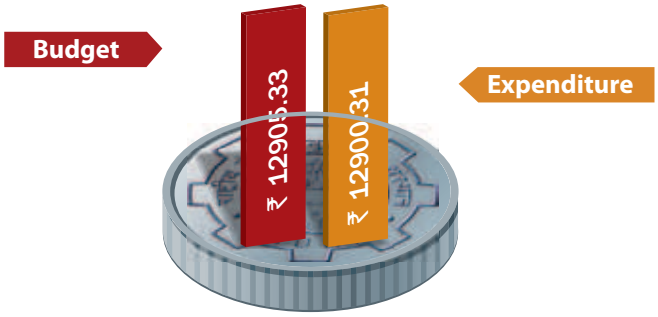
Financial Outlays & Expenditure during 2011-12

(₹ in lakhs)

Head	Budget	Expenditure
Non-Plan	10388.23	10386.61
Plan	2190.00	2189.81
Strengthening of Deemed University	250.00	284.34
KVK/TTC	77.10	75.55
Total	12905.33	12900.31

The Revenue Receipts of the Institute and the Regional Stations for the year 2011-2012 were ₹ 787.03 lakhs.

FINANCIAL OUTLAY



Revenue Generation (2011-2012)

Items	Amount (₹ in Lakhs)
Sale of Milk	228.79
Interest on STD	158.54
Other Receipts	399.70
Total	787.03

Position of Manpower at NDRI, Karnal and its Regional Stations as on 31.03.2012

Type of Posts	Existing		Vacant	Additional Proposed **	Total	
	Approved by D/o Expenditure	In position			Sanctioned + Additional	Existing + Additional
Scientific	194#	154	40	20	194+20	154+20
Administrative (Group A&B)	36	29	07	-	-	-
Technical	368	300	68	15	368+15	300+15
Administrative (Group B&C)	127	130*	24*	04	127+4	130+4
Auxiliary	-	-	-	-	-	-
Supporting	779	618	161	11	779+11	618+11
Casual Labour	-	-	-	-	-	-
Total	1504	1231	300	50	1468+50	1202+50

**27 Post of UDC are excess due to restructuring of administrative and allied cadre post*

***As approved by the Oversight Committee for implementation of 27% OBC reservation*

#Scientific cadre strength at NDRI (162) + SRS (22) + ERS (10) = 194

2 RESEARCH ACHIEVEMENTS

Dairy Cattle Breeding

GENETIC IMPROVEMENT OF MILCH ANIMALS THROUGH IDENTIFICATION AND DISSEMINATION OF SUPERIOR GERMPLASM BY APPLICATION OF EMERGING REPRODUCTIVE AND MOLECULAR TECHNOLOGIES

Integrated Genetic Improvement of Dairy Cattle and Buffaloes Under Open Nucleus Breeding System

A total of 119 KF, 78 Sahiwal and 80 Murrah young males were reserved for progeny testing during the project period (2007-2011). The ranges for the expected predicted difference (EPD %) and dam's best 305-day milk yields for the three breeds were 1.57-18.44, 0.24-23.10 and 1.69-18.63% and 4546-8648, 1906-3811 and 2330-4341 kg, respectively. Similarly, elite cows/buffaloes were selected for nominated matings with proven bulls.

Performance of elite herd used for nominated matings (2007-2011)

Traits	KF	SW	MU
Range of number of elite cows	52-109	27-49	54-75
Proportion of the milch herd (%)	(23-41%)	(21-26%)	(34-38%)
Average EPA of elite cows/buffaloes (kg)	4492-5520	2199-2440	2339-2371
Average EPA of all cows/buffaloes (kg)	4049-4247	1848-2028	2153-2197
Avg. LY of elite cows/buffaloes (kg)	4604-5501	2468-2773	2897-2937
Avg. LY of all cows/buffaloes (kg)	4127-4305	1882-2046	2158-2207
Best lactation 305D milk yield (kg)	5018-8648	2095-4745	2504-4496

Two sets each of Sahiwal (11 bulls) and KF (17 bulls) and three sets of Murrah bulls (43 bulls) were evaluated during the period. Out of these bulls, 4 Sahiwal, 5 KF and 3 Murrah bulls were selected as proven bulls with their EBVs ranging from 1641-1917 kg, 3228-4144 kg and 1972-2116 kg, respectively; while their superiority over herd average ranged from 9.33-27.73%, 12.00-16.70% and 8.41-17.26%, respectively. During 2007-2011, a total of 2152 KF and 2325 Murrah female progeny born from bulls under field conditions.

Number of AIs, conception rate and crossbred daughters born under field conditions

Year	AI	CR%	M	F	Total
2006-07	2639	40.2	318	323	641
2007-08	2625	46.1	444	437	881
2008-09	2494	48.9	455	420	875
2009-10	2755	48.9	479	446	925
2010-11	3070	47.9	560	526	1086
Total	13, 583	46.4	2256	2152	4408

Number of AIs, conception rate and Murrah daughters born under field conditions

Year	AI	CR%	M	F	Total
2006-07	2061	39.2	323	318	641
2007-08	2594	45.1	337	323	660
2008-09	1942	45.8	403	340	743
2009-10	2563	49.3	469	413	882
2010-11	2810	50.64	566	479	1045
Total	11, 970	46.0	2098	1873	3971

The data on body weights of various breeds at different stages of life were analyzed to monitor the growth rate. The growth bands were constructed to select the dairy animals at different stages of life.

Least squares means of body weights (kg) in cattle and Murrah buffaloes

Breed	Birth weight	6 months	12 months	18 months	24 months	30 months
Sahiwal	20.54 (1332)	81.48 (677)	134.86 (684)	199.69 (664)	250.21 (672)	300.59 (650)
Karan Fries	27.83 (378)	97.85 (378)	161.77 (378)	234.45 (378)	301.86 (378)	-
Murrah buffaloes	32.63 (254)	103.03 (254)	162.67 (254)	254.92 (254)	344.49 (254)	418.17 (254)

During the period, a total of 3,72,770 doses of frozen semen of Karan Fries, Sahiwal and Murrah bulls were produced and 4,70,134 doses of frozen semen of three breeds were disseminated (sold and supplied) through ABRC, NDRI to various dairy development agencies / institutes and farmers.

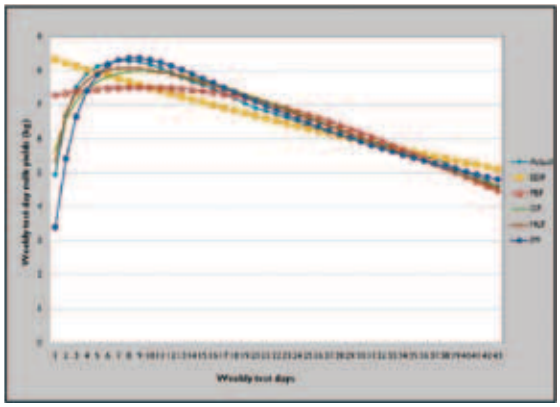
Breed wise production and dissemination of male germplasm

Year	KF		SW		MU	
	FS Production	FS Dissemination	FS Production	FS Dissemination	FS Production	FS Dissemination
2007	34040	37121	27620	18901	7480	27888
2008	35350	42495	9720	25736	17080	27305
2009	45450	70202	19650	22427	27400	38395
2010	32250	48034	12620	15175	16800	30698
2011	36747	32764	17480	9242	33083	23751
Total	183837	230616	87090	91481	101843	148037

FS = Frozen Semen

Sahiwal cattle

- Five models (EDF=Exponential decline function; PEF=Parabolic exponential function; GF=Gamma type function; MLF=Mixed log function; IPF= Inverse polynomial function) were used to fit lactation curve based on weekly test day milk yields (WTDMYs) in Sahiwal cattle. The inverse polynomial function (IPF) was found to be the best fit (R2 value = 99.8%).



Observed and predicted WTDMYs (kg) for various lactation curve function in Sahiwal cattle

- The growth curves up to 6 months of age were linear in nature in both male and female Sahiwal calves. Average daily weight gain from birth to 6 months of age was 339.11g/day in female calves and 333.50 g/day in male calves. The growth bands were constructed for male and female calves using 26 weeks body weight in Sahiwal calves. These growth bands can be used as a criterion of selection of young calves at an early age.
- For prediction of first lactation 305-day milk yield, Multiple Linear Regression (MLR) and Artificial Neural Network (ANN) models were developed using body weights at different ages as independent variables and FL305DMY as dependent variable and the accuracy of fitting both models was compared. The accuracy of prediction from both the models was observed to be very low. However, the accuracy of prediction was comparatively higher from ANN model than MLR model for test set of data. As the ANN predictions gave higher R2 values with lower RMSE and SD ratio in comparison to MRA in test data set, it can be interpreted that ANN was comparatively more accurate to predict FL305DMY using body weights in Sahiwal cattle.

Karan Fries Cattle

- The accuracy of prediction of 305-day milk yield based on monthly milk yields was comparatively higher than the monthly test day milk yields (90% versus 64%).
- It was concluded that either of the three methods viz., SRLS, LSQ and BLUP could be used for genetic evaluation of Karan Fries sires using the key test day milk yields, monthly milk yields and cumulative monthly milk yields due to high rank correlations between them and comparable efficiency and accuracy of these sire evaluation methods. However, keeping in view the simplicity of LSQ compared to BLUP and SRLS, it may be recommended for use in estimating the breeding values of sires based on actual 305-day or less and predicted lactation milk yield.
- Based on fitting of stepwise multiple regressions, the regression equation with 4 variables viz. MTDY 4, MTDY-6, MTDY-9 and MTDY-2 was considered more appropriate for prediction of first lactation 305-day milk yield with 86% accuracy and 6.79 percent error of prediction in 305-day milk yield.
- The comparison of prediction equations evolved on the basis of fortnightly, monthly and bimonthly test day milk yields for predicting the 305-day milk yield revealed that the accuracy of prediction did not differ significantly from each other ranging from 86 to 87% only.
- The heritability estimates of various economic traits were estimated using mixed model methodology using three types of models in Karan Fries cattle. The heritability estimate in three trait model combining FL305MY, fat yield and SNF yield (0.25±0.02) was higher than single trait FL305MY (0.24±0.09) suggesting that multi-trait model should be used for genetic evaluation.

Murrah Buffaloes

- The performance recording including information on daily, weekly and monthly test day milk yield and part lactation records of the daughters of various test bulls were generated. The lactation curve models were developed for Murrah buffaloes. Four functions (Inverse quadratic polynomial, exponential, polynomial regression and mixed log functions) were explored to weekly and monthly test day milk yield of buffaloes for developing three and five parameters lactation curve models. The models can be used for predicting weekly, monthly and total lactation milk yield in Murrah buffaloes in organized and rural households.
- The optimum models for prediction of breeding efficiency of Murrah buffaloes has been developed with the fitted accuracy of 70.21 to 85.09 %. Indices of breeding efficiency of Murrah buffaloes have also been developed.
- The waiting period or days to first service should be 63 days for Murrah Buffaloes. The daughters pregnancy rate (DPR) of Murrah buffalo has also been standardized. The conversion of first service period to DPR 63 for Murrah buffalo should be DPR 63 = 0.0033 (274 – FSP).
- Three method such as Contemporary Comparison, Least-squares and Best Linear Unbiased Prediction (BLUP) were used for evaluation of buffalo bulls using single production traits (part lactation traits of first lactation) and the combination of production traits (part lactation traits of first lactation) and reproduction trait (DPR63). It was observed that Contemporary Comparison Method should be used for evaluating the Murrah bulls using test day 5 milk yield (TD5MY). Murrah bulls should also be evaluated based on TD5MY and DPR63.

Multiplication and Dissemination of Tharparkar Germplasm

During the period (January-December, 2011), a total of three males were reserved on the basis of EPD, dam's best 305 days lactation yield, breed characteristics and physical conformity for selection of young male calves for future breeding. The dam's best 3054days lactation yield those reserved males varied 1766 to 2394 kg. Bulls identified, reserved for breeding were housed in separate pens and monitored for growth. Young males maintained at ABRC, were monitored and trained for semen donation. A total of 104 AI were performed with frozen semen of two bulls resulting in 37 conceptions. The overall conception rate was 36%. Average production and reproduction performance of Tharparkar cattle at NDRI herd

(Cows calving during January-December, 2010) was computed for performance traits. Average age at first at calving was 1164 days. Averages for TMY (kg), 305-MY (kg), LL(days), DP (days), SP (days) and CI (days) were 1698, 1395, 236, 182, 128 and 419, for first lactation and 1457, 1348, 246, 191, 118 and 380, respectively for all lactation. Four bulls were under regular semen collection. A total of 4824 doses of frozen semen from four Tharparkar bulls were produced. A total 260 doses of frozen semen of three Tharparkar bulls were supplied/ sold to the farmers/ developmental agencies. Efforts were also initiated for procurement of Tharparkar germplasm (Male claves/ Semen) from other sources.

Cytogenetical and Molecular Evaluation and Mapping of QTLs of Milk Production and Fertility Traits in Cattle and Buffaloes

Cytogenetical conventional studies: In livestock species infertility and sub fertility cause quite huge losses to breeders and owners. These defects are due to nutritional deficiencies, hormonal imbalance or genetical deviations. Genetic architecture is basis of most of the defects, which can be visible in chromosomes at gross level. Chromosome evaluation was carried out using conventional, and various banding patterns viz. C-, R- and G-banding of animals of three species (cattle, buffalo and goats) of both the sexes with different reproductive problems. Over 300 animals were used in the study. The examination of metaphases of these animals revealed numerical or structural chromosomal anomalies. In one study among these 107 animals individuals (87.15%) showed a normal complement and 13 animals (12.15%) revealed chromosomal aberrations. On examination of metaphases of these animals found one case of numerical chromosomal abnormality (XO, configuration). There were four animals with XX/XY chimaerism of cattle, three cases of intersexuality (XX) in goats. Two cases (one cattle and one buffalo) of deviation in band patterns of chromosomes were observed. One intersex goat was found expressing sexual behaviour, XX /XY rare example of horned intersex goat.

Fragile X-chromosomes in males: The present investigation, carried out on 32 breeding bulls of Sahiwal, Karan Fries cattle and Murrah buffaloes, on three major aspects viz., semen evaluation, cytogenetic examination of fragile X- chromosomes and molecular assessment of fragile-X chromosomes. The results revealed that seminal parameters were significantly different between categories of bulls. Seminal parameters of poor semen freezability and normal bulls were significantly different from poor semen quality animals. Significant differences in total fragile sites were found between categories of bull but the different breeds were not significant. The fragile sites on the long and short arms of X-chromosome were not significant between breeds and categories of bulls.

Overview of results suggested that the seminal parameters were negatively associated with fragile sites. Detection of fragile sites was found to be associated with subfertility problems like poor libido, poor semen freezability and abnormal semen quality in breeding bulls. Primers specific to fragile sites detected could confirm existence of fragile sites on X-chromosome. Chromosomal abnormalities are quite common causes of specific types of disease and reproductively problematic animals.

Genetic polymorphism of milk proteins: Work was carried out on leptin, DGAT (DGAT1, DGAT2 and MOGAT2) and butyrophilin candidate genes in Murrah, Surti and Bhadawari buffaloes. The salient findings are described below:

Leptin gene: Leptin SSCP polymorphisms after direct DNA sequencing revealed two SNPs at nucleotide positions 25 and 316 of the sequence (EU078405; EU194869) within exon 3 of Murrah buffalo indicating polymorphic nature of region. Polymorphic leptin allelic variants sequences of Murrah buffalo identified using LEPE3 & LE3C primer revealed five & six computational SNPs, respectively.

STAT5A gene: STAT5A candidate gene analysis revealed three SSCP polymorphisms viz. STE6I15, STE14151 and STF at intron 15, exon 14 and exon 7 of STAT5A gene respectively in Murrah, Surti and Bhadawari breeds of buffaloes. SSCP patterns of STAT5A gene viz; STE6I15 and STF were found to be differing significantly for 305 days milk yield in Murrah Buffaloes. Murrah buffaloes with STAT5A STE6I15 SSCP variant B had higher least squares mean for milk yield (3239.84 kg) as compared to pattern A (2473.80 kg). Murrah buffaloes with STAT5A STF SSCP variant B had higher least square mean for milk yield (2324.87 kg) as compared to pattern A (1838.27 kg).

DGAT GENE (DGAT1, DGAT2 & MOGAT2): DGAT2 gene did not exhibit the SSCPs however, the SSCP polymorphisms were found at the 3' UTR region of exon 5 of buffalo MOGAT2 Gene. Direct DNA sequencing of polymorphic SSCP patterns

of MOGAT2 revealed one SNP (T-C substitution) in exon 5 at 193rd nucleotide position (denoted as c.193 T>C) of Murrah buffalo gene sequence (EU239373, EU239374). Polymorphic Murrah buffalo MOGAT2 allelic variants sequences (EU239373) identified using MOIN5C revealed 11 SNPs.

Butyrophilin gene: Three SSCP variants were detected in BTI1 amplified fragment of Murrah, Surti and Bhadawari butyrophilin gene (BTI1 SSCP polymorphism) and direct sequencing of the Murrah buffalo fragment revealed seven SNPs present among three SSCP variants. Eleven computational SNPs were detected after comparison of butyrophilin variants A sequence of Murrah buffalo and cattle reference sequence. Butyrophilin BTI1 SSCP Polymorphism identified was differing significantly (P≤0.05) with 305 days lactation milk yield of Murrah buffaloes. Murrah buffaloes with BTI1BB genotypes had 683.93 kg and 320.48 kg higher milk yield as compared to BTI1AA and BTI1CC genotypes, respectively. A neighbor-joining tree constructed (Tamura-Nei genetic distance model) based on leptin, STAT5A, MOGAT2 and butyrophilin consensus sequence of Murrah buffalo and related consensus reference sequences of other species at same gene region agreed with their taxonomic relations.

Beta casein gene in Tharparkar cattle: Tetra primer ARMS- PCR analysis was used for beta casein gene on of Tharparkar cattle. Total 3 genotypes AA, AB and BB were found in the selected 50 females. Study revealed that frequency of frequency AA genotype (0.94) was quite higher than AB (0.04) and BB (0.02) genotypes. Frequency of A and B allele was 0. 96 ± 0.0195 and 0.04 ± 0.0195, respectively.

Alpha lactalbumin gene in Tharparkar cattle: PCR-RFLP analysis was used to investigate alpha lactalbumin gene. Analysis revealed presence of two genotypes AB and BB in the selected Tharparkar animals. Frequency of AB and BB genotype was 0.38 and 0.62 respectively. The third genotype AA was not observed in the population. The frequency of B allele (0. 81±0.0392) was predominately higher than A allele (0.19±0.0392). Though no significant association could be observed between alpha lactalbumin gene variants and milk yield at 1% and 5% level of significance, however, there was difference in the means of milk yields as animals with BB genotypes showed higher milk yield.

Genetic variability in exon V of the MOGAT2: Study was undertaken to evaluate the genetic variability in exon V of the MOGAT2 gene using a non-radioactive PCR-SSCP method.

Molecular investigations on fertility genes: Several reasons of male infertility exist; spermatozoal morphology and motility are quite important based genetical factors. During the year TNP-1 and TNP-2 genes responsible for synthesis of transition protein-1 and transition protein -2 respectively were studied. In this study 29 KF, 13 SW and 18 MU bulls were selected from the herd. DNA of these selected animals was isolated from blood by using phenol-chloroform method. Three primers one for TNP-1 and two for TNP-2 gene were used in this study. PCR-SSCP technique was used to screen the animals. Sequencing of different variants of PCR-SSCP patterns and there analysis revealed three SNP's at 205, 340 and 346 bp position of intronic region between two patterns on TNP-1 gene, two SNP's at 182 bp and 186 bp position of intronic region between two patterns of first primer of TNP-2 gene. Breed/species CLUSTAL W multiple alignment of obtained sequence revealed variation with reference Bos taurus sequence for this two genes at exonic as well as intronic regions. BLAST homology study between related species indicated obtained TNP-1 (variant-C) sequence had 96% maximum identity with Bos taurus, 93% with Capra pyrenaica and 92% with Ovis aries. Whereas TNP-1 (variant-D) had 97% maximum identity with Bos taurus sequence and rest were same as variant-C. Variant-E and variant-F sequence of first primer of TNP-2 gene showed 97% and 96% homology with Bos taurus TNP-2 gene sequence. Analysis of variance study between different SSCP patterns and seminal parameters revealed significant effect of variant-C and variant-D on aniline blue test result of spermatozoa. DNA repository for all these animals was made and stored at low temperature freezers.

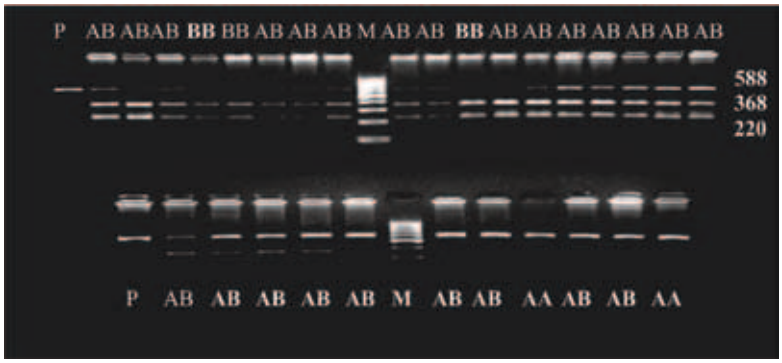
Evaluation of zygosity in twin born dairy animals using PCR –RFLP method: Investigation was carried out on 62 animals of Sahiwal, Hariana, Karan Fries, Karan Swiss and Holstein Frisian breeds among cattle, Murrah buffalo and Alpine X Beetal (AB) and Saanen X Beetal (SB), among goats. Chromosome preparations were made by short term lymphocyte culture setup from eight cattle calves, one buffalo and two goats. Heterozygous twins showed chimaerism of sex chromosomes both on molecular and cytogenetic basis and Hariana breed showed parallelism of sex chromosomes. Molecular aspects were studied using 12 primers on the DNA of the 62 animals out of which 38 animals were either twins or single member from the twins and 24 were

control. The specific primers revealed similarity in band patterns in co-twin, amplification of probe associated with Y chromosomes in female co-twins confirmed the admixture of blood of both male and female foetuses in uterus. Primers of intersexuality revealed XX specific band patterns in case of goat kids. The study revealed usefulness of molecular cytogenetics in early detection of freemartinism in cattle and buffaloes, and intersexuality in goats.

Molecular Characterization and Identification of Polymorphism in Mastitis Related Genes in Sahiwal, Karan Fries Cattle and Murrah Buffaloes

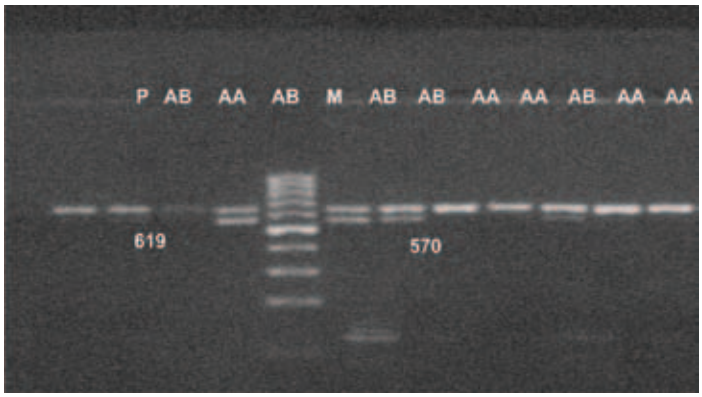
Molecular characterization and identification of polymorphism CARD 15 Gene in Sahiwal cattle: Exon 12 of caspase activating recruitment domain 15 (CARD 15) gene in 162 Sahiwal cattle was analyzed by PCR-RFLP using PvuII and SacI restriction enzymes with five sets of primers, which revealed polymorphism in two primer-restriction enzyme combinations. Seven nucleotide changes (SNPs) were found in the 3'UTR region of Exon 12, of this four in contig 4 and one each in contig 1, 2 and 5. Association of polymorphic pattern of Primer 2-SacI and Primer 5-PvuII with incidence of mastitis were found to be non- significant.

PCR-RFLP of Contig 12.5 of CARD 15 using PvuII Restriction Enzyme



AB Genotype :Three bands (588,368,220 bp)
BB Genotype : Two bands (368, 220 bp)
AA Genotype : One band (588 bp)
P: Undigested PCR Product (588bp)
M : 100 bp DNA Ladder

PCR-RFLP of Contig 12.2 of CARD 15 using SacI Restriction Enzyme



AA Genotype : One band (619 bp)
AB Genotype : Two bands (619,570 bp)
P : Undigested PCR Product (619bp)
M : 100 bp DNA Ladder

Genotypic and allelic frequencies of CARD 15 in Sahiwal Cattle

Primer-RE Combination		Frequency				
		Genotypic (%)			Allelic (%)	
		AA	AB	BB	A	B
PvuII	Contig 12.5	1.9 (3)	91.9 (149)	6.2 (10)	47.9	52.1
	Contig 12.1, 12.2, 12.3 and 12.4 did not show cutting site in Bos indicus					
SacI	Contig 12.2	46.9 (76)	53.1 (86)	Nil	73.5	26.5
	Contig 12.1, 12.3, 12.4 and 12.5 did not show cutting site in Bos indicus					

Network Project on Buffalo Improvement

The breeding programme in the Murrah herd was followed for test mating using semen of eight test bulls of XII set and three test bulls of XIII set at the institute herd and the test mating was continued up to March, 2012. The dams' best lactation 305 day or less milk yield of the test bulls of XII set and XIII set had ranged from 2631 to 3222 kg and 3114 to 3617 kg, respectively.

Average age at first service of buffaloes was 31.06 months and average age at first calving of buffaloes was 42.13 month. Average age for initiating training of the young bulls and age at first collection was marginally reduced to 25.03 and 32.99 months. The average service period of buffaloes was significantly reduced to 120.66 days. The overall mortality was 5.89% in female buffaloes and reduced to 14.75% in male buffaloes however, the female calf (0-3 months) mortality was 11.59%. The overall female conception rate in the herd was increased to 37.32%. The conception rate was estimated based on pregnant buffaloes up to January, 2012. Forty nine more daughters and fifty seven male calves were born including nine elite calves in the herd. The milk production and productivity of buffaloes were increased in the herd. The wet and herd average was increased to 6.79 and 3.03 kg.

Selection of young Murrah bulls: A total of eight Murrah male calves were reserved during the period (2011-12) on the basis of Expected Predicted Difference and dam's best 305 d or less lactation milk yield, breed characteristics and physical conformity for selection of young male calves for future breeding. The dam's best 305 days lactation milk yield of reserved males ranged from 2545 in first lactation to 4341 kg. The EPD and superiority of reserved Murrah male calves ranged from 63 to 387 Kg and 2.87 to 17.53 %, respectively. The center proposed five bulls out of which one breeding bull was selected for test mating under XIII Set.

Progeny test evaluation – set-wise: Genetic evaluation of VIII set of Murrah bulls using Contemporary Comparison Method was completed and Bull No. MU 4813 having sire index of 2101 kg and dam's best lactation 305 days milk yield of 3016 kg was declared as second best ranking proven bull with about 12.59% superiority over contemporary daughters. The information on 305 days milk yield of daughters were collected for IX set of bulls.

Bulls for elite mating at the institute herd: The breeding programme in the Murrah herd was followed for nominated mating using semen of Two Proven Murrah Bulls of VI and VII Sets and of one Proven Murrah Bull of VIII Set. Nominated mating using two Proven Murrah Bulls of VIII Set was continuing in the herd. A total of 61 Murrah were identified as elite animals. The elite buffaloes were used for nominated matings with the proven bulls under the breeding programme. The average lactation milk yield of these elite Murrah buffaloes was 2962 kg which was 38.28% higher than the herd average. The best lactation milk yield of elite Murrah buffaloes ranged between 2506 to 4341 kg.

Impact analysis: The germplasm of genetically superior progeny tested proven bulls is being used on elite cows in organized herds for production of high-pedigreed bulls for further multiplication and production of superior germplasm and establishment of elite herds. Superior 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.

Germplasm production and dissemination: The NDRI center produced 13340 doses of frozen semen from four Murrah test bulls. The center supplied 2000 doses of frozen semen to other centers. In addition 2336 doses of semen were supplied to NDRI field unit and 18,129 doses of frozen semen to farmers and other dairy development organizations during the period.

Network Project on Buffaloes (Field Unit)

A total of 2995 were performed in Murrah Buffaloes under field conditions during 2011-12 and as a result 49.1% conception rate was obtained. The highest conception rate was observed in the month of November (56.64 %) and the lowest was in the month of Aug (43.43%). Across the villages, the highest conception rate was observed in Rindal (60.53%) and lowest was observed in the village Janesaron (34.82%). A total of 1086 (583 male and 503 female) Murrah buffalo calves were born in the farmers' herds and performance data on 784 buffaloes have been recorded for evaluation of bulls under field conditions. The total herd strength of registered females and the breedable females at different centers was 5622 and 4557 respectively. As many as 13 breeding bulls belonging to the 11th and 12th set were used for AI during the year.

Indigenous Breed Project (Sahiwal Cattle)

The first set of 8 Sahiwal bulls has been put under progeny testing at the germplasm and data recording units. The dam's best yield of these bulls ranged from 2503 – 3704 kg. A total of 1710 semen doses have been provided to various data recording units. A total of 1055 AIs have been done at NDRI Farm (germplasm unit) and 5 data recording centres with the semen of these bulls and a total of 371 pregnancies have been recorded. The average conception rate of 35.17% was observed with a range of 22.35% to 45.27% at various herds.

Livestock Production And Management

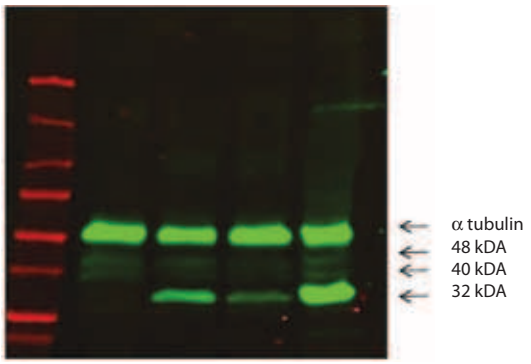
Semen Quality Improvement and Fertility Enhancement

Testicular biometry, seminal characteristics and freezability in crossbred bulls: Relationship of testicular parameters such as scrotal circumference (SC), testicular length (TL), testicular volume (TV), testicular weight (TM) and shape of the testis with sperm production was studied in crossbred bulls belonging to different age groups. It was inferred that the testicular development takes place at a faster pace during early ages and reaches high level of growth at 3-4 years age and then remains in a plateau. There was no significant difference between bulls of different age groups in terms SC, TL, TW and ejaculate volume. Similarly, the sperm concentration/ml was also higher, though not enough to be significant in the bulls belonging to 3-4 years of age compared to those in 2-3 years age group. Both the ejaculate volume and sperm concentration/ml of ejaculate did not differ significantly between the bulls in 3-4 years and 4-5 years age group. Though non-significant, a negative association was observed between ejaculate rejection rate (ERR) and SC, ERR and TL, ERR and TM, and ERR and TV. However, the SC was positively associated with sperm concentration. Similarly, the association of sperm concentration with TL, TV and TM were positive.

Grandsire-sire-son relationship in terms of semen quality: Studying the semen quality details over generations would give an idea about how semen quality is being altered through generations. The mean age at first semen collection (AFSC) was 718.14 ± 13.18 days in grand sires (GS), which increased to 783.86 ± 25.46 days in sires that in turn decreased to 716.08 ± 40.03 days in the progeny. But the age at first semen freezing (AFSF) showed different trend. There was a linear increase in AFSF from GS to son. In the GS the AFSF was 767.14 ± 25.82 days, which increased to 831.43 ± 31.17 days in sires. The AFSF further increased in son (871.25 ± 61.82 days), which was higher compared to both GS and sires. On contrary to the AFSF that increased from GS to son, the semen production period (SPP) showed a significantly ($P<0.05$) decrease. The SPP was significantly ($P<0.05$) higher in GS (1058.71 ± 129.72 days) than bulls but there was a no significant difference between sire and son in terms of SPP. The ERR was significantly ($P<0.01$) higher in son compared to GS but there was a no significant difference between sire and son.

Dynamics of cryo-capacitation during cryopreservation – A study on boar model: Protein tyrosine phosphorylation (PTP) in the sperm is associated with capacitation in several mammalian species. Although tyrosine phosphorylated proteins have been demonstrated in cryopreserved sperm indicating capacitation-like changes during cryopreservation, these changes have not yet been quantified objectively. The PTP, intracellular calcium ($[Ca^{2+}]i$) and sperm kinematics were monitored throughout the process of cryopreservation and studied the relationship among them in boar spermatozoa. Sperm kinetics, assessed by CASA, showed significant alterations during cryopreservation. The curvilinear velocity, average path velocity and straight line velocity of the sperm decreased significantly during cryopreservation. While the percentage of sperms with high $[Ca^{2+}]i$ declined, the global PTP in the sperm increased significantly during cryopreservation. Specifically, cooling

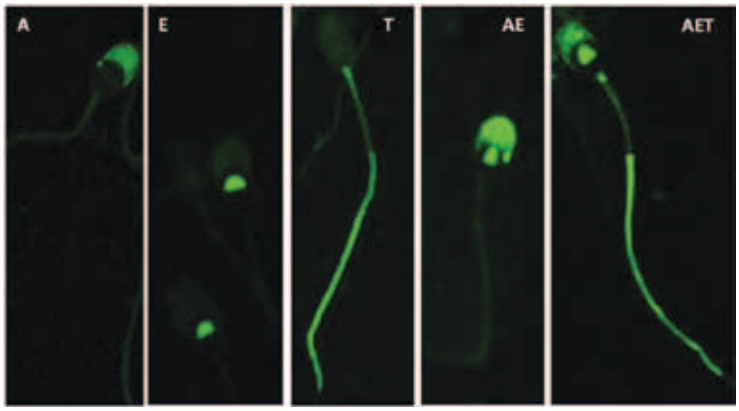
to 5°C induced PTP in the spermatozoa and a 32 kDa protein, not observed in fresh semen, appeared after cooling and was consistently present in the sperm throughout various stages of the cryopreservation process. While the level of expression of this phosphoprotein decreased after addition of second extender, frozen-thawed spermatozoa showed an increased expression. The proportion of sperm cells with PTP in the acrosomal area was also significantly increased during cryopreservation indicating that the PTP might be associated with capacitation-like changes. These results provided the first quantitative evidence on dynamic changes in the subpopulation of boar spermatozoa undergoing tyrosine phosphorylation during cryopreservation.



Cryopreservation induced tyrosine phosphorylation in spermatoza (32 kDa phosphoprotein was not present in fresh sperm but appeared during cryopreservation)

Oviductal fluid induces tyrosine phosphorylation in spermatozoa: Following insemination, spermatozoa are retained in the isthmic region of the oviduct, where essential steps of capacitation are co-ordinated. Although a majority of the spermatozoa are exposed to similar conditions in the oviduct, the speed of the response varies with the male and the state of spermatozoa. Individual boar variations in terms of the ability of spermatozoa to undergo tyrosine phosphorylation in response to isthmic oviductal fluid were evaluated. Cryopreserved spermatozoa from four boars were incubated with pre- and post-ovulatory oviductal fluid for 6h. Sperm kinematics, global protein tyrosine phosphorylation and dynamics of different phosphorylation patterns were analysed at hourly interval. The percentages of phosphorylated spermatozoa in the pre-ovulatory oviductal fluid treated group were significantly higher than in the other treatment groups. However, motility, velocity and protein tyrosine phosphorylation in spermatozoa in response to oviductal fluid and control media showed differences between boars. Spermatozoa from all four boars showed strong expression of a 19 kDa phosphoprotein while spermatozoa from two boars showed strong expression of a 32 kDa phosphoprotein when incubated with pre ovulatory oviductal fluid. While phosphorylation of proteins in the acrosome and the equatorial segment of the sperm were noticed at an early stage during incubation with oviductal fluid, the tail phosphorylation appeared at later stage of capacitation.

Freezing method alters the response of cryopreserved spermatozoa to oviductal fluid: Sperm capacitation takes place in the oviduct and protein tyrosine phosphorylation of sperm proteins is a crucial step in capacitation and acquisition of fertilizing potential. Cryopreserved spermatozoa show altered expression of protein tyrosine phosphorylation in the oviduct. Two freezing methods (conventional-CF and simplified- SF method) were compared for their effect on the ability of boar spermatozoa to undergo protein tyrosine phosphorylation in response to oviductal fluid. Cryopreserved boar-spermatozoa were incubated with pre- and post-ovulatory ODF for 6h at 38°C under 5% CO_2. Aliquots of sperm samples were taken at hourly interval and analyzed for kinematics and protein tyrosine phosphorylation. Global protein tyrosine phosphorylation in spermatozoa was measured using flow cytometry and different patterns of phosphorylation were assessed using confocal microscopy. Immediately after thawing, no significant difference was observed in post-thaw sperm motility, velocity and global tyrosine phosphorylation between the two methods of freezing although the freezing method significantly influenced the effect of oviductal fluid on these parameters during incubation. While spermatozoa frozen by the CF method showed significantly higher proportion of phosphorylation in response to pre-ovulatory ODF during incubation, spermatozoa frozen by the SF method did not elicit such significant response as there was no significant difference in the proportion of tyrosine phosphorylated spermatozoa between treatments at any given time during incubation. If the CF method was used, the proportion of spermatozoa displaying either tail or full sperm phosphorylation increased in response to both preovulatory (EODF) and postovulatory oviductal fluid. However, when the SF method was used, a significant increase in these patterns was noticed only in the EODF treated group. This study demonstrates that pre-ovulatory isthmic ODF induce tyrosine phosphorylation in a higher proportion of boar spermatozoa compared to the post-ovulatory fluid and that the method of freezing significantly influences the response of post-thaw spermatozoa to porcine ODF.



Different patterns of protein tyrosine phosphorylation in boar spermatozoa detected by immunofluorescence using confocal microscope. A- fluorescence over the acrosomal area (pattern A); E, fluorescence in the equatorial segment (pattern E); T, tail fluorescence (pattern T); AE, fluorescence in both the acrosomal area and the equatorial segment; AET fluorescence in the acrosomal area, equatorial segment and tail of the spermatozoa.

Herd Health Management

Herd health monitoring for identification of primary risk factors involved in different production performance Karan Fries cattle in tropical climatic condition management system: Maintaining healthy herd is a constant challenge for modern dairy producers. Crossbreds appear to be more prone to infectious disorders as compared to pure breeds. The present study was conducted to observe the mineral profile in feeds and fodders in different seasons and to observe the metabolic profiles and mineral profiles in different physiological stages of KF cattle in different seasons. The study indicated that the transition period is very critical period of lactation cycle and proper nutritional care and management of the animal is necessary during this period in different seasons to ensure better health. Herd status regarding metabolic and mineral profiles needs to be evaluated regularly in different seasons to achieve set targets in terms of production performance by proper feeding and mineral supplementation. Monitoring criteria to identify shortfalls in feeding and management were identified as primary risk factor for production loss in crossbred cattle.

Pre-partum bio-markers (behavioural and biochemical) for prediction of post-partum metritis in crossbred cattle: Metritis is a common reproductive disorder in dairy cows with consequences ranging from no effect on reproductive performance to permanent sterility. Metritis contributes to increase voluntary waiting period and days open; decrease conception rate and increase culling rate. The study revealed that the critical threshold value of total cholesterol, non-esterified fatty acids (NEFA) and NEFA: total cholesterol ratio can be used as biomarker for better prediction of metritis whereas, glucose, beta-hydroxybutyrate (BHBA) and blood urea nitrogen (BUN): BHBA ratio can be used as good biomarker for early diagnosis of metritis. Receiver operating characteristic (ROC) analysis technique for visualizing, organizing and selecting diagnostic variable based on their performance was used on diagnostic variable to discriminate between two mutually exclusive states. This test evaluates the discriminatory power of a diagnostic test for the selection of cut off values and for comparison between tests for accurate diagnosis.

Clean Milk Production

Comparative study on milk parameters in Holstein crossbred cows reared under organized and traditional dairy animal production systems: Milk somatic cell count (SCC), pH and electrical conductivity (EC) was studied in normal and mastitis affected crossbred cows reared under organized and traditional production systems. The effects of parity, milk yield and stage of lactation on these milk parameters in normal and mastitis affected cows in both the systems were also studied. In both organized and traditional farms, the milk pH was significantly higher in clinical mastitis affected cows compared to both healthy and subclinical mastitis affected cows. Like in case of milk pH, the EC was also significantly higher in clinical mastitis affected cows compared to healthy and subclinical mastitis affected cows. In both organized and traditional farms, the milk EC in subclinical mastitis affected cows was significantly higher than the healthy cows.

There was a significant increase in milk SCC from healthy to clinical mastitis affected cows in both traditional and organized farms irrespective of parity. The values of SCC in healthy and subclinical mastitis affected cows were lower in traditional farm compared to the organized farm at any given stage of lactation. The effects of parity, milk yield and stage of lactation on the milk SCC, pH and EC between the organized and traditional production systems was not significant. A positive correlation between EC and SCC (r=0.723), a moderate (r=0.510) but non-significant correlation between EC and pH and a low between pH and SCC (r=0.378) was observed. The correlation between milk pH and EC was significant in both traditional and organized farms irrespective of the condition of the milk. The results of the present study suggest that the production system had an effect on milk pH, SCC and EC values and combined use of these parameters could be used to detect mastitis in crossbred cows.

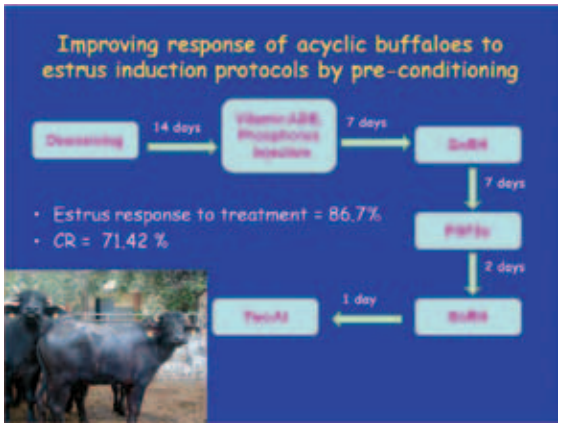
Effects of parity, season, stage of lactation and milk yield on milk parameters in crossbred cows: The effects of season, stage of lactation, parity and milk yield on milk pH, EC and SCC of apparently healthy crossbred cows was studied. A total number of 50 healthy crossbred cows were monitored for these milk parameters across three (autumn, winter and summer) seasons. No significant difference could be observed in milk pH and EC in cows belonging to different parity. However, milk samples obtained from the cows belonging to >4th parity had significantly higher SCC values as compared to other parities. The milk pH and EC was not affected significantly by the season. However, the milk SCC was significantly higher during summer as compared to both autumn and winter seasons. No significant differences in milk parameters were observed between different stages of lactation as well as between different levels of milk yield. However, the milk EC and SCC were higher during late lactation period. A positive correlation was observed between EC and SCC (r=0.099). A moderate (r=0.309) but significant correlation was observed between EC and pH, while the correlation between pH and SCC was low (r=0.054).

Immune-Competence of Neutrophilic Function

Molecular basis for modulation of immune-competence of neutrophilic function in vivo and in vitro of high producing cows and buffaloes peripartum: To study the effect of vitamin E (VE), Copper (Cu), Zinc (Zn) supplementation on the udder health, milk production and composition, 30 pregnant cows were taken and divided into 5 groups. One group was supplemented with VE, other with Cu, next with Zn and also one group with a combination of VE, Cu and Zn from 30 days before to 45 days after calving. Unsupplemented group served as control. Blood neutrophils and lymphocytes were isolated and studied for their phagocytic activity (PA) and lymphocyte proliferation rate (LPR). Supplementation of micronutrients like Cu, Zn and a combination of all these nutrients significantly (P<0.01) increased the PA of experimental cows as compared to control (unsupplemented) cows during the prepartum period. During postpartum all the micronutrients (VE, Cu, Zn and their combination) showed a significant (P<0.01) increase in the PA of experimental cows as compared to control cows. Of all the groups, significant (P<0.01) and maximum PA was observed in the combination group followed by Zn supplemented group during both the pre and postpartum period. Milk samples were also collected weekly from cows. Significantly higher (P<0.01) somatic cell counts (SCC), was found in colostrums of control group followed by VE, Cu and Zn group. Significantly higher (P<0.01) milk SCC was found in control group followed by VE, combination, Zn and Cu group. Milk neutrophils percentage were significantly lower (P<0.01) in combination group followed by Cu, Zn, VE and control group. Total immunoglobulins in colostrum were highest (P<0.01) in combination group. Daily milk yield was higher in combination group, but, no significant differences were observed between treatments. Supplemented cows had significantly (P<0.05) higher fat and protein content. Micronutrient supplementation lowered milk SCC and neutrophils, leading to better udder health and milk production. Supplementation increased the total colostral immunoglobulins and thus may improve calf health.

Improving estrus response and fertility in acyclic buffalo heifers: Delayed age at sexual maturity is one of the major problems associated with poor reproductive efficiency in buffaloes. On contrary to Egyptian buffaloes, which attain sexual maturity at an early age, Murrah buffaloes reach sexual maturity at the age of 31 – 36 months. Different protocols have been used to advance the age at puberty in buffaloes but the response was poor to the hormonal protocols. Low fertility with estrus induction protocols is yet another but the most significant problems in buffalo heifers. Our experience and earlier research findings showed

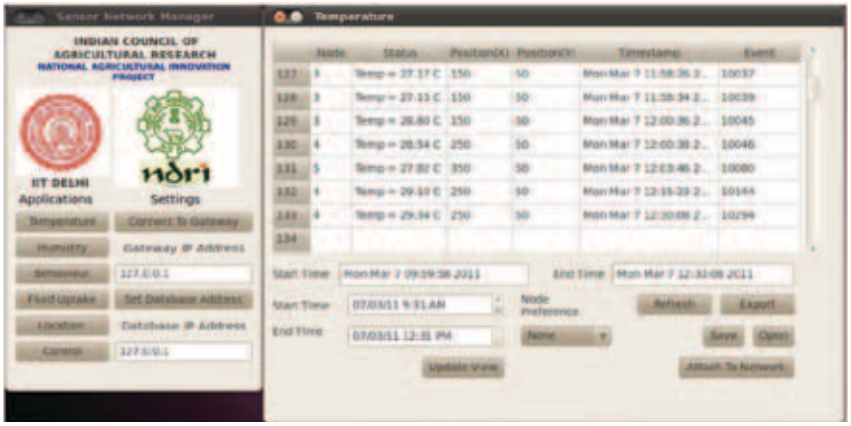
that the estrus response and fertility to Ovsynch protocol was higher in buffaloes with good body condition. Thus, it was assumed that conditioning buffalo heifers by proper deworming, Vitamin and Mineral supplementation might increase the effect of estrus induction protocol. For this purpose, a total of 30 acyclic Murrah buffalo heifers (crossed the normal age of sexual maturity and acyclicity was confirmed using progesterone levels and ultrasound evaluation two times at 11 days interval) were used for experimentation. For one group of heifers Ovsynch protocol (Buserelin acetate 10µg on day 0 and day 9, Cloprostenol sodium 500 µg on day 7) was applied directly without any deworming or supplementation of Vitamins or Minerals. In this group, only 3 heifers responded to the treatment (heifers showed estrus) but none of them conceived. Heifers in other group were administered with Vitamin A (30 lakh IU), D_3 (10 lakh IU) & E (500 mg), phosphorus (2g) per heifer and Ivermectin (0.2 mg/kg body weight). In this group, only one heifer showed estrus signs within a month after treatment. In the third group, the heifers were first administered with Vitamin A, D_3, E, phosphorus, Ivermectin and one month later Ovsynch protocol was applied. In this group, 90.48% of heifers responded to the treatment and 47.61% heifers conceived in first insemination and 45.45% conceived after second insemination leading to an overall conception rate of 71.42%. These results demonstrate that estrus induction could be achieved in non-cyclic buffalo heifers and conditioning the buffalo heifers before application of exogenous hormones improves the estrus response and fertility. This protocol has substantial potential to augment estrus in non-cyclic buffalo heifers, especially under field conditions where the heifers are generally neglected in terms of body conditioning.



Conditioning protocol before applying estrus induction protocol and the buffalo heifers conceived through this procedure

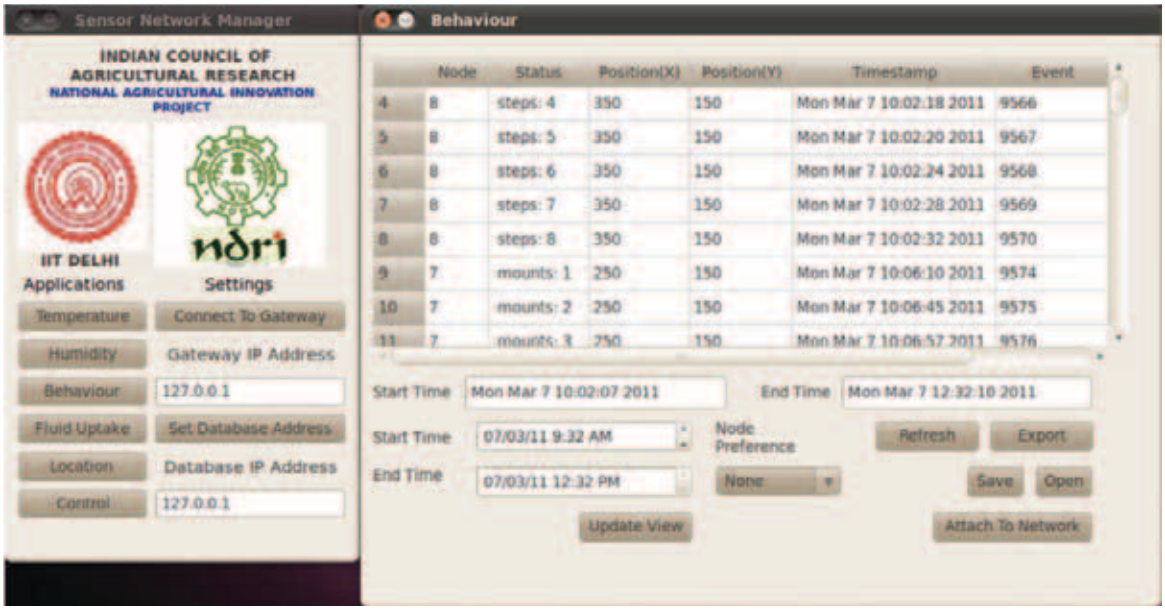
Development of Wireless Sensor Network for Animal management

- Sensor network was created to automatically drive stall climate control system (fans, misting and exhaust systems) for controlling ambient conditions depending on user requirements such as temperature humidity index (THI).



Temperature and Humidity events in user application

- Online four quadrant weigh-bridge for study of weight shifting in normal and lame dairy cattle for lameness prediction – The equipment developed could be used for research to (a) model / study weight shifting in four legs in different physiological stages of animals for predicting lameness and (b) to acquire body weight through sensor network and animal identification technologies.
- Prediction of metritis in post partum postpartum crossbred cows using pre-partum feeding and social behavior – Method developed for behavior analysis and development of prediction model after confirmation of postpartum metritis in crossbred cows through biochemical and metabolic profile analysis.
- Prediction model was developed for milk SCC from milk EC and pH and other production data in crossbred cows. Accurate prediction of subclinical mastitis from production, milk EC and pH by using soft computing tools – This methodology could be used for development of equipments for early detection of subclinical mastitis.
- Miniaturized sensor nodes developed for ankle bound Pedometer for Activity Monitoring and Back strap for Mount Detection for heat detection in cattle and buffaloes.



Step and Mount events in user application

- Wireless sensor network was used to control delivery and uptake of feed and fluid from the indigenously developed smart kiosks. Amount of feed and fluid delivered was controlled by the network depending on animal requirements.
- Routing algorithms were developed that allowed sensor nodes to communicate among themselves and events of interest over multiple hops to a central server. A major application is sending events from the smart weighbridge station to the server.

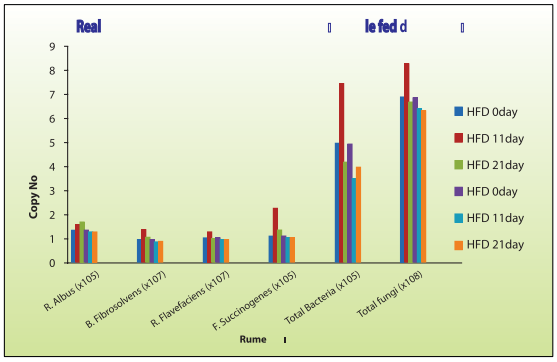
RAISING PRODUCTIVITY OF DAIRY ANIMALS THROUGH IMPROVED FEEDING STRATEGIES, EFFICIENT NUTRIENT UTILIZATION AND USE OF NON-CONVENTIONAL FEED RESOURCES.

Identification of Acetogenes in Buffalo Rumen

The partial nucleotide sequence encoding formyltetrahydrofolate synthetase (FTHFS) and 16S rRNA genes were amplified in PCR to identify the acetogens and methanotrophs, respectively. It was found that the novel acetogens with FTHFS gene and novel methanotrophs with 16S rRNA gene sequences similar to uncultured rumen bacteria were present in rumen of Murrah buffalo.

Quantification of Different Rumen Microbes

The targeted bacteria were the total bacteria, total anaerobic fungi and all the four major groups of fibrolytic bacteria (*F. succinogenes, R. Flavefaciens, R. Albus* and *B.fibrosolvens I*). To establish a quantitative assay, plasmids containing the amplified target region of each species were cloned by using the Stratagene Blunt End cloning kit. The real time quantification results indicated that when the animals were fed on high fibre diet, number of different microbial groups increased from 0 day to 11 days period, thereafter, the number showed a decrease up to 21 days, except *R. albus.* On the other hand, when the animals were fed on high concentrate diets, the number of all microbial groups showed a decreasing trend on 11 day, after which their number remained almost similar up to 21 days. However, the number of total bacteria showed an increase from 11 day to 21 day. The results further showed significant differences in the number of different microbial groups when fed on different diets.



Effect of diets on the number of different rumen microbial groups over different time intervals

Studies on Reductive Acetogenesis and Methane Mitigation

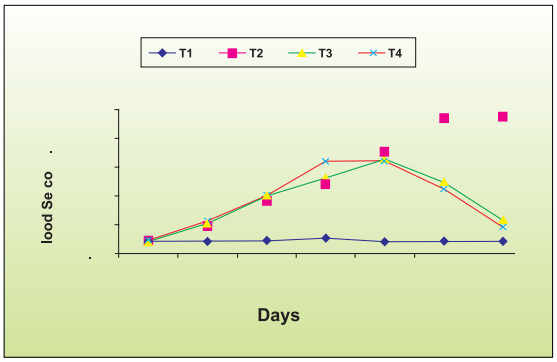
In vitro studies on ingredients and rations revealed that chicory and berseem, mustard cake and cotton seed cake and red sorghum grain were more effective than others in a mixed diet combination in terms of lower methane production and higher reductive acetogenesis. Amongst 45 different types of rations, chicory and cluster bean meal with white sorghum grain had higher true organic matter digestibility, methane oxidation and reductive acetogenesis and lower methane production (g/kg IVOMD), thereby indicating that such a ration could be the best choice. The desirable effect on methane production was observed when 1 or 2g of sodium sulphate or 1g of *S. cerevisiae* was added in mustard cake containing sorghum fodder based ration. The reduced digestibility alongwith methane production was observed when anthraquinone supplemented @ 4 and 6 ppm in 30 ml of rumen fluid. Methane production decreased while reductive acetogenesis increased in cotton seed cake containing berseem based rations.

The *in vivo* studies indicated that the TDN values were comparable while methane emissions reduced and reductive acetogenesis improved in groups where animals were fed on cotton seed cake containing rations. Methane emission decreased while TDN values increased significantly ($P<0.05$) with the supplementation of Na_2SO_4 in buffalo ration. The study also indicated that the formula based on chemical composition as per NRC (2001) could be adopted for Indian feeds to determine their TDN values.

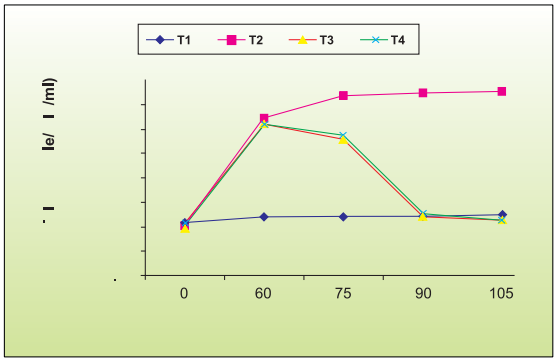
The Effect of Pentasulphate Vis-À-Vis Arsenic in Alleviating Chronic Selenosis and the Expression Kinetics of Selenium Responsive Genes (GP-X) in the Animals

The buffalo calves in control group (T1) were fed recommended diets. The animals in groups T2, T3 and T4 were supplemented with 10 ppm of Se through sodium selenite until blood Se level approached 1.5 ppm, which happened at 60d of feeding. Thereafter, animals were given supplementary arsenic (40 ppm of diet) in form of sodium arsenite and pentasulphate mixture (9g/100kg BW) in groups T3 and T4, respectively in addition to Se (10 ppm). The animals in group 1 (T1) were given ration without any supplementary

Se. The results showed that supplementation of 10 ppm Se to the control diet did not adversely affect feed intake and digestibility of nutrients except that of CP in buffalo calves. Supplementation of either pentasulphate mixture or arsenic to the control diet already supplied with extra 10 ppm Se did not affect feed intake and digestibility of nutrients except that digestibility of CP was improved after supplementation of pentasulphate mixture and arsenic in buffalo calves. Se supplementation to the control diet led to marked (P<0.01) increase in Se absorption and Se retention in the body. Elevated (P<0.01) levels of plasma alanine amino transferase (ALT), aspartate amino transferase (AST), alkaline phosphatase and serum creatinine were also observed in the group of animals supplemented with 10 ppm Se. Supplementation of 10 ppm inorganic Se to the control diet significantly (P<0.01) elevated systemic blood Se load, erythrocyte GPx activity and hair Se levels showing chronic selenosis.



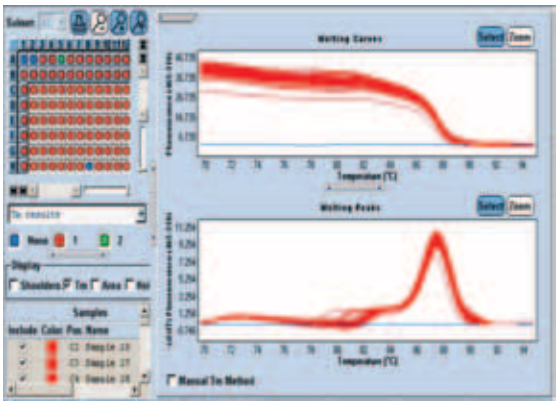
Periodic blood selenium concentration (ppm)



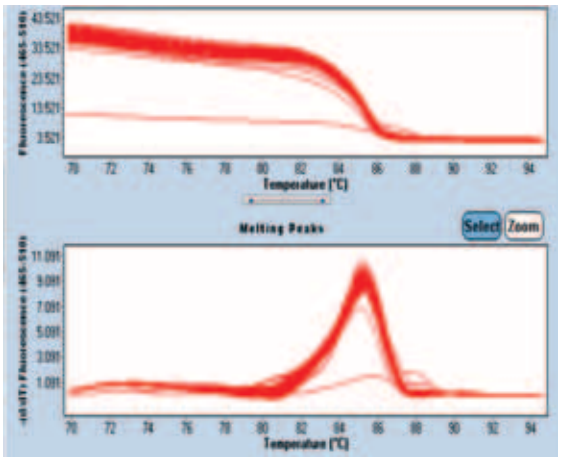
Periodic erythrocyte glutathione peroxidase activity (nmol/ min/ml)

There was significant (P<0.01) reduction in levels of blood Se, hair Se, erythrocyte GPx, plasma ALT, AST, alkaline phosphatase and serum creatinine levels when pentasulphate mixture or arsenic were supplemented to the control diets containing added 10 ppm of Se. Their levels reached almost basal levels after 45-55 days of start of their supplementation showing alleviation of chronic selenosis.

The real time based q-PCR analysis indicated increase in mRNA expression of GPx1 and thioredoxin reductase (TRR) Se responsive selenoproteins in Se treated groups.



Dissociation curve for GPx gene in lymphocytes



Dissociation curve for TRR gene in lymphocytes

The TRR gene could be more reliable indicator of chronic selenosis as compared to GPx_1. Both pentasulphate mixture @9g/100 kg body weight and arsenic @40 ppm given orally seemed to be effective in alleviating chronic selenosis in buffalo calves.

Dietary Supplementation of 'Product A' on Nutrient Utilization and Milk Production Performance in Dairy Cattle

Animals of experimental group were supplemented extra with 4% product A on dry matter basis. Digestibility coefficients of different nutrients were similar in both groups. Average fortnightly milk yield and body weight were not influenced by the dietary supplementation of product A. However, average daily milk yield and FCMY per day increased by 13.45 and 12.15 % over control group in 98 days of experimental feeding. Methane

production in treatment group reduced to 107.03g from 150.8g/animal/day due to supplementation of product A.

Two potent products i.e. product B and product C were also evaluated for their effect on growth performance, nutrient digestibility and methane production in buffalo heifers. Animals in treatment groups 1 and 2 were fed the same ration plus product B @ 4% and product C, @ 2% on dry matter basis. The overall mean DM intake was 6.45, 6.60 and 6.08 kg d^{-1} in control and treatment groups 1 and 2, respectively. DM intake and digestibility coefficients of different nutrients were similar in all 3 groups. The average daily growth rates in heifers of control, group 1 and 2 were 450, 610 and 470 g day^{-1}, respectively. The growth rate was the lowest in control group and the highest in group 1 supplemented with product B ($P<0.05$). Methane production in control, treatment groups 1 and 2 was 111.90, 100.52 and 88.98 g/animal/day, respectively.

Energy and Nitrogen Release Pattern of Some Commonly Available Cattle Feedstuffs and Development of Synchrony Index

Four feeds each of cereal grains/byproducts (sorghum grain, maize grain, wheat bran and deoiled rice bran), protein sources (mustard cake, groundnut cake, soybean meal, and guar meal), green fodders (oat, berseem, sorghum and maize fodder) and wheat straw were evaluated *in sacco* for rumen degradation kinetics.

Six isonitrogenous and isocaloric TMRs were formulated and their synchrony index (SI) was calculated using hourly release of OM and N *in sacco*. Two each of high synchronous (HS; SI 0.86 and 0.82), medium synchronous (MS; SI 0.77 and 0.0.76) and low synchronous (LS; SI 0.56 and 0.55) rations were evaluated *in vitro.* Efficiency of microbial protein synthesis (EMPS) was significantly higher in HS and MS rations than in LS rations.

HS (SI 0.86) and LS (SI 0.56) rations were fed to twelve crossbred lactating cows in mid lactation. There was no difference in body weights of cows at the end of the experimental period. Voluntary feed intake, daily milk yield, milk composition, feed conversion efficiency, nutrient digestibility and N balance were similar in HS & LS diets. Blood urea N was significantly higher in LS group than that of HS group. Urinary purine derivatives excretion, total purine absorption and MN flow to intestine was similar in both the groups. Hence, synchronization of ruminal release of dietary energy and N did not improve lactation performance of crossbred cows in mid lactation at the level of milk production in the present study.

Fortification of Low Grade Roughage Based Complete Feed Blocks with Ruminal Fungal Zoospores

There was significant improvement in growth rate, digestibility of proximate principles and rumen fermentation in male buffalo calves fed wheat straw based complete feed block incorporated with zoospores of elite fungi *Neocallimastix sp*.GR-1 isolated from a grazing and browsing goat. Hence, anaerobic rumen fungi viz *Neocallimastix sp GR1* and *Orpinomyces joyonii,* could be promising anaerobic fungi that can be exploited as animal probiotics. These animal probiotics could be used for both growing as well as lactating buffaloes to enhance digestibility of nutrients, rumen fermentation pattern, digestible energy in terms of % TDN and nutritive value of TMR consisted of low grade roughages.

Effect of Different Sulphur Sources on the Growth and Digestibility of *Anaeromyces* for Fortification of Straw

Three different sulphur sources i.e. sodium sulfide (T1), methionine (T2) and cysteine (T3) were taken at a concentration of 0.2%. The culture without any sulphur source was also taken as control (TO). The results indicated a significant increase in the digestibility with different sulphur sources as well as time intervals. The maximum digestibility was observed in T1 (20.03%) followed by T2 (17.57%) after 24 h of incubation. However, the digestibility was less than control in case of T3. After 48 h of growth, an increase in digestibility was observed in all groups except T1. Acetate production was the highest in T1 (6.23 mM) and the lowest with methionine (3.01 mM) after 24 h of incubation. At 48 h of incubation, maximum increase as well as production of acetate was obtained with T3 (8.05 mM). Overall, a significant increase in acetate production was found with different sulphur sources as well as time intervals. The results of propionate and butyrate also showed similar patterns like acetate.

Status of Heavy Metals and Essential Trace Elements in Milk Samples Collected from Delhi and Punjab

The milk samples were collected from different districts of Delhi and Punjab and analysed for heavy metals and/or trace minerals. The levels of lead and cadmium in milk samples (N=80) collected from 5 districts of Delhi (North, East, Central, West and New Delhi) averaged 0.163 (0.015 to 0.935) ppm and 0.016 ppm (0.002 to 0.09), respectively, which were below the MRL (Pb-2.5ppm, Cd-1.5; PFA, 2009).

In milk samples collected from Punjab (Amritsar, Rupnagar, Jalandhar, Kapurthala, SAS Nagar, Fatehgarh, Ludhiana and Nawashahr), the overall concentration of Fe, Cu, Zn and Mn across the districts was found to be 0.69, 0.28, 3.56 and 0.33 mg/litre, respectively. The concentration of Fe varied from 0.47 (Kapurthala) to 0.87 mg/litre (Amritsar) while the variation in Cu was recorded from 0.07 (Kapurthala) to 0.59 mg/litre (Nawashahr). Similarly, Zn and Mn levels ranged from 3.06 (Kapurthala) to 4.31 (Rupnagar) and from 0.14 (Fatehgarh) to 0.51 mg/litre (Amritsar), respectively. Within a district, the concentrations of all the essential elements in milk differed significantly (P<0.01). The overall mean concentrations of Cd and Pb were observed to be 1.46 and 27.30 µg/litre, respectively. The level of Cd was below the detectable limits in the samples collected from Kapurthala district while the highest values (2.36µg/litre) were observed in Rupnagar district. For Pb, the lowest (13.25) and the highest (48.99 µg/litre) concentrations were recorded in Kapurthala and Mohali, respectively. Variations existed in the concentrations of all the trace mineral elements collected from different places. The values, though, were in the reported range. Levels of Cd and Pb in the all the milk samples were below MRL.

Effect of Certain Micronutrients Supplementation on Immunity, Udder Health and Productive Performance of Crossbred Cows

Supplementation of vitamin E @ 1000/cow/d alongwith Zn 80 ppm was more effective than Zn alone in combating clinical and sub-clinical mastitis in crossbred cows. Supplementation of Zn alone or its combination with vitamin E to cows during dry period reduced incidence of retained placenta, postpartum estrus interval and number of service per conception. The days open recorded in groups T0, T1 and T2 were 104.00, 94.75 and 86.36, respectively. The number of postpartum metritis cases in groups T0 (Control), T1 (+Zn) and T2 (+ Zn & Vit. E) were 3, 2 and 2, respectively. The reduction in occurrence of metritis was 12.5% in both treatment groups. The number of days required to recover from metritis were 20.0, 17.0 and 12.5 in groups T0, T1 and T2, respectively. Tocopherol content of colostrum averaged 3.98, 4.12 and 4.80 µg/mL and was significantly (P<0.01) higher in group T2 compared to other groups.

Plasma vitamin E concentration at 60 days prepartum was 3.68, 3.26 and 3.52 µg/mL which decreased to 1.32, 1.62 and 2.10 µg/mL at parturition in the three respective groups showing significantly less decrease in vitamin E supplemented group 3. The status of plasma antioxidant enzymes (SOD, catalase, total antioxidant activity) and immunoglobulin was better in groups 2 and 3 as compared to group 1. The lymphocyte stimulation index (SI) at 60 days prepartum in different groups averaged 1.503, 1.459 and 1.495. At 15 days prepartum, the cows from groups T1 and T2 maintained significantly (P<0.01) higher SI.

Supplementation of micronutrients from 60 days prepartum to 90 days postpartum improved the immunity status and reduced the incidence of clinical and sub-clinical mastitis and incidence of reproductive problems in crossbred cows. Supplementation of Zn, Cu and vitamin E improved the milk yield of cows. Vitamin E supplemented cows produced milk with higher vitamin E content.

Effect of Micronutrient Supplementation on Induced Oxidative Stress with Toxic Heavy Metals in Relation to Immune Response and Gene Expression Profile in Lactating Goats

Dietary exposure of arsenic @50ppm for 12 months neither produced any clinical symptoms nor had any effect on DMI, body wt. and production performance but showed an adverse effect on oxidative stress, biochemical and immunological parameters. Dietary treatments did not show any significant effect on minerals i.e Cu, Zn and vitamin E content in milk in all the supplemented groups, however, As level in plasma and milk increased significantly in As fed group but Vitamin E supplementation @ 150 IU/d showed lesser increase in plasma and milk As level. Due to supplementation of vitamin E, the As deposition in Hair and hoof was less, which was confirmed by the results of metabolic trial (P<0.05) Relative expression of SOD showed up regulation at 3 months followed by down regulation in all the

treatment groups whereas relative expression of IL2 was also down regulated and vitamin E treatment groups showed less down regulation.

Diversity Study of CLA Producing Indigenous *Butyrivibrio spp.*, its Subsequent Utilization as a Probiotic for Animals and Gene Expression Pattern of Enzymes Involved in Biohydrogenation of Fatty Acids

Effect of the selected plant extracts on CLA enhancement and important rumen fermentation parameters such as total gas production, individual gases, volatile fatty acid production was analyzed in-vitro, which was subsequently validated with in-vivo investigation. A 360% increase in CLA production was observed in case of supplementation with 4% of J. palak plant extract. Overall positive effects on rumen fermentation parameters were observed after supplementation with S. nigrum and J. palak. Cuminum cyminum (P<0.05) had desirable effects on PUFA, TVFA and digestibility,. In the rumen and milk, CLA (32 & 11.7%, P<0.05, P<0.1, respectively) and VA (11 & 8%, P<0.05) concentration increased with C. cyminum extract supplementation. C. cyminum enhanced PUFA (+21%) and MUFA (+8%) in the rumen because of reduction in SFA (-8%, P<0.05). Moreover, milk PUFA was 14% higher in C. cyminum supplemented goats with no effect on milk yield (P<0.05). Total VFA in two supplemented groups (T1 & T2) was 95.6 and 95.02 mmol/L, respectively, whereas it was 91.37 mmol/L in control (P<0.05). C. cyminum extract altered relative abundance of Butyrivibrio, Prevotella and Fibrobacter sp. in T1 (5, 28, 3%) and T2 (5, 27, 3%), respectively, compared to control (4, 31, 2%, P<0.05). C. cyminum did not inhibit growth of CLA-producing bacteria but suppressed the growth and activity of other competitor bacteria such as Sterptococcus bovis, Peptestreptococcus anaerobios, Lachnospira multiparus and decreased the biohydrogenation activity of Butyirvibrio proteoclasticus . C. cyminum increased CLA and VA in milk by manipulation of microbial ecosystem and linoleic acid metabolism in the rumen.

Dairy Cattle Physiology

Studies on Physiology of Lactation in Dairy Animals

Molecular basis for modulation of immune-competence of neutrophilic function *in vivo* and *in vitro* of high producing cows and buffaloes peripartum: To study the effect of Vitamin E (VE), Copper (Cu), Zinc (Zn) supplementation on the *in vitro* phagocytic activity (PA) and lymphocyte proliferation response (LPR) of blood neutrophils and lymphocytes, thirty Sahiwal pregnant cows (6 in each group) in their late gestation at 30 days before the expected date of calving were selected from the NDRI experimental herd and supplemented with various micronutrients from 30 days before calving to 45 days after calving. Cows were supplemented individually with VE (1000 IU/cow/day), Cu (20 ppm/cow/day) and Zn (80 ppm/cow/day) and also with a combination of VE, Cu and Zn to study cumulative effect of all micronutrients. One group without any supplementation acted as control. Blood neutrophils and lymphocytes were isolated and studied for their PA and LPR. Supplementation of micronutrients viz. Cu, Zn and a combination of all these nutrients significantly (P<0.01) increased the PA of experimental cows as compared to control (unsupplemented) cows during the prepartum period. During postpartum all the micronutrients (VE, Cu, Zn and their combination) showed a significant (P<0.01) increase in the PA of experimental cows as compared to control cows. Of all the groups, significant (P<0.01) and maximum PA was observed in the combination group followed by Zn supplemented group during both the pre and postpartum period. A significant (P<0.01) increase in LPR of B lymphocytes was observed in combination supplemented group during the prepartum period and during both the pre and postpartum period in the Cu supplemented group.

Effect of micronutrients supplementation on hormones, milk yield, udder health and immunity in crossbred and indigenous cows: The effect of micronutrients on hormones, immunity and milk yield was studied on twenty four crossbred cows selected 60 days before expected date of calving. The cows were divided in 4 groups based on their parity and previous milk production. Group 1 cows were fed on control diet, Group 2 (control diet + 60 ppm Zn), Group 3 (control diet + 1000 IU vitamin E/d) and Group 4 (control diet + 60 ppm Zn + 1000 IU vitamin E/d). The feeding of micronutrients was continued upto 90 days after calving. Leptin levels decreased before calving and remained low after calving. Insulin concentrations differed according to days postpartum: levels

started to decrease before parturition, minimum concentrations were found around parturition but levels were fully recovered after 30 days postpartum. Plasma concentration of GH increased at parturition and remained elevated after calving. There was a significant difference between groups (P<0.01) and days (P<0.01) in leptin, insulin and GH levels. Lymphocyte proliferation index was significantly higher in cows supplemented with micronutrients between days (P<0.01). Total Ig was 34.65 ± 1.14 mg/mL in control group of cows and was 37.31 ± 1.58, 38.93 ± 1.53 and 35.83 ± 1.15 in vitamin E, vitamin E & Zn and Zn supplemented groups. Plasma vitamin E level varied significantly between groups (P<0.01) and between days (P<0.01). Milk yield was found to be significantly higher in cows supplemented with micronutrients. Milk protein and lactose did not vary significantly. In SCC, there was significant decrease in vitamin E and Zn supplemented group. DMI (kg/day) was 11.0± 0.10 in control group of cows. DMI in vitamin E, vitamin E & Zn and Zn supplemented groups was 11.65 ± 0.08, 11.88 ± 0.34 and 11.52 ± 0.12 kg/day, respectively. Also, digestibility of the cows supplemented with micronutrients was found to be improved.

Effect of vitamin E supplementation on levels of leptin and insulin hormone in indigenous and crossbred cows: The effect of vitamin E supplementation on levels of hormones, immunity, blood metabolites and milk yield was carried out in 12 Sahiwal cows divided in two groups of six cows each. One group of cows was taken as control and the other group of cows was supplemented with vitamin E during dry period and early lactation @ 1000 I.U./day/cow. Glucose level declined from dry period towards calving from 57.51 to 35.87 mg/dL in control group and from 58.17 to 40.13 mg/dL in vitamin E supplemented cows. NEFA levels were significantly higher in control group as compared to supplemented group of cows. Leptin levels were higher during dry period, declined in early lactation and again increased in mid lactation. The overall average leptin levels were 4.48 ±0.24 and 4.92±0.21ng/mL in control and vitamin E supplemented groups. Plasma insulin levels were significantly (P<0.05) higher in supplemented group as compared to control group of cows. Plasma GH levels increased towards calving and during early lactation. Total Ig levels significantly improved and plasma vitamin E levels were significantly higher in supplemented group of cows. Antioxidant status as indicated by SOD and catalase enzymes was improved by supplementation of vitamin E. Milk yield was significantly higher in supplemented cows. Supplementation of vitamin E resulted in increase in leptin, insulin and growth hormones, increase in glucose levels, decrease in NEFA levels, improvement in immunity of crossbred and Sahiwal cows and increased milk production. The significant correlations between the plasma concentrations of leptin, insulin, GH, glucose and NEFA represented co-regulation by energy balance, and perhaps a role for these factors in mediating the effect of energy balance on leptin synthesis.

The hormones and antioxidant status of high and low producing crossbred cows was studied in twelve crossbred cows selected around 60 days before expected date of calving for experiment. The animals were grouped on the basis of their milk production as high (> 15 kg/day) and low (< 10 kg/day) producers based on their previous milk yield. Blood samples were collected before and after calving. There was significant variation in leptin, insulin and growth hormone levels between groups (P<0.01) and between days (P<0.01). Plasma glucose and NEFA were found to be significantly higher (P<0.01) in high yielding cows as compared to low yielding cows. Average value of total plasma antioxidant activity was 1377.39±23.00 and 1313.09±14.99 FRAP value (µM/L) in high and low yielding cows, respectively.

Development of plasma catecholamine's assays for evaluation of sympathetic neuronal function and milk production performance in heat stressed cows: An increase in THI score >80 significantly decreased DMI, milk yield, plasma T_4, IGF-I, cortisol, glucose levels and increased plasma NEFA concentrations without affecting T_3 and insulin. THI was positively correlated with physiological responses RR, PR and ST. Values of RR, PR and skin temperature were more in the evening than in the morning hours (P<0.01) in summer season. Further, magnitude of change in PR and RR between morning and evening hours was significantly higher (P<0.05) in hot- humid season. Plasma cortisol and glucose levels were more in high producing cows (>10.0 kg/d) than the low producers (<10 kg/d), however plasma IGF-I and INS levels were similar.

The dry matter intake was higher during winter (P<0.05) than in summer season. The feed efficiency was similar in hot-humid and winter in comparison to higher FE (P<0.05) observed in hot-dry season, indicating thereby that both the seasons stress the animals and adversely affect the feed efficiency. The lower feed efficiency in winter

season than in summer season was attributed to limited energy availability leading to mobilization of the body reserves (as reflected by more NEFA) in a loose housing management system. This fact was further evidenced by higher intake of TDN and CP (g)/kg for milk production. Contrary to this, cows consumed (P<0.05) less TDN and CP (g/d) for milk production during hot-dry season. Plasma T_4 levels were lower (P<0.05) during hot-dry season than hot–humid and winter season. However, plasma T_3 and insulin levels were not different. Plasma glucose level was low in hot-dry season than the winter season. Cows having more metabolic weight consumed more DM, produced more milk and showed higher feed efficiency. The body weight of the cows varied significantly (P<0.01) during different seasons. The DMI/100kg $W^{0.75}$ also varied between seasons (P<0.01) leading to significant variation in fat, protein and lactose content of milk.

Administration of epinephrine (1 µg/kg/d, i.v.) for 5 days did not influence plasma insulin, glucose and cortisol levels. Plasma epinephrine and nor-epinephrine concentration increased (P<0.01) concomitant to decline in milk yield on day 1 of epinephrine injection and thereafter till day 7 post-injection. The recovery of milk yield and epinephrine to the normal level after treatment confirms the role of epinephrine and nor-epinephrine hormones in milk secretion of cows.

Augmentation of Fertility

Evaluation of plasma IGF I and other biomarkers for monitoring growth and reproductive health in female Karan Fries cows with probiotic supplementation: Supplementation of yeast culture, *Saccharomyces cervisiae* to post weaned calves @ 300g/quintal of concentrate from seven months of age onwards increased average daily gain in low body weight group as compared to normal growing calves. The plasma IGF I (P<0.01) increased and plasma Haptoglobin concentration (P<0.01) decreased. Similar changes in endocrinological parameters were observed in *Saccharomyces cervisiae* supplemented animals suffering from different reproductive problems like repeat breeding, anestrus and metritis. The conception rate in anestrus and repeat breeding cows was higher on supplementation of yeast culture, further, the decrease in milk in non supplemented group was reduced. Hence, it can be concluded that supplementation of yeast culture in wheat straw based diet can improve growth of slow growing calves and increase conception rate of cows suffering from different reproductive problems for increasing productivity.

Adaptation and facilitation of livestock to impending climatic changes through shelter management: The effect of temperature variability was assessed on twelve each of Sahiwal, Tharparkar, Karan Fries cattle and Murrah buffaloes. Animals were divided into two groups viz growing and adult having six animals each. The study was conducted on different groups of animals during hot humid, winter, spring and summer seasons. Another study was conducted on all groups of animal in controlled climatic conditions at 42^0C and 44^0C temperature with relative humidity 40 to 42%. The physiological observations (RR, PR, RT and ST) were recorded in morning and afternoon during different seasons and before and after 4 hours of exposure in controlled climatic conditions. Jugular blood samples were collected for hematological and biochemical parameters. Environmental variables viz dry and wet bulb temperature and RH was recorded. Plasma enzymes ALP, ALT and AST were significantly higher in Murrah buffaloes followed by KF and Zebu cattle. During different seasons physiological and biochemical parameters showed a positive correlation (P<0.05) whereas, hematological parameters showed negative correlation (P<0.05) with Tmax and temperature humidity index (THI) in different breeds of cattle and Murrah buffalo. The study indicated the maximum variability in physiological parameters and cortisol in KF than Zebu cattle and murrah buffaloes. The study suggested that all the groups of animals required protection during extreme climatic conditions. The KF and Murrah buffaloes require extra protection during the high temperature conditions.

Quantification of discomfort level under thermal, exercise and nutritional stresses in goats: Twelve weaner kids of Alpine x Beetal cross of approximately four to five months of age were randomly divided into two groups. Group 1 (6 no) was kept as control throughout the experiment and offered concentrate @ 400 g per animal per day and green fodder *ad libitum*. Group 2 (6 no) was put on restricted feeding and was offered feed about 50% of their *ad libitum* intake. After three weeks, goats of group 2 were exposed in a climatic chamber for two hours daily for a period of six days at each exposure temperature of 40°C, 42°C and 44°C continuously. After exposure, group 2 was switched over to *ad libitum* feeding. The body weights were recorded at weekly interval. Feed intake was recorded daily. Physiological responses, respiration rate (RR), pulse rate (PR) and rectal

temperature (RT) were recorded at 7.00AM and at the end of exposure. Three replicates were taken for recording of physiological responses at each exposure temperature of 40°C, 42°C and 44°C. The initial body weights (0 day) of group 1 and group 2 were 15.0 ± 0.5 and 14.5 ± 0.36 kg, respectively. The body weight of group 1 increased significantly at each week interval and was 20.75 ± 0.82 kg at the end of 9 weeks of experiment. The increase in body weight at group 2 was insignificant up to 6 weeks of experiment, but increased significantly after switching over to *ad libitum* feeding.

The DMI of group 1 and group 2 between days 1-21, 22-42 and 43-63 of experiment were 4.42 ± 0.06, 4.67 ± 0.06 and 4.19 ± 0.05 and 2.14 ± 0.03, 2.08 ± 0.06 and 3.99 ± 0.07, respectively. In the first six weeks of experiment, the weight gain was significantly higher in group I as compared to group 2 but after switching over to *ad libitum* feeding, weight grain was compensate in both groups but group 2 animals could not compensate the loss in body weight occurred due to combined stress of feed restriction and high temperature.

Respiration rate (RR) of group 1 and group 2 were at par before exposures. It increased significantly in group 2 after exposure at 40, 42 and 44^{o}c. The pulse rate and rectal temperature were significantly lower in group 2 than group 1. The PR and RT increased significantly in group 2 and the increase was much higher than group 1 indicating that group 2 animals experienced more stress and heat tolerance of group 2 was lower than group 1. It was concluded from this study that the distress level was more in group 2 animals and these animals could not compensate the loss in body weight occurred due to feed restriction and high temperature.

Impact of thermal stress and vitamin- E supplementation on heat shock protein-72 and antioxidant enzymes in Murrah buffaloes*:* The relationship of HSP72 mRNA expression in lymphocytes with antioxidant enzymes (Superoxide dismutase and catalase), blood profile (TEC, TLC, DLC and N: L ratio), physiological responses (RR, PR, T_{re} , T_{skin} and heat storage) and the effect of vitamin E supplementation (summer and winter) on different parameters in different physiological stages of Murrah buffaloes were assessed. Growing buffalo calves, heifers and lactating Murrah buffaloes were exposed at 38 ± 1° C with 50 ± 2% RH (Exposure- I) and at 42 ± 1°C with 40 ± 2 % RH (Exposure- II) in climatic chamber. The HSP72 mRNA expression in lymphocytes and erythrocytic antioxidant enzymes (SOD and CAT) activity increased significantly (P<0.05) in all the stages of Murrah buffaloes. The magnitude of increase in both HSP72 mRNA expression in lymphocytes and antioxidants (SOD and CAT) was higher at exposure- II. In another study, the experimental animals of growing, heifers and lactating buffaloes (6 each) were fed vitamin E @ 500,800 and 1000 IU/animal/day, respectively whereas control groups of animals were maintained on normal feeding and management for a period of 30 days during summer and winter season. The results indicated that, the HSP72 mRNA expression and antioxidant enzymes (SOD and CAT) decreased significantly (P<0.05) in experimental group of buffaloes as compared to control group during both the seasons. Overall values of α-tocopherol was significantly (P<0.01) higher in experimental groups as compared to control group. From the results of the study it could be concluded that thermal stress (climatic chamber and stress seasons) had a significant negative impact on buffalo physiology by increasing the levels of HSP72 mRNA expression in lymphocytes, antioxidant enzymes (SOD and CAT), physiological responses (RR, PR, T_{re}, T_{skin} and heat storage) and deviating the normal picture of TEC,TLC, DLC and N:L ratio.

The feeding of vitamin E to buffaloes showed a positive impact by lowering the levels of thermal stress markers viz., HSP72 mRNA expression in lymphocytes, antioxidant enzymes (SOD and CAT), N:L and improving the levels of α- tocopherol in blood plasma of all categories of Murrah lactating buffaloes. The milk yield also increased in vitamin E fed group buffloes during summer and winter season. Therefore, supplementation vitamin E is helpful in sustaining the animal productivity during thermal stress conditions.

Impact, Adaptation and Vulnerability of Indian Livestock to Climate Change

In order to observe the effect of thermal stress on physiological, enzymatic and hormonal parameters in periparturient cows, ten each of Sahiwal and KF calves were selected and further equally divided into two groups viz. high and low yielders. All the animals were maintained under normal conditions of feeding and management followed at farm. The blood samples were collected from all the animals at 15 day interval starting from 45 days prepartum to 45 days postpartum. The plasma cortisol and NEFA levels were found to be significantly higher (P<0.05) during summer season compared to winter season. The levels of cortisol and NEFA were significantly higher (P=lt;

0.05) on the day of parturition (0 days) compared to the levels found during different intervals of collection during prepartum and postpartum. The plasma levels of blood glucose and insulin were significantly lower (P<0.05) on the day of calving in both the breeds, seasons and groups as compared to respective values of prepartum and postpartum at different intervals. Plasma leptin levels were significantly (P<0.05) lower whereas HSP 72 showed significantly higher levels during summer season compared to winter season in both the breeds of cattle. Plasma T3 and T4 levels were significantly lower during summer season compared to winter season in both groups and breeds. The physiological responses viz. RR, HR, RT and ST were significantly (P<0.05) higher during summer and on the day of parturition compared to winter and prepartum values, respectively.

Expression of HSP70 genes in heat and cold adapted goats (Capra hircus): A common physiological response of organism to environmental stresses is the increase in expression of heat shock proteins (HSP's). To investigate the factors affecting the heat and cold adaptation the present study was conducted to quantify expression of HSP70 genes in heat and cold adapted Indian goats (Capra hircus). The systematic study was performed on two heat adapted goat breeds (Sirohi and Barbari) and two cold adapted goat breeds (Gaddi and Chegu) maintained in their natural habitat (hot-dry and cold-high altitude) during winter, spring and summer. Total RNA was isolated from blood leukocytes. The cDNA fragment homologues of Hsp70 cognate forms (HSPA8 or HSC70) and inducible (HSPA1A or HSP72) were cloned and sequenced. Then real-time PCR was carried out to quantify hsp70 gene expression. The results clearly demonstrated that the gene homologues of hsp70 cognate (HSPA8 or HSC70) and inducible (HSPA1A or HSP72) forms were present in both heat and cold adapted goats like other mammalian species. The abundance of mRNA transcripts for the inducible form was significantly up-regulated in response to high and low temperature stimuli during summer and winter respectively, where as the cognate form was mildly up-regulated in response to cold and heat stress. During summer the expression of hsp70 genes was high in both Chegu and Gaddi cold adapted goats and behavioral differences were noticed. During winter high HSP70 expression was observed in heat adapted Sirohi and Barbari goats. The study suggests that HSP70 genes are expressed in both cold and heat adapted goats, however, the level of expression is higher in cold adapted goats during summer than in heat adapted goats. The differences in relative expression of HSP70 genes observed in cold adapted and heat adapted goats are related to adaptation response to their natural habitat.

Animal Biotechnology

Faster Multiplication of Superior Germplasm for Development of National Milch Herds

Birth of a cattle calf named 'Holi' produced by OPU-IVF technique: Oocytes were collected from the ovaries of Sahiwal cattle by follicular aspiration using an ultrasound machine with a transvaginal convex transducer with a needle guide, single lumen 18-gauge 55 cm long sterile needle with an ultrasound echo tip and a vacuum pressure of 80 mm Hg. Oocytes were then subjected to *in vitro* maturation, *in vitro* fertilization and *in vitro* culture for development of embryos. When the embryos developed to the transferable stage i.e., the blastocyst stage, these were transferred to the recipient, which led to the birth of a female calf with a normal birth weight of 23 kg, on 7th March, 2012. The female calf was named 'Holi'. This procedure allows carrying out research in cattle oocytes since cow slaughter is banned in this country. Further, this technology will also be useful for infertile, aged/tired and problematic yet valuable dairy cattle, and for those which do not respond to conventional embryo transfer program.

OPU-IVF, Calf 'Holi' with surrogate mother

Production of embryonic stem cells: Buffalo embryonic stem (ES) cells were derived from *In vitro* fertilized, parthenogenetic and handmade cloned embryos and were characterized by alkaline phosphatase and immunofluorescence staining of pluripotency-related surface markers. The studies were conducted to understand, Y-27632, in presence of FGF-2 and LIF, resulted in higher colony growth and increased expression of NANOG gene. Feeder-CM resulted in a significant increase in growth of buffalo ES cells on gelatin coated plates, however, culture on feeder layer gave better results than that on gelatin coated dishes. In another study, expression of WNT3A, its receptors and intermediate signaling pathways were found to be conserved in buffalo ES cells from the different sources examined, whereas expression of WNT3A was found to be down-regulated in embryoid body and fetal fibroblast cells. WNT3A (200 ng/ml) together with exogenous FGF-2 and LIF was found to result in self-renewal and proliferation of undifferentiated buffalo ES cells. However, WNT3A was insufficient to substitute for exogenous FGF-2 and LIF to maintain undifferentiated buffalo ES cells. Real time PCR and immunoblotting studies showed that Dkk1 (250 ng/ml) was able to inhibit WNT3A signaling pathway while SFRP2 (250-500 ng/ml) was not. Supplementing the ES medium with Bio (0.5-5 µM) or Iq1 (2-6 µg/ml), either alone or in combination with WNT3A, had no significant effect on pluripotency or growth of buffalo ES cells. Differentiation studies on WNT3A transfected buffalo ES cells showed that WNT3A resulted to the formation of scaffold like structure and inhibition of neural cell differentiation.

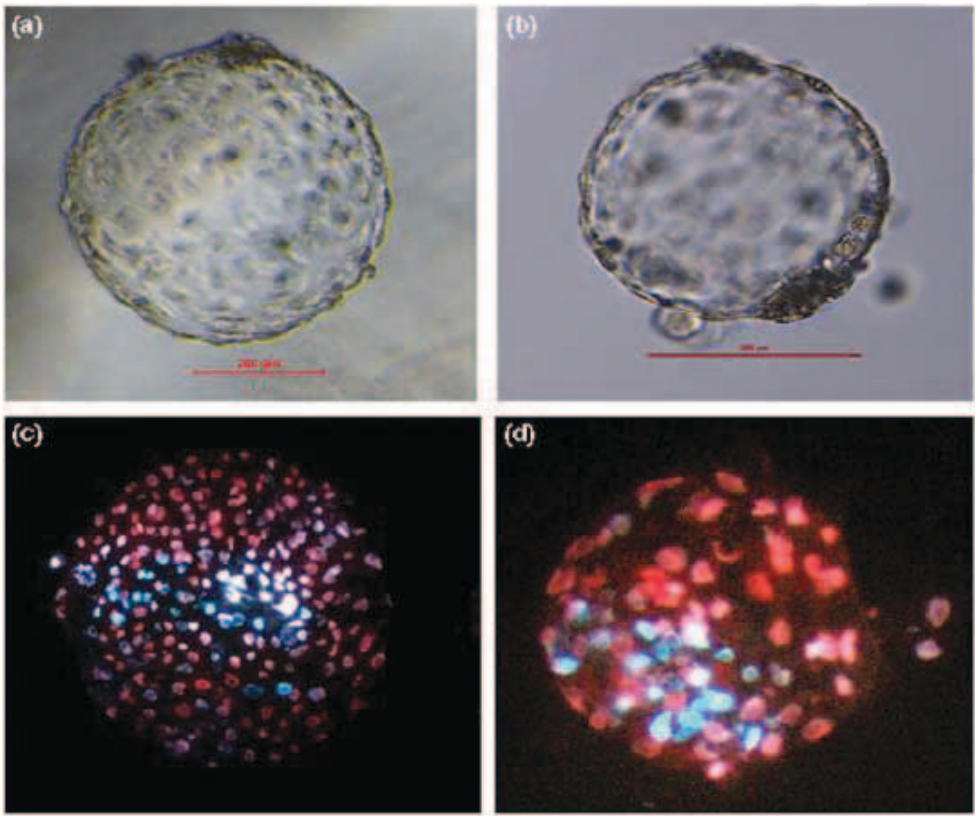
In another study, ES cells were successfully established from IVF, parthenogenetic and HMC embryos. Primary colony formation rate of HMC-derived ICM's was lower than that of IVF and parthenogenetic ICMs. Further, IVF derived ES cells were cultured with LIF (0, 1000, 2000 and 4000 U/ml) or LIF signaling inhibitors [Jak inhibitor 1 (3 µM and/or 6 µM) and U0126 (10 µM)] The highest primary colony formation rate, the maximum passage number for which ES cells survived and a high expression of transcription based pluripotency markers was obtained with 1000 U/ml LIF. LIF did not seem to have any mitogenic effects on buffalo ES cells but expression of some important active intermediates of JAK/STAT pathway suggested that it was essential for the maintenance of pluripotency. Sequences of gp130 and LIFR were submitted to NCBI GenBank under Acc. No. HQ221998 and HQ221999 respectively. Blocking JAK/STAT pathway by inhibition of JAK (Jak inhibitor 1) and MAP kinases (U0126) affected colony size and expression of transcription-based pluripotency markers. Presence of active JAK/STAT pathway components were detected by western blot analysis in addition to RT PCR. Culture of ES cells was modified by addition of ROCK inhibitor which seems to support the self renewal of buffalo ES cells. No significant difference was observed in the expression of developmentally important genes studied by real-time PCR among ES cells from three sources except in case of NANOG which was significantly higher in HMC derived ES cells.

Spermatogonial stem cell (SSC)-like cells were isolated from prepubertal buffalo testes obtained from slaughterhouse by double enzyme treatment, and were enriched by filtering through 80 µm and 60 µm nylon net filter, differential plating on lectin coated dishes and Percoll density gradient centrifugation. SSCs were characterized by examining expression of DBA and C-KIT by immunofluorescence staining. Expression of LIN28, a marker of pluripotency, and TAF4b, associated with self renewal, was examined by real time PCR. SSC-like colonies were subcultured twice after which they were cultured under different conditions. The colonies were divided into two groups based on the type of feeder layer used i.e., Sertoli cell feeder layer (SCFL) or fetal fibroblast feeder layer (FFFL). Each of these groups was further subdivided into 4 sub-groups based on type of culture medium (DMEM+10% FBS or KO-DMEM+15% KO-SR) and presence or absence of GDNF. A combination of SCFL and DMEM was found to be suitable whereas both KO-DMEM and FFFL were found to be unsuitable for culture of these cells. GDNF did not affect cell proliferation and LIN28 expression but had a positive effect on TAF4b expression. A method was standardized for the isolation of buffalo SSC-like cells and these cells were characterized by examining the expression of DBA and C-KIT.

Production of IVF and cloned embryos: The effects of O2 concentration (5% vs 20%) during *In vitro* maturation (IVM), fertilization (IVF) and culture (IVC) or supplementation of IVM and IVC media with cysteamine (50 and 100 µM, respectively; IVM, IVF and IVC carried out in 20% O2), on blastocyst rate and relative mRNA abundance of anti-apoptotic genes BCL-2 and MCL-1 and pro-apoptotic genes BAX and BID by real-time qPCR in immature and *In vitro*-matured buffalo oocytes and in embryos at 2-, 4-, 8- to 16-cell, morula and blastocyst stages were examined. The

blastocyst rate was significantly higher ($p<0.05$) while the percentage of TUNEL-positive cells was significantly lower ($p<0.05$) under 5% O2 than that under 20% O2. The mRNA expression of BCL-2 and MCL-1 was higher ($p<0.05$) and that of BAX and BID was lower ($p<0.05$) under 5% O2 than that under 20% O2 concentration at many embryonic stages. Following cysteamine supplementation, the blastocyst rate and the relative mRNA abundance of BCL-XL and MCL-1 was higher ($p<0.05$) and that of BAX but not BID was lower ($p < 0.05$) at many stages of embryonic development, although it did not affect the percentage of TUNEL positive cells in the blastocysts significantly. The mRNA expression pattern of these genes during embryonic development was different in 5% vs 20% O2 groups and in cysteamine supplemented vs controls. At the 8- to 16-cell stage, where developmental block occurs in buffalo, the relative mRNA abundance of BCL-2 and MCL-1 was highest under 5% O2 concentration and that of BAX and BID was highest ($p<0.05$) under 20% O2 concentration.

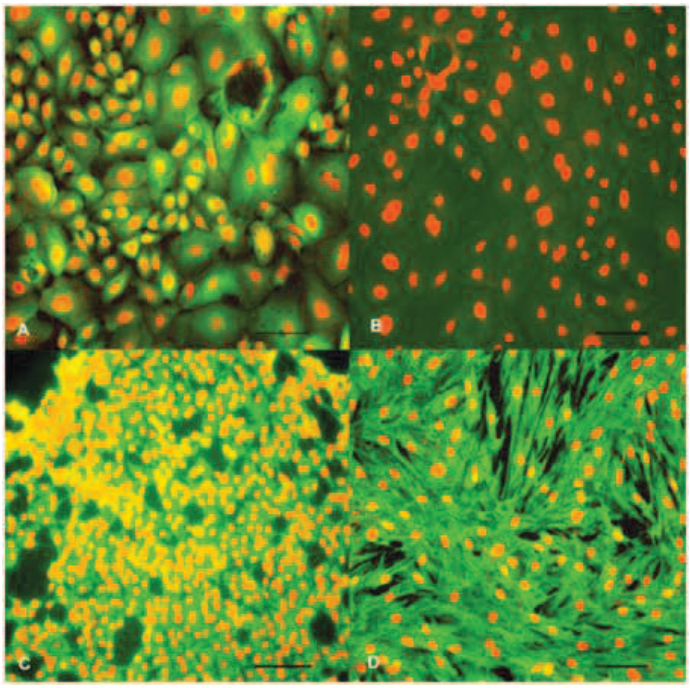
Somatic cells in milk are a potential source of nuclei for nuclear transfer to produce genetically identical animals; this is especially important in animals that are susceptible to risks of bacterial infection on biopsy collection. In this study, a minimum of 10 milk samples were collected from each of the three buffaloes representing Murrah breed. All the samples were processed immediately and cell colonies were obtained. Cell colonies from one buffalo (MU-442) survived beyond 10 passages and were evaluated by fluorescence microscopy and used in nuclear transfer experiments. In culture, these cells expressed vimentin, indicating they were of fibroblast origin similar to ear cells. The effectiveness of cloning was compared using those milk-derived fibroblast (MDF) cells and fibroblast cells derived from the ear (EDF). Fusion and cleavage rates of MDF-NT and EDF-NT embryos were found to be similar (92.43 ± 1.28% vs 94.98 ± 1.24%, and 80.27 ± 1.75% vs 84.56 ± 3.73%, respectively; $p > 0.01$); however, development to blastocyst stage and total cell number was higher for EDF-NT embryos (50.24 ± 2.54%, 227.14 ± 13.04, respectively, $p < 0.01$), than for MDF-NT embryos (16.44 ± 0.75%, 170.57 ± 4.50 respectively). It was inferred that somatic cells from milk could be cultured effectively and used as nucleus donor to produce cloned blastocyst-stage embryos.



Cloned buffalo blastocysts produced by using somatic cells isolated from (a) ear fibroblast or (b) milk as donor cells. (c) and (d) represent differential staining of respective blastocysts

Genetic Improvement of Milch Animals through Identification and Dissemination of Superior Germplasm by Application of Emerging Reproductive and Molecular Technologies

Establishment of a spontaneously immortalized buffalo mammary epithelial cell line (BuMEC): Buffalo mammary tissue collected from slaughter house was processed enzymatically to obtain a heterogenous population of cells containing both epithelial and fibroblasts cells. Epithelial cells were purified by selective trypsinization and were grown in plastic substratum. The purified mammary epithelial cells (MECs) were characterized for mammary specific functions by immunocytochemistry, RT-PCR and western blot. The established buffalo mammary epithelial cell line (BuMEC) exhibited epithelial cell characteristics by immunostaining positively with cytokeratin 18 and negatively with vimentin. The BuMEC maintained the characteristics of its functional differentiation by expression of β-casein, κ-casein, butyrophilin and lactoferrin. BuMEC had normal growth properties and maintained diploid chromosome number (2n=50) before and after cryopreservation. A spontaneously immortalized buffalo mammary epithelial cell line was established after 20 passages and was continuously subcultured for more than 60 passages without senescence.



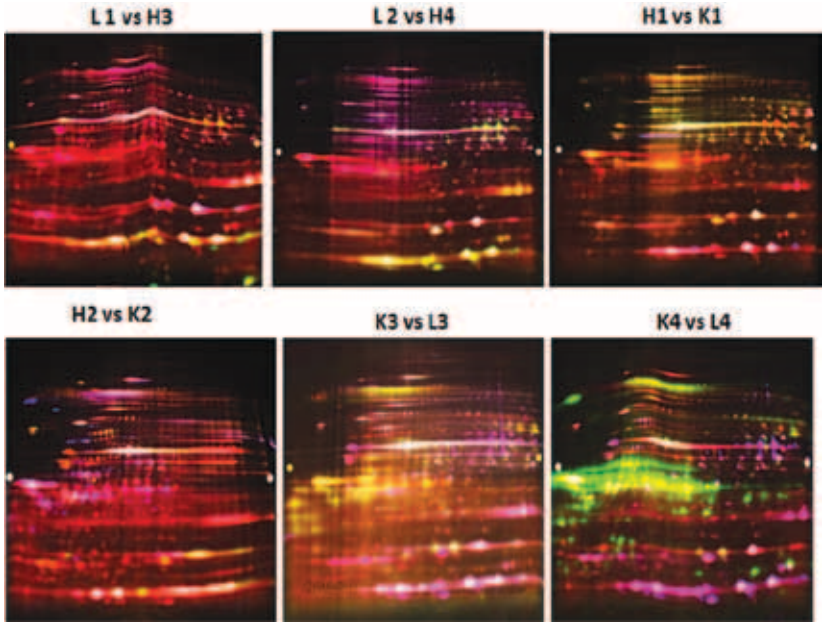
Immunostaining for cytoskeletal markers in BuMECs: *A: Cytokeratin 18 staining in BuMECs;B: Vimentin Staining in BuMECs;C: Cytokeratin 18 staining in MDBK cells (Positive control for Cytokeratin 18); D:Vimentin Staining in skin fibroblasts (Positive control for Vimentin) Scale bars, 100 μm.*

Molecular cloning and expression analysis of MGP-40: MGP-40 is a 40 kDa glycoprotein, which is expressed in the mammary gland during involution. To explore the potential of MGP-40 as a prognostic biomarker of lactation persistency, study was conducted to understand the functional significance of MGP-40 in the mammary epithelial cells and expression analysis of MGP-40 in milk during lactation. MGP-40 cDNA was synthesized by RT-PCR and the full length sequence of MGP-40 was determined by RACE. The size of MGP-40 gene was 2205 base pairs, which included 437 bp (5′ UTR), 1089 bp (ORF) and 679 (3′ UTR). Expression analysis of MGP-40 in different tissue samples such as mammary gland, mammary epithelial cells, intestine, heart, spleen, liver, lungs, kidney, ovary and testis tissues revealed that MGP-40 was expressed in mammary gland, mammary epithelial cells, intestine with relatively low level expression in heart and spleen and no expression was observed in liver, lungs, kidney, ovary and testis tissues. MGP-40 cDNA was cloned in pET22b+ for expression and recombinant MGP-40 was purified from a recombinant clone of *E. coli*. For functional characterization of MGP-40 in mammary epithelial cells, effect of MGP-40 on cell proliferation and cell death was studied. No significant effect of MGP-40 was observed on cell proliferation and cell death. However when MGP-40 was added to the cell culture medium in the presence of IGF-1 there seemed to be enhanced cell proliferation.

For expression analysis of MGP-40 in animals during lactation, native MGP-40 was purified from milk by following a series of chromatographic protocols. Polyclonal antibody against recombinant native MGP-40 was developed. During peak lactation the expression of MGP-40 was almost non-detectable suggesting that in an actively proliferating state, the expression of MGP-40 was less. During late lactation the level of MGP-40 start to increase and during involution the level was very high. It was observed that there was over expression of MGP-40 during both sub-clinical and clinical mastitis. A major problem in Sahiwal cows is the inconsistent lactation (short / truncated lactation). It was also observed that level of MGP-40 was found to be comparatively higher in short lactating animals in comparision to normal lactating animals.

Identification of Differentially Expressed Proteins in Lactating Cows Having Varied Lactation Potential (High *vs* Low Producing Cows)

To identify probable biomarkers of lactation potential in lactating cows differential expression analysis of proteins in mammary epithelial cells in high vs low producing Sahiwal cows was performed by differential in gel electrophoresis (DIGE) techniques within a pI range of pH 4-7 followed by Mass Spectrometry (Fig.1). The differentially expressed proteins were analyzed by decyder software. Twenty eight (28) differentially expressed proteins having potential / probable role in milk yield were identified. The most strongly regulated proteins are cytoskeletal components, calcium-binding proteins, regulators of cellular metabolism and regulators of protein stability. The identified proteins were further being evaluated for their biomarker potential.



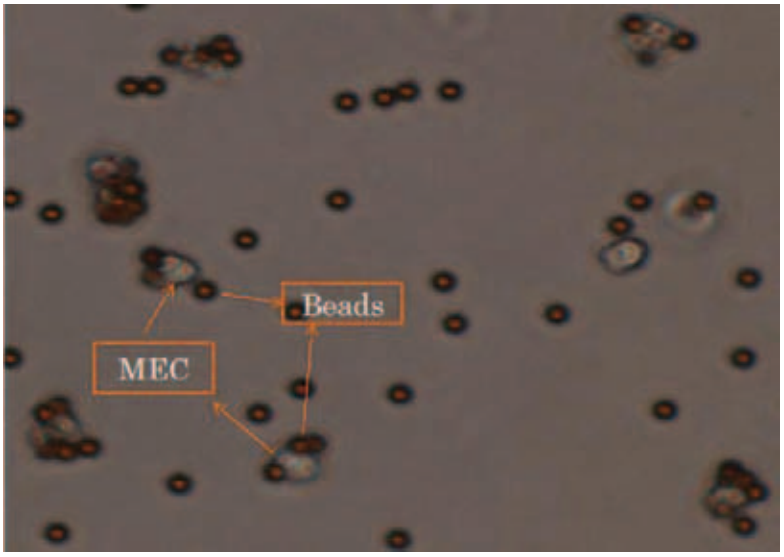
DIGE analysis of Sw-Hy vs Sw-Ly vs KF-Hy samples. DIGE images were scanned after SDS-PAGE. The gels were scanned using three lasers corresponding to Cy2, Cy3 and Cy5 wave lengths. The green colour spots represesent down regulation and red colour spots represent up regulation. Sw-Hy: Sahiwal high yielding; Sw-Ly: Sahiwal low yielding; KF-Hy: Karan Fries high yielding. L: Low producer, H: High producer.

Proteome Analysis of Buffalo Mammary Epithelial Cells (MECs) Isolated from Milk

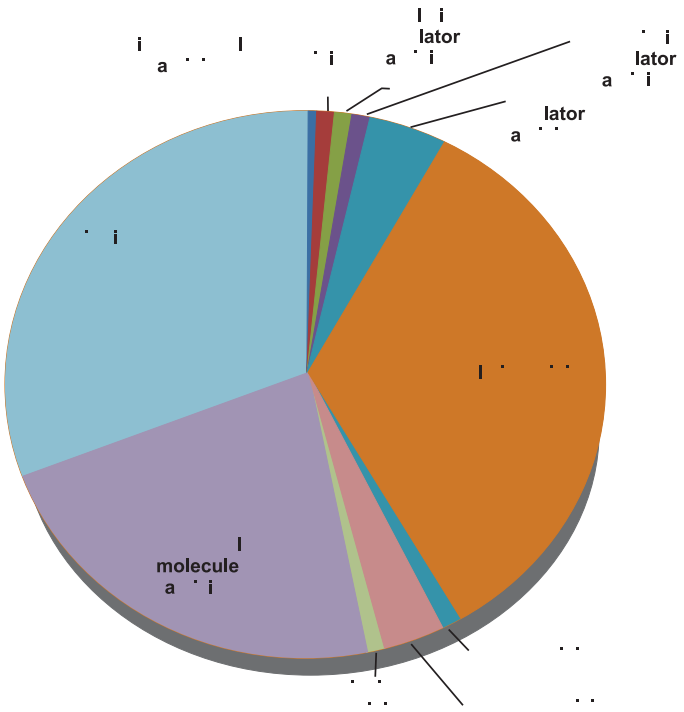
MECs were isolated from milk using immunomagnetic beads and characterized by RT-PCR using MECs specific genes like cytokeratin 8, α-Lactalbumin and epithelial membrane antigen. The protein composition of buffalo MECs was characterized by Mass spectrometry (1D gel-LC-MS/MS) analysis. A total of around 420 proteins were identified and classified based on the biological process, molecular function and protein class using Panther classification system and bioinformatics tools. 20 proteins were found, which were up/down regulated 1.5 fold in high and low milk producing animals with $p \leq 0.05$. Similarly, 22 proteins were identified which were up/down regulated 1.5 fold at different stages of lactation with $p \leq 0.05$. Principal Component

Analysis demonstrated that 97.5% of the variance (PC1) separated high and low yielder samples as expected. Only 1.8% of variance (PC2) separated the samples of same group (high or low). Similar results were obtained for protein features resolved in the pH 4-7 range for different stages of lactation experiment (PC1 _ 72.8% for among the groups and PC2 _ 24.4% within the group as expected).

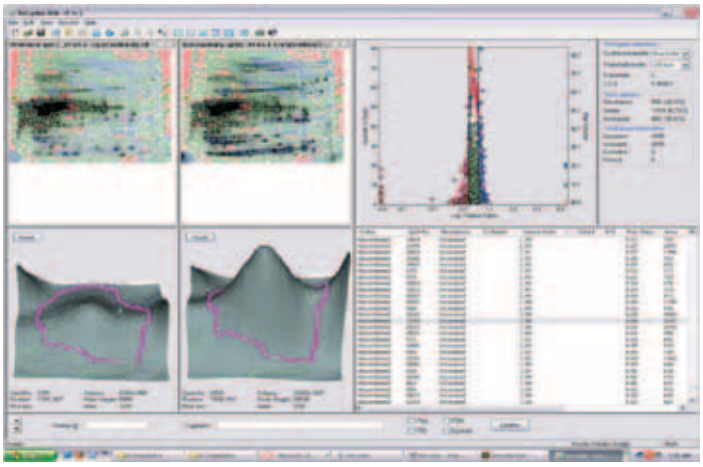
This analysis also demonstrated that there was significant variation between early and late stages in comparison to early and peak or late and peak stages of lactation. Most of these differentially regulated proteins were involved directly or indirectly in different functions of mammary gland.



Isolation of buffalo mammary epithelial cells (MECs) from milk by immunoaffinity methods



Categorization of MEC proteome based on molecular function



Differential in gel analysis for high and low yielding buffaloes

Purification and Characterization of Buffalo milk Xanthine Oxidoreductase (XOR)

XOR is involved in purine catabolism for oxidative hydroxylation of xanthine to uric acid and formation of reactive oxygen and nitrogen species. Buffalo XOR cDNA (4.4 kbp, Acc. No. NM 173972.2) was cloned and sequenced. The alignment of protein sequence indicated a similarity of 97.4%, 95.5% and 89% with XOR sequence from cattle, goat and human, respectively. XOR is a protein of 1332 residues and divided into three main domains, viz. N-terminal Fe/S domain (20 kDa) followed by FAD domain (40 kDa) and C-terminal molybdenum cofactor (Moco) domain (85 kDa). Sequence similarity of Fe/S and Moco domains was greater than the overall similarity of full length XOR, while FAD domain was less conserved.

Buffalo milk XOR was purified to homogeneity (~17 mg/L) with a molecular weight of 147,105Da. XOR showed oxidase and dehydrogenase activity of 0.65 ± 0.07 U/mg and 0.26 ± 0.03 U/mg, respectively. In comparison cattle XOR showed XO activity of 1.32 U/mg. Buffalo XOR showed anti E. coli activity that was almost half of cattle XOR. The kcat and Km values for buffalo XO were 1.6 min^{-1} and 16-20 µM for xanthine, respectively.

Cofactor analysis suggested 88.7% site occupancy at Fe/S centre. The Mo content was 34% as compared to 55-60% in cattle XOR. Homology modelling of the buffalo XOR indicated some important variations around FAD centre as compared to cattle XOR. The study provided important clues to the underlying mechanism responsible for biochemical differences between XOR of buffalo and other species.

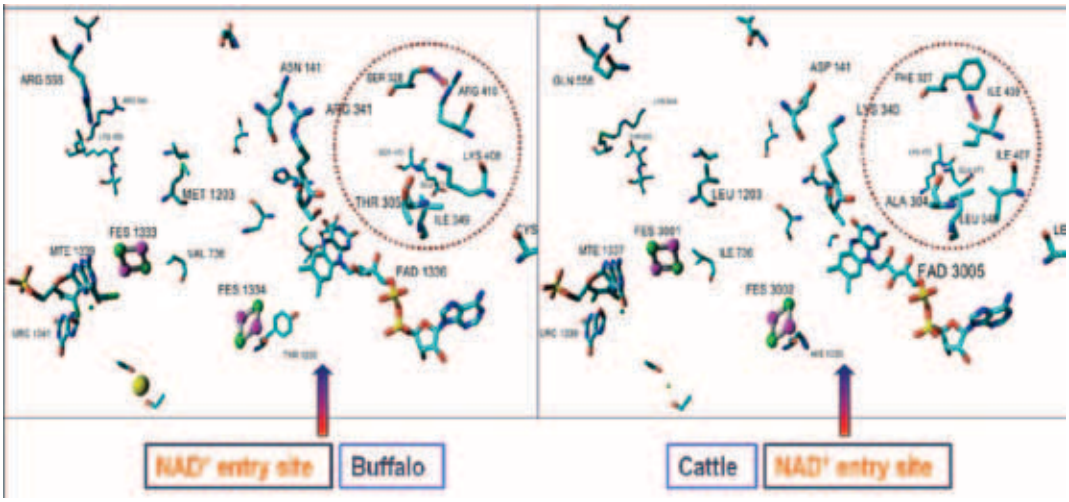
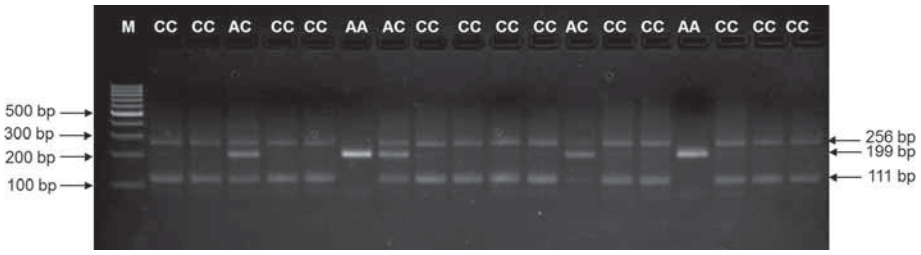


Figure: Structural comparison of buffalo and cattle XOR at the position of variations between the two species. The circles surround residues which differ in the pocket near FAD binding site. Note the cattle pocket contain mainly hydrophobic residues, which are replaced by the charged hydrophilic residues in the buffalo XOR.

PCR-based Method for Differentiating A1 And A2 Beta Casein Containing Milk

The DNA samples obtained from the milk were used for presence of A1 and A2 beta-casein by using allele-specific PCR. Four different allele specific PCR based primers were designed and simple PCR was optimized to distinguish the A1 and A2 type of beta casein. This process can be applied to milk and all products processed from that milk for identification of A1 and A2 milk type.

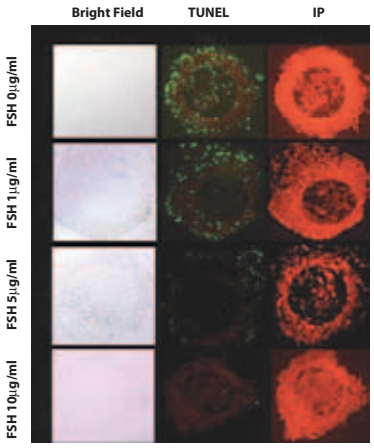
A mutation in the DNA sequence coding for the beta casein protein protein at nucleotide position 200 resulted in the replacement of a cytidine base with adenine base. Thus the triplet codon affected by this change codes for histidine (CAT) rather than for proline (CCT) at the amino acid position 67 of the protein. Thus the histidine at position 67 resulted in the cow producing beta casein A1 while the proline resulted in the cow producing beta casein A2.



The 199 bp PCR product indicates the presence of A1 beta casein allele, whereas the111bp PCR product indicates the presence of A2 beta casein alleles.

Genomics of Buffalo Follicular Cells and Oocytes

Cathepsin B gene expression was identified as very crucial for deciding the apoptotic fate of buffalo oocytes. Supplementation of a protease inhibitor (E-64) and FSH in IVM medium was effective in suppressing apoptosis of cumulus cell and resulted in at least 5% higher hatched blastocyst rate and increased total ICM cell numbers signifying better health of blastocysts.



Effect of FSH supplementation on apoptotic fate of buffalo oocytes

Animal Biochemistry

Effects of Prebiotic and Aloevera, on Metabolic Activity and Survivability of *L. casei* NCDC 19

Lactobacilli is important health promoting bacteria generally added to fermented foods and other foodstuffs. It is of great relevance to investigate the effectiveness of different types of soluble fiber and other additives in terms of stimulation of lactic cultures and their effect on metabolic activity & survivability of organisms added in products. The effects of inulin, maltodextrin and *Aloevera* on ACE inhibitory activity, extent of proteolysis during fermentation and survival of a potential probiotic (*Lactobacillus casei*) during storage of fermented milk were investigated. Among the different NCDC cultures screened for ACE inhibitory activity, *L. casei* NCDC 19 exhibited highest ACE inhibition as well as the extent of proteolysis. A slight increase in the ACE inhibition and extent of proteolysis in fermented milk was observed by maltodextrin addition, but the difference in the ACE inhibition was not statistically significant compared with the control. Addition of inulin did not affect ACE inhibition property of fermented milk. In presence of *Aloevera,* an increase in extent of proteolysis and ACE inhibitory activity was observed in comparison to control. Maltodextrin and inulin addition did not affect the viable counts

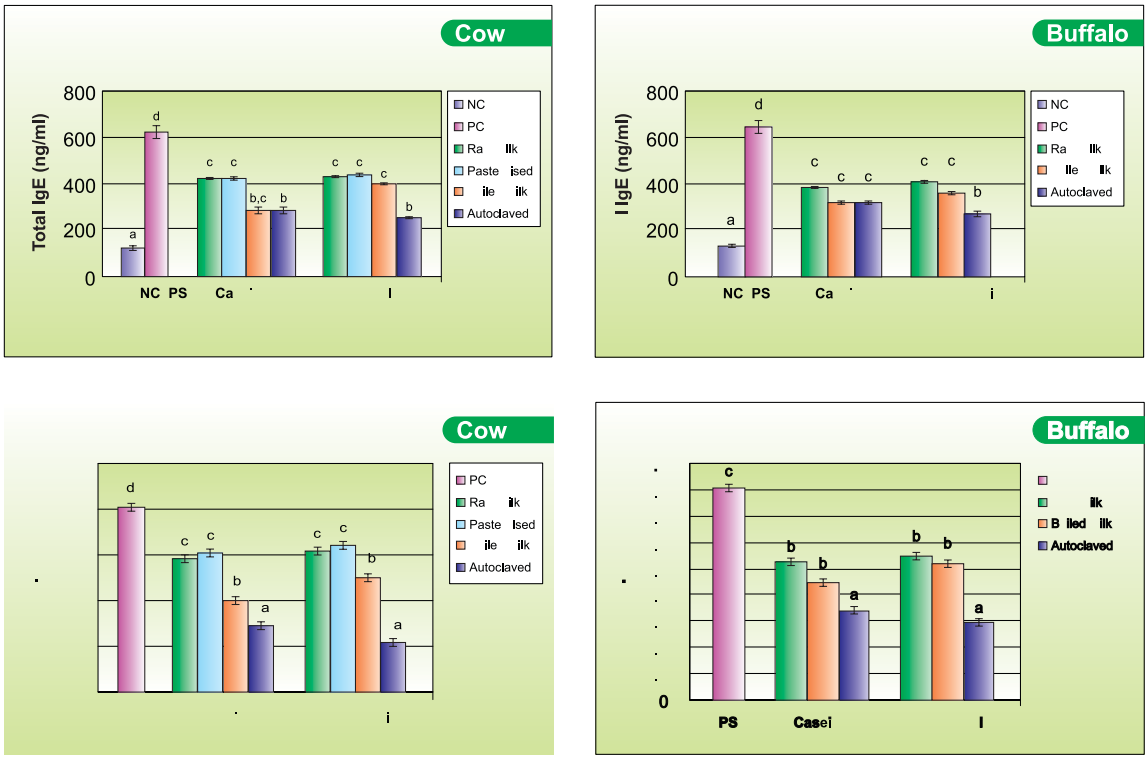
(log cfu/ml) of *L. casei* NCDC 19 significantly during storage of fermented milk for 7days. *Aloevera* addition led to increase in viable counts of fermented milk and were also maintained in sufficiently high number during storage.

Almond Exhibits Stimulatory Effect on Proliferation of *Lactobacillus rhamnosus*

Three strains of *Lactobacillus rhamnosus* of dairy origin and LGG were compared for their probiotic attributes. *L. rhamnosus* NCDC 17 was the best strain in terms of acid tolerance and antimicrobial activity, and exhibited good bile salt tolerance and cell surface hydrophobicity. The effectiveness of finely ground almond was investigated for *in-vitro* stimulation of growth of *L. rhamnosus* NCDC 17 and LGG. Supplementation of finely ground almond to basal medium (2%, w/v) had good stimulatory effect on proliferation of *L. rhamnosus* NCDC 17 and LGG, however, LGG fared comparatively better than *L. rhamnosus* NCDC 17. The two varieties of almond tested were equally effective in stimulation of growth of both the strains of *L. rhamnosus*.

Effect of Thermal Processing on Milk Allergenicity

Swiss albino male mice of about three weeks age were randomly divided into fourteen groups of seven animals each and injected with total caseins and whey proteins obtained from raw and processed (pasteurized, boiled and autoclaved) cow milk and buffalo (boiled and autoclaved) milk, respectively. There were two control groups (-ve control injected with adjuvant only and +ve control injected with ovalbumin). To check the humoral response against milk proteins, total IgE , specific IgE and total IgG levels of antibodies were estimated in the sera of animals. Autoclaving of cow and buffalo milk reduced the total and protein specific IgE levels significantly ($P \leq 0.05$) as compared to raw and pasteurized milk proteins. Thermal processing of milk did not exhibit statistically any variations in total IgG levels on sensitization of animals with cow whey proteins and buffalo caseins. Significant decrease ($P \leq 0.05$) in lymphocyte proliferation index in presence of mitogens (Con A and LPS) and respective milk proteins were also observed in animals sensitized with autoclaved milk proteins.



Impact of milk thermal processing on total and specific IgE

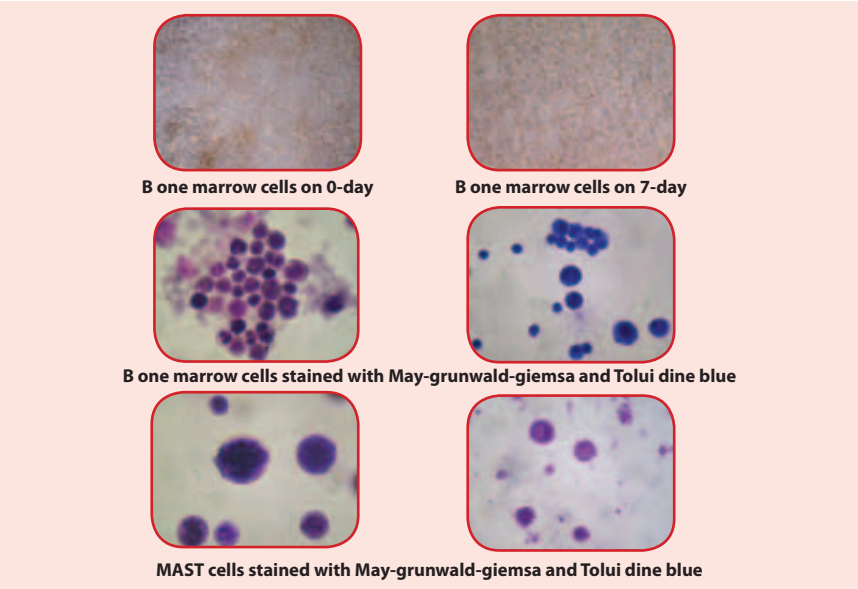
Development of Oral Tolerance to Milk Proteins

Oral tolerance to cow milk caseins and whey proteins were observed in four groups of mice of three weeks of age reared with feed without milk proteins (control groups) and oral intubation with cow caseins and whey proteins, respectively (experimental groups) followed by intra-peritoneal sensitization with respective milk proteins. It was

observed that the intestinal fluid of experimental groups had remarkably higher ($P \leq 0.01$) total IgA levels than the respective control groups. On the other hand, total IgE levels decreased significant ($P \leq 0.01$) in whey protein group on oral sensitization with this protein. In order to assess the, TH_1 and TH_2 responses, changes in levels of pro-inflammatory and regulatory interleukins (IL-10, IL-4, IFN-γ and TGF-β) were observed in cultured splenocytes of test animals. It was observed that on oral intubation with cow caseins and whey proteins the IL-10 levels increased significantly ($P \leq 0.01$) while there was significant decrease ($P \leq 0.01$) in the levels of IL-4 in both experimental groups than their respective control groups. Expression of IFN-γ and TGF-β were also observed in spleen of control and experimental groups by RT-PCR.

Cell Culture System for Studying Allergenic Response of Casein Derived Peptides

To develop mouse mast cell allergy model, protocol was standardized to differentiate mouse bone marrow cells into mast cells in presence of conditioned media derived from Con A. Mast cell degranulation assay showed significant release of histamine in presence of calcium ionophores, ovalbumin and cow beta lactoglobulin as compared to negative control in which no histamine release was observed. Similarly, remarkably less ($P \leq 0.05$) release of histamine and tryptase were observed in presence of caseinophosphopeptides and angiotensin converting enzyme (ACE) inhibitor peptides than casomorphin-5 (BCM-5) peptides demonstrating the allergenic properties of these bioactive peptides of hydrolysed milk proteins.

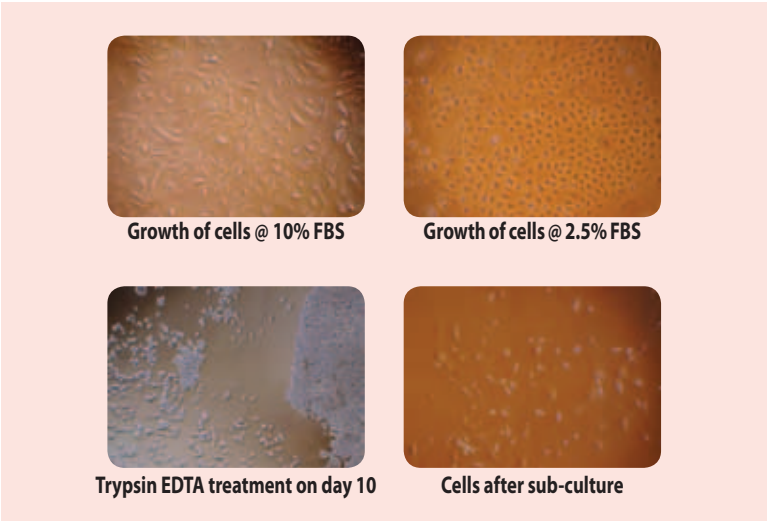


Culturing of Primary Intestinal Epithelial Cells for Evaluation of Cytomodulatory Property of Milk Bioactive Peptides

The culturing conditions of primary intestinal epithelial cells were standardized and it was observed that the cells isolated from the intestine by direct opening of slit showed poor growth and most of them differentiated into fibroblasts. When individual cells obtained after collagenase/ dispase digestion were plated, cells could not survive. Culturing of intact crypts caused the better growth suggesting that the growth of epithelial cells requires neighbouring cells to support. It was also observed that the growth was better, when the density of crypts seeded was more; this suggested that close contact between crypts is required for proper growth. The growth of epithelial cells was observed to be better, when the cells were cultured with 4.5% glucose media, 2.5%FBS, 50ng EGF and 6.8 mM sodium pyruvate. Confirmation of epithelial cell was done by immunocytochemistry by using anti-cytokeratin and anti-vimantin antibodies. No cytotoxic effect of milk derived bioactive peptides viz. Caseinophosphopeptides, β-casmorphin (BCM), ACE-inhibitory peptide (VPP) at concentration of 1mg on $1x10^5$ primary intestinal epithelial cells was observed.

Analysis of Expression and Mechanism of LPS Induced Regulation of *Cyp19* Gene in Buffalo Ovary

Uterine infection after parturition is one of the most common endemic diseases of dairy cattle and buffalo, leading to infertility by disrupting uterine and ovarian function. To classify the infected and

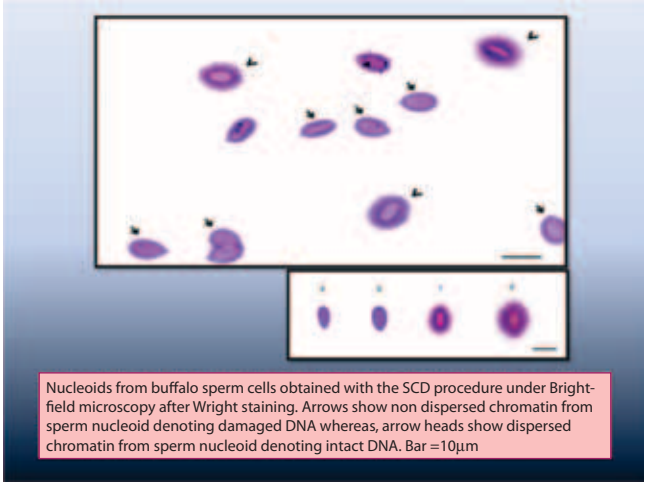


Culture of primary intestinal epithelial calls

non-infected animals, mucus and blood from the uterine tract and jugular vein, respectively, were collected after 21 days of postpartum. Morphologically, infected and normal animals were categorized based on the presence of clear or translucent mucus (control/no infection) and flecks of white or off-white pus, respectively. Estradiol in plasma of animals was measured. Results showed that animals with mucopurulent white flecks mucus had lower peripheral concentration of estradiol as compared with clear mucus producing animals. Expression analysis of *Cyp19* transcripts in leucocytes showed that animals with mucopurulent mucus had low copy number of *Cyp19* gene expression in leucocytes as compared to normal animals. Further, to see the effect of LPS on ovarian function *in vitro,* granulosa cells were cultured and dose dependent effect of LPS was evaluated on *Cyp19* gene expression and estradiol production. Interestingly, result showed that both *Cyp19* gene expression and estradiol production gene were found to be significantly lower than control.

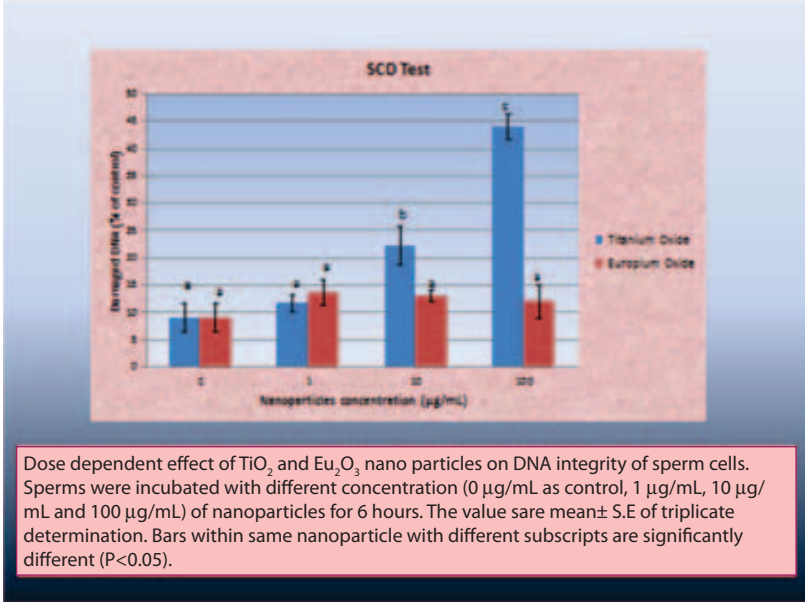
Affects of Nanoparticles and Carbon Nanotubes on Buffalo Spermatozoa Functionality

Effect of different concentrations (1 µg ml^{-1},10 µg ml^{-1} and 100 µg ml^{-1}) of PLGA nanoparticles (NPs) (<100nm) on viability, membrane integrity, capacitation status and DNA integrity of buffalo spermatozoa was studied. Sperm chromatin dispersion (SCD) test and acridine orange test (AOT) were employed to detect DNA fragmentation in sperm treated with PLGA NPs. It was found that there was no significant ($P<0.05$) decrease in cell viability and membrane integrity till four hours incubation period with NPs. In DNA fragmentation assay, there was a dose dependent increase in the DNA fragmentation only at physiologically higher concentrations.



Nucleoids from buffalo sperm cells obtained with the SCD procedure under Bright-field microscopy after Wright staining. Arrows show non dispersed chromatin from sperm nucleoid denoting damaged DNA whereas, arrow heads show dispersed chromatin from sperm nucleoid denoting intact DNA. Bar =10µm

A TEM image of nanoparticles after suspending the particles in sp-TALP and sonicating for a period of time was also obtained and the image showed that the primary nanoparticle size was within a range of 100–120 nm in diameter with a few particles around 80-90 nm. Buffalo spermatozoa were incubated in sp-TALP media in the presence and absence of europium oxide nanoparticles for 6 h. There was no significant change observed in sperm viability upto 3 h of incubation with 1, 10, 100 µg/mL of the nanoparticles but at 6 h, sperm viability significantly decreased with 100 µg/mL of the NP as compared to control. Eu_2O_3 nanoparticles did not affect spermatozoa viability at 1 and 10 µg/mL appreciably right upto 6 h of incubation period. Scanning electron microscopy of spermatozoa loaded with the nanoparticles revealed attached europium nanoparticles on the surface/membrane of spermatozoa (head and tail both). Membrane integrity of spermatozoa was decreased (by about 19, 11, and 16 percentage points over control) with increase in concentration (1, 10 and 100 µg/mL) of nanoparticles at 6 h but not appreciably till 3 h. Interestingly, an increase in capacitation was found by 19 and 11 percentage points at 1 and 10 µg/mL of europium nanoparticles followed by 10% decrease at 100 µg/mL as compared to control. Transmission electron microscopy of spermatozoa incubated with europium nanoparticles for 6 h revealed presence of nanoparticles inside head and tail region. DNA integrity of spermatozoa incubated with nanoparticles observed by sperm chromatin dispersion test (SCDT) showed dose dependent increase in DNA damage. In a preliminary experiment that was carried out on the motility of the europium nanoparticle loaded buffalo sperm cells (10^8cells/mL) at concentration of 10µg/mL, 40µg/mL and 80 µg/mL at 0h, 3h, and 6h incubation was recorded. It was found the sperm motility increased upto 7, 7.5 and 11 percentage points at 10µg/mL, 40µg/mL and 80 µg/mL of nanoparticles, respectively at the start of the incubation as compared to control. However, there was no significant difference in sperm motility at 100 and 120 µg/mL of nanoparticle concentration at even the start of incubation. The effect of biodegradable PLGA nanoparticles on the biocompatibility status with reference to sperm functions was studied and no significant effect was observed thereby supporting the biodegradability of the nanoparticles.



Dose dependent effect of TiO_2 and Eu_2O_3 nano particles on DNA integrity of sperm cells. Sperms were incubated with different concentration (0 µg/mL as control, 1 µg/mL, 10 µg/mL and 100 µg/mL) of nanoparticles for 6 hours. The value sare mean± S.E of triplicate determination. Bars within same nanoparticle with different subscripts are significantly different (P<0.05).

Apoptotic Markers in Fresh and Cryopreserved Buffalo (*Bubalus bubalis*) Spermatozoa

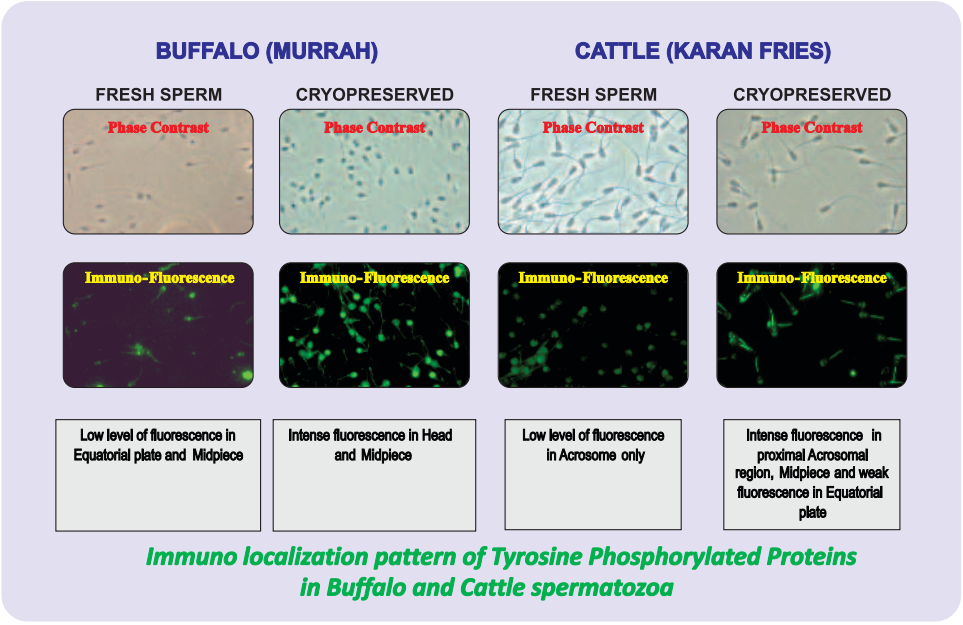
Freshly collected buffalo semen of more than +3.0 mass activities was splitted for analysis of fresh and cryopreserved semen in egg yolk tris extender. Apoptotic and necrotic spermatozoa were detected and quantified in fresh and cryopreserved spermatozoa by fluorescent microscopy using Annexin V –FITC and PI assay kit from Sigma Chemical Co. USA. Fresh spermatozoa had significantly lesser number of early apoptotic (2% vs 3%), late apoptotic (3% vs 32%) and necrotic cells (6% vs 11%) compared to the cryopreserved spermatozoa, respectively. Mitochondrial sperm membrane potential was found to be decreased in cryopreserved spermatozoa (63.26 ± 3.80%) compared to the fresh spermatozoa (75.15 ±

1.48%) as assessed by fluorescent microscopy. Further studies are in progress for analysis of above parameters during various stages of cryopreservation and also using soya milk extender for cryopreservation of buffalo spermatozoa.

Immunocytochemical Localization of Tyrosine Phosphorylated Proteins during Cryopreservation of Bovine Spermatozoa

The closely related bovine species viz. buffalo and Karan Fries were differentiated in terms of functional attributes of cryopreserved spermatozoa on the basis of immunocytochemical localization of tyrosine phosphorylated proteins. These were localized at equatorial plate and mid piece (weak fluorescence) in fresh, and entire head and mid piece (intense fluorescence) in cryopreserved buffalo spermatozoa as compared to Karan Fries where weak fluorescence was observed at the acrosome in fresh and intense fluorescence at the acrosome and mid piece in cryopreserved spermatozoa. Three isozymic forms of glutathione-s-transferase Mu3 (an antioxidant enzyme) were found to be tyrosine phosphorylated during cryopreservation of buffalo spermatozoa out of five isozymes identified in cryopreserved spermatozoa. The cryopreservation of buffalo and Karan Fries semen in the new soya milk extender showed lesser extent of protein tyrosine phosphorylation in the frozen thawed spermatozoa as compared to conventional egg yolk extender.

The extent of lipid peroxidation, production of superoxide anion and hydrogen peroxide by the frozen thawed spermatozoa were significantly lower in semen frozen in the soya milk extender compared to the egg yolk extender. The addition of taurine, trehalose and taurine + trehalose to the extender significantly decreased the level of cAMP, the extant of lipid peroxidation, superoxide anion and hydrogen peroxide production in the cryopreserved semen compared to their absence in both the extenders

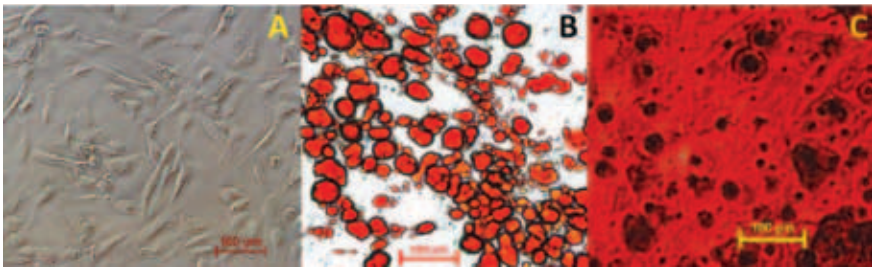


Immuno localization pattern of Tyrosine Phosphorylated Proteins in Buffalo and Cattle spermatozoa

Differentiation of Adipose Derived Mesenchymal Stem Cells into Adipocytes and Osteocytes

Mesenchymal stem cells (MSCs) were isolated from mouse adipose tissue after its treatment with collagenase type 1A. The cell preparation was filtered through 41µm nylon filter. The filtered cells were centrifuged at 1500 rpm (5 min.) and pelleted cells were cultured at 37°C, 5% CO_2 in DMEM –LG medium with 15% FCS. After 24 hours, cells were extensively washed with PBS to remove non-adherent cells. The medium was changed every two-three days. When cells reached 70% confluency, these were trypsinized using 0.05% trypsin in 0.02% EDTA-PBS. The cells were maintained upto 5 passages. The differentiation of MSCs into adipocytes was achieved by replacing medium in proliferating cells (70% confluency) with adipogenic medium (DMEM-HG, FCS 15%, dexamethasone 10-6 M, 5µg/ml insulin, 50µM indomethacin, 0.5µM Isobytylmethylxanthine). The medium was replaced at every alternate day and at day 14, most of cells were differentiated into mature adipocytes, and therefore, could be stained with Oil Red O, a lipid binding dye.

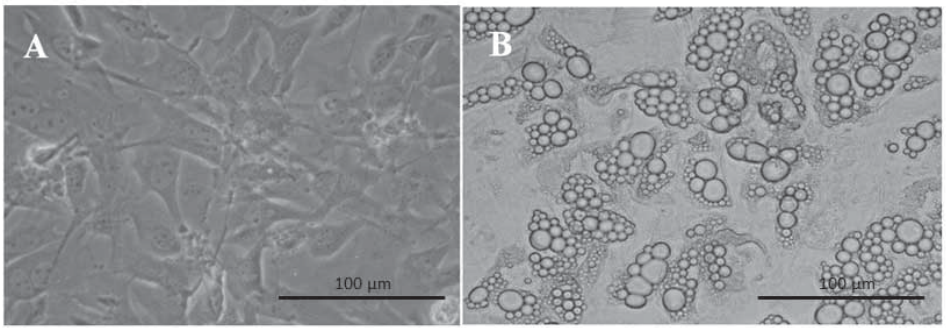
The differentiation of MSCs into bone cells (osteocytes/osteoblast) was achieved by culturing MSCs in medium DMEM-LG supplemented with 15% FCS, dexamethasone 10-8M, β-glycerophosphate 10 mM and ascorbate-2-phosphate 50µg/mL for 14 days. The medium was replaced at every alternate day. The differentiated cells were visualized by staining with calcium specific dye, Alizarin Red. Mineralized matrix in differentiated cells was visible.



Proliferation and differentiation of mesenchymal stem cells. (A), proliferative stage; (B), mature adipocytes stained with Oil Red O; (C), osteocytes/osteoblast with Alizarin Red.

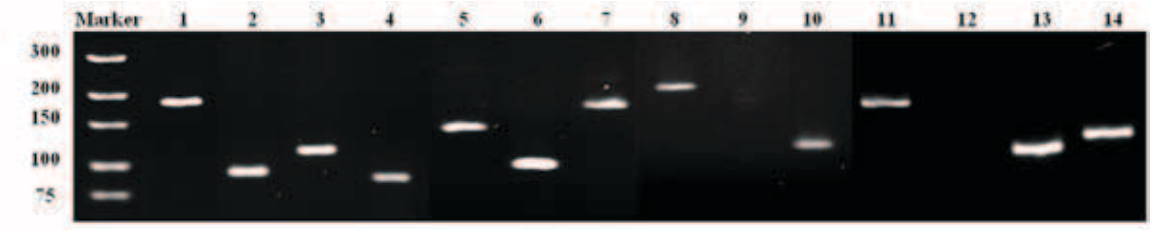
Developmental Gene Expression in Proliferating Brown Adipocytes

Adipose tissue plays important role in the regulation of energy homeostasis and metabolism. Adipose tissue is of two types, referred as white adipose tissue (WAT) and brown adipose tissue (BAT). WAT and BAT are functionally distinct cell types characterized by their opposing metabolic properties. The principal role of WAT is the storage and release of trigycerides in response to energy levels. By contrast, BAT is a unique fat depot in mammals for oxidation of dietary fuel substrates without production of chemical energy. Brown adipose tissue was collected from interscapular region and treated with collagenase. The suspension was filtered through 100 µm nylon filter and filtrate was centrifuged at 2200 rpm (10 min.) and pellet referred as stromavascular fraction was used for proliferation and differentiation. Cells were cultured in DMEM-LG, 15% FBS, 3nM insulin, 10mM HEPES, 50IU penicillin, 50µg/mL streptomycin and 15µM ascorbic acid. Non-adherent cells were removed after 24 hours by extensive washing with PBS. Medium was replenished every alternate day. At about 6-7 days, cells reach 80% confluency. Differentiation was achieved by culturing proliferated cells (80% confluency) in induction medium (DMEM-LG, 10% FBS, 10mM HEPES, 50IU penicillin, 50µg/mL streptomycin, 500nM 3-isobutyl-1-methylxanthine, 2µg/mL dexamethasone, 125nM indomethacin, 1nM triidothyronine, 20nM insulin) for 48h and then in differentiation medium (DMEM, 10% FBS, 1nM triidothyronine, 20nM insulin) for 5-6 days with replenishment of medium for every alternate day. During proliferation stage, cells were fibroblast like cells whereas differentiated cells had multilocular fat globules.



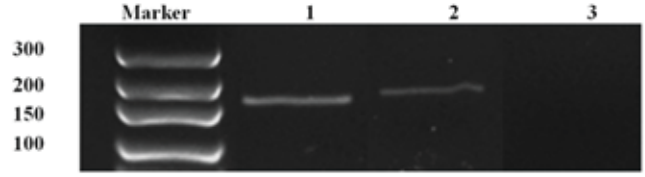
Proliferation (A) and differentiation (B) stage of brown adipocyte in culture from Mus musculus

Hox A1, HoxA5, HoxC4, HoxC8, HoxC9, Gpc4, Sfrp2, Shox2, Thbd, En1, Tbx15, Nr2f1 developmental gene and pref1 marker were expressed during proliferation. However, HoxA2 (reported in kidney) and HoxB1 (reported in subcutaneous WAT)) developmental genes were not expressed.



Expression of developmental genes at proliferation stage

Lane 1, En1; Lane 2, Tbx15; Lane 3, Nr2f1; Lane 4, HoxC8; Lane 5, HoxA1; Lane 6, HoxA5; Lane7, HoxC4; Lane 8, Shox2; Lane 9, HoxA2; Lane 10, Thbd; Lane 11, HoxC9; Lane 12, HoxB1; Lane 13, Gpc4; Lane 14, Sfrp2.



Absence of expression of HoxA2 in proliferating brown adipocyte

Lane 1, pref1 (marker gene for proliferation stage of adipocytes); Lane 2, HoxA2 (Kidney; positive control); Lane 3, HoxA2 (proliferating brown adipocytes)

Dairy Technology

Development of Mixed-Fat and Cheese Based Spreads Using Dairy and Non-Dairy Functional Ingredients

The study was undertaken with the objective to develop a technology for manufacture of Mixed-Fat Chocolate Spread (MFCS) using functional dairy and non-dairy ingredients, which would have superior nutritional quality, good storage stability and at the same time encouraging consumers' response. The ingredients used for preparation of MFCS were cooking butter, olive oil, skim milk powder (SMP), cocoa powder (CP), sugar and whey protein concentrate (WPC) or butter milk solid (BMS). Various ingredients were optimized for formulation of product using Response Surface Methodology. The study also demonstrated that use of biopreservative (MicroGARDTM) in WPC based MFCS, decreased the rate of spoilage of the product as compared to MFCS without preservative sample of MFCS. In the second phase, processed cheese spread was incorporated with functional ingredients like inulin, phytosterol and ω-3 fatty acid. Due to addition of these functional ingredients, the production cost of functional processed cheese spread (FPCS) increased by ~ 48% as compared to control. However, this FPCS was accepted by most of the consumers (93%) due to its good flavour and spreadability and it was nutritionally and functionally sound.

Physio-chemical Characteristics of *Kheer Mohan*

Market samples of Kheer Mohan were collected from four different places namely Gangapur city (SWM), Kurgaon, Sapotra and Karoli from different shops and subjected to consumer preference at each place. Both Sawai Madhopur and Karoli are two nearby districts in Rajasthan. Through the consumer preference, three most preferred samples were brought to NDRI, Karnal. These samples were subjected to chemical, physical and microbiological analysis. The most preferred market sample of Kheer Mohan had 76.39 % TS, 9.26% fat, 8.51% protein, 4.30% lactose, 53.52% sucrose and 0.81% ash content. The colour values were L*(40.41), a*(14.56) and b*(31.66). TPA attributes of sample: hardness (49.65 N), Fracturability (30.98 N), cohesiveness (0.08), Gumminess (3.89 N), Springiness (0.51 mm) and chewiness (2.10 N.mm).

Best *Kheer Mohan* samples were also compared with other similar products namely, *Cham cham, Kheer mohan (*West Bengal*) and Chhana Balushahi* (Bihar), and were found to be significantly different from the samples of *Kheer Mohan* of Rajasthan.

Process Development for the Production of Functional Butter

Functional ingredients such as Conjugated Linoleic Acid (CLA) in the form of triglycerides and phytosterols (PS) in the form of esters were used for development and functional butter. Functional butter with 4% CLA and 12% PS added to cream before pasteurization followed by butter making found to be organoleptically superior compared to other samples. Functional butter secured sensory score of 92 where as control butter secured 94 on ADSA score card and hardness values measured at -20 □ C, using texture analyzer, were 19.25 ± 1.10 N and 20.10 ± 2.73 N, respectively. Study of the hypocholesterolemic effect of functional butter in rat model is in progress.

NETWORK PROJECT ON R & D SUPPORT FOR PROCESS UP-GRADATION OF INDIGENOUS MILK PRODUCTS FOR INDUSTRIAL APPLICATION

Technology of *Channa Murki*

Shelf life studies on dry-type *channa-murki*: The studies were aimed at ascertaining the extent of physico-chemical, sensory and microbiological changes in the 'dry-type' *chhana-murki* packaged in 5-ply nylon bags with modified atmosphere packaging (nitrogen flushing) and stored at 102°±1°C. The results indicated that the magnitude of pH drop and the increase in HMF concentration were lower in MAP samples. The increase in FFA value was apparently small and the oxidative changes were within the acceptable limit. The extent of proteolysis in dry-type *chhana-murki* increased marginally with the length of storage, the increase being slightly lower in MAP samples. The redness (Hunter a*) in the product increased and yellowness (b*) decreased, the change being lower in nitrogen-flushed product. The TPA hardness of samples without MAP and with MAP increased from 148.34 N to 242.54 N and 225.58 N, respectively after 6 weeks. A marginal increase in TPA springiness was observed and the cohesiveness of both the types of dry-type *chhana-murki* also increased with the progress of storage. TPA gumminess and TPA chewiness showed a trend similar to the one noticed for hardness. Sensory analysis of the product revealed that the product with or without MAP appeared to be acceptable for a period of up to 5 weeks at 10°C. The microbiological studies revealed that in the product packaged without MAP (control), the SPC increased from log10 1.31 cfu/ g to log10 1.44 cfu/g, whereas in MAP samples, the SPC increased to log10 1.40 cfu/g after 6 weeks of storage. The Y&M count in the *chhana-murki* samples without and with MAP increased to log10 1.04 cfu/g and log10 0.77 cfu/g, respectively after 6 weeks of storage. Consumers' response to *chhana-murki* was quite favorable; 52.9% of males respondents and 46.9% females rated the product as ''excellent'', 36.4% males and 35.8% females as ''very good''and 11.1 and 17.3%, respectively rated the *chhana-murki* as ''good''. The overall acceptability of the product was 8.41 by males and 8.30 by females, the global average being 8.36 (i.e. between 'very good' and 'excellent'). The cost of production of *Chhana-murki* was estimated as ₹ 138.28 per kg in 500 g polypropylene pouches.

Shelf-life evaluation of functional chhana murki: Changes in microbial, physico-chemical, rheological and sensory quality of functional *channa murki* (FCM) were evaluated during storage under refrigeration (10 ± 1°C). In products stored at ambient temperature (30 ± 1°C), oozing out of moisture into the coating made the product wet, sticky and unsightly within 24 h. The product was packed either under ordinary atmosphere or with nitrogen flushing in multilayered co-extruded pouches. Average moisture content of fresh FCM samples was 14.40 percent which steadily decreased during the first 9 days of storage. Average water activity of fresh FCM samples (0.823) decreased ($p \leq 0.01$) in both types of packaging till 9th day followed by a slow increase. A gradual but statistically significant ($p < 0.01$) increase was observed in FFA and HMF contents of all FCM samples during storage. The tyrosine value increased from an initial 9.3 µg/ml to 23.0 µg/ml and 22.3 µg/ml in samples packaged under atmospheric and nitrogen flushed conditions, respectively after 15 days. The TBA value of FCM packed under atmospheric conditions increased from 0.018 to 0.051 while in the FCM packaged under nitrogen, it increased to 0.048. The instrumental hardness, adhesiveness and springiness tended to increase and the increase was significant ($p \leq 0.01$) only after 15 days. The cohesiveness of FCM in both the types of packaging decreased progressively with the storage period. Gumminess and chewiness also showed a trend similar to the one noticed in hardness. There was very slight but significant ($p \leq 0.01$) decline in resilience of the product as well. The average SPC count increased from initial 0.42 log cfu/g to 1.81 log cfu/g after 15 days of storage in samples without nitrogen whereas in nitrogen flushed samples, it increased to 1.67 log cfu/g. No mould or yeast counts could be detected in fresh samples.

Y&M were noticed only on 15th day in both the types of packaging. Coliforms were absent in fresh as well as stored samples irrespective of packaging type. Consumer acceptance studies revealed that out of 135 correspondents, 117 (i.e. 87.4 percent) 'liked' the product whereas 11.85 percent of total respondents rated the product as 'excellent', 32.59 percent as 'very good', 37.78 percent as 'good', 8.89 percent as 'fair' and rest 8.89 showed no response. No adverse remarks or criticism was received. The shelf life of the product was found to be about two weeks as indicated by the sensory analysis data (acceptable score, 6.0). The cost of production of FCM was estimated as Rs. 253.92 per kg in 500 g multilayered co-extruded pouches.

Aloe Supplemented Probiotic *Lassi*

Effect of heat treatment and concentration of Aloe vera on Immunostimulatory activity of Aloe vera: *Aloe vera* samples subjected to different time-temperature combinations viz. 70°C/10 min, 80°C/10 min, and 121°C/16 min, were tested for immunomodulatory activity against control *Aloe vera* (no heat treatment) sample as well as two positive controls namely Concanvalin A and LPS. It was observed that there was no significant decrease in immunomodulatory activity of *Aloe vera* upon heating. It was also observed that with increasing concentration of *Aloe vera,* the immunostimulatory activity decreased on mice spleen cells. One µl *Aloe vera* exhibited highest immunostimulatory activity.

In-vitro prebiotic activity of Aloe vera: *Aloe vera* was supplemented at 0, 20 and 100% levels in MRS broth and at 0 and 20% levels in skim milk followed by inoculation (@ 1%) with the 5 selected potentially probiotic strains. Probiotic counts were enumerated at 12, 24 and 48 hrs in case of MRS broth and at 12 and 18 hrs in case of skim milk supplemented with *Aloe vera*. Results indicated that *Aloe vera* supplemented samples were associated with higher probiotic count (for all the 5 strains) than the control samples (0% *Aloe vera*). There was almost more than 2 log cycle increase after 12 hrs of incubation and more than almost 3 log cycle increases after 18 hrs of incubation.

Physico-chemical and sensory characteristics of Aloe vera supplemented dahi and lassi: Five samples of *dahi* were prepared using 5 lactobacillus strains and evaluated for physic-chemical and sensory properties. Among the five cultures, *Lactobacillus rhamnosus* and *Lactobacillus paracasei ssp. paracasei* were associated with better acid production, lower whey separation and higher viscosity. The sensory score of *lassi* was also better when prepared form these two strains compared to other strains. But the probiotic attributes of the *Lactobacillus rhamnosus* were not promising. Hence, it was decided to conduct compatibility trails of these five strains with dahi cultures and the best two dahi culture compatible strains would be chosen for further final product (*lassi*) development.

Survey on Pollutants and Contaminants

Survey of pollutants and contaminants in milk and selected milk products: Milk samples (80 no.) were collected from East, Central, North, West and New Delhi in two seasons (summer and winter) for analysis of organophosphate and organochlorine pesticides residues using High Performance Liquid Chromatography (multipesticide residue analysis method). From each district, 2 villages were selected. A minimum of 6 samples were collected from each district. Heavy metals (cadmium and lead) were also analysed using Atomic Absorption Spectrophotometer. Average of some samples showed above MRL values for OP pesticides; DMT (0.040-0.126), MCP (0.125-1.077) and DZN (0.005-0.119) ppm, whereas for OC pesticides; ESF (0.180-0.518) was above MRL. The levels of lead and cadmium in milk collected from Delhi averaged 0.163 (from 0.015 to 0.935) ppm and 0.016 ppm (from 0.002 to 0.09), respectively which were below the MRL (Pb-2.5ppm, Cd-1.5; PFA, 2009).

Novel Approaches for Production of Nutraceuticals from Milk and Indian Herbs for Potential Use in Functional Dairy Foods

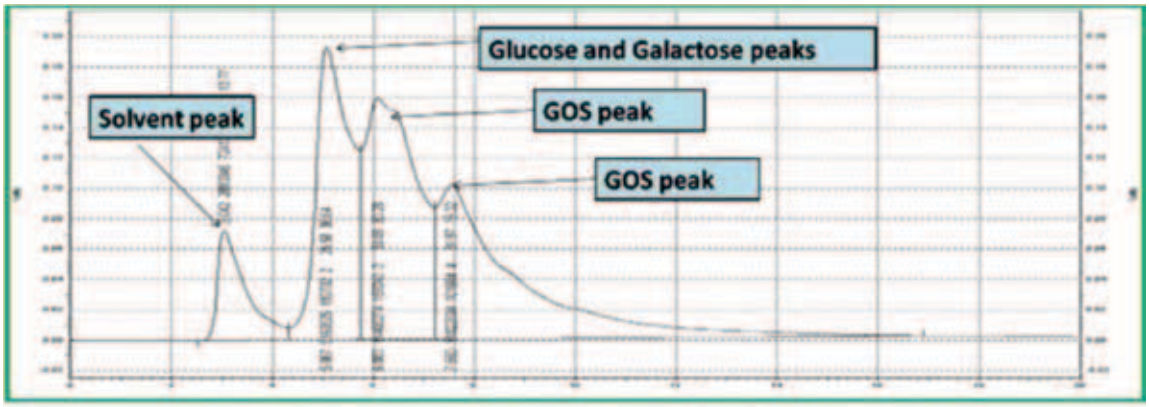
Production of nutraceuticals like antioxidant and antimicrobial peptides from milk

- An aminopeptidase (pepX) with possible role in generation of bioactive peptides, was purified to homogeneity by ion-exchange (MonoQ) chromatography. The PepX protein was eluted at 0.35 M NaCl concentration gradient at pH 7.4.
- The purified X-prolyl dipeptidyl aminopeptidase (PepeX) was characterized. The kinetics study of purified enzyme was also performed. The enzyme was found to be stable at 36°C-37°C temperature and pH of 6.0 to 7.0.
- Six *Lactobacilli* isolates were screened for highly proteolytic activity and their molecular typing was performed.

Production of Galactooligosaccharides (GOS) from whey through microbial or enzymatic hydrolysis

Study of transgalactosylation reaction for GOS production using β-galactosidase extracted from the strains of *Streptococcus thermophilus* and *Kluyveromyces spp.* revealed that GOS could be produced with 15-20% lactose concentration at 40^0C temperature, 6.8-7.2 pH and 20-30 units of enzyme/mL of lactose solution. A steady state was observed in transgalactosylation reaction after 6 hr. The optimum GOS production was found to be between 27.68- 38.47 g/L.

During laboratory animal studies (mice), it was found that feeding of GOS effectively reduced the adherence of *Listeria monocytogenes,* an emerging pathogen in intestine, liver and spleen. The population of *Listeria monocytogenes* in intestine, liver and spleen was reduced significantly after feeding GOS @ 60 gm/kg of diet. GOS was also found to have Immunomodulatory effects as elucidated by the elevated conc. level of IgA and IgG in blood plasma of mice after feeding of GOS @ 60 gm/kg of diet.



GOS production at 20 % lactose conc. after 5 hr of incubation

Enhancement of Conjugated Linoleic Acid (CLA) Production in Milk

- Supplementation with *C. cyminum* extract in the diet enhanced Butyrivibrio sp. and altered relative abundance of *Butyrivibrio, Prevotella* and *Fibrobacter* sp. which resulted in increased CLA concentration **(32%)** *in vitro* without affect on ruminal fermentation.
- *In-vivo* experiments with lactating goat fed with *C. cyminum* extract resulted in modified fatty acid profile of the milk by increasing the CLA, VA, LA, PUFA (+21%) and MUFA (+8%) concentration in goat milk.

Interaction of Major Milk Constituents with Herbal Components

- The antioxidant activity of herb extracts (aqueous and ethanolic) were evaluated at 200 ppm using the β-carotene–linoleic acid coupled oxidation model system. The antioxidant activity exhibited by ethanolic extracts of shatavari, ashwagandha and vidarikand were significantly greater than their aqueous extracts.
- Sodium caseinate and WPC added with herb extracts were resolved on Urea-PAGE and SDS-PAGE. No difference in mobility based on charge or size of protein molecules was observed. But the intensity or width of the band was different as compared to that of sodium caseinate and WPC indicating protein-polyphenol binding. Interactions of milk protein with herb extract were observed. This might be due to interaction with steroidal alkaloids, steroidal lactone, saponins, flavonoids etc. which were present in these extracts. Hydrogen bonds were also involved.
- Addition of herb extract to milk improved its antioxidant activity as measured by ABTS method compared to control milk, indicating that the total phenolics, ascorbic acid and total flavonoids had higher correlation with total antioxidant capacity.

Validation of Bioactivity of Nutraceuticals (CLA, GOS and Herbal Biocomponents)

Bioactivity of herbal components (1% Shatavari, 0.3% Ashwagandha, 0.4% Vidarikand) were assessed for antioxidative and immunomodulatory potential in mice as animal model. Animals fed with milk containing herb extracts resulted in increased phagocytic activity of peritoneal macrophage as compared to control milk. Increase in proliferation of lymphocytes was also observed when incubated with LPS and Con A as mitogen after 4 weeks of dietary regimen. Animals fed with milk containing herb extract resulted in decline in acid reactive substances (TBARS values) in liver and RBC lysate after 4 weeks of dietary regimen indicating decreased lipid peroxidation. Increase in reduced glutathione content in liver and RBC lysate was observed after four weeks of dietary regimen as compared to control. In-vivo experiments with lactating goat fed *C. cyminum* extract resulted in modified FA profile of the milk by increasing the CLA, VA, LA and PUFA concentration in goat milk. *C. cyminum* enhanced PUFA (+21%) and MUFA (+8%) in the rumen with the cost of SFA (-8%, $P<0.05$). Moreover, milk PUFA was 14 percent higher in *C. cyminum* supplemented goats with no effect on milk yield ($P<0.05$).

Development of E-courses for B.Tech (DT) Degree Programme

Initiated in June 2009, content development in 26 courses assigned to NDRI Karnal was completed and peer reviews as well as peer review meetings on these courses were conducted.

Out of 32 (26 NDRI + 6 SVVU) courses, 13 courses were subjected to PG students review at NDRI, Karnal, These 13 courses, having already been transferred to the POODLE (Portable MOODLE) platform, were nearly ready for off-line delivery to the end-users. The remaining course reviews would be accomplished in the following year i.e. by 30th June 2012. During the course of the sub-project, several internal review meetings including two meetings chaired by the Consortium Leader & Director, NDRI were conducted. Also, the project progress was reviewed at two review meetings organized by NAIP under the chairmanship of Director General, ICAR.

Composite Dairy Foods with Enhanced Health Attributes

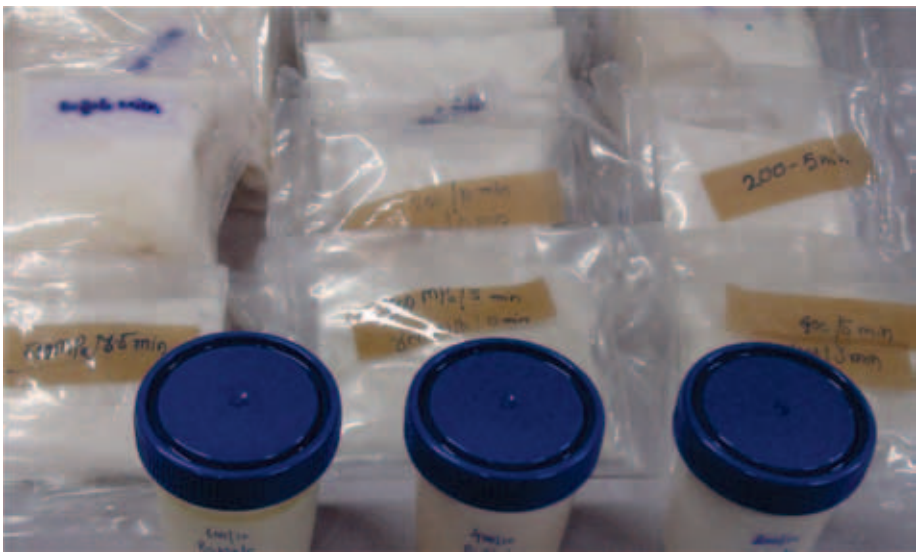
Whey protein concentrate, barley flour and refined wheat flour were successfully used for the manufacture of high-protein biscuits and found to be sensorily acceptable. The resultant biscuit contained 2.54 g/100 gm β-glucan. Validation trials conducted in rats' show that haemoglobin (mg/dl) and ferritin concentration increased significantly by ~ 25% and 70% in rats with normal iron status and animals with induced anaemia respectively by feeding above-mentioned biscuits. Pearl-millet based set fermented product was formulated and it was found that the processing treatments given to pearl millet reduced the phytate level (by 10%). The product under refrigeration (5-7°C) was found be acceptable up to 18 days. Vermicelli based on Barley and corn flour was formulated in order to formulate ready-to-cook vermicelli kheer mix suitable for diabetics. Barley flour was successfully incorporated along with corn flour in order to get maximum sensory scores. The level of vermicelli, milk solids and cooking time was also optimized. Extruded and powdered grains were used in formulation of nutri-mix meant for community feeding in combination with milk solids. Optimized formulation of nutrimix would meet 72.2% of RDA for protein, 44% of RDA for calorie and 11% of RDA for calcium requirement. The cost of the formulation was calculated to be ₹11.77/- per 100 grams of serving.

Investigation on High Pressure Induced Effect on Quality Characteristics of Buffalo Milk

Increase in shelf-life of buffalo as well as cow milk on high pressure treatment: Shelf-life investigation of HHP treated samples of both cow and buffalo milk revealed that milk processed at 400 MPa for 10 min could be stored up to 20 day under refrigerated condition (5 ± 2^0C). HP treated milk samples were also evaluated for the change in color, acidity, viscosity, pH, and Heat Coagulation Time (HCT) and there was non-significant change in these parameters during the period of storage. The microbial analysis showed that the bacterial population was dominated mainly by *cocci*. Acidification due to the slow growth of lactic acid bacteria resulted in spoilage of milk after 20th day. The findings of the investigation showed the prospects of applying high pressure treatment for improving the shelf-life of milk without affecting the functional characteristics.

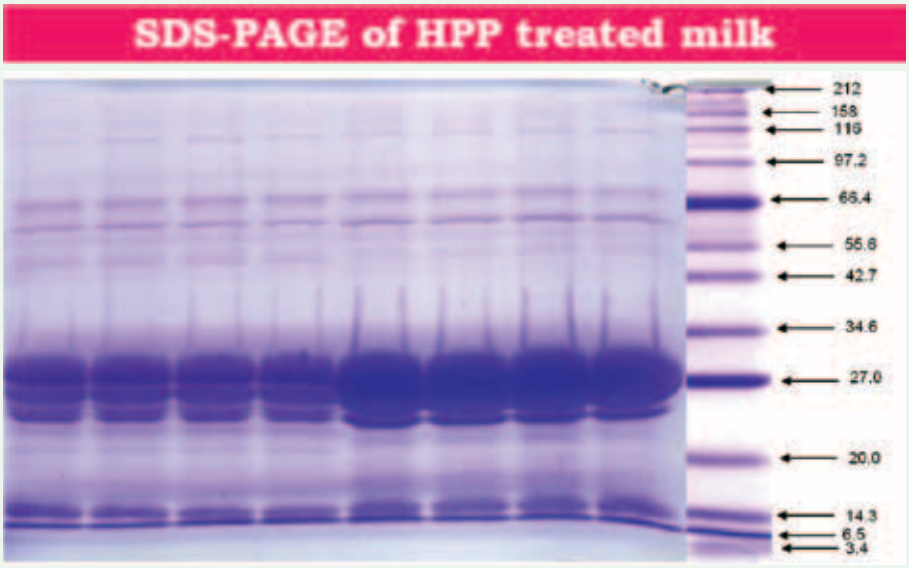
Elucidation of Behaviour of Buffalo Milk Proteins on High Pressure:

Electrophoretic pattern of treated milk samples showed that mainly casein fraction was affected. Pressure treatment at 400 MPa and above resulted



HP Treated Buffalo Milk Samples Stored Under Refrigeration Temperature

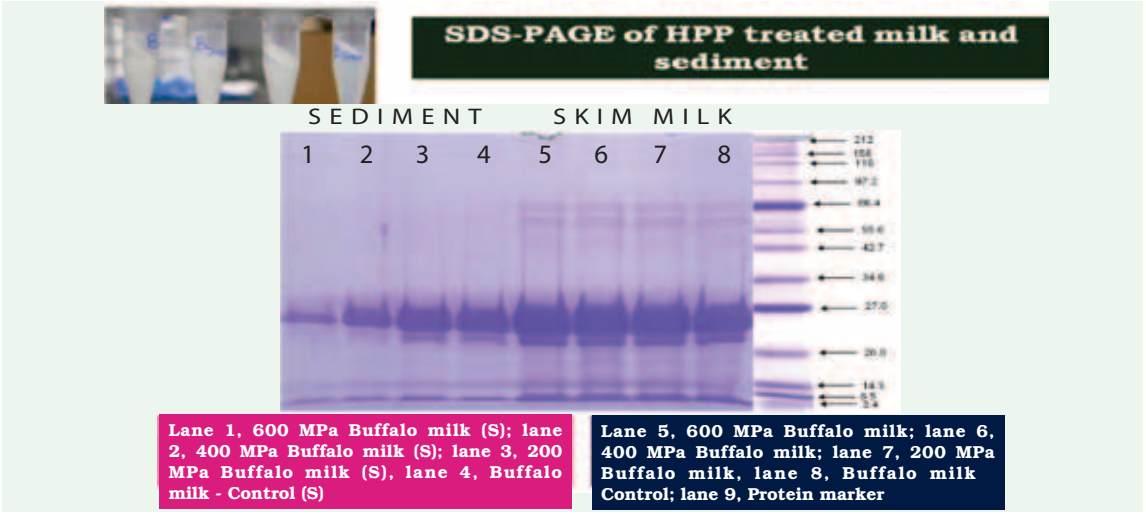
in rapid dissociation of casein micelle. Treated milk gets separated on centrifugation that indicated that micellar proteins were denatured. Serum proteins mainly bovine serum albumin (BSA),α –Lactalbumin, and β-Lactoglobulin partially denatured due to pressurization. Disruption of casein micelle in buffalo at 400 MPa or above pressure for 10 minutes indicated that casein fraction was the major site for high pressure induced effect. The change in casein fractions also affected the properties such as viscosity and colour, apart from affecting HCT and rennet coagulation time (RCT).



Lane 1, Cow - control; lane 2, 200 MPa Cow milk; lane 3, 400 MPa Cow milk; lane 4, 600 MPa Cow milk;

Lane 5, Buffalo - control milk; lane 6, 200 MPa Buffalo milk; lane 7, 400 MPa Buffalo milk, lane 8, 600 MPa Buffalo milk; lane 9, Protein marker

Electrophoretic Pattern of HP Treated Cow & Buffalo Milk Samples



Electrophoretic Pattern of Sediment and Serum Portion of HP Treated Buffalo Milk Samples

Development of Geriatric Dairy Food Having Prophylactic Attribute Against Alzheimer's Disease

Trials were initiated to develop technology of curcumin fortified *lassi*. As curcumin is insoluble in water two suitable matrix material *viz*., Tween–80 and β-cyclodextrin (β-CD) were used for binding/ encapsulation of curcumin before incorporation into lassi. Different ratios of curcumin to binding materials were tried. When added to lassi @160 ppm before homogenization, the highest retention of curcumin (147 ppm) was obtained when the component was mixed @ 1:5 wt/wt ratio with Tween-80. In case of β-CD the retention was 132 ppm, whereas the control lassi retained only 79 ppm curcumin. Sensorially, addition of curcumin only changed the colour of product and had no effect on any other attributes.

Dairy Chemistry

Antioxidant Polyphenol Extract (Strawberry) Fortified Stirred Dahi

Consumption of polyphenol-rich foods has been associated with a reduced risk of oxidative-stress-mediated diseases such as cancers, heart and neurodegenerative diseases. The low calorie PP fortified stirred dahi was prepared cultured with NCDC 167 and 261. The developed product had a better flavour and appearance with comparable compositional and physico-chemical parameters. However, the acidity of PP fortified stirred dahi was slightly higher than control. Antioxidant activity and total phenol content of developed product was significantly higher ($p<0.05$) than control. Antioxidant activity (ORAC-FL) and total phenolic content significantly decreased ($p<0.05$) after 9th day of storage and then remained unchanged until 21 days of storage at refrigeration temperature. No significant difference ($p>0.05$) was observed in DPPH radical scavenging activity during the storage.

Functional Properties of Ice-Cream and Milk Beverages Incorporated with Whey Protein Ingredients

In the present study the Whey protein hydrolysates (WPHs) were prepared from WPC-70 by using different commercial proteases Flavourzyme, Alcalase, Corolase PP. These WPHs were analyzed for the protein contents and degree of hydrolysis (DH). The corolase WPH showed max. degree of hydrolysis as compared to Flavourzyme and Alcalase WPHs. The antioxidant activities of WPHs were evaluated using *In vitro* and in vivo assays. The TEAC (Trolox equivalent Antioxidant activity) of all the hydrolysates i.e. Flavourzyme, Alcalase and Corolase was higher than the WPC. The corolase WPH showed the maximum antioxidant activity. The Flavourzyme WPH and Alcalase WPH were investigated for antioxidant activity by carrying out in vivo studies in mice as animal model. The result showed that the antioxidant enzymes (AOE) viz. Catalase, SOD, Glutathione peroxidase activities in blood increased significantly in WPH fed groups. In liver

homogenate, the Catalase and Glutathione activity increased significantly in the groups fed with WPHs compared with oxidized oil fed group. The level of TBARS in blood and liver homogenate of the group fed with WPHs decreased significantly as compared to the groups fed with oxidized oil. The ACE inhibitory activity of Flavourzyme, Alcalase, Corolase was higher than WPC. The antioxidant activity was increased after addition of 1% and 2% Flavourzyme, Alcalase, Corolase WPHs in strawberry and chocolate flavoured milk compared to control. The antioxidant activity increased after addition of 1% Alcalase and Flavourzyme WPH in both vanilla and chocolate ice cream. The overrun and melting resistance of ice cream prepared with the addition of 1% WPHs increased significantly.

Caseinophosphopeptides Enriched Ingredient from Buffalo Casein

Caseinophosphopeptides (CPPs) were biologically active sequences obtained by *in vitro* enzymatic and/or by *in vivo* gastrointestinal digests of the appropriate precursor milk casein proteins. Caseinophosphopeptides contain highly polar acidic sequences of three phophoserines followed by two glutamic acid residues (SpSpSpEE), which are the binding sites for minerals. In the present study, the process for production of caseinophosphopeptides by hydrolyzing buffalo casein with digestive enzyme was optimized by using response surface methodology. A new method for the enrichment of CPPs was developed by using membrane filtration and compared with the traditional method of isolation by ethanol precipitation. It was found that the peptides seperated by both the methods were having comparable Ca binding, Ca solubilising ability and antioxidant activity. The peptides in both the products were separated by FPLC and identified by LC-MS/MS. Both the samples contain same phosphopeptides of buffalo casein i.e. αs_1 - CN(37-58), αs_1 -CN (35-58), αs_1 -CN (43-58), αs_2-CN(2-21), β-CN(2-27) (Table:1). These sequences matched with already known sequences in the literature and identified as mineral binding and anticariogenic peptides. These caseinophosphopeptides enriched ingredient could be used in various health promoting foods for enhancing the minerals absorption. This new method developed using ultrafiltration could be scaled up for the commercial preparation of caseinophosphopeptides enriched ingredient.

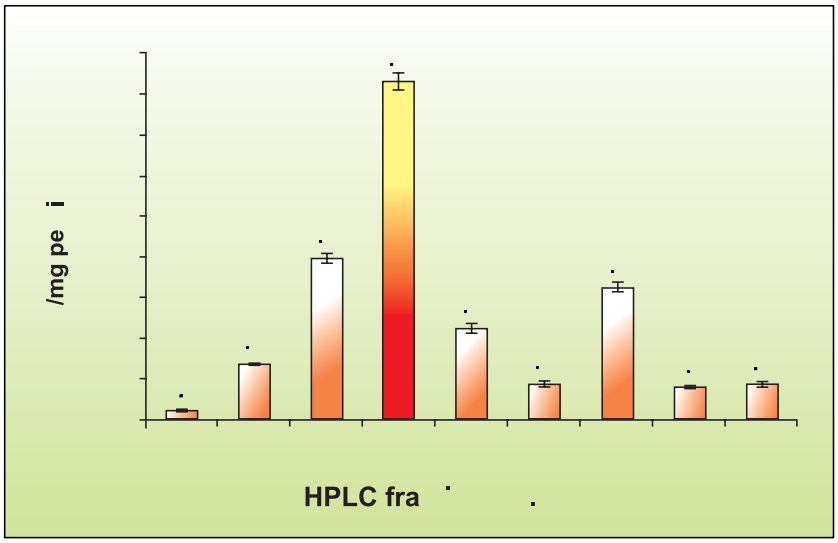
Caseinophosphopeptide sequences obtained by LC-MS/MS

Precursor Protein	PEPTIDE SEQUENCE	Mw (Dalton)	No. of phosphate group
αs1-CN(37-58)	VNELSTDIGSESTEDQAMEDIK	2650.46	3
αs1-CN(35-58)	EKVNELSTDIGSESTEDQAMEDIK	2907.10	3
αs1-CN(43-58)	DIGSESTEDQAMEDIK	1913.78	2
αs2-CN(2-21)	HTMEHVSSSEESIISQETYK	2641.15	4
αs2-CN(138–142)	TVDMESTEVITK	1431.72	1
β-CN(2-27)	ELEELNVPGEIVESLSSSEESITHINK	3141.90	4
β-CN(32-47)	FQSEEQQQMEDELQDK	2091.99	1

Production and Characterization of Casein Derived Antioxidative Peptides by Proteinases from Lactobacillus

Skim milk fermented with nineteen selected Lactobacillus strains from ten species was evaluated for antioxidant activity by ABTS decolourization assay. The radical scavenging activity varied between 0.12 to 0.49 mM TEAC and the proteolytic activity varied between 0.40 to 2.25 mM Leu. Seven strains including *L. delbrueckii* subsp. *bulgaricus* NCDC08, *L. plantarum* NCDC25, *L. casei* subsp. *casei* NCDC17, *L. rhamnosus* NCDC24, *L. paracasei* subsp. *paracasei* NCDC63, *L. fermentum* NCDC141 and *L. helveticus* NCDC288 exhibited the highest correlation between antioxidant and proteolytic activity. On hydrolysis of casein with crude enzyme preparation from these strains, the antioxidant activity increased by 3-4 folds as compared to endogenous antioxidant activity. The cell envelope proteinases (CEP) from L. helveticus NCDC288 and *L. rhamnosus* NCDC24 were purified on High load Q-sepharose HP 16/10 column. The purified enzyme showed a single protein band on SDS-PAGE. The recovery of the enzyme activity of *L. helveticus* NCDC288 CEP was 20.53 % with approximate molecular weight of 100 kDa and 18.63 % for *L. rhamnosus* NCDC24 CEP with approximate molecular weight of 50 kDa.

The effect of process variables such as hydrolysis temperature, pH and enzyme to substrate (E/S) ratio on antioxidant activity of casein hydrolysate was investigated systematically using response surface methodology (RSM). Highest radical scavenging activity of 1.80 TEAC / mg peptide (12.30 % DH) was obtained from casein hydrolysed with E/S ratio 0.50, pH 9.10 and temperature 42.0°C using proteinases from *L. helveticus* NCDC 288. The casein hydrolysed with crude proteinases from *L. rhamnosus* NCDC24 showed radical scavenging activity of 1.92 TEAC / mg (16.80 % DH) under the hydrolysis conditions with E/S ratio 0.6, pH 9.0 and temeprature 41.0°C. Twenty five peptides were identified by LC/MS from UF 3 kDa permeate of *L. helveticus* NCDC288 proteinase hydrolysed casein. Seven of these peptides fragments β-CN 94-105 (GVSKVKEAMAPK), β-CN 169-176 (KVLPVPQK), β-CN 178-182 (VPYPQ), β-CN 178-186 (VPYPQRDMP), β-CN 193-202 (YQEPVLGPVR), β-CN 194-206 (QEPVLGPVRGPFP), VLGPVRGPFPI (197- 207) shared sequence homology with nine previously identified antioxidative peptides. The peptides exhibiting highest antioxidant activity were separated on C18 column using RP-HPLC. Nine different fractions were collected and analysed for antioxidant activity. As depicted in fig.1 the fraction 4 exhibited highest antioxidant activity was further sequenced by LC/MS. Following the sequence interpretation, the first peptide GVSKVKEAMAPK (m/z 1250.59) matched with sequence β-casein (94- 105) and the second peptide RPKHPIKHQGLPQ (m/z 1535.21) matched with sequence αS1-CN (1 – 13).



ABTS Radical Scavenging activity of RP-HPLC fractions of the 3kDa permeate obtained from casein hydrolysate by crude proteinases from L. helveticus NCDC288

Preparation and Characterization of Nano/ Microemulsions of Clove Oil Using Whey Protein Concentrates

The clove oil exhibit antimicrobial activity and this effect of clove oil are attributed to eugenol, which is the major active constituent. In the present study, to enhance their antimicrobial activity, and minimizing their impact on quality attributes of final product, the clove oil was encapsulated into nano/microemulsions. These emulsions (O/W) were prepared using clove oil as core material (1%, 2%, & 10%) and whey protein concentrate (WPC-70) as wall material (0.1%, 0.2% and 1%) by sonification. The size of the emulsion droplet depended upon the concentration of the WPC and clove oil and it ranged from 150.5 ± 34.9 to 348.5 ± 103.4 nm. With the increase in WPC concentration, there was increase in size, while with increase in oil concentration; there was decrease in droplet size. The particle size decreased in with increase in sonification time. The antimicrobial activity of the prepared nanoemulsions was measured against E.Coli (non-pathogenic) strain. The measured antimicrobial activity was significantly affected by the formulation of nanoemulsions, where different concentrations of clove oil were encapsulated. It was observed that clove oil and WPC emulsions showed antimicrobial activity against E.Coli and there was one log cycle reduction in the CFU/ mL on addition of 1mL emulsion which contains approximately 20 µL of clove oil. All the emulsions

showed good stability even after heating at 80°C for 30 min.

A New Simple and Rapid Test for Detection of Detergent in Milk Developed

A simple colour based test for detection of detergent in milk was developed. The test is sensitive enough to detect presence of 20 mg laboratory grade detergent in 100 mL milk implying that even 2 liters of synthetic milk added to 100 liters of milk can be easily detected. The test is colour based and results are available just after mixing of reagents and milk samples. The test can detect all brands of commercial detergents available in the market. The test does not require use of any equipment and the cost of ingredient used for preparation of test reagent is very low. This test is extensively validated at accredited lab and at a milk plant. Field trials have also been completed. The test is now ready for commercialization and product will come in the market soon.

Rapid method for the detection of detergent in milk indicating purple and blue colour in lower layer in pure and adulterated milk

Quantitative Method for Estimation of Levels of Detergent in Milk

A method for quantitative estimation of anionic detergent in milk was developed. The linear relationship between the absorbance and the detergent concentration in milk was observed up to 80 mg L-1 and 300 mg L-1 in SDBS (sodium dodecylbenzensulfonate) and Labolene, respectively and the calculated value of correlation coefficient (R2) was 0.99. The method was validated in milk samples by spiking milk samples with different levels (150, 400 and 800 mg L-1 Labolene) of detergent. The recovery was quantitative. The method could be applied in milk samples adulterated with synthetic milk.

Fluorimetric Method for the Detection of GMP in Milk Samples

GMP is the major source of sialic acid in sweet whey and is also a marker peptide of sweet whey adulteration in milk. For the detection of adulteration of milk with sweet whey, GMP in adulterated milk sample was selectively precipitated using TCA. Since GMP contains bound sialic acid, the precipitated GMP was subjected to fluorescence measurement. The correlation between the fluorescent intensity obtained and the level of cheese whey in milk sample was linear and was used for the detection of cheese whey adulteration in milk. The method was validated in milk samples added with different levels of cheese whey. The method is rapid and takes less than 1 hour.

Development of Strategies for Detecting Milk Fat Adulteration with Admixture of Animal Body Fats and Vegetable Oils

Cow and buffalo ghee samples were prepared in the laboratory by creamery butter method under standard conditions of clarifying at a temperature of 115°C/flash. Goat, sheep and pig body fat were prepared separately from their respective adipose tissues collected from the local slaughterhouse. Vegetable oil with specific characteristics of higher RM and moderate B.R- reading was procured from a local oil trader. Admixture of vegetable oil and buffalo body fat (MX1 and MX2) was prepared in such a way so that the physico-chemical constants of the admixture were close

to the values prescribed for pure ghee. Physico-chemical constants of pure ghee and adulterant fats were determined. Similarly, other tests like crystallization time, apparent solidification time and complete liquefaction time of all the samples was determined. Adulterated samples using cow ghee and above said adulterants were also prepared in such a way so that the physico-chemical constants of the adulterated ghee samples remained with in the prescribed standards. It was observed in the study that in case of cow ghee, 2% was the maximum possible level of body fats which could be accommodated, where as adulteration with MX1 to the tune of 50% remained undetected on the basis of PFA standards prescribed for pure ghee. However, on considering the Polenske Value (AGMARK) the maximum level of MX1 adulteration which remained undetected was 20%. Other tests, which are to be validated, are under study.

Effect of Processing Treatments on Polyphenol Content of Pearl Millet

Pearl millet also popularly known as Bajra in India is an important food crop of semi arid areas of the world and is termed as 'neutricereal' in view of its good nutritional specialties such as complex carbohydrates, high proportion of dietary fibers and of other phyto-chemicals with neutraceutical qualities. But, the pearl millet contains polyphenols as anti-nutrients, which affects the mineral bioavailability and protein and carbohydrate digestibility of food grains. They are also responsible for grey pigmentation in millet grains and undesirable grey discolouration in millet flour. Therefore, a study was conducted to determine the effect of soaking, pressure cooking, steaming and germination on polyphenol content of pearl millet (variety Pro Agro's 9444). The unprocessed pearl millet (control) had 252.76mg/100g polyphenol content, which was reduced to 126.21 mg, 131.67 mg, 109.58 mg and 169.50 mg per 100g as a result of 12 hour soaking, 5 minutes pressure cooking, 15 minutes steaming and 52 hours of germination, respectively. The maximum reduction was seen as a result of 15 minutes steaming. Thus, study showed that optimized combination of the above treatments can be useful in the preparation of pearl millet based foods for vulnerable age group using these processing treatments so that the mineral bioavailability remains high and product appears appealing to the consumers.

Effect of Addition of Antioxidants (BHA and TBHQ) on the Stability of Poly-Unsaturated Fatty Acids and Prevention of Cholesterol-Oxidation-Products Formation in Ghee during Storage and Heating

Ghee during storage and heating at high temperatures undergoes oxidative deterioration and thermal decomposition, resulting into loss of valuable nutrients such as fat soluble vitamins and essential fatty acids. To overcome this problem, the addition of antioxidants is generally practiced. The polyunsaturated fatty acids (PUFAs) are of great dietary significance. Cholesterol-Oxidation-Products (COPs) are formed when cholesterol containing foods are processed and stored. The presence of COPs in foods is a health and safety concern because of their toxic effects. This study was carried out to know as to how much protection is provided by the antioxidants (BHA and TBHQ) against the losses of PUFAs and also against formation of harmful COPs in ghee during storage and heating.

In fresh ghee total PUFA content was found to be 2.5031% which reduced to 2.2255% after 6 months of storage. Total PUFA contents in ghee samples containing BHA @ 5, 10, 20mg/100g of ghee were 2.2776, 2.3803 and 2.4324%, respectively after 6 months of storage. The corresponding values in ghee samples containing TBHQ at similar levels were 2.2985, 2.3954 and 2.4457%, respectively. PUFA content was adversely affected by heating of ghee at 200°C as it decreased from an initial level of 2.5964 to 2.0962 after 40 min. Addition of antioxidants offered some protection to ghee in preventing the loss of PUFAs. TBHQ was found to be slightly more effective than BHA.

Fresh ghee contains cholesterol 5α, 6α-epoxide at the level of 1.11ppm. 25- hydroxy cholesterol was not detectable in fresh as well as stored ghee. After six months, the level of cholesterol 5α, 6α-epoxide was increased to 3.21 ppm. During heating at 200°C, there was appreciable formation of cholesterol 5α, 6α-epoxide in ghee. 25 –hydroxy cholesterol remained undetected up to a heating period of 15 min. Addition of antioxidants restricted the formation of COPs. Complete destruction of BHA and TBHQ at 5, 10 and 20 mg/100 g levels at 200°C occurred after 10, 20 and 40 min; and 5, 10 and 20 min, respectively.

The study concluded that antioxidants offered protection to loss of PUFAs and in preventing the formation of COPs in ghee during storage at 37°C. Whereas, at 200°C, these antioxidants were less

effective for the purpose as the antioxidants were themselves destroyed quickly during heating at such a high temperature.

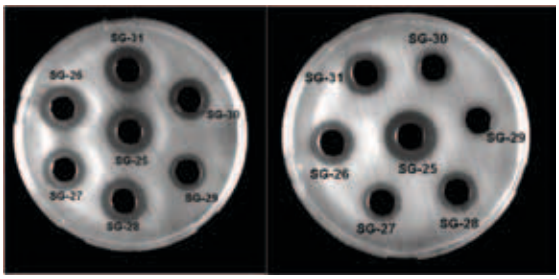
Detection of Skim Milk Powder in Fresh Milk in Presence of Preservatives

Fresh milk supply is often supplemented with recombined milk prepared by using water, butter oil, skim milk powder. A study was therefore carried out to determine the minimum level of skim milk powder in fresh milk and determining the concentration of lactulose, free thiol and HMF in presence of preservatives. Different concentration of skim milk powder (0.5, 1, 3, 5, 7 and 10%) was added to raw milk and was analyzed for lactulose, free thiol and HMF. Raw milk showed HMF value as 2.68 ± 0.09µM whereas milk containing 5% SMP showed HMF content as 7.03 ± 0.04 µM clearly indicating a significant difference in HMF value when compared with raw milk containing no SMP. Raw milk containing preservatives formalin (0.04%) and 100 ppm of hydrogen peroxide showed high value of HMF i.e. 34.98 ± 0.6 µM and 25.26 ± 0.14 µM. Likewise free thiol content in raw milk without SMP showed a value of 20.05 ± 0.16 µM whereas addition of 5% SMP to raw milk showed a decrease in the value of free thiol content as 16.92 ± 0.04 µM. increase level of free thiol content i.e. 26.15 ± 0.16 µM and 23.98 ± 0.58 µM were observed in raw milk when preserved with formalin and H2O2.

Dairy Microbiology

RESEARCH ON NUTRACEUTICALS FROM MILK, FUNCTIONAL FOODS WITH PREBIOTICS, MICRONUTRIENTS AND OTHER BIOACTIVE COMPOUNDS FOR IMPROVED HUMAN HEALTH

Development of traditional fermented dairy products enriched with an indigenous probiotic strain for promoting the health and well being of consumers: The identity of the indigenous putative probiotic lactobacillus isolates selected for this study were previously identified based on PCR using genus and species specific primers, partial 16S rRNA sequencing and RAPD patterns. Multilocus sequence typing MLST was also explored for confirming the exact identity of the selected indigenous probiotic isolates. Primers were designed for 16S rRNA (1.4kb amplicon) alongwith two of the house keeping genes i.e. *phes* (519 bp) and *rpo*A (863 bp). On the basis of sequencing of PCR products of *phe*, the lactobacilli were redesignated : Lp9 as *L. plantarum*; S7 - *L. pentosus*; Lp91 - *L. plantarum*; Lp75-*L. plantarum* and Lp100 - *L. plantarum* which were previously identified as *L. paraplantarum, L. pentosus, L. fermentum, L. fermentum* and *L. plantarum*. The five probiotic lactobacillus strains were also studied for relative expression of 'TNF-α'. Out of the five probiotic strains used in this study, two strains viz. Lp9 and Lp91 were able to bring about a significant (P<0.001) level of down regulation of 'TNF-α' expression by -1.34 and -1.45, respectively relative to the control. A total of forty *Lactobacillus* strains were also tested for their antagonistic effects against pathogens using *Salmonella enterica* var. Typhi, *Shigella dysenteriae*, *S. aureus* and *B. cereus* as indicator organisms. The antibacterial activity of some of the probiotic *Lactobacillus* isolates SG-25 to SG-31 against *Salmonella enterica* serovar. Typhi and *Shigella dysenteriae* has been shown in the following figures.



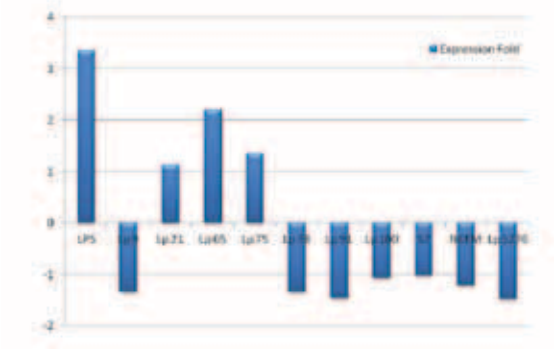
Salmonella enterica serovar. Typhi *Shigella dysenteriae*

Formulation of whey based cost effective media for biomass production and preservation of lactobacilli : Whey was supplemented with desirable nutrients after comparing the composition of whey and MRS broth. Yeast extract @ 0.25% (WBM-YE) or 0.50% casein hydrolysate (WBM-CnH) or 0.1% casein hydrolysate and 0.1% yeast extract (WBM-COMB) supplementations in whey basal medium yielded maximum growth of *Lactobacillus casei* NCDC 298, which was comparable to the growth in MRS broth. Growth performance of 10 different species of *Lactobacillus* in the above three types of whey based media were comparable to MRS broth. *L. casei* NCDC 298 was cultured in all the three whey based media at fermenter scale (2.0 lit culture volume) by external neutralization (pH 5, 6, 7) and without

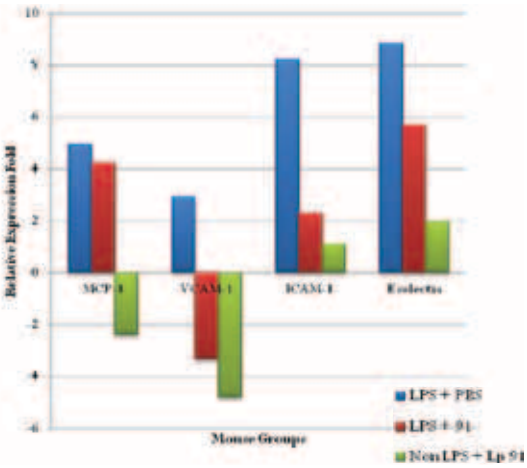
controlling pH. At pH 6.0, growth rates were higher (μ ~ 0.45) and comparable for all the whey based media and MRS broth. The viable counts reached ~9.5 log cfu/mL after 12 h (stationary phase) at 37°C in all the media from an initial inoculum of ~7.0 log cfu/ mL. The cell biomass was concentrated by centrifugation (10,000 rpm for 10 min at 4°C) and the cell recovery was >95%. The cell biomass was preserved as frozen concentrate as well as freeze dried powder forms and the viable counts remained unchanged for 60 and 75 days, respectively. The *Lactobacillus* counts did not decline in kulfi during storage upto 30 days.

Anti-inflammatory potential of putative probiotic lactobacilli in LPS stimulated cell line and mouse model : A total of eight indigenous putative probiotic lactobacilli and two reference strains were included in the study for evaluating their anti-inflammatory and anti-atherogenic potentials by RT-qPCR. Lp9, Lp78, Lp91 and NCFM were able to bring about a significant (P<0.001) level of down regulation of 'TNF-α' expression by -1.34, -1.45 and -1.21 fold, respectively. All the cultures showed significant level of (P<0.001) IL-6 up regulation in THP-1 cells. Lp91 was selected for studying the relative expression of various pro-inflammatory cytokines, chemokines and adhesion molecules in an in vivo LPS mouse model based on its ability to down regulate 'TNF-α' in THP-1 cells. In LPS stimulated (2 h) mice group fed with Lp91 for 10 days, there was decrease in relative expression of TNF-α' from 4.607 in LPS mice group to 3.102 fold. Similarly, under the same conditions, IL-6 expression decreased from 32.33 to 10.023 fold. However, with regard to chemokine 'MCP-1', there was only 14.66% inhibition of expression in mice group fed with Lp91 followed by LPS challenge. LPS stimulation was able to induce the 'VCAM -1' and 'ICAM-1' expression significantly (p<0.037) in mice at the level of 2.939 and 8.224 folds, respectively with respect to control group. However, treatment with Lp91 alongwith LPS resulted into a significant down regulation of 'VCAM-1' to the extent of -3.135 whereas 'ICAM-1' expression declined to 2.279 fold.

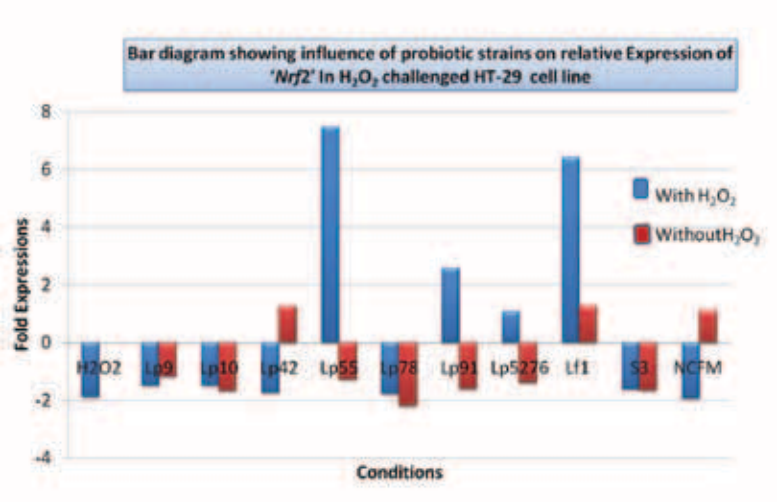
Bar diagram showing Expression of TNF-α by 10 *Lactobacillus* cultures



Bar diagram showing expression of MCP-1, VCAM-1, ICAM-1 and Eselectin LPS induced mouse model



Ameliorative effects of antioxidative probiotic lactobacilli in colitis mouse model: A total of eight indigenous putative probiotic lactobacilli having strong antioxidative potentials alongwith two reference strains were evaluated for '*Nrf*2' (the master regulator of phase-II anti-oxidative enzyme system) expression in HT-29 cells under H_2O_2 stress by RT-qPCR as well as for lipid peroxidation inhibition. Three of the strains viz. Lp55, Lp91 and Lf1 induced a significant (p<0.001) up-regulation in the expression of '*Nrf*2' in HT-29 cells at the level of 7.48, 2.58 and 6.43 folds. Probiotic *Lactobacillus* strains S3, Lp55, Lf1 Lp78 and Lp91 led to a significant reduction in MDA levels (1.44 ± 0.18, 1.88 ± 0.26, 2.81 ± 0.08, 3.27 ± 0.43 and 3.83 ± 0.88 μM, respectively) in HT-29 cells. Lf1 was selected for studying the relative expression of '*Nrf*2', lipid peroxidation inhibition and expression of antioxidatant enzyme genes in DSS colitis mouse model. Colitis mouse group was fed with Lf1 for 7 days followed by DSS challenge alongwith the probiotic strain during the last five days. The DAI and histological scores of colitis Lf1 treated mice improved significantly compared to those in colitis mice. The colitis Lf1 treated group had decreased MDA levels as compared to colitis control (37.92 ± 6.31 vs 91.13 ± 5.76 μM/g). There was no significant up regulation of '*Nrf*2' expression in either colitis or non colitis groups. The expression of 'SOD2' decreased from – 100.00 fold in colitis group to -37.037 fold in colitis Lf1 treatment group. Almost, a similar trend was observed in case of 'thioredoxin' expression.



Production of antimicrobial bioactive peptides from milk proteins by proteolytic Lactobacillus spp.: The antimicrobial activity of whey and casein derived peptides was tested against six antibiotic resistant pathogenic cultures. MIC of different antibiotics was higher for *Pseudomonas* i.e. 240-256 µg, whereas MIC for *Listeria monocytogenes* was in the range of 0.5-10 µg for all the antibiotics. A total of 13 lactobacilli viz. C2, C6, C14, C17 C34, C36, NCDC 13, 14, 16, 19, 63, 214, 298 were selected for the fermentation of whey and sodium caseinate for antimicrobial peptide production. Sodium caseinate fermentates of all the cheese isolates of *Lactobacillus* spp. were found to be more inhibitory to *L. monocytogenes*, *S. typhi, S. aureus, E. coli* and *E. faecalis* and least to *B. cereus* and *Pseudomonas* spp. Whey fermentate peptide fractions of cheese isolates of lactobacilli were more inhibitory to *L. monocytogenes*, *E. coli*, *S. typhi*, *S. aureus*, *E. faecalis* and *Pseudomonas* spp. 10kDa permeate fractions of sodium caseinate of all the standard Lactobacillus cultures inhibited *S. typhi*, *L. monocytogenes* and *E. coli*. *S. aureus* was inhibited by Lb13, Lb19 fermented sodium caseinate 10 kDa permeate fractions. *L. monocytogens*, *E. coli*, and *S. typhi* were inhibited by 10 kDa permeate of standard *Lactobacillus* whey fermentate. *Pseudomonas* was not inhibited and Lb19, Lb63, Lb13 and Lb15 inhibited *S. aureus*. C2, C14 and NCDC Lb13 produced heat stable and storage stable broad spectrum antimicrobial peptide fraction from whey. C2, C6 and C14, NCDC16 and 63 produced stable and broad spectrum antimicrobial peptide fraction in sodium caseinate. All the *Lactobacillus* cultures were able to produce antimicrobial peptides against antibiotic resistant pathogens from whey and sodium caseinate. Peptide fractions of 5 kDa permeate had more antimicrobial activity against antibiotic resistant pathogens. MIC of the 5 kDa whey protein derived peptides of *L. rhamnosus* C2 and C6 were in the range of 24-36 µg/mL and 80 µg/mL against antibiotic resistant *Pseudomonas* and *S. aureus*.

Cumulative effect of herbs and Leuconostoc spp. on enzymes (α-amylase and α-glucosidase) linked to diabetes: The study included isolation of EPS producing *Leuconostoc* spp. both from dairy and non-dairy sources as well as evaluation of their enzyme (α-glucosidase and α-amylase) inhibitory potential in combination with herbs (Jamun and Tulsi). The isolates and the reference strains were first screened for α-glucosidase production and only seven isolates including reference cultures were non-α-glucosidase producers which were used for further studies. Isolates were identified as *Leuconostoc* using genus specific primers. Isolate CRB3 giving best results was identified as *L. mesenteroides* ssp. *dextranicum*. Isolates and reference cultures were further tested for α-amylase and α-glucosidase inhibitory activity. Isolate CRB3 (34.14 and 54.46%, respectively) and reference strain NCDC31 (37.95 and 59.31%, respectively) showed maximum level of inhibition. Cultures were then also tested in combination with herbs (Jamun and Tulsi) for α-amylase and α-glucosidase inhibition, wherein isolate CRB3 (44.13 and 90.85%, respectively) and NCDC31 (48.73 and 91.31%, respectively) showed improved inhibition. The results indicated that Leuconostoc CRB3 and NCDC31 in combination with herbs could be effectively used as digestive enzyme inhibitors.

Probiotic potential of *Lactobacillus rhamnosus* RSI3 isolated from traditional cereal-based fermented dairy product: Probiotic potential of a *Lactobacillus rhamnosus* RSI3, a strain isolated from a traditional cereal-based fermented milk product

(Raabadi), alongwith a reference strain *Lactobacillus rhamnosus* GG (LGG) was established by using *In vitro* tests which included acid tolerance, bile tolerance, bile salt deconjugation, cell surface hydrophobicity, antimicrobial activity, beta galactosidase activity and sensitivity to antibiotics. The *in vivo* evaluation consisted of the study of effect of strains on the high fructose diet (HFD) induced diabetes in rats and its complications. Both the strains invariably showed appreciable tolerance during *in vitro* evaluation and RSI3 was observed to perform better. During *in vivo* evaluation, after 10 weeks, the haemoglobin content of normal control, diabetic control group, LGG fed group and RSI3 probiotic fed groups were 14.11 ± 0.52%, 5.94 ± 0.25%, 14.53 ± 0.39% and 14.45 ± 0.20%, respectively. Similarly, levels of antioxidative enzymes in liver and RBC such as Catalase, Super Oxide dismutase and Glutathione peroxidase significantly increased in probiotic fed groups of rats. The level of Glutathione peroxidase in probiotic fed groups after 10 weeks significantly increased in liver i.e. 39.32 ± 2.32, 13.50 ± 15.11, 43.38 ± 3.28, 38.65 ± 14.38 (U/mg). However, there was a slight improvement in lipid profiles, including the reduction of serum/plasma total cholesterol, low density lipoprotein (LDL)-cholesterol, very low density lipoprotein (VLDL)-cholesterol and triglycerides. The RSI3 was further used for development of a functional fermented milk product along with *S. thermophilus* ST20 as a co culture with acceptable sensory and shelf life of three weeks at refrigeration temperature.

Development of defined starter for preparation of a cereal based functional fermented milk product: The present study was carried out to develop defined starter for preparation of cereal-based fermented milk product by bioprospecting phytase producing indigenous strains of lactic acid bacteria from samples of Indian traditional product Raabadi and to develop a cereal based functional fermented milk product using these as starter culture alongwith prolific Vitamin B12 production prpropionibacteria as an adjunct culture. As many as 25 domestic raabadi samples were collected from different villages of Rajasthan and Haryana and a total of 135 isolates were recovered. Nine potent phytate degrading lactobacilli were identified as *L. rhamnosus*, five as *L. fermentum* and rest three as *L. brevis* by phenotypic as well as genotypic techniques. The isolate RSI3 (*L. rhamnosus*) showed maximum phytase activity (0.011187 enzyme unit min-1 mL-1). RSI3 also exhibited appreciable antimicrobial activity against *E. coli* ATCC 25922 and *S. aureus* NCDC 110 as well as towards *Aspergillus flavus* NCDC 226, *Rhizopus oryzae* NCDC 52 and yeasts Candida butyri NCDC 280. Since RSI3 didn't happen to be a good acid producer, it was paired with a prolific acid producing compatible *S. thermophilus* ST20, a native strain isolated from dahi as a part of another study in the laboratory. With these strains as starter cultures, a method for cereal based fermented milk product was standardized using skim milk and ungerminated pearl millet (Pennisetum glaucum) flour as raw material and cumin (Cuminum cyminum), black pepper (Piper nigrum), curry patta (Murraya koenigii) and salt as flavouring agents to improve the sensory quality of the product. The product was acceptable upto 21 days (at refrigeration temperature) and coliform and yeast and molds were absent in 0.1 g of the sample. Inclusion of Propionibacteria significantly increased vitamin B_{12} content upto 25.39%. The developed pearl millet based fermented skim milk product with a detailed compositional information is a wholesome product with functional attributes and an extended shelf life.

Characterization of 'gal' operon in galactose fermenting strains of *Streptococcus thermophilus*: *S. thermophilus* is considered as the second most important industrial dairy starter extensively used as a starter culture for the production of yoghurt and certain cheeses. The present study was aimed at exploring the galactose positive S. *thermophilus* available in our laboratory. A total of six streptococcal isolates were collected of which 4 isolates (AJM, JM1 AUKD8 and KM3) were identified as *S.thermophilus* by species specific PCR and sequencing of 16S rRNA gene. AJM utilized 0.58% of galactose in J8 broth containing 1% galactose followed by KM3 (0.53%), JM1 (0.37%) and 0.07% (AUKD8). In milk fermentation, AJM released less galactose (0.27%) followed by KM3 (0.3%) and JM1 (0.45%).AJM isolate released less galactose upto 0.49% when fermented with *L.bulgaricus* (NCDC 04) followed by KM3(0.51%) and 0.60%) than NCDC 218 (0.79%) after 10 hrs of fermentation. The stability of gal+ isolates was more in broth than milk. The gal-lac gene order (galRKTEM-lacSZ) is conserved and individual size of the gene are highly similar. But the galRK intergenic region of the gal+ isolates (AJM, JM1& KM3) possessed single base pair deletion at -35 region of galR promoter and C to T substitution at -10 box of galK region. In constrast, AUKD8 has A to T substitution at preceding -10 box. The expression of galK and galM grown in galactose containing medium showed higher expression in case of AJM - 30 and 7.6 fold respectively, followed by KM3 and JM1. In addition, galR, galT and galE showed high expression in galactose medium than lactose and glucose medium. Yoghurt prepared

with gal+ isolate AJM contained less galactose 0.37% followed by KM3 (0.51%) and JM1(0.65%) as compared to gal- NCDC 218 (0.98%) after 4h of fermentation. In addition, Mozzarella cheese prepared with gal+ AJM +gal+ *L.helveticus* (NCDC 292) expelled less galactose(0.15%) followed by KM3 + NCDC 292 (0.3%) and JM1+NCdc 292 (0.33%) as compared to gal+ *S.thermophilus* and gal- *L.bulgaricus* and NCDC 218 + NCDC04. Furthermore, browning in AJM+NCDC292 showed high L* value (76.09 ± 0.37) than control NCDC 218+NCDC04 (66.68 ± 0.4). In conclusion, this study showed that gal+ isolates needs to sequenced completely to know difference between isolates and needs to be explored for EPS production as gal+ can provide precursors for EPS production.

Development of synbiotic tulsi dahi for cholesterol reduction: Three lactic cultures i.e. *Streptococcus salivarius* ssp. *thermophilus* ST-1, *Lactobacillus plantarum* LT-7 and *Lactobacillus delbrueckii* ssp. *bulgaricus* LB-2 were evaluated for their bile salt hydrolase, cholesterol reduction, cell surface hydrophobicity and cell aggregation properties to be used for manufacture of synbiotic tulsi dahi. All cultures exhibited intense precipitation of sodium taurocholate hydrate and sodium taurodeoxycholic acid indicating their bile salt deconjugation ability. The cholesterol reduction in MRS broth was found to the tune of 15.90, 28.07, 43.80% by S. salivarius ssp. *thermophilus* ST-1, *L. plantarum* LT-7 and *L. delbrueckii* ssp. *bulgaricus* LB-2, respectively. Cell surface hydrophobicity of 18 hr fresh cultures viz., *S. thermophilus* ST-1, *L. plantarum* LT-7 and *L. delbrueckii* ssp. *bulgaricus* LB-2 showed 21.1, 32.6 and 28.16% using xylene as the hydrophobic solvent. These cultures also exhibited 7.5, 34.89 and 18.24 % cell aggregation.

Development of synbiotic herbal yoghurt for enhanced food safety and oxidative-stress management: Probiotic cultures of *Lactobacillus delbrueckii* ssp. *bulgaricus* LB-2 and *S. salivarius* ssp. *thermophilus* ST-1 and essential oils of tulsi (Ocimum sanctum) and pudina (Mentha piperita) exhibited inhibitory activity towards indicator strains (*Salmonella typhi* NCDC113, *Bacillus cereus* ATCC13061, *Staphylococcus aureus* NCDC110, *Escherichia coli* ATCC25922, *Listeria monocytogenes* ATCC15303, *Candida pseudotropicalis* NCDC44 and *Geotrichum candidum* NCDC228). *L. delbrueckii* ssp. *bulgaricus* LB-2 exhibited higher antimicrobial activity as compared to *S. salivarius* ssp. *thermophilus* ST-1. Based on lowest minimal inhibitory and microbicidal concentrations, *O. sanctum* was selected for detailed investigations. Inulin @ 3% was found to be optimum as it enhanced specific growth rate (μ) and reduced doubling time (Td) of probiotic cultures as compared to maltodextrin and did not adversely affect sensory, rheological and probiotics quality of synbiotic herbal yoghurt. Culture level @1% and essential oil @ 0.5μL/mL at incubation temp of 42°C/6h resulted into statistically significant ($P<0.01$) better product in terms of quality parameters. The developed product has a shelf life of >15 days at refrigerated storage as per World Health Organization guidelines, wherein probiotic viable counts were 10^8-10^9 cfu/mL. Synbiotic herbal yoghurt exhibited improved antimicrobial activity towards indicator organisms. The phenolic and antioxidative content of optimized product was estimated to be 7 mg GAE/100mL and 763.8 μM/L trolox equivalent, respectively. The *in vitro* observations revealed potential of developed synbiotic herbal yoghurt for enhanced food safety and oxidative stress management.

VALUE ADDITION TO TRADITIONAL MILK PRODUCTS THROUGH APPLICATION OF NEW PROCESSES, BIOTECHNOLOGICAL INTERVENTIONS, PACKAGING AND MECHANIZED MANUFACTURING SYSTEM.

Micro-encapsulation of Bacteriocins for their Controlled Release: The present study was aimed at isolation and characterization of bacteriocinogenic LAB from fermented dairy and cereal products active against Gram positive as well as Gram negative bacteria. A total number of 1200 isolates of LAB were isolated and screened for their antibacterial activity out of which 55 isolates were selected. Amongst these 55 isolates, 8 isolates showed good antimicrobial activity against some of the Gram-positive food organisms viz., *Pediococcus acidilactici* LB-42, *Bacillus subtilis*, *Listeria monocytogenes* (ATCC 53135), *Listeria monocytogenes* (MTCC 657), *Enterococcus faecalis* (NCDC 122), *Enterococcus feacium* (DSM 20477) , *Lactobacillus plantarum* (NCDC 021), *Enterococcus fecalis* (ATCC 29212), as well as Gram-negative organisms viz., *E.coli* 0157:H7 and S.typhi (NCDC 113) . The selected 8 isolates were characterized by genus specific PCR. Five isolates belonged to the genus *Lactobacillus* and three isolates belonged to the genus *Lactococcus*. The bacteriocin production by the selected LAB was optimized with respect to the culture media, initial pH of the culture medium, growth temperature and inoculum levels. Five isolates showed maximum bacteriocin production in MRS broth whereas other 3 isolates were found to produce maximum amount of bacteriocin in M17 broth at pH 7.0 after 24h incubation at 37°C. Further

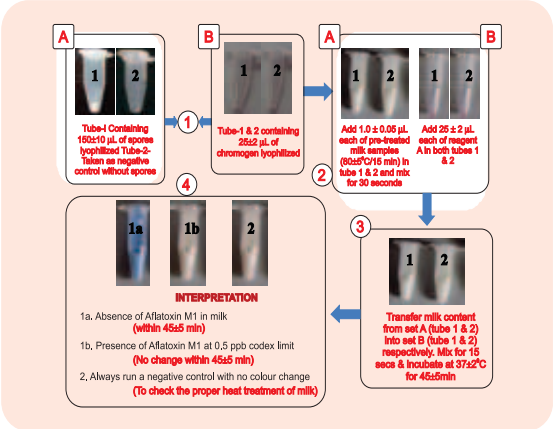
the bacteriocins were encapsulated in sodium alginate using the newly fabricated machine and the release kinetics for the bacteriocins was tested in broth against *Listeria monocytogenes*. Bacteriocins of these strains are quiet heat stable and active over a wide range of pH indicating that these can be exploited in the biopreservation and safety of acidic as well as non acidic foods.

Bacteriocin resistance among dairy pathogens and spoilage bacteria: The Gram-positive bacteria studied in this work differed considerably in their sensitivity to nisin, pediocin 34 and enterocin FH99. Bacteriocin resistant variants of *L. monocytogenes* ATCC 53135, *L. monocytogenes* MTCC 657, *E. faecium* DSMZ 20477, *E. faecium* (VRE) and *E. faecalis* ATCC 29212 were developed. Bacteriocin cross-resistance and the antibiotic susceptibility of wild type and their corresponding resistant variants were assessed and it was observed that the acquired resistance to a bacteriocin may extend to other bacteriocins within the same class or even in other classes and can also alter the antibiotic susceptibility/resistance profile of bacteria. Sensitivity of bacteriocin resistant variants to common food preservatives viz. sodium chloride, low pH, sodium nitrite and potassium sorbate was compared with the wild (sensitive-type) strains in order to determine whether resistance to bacteriocins confers cross-resistance to these common food preservatives. Nisin, pediocin 34 and enterocin FH99 resistant strains did not show intrinsic resistance to low pH, sodium chloride, potassium sorbate, or sodium nitrite. In an attempt to clarify the possible mechanisms underlying bacteriocin resistance in *Listeria* and *Enterococcus* strains, surface properties such as cell surface hydrophobicity were analyzed and compared between the wild types and the bacteriocin resistant variants. The addition of divalent cations significantly reduced the inhibitory activity of nisin, pediocin 34 and enterocin FH99 against resistant variants of *L. monocytogenes* ATCC 53135 and MTCC 657, *E. faecium* DSMZ 20477, *E. faecium* (VRE) and *E. faecalis* ATCC 29212. The addition of EDTA, however, restored this activity. Ultra structural profiles of bacteriocin sensitive *L. monocytogenes* ATCC 53135, *E. faecium* (VRE) and E. faecalis ATCC 29212 and their bacteriocin resistant counterparts revealed that the cells of wild type strains were in pairs or in short chains, whereas, nisin, pediocin 34, and enterocin FH99 resistant variants tend to form aggregates. When the cell wall was removed, the wild type strains of *L. monocytogenes* ATCC 53135, *L. monocytogenes* MTCC 657, *E. faecium* DSMZ 20477, *E. faecium* (VRE) and *E. faecalis* ATCC 29212 and their resistant variants to nisin, pediocin 34 and enterocin FH99 showed identical sensitivity to the three bacteriocins. However, the protoplasts of the resistant variants appeared to be more resistant to bacteriocins than the protoplasts of their wild type counterpart. An increase in amino group containing phospholipids in the nisin resistant variants of *L. monocytogenes* ATCC 53135 and *L. monocytogenes* MTCC 657; pediocin 34 and enterocin FH99 resistant variant of *E. faecium* DSMZ 20477 and *E. faecium* VRE was observed. It was observed that mannose, glucose, fructose and cellobiose had an effect on sensitivity of *L. monocytogenes*, *E. faecium* and *E. faecalis* strains to nisin, pediocin 34 and enterocin FH99. It underlined that the level of sensitivity was tightly linked to sugar availability, suggesting that sugars (mannose, glucose, fructose and cellobiose) directly causes expression of a molecule responsible for sensitivity to nisin, pediocin 34 and enterocin FH99. From the Real Time PCR studies, it was observed that σ 54 was involved in conferring resistance to nisin, pediocin 34 and enterocin FH99. In case of *L. monocytogenes* ATCC and *E. faecium* VRE, IIC and IID genes were down-regulated. In *L. monocytogenes* ATCC 53135 and *E. faecium* VRE. Gene glpQ, which encodes a putative glycerophosphoryl diester phosphoesterase, was also down regulated.

CLEAN MILK PRODUCTION WITH A FOCUS ON EMERGING HEALTH CONCERNS AND DEVELOPMENT OF NEW GENERATION TOOLS FOR ENSURING QUALITY CONTROL THROUGH APPLICATION OF NEWER CHEMICAL, BIOTECHNOLOGICAL/ NANOTECHNOLOGICAL INTERVENTIONS

Development of Biosensors and micro-techniques for analysis of pesticide residues, Aflatoxin, heavy metals and bacterial contamination in milk : Spore based bioassay for monitoring Aflatoxin M1 in milk was developed based on the principle that specific indicator enzyme (s) are produced by active bio-sensing molecules which act specifically on chromogenic/or fluorogenic substrate resulting in coloured reaction/or fluorescence as end product which is measured semi-quantitatively by either visually/or using optical system at specific excitation/ emission spectra. The bioassay was validated with AOAC approved Charm 6602 and ELISA test with real samples under field condition and could find industrial application for monitoring Aflatoxin M1 at 0.5 ppb in milk as set by Codex. The detailed test procedure and interpretation protocol was finalized (Fig) which takes only 45 min. The test can be applied at Dairy

farm, reception dock, manufacturing unit and R & D centre and can detect Aflatoxin M1 in raw, heat treated and dried milk products.



Spore based assay for monitoring aflatoxin M1 in milk using Chromogenic substrate

Development of spore based assay on gold chip: Bioassay for detection of Aflatoxin M1 in real time of 15-20 min was achieved on gold chip immobilized with 1.0 µl spore with exposer of 25 µL milk and 0.5 µLfluorogen.

Development of Spore Germination Based Technology for Detection of Bacterial Contamination in Milk (Enterococci/ Listeria/ Coliform /*E .coli* O157:H7/ *Campylobacter*)

Development of micro-technique for detection of Enterococci in milk : A test which involves enzymatic reaction of *enterococci* in newly developed selective medium was developed. The process efficacy was checked with conventional method (ISO 7899-2:1984) and could be used for detection of *enterococci* in different types of milk system within 5-12 hrs as per standards recommended by the BIS. The cost effective process could also find applications for assessing the hygiene status of equipments/utensils, air, water, personnel and plant environment. The kit is cost effective (Rs.0.90 per test) and possesses better sensitivity and consistency in colour development within 5-12 hrs. The kit was validated with conventional method (ISO 7899-2:1984) and was applicable with wide spectrum of applications for raw, pasteurized and dried milk.

Development of Esculin Based Sodium Azide Medium (EBSAM) for the selective isolation and differentiation of Enterococci in milk: A selective medium for isolation and differentiation of Enterococci was developed. The medium was devised by addition of selective agents, buffering agents and nutrient sources and was tested for its selectivity using different β-D glucosidase positive contaminants. The selective medium could find applications in dairy industry and R and D institutions for being cost effective.

Spore germination: An innovative approach for detecting enterococci in milk: Eight *Bacillus megaterium* strains procured from ATCC and MTCC were screened for acetyl esterase activity. MTCC-3 was found to produce acetyl esterase significantly and selected for spore production. MTCC-3 strain showed maximum spore production up to 82 ± 7% in sporulation medium. Heating of spores for 10 min. at temperatures varying from 60 to 80°C reduced the baseline fluorescence. Spores heated at 60°C prior to incubation with dextrose had little effect on germination (3.1 fold) while enhanced stimulation was observed at 70 and 80°C i.e. 6.7 and 12.1 fold. The heat treated spores at 6.57 log counts in buffer when mixed with dextrose (heated to 100°C/15 min) at concentration varying from 2mM–100 mM showed germination rate varying from 10.68 to 15.85 fold. Maximal germination of spore's quantified based on increase in fluorescence from 15.62 ± 1.15 (X103) to 25.52 ± 3.12 (X103) was achieved after 2 hr of incubation. The sensitivity of the bioassay was determined by immobilizing the spores on sensor disk by air drying in incubator at 37°C/3.30 hr. The lowest detection limit of Enterococci using spore based assay was 5.66 log counts in 2:30 min and the spore germination rate varied from 2.33-14.5 folds. The bioassay was also carried out by immobilizing spores (4.71 log counts) on Gold chip for its miniaturization based on Integrated Optical Density (IOD) which increased from 7.069 ± 1.30 to 14.493 ± 1.41 at specific spore area of 2.1 ± 0.5 µm2. The sensitivity of assay on gold chip was improved to 5.43 log counts and assay time reduced to 45 min. The optimized spore based assay on sensor disc was also carried out with milk spiked with Enterococci following protocol already developed. Bioassay offers better sensitivity i.e. 5.66 log count compared with 7.52 log counts as observed with EBSAM medium and reduction in time up to 2-3 h for detecting Enterococci in milk was observed.

Monitoring of Drug Residues and Environmental Pollutants

Optimization of time–temperature combination for inactivation of residual marker enzyme and activation of spores in suspension: The spore suspension was heated at temperature varying from 75-115°C with the time period varying

from 5-30 min. The residual enzyme activity was observed at temperature ≤75°C up to a period of ≤7 min. However, subsequent increase in temperature up to 100°C with a time period of 5 min resulted in complete inactivation of α-D-glucosidase activity, but without activation of spores as evident from germination time of 2 h 45 min. The temperature of heating was further increased to 115°C with time of 5-10 min. A significant reduction in spore germination time from 2 h 45 min to 2 h was achieved with average time temperature combination of 112.5 ± 2°C for 6 ± 0.5 min.

Screening and selection of germination medium, inducer and its optimization: Six different growth media for spore germination were evaluated. The spore germination time varied from 2-24 hrs. The new optimized medium containing peptone 5 ± 0.5 g/L, tryptone 3.5 ± 0.5 g/L, yeast extract 2.5 ± 0.5 g/L, beef extract 1.5 ± 0.25 g/L, dextrose 0.75 ± 0.25 g/L and starch 0.75 ± 0.25 g/L as an inducer showed promising results with spore germination within 2 hrs.

Detection of Antibiotic Residues and Aflatoxin MI in Milk

Survey on forty four (44) raw milk samples collected from Delhi and nearby Delhi village like Narela, Singhu, Khampur, Bhalswa, Tikri was carried out for antibiotic residues at codex MRL limit using microbial receptor assay Charm 6602 system and microbial inhibition based assay i.e. MDR test kit. The incidence of β-lactam group was 11.36% at ≥ 4.0 ppb in five samples of raw milk. Streptomycin was detected at ≥ 200 ppb in one sample (2.27%). One sample of raw milk was found positive for sulpha group ≥ 100 ppb as well as for β-lactam group. Gentamycin, tetracycline and erythromycin group could not be detected in any of the samples tested. The overall incidence of antibiotic residues was 13.63 %. Samples were also analyzed using MDR test kit developed at NDRI and results obtained followed the same pattern as observed with Charm 6602 assay tetracycline, gentamycin, penicillin and are used more frequently.

RAISING PRODUCTIVITY OF DAIRY ANIMALS THROUGH IMPROVED FEEDING STRATEGIES, EFFICIENT NUTRIENT UTILIZATION AND USE OF NON-CONVENTIONAL FEED RESOURCES

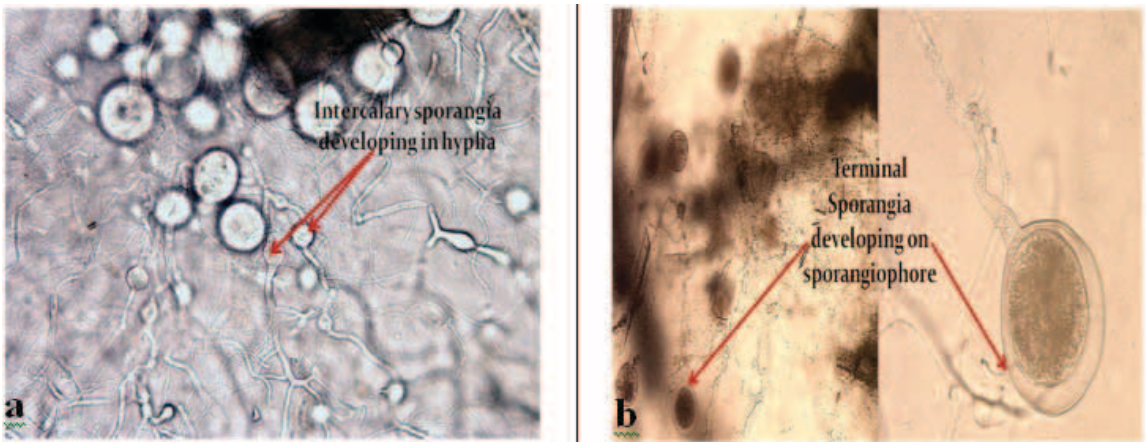
Network project on Veterinary Type Cultures – Dairy Microbes: A Scheme on Dairy Microbes under the programme of VTCC (NRCE, Hissar) in Network Mode was initiated during XI Plan by ICAR, New Delhi. Different strains of *Lactococcus* spp., and *Leuconostoc* spp. were isolated from different sources such as fermented milks, vegetables, fruits, etc. across India and mixed strains O and LD type cultures. Seventeen of *Lactococcus lactis* were identified by genus and species specific PCR and partial sequencing of 16 rRNA gene. EPS producing strains (*Leuconostoc mesenteroides* subsp. mesenteroides) were identified. The fast, medium and slow acidifier strains of *Lactococcus lactis* ssp. *lactis* and proteolytic strains of *Lactococcus lactis* were identified and could be used for preparation of various fermented milk products.

Diacetyl and EPS producing strains of *Leuconostoc* spp. were characterized and could be used as starter cultures for low fat fermented milks and production of EPS for use as natural bio-thickeners/ stabilizers in various foods.

Rumen Microbes: The rumen bacteria (*Megasphaera elsdenii*, *Eubacterium limosum*, *Streptococcus gallolyticus* and *Veillonella parvula*) and anaerobic fungi (*Orpinomyces joyonii, Orpinomyces intercalaris* and *Aanaeromyces elegans*) from goat and buffalo, respectively were isolated, characterized and identified. These anaerobic fungi were found to be the most efficient fibre degraders and thus, could be used as direct-fed microbial for enhanced ruminant productivity, whereas the isolated bacterial cultures have been vastly reported for their various roles as urea hydrolyzer, acetogens, tannin degrader, acid utilizer, respectively.

Conjugated linoleic acid (CLA) producing potential and genetic heterogeneity of rumen fungi): Rumen fungi isolated from cattle, buffalo and goat showed variations and inconsistencies in morphological features. Molecular characterization showed presence of *Anaeromyces*, *Orpinomyces*, *Neocallimastix*, *Piromyces* and *Caecomyces*. The restriction enzyme AluI digested D1/D2 domain of large subunit rDNA (LSU) products of all known genera of fungi into distinct fragments. This enzyme was also used as a RFLP marker for species level differentiation in *Orpinomyces* spp. Genus and species specific primers were successfully developed for filamentous group of these fungi. Enzyme assays showed that both monocentric and polycentric group of fungi produce nearly equal CMCase, avicelase, xylanase, β-glucosidase and acetyl esterase with few genus to genus or species to species variations, but p-coumaroyl and feruloyl esterase activities were better in monocentric group. Overall, *Neocallimastix* spp. and *O. joyonii*

showed higher enzyme activities than other isolates. Their biohydrogenation potential also varied among different isolates with no specific patterns. *O. joyonii* was best both in terms of CLA production and rate of biohydrogenation. The pH of 6.5 or 7.0 and temperature of 37°C and 39°C had no significant effect on CLA production, whereas, at pH 6.0 and temperature 41°C, CLA production decreased. Using different sources of LA, maximum CLA was produced, when safflower oil used as substrate, followed by sunflower and soybean oil at all the concentrations. However, with increasing concentrations, an increase in CLA was observed. Results indicated that only morphological features cannot be relied upon for the accurate identifications and LSU region can be used for species level identification and differentiation of anaerobic fungi.



(A) **(B)**

Different patterns (as indicated by arrows) of sporangia development (a) Terminal in O. joyonii (Magnification, ×200); (b) Intercalary in O. intercalaris (Magnification, ×400)

Dairy Engineering

Development of Scale up Design of Continuous Khoa Making Machine for Handling Concentrated Milk

Detailed study of the existing three stage SSHE was undertaken to identify various factors important for scale up design. The process design parameters included the degree of concentration required, the feed rate and product temperature, the scraper r.p.m. and steam pressure in each SSHE. Modeling equations were developed to relate different design variables. The scale-up design calculations were made for concentrated milk (30% TS at 4°C) with feed rate of 500-1000 kg/hr. Length to diameter ratio for scaleup model was kept constant (L/D=3.54, as for existing system). The maximum heat transfer area required for per stage was 1.67-3.35 m2. For 5 tonnes/day khoa production the design parameters for SSHE were scaleup ratio = 1.4, L = 1.865 m and D = 0.526 m. Estimated steam pressure required in the 1st, 2nd, and 3rd stage was 5, 4 and 3 kg/cm2, respectively at feed rate of 900 kg/h concentrated milk (30% T.S.).

Studies on In-line Production of Indian Dairy Products for Commercial Exploitation

Rabri is a concentrated, sweetened whole milk delicacy, containing several layers of clotted cream. Rabri production involves initially fast evaporation of milk to concentrate upto 35% TS, slow heating with intermittent scrapping and fanning or air contact at milk surface for skin formation, removal of clotted cream layer (CCL), concentrating milk to desired final concentration, addition of sugar and mixing of CCL to sweetened concentrated milk(SCM). Scraped surface heat exchanger (SSHE) with high heat transfer coefficient was selected for carrying out initial concentration of milk and conical process vat (CPV) with variable heating surface and opened to atmosphere was selected to carry out remaining unit operations. Processing parameters selected for optimization were initial concentration in SSHE (25-31% TS), final concentration in CPV before addition of sugar (35-45%) TS), CCL/SCM ratio (0.10-0.25) and steam pressure in CPV during removal of CCL (0.5-1.5 kg/cm^2). Operational parameters

Three stage scraped surface heat exchanger

were optimized by using Response Surface Methodology (RSM). Optimum parameters for Rabri production were predicted as 29.90% TS initial concentration, 39.41% TS final concentration before addition of sugar, CCL/SCM ratio 0.16 alongwith 0.75 kg/cm^2 steam pressure in CPV during removal of CCL. Rabri produced by using optimized operating parameters gave average sensory score viz. flavour, body and texture, colour and appearance and overall acceptability as 7.97, 7.93, 8.23 and 8.067, respectively, the average textural attributes score for firmness and stickiness value were 0.354N and -0.0528N, respectively, the average colour characteristic values for L*, a* and b* were found to be 75.907, 1.14 and 16.3197, respectively. The predicted score and observed score of all sensory attributes, textural attributes and colour characteristics were compared and statistically analysed by Student's t-test at 5% level of significance. Rheological characterization of Rabri was done in terms of flow behaviour

Integration of scraped surface heat exchanger with conical process vat for In-line production

index and consistency coefficient. The consistency coefficient and flow behaviour index of Rabri prepared by using optimized solution were found to be 0.030527 kgf.sec/m^2 and 0.7258, respectively, which indicated that Rabri being non-newtonian fluid follows shear thinning behaviour.

Development of Technology for Continuous Manufacture of Ghee using Three Stage SSHE

The mechanization of ghee making was done using three stage scraped surface heat exchanger, hooked-up with continuous butter melter. The butter drawn from cold storage at 5°C was melted with the help of continuous butter melter and fed at 90°C into the feeding tank of three stage SSHE. Feeeding rate of molten butter in the first stage SSHE was fixed at 240 kg/h and rotor speed of third stage was fixed at 20 rpm. Four levels of rotor speed (100, 125, 150, 175 rpm) were chosen for first and second stage SSHE. And steam pressure in the first, second and third stage was kept at 1, 2 and 3 kg/cm^2. The sensory evaluation and chemical properties indicated that best quality product was obtained at processing temperature of 118-121°C.

Dairy Economics, Statistics & Management

Performance Appraisal of Dairy Products Manufacturing Enterprises in India

Industrial de-licensing in 1991 has led to sharp increase (136%) in the number of dairy plants in the organised sector, yet the share of this sector in milk processing was only 38.4% in 2005-06. Within the organised sector, in terms of number of plants, there was a structural change towards Private Ltd. Companies, but in terms of milk handled, the cooperatives continue to dominate. Milk processing in India is dominated by the unorganised sector, although after 2000-01, there was a decline in number of unorganised dairy manufacturing units in the country. However, this trend is not universal across states, as unorganised manufacturing units declined in Maharashtra, MP and Bihar, while in most other states their numbers either stagnated or increased. Highest concentration of unorganised manufacturing units (more than 70% share in India) is in West Bengal and Uttar Pradesh. The own-account manufacturing enterprises, smallest sized units in unorganised sector predominate, but their number and share has been declining

over time. Also, there is decrease in rural-urban ratio of manufacturing units. Across states, during 1994/95-2005/06, decline in smaller-sized units and increase in larger-sized units in the unorganised sector occurred in several states, such as, Rajasthan, Maharashtra, MP, Assam, Andhra, Haryana, Punjab, Bihar and Karnataka.

The employment growth in the unorganised sector is high, but the real Gross Value Added per enterprise is slow. The workforce in unorganised milk processing is male dominated with only 25% share of females. Increasing employment intensity in unorganised sector coupled with low labour productivity, emphasises on the need for HRD development in the sector. The unorganised dairy products manufacturing units face a number of constraints related to input availability and marketing their products. Shortage of capital is the most important constraint faced by these units.

The organised milk processing sector had shown a lack-lustre performance in the past two decades, with growth in real value of output per factory slowing down drastically from compound annual rate of 8.66% during the 1980s to 1.53% during the 1990s and further to 1.06% in the ongoing decade. Post 1990s increase in net value added received a sharp setback during the global economic crisis. Similarly, the real profits that had picked-up after 1999-2000 registered a steep decline during global crisis. The growth in labour productivity was positive in the organised sector, but the capital productivity growth was not encouraging due to gross under-utilisation of installed capacity in the dairy plants. The Total Factor Productivity Growth in the organised segment increased at the compound annual rate of 7.18% during 1980/81-2008/09, yet the decadal trends showed a slowing down of TFP growth. The states with high TFP growth were, Andhra Pradesh, Gujarat, Karnataka and Madhya Pradesh; slow growth in TFP was estimated in Kerela, Maharashtra, Punjab, and Uttar Pradesh; while in Haryana, Tamil Nadu and West Bengal the TFP growth was negative. The mean Technical efficiency score worked out to be 0.86, implying that substantial possibility of increasing the output by improvement in efficiency levels existed in the dairy industry.

Based on the time series data of dairy plants in the organised sector and unit record data at different points of time of dairy processing units in unorganised sector, the study focused on several aspects of their performance that would provide the base for formulation of policy planning for development of dairy processing sector. The study also recommended initiation of vocational and short-duration training programmes for entrepreneurship development in dairy product manufacturing at small scale.

Analysis of Indo-Iran Trade Potential in Livestock Products

In 2008-09, India exported livestock products of over US$ 28 million to Iran and imported livestock goods worth approximately US$ 16 million from there. In tune with the changing business environment, Iran is also exploring new trading avenues in the world's fifth largest economy, i.e., India that has a buoyant livestock sector and largest livestock population in the world. Based on the premise that livestock being an important economic sector in both the countries, it can serve as a source of strengthening the economic cooperation between India and Iran, the study identified the potential tradable livestock products and inputs, using the export-import data from 1997 to 2010.

The potential exportable products from India to Iran are: meat of bovine animals, especially, frozen and boneless and also fresh and chilled boneless meat, skimmed milk powder, butter and fat based products, bird's egg in shell, carded or combed fine animal hair, combed wool in fragments & wool tops and vaccines for veterinary medicine. The importable items for India are: raw skins of sheep or lamb with or without wool on, tanned or crust hides and skins of bovine or equine animals, in wet or dry state, tanned or crust hides & skins of sheep & lambs without wool in wet or dry state, greasy wool and degreased wool not carded or combed.

Drawing broad inferences from the unit cost of imports, it was found that in comparison to the top three suppliers of frozen bovine meat to Iran, the unit cost of imports was lowest from India ($1.6/kg); hence, India can be more price competitive than other suppliers in the Iranian markets. In case of dairy products also, although India's share in Iranian markets was very marginal, yet the lower import price show that India can have good bargaining power in Iran for its dairy products.

On the export side, the unit value realisation of Iranian exports of raw skins of sheep or lambs was highest in Indian market ($3.61/kg). Even in case of tanned or crust hides and skins of bovine/equine animals, in terms of prices the Indian markets were more attractive for Iran than Turkey and Italy. The prices realised by Iran for exports of tanned or crust

sheep skin were also at par with other major buyers of the product from Iran.

The study concluded that although the present level of livestock trade between the India and Iran is low, there is good potential of enhancing bilateral trade between India and Iran for a number of livestock products. The major competitors of India in Iranian markets would be EU countries, Australia and New Zealand who are regular suppliers to Iran. India has been a supplier with fairly lower import costs to Iran and a buyer giving reasonably good value realisation for the Iranian exports; thus, substantiating the possibility of enhancing trade in livestock products between Iran and India. Initiatives like, increasing the exportable surplus, improving transportation infrastructure, and regional trade agreement with West Asian countries could be a few important options for India for strengthening its trade ties with Iran for the livestock sector.

Economics of Milk Production in Vidarbha Region of Maharashtra

The rain fed agro ecosystem occupies 68% of India's cultivated area and supports 40% of the human and 65% of the livestock population. Irregular crop failure due to uncertain rainfall is common phenomenon in this area. Under such circumstances, dairy production is an important component of livelihood and nutritional security in rain fed areas to improve the livelihood of farmers. The study was taken up in Vidarbha region of Maharashtra. Among the eleven districts in Vidarbha region, two districts were selected randomly. Out of those two districts, total 120 sample households were selected. The overall average herd size was 2.85 and operational land was 9.47 acres in which 88.2% of land was under rain fed area.

In general, Vidarbha region holds highest per cent of livestock population (28%) but contribution to the total milk production of the state (12%) was very low. On the basis of the study, it could be projected that in the study area, cotton and soyabean were the major domain of household level income followed by jowar and wheat whereas livestock played as a secondary sources of income. While comparing the percentage contribution of different sources of household level income, it was found that the income from cash crop (49.31%) was dominant in the study area followed by the income from cereal crops (7.41%). However, interestingly, it was observed that the percent contribution of (cereal) crop income was lower than the income generated from the livestock sector mainly from dairy sector (25.04%). This indicated that dairying was playing a major role to reduce the risk (0.82) and uncertainty as compared to crop income (1.26). The livestock sector particularly dairying helped to secure the rural livelihood in the study area. The major aim of farming system research is to ensure work and income security to family farmers operating small holdings. Therefore, major emphasis should be given to the dairy enterprises in order to reduce the risk in such regions.

Inclusive Growth through Livestock Sector

The study focused on understanding the approach adopted and pathways to achieve development objectives in the dairy sector and lessons learnt in order to integrate with other sub-sectoral activities of the agricultural production systems to improve the stability, reduce the volatility and enhance the rural livelihood through inclusive participation of disadvantageous sections. Since the bovine populations are more evenly distributed than the landholdings and dairy as well as other livestock sectors provide the means for more inclusive and equitable growth of the landless, marginal and small dairy households. The most compelling evidence towards this is the continued dominance of smallholders in all the states, even where there is steady economic growth like Gujarat. The outcome of the study shows that the income from off farm, dairy farm and livestock source has an equalising effect on the distribution of total income for all categories of farm households, which otherwise, corroborates the hypothesis of relative income equalising effect through dairying and livestock farming as compared to distribution of incomes through crop.

Sustenance of Rural Livelihoods through Dairy Value Chains

Transition of Indian dairy sector from deficiency to sufficiency was achieved by a series of policy interventions by the government dairy development had transformed from the earlier phase of slow growth rate of milk production and its utilisation in the form of value addition in milk products to a high growth rate of milk production and value-added milk products. Thus, their forward and backward linkages could be strengthening the dairy units in future, which could be possible only through the inclusive growth process. In this

process, production by the masses, processing by the masses and the consumers' diverse demand are also satisfied. Furthermore, dairy as an enterprise is the option available to landless and socially marginalised group as around 22% milk is processed into the small and tiny units; they have capability to manufacture the traditional dairy products in the rural and urban settings. However, problems with the small and tiny milk processing units are that they are unable to scale up the business to the large scale because market size is limited for them and they are using labour intensive technology. Therefore, there is a need to support the tiny, small and medium size dairy processing units under formal banking system and collective market based marketing programmes. The challenge (or opportunity) is to improve the earnings of farmers by enhancing the productivity of their milch animals; and by transforming the supply chain that links them to consumers so as to provide them with a larger share of the consumer's price. The challenge is also to raise aggregate farm income. The study pronounced that the unorganised food processing sector is transforming from labour to capital intensive structure. Hence, there is a tendency to employ more skilled labour to manage the growing capital. Most of the sub-sectors are facing decreasing returns to scale. In the unorganised food processing, there are two sub-sectors where substitutability of labour for capital exists, which implies that still there is scope for employment of skilled labour force. In order to boost up the food processing, two policy areas deserve attention, i.e., skills and the infrastructural development in addition to entrepreneurship.

Economics of Goat Rearing in Rajasthan

Goat alone accounts for around 8% of the total gross domestic product from the livestock sector through its contribution in terms of milk, meat, manure, fibre, skin, etc. The study was undertaken in Rajasthan with the broad objectives, viz., to estimate the cost of goat rearing at different age groups and production group and returns in goat milk and meat production, to assess utilisation and disposal pattern of goat milk, to work out goat marketing efficiency, to examine the factors influencing the sale price of goat and to identify constraints faced by the goat rearing households. The study revealed that labour influences the overall cost of production as it contributed 80% to the total maintenance cost. Overall daily milk production per flock was found to be 10.25 litres from which 4.17 litres were retained for home consumption. Milk utilisation pattern revealed that 40% goat milk was used as value addition in the form of tea (41.49%), liquid form (30.70%), ghee (22.06%) and curd (5.76%) and rest of the total milk (60%) was found to be supplied to cater to the demand locally. The study revealed that more than 70% goat animals were disposed off to the traders.

Economic Impact of Integrated Dairy Development Project on Rural Households in Meghalaya State

The study was conducted in Meghalaya state to investigate the economic impact of the Integrated Dairy Development Project (IDDP) on members and non-members with special focus on the economics of milk production, input-output relationship, resource use efficiency, production, consumption, marketed surplus and disposal pattern of milk, income and employment generation and viability of the project. All the four districts, viz., East Khasi Hills, Ri-Bhoi, Jaintia Hills and West Garo Hills where IDDP was launched were selected for the present study. The study found that net return per litre of milk production of member group was (₹2.71), much higher than that of non-member, which recorded only ₹1.81. The marginal value productivity indicated that green fodder and concentrate were over-utilised while labour was under-utilised in both household groups. The average marketed surplus of member group, i.e., 26.05 litres was much higher than that of non-member, which was only 20.93 litres. Of the total marketed surplus, member group disposed 85.09% to dairy co-operative society, 10.32% to local consumers and the rest 4.58% to tea shop while non-member group disposed 32.59% to private dairy, 36.01 to local consumers, 20.26 per cent to tea shop and the remaining 11.15% to dairy co-operative society, respectively. Annually, dairying provided an average employment of 171.22 man days for member, which was much higher than that of non-member (142.59 man days). On an average, member household spent 4.03 hours per day on dairy enterprise. On the other hand, non-member household spent 3.38 hours per day on dairying. Annually, dairying generated a net income of ₹18,515 per household for member group which was more than double of non-member group, which recorded only ₹9,071. The Gini-concentration ratios for member and non-member

group were 0.58 and 0.68, respectively; indicating that income was more uniformly distributed in member group as compared to non-member group.

Economics of Milk Production, Marketed Surplus and its Disposal Pattern in Nagaland

Traditionally, the Nagas rear animals only for meat and drought purpose. Most of the dairy animals are reared by the Nepalese. The animals are either reared on loose grazing or poor quality feeds and fodder where tree leaves and wild grasses constitute the green fodder while paddy straw was the main source of dry fodder. The study was undertaken in Kohima and Dimapur districts of Nagaland to work out the cost and returns from milk production, to study the marketed surplus of milk, its disposal pattern, to estimate the resource use efficiency in milk production and to identify the various constraints in milk production and its marketing.

The average net maintenance costs per day for crossbred and local milch cows were worked out to be ₹85.96 and ₹42.40, respectively. The average daily milk yield of milch crossbred and local cows was found to be 4.39 and 1.47 litres, respectively. The average per litre cost of milk production for crossbred and local milch cows worked out to be ₹19.58 and ₹29.08, respectively. The net returns was found to be positive for crossbred cows while it was negative for local cows across all the herd size categories of the selected sample households. The estimation of MVP from the fitted production function showed that the effect of concentrate feeding was positive and significant for crossbred cows while the effect of green fodder was positive and significant for both crossbred and local cows and concentrate for crossbred cows in the study area. The overall marketed surplus of milk was estimated to be 12.26 litres which was 85.83% of the total milk produced. The disposal pattern of milk showed that 59.18% of the marketed surplus of milk was disposed off directly to local consumers and the rest 40.82% to Milk Producers Cooperative Societies (MPCS). The analysis of constraints showed that low availability and high price of concentrate was the major production constraints faced by the dairy farmers followed by lack of availability of green fodder. Low price of liquid milk was found to be the major marketing constraint among the cooperative members while delay in payment by the local consumers was the major constraint faced by the non-cooperative members.

Dairy Extension

Analysis of Reproductive Disorders of Dairy Animals in Alwar District of Rajasthan

The overall knowledge of the farmers regarding reproductive disorders was 65.41 percent and majority (52%) of the farmers had medium knowledge regarding reproductive disorders in Alwar district of the Rajasthan. Anoestrus and repeat breeding were major reproductive problems in dairy animals. Breed-able herd size was positively and significantly correlated with incidence of reproductive disorders whereas knowledge was negatively and significantly related with incidence of reproductive disorders. Lack of knowledge regarding balanced feed and lack of government schemes for managing dairy herd were major constraints faced by farmers in reproductive disorder management. Use of scrub bulls for breeding and treatment of animals by village-quacks or untrained persons were major constraints faced by veterinary officers in reproductive disorder management.

Entrepreneurial Behaviour of Milk Processors in Karnal District of Haryana

Milk vendors were identified as most important source of milk supply to (46.34%) respondents of the milk processing units. About 58% of milk processors sell their milk and milk products in Karnal city or nearby cities, while few of the milk processors were selling their milk products in metro and nearby states also. The findings of the study highlighted certain manipulable variables and factors, which must be considered while conceiving plan for promoting entrepreneurship among milk processors. Penetration of modern retail formats (e.g., Super Market) leads to increased attention to quality by the growing middle class and may work against these markets, which are otherwise competitive and efficient. Since large retail chains tend to purchase only from modern, large scale processing plants, the competitive intensity will increase in the processing sector. The quality gap can be bridged to a large extent by introducing training and certification programmes for milk processors.

Study of Input Delivery System of Department of Animal Husbandry in Purnia District (Bihar)

The finding revealed that the Department had inadequate technical staff, less developed infrastructure at village level and almost no vehicles and stockman centres were in poor working condition in Purnia district of Bihar. Equipments of treatment and storage facilities were also found inadequate. Huge livestock population and vast coverage area per dispensary were noticed in general and less AI facility in particular. Veterinary Assistant Surgeon (VAS) was mostly consulted by the respondents when the case was beyond the scope of quack. Quacks were mostly consulted person for treatment of animals due to easy availability and less charges. Majority of respondents purchase medicine from market and they need to pay to VAS for treatment. Regarding service availability, majority of respondents had opined irregular service, may be due to frequent absence of VAS from dispensary. Among various constraints faced by the Department of Animal Husbandry (DAH) officials in channelizing inputs and services to dairy farmers, inadequate manpower was ranked as the most severe constraint followed by vast area of coverage, poor transport facility, huge livestock population, low input availability, inadequate finance and ignorance of farmers, respectively.

Role of an NGO in Sustainable Livelihood Generation of Tribal Dairy Farmers in Nandurbar District of Maharashtra

The majority (62.50%) of tribal farmers was in young age group and 30.46% farmers had primary education. Majority 52.34% belonged the joint family, 33.60% were landless farmers and the percentage of the farmers having medium herd size (4-6) animals was 44.50% whereas 69.54% and 62.50% farmers were having mass media exposure and contact with extension agencies, respectively. Majority (60%) of the NGO personnel perceived "poor purchasing power of tribals" as one of the major constraint followed by "transportation problem in selected area in Nandurbar district of Maharashtra.

Production and Disposal Pattern of Milk in the Jammu Region (J &K): A Market-Led Extension Perspective

Fifty five per cent of the respondents disposed of their milk through the direct consumers, 25% disposed it through the milk vendors and 8.75% sold the milk to shops & halwais. The remaining 11.25% respondents disposed of their milk through milk co-operatives in Jammu region of the state of Jammu & Kashmir. Majority of the respondents (70%) fell in the medium category of distance from the milk market. The major problem faced by the farmers in the Jammu region was non-availability of veterinary staff at animal health centres. Lack of standardization of prices of the milk was the most serious constraint experienced by the farmers in milk disposal pattern. Assured market for milk was perceived as the major strength of market-led extension. Lack of standardization was perceived as the major weakness of market-led extension. Perishability of milk and exploitation by middlemen involved in the milk disposal were perceived as the potent threats of market-led extension.

Dairy Management Profile of Ethnic Groups of Chotanagpur Region: An Exploratory Study

A significant percentage (41.66%) were marginal farmers, majority (58.33%) of the respondents had small (upto 3 animals) herd size, a considerable percentage (49.16%) had medium (5-10 litres) milk production, a sizeable percentage (55%) had medium (5-10 litres) milk sale and most of them (60.84%) had low level of milk consumption in Chotanagpur region of Jharkhand state. A considerable percentage (36.67%) of the tribal respondents followed grazing and majority (81.67%) of them were not practicing navel cutting. The tribal respondents diagnosed pregnancy in dairy animals by seeing increased size of belly and urine colour. The major information need in case of breeding, feeding, management and health care were 'selection of improved breed', 'feeding of milch animals', 'care of milch animals' and 'vaccination against contagious diseases', respectively. The major constraints expressed by the respondents in the areas of breeding, feeding, management and health care and marketing were 'lack of artificial insemination facility', 'lack of credit facilities for purchase of feeds, fodders and mineral mixture', 'non-availability of diagnostic facilities' and 'lack of organised milk marketing facilities', respectively.

Entrepreneurial Behaviour among Beneficiaries of Dairy Venture Capital Fund Scheme in Ahmednagar District of Maharashtra

Education, training received, land holding, experience in dairying, herd size, milk production,

total annual income, mass media exposure and extension contact had shown positive and significant relationship whereas age showed negatively significant relationship with entrepreneurial behaviour of beneficiary dairy farmers. Laborious procedure for getting loan, delay in loan sanctioning, inadequate loan amount and financial burden of contribution were some of the serious constraints faced by beneficiary dairy farmers whereas low education levels of farmers, low recovery of loan and non co-operation from farmers were perceived as most serious constraints by officials in implementing the Dairy Venture Capital Fund Scheme in Ahmednagar district of Maharashtra.

Status and Prospects of Smallholder Milk Production System in Eastern Haryana

Milk production by smallholder had medium level of contribution to their sustainable livelihood. Contribution of dairying to food security and asset creation was low where as majority of the respondents belonged to medium level of input recycling, employment generation and nutritional security. Sustainable Livelihood Index was positively and significantly correlated with landholding, milk production and annual income. The major constraints identified were low availability of green fodder round the year, high cost of concentrates, risk of keeping high cost animal and incidence of reproductive disorders in dairy animals.

Farmer Participatory Trials to Manage Fodder Scarcity in Rainfed Areas

Training on establishment of perennial grasses and fodder tree was organized at IGFRI, Jhansi and10 progressive dairy farmers were provided training on nursery raising, transplanting of perennial grasses and sapling of fodder trees. An exposure visit to Central Research Farm of IGFRI, Jhansi was also conducted to provide first-hand information to the farmers.

- It was observed that Lucerne + Napier based round the year fodder production system produced 1030 q green fodder/ha in a year. Whereas Lucerne + Guinea based round the year fodder production system produced 1110 q green fodder/ha in a year. Similarly, Avika Bajra Chari (AVKB-19) produced 230 q green fodders at 55-60 days cutting and leftover for regrowth and produced 10.00q grain per hectare. The Avika Bajra is very much liked by the farmers as it fulfills the green fodder and grains requirement of the farmers in the rainfed area. Whilst Guinea grass produced 1800q/ha green fodder under Horti-pastrol system.
- It was calculated that the dry fodder feeding during rainy, winter and summer season was 3.38, 6.02 and 6.48 kg per animal before implementing the interventions, however same was 3.38, 6.39 and 5.24 kg/animal, respectively after implementing the feed and fodder interventions.
- It was also noticed that green fodder feeding during rainy, winter and summer season was 15.62, 1.69 and 12.65 kg per animal before implementing the interventions, but after interventions, same was 20.66, 9.96 and 16.52 kg/animal, respectively.
- The overall gain in farmers' knowledge on dairy animal feeding was 10.40 percent. Before introducing the feed and fodder interventions (2009) the knowledge was 38.19% and in October 2011, the knowledge was 48.59% in the study area.
- After implementation of intervention the fodder scarcity period was reduced among marginal farmers to 65 days, among small farmers to 75 days and among large farmers to 60 days.

Southern Regional Station, Bangalore

Genetic Improvement of Milch Animals Through Identification and Dissemination of Superior Germplasm of Region Specific Breed of Cattle and Buffaloes Through Application of Emerging Reproductive and Molecular Technologies

Characterization of DQA 1 gene: The DQA1 gene located in the MHC locus of BoLA class IIb region shows high level of expression and is highly polymorphic in nature. The major polymorphisms in DQA1 gene is concentrated in the exon 2 region of the gene and hence, considered as the target region of study. The Single Stranded Conformation Polymorphism (SSCP) analysis was carried out for 90 Deoni DNA samples collected from NDRI SRS,

Campus for characterization of DQA1 gene. Out of the total 90 Deoni samples analyzed from SSCP analysis a total of 8 unique SSCP patterns were clearly observed. The SSCP patterns I, II and III were revealed as single unique SSCP bands, having unique variations in their mobility shifts. The single SSCP banding pattern may indicated that the above three SSCP patterns were found homozygotic in nature. All the remaining SSCP patterns IV to VIII were observed having about 2 to 4 SSCP bands with distinguishable unique SSCP patterns. The multiple banding patterns observed might indicate the heterozygotic nature of the samples analyzed. To confirm the homozygotic and the heterozygotic nature of the samples, and to establish the sequence identity of the above 8 unique SSCP patterns observed in Deoni populations, DNA sequencing of the 8 identified SSCP samples are being carried out alongwith population genetic analysis.

Association of allelic polymorphism at DRB3.2 under MHC II locus with FMD in indigenous cattle: Conducted survey work and characterization and BoLA DRB3 and DQAI polymorphism were studied. Animals with specific BoLA typing were considered for vaccination and both pre and post vaccinated conditions were investigated for estimation of immunological parameters and status of FMD virus antigen. *In vitro* proliferative response measurements were conducted with the lymphocytes isolated from experimentally vaccinated calves of Deoni and Malnad Gidda. The average proliferation index with inactivated virus reached 3.7 in Deoni and 5.7 in Malnad Gidda native cattle indicating Malnad Gidda showed higher cellular response to FMDV antigen and sub viral practices than Deoni breed. BoLA typing studies showed that locus DRB3.* 11, 15, and 9 were more prevalent in Malnad Gidda cattle than Deoni. Studies on immune response in vaccinated animals showed that animals with BoLA DRB3.2*15 in Malnad Gidda cattle were more resistant than other genotypes. Malnad gidda cattle, which did not show any antibody titres (log 0.9) in prevaccinated sera showed maximum antibody titres of log 2.7 indicating that the animals expressed 10 fold high antibody response with single injection. This indicated that Malnad Gidda animals mounted robust immune response to the virus as and when the animal was exposed to the pathogen which helped in rapid clearance of the virus from mucosal tissue.

Malnad Gidda cattle mount robust immune response against Foot and Mouth Disease

Management of breeding bulls maintained by commercial semen stations: Four commercial semen stations, two each from Karnataka and Kerala were visited and information on genetic merit, performance and management of breeding bulls was collected and analysed. A total of 206 breeding bulls (purebred Holstein Friesian- 96, Jersey-63, HF crossbred-22, Jersey crossbred- 23, Tharparker-5, Red Sindhi- 1, Rathi- 5 and Murrah-46) were maintained at these semen stations. Except in one semen station, breeding bulls in all other stations were tethered round the clock, had no access to loafing / open area and the average floor space in covered area of these stations was 2.62 m^2, which was found to be grossly inadequate. However, in one of the stations an access to loafing area was provided to all the breeds maintained, the average floor space in covered and open area were 23.97 m^2 and 22.88 m^2, respectively. In one of the semen stations maintaining HF bulls, it was observed that nearly 15-20% bulls were suffering from swollen hock, soft hooves, rear leg toe out

condition. In general, the depth of feeding manger was found to be inadequate in all bull sheds. On an average, the quantity of green fodder, hay, concentrate and mineral mixture fed were 30 kg, 4 kg and 36 gm, respectively. In one of the stations, a negative energy balance and deficiency of minerals viz. Cu, Zn, Ca were observed in about 20-25% HF bulls. Similarly, in another station, symptoms of parakeratosis were observed in about 30-40 % Murrah bulls, indicating Zn deficiency.

Genetic characterization of HSP70 gene and its association with thermo tolerance and reproductive performance in cattle: A group of proteins known as Heat Shock Proteins (HSPs) are synthesized during heat stress. Polymorphisms in HSP genes have been reported to be associated with heat tolerance and reproductive performance in cattle. *Bos indicus* cattle survive and perform better under heat stress as compared to Bos taurus breeds. Five hundred thirty-nine base pair segment of the Hsp 70 gene promoter region was amplified under optimized conditions using the DNA extracted by high salt method for Deoni, Holstein Friesian crossbred cattle and Holstein Friesian cattle using primers HSP-Pro749F and HSP-Pro 1268R. Single Stranded Conformation Polymorphism (SSCP) analysis was carried out. The PCR products giving unique SSCP patterns were further analyzed by direct sequencing. Sequence data were analyzed using Bioedit software CLUSTAL W multiple alignments for detecting single nucleotide polymorphisms. The BLAST analysis was performed to study the homology of sequences with sequences from related species. Sequence homology studies using NCBI databank sequences were carried out for the promoter region of HSP 70 gene. The obtained sequence had 99% homology with *Bos indicus* sequence (Kankrej breed, Ongole breed sequence) and 98 % homology with *Bos taurus* cattle. Three SSCP patterns were observed in Deoni cattle and two SSCP patterns were observed in HF crossbred cattle. The PCR-SSCP analysis of HSP70 gene promoter region revealed three genotypic combinations viz, AA, AB and BB in the frequencies of 0.034, 0.254 and 0.712 in Deoni cattle, respectively. The genotypic frequency of AB and BB genotypes were 0.429 and 0.571 in crossbred cattle. Studies on Association of SSCP patterns with performance traits in Deoni cows indicated AFC, calving interval and lactation length were similar among cows belonging to three SSCP patterns. Lactation yield was higher in cows with AB and BB patterns as compared to cows with AA pattern.

Single Nucleotide Polymorphisms in Heat Shock Protein (HSP) 90AA1 Gene in Deoni Cattle

Polymerase Chain Reaction (PCR) – Single Strand Conformation Polymorphism (SSCP) analysis of HSP90AA1 genes were carried out in Deoni breed of cattle. The exons 1 to 7 of HSP 90AA1 showed monomorphism with similar pattern in all the 72 animals studied. Three unique SSCP patterns with a genotypic frequency of 0.250, 0.638 and 0.111, respectively were observed in exon 8. Two SSCP patterns with a genotypic frequency of 0.153 and 0.847 were observed in exon 9 of HSP90AA1 gene. The PCR-SSCP analysis of exon 10 revealed two unique SSCP patterns with a genotypic frequency of 0.236 and 0.764, respectively. Based on the differences in the SSCP patterns, allelic variants were selected and sequenced to confirm polymorphism. The sequence analysis of Exon 8 revealed T → G transversion at position 3650 of HspAA1 gene (GenBank accession number NC-007319 as reference sequence). The observed polymorphism (T→G) at position 3650 results in substitution of an amino acid from Phenylalanine to Leucine. The cows having TG genotype had significantly higher age at first calving as compared to cows with TT and GG genotypes (P≤0.01). There was no difference in calving interval in cows with different genotypes. The detected polymorphisms at position 4111 (C → G) in exon 9 and at position 4578 (A → G) in exon 10 were silent mutations in the coding region and had no association with reproductive performance in Deoni cattle. The study indicated the usefulness of genetic characterization of HSP 90 gene in association studies between reproductive traits and SSCP patterns.

Developing protocol to formulate designer concentrate supplement for synergistic affect on microbial protein production in rumen, nutrient utilization and milk production in cattle: *In vitro* gas production (IVGP) on 27 concentrates feedstuffs, 3 roughages, 12 concentrate mixtures, 4 complete roughage based diets were measured and subjected to first order gas kinetic models to determine asymptote of gas production (Yα), half time of Y_{max}, lag time (λ) of initiation of

fermentation and, rate constant (k) were calculated. Based on the k value feedstuffs were grouped and associative effect of two or three different feedstuffs; grains, cakes and brans on fermentation kinetics were studied.

Studies on Certain Behavioural Patterns in Deoni Breed of Cattle under Loose Housing System

Research was carried out to study oestrus, parturition, milking and suckling behaviour in Deoni cattle and to find out the effects of diurnal pattern, season and parity on oestrus and milking behaviour. The different behavioural patterns of experimental animals were studied by visual observation technique. In Deoni cattle, majority of the animals showed mucus discharge, hyperaemia of vulval mucosa, homosexuality, swollen vulval lips, rubbing/sniffing/licking, stand to mount and restlessness. It could be inferred that Deoni cattle exhibited significantly better degree of oestrus symptoms. Majority of the animals came into oestrus during early morning hours, extra vigilance could improve the oestrus detection rate during these hours. The most characteristic symptoms indicating initiation of parturition exhibited by Deoni cattle were raising of tail and arching of back, thereafter expulsion of fetus occurred within two hours without any intervention.

Incidence of Mastitis in Crossbred Dairy Cattle under Field Conditions

The study was carried out to investigate the prevalence of mastitis and to study the effect of parity, stage of lactation, level of production, teat-tip-to-floor distance, milking system, body condition score (BCS), animal hygiene, udder / teats characteristics on the incidence of mastitis in crossbred dairy cattle under field conditions. A total of 507 crossbred cows (Graded HF, HF and Jersey crossbred) were examined for mastitis using California Mastitis Test (CMT), Mastrip and pH tests. In addition, somatic cell count (SCC) and chloride test were performed on milk samples of 129 animals. Taking into consideration CMT, Mastrip, and pH tests, the overall prevalence of mastitis in crossbred cows in the study area was 27.07 %. The result showed that the overall prevalence of subclinical and clinical mastitis in crossbred cows using CMT was 22.09 and 4.34 %, respectively. On the basis of results obtained in the present study it could be concluded that mastitis is prevalent and one out of every four animals is suffering from this disease. California Mastitis Test and somatic cell count should be done regularly for monitoring udder health status of dairy animals. Although mastitis cannot be eradicated under farming conditions, its occurrences can be kept at low if proper milking procedure, animal hygiene and preventive measure are adopted.

Effect of Source of Carbohydrate from Different Grains on Rumen Microbial Protein Production and Milk Production in Deoni Cows

Starch, reducing and non-reducing sugars source from maize, sorghum, finger millets and oats were quantified and maize, sorghum and oat grains were fed alongwith soya oils seed meal to Deoni cows. Inclusion of sorghum grains in the dairy animals ration improved rumen microbial protein (MBP) production, its efficiency, milk fat and protein yield. Feeding of oats though yield, comparatively lesser MBP production than sorghum, efficiency of total milk yield and total solids secretion would be higher than sorghum. MBP production on maize grain, which commonly used in dairy ration, was 25% lesser than it was on either sorghum or oat grains. However, maize supplementation improved milk yield and, lactose and mineral content than other 2 grain but not milk protein or fat content.

Characterization and process standardization for production of khoa-jalebi: *Khoa-jalebi* is a popular khoa based sweet consumed in central parts of India. A survey work was conducted in six cities in that region, namely, Nagpur, Nasik, Wardha, Bhandara, Indore and Raipur to collect information on various aspects of *khoa-jalebi*. Based on the information and data collected and evaluation of samples, *khoa-jalebi* was characterized. The method of preparation of khoa-jalebi was standardized. Diffusion is one of the key processes in *khoa-jalebi* manufacturing as it gives not only the desired sweetness but also contributes to its typical texture. The study was also carried out to study the diffusion of sugar syrup in *khoa-jalebi* as a function of sugar syrup concentration and temperature of diffusion. Sugar syrup concentration of 50°C, 60°C, and 70°C Brix and diffusion temperatures of 50°C, 60°C and 70°C were selected. After frying, Jalebi coils were dipped in sugar syrup at varying set of

conditions and then removal after specific time intervals for determining the moisture content, sugar content, water activity and hardness. The product was evaluated for sensory acceptance. Fresh khoa-jalebi prepared by standard method was packaged in low barrier materials (like paper box, butter paper and LDPE) and high barrier materials [like Al foil, Metalised Aluminium Pouch 320 gauge (MAlP320) and Metalised Aluminium Pouch 140 gauge (MAlP140)] and stored at 30 ± 10°C for evaluation of shelf life. It was concluded that *khoa-jaleb* had a shelf-life of 4 - 6 days in low barrier materials and 6 -10 days in high barrier materials at 30°C.

Application of energy monitoring and targeting system in a dairy plant: The commercial dairy plant selected for the implementation of the system was studied and based on analysis classified to energy based micro units. The energy units were selected based on the power source (electrical, LDO / steam or LPG) and the process flow line of the products studied. The system support required for developing the energy targets during onsite monitoring of the processes was developed by integrating the thermodynamic constants required by the system and regression analysis using MS Excel Sheets. Individual product based specific energy consumption targets were set during manufacture of the 6 major products of the unit, namely *khoa, peda, mysore pak, dry fruit burfi, canned gulabjamun* and *besan laddoo*. The set targets were monitored on a weekly frequency and revised based on observations. During monitoring, the possible sources for inefficient energy use were also noted for corrective action. Among the products studied, *Mysorepak*, a very popular product, was observed to consume least energy at 17.2 kJ/kg of product; while products like *canned gulabjamun* and *dry fruit burfi* were found to consume more units of energy. The system was found to be useful for improving the energy efficiency of manufacturing plants and also contributed the energy component of product costing.

Heat and mass transfer phenomena during manufacture of gulabjamun and pantoa: Frying of *gulabjamun* dough, weighing 15 g each, was carried out in an electric-powered mini fryer. During frying, the development of crust colour (lightness, hue and chroma) of the product was measured using computer vision technique while the core temperature was recorded using a needle-type temperature probe. The frying temperature levels selected for optimization were 135, 145 and 155°C and frying durations were 120, 300 and 480 s. Statistical analyses with response surface regression revealed that core temperature, lightness, hue and chroma value of *gulabjamun* correlated significantly ($P < 0.05$) with frying temperature and time. The optimum temperature and time of frying were determined as 143.8°C and 479.8 s, respectively, which resulted in core temperature of 104.2°C, lightness value of 37.4, hue value of 40.7 and chroma value of 22.0. The adequacy of the response surface model was validated at the optimized conditions. Mass transfer during soaking of *gulabjamun* in sugar syrup was analyzed. The *gulabjamun* balls were fried under the optimized conditions (144°C and 480 s) using RSM. The main effects of temperature, concentration and time of soaking in sugar syrup on sucrose uptake, moisture content, volume change and texture of *gulabjamun* were studied. Modeling the heat and mass transfer phenomena of *gulabjamun* during frying was also carried out.

Development, characterization and evaluation of edible films and coatings for selected dairy products: The tensile stresses, strains and moduli of the films were determined using the texture analyzer equipped with a 50 kg load cell. The tensile tests were performed according to ASTM D882-97 standard with minor modifications. The films were cut into 25 mm width strips. The thickness of the films was measured using a digital caliper. A/TG grips (probe) were used to hold the specimens and the tensile elongation test was performed. The tensile strength, strain and moduli were computed using the cross sectional area of the film. The tensile strength of casein and starch film was in the range of 0.51-3.53 MPa and 1.50-3.22 MPa, respectively. Similarly, the Young's modulus of casein and starch films ranged from 4.2-29.42 and 9.14-19.61 MPa, respectively. The tensile strain of starch film was higher than that of casein film. Casein film had a maximum tensile strain of 14.8% while the starch film had a maximum tensile strain of 24%.The wide variations in the tensile strength and moduli were due to variation in the drying conditions. Therefore, controlled drying conditions were suggested. The water vapour transmission rate (WVTR) was estimated

gravimetrically using modified ASTM standard E96-95. The WVP of casein films plasticized with 1:0.5 ratio of biopolymer: glycerol ranged from 9.6 to 11.2 g mm/m^2 h kPa while the corresponding values of starch films were 10.3 to 12.4 g mm/m^2 h kPa.

Green gram dhal payasam dry mix: Green gram dhal payasam is a popular pulse based dairy product in the southern region. A method for the preparation of ready to reconstitute *payasam dry mix* incorporating ground green gram dhal and poppy seeds and skim milk powder was standardized and a dry product containing either sucrose (50%) or sucralose (3200 ppm) was prepared. Analysis of the proximate composition of the two mixes revealed that the mix with sucralose had significantly lower level of carbohydrates and higher levels of protein and fat. Both the products on reconstitution yielded payasams of acceptable sensory quality. The level of sucralose in the reconstituted product was about 570 ppm. The products packed in LDPE pouches and stored at 37°C kept well for four months as observed by sensory evaluation of the reconstituted product and chemical analysis of the dry product.

Development of Foxtail millet – milk solids dry mix: Foxtail millet is a nutritious staple millet of the region. A ready-to-reconstitute malted foxtail millet – milk solids dry mix using foxtail millet malt powder, sugar and skim milk powder was standardized. Malted and fine ground foxtail millet powder was blended with ground sugar and SMP in a predetermined ratio to form the dry mix. Reconstitution of the mix was standardized as boiling 1 part of the mix with 4 parts of water and cooking for 5 min to yield an acceptable product. Proximate composition of the standardized mix indicated that the mix had 1.56, 1.96, 14.54, 78.19, 3.75 and 0.048% of moisture, fat, protein, total carbohydrates, ash, and calcium, respectively and 100 g of the mix provides about 390 k cal of energy. Storage trials indicated that the dry mix packed in LDPE kept well for a period of 4 months at 37°C

Finger millet (Ragi) - milk beverage: The unit operation of popping is commonly employed for ragi to improve its aroma, texture and shelf – life. Therefore, an attempt was made to develop a dry mix using popped ragi and milk solids. Ragi grains were evaluated for its degree of popping after moistening with different levels of water and the optimum level of moistening was selected based on maximum popping. Incorporation of milk solids in the mix in the form of WMP, SMP and WPC were attempted. Levels of popped ragi powder, malted wheat powder, sugar and milk solids were optimized. The dry mix was reconstituted to desired sensory quality by cooking 30 g of the mix in 100 ml potable water for 3 min. The dry mixes packed in LDPE and multilayered pouches kept well during storage at 37°C for a period of 3 months.

Extension of shelf-life of Channa Jhilli: *Channa Jhilli* prepared according to the standardized procedure was evaluated for its shelf life. The samples were packed at room temperature with and without preservative and hot packed at 70°C in two different packaging materials namely; stand up pouch and polypropylene tub. For hot filling, the samples were packed alongwith sugar syrup at 70°C; while for packing with preservatives, sorbic acid at 1000 ppm was added to the sugar syrup and then packed at room temperature in the packaging materials. The shelf life of the packed *channa jhilli* samples was evaluated at room temperature and under refrigeration. *Channa Jhilli* stored at room temperature without any treatment had a shelf – life of 5-6 days when packed in pouch and 4-5 days when packed in tub. Hot filled *channa jhilli* samples showed a shelf-life of 10-12 days in pouch and 7-8 days in tub at room temperature. Addition of 1000 ppm sorbic acid extended the shelf-life up to 22-25 days at room temperature when packed in pouch and 20-22 days when packed in tub under the same conditions of storage. *Channa jhilli* showed a longer shelf-life under refrigerated storage. *Jhilli* packed at room temperature remained good for about 30 days when packed in pouch and about 25 days when packed in tub. The hot filled samples in both pouch and tub were acceptable even after 30 days. The samples added with preservatives and packed in pouch and tub also had good acceptability even after a month of storage under refrigeration.

Microbiological analysis of Carrot halwa and Kashi halwa: *Carrot halwa* and *Kashi halwa* were evaluated for their microbial quality. The microbiological quality of *carrot halwa* prepared by retort processing showed that the bacterial count in fresh samples was less than 10/g and the count did not increase during 4 weeks of storages

at 37°C. At the end of 5 weeks of storage, the *halwa* showed an increased bacterial count which did not impair the sensory quality of the product. The lower water activity of the product (a_w = 0.90), high sugar content (around 40%) and prolonged desiccation during product preparation might have restricted the bacterial count and their growth. The yeast and mold count was less than 10 / g during the storage period. The initial bacterial count in *kashi halwa* processed by steaming for 10 min and pressure cooking at 5 psi for 5 min was 80 and 60/g, respectively. Both the heat treatments were found effective in improving the shelf life to more than 75 days at 35°C. At the end of 75 days of storage, the count marginally increased to 120 and 110/g, respectively. As in the case of *carrot halwa*, the product did not show any deterioration in sensory quality due to bacterial growth. The yeast and mold counts were less than 10/g during storage period. The water activity of *Kashi halwa* was 0.835 and its sugar content was about 47%.

Economic analysis of manufacture of dairy products in organized dairies: The relevant data pertaining to the two dairies in Karnataka, one Dairy each from Andhra Pradesh, Tamil Nadu & Pondicherry in respect of product mix, production processes, cost of production of selected dairy products, marketing & developmental activities including impacts made were collected by personal interview during the visits. By and large, the selected dairy products were similar in most of the cases while, cost of production varied considerably across the dairies largely because of scale of production and variation in milk procurement price & other input prices. The dairies created a good infrastructure & provided useful services to milk producers which had salutary effect on development of dairying in the region & livelihood of dairy farmers.

Application of Whey based Jaggery in Some Dairy Products

One of the byproducts of dairy industry, which has beneficial physiological effects. The disposal of whey adds to the cost of operations in a dairy plant as it requires appropriate treatment due to its high BOD content. In order to effectively utilize whey, an attempt was made to develop a process for the production of whey-based jaggery and to study the feasibility of its application in dairy/food products. In order to improve the quality of the jaggery neutralization of paneer whey (PW) and additives like cane sugar, cane jaggery and sugarcane juice at different levels were attempted. The effect of these on the quality of jaggery was studied and optimized to improve acceptability of the final product. Addition of cane sugar @ 15% of neutralized whey; jaggery @ 15% of neutralized whey; fresh sugar cane juice @ 1:1 with normal or neutralized whey (w/w) were found to yield acceptable quality jaggery. Use of cheese whey (CW) also showed a similar trend. The three additives tried, admixing with sugar cane juice was found to yield better quality product. The optimized jaggery making process involved heating whey alongwith the selected additive in an open pan for evaporation of water; controlling heating to desirable boiling point and cooling for crystallization and jaggery formation. Peda prepared using PW and CW jaggery was found to be of acceptable quality with 7.44 and 7.45 as mean acceptance scores. *Okkarai* (Bengal gram payasam) prepared using PW- jaggery was found to be of highly acceptable quality, as indicated by mean acceptability score of 7.67 which was greater than 7.40 for control sample containing cane jaggery. It was concluded that paneer whey and cheese whey could be directly utilized for jaggery making, by conventional method, by admixing with sugar cane juice.

Development of Ergogenic Drinks from Hydrolysed Whey

Ergogenic drink was developed from hydrolysed cheese whey to serve as a vehicle to deliver functional ingredients like smaller molecular weight peptides, monosaccharides (glucose & galactose) and omega-3 fatty acids for easy absorption of the nutrients by the consumers. Whey protein and lactose were hydrolysed, Omega 3 fatty acids from flax seed oil was incorporated to enhance functionality. Sugar, starch, and mango pulp were added to improve the taste and palatability of the drink. Hydrolysis of whey protein was optimized to about 8% to obtain small peptides with minimum bitterness and lactose to about 50% to maintain the unique beneficial properties. Flax seed oil @ 1.5% was incorporated to enrich omega 3 fatty acids content. Sugar, mango pulp , starch and micro crystalline cellulose of 7.5, 4.5, 0.8 and 0.2% were added,

respectively and homogenized for homogeneous, uniform and improved consistency and palatable taste. Electrophoretic study was carried out for characterization of peptides. Presence of omega 3 fatty acid in final ergogenic drink was estimated using gas liquid chromatography. Sensory evaluation showed better scores of the ergogenic drink, except for flavour, as compared to control because of homogenization and supplementation of ingredients. Drink was packed in flexible aluminum standy pouches and thermised in water bath for 65°C/10min. Sensory, physico-chemical and microbiological evaluations revealed the shelf life of thermised samples was 16 days at refrigeration and 4 days at room temperature and that for non thermised drinks was 12 and 2 days at refrigeration and room temperature, respectively.

Utilisation of Concentrated and Lactose Hydrolysed Whey in Preparation of Bread

Whey is the byproduct obtained during the manufacture of paneer, chhana and chakka. The drainage of whey is not only causing environmental pollution but also losing valuable milk solids such as lactose, whey proteins and minerals. In the present investigation attempts were made to utilize concentrated and lactose hydrolysed whey in production of bread. The studies on the effect of whey solids on hydrolysis of lactose showed that 89% of lactose could be hydrolysed in normal whey, while the degree of hydrolysis reduced with the increase in total solids (TS) in whey. Studies on effect of incubation period indicated 58% of lactose was hydrolysed in concentrated whey at the end of 1 hour of incubation. Use of concentrated whey with 30% TS significantly increased the proofing time but addition of extra water to dough could bring down the proofing time equal to that of control. Use of 3% yeast was found optimum to proof the dough in about 60 min. Baking of bread at 180°C for 20 min resulted in production of bread with good sensory qualities. Hydrolysis of lactose in whey significantly improved the overall acceptability quality compared to the bread prepared by using unhydrolysed whey. Use of hydrolysed whey could help in reducing the use of cane sugar by 50% in bread preparation. The bread prepared by using concentrated and hydrolysed whey had a shelf life of 5 days at 37°C when packed in high density polyethylene (HDPE) pouches.

Incorporation of Concentrated Lactose Hydrolysed Whey in Production of Soup Sticks

Whey is one of the major byproducts of organized dairy industry all over the world. Due to very high biological oxygen demand (40000 – 50000 mg / kg), whey is considered as a serious pollutant and requires expensive treatment before its disposal. However, addition of whey especially in concentrated form increases the lactose content of the food products. This may cause lactose intolerance, a disorder due to deficiency of lactase in the digestive system. Hence, a study was initiated with the objective of optimizing process conditions in the production of soup sticks by utilizing concentrated lactose hydrolyzed whey. Paneer whey concentrated to 30% TS can effectively be used as diluent replacing water in the production of soup sticks. The replacement not only improved the nutritional attributes but also contributed to the economy of operation of dairy plants reducing the cost of effluent treatment. The use of concentrated whey, however, resulted in increase in the lactose content. The lactose content could effectively be reduced by using appropriate enzyme treatment. Incorporation of paneer whey concentrated and lactose hydrolysed to an extent of 50% did not affect sensory parameters of soup sticks. A proofing time of 30 minutes and baking temperature of 150°C were observed to be optimum for obtaining desired sensory attributes in soup sticks prepared by using concentrated and lactose hydrolysed whey as diluents. Soup sticks prepared utilizing concentrated and lactose hydrolysed whey had 5.20, 13.23, 9.65, 65.83 and 2.35% of moisture, fat, protein, total carbohydrates and ash, respectively. The lactose content in the soup sticks prepared with the lactose hydrolysed whey was 3.65% compared to 7.30% in the case of samples prepared without the lactose hydrolysis. The product stored at 37°C remained in good condition for 9 days without any deterioration in sensory attributes and with marginal changes in the microbiological quality. The changes in physicochemical properties during storage were also marginal. The study revealed that concentrated and lactose hydrolysed paneer whey could effectively be used in the production of soup sticks with definite economical benefits.

Development of Mathematical Models for Prediction of Shelf-life of Cheese Puri Mix

Mathematical models were developed to predict the shelf life of cheese – puri mix using two approaches, namely, deterioration due to moisture absorption and of lipid oxidation. Deterioration of the product due to absorption of moisture was anticipated to be manifested as non–enzymatic browning (NEB) and cakiness, while the index for oxidative rancidity was described in terms of peroxide value, which was expressed as a function of headspace oxygen concentration. The critical limits for moisture content and headspace oxygen concentration for these deteriorative indices were also subjectively established. The packaging material, low density polyethylene (350 gauge), was characterized for its water vapour transmission rate and oxygen permeability. The shelf life, at 38˚C and 95 % RH, was predicted to be 270 days based on moisture absorption, while it was predicted to be 180 days due to development of oxidative rancidity. Thus, the models predicted that the sample would spoil earlier due to lipid oxidation. The actual shelf life was determined to be 165 days; thereafter the sample was rejected due to rancidity development. The developed models showed a 90 % agreement with actual shelf life of cheese – puri mix, indicating the adequacy of the prediction.

Modeling of Time-Independent Rheological Behaviour of Lassi

The rheological characteristics of lassi were studied by using a computer-controlled rotational viscometer over a range of total solids (TS) sugar contents and with stabilizers such as carrageenan, pectin and locust bean gum (LBG). The viscometric data were converted into the basic shear stress vs. shear rate form using Mitschka method. From the shear rate-shear stress data, the flow nature of lassi was evaluated. The apparent viscosities of the systems decreased with increasing shear rate, indicating pseudoplastic behaviour with yield stress. The rheological behaviour of lassi was adequately described by the Herschel-Bulkley and Casson models with a high coefficient of determination (R^2) and low root mean square error (RMSE). The Ostwald De Waele model did not fit very well because of the yield stress in lassi. The Herschel-Bulkley yield stress (σ0), consistency coefficient (k) and the flow behaviour index (n) were determined as 0.638-7.725 Pa, 0.330-0.834 Pa.sn and 0.514-0.701, respectively. The main and interaction effects of these selected factors on the apparent viscosity, yield stress, consistency coefficient and flow behaviour index were found to be highly significant. Thus, wide ranges of apparent viscosities, yield stress, consistency coefficients and flow behaviour indices were observed by varying the sugar and TS contents and by selecting the stabilizer type. Of all factors, TS seemed to have the highest influence on the rheological behaviour of lassi. An increase in the concentration of TS was accompanied by an increase in the pseudoplasticity, consistency coefficient and yield stress. However, the effect of sugar on flow behaviour of lassi was quite opposite to that of TS. The flow parameters of lassi were positively influenced by both pectin and carrageenan. Carrageenan at 0.15% concentration was found to be the most suitable stabilizer for lassi. LBG-added samples showed visible whey separation owing to precipitation of milk proteins, and hence, it was recommended to stabilize lassi.

Eastern Regional Station, Kalyani

Studies on Organic Milk Production System in the Plains of West Bengal

The lactation yield (mean 305 days) under organic management was 2288 kg. The average service period and number of AI/conception were 114 days and 1.5 respectively. The fodder was grown organically with farm yard manure @ 25 tons per hectare. In kharif season, organic fodder like maize, cowpea and sorghum sudan grass hybrid were grown. In rabi season, berseem, chinese cabbage and oats were grown as fodder crops. The average yield of berseem (1st and 2nd cut), oats and maize fodder in 2010 and 2011 were 452, 285 & 260 and 435, 274 & 246 quintals per hectare under organic management. Total 51 samples (soil, water, feed and fodder) collected from farm and field were analyzed for estimation of heavy metals. Both Mercury and Arsenic were found within the permissible limit for all types of samples. The Cadmium level in most of the samples exceeded the permissible limit. The lead value of soil

samples was found to be within the permissible limit. However, the high concentration of lead was observed in all types of fodder samples as well as in water samples. The residue concentrations of three pesticides (commonly used in the area i.e., Endosulfan, Chlorpyrifos and Cypermethrin) in milk were also determined. The levels of pesticide were within the permissible limit for the milk samples during the year 2010-2011. The levels of Endosulfan and Cypermethrin for all the feed and fodder samples were within the permissible limit. The residue concentrations of three antibiotics (Amoxicillin, Cefitriaxone and Enrofloxacin) in milk were also determined. Milk samples obtained from cows under organic management system had antibiotic residues within the permissible limit.

Women Dairy Co-operatives in Orissa, and Nagaland

To study the impact of women dairy co-operative societies in dairy development in the eastern and north-eastern part of India, series of survey were conducted in Odisha and Nagaland. Women members in the Sidehswary Women Dairy Co-operative Society, Puri district of Odisha were actively involved in milk production and disposal chain; average milk production per day was 248 kg of the society which was sold @ ₹ 16.98/litre. There was 72% crossbred cattle (Holstein and Jersey crosses) in the society but majority belongs to Jersey crosses. Conception rate of AI done by women inseminator was recorded between 37-42 % during the year under report. The 68.33% members of the society belonged to marginal farm category, who reared 2-3 crossbred cattle.

In Nagaland, Kohima Milk Union is one of four milk unions in the state. There are 10 women dairy cooperatives, 6 general dairy cooperatives and 5 community dairy farms functioning and supplying 3500 to 4000 litres of milk to Kohima dairy plant during the month of December, 2011. Two women dairy cooperative societies i.e., Bido women dairy cooperative society (15 members of tribal community), Jotsoma village, and Vitho women dairy cooperative society (21 members), Chedema village, were actively involved in production and supply of milk to the Kohima dairy plant. Artificial insemination facilities were available in the society. The society members got ₹ 22/- to 24/- per litre of milk price depending on the level of Fat and SNF. Hence, members of the women dairy co-operative societies were actively involved in socio-economic upliftment of their families through scientific dairy farming and organized milk disposal system.

Micro Nutrient Mapping and Their Evaluation in Improving Production and Reproductive Performance of Dairy Animals in Eastern Region of India

Earlier survey in the eastern region showed that most of the farmers did not supplement their animals with mineral mixture and as a result animals suffered from anestrous and repeat breeding problem. General ignorance as well as high price of the commercial mineral mixture was probably the reasons behind the reluctance of the dairy farmers in supplementing the dairy animals with mineral mixture.

Baseline data on production and reproduction of dairy animals were collected in some states of eastern and north eastern India. Feeds, fodder and soil samples were collected from Arunachal Pradesh, Nagaland and Meghalaya through ICAR centres of those states. The major feed resources available in Arunachal Pradesh were maize grit, maize bran, millet grain, millet straw, maize stover, pasture grasses and tree fodders. In Meghalaya, the major feed resources available were crushed maize, concentrate mixture, rice grit, wheat grain, mustard cake, straw, pasture grass, bamboo leaves and other tree leaves. The common feed resources available in Nagaland were concentrate mixture, mustard cake, rice grit, paddy straw, pasture grass, bamboo leaves, banana leaves and other tree fodder. Feeds, fodder and soil samples were being collected from different AERs of West Bengal. Mostly feeds and fodders were found to be deficient in Ca, P, Zn, Cu, Co and Mn. Accordingly, a low cost mineral mixture was formulated having Di-calcium, Phosphate, Zinc Sulphate, Copper, Sulphate, Cobalt Sulphate and Manganese Sulphate.

Evaluation and Utilization of Brewers Spent Grain as Cattle Feed Supplement

Brewers spent grain was procured from local distillery plant and chemical composition was monitored at regular interval. The average content (as % DM) of CP, EE, CF, Total ash, NFE, AIA, NDF, ADF and OM in brewers spent grain samples were 22.5, 7.3, 17.5, 3.2, 48.5, 1.22, 59.0, 23.5 and 96.8%, respectively. The concentration of some important mineral elements in Brewers spent grain was also being analyzed.

In vitro gas production trials with Brewers spent grain (BSG) were conducted to study the *in vitro* total gas production pattern. Samples collected during different seasons were processed and

pooled to make a representative sample and subjected to *In vitro* gas production trial. The rumen fluid was obtained from two male Jersy crossbred calves. Paddy straw, paddy straw + BSG (75:25), paddy straw + BSG (50:50) and paddy straw + BSG (25:75) were also subjected to *In vitro* gas production trial. The samples of each feed (weighing around 200 mg) were put into 100 ml calibrated syringes with rumen fluid and buffer solution (about 30 ml) and incubated at 39°C for 96 hour. The record of gas volume was taken at 0, 2, 4, 6, 8, 12, 18, 24, 36, 48, 72 and 96 hours of incubation. The total gas production/g substrate was gradually increased with the increase in BSG level in substrate. A growth trial was initiated on crossbred calves to see the effect of feeding sun dried BSG replacing concentrate mixture @ 20 % level on body weight gain, feed conversion efficiency and economics of feeding.

Nutritional Evaluation of Azolla for Utilization in Ruminant Ration

An experimental Azolla production unit was established at ERS campus and the cultivation of Azolla was being standardized. Fresh yield, DM content and CP content of Azolla were being regularly monitored. The DM content in Azolla ranged from 4.82 to 7.02%. The CP content (%DM) ranged from 20.27 to 29.67%. The average content (% DM) of CP, EE, CF, Total ash, NFE, AIA, NDF, ADF and OM in Azolla samples analyzed till date were 23.68, 4.14, 9.2, 18.63, 43.26, 2.47, 48.65, 32.79 and 82.66, respectively. The concentration of some important mineral elements in *Azolla mycrophylla* were also being analyzed.

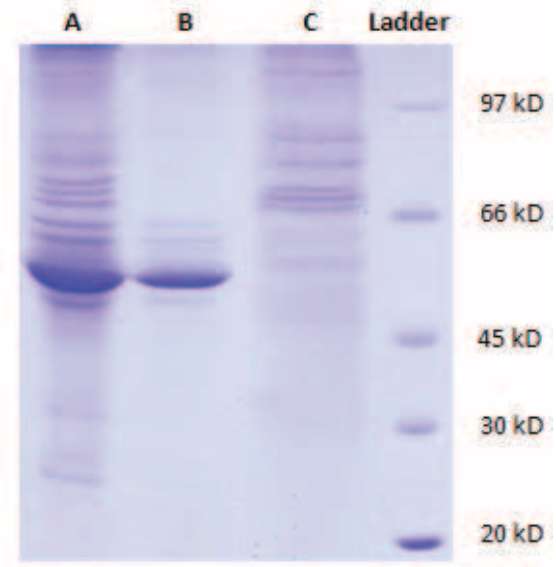
In vitro gas production trial with *Azolla mycrophylla* was conducted to study the *In vitro* total gas production pattern. Azolla samples collected during different seasons at fortnightly interval were processed and pooled to make a representative sample and subjected to *In vitro* gas production trial. Paddy straw, paddy straw + Azolla (75 : 25) , paddy straw + Azolla (50:50), paddy straw + Azolla (25:75) were also subjected to *In vitro* gas production trial. The samples of each feed (weighing around 200 mg) were put into 100 ml calibrated syringes with rumen fluid and buffer solution (about 30 ml) and incubated at 39°C for 96 hours. The record of gas volume was taken at 0, 2, 4, 6, 8,12, 18, 24, 36 48, 72 and 96 hours of incubation. During the incubation there were also media blanks (rumen fluid + Buffer solution).

Experimental Azolla Production units at ERS

In case of *In vitro* DM Disappearance trial, Azolla samples were subjected to *In vitro* incubation in rumen fluid as per standard procedure for 24 h, 48 h, 72 h and 96 h. Media blanks (rumen fluid + Buffer solution) were also run during the incubation. After termination of incubation, the contents of the flasks were filtered through pre-weighed Gooch crucibles (G1) and dried in the oven for 24 h and weighed to get the apparent DM Disappearance. The dried contents were refluxed in NDS for 1 h in spout less beaker and then filtered through same crucible and then dried in the oven for 24 h and then weighed to get the IVTDMD.

Purification of Heparin Binding Oviduct Specific Proteins and Their Effect on In Vitro Embryo Development in Cattle

Purification of heparin binding oviduct specific proteins (OSPs): Cattle native oviduct specific proteins (cOSPs) were isolated from cattle oviducts



SDS-PAGE analysis of purified heparin binding cOSPs from cattle oviduct

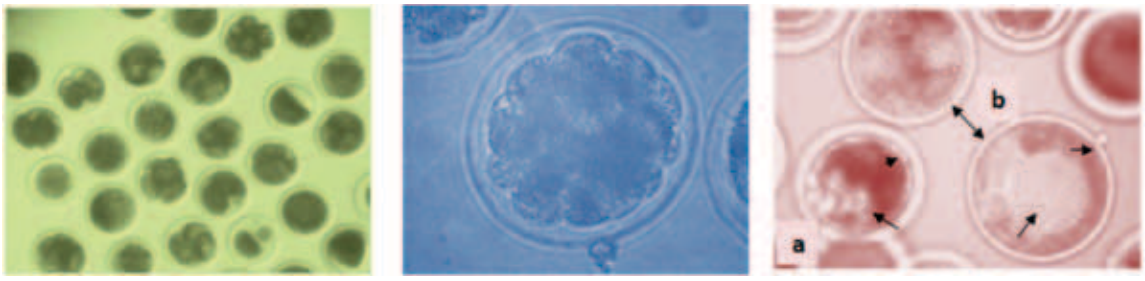
obtained from slaughter house and precipitated by ammonium sulphate (60%), followed by overnight dialysis using buffer and purified by high performance liquid chromatography (HPLC) system with a hightrap heparin prepacked column (GE Healthcare). On the basis of HPLC purification, these cOSPs were divided into three fractions i.e. (A) Total proteins (TP), (B) Heparin unbound proteins (HUBP) and (C) Heparin bound proteins (HBP), and checked in SDS-PAGE analysis.

Biological effects of cOSPs on *In vitro* Embryo development: Three fractions of oviduct specific proteins (TP, HUBP & HBP) were used in three different concentrations (1, 10 & 30 µg/ml) for *In vitro* maturation, sperm preparation, *In vitro* fertilization and *In vitro* culture of cleaved embryos. The control group was not supplemented with OSP. A total of 1346 usable oocytes were used for *In vitro* fertilization, out of which a total of 264 usable quality oocytes (COCs) were subjected to IVF in control group where the cleavage and blastocyst formation rate were 63.5% and 17.9%, respectively. In TP group, the overall cleavage and blastocyst formation rate were 60.0%, 73.9% & 40.8% and 18.8%, 29.6% & 22.7% in 1, 10, & 30 µg/ml concentrations, respectively. In HBP group the overall cleavage and blastocyst formation rate were 54.2%, 63.2% & 42.9% and 21.7%, 25.9% & 25.0% in 1, 10, & 30 µg/ml concentrations, respectively. In HUBP group the overall cleavage and blastocyst formation rate were 55.3%, 59.6% & 31.8% and 25.6%, 24.2% & 14.2% in 1, 10, & 30 µg/ml concentrations, respectively. The highest blastocyst number (29.6%) was found when 10 µg/ml concentration of total OSP fraction (TP) was supplemented in the culture media for IVM, IVF and IVC.

Evaluation of Lactation Traits of Crossbred Cattle at ERS, NDRI, Kalyani

Selection for milk yield in dairy cattle is generally based on the lactational performance records. To maintain the genetic variation, which is the basic source of breed improvement, proper evaluation of production performance of the breed is necessary. Therefore, the present study was undertaken to evaluate the effect of various non-genetic factors on various lactation traits of crossbred cattle of the Institute herd to estimate genetic and phenotypic parameters of different lactation traits of crossbred cattle and to evaluate and compare the production performance with respect to lactation traits of crossbred cattle of different genetic combinations/ groups.

Data of 250 crossbred (Jersey crosses) animals, maintained at the ERS of NDRI Kalyani, Nadia, were collected since 1972. The animal-wise lactation data pertaining to 305 days milk yield, total milk yield and lactation length of animals were collected for all available lactations. The genetic constitutions of each animal, their sires and dams were deduced after back tracing of the pedigree of the animals. The data were being collected and computerized and simultaneously, standardization of data was also being carried out.



A B C

In vitro developed Cattle embryos (A. Early stages, B. Morula & C.Blastocysts: a) early blastocyst, b) expanded blastocyst- arrow indicating blastocoel cavity and trophoblast cell layer) using OSP as a culture media supplement

3 TRANSFER OF TECHNOLOGY

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. 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.

Infertility and Veterinary aid Campaigns

A total of 60 camps were organized in Kulwaheri, Budhakhera, Bazidpur, Kharajpur & Ganjogarhi villages. During the campaigns 1600 cases were treated for reproductive disorders and various Vety. Ailments. Deworming and tick control programmes were conducted for Endo & Ecto-parasites (2867 and 1210). Special attention was given to improve the productive & reproductive cause of farmers' animals by diagnosis and proper treatment.

Fodder Demonstration

To maintain round the year supply of green fodder at farmers' field, demonstrations of high yielding varieties Berseem (BL-42) Oats, (JHo-822), Maize (Vijay Composite) fodder crops were organized. Farmers were also educated about the improved practices of fodder production.

Kissan Sanghosthi

The Extension Division organized 56 Kissan Sanghosthies in adopted villages so as to improve the dairy farming practices and to ensure adoption of scientific technologies developed at Institute. A total of 856 farmers participated in these programmes and lectures were organized on common cattle diseases and preventive measures, improved feeding practices, mastitis control programme, clean milk production, reproductive management, utility of record keeping, schedule for deworming & tick control, role of green fodder in animal diet, improved package of practices of fodder crops (berseem, oat, maize, sorghum), role of by-pass fat and protein in animal production, balanced feeding, silage making, low cost feeding technologies, role of dry cow therapy, regular vaccination for HS, FMD & B.Q., care of new born calves, care of advance pregnant dairy animals and value added milk products.

Question/answer sessions were also arranged in these sessions which provided excellent opportunities to the farmers and subject matter specialists addressed their day to day problems and also collected the feedback on the extension programmes.

Dairy Education at Farmers' Door

Under this programme, a team of subject matter specialists from production, processing and management group organized Dairy Education at Farmers' Door in various villages on 2nd Saturday of every Month. Scientists also obtained feedback from the participating farmers.

Advisory Services

The Division provided 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.

KRISHI VIGYAN KENDRA & DAIRY TRAINING CENTRE

Krishi Vigyan Kendra (KVK) at NDRI, Karnal became operational in July 1976. Subsequently, this Kendra has developed infrastructure to run the need based skill oriented training programmes through "Learning by Doing". Three fundamental principles viz., (i) agricultural production – the prime goal, (ii) work experience – the main method of imparting training and (iii) weaker section of the society – the main target group, are always kept in mind.

The main aim of KVK is to accelerate agricultural production and allied activities for improving economic status of farmers and create job opportunities for the poorest amongst the poor in the rural areas.

Mandate

- To conduct "on farm testing" of identified technologies in terms of location specific sustainable land use systems.
- To organize frontline demonstrations on various crops to generate production data and feedback information.
- To organize short and long term vocational training courses in agriculture and allied vocations for the farmers and rural youth for higher production on farms and generating self employment.
- To organize training to update the extension personnel with emerging advances in agricultural research on regular basis.

Training Programmes Organized by KVK (January to December, 2011)

Title of the course	Duration (days)	No. of courses	No. of beneficiaries	Man days trained
(A) On-Campus Programmes				
Dairy Production				
At KVK	4-11	7	264	1730
Sponsored	3-5	52	1577	7187
Dairy Processing	5	6	125	625
Crop Production	3	3	61	183
Vermiculture	3	3	72	216
Bee-keeping	4	3	107	428
Fish Farming	4	2	34	136
Home Science	1-5	13	247	805
Short Integrated Training Programmes	1-2	117	4215	4873
Total (A)		**206**	**6702**	**16183**
B) Off-Campus Programmes				
Dairy Production	1	7	161	161
Dairy Processing	1	4	64	64
Crop Production	1	10	165	165
Vermiculture	1	1	16	16
Bee-keeping	1	1	17	17
Fish Farming	1	1	17	17
Home Science	1-40	10	941	2417
Total (B)		**34**	**1381**	**2857**
Grand Total (A) + (B)		**240**	**8083**	**19040**

Sponsored Courses Conducted (January to December, 2011)

Title of the Course	Duration (Days)	No. of courses	No. of beneficiaries	Mandays trained
Scientific Dairy Farming for Farmers sponsored by State Departments Lucknow, Uttar Pardesh.	5	1	24	120
Scientific Dairy Farming for Farmers sponsored by Agricultural Technology Management Agency (ATMA), Rajasthan.	5	7	229	1145

Scientific Dairy Farming for Farmers sponsored by Different Agencies and Department of Himachal Pradesh.	3	7	213	639
Scientific Dairy Farming for Farmers sponsored by ATMA from Bihar.	5	17	510	2550
Scientific Dairy Farming for Rural Youth sponsored by Animal Husbandry Department of Gujarat State.	5	1	35	175
Scientific Dairy Farming for Dairy Farmers sponsored by Various Departments of Jhakhand.	3-5	11	357	1513
Scientific Dairy Farming for Extension functionaries sponsored by Various Departments of Assam.	5	5	123	615
Scientific Dairy Farming for Rural Youth sponsored Milk Union Manipur State.	5	2	60	300
Scientific Dairy Farming for Dairy Farmers sponsored by ATMA from Odisha.	5	1	24	120
Scientific Dairy Farming for Farmers sponsored by State Department Uttrakhand.	5	1	30	150
Total		**53**	**1605**	**7327**

(Revenue generated from sponsored courses = ₹11,64,313/-)

Extension Activities of KVK

- KVK through its four stockman centres in the adopted villages, namely: Taprana, Kailash, Phusgarh and Jundla Gate, Karnal attended 12,067 cases, out of which 154 cases were for general treatment, 81 for infertility treatment, 132 for dehorning, 119 for pregnancy diagnosis, 2,891 A.Is. in dairy animals and 8,650 cases were for FMD vaccination. Through artificial insemination 1,798 calves were born.

- Subject matter specialists of KVK organized 10 one day camps on fertility, deworming, tick control, general treatment and pregnancy diagnosis and attended 1,333 cases in adopted villages to create awareness among farmers about animal infertility problems and dairy management aspects.

- Zero tillage technology in wheat crop production was demonstrated to various groups of farmers and farm women of the Karnal district and also to farmers from other states.

- KVK under the Cereal System Initiative for South Asia Programme organized various experiments and front line demonstrations on direct seeding of rice using different varieties of paddy.

- KVK in association with KRIBHCO organized a programme on capacity building for about 80 beneficiaries at village Shamgarh District Karnal on 16-02-2011.

- In the month of November and December 2011, KVK in association with KRIBHCO, IFFCO and NFL organized 5 different programmes for the seed and pesticide dealers from different districts of Haryana in which more than 500 participants were imparted training on mobile monitoring of fertilizers.

- KVK in association with a NGO "Rashtriya Yuva Sangthan" celebrated International Women Day as Women Empowerment Day in village Dhakwala, district Karnal on 9th March, 2011, in which more than 500 farm/rural women/girls volunteers of NGOs and women extension workers from 12 villages of the district participated.

- KVK organized two mahila sangoshties in village Bazida Jatan and village Rasina on preparation of milk products and pickle making for 80 and 15 beneficiaries, respectively.

- KVK celebrated "Women in Agriculture" day on 04.12.2010 in village Bhaini Khurd of Karnal district in which about 110 farm women participated. They were apprised of various scientific technologies in dairy farming, crop production, milk processing and home science.

- During the reporting period, total six on-farm trials of cauliflower crop (Doctor early special and Nutan early wonder varieties) were laid on 2.42 hectare area under irrigated conditions on different farmers field.
- Front Line Demonstrations on Mustard Pusa Vijay variety was organised in 6 hectares area on farmers' field. An average production of 14.75 quintal per hectare was observed. An increase of 17 per cent was observed as compared to local check plots.
- During the Rabi season 2010-11, a total of 10 front line demonstration (FLDs) on Gram crop (variety HC-5) were laid in 4.0 hectare area under irrigated conditions. An average production was observed to be 16.40 q/ha which was 14.68% higher than local check.
- During the summer season, variety SML-668 procured from PAU Ludhiana was used in laying 15 demonstrations in 6 ha area in different villages of the district. In the demonstration plot, an average production was observed 5.41 q/ha.
- During the Rabi season 2010-11, wheat variety DBW-17 and HD-2894 was used on 21 demonstration plots covering 8.45 hectare area under irrigated conditions.
- During the year, a total of 14 on farm trials were conducted on Berseem in 4.8 ha area using variety Mescavi, BL-42 and HB-1 and 14 On Farm Trials on wheat in 5.6 ha. Area using variety HD-2894, HD-2851, HD-2932, WR-544 and DBW-17 were arranged in different villages of Karnal district.
- During the year, a total of 10 on farm trials on Paddy were conducted in 4.0 ha area using variety PB-1 and Pusa- 1121 and 7 on farm trials on Jowar Fodder (multicut) were also conducted in 2.22 ha using variety S.S.G and Sudax Chari-1 in different villages of Karnal district.

Revenue Generated by KVK/DTC

Total revenue generated at KVK through various activities during January to December 2011 was ₹30,23,307/-.

Agricultural Technology Information Centre (ATIC)

Keeping in view the significance of information and Communication techniques (ICT) in the current scenario, Agriculture Technology Information Centre is fully functional since November, 2004. The Agricultural Technology Information Centre (ATIC) is a single window system with an objective to help the farmers, entrepreneurs, extension workers, development agencies, non-governmental organizations (NGO's), private organizations and other stakeholders, both to provide solutions to their location specific problems and make available all the technological information along with technology inputs and products for testing and use by them.

During last year 23200 farmers from 17 states visited ATIC which included 79 delegates from different countries such as USA, Ethiopia, Denmark, Finland, Kajaktistan, Nepal, etc. To improve health & productivity of dairy animals, different technological interventions in the area of Nutrition, Breeding, Physiology and Health Care were suggested to 21468 stake holders whereas 3458 stakeholders were suggested different technological interventions in the area of livestock production management and milk processing and 1242 cases were referred for specialized guidance to different divisions of the Institute and 1790 cases to sister institutes located at Karnal. During above said period, the centre generated revenue of Rs. 908678/- which includes Rs.136090/- from sale of publications & Rs. 772588/- from sale of seeds and cultures. Agricultural Technology Information Centre also provided on-line guidance to 5216 stakeholders through e-mail and telephone (Toll Free-1800-180-1199) whereas 1092 video shows were organized for the visitors.

4 EDUCATION AND TRAINING

NDRI is the premier Institution of International repute in Human Resource Development for growing dairy industry in India. NDRI conferred with the status of "Deemed to be University" vide Govt. of India, Ministry of Human Resource Development, Department of Education Notification No. F. 9-15/85-U.3 dated 28.3.1989, is well equipped with modern laboratories and highly qualified faculty to meet emerging needs of the Dairy Industry. The university offers academic programmes both at under-graduate and post-graduate levels in the field of Dairy Science and Technology. The following courses were offered by NDRI Deemed University during the academic session 2011-12.

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. The graduates are expected to acquire the necessary skills for all the essential operations in a milk processing plant.

Master's and Doctoral Degree Programmes

The Institute offers Masters' degree programmes in the following disciplines: i) Dairy Microbiology; ii) Dairy Chemistry; iii) Dairy Technology; iv) Dairy Engineering; v) Animal Biochemistry; vi) Animal Biotechnology; vii) Animal Genetics and Breeding; viii) Livestock Production and Management; ix) Animal Nutrition; x) Animal Physiology; xi) Dairy Economics; xii) Dairy Extension Education, and xiii) Agronomy (Forage Production).

The Institute offers Doctoral programmes in all the above disciplines except Agronomy (Forage Production).

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

Master's degree	₹ 7560/- P.M. for two years plus ₹ 6000/- per annum as contingency.
Ph.D.	₹ 10,500/- P.M. for three years and ₹ 10,000/- per annum as contingency.
Ph.D. (In-service)	₹ 1000/- P.M. for three years and ₹ 10000/- per annum as contingency.

ICAR Junior Research Fellowship

Master's degree	₹8640/- P.M. (for non veterinarians) and ₹ 12,000/- P.M. (for veterinarians) for two years and ₹ 6000/- per annum as contingency.

ICAR Senior Research Fellowship

Ph.D.	₹12000/- P.M. (for non veterinarians) for 1st and 2nd year and ₹14,000/- for 3rd year; and Rs. 10000/- per annum as contingency.
Ph.D.	₹14,000/- P.M. (for veterinarians) for 1st and 2nd Year and ₹ 15000/- for 3rd year; and ₹ 10000/- per annum as contingency.
Ph.D. (In-service)	₹1000/- P.M. for 3 years and ₹ 10,000/- per annum as contingency.

National Talent Scholarship

The National Talent Scholarship (NTS) @ ₹ 1000/- per month is awarded by ICAR on merit to B. Tech. students, provided that the university/institute is located outside the state of his/her domicile.

A number of scholarships are offered by corporate and individual donors i.e. M/s Nestle India Ltd., Dr. L. C. Sikka Memorial Trust, Dr. D. Sundaresan Memorial, Dr. P. G. Nair Award, Bhogi Bhai and Sushila Ben Mehta Trust, Dr. I. S. Verma Memorial, Alumni Silver Jubilee Scholarship, Dr. P. Bhattacharyya Memorial Trust, M. M. Malik Memorial Scholarships and Prof. R. D. Verma Scholarship.

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 Masters 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 ₹ 20,000 to 60,000/- per month. In addition to employment, a number of students also opt for higher studies in India and abroad.

Counselling for Admissions

Counselling for admission to UG and PG programme was held by the Education Division of ICAR on 15th June, 2011 and 27th, 30th June and 1st July, 2011, respectively at NASC Complex, New Delhi. Counselling for admission to Ph.D. Programme was held on 11th – 13th July, 2011.

Entrance Examination

An all India Competitive Entrance Examination for admission to Ph.D. programme for the session 2011-12 was conducted by NDRI on 19th June, 2011 at three centres i.e. Karnal, Bangalore and Kalyani.

Admissions

During academic session 2011-12, a total of 44 students joined B.Tech. (Dairy Technology), 140 students joined Masters programme including two foreign nationals, one from Vietnam and one from Nepal, and 106 students including one foreign national from Ghana joined the Ph.D. Programme.

Degrees Awarded

During the period under report, 20 B.Tech. (DT), 104 Masters in Dairying and 37 Ph.D. students were awarded degrees during 10th Convocation of NDRI.

Meetings

- 69th Meeting of the Standing Committee on Course Curricula and Academic Affairs was held on 4th October, 2011.
- 70th meeting of the Standing Committee on Course Curricula and Academic Affairs was held on 1st February, 2012.
- 47th meeting of the Standing Committee on Faculty, Students Problems and Discipline was held on 3rd February, 2012.
- 32nd Meeting of Academic Council was held on 14th February, 2012.

Tenth Convocation of NDRI Deemed University

Tenth Convocation of NDRI Deemed University was held on 21st February, 2012. Padma Vibhushan Dr. M.S. Swaminathan, Member of Parliament (Rajya Sabha) & Chairman, M.S. Swaminathan Foundation delivered the Convocation Address. Dr. A.K. Srivastava, Director & Vice Chancellor, NDRI Deemed University presented the Convocation Report. A total of 161 students (including 40 girls) were conferred different degrees i.e. B.Tech. (Dairy Technology) -20, Master's -104 and Doctoral – 37. Four topper students were awarded the Director's Gold Medals; Ms. Chitra Gupta (B.Tech, Dairy Technology); and Ms. Gurpreet Kaur (Processing Group), Mr. Pankaj Kumar. (Production Group), Mr. Gagandeep Singh (Management Group) in the Master's degree programme. Ms. Tashi Zangmo (B. Tech., Dairy Technology), Ms. Richa Singh, M. Tech. in Dairy Chemistry (Processing Group), Mr. Amit Kumar, M.V. Sc. in Animal Genetics & Breeding (Production Group) and Mr. Ashok Baindha, M.V.Sc. in Dairy Extension Education (Management Group) were awarded Merit Certificates for securing second position in B.Tech and different groups in Master's degree programmes, respectively.

Award of Honorary Degrees

Honorary degree of Doctor of Science -D.Sc. (Honoris Causa) was conferred on Dr. R. Nagarcenkar former Director, NDRI & Dy. Director General (Edn.) and Dr. N. R. Bhasin President Indian Dairy Association & former Principal Secretary to Government of Rajasthan during the 10th convocation of NDRI, in recognition of their contribution in dairy education, research and development of dairy sector.

Best Thesis Awards

Best Thesis Awards for Master's and Doctoral theses (one each in Production, Processing and Management groups) carrying a citation, a certificate and ₹5000 for Best Master's Thesis and ₹10,000 for Best Doctoral Thesis. Two theses in each programme were recommended by committees in each discipline. The students presented their theses before the Award Committee. The award committees evaluated the theses and gave their recommendations for the Best Thesis Awards in their respective groups as given below:

Best Doctoral Thesis Awards

Group	Name of the Student	Name of the Guide	Discipline
Processing	Ms. Gurpreet Kaur	Dr. R. K. Malik	Dairy Microbiology
Social Science & Management	Mr. Raj Kumar Yogi	Dr. N. K. Verma	Dairy Economics.
Production	Ms. Nisha Jha	Dr. S. S. Kundu	Animal Nutrition

Best Master's Thesis Awards

Group	Name of the Student	Name of the Guide	Discipline
Processing	Mr. Amit Kumar Barui	Mr. Rajan Sharma	Dairy Chemistry
Social Science & Management	Mr. L. L. Michal Khoveio	Dr. D. K. Jain	Dairy Economics
Production	C. S. Patil	Dr. A. K. Chakravarty	Animal Genetics and Breeding

Dr. D. Sundaresan Memorial Lecture Award

The Third Dr. D. Sundaresan Memorial Lecture Award was bestowed on Agricultural Scientist, Padma Vibhushan Dr. R. S. Paroda, Former Secretary, DARE and Director General, Indian Council of Agriculture Research and presently the Chairman, Haryana Farmers' Commission on 10th February, 2012. The award carries an amount of ₹20,000, a citation, shawl and certificate.

Dr. M.S. Swaminathan delivering convocation address during Tenth Convocation of NDRI

Dr. K. K. Iya Oration Award

The First Dr. K. K. Iya Award was bestowed on Dr. V. K. Taneja, Vice Chancellor, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana on 14th February, 2012. The award carries an amount of ₹ 20,000, a citation, shawl and a certificate.

Dr. N. N. Dastur Oration Award

The First Dr. N. N. Dastur Oration Award was bestowed on Dr. Tej Partap, Vice Chancellor, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar on 27th February, 2012. The award carries an amount of ₹ 20,000, a citation, shawl and a certificate.

Presentation of Academic Achievements and Innovations in Teaching

The Heads of Divisions presented the innovations and significant achievements of their Divisions in education/research and consultancy during the year 2011-12 on 6th February, 2012. The faculty and students participated in the deliberations.

Group Photo of Academic Procession during Convocation 2012

5 HONOURS / AWARDS

- **Dr. A. K. Srivastava**, Director, NDRI received **"Chellapa Memorial Oration Award"** of Indian Society of Veterinary Pharmacology & Toxicology for the year 2011.
- **Dr. Ramya Iyer**, Ph.D. Scholar, Dairy Microbiology Division was given **"Jawaharlal Nehru Award"** for P.G Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2010. She did her Ph.D. work under the guidance of Dr. S. K. Tomar.
- **Dr. Rekha Ravindra Menon** received the **"Jawaharlal Nehru Award"** (2010) for Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences at ICAR.

Best Doctoral Thesis Awards (Convocation - 2012)

- Ms. Gurpreet Kaur, Ph.D. in Dairy Microbiology (Processing Group), Major Advisor: Dr. R. K. Malik, Principal Scientist.
- Mr. Raj Kumar Yogi, Ph.D. in Dairy Economics (Management Group), Major Advisor: Dr. N. K. Verma, Principal Scientist.
- Ms. Nisha Jha, Ph.D. in Animal Nutrition (Production Group), Major Advisor: Dr. S. S. Kundu, Head.

Best Master's Thesis Awards

- Mr. Amit Kumar Barui, Dairy Chemistry (Processing Group), Major Advisor: Mr. Rajan Sharma, Sr. Scientist.
- Mr. L.L. Michal Khoveio, Dairy Economics (Management Group), Major Advisor: Dr. D. K. Jain, Principal Scientist.
- Mr. C. S. Patil, Animal Genetics and Breeding (Production Group), Major Advisor: Dr. A. K. Chakravarty, Principal Scientist.

- **Dr. Sachin K. Shelke** was conferred **"Dr. S. K. Ranjhan Award"** (2009-2011) by the Animal Nutrition Society of India for the best Ph.D. thesis entitled "Milk production, immune status and reproductive performance of murrah buffaloes supplemented with rumen protected fat and protein" under the guidance of Dr. S. S. Thakur.
- **Dr. P. Narender Raju**, Scientist, Dairy Technology Division, NDRI, Karnal receiving **"Young Researcher Award"** at the "International Conference on Functional Dairy Foods-2011" organized by Dairy Technology Society of India and NDRI, Karnal during 16th - 19th November, 2011 at NDRI, Karnal.
- **Mr. Vikas Sangwan** got **"Young Scientist Presentation Award (Second Best)"** for the paper presentation entitled "Galactooligosaccharides production by S. thermophilus" at nternational Conference on Functional Dairy Foods, Dairy Technology Society of India (DTSI), NDRI, Karnal (16th – 19th, November 2011).
- **Ms. Seema**, Dairy Microbiology Division was given **"Young Scientist Award"** for the year 2011 for her paper on "Effect of oat and milk based probiotic fermented product on Type 2 Diabetes" at National seminar on fermented foods, BHU, Varanasi held on 8th - 9th April, 2011.
- **Ms. Prerna Saini** got **"Young Scientist Award"** for her oral presentation on "Production and characterization of caseino phosphopeptides from buffalo casein" at National Seminar on Fermented Foods, Banaras Hindu University, Varanasi, held at 8th - 9th April 2011.
- **Dr. S. Ganguly** and **Dr. (Mrs.) L. Sabikhi** were awarded the **"Young Researcher Award"** (2011) for the paper "Fermentation dynamics of a probiotic strain of Lactobacillus acidophilus (NCDC-13) in a composite dairy-cereal substrate" presented at the National Seminar on Recent Advances in the Development of Fermented Foods. BHU, Varanasi. 8th-9th April, 2011.
- **Ms. Veena N.**, **Dr. Sumit Arora**, **Dr. R. R. B. Singh** and **Dr. (Mrs.) Suman Kapila** were awarded **"1st Prize for Oral Presentation"** on "Effect of addition of Shatavari in milk on functional, immunomodulatory and antioxidative properties" during the National Conference on "Current Status and Recent Advances in Medicinal and Aromatic Plants Research" held at Gandhi Medical College & Hospital, Mushirabad, Hyderabad.
- **Ms. Madhumita Majumdar**, and **Dr. B. Surendra Nath** were awarded **"1st Prize for Oral Presentation"** on "Optimization of conditions for Seliwanaff's method for

estimation of sucrose content in gulabjamun" at National Conference on "19th West Bengal State Science & Technology Conference" held at Kolkatta from 1st – 2nd March, 2012.

- **Dr. Raka Saxena**, **Dr. Smita Sirohi** and **Ms. Massoumeh N. Zadeh** were awarded the **"Best Paper Award"** by IDA for the paper entitled "Aftermath of global economic crisis: impact on Indian dairy sector" published in Indian Journal of Dairy Science for the year 2010.

- **Dr. P. K. Roy**, **Dr. R. B. Singh, Dr. A. Chatterjee** and **Dr. R. C. Saha** were awarded the **"Best Paper Award"** by IDA for their paper entitled "Micro climatic variables under different dairy cattle shelter systems of rural West Bengal and its impact on milk production published in Indian Journal of Dairy Science for the year 2010.

- **Dr. Archana Verma, Mr. Bharat Kumar, Mr. Indrasen Chauhan, Dr. I. D. Gupta** and **Dr. R.S. Gandhi** received **"Best Paper Award"** for Research paper on "Molecular characterization of fore-brain embryonic zinc finger like gene in Murrah buffalo" presented during National Conference on Biotechnology, Bioinformatics and Bioengineering at Kolhapur from 24th -25th February, 2012.

- **Mr. Nitin Tyagi, Dr. S. S. Thakur** and **Mr. Sachin Shelke** were awarded **"Outstanding Paper Award"** for the period (2009-2011) by Animal Nutrition Society of India for their research paper "Effect of feeding bypass fat supplement on milk yield, composition and nutrient utilization in cross bred cows", published in the Indian Journal of Animal Nutrition Vol.26: 1-8.

- **Ms. Prerna Saini, Dr. Bimlesh Mann, Dr. Rajesh Kumar, Ms. Anuradha Kumari** and **Mr. Parbhakar Padhghan** got **"Best Poster Presentation Award"** for their paper entitled "Production and identification of caseinophosphopeptides from buffalo casein" presented in the XL Dairy Industry Conference held at New Delhi from 2nd -5th Feb. 2012.

- **Mr. Laxmana Naik, Ms. Neelima Sharma, Dr. Rajan Sharma** and **Dr. Y. S. Rajput** got the **"Best Poster Award"** on the topic Glycomacropeptide - Star functional ingredient from milk, in the 'Poster - Walkway Discovery' at 7th Nutra India Summit, held on 15th – 17th March 2012, at The Lalit Ashok, Bangalore.

- **Ms. Isha Sharma, Ms. Rachna Monga, Mr. Natwar Singh** and **Dr. Dheer Singh**. Animal Biochemistry Division were awarded **"Best Poster Presentation (First Prize) Award"** for their poster paper entitled "Transcriptional control of peroxisome proliferators activated receptor –gamma by novel tissue specific promoter" in National Symposium on recent advances in reproductive biotechnology: Retrospective and prospective vision held at NDRI, Karnal on 30th - 31st January, 2012.

- **Mr. V. P. Varma, Mr. S. Sebastian, Mr. M. Kapasiya, Dr. (Mrs.) S. Kapila, Dr. A. K. Dang** and **Dr. R. Kapila** were given **"1st Prize"** in the session of immune response and therapy for poster presentation entitled " Lactobacillus heveticus fermented milk modulates innate immunity by activating macrophages and neutophils" in Biotech 2012 " Current Advances in Biotechnology and Medicine" organized by Institute of Liver and Biliary Sciences and Biotechnology Society of India on 24th - 25th February, 2012 at Delhi.

- **Mr. P. Mishra, Dr. (Mrs.) L. Sabikhi, Mr. R. R. Mishra**, and **Mr. N. Misra**, were awarded the **"Best Poster Award"** for their poster on "Development of fermented pearl millet khichri and its sensory attribute analysis" at the National Seminar on Recent Advances in the Development of Fermented Foods held at BHU, Varanasi on 8th – 9th April, 2011.

- **Mr. S. Kumar and Dr. S. K. Kanawjia**, bagged **"Best Poster Presentaion Award-2011"** for their poster on "Process development for manufacture of reduced sodium feta cheese from buffalo milk using microbial rennet", at the National Seminar on Recent Advances in the Development of Fermented Foods held at BHU, Varanasi on 8th – 9th April, 2011.

- **Ms. Richa Singh, Dr. Rajesh Bajaj, Dr. Bimlesh Mann, Mr. Ramesh V.** and **Ms. Seema Rana** were given **"Best Paper Award"**

for their paper on "Antioxidant potential of strawberry polyphenol extract in presence of milk proteins" at the National Seminar on Recent Advances in the Development of Fermented Foods held at BHU, Varanasi on 8th – 9th April, 2011.

- **Ms. Richa Singh, Mr. Rajesh Kumar, Mr. Ramesh V., Ms. Seema Rana, Dr. (Mrs.) Bimlesh Mann** and **Ms. Anuradha Kumari** were given **"2nd Best Poster Award"** for their poster on "Antioxidant potential of strawberry polyphenol extract in presence of milk proteins" at the National Seminar on Recent Advances in the Development of Fermented Foods held at BHU, Varanasi on 8th – 9th April, 2011.

- **Ms. M. Archana, Dr. S. Mandal, Dr. S. K. Tomar** and **Dr. R. Singh** got **"Second Best Poster Award"** for "Characterization of lactic acid bacteria in mixed strain mesophilic ld-type dahi cultures" in National Seminar on Recent Advances in the Development of Fermented Foods held at BHU, Varanasi on 8th – 9th April, 2011.

- **Mr. Ali, Babar, Dr. S. K. Tomar, Mr. Vikas Sangwan** and **Dr. R. R. B. Singh** were given **"Best Poster Award"** for the paper "Production of galactooligosaccharides (GOS) from whey using enzyme isolated from Kluyveromyces spp. and assessment of their prebiotic potential" during International Conference on Functional Dairy Foods, 16th – 19th November, NDRI, Karnal.

- **Mr. Kamal Gandhi, Dr. Sumit Arora** and **Dr. R. R. B. Singh** were given **"Best Poster Award"** for their paper "Effect of herb extract (Pueraria tuberosa/vidarikand) incorporation on storage stability of ghee (clarified butter fat)" during International Conference on Functional Dairy Foods, 16th – 19th November, NDRI, Karnal.

- **Mr. Parbhakar Padhghan, Dr. Bimlesh Mann, Dr. Rajesh Kumar, Ms. Prerna Saini** and **Ms. Anuradha Kumari** were given **"Best Poster Award"** for "Biofunctional properties of traditional Indian Lassi prepared from buffalo milk " in Indian Dairy Conference on Dairying: Path to Sustainability held at Kolkata, 4th – 6th February, 2011.

- **Mr. G. Thakur, Mr. N. Kumar, Mr. H. V. Raghu** and **Mr. M. Balhara** were awarded **"First Prize"** for the development of a novel micro technique and media for selective enumeration and detection of Enterococci in milk (FQ-05) at the XXI ICFOST on innovations in food science and technology to fuel the growth of the Indian food industry organized during 20th - 21st January, 2012 at Pune, India.

- **Dr. I. K. Sawhney** and **Dr. P. S. Minz** received **"1st Best Paper Award"** for "Khoa ko satat roop se thanda karne kye liye yantrikrit pranali ka vikas" organized by Rastrabhasha unit on 14th September, 2011.

- **Ms. Uma T. Maheswari, Dr. Rameshwar Singh**, **Mr. Prashant** and **Dr. Sudhir K. Tomar**, Dairy Microbiology Division were given **"Second Prize"** for their poster paper on "Evaluation of genotypic heterogeneity of Streptococcus thermophilus strains isolated from dairy and plant sources in India" during Annual Institute of Food Technologist meeting held at New Orleans (11th -14th, June 2011).

- **Mr. Anbukkarasi. K., Mr. Dhiraj Nanda, Ms. Uma Maheswari, Mr. T. Prashant** and **Dr. Rameshwar Singh**, Dairy Microbiology Division got **"Second Prize"** for their poster paper on "Molecular characterization of gal operon in galactose fermenting S. thermophilus strains isolated from natural sources" during National Conference on "New Horizons in Bioprocessing of Foods organized by Department of Food Engineering and Technology, SLIET, Longwal, Panjab on 25th – 26th February, 2011.

- **Mr. Laxmana Naik, Dr. Bimlesh Mann, Dr. Rajesh Bajaj** and **Dr. R. B. Sangwan** were given **"Best Poster Award (Second Prize)"** for "Optimization of bio-functionality and techno-functionality of whey protein hydrolysates by trypsin enzyme" under the process and product development category, during the 2nd International Conference on

Functional Dairy Foods held at NDRI Karnal from 16th – 19th November, 2011.

- **Mr. V. H. Miri, Mr. A. Tyagi, Dr. A. K. Tyagi** and **Dr. R. R. B. Singh** were given **"Second Best Poster Award"** for their paper "Effect of plant extracts on rumen bacterial population and CLA concentration" during International Conference on Functional Dairy Foods, 16th – 19th November, NDRI, Karnal.

- **Ms. K. C. Neethu, Ms. F. Magadaline Eljeeva Emerald, Dr. B. Surendra Nath, Ms. M. K. Vedavathi, Dr. Menon Rekha Ravindra, Dr. P. Heartwin Amaladhas** and **Dr. B. V. Balasubramanyam** got **"3rd Prize Poster Presentation"** entitled "Sensory evaluation modeling of buttermilk drinks using fuzzy logic approach" (during the National Conference on ''Appropriate Technologies for Indian Food Industries" organized at UAS, GKVK, Bangalore from 5th – 6th March, 2012.

- **Dr. Dheer Singh**, Animal Biochemistry Division was awarded **"SAB Eminent Biotechnologist Award 2011"** by Society for Applied Biotechnology at the 2nd National Conference on Biotechnology, Bioinformatics and Bioengineering, held at Kohlapur, Maharashtra on 24th- 25th Feb., 2012.

- **Dr. Dheer Singh**, Animal Biochemistry Division was awarded **"Fellow Award 2011"** by Society For Applied Biotechnology at the 2nd National Conference on Biotechnology, Bioinformatics and Bioengineering held at Kohlapur, Maharashtra on 24th- 25th Feb., 2012.

- **Dr. Chander Datt** and **Dr. S. S. Kundu** received **"Second Prize"** for Hindi Book "Gai-bhains ke shawakon ka vaigyanik dhang se poshan avum prabandhan, during Hindi Divas held in Sept., 2011

- **Dr. Chander Datt, Dr. N. P. Singh and Dr. K. M. Bujarbaruah** got **"Third Prize"** for Hindi article "Pashu aur kukkut ahaar gunvatta- jaanch ke asaan tarike" during Hindi Divas held in Sept., 2011 published in Krishi Chayanika.

- **Ms. Isha Sharma** and **Dr. Dheer Singh** Animal Biochemistry Division were awarded **"Best Oral Presentation (Third Prize) Award"** for their poster paper entitled "Direct action of natural and synthetic ligands on buffalo granulosa cell proliferation and steroidogensis" in International conference on reproductive health with emphasis on strategies for family planning, 22nd meeting of Indian society for study of reproduction and fertility (ISSRF) held at AIIMS, New Delhi, India from 19th-21st February, 2012.

- **Ms. Sakshi Khurana** and **Dr. V. K. Gupta** were awarded **"Third Prize"** for the poster entitled "Quality of cow milk set dahi as affected by ultrfiltration concentration of milk" in the field of Dairy processing at XL Dairy Industry Conf., New Delhi held from 2nd – 5th February, 2012.

- **Dr. K. Khamrui, Mr. Sanket Borad and Mr. Gunvant Rathod** got **"First Prize"** in the 4th National Dairy & Food Quiz Contest held at SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat during 22nd – 23rd September, 2011.

- **Dr. K. Khamrui, Ms. Anu Kumari, Ms. Rashmika Asari** and **Mr. Anuj Pal** got **"Third Prize"** in the 8th National Dairy Product Judging Contest held at SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat during 22nd – 23rd September, 2011.

- **Dr. V. K. Batish**, Former Head and Emeritus Scientist has been elected Fellow of National Academy of Agricultural Sciences for the year 2012-2013 for his outstanding contributions in the area of Biotechnology and Microbiology, particularly in the area of Probiotics.

- **Mr. Harsh Panwar**, Ph.D. student working under the guidance of Dr. Sunita Grover was awarded **"Inspire Fellowship"** from Department of Science & Technology from January, 2011.

- **Mr. Harsh Panwar**, Ph.D. student working under the guidance of Dr. Sunita Grover was awarded **"Commonwealth Split Site Scholarship"** from Commonwealth

Scholarship Commission, UK tenable in Queens University, Belfast (UK) from October 2011 till October 2012.

- **Mr. S. Hati, Dr. D. N. Gandhi, Dr. S. Vij, Dr. S. Mandal** and **Mr. M. Dahiya** got **"Second Best Paper Award"** of IDA for their paper "Process optimization for a drinkable acidophilus milk" published in the "Indian Journal of Dairy Science" for the year 2010.
- **Dr. S. K. Tomar** was awarded **"European Union ERASMUS MUNDUS"** visiting Fellow award, 2010.
- **Ms. Poonam** and **Dr. S. K. Tomar** received **"First Prize"** for their paper "Trehalose utpadak dairy Propionibacteria ka vilagan avam nirupan" in NDRI Rajbhasha Samaroh Poster Competition 2011.
- **Mr. Vikas Sangwan** and **Dr. S .K. Tomar** got **"Second Prize"** for their paper "Streptococcus thermophilus main nishkriht kiye gaye enzyme dwara whey se GOS ka utpadan avam is ke probiotic prabhavon ka mulyakan" in NDRI Rajbhasha Samaroh Poster Competition 2011.
- **Dr. Smita Sirohi** was invited to act as Member Secretary of Sub-group IX on "Investment, credit, insurance and animal husbandry statistics" under Planning Commission Working Group on Animal Husbandry & Dairying for the 12th Five Year Plan.
- **Dr. A. K. Sharma** was invited to join the Editorial Board of the: "Journal of Computer Technology and Applications" by STM Journals, the Consortium e-Learning Network Private Ltd., (CELNET) Noida, INDIA.
- **Dr. S. Kulkarni**, Head, SRS, Bangalore was nominated for the second term as Scientific Committee Panel member on food additives, flavourings, processing aids and materials in contact with food by the Food Safety and Standards Authority, New Delhi.
- **Dr. S. Kulkarni**, Head, SRS, Bangalore was elected as Chairman, Indian Dairy Association (SZ) from 2011-2014.
- **Dr. Satish Kulkarni, Dr. B. Surendra Nath, Dr. B. C. Ghosh** and **Dr. B. V. Balasubramanyam** were qualified as Lead Auditor after successfully completing the course on the Food Safety Management Systems of ISO 22000:2005 conducted during the 13th – 17th September 2011 at Bangalore by the Indian Register of Shipping, Mumbai.

Dr. Rekha Ravindra Menon receiving Jawaharlal Nehru Award 2010 from Hon'ble Union Minister for Agriculture, Sh. Sharad Pawarji

6 RESEARCH COLLABORATIONS

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

Linkages with International/National Agencies

Area	Project/PI	Sponsoring Agency
Reproduction Genomics	Fertility Performance and Analysis of *CYP19* Gene Regulation in Buffalo (Dheer Singh)	DBT
Bioactive/Nutraceutical/ Therapeutic Milk Proteins	Energetics and Dynamics of Protein Stability and Iron Binding Properties and their Modulation by Domain-Domain Interactions in Lactoferrins from Various Animal Species (J. K. Kaushik)	DBT
Genomics	Cloning, Expression and Functional Characterization of a Mammary Gland Protein MGP-40 Expressed during Mammary Gland Involution and Exploring its Potential as a prognostic Mammary Biomarker in Farm Animals (A. K. Mohanty)	DBT
Embryo Production Techniques	Conservation and Multiplication of Germplasm of Yak (Poephagus Grunniens L.) and its Hybrid using *in vitro* Embryo Production Techniques (M. S. Chauhan)	DBT
Reproduction Genomics	Comparative Analysis of Epigenic Regulation of the *Cyp19* Gene in Buffalo and Cattle (Dheer Singh)	DST-DFG (Indo-German Project)
Medical and Nutritional Sciences	Mechanisms of Cholesterol Transfer into Milk – A Comprehensive Gene Expression and Metabolism Study in Buffalo and Cattle (B.S. Prakash).	DST-DAAD
Nutrition and Immunity	Effect of Micronutrients Supplementation on Hormones, Milk Yield, Udder Health and Immunity in Crossbred and Indigenous Cows (A. Aggarwal)	DBT
Embryo Production	Embryo Production by Ovum Pick-up from Live Cattle (M. S. Chauhan).	DBT
Stem Cell	Reprogramming of Goat Fibroblast Cells by Introducing Transcription Factor Genes to Produce Induced Pluripotent Stem (ips) Cells (D. Malakar)	DBT
Animal Nutrition	Rumen Microbial Manipulations for Mitigation of Methane Emission and Productivity Enhancement in Dairy (S. K. Sirohi).	NFBSFARA
Micro-encapsulation	Micro-encapsulation of Bacteriocins for their Controled Release (R. K. Malik)	CIPHET, Ludhiana; (NFBSFARA)
Cellular Immunity	Molecular Basis for Modulation of Immuno Competence of Neutrophilic Function in vivo and *in vitro* of High Producing Cows and Buffaloes Peripartum (A. K. Dang and Shiv Prasad)	DBT
Quality Assurance	Developing & Evaluation of Multiple Micro-nutrient (Mineral & vitamins) Fortified Milk for Consumer Market (Sumit Arora).	DBT
Probiotics	Development of Traditional Fermented Dairy Products Enriched with an indigenous Probiotic Strain for Promoting the Health and well being of Consumers (Sunita Grover)	MFPI
Quality Assurance	Investigations on High Pressure Induced Effect on Quality Characteristics of Buffalo Milk (A. K. Singh)	NFBSFARA

Animal Production	Bovine Sub-clinical Mastitis in Crossbred Dairy Cattle, Early Diagnosis and Control for Enhancement of Milk Production under Field Conditions : An Integrated Approach (D. N. Dass)	NABARD
Sire Evaluation	Indigenous Breed Improvement Programme (Sahiwal cattle) (R. S. Gandhi)	PDC, Meerut; Govt. Livestock Farm, Lucknow; Govt. Livestock Farm, Hisar; GADVASU, Ludhiana; Sh. Gaushala Trust, Bhiwani
Extension Service	Dairy Extension Education and Services at Farmers' Door through Mobile Extension Unit: Action Research (Jancy Gupta)	NABARD
Reproduction	Deciphering the Mechanism of Aberrant Maternal Recognition of Pregnancy Events in Sheep and Buffalo under Heat and Nutritional Stress (T. K. Datta)	NFBSFARA
Climate Change	National Initiative on Climate Resilient Agriculture (R. C. Upadhyay)	CRIDA
Probiotics	Application of Probiotics in Alleviating Allergic Responses and Immuno-senescence (Rajiv Kapila)	DBT
Crossbred Male Infertility	Molecular Characterization of A Semi-domestic Cattle Breed of Jammu and Kashmir (S. De.)	DBT

Linkages with State Agricultural Universities/State Departments/Other ICAR Institutes/Industries

Area	Project/PI	Collaborating Agencies
Indigenous Milk Product Technologies	Network Project on R&D Support for "Process Upgradation of Indigenous Milk Products for Industrial Application" (G. R. Patil).	AAU Anand; WBUAFS, Mohanpur (W.B.); SRS, Bangalore; BHU, Varanasi.
Organic Farming	Studies on Organic Milk Production System in the Plains of West Bengal (P. K. Roy).	Department of Veterinary Pharmacology & Toxicology, WBUAFS, Kolkata
Progeny Testing of Murrah Buffaloes	Network Project on Buffalo Improvement (A. K. Chakravarty and Avtar Singh).	CIRB, Hisar; PAU, Ludhiana and CCS HAU, Hisar; IVRI, Bairelly; NDAUT, Faizabad
Environmental Physiology	Impact Adaptation and Vulnerability of Indian Agriculture to Climate Change (R. C. Upadhyay).	ICAR (Network Project)
Environmental Physiology	Adaptation and Facilitation of Livestock to Impending Climatic Changes through Shelter Management (R. C. Upadhyay).	ICAR (Network Project)
Reproduction Genomics	Buffalo Production and Reproduction Genomics (T. K. Datta).	Niche Area (ICAR)
Rumen Manipulation	Rumen Microbial Manipulation for Mitigation of Methane Emission and Productivity Enhancement in Dairy Animals (S. K. Sirohi and A. Santra).	NIANP, Bangalore; IVRI, Izatnagar (NFBSRA)
Genomics	Molecular Characterization of Semi Domestic Cattle Breed of Jammu and Kashmir (S. De.).	Doda, SKUAST, Jammu

Endocrinology	Development of Plasma Catecholamines Assays for Evaluation of Sympathetic Neuronal Function and Milk Production Performance in Heat Stressed Cows (Mahendra Singh).	RTAC, BRNS, Mumbai
Quality Assurance	Monitoring of Drug Residues and other Environmental Pollutants (N. K. Goel).	College of Veterinary Science, Mumbai; Chennai; Kolkatta; Gujrat; Pantnagar; A. P.; M. P.; Ranchi; Guwahati; Patna; NRC on Yak, Dirang; NIANP; Bangalore; Outreach Project (ICAR)
Microbiology	Scheme on Dairy Microbes under Network Mode (Remeshwar Singh).	ICAR Network
Lactation Physiology	Candidate Gene Analysis and Identification of Allelic Variants Associated with the Incidence of Mastitis in Dairy Cattle and Buffalo (A. K. Dang).	NBAGR
Feed Resources	Nutritional Evaluation of Azolla for Utilization in Ruminant Ration (A. Chatterjee).	Regional Station for Forage Production and Development, Kalyani, Govt. of India.
Feed Resources	Evaluation and Utiliztion of Brewers Spent Grain as Cattle Feed Supplement (A. Santra).	Dept. of Animal Nutrition, WBUAFS, Kolkata
Conservation of sheep	Conservation of Garole Sheep (Ajoy Mandal)	Directorate of Animal Resources and Animal Health, Govt. of West Bengal. State Livestock Farm, Kalynai, Nadia

NAIP Projects

Area	Project/PI	Collaborating Agencies
NDRI as Lead Institute		
Oocyte/Embryo/ Genomics	Elucidating the Physiological and Genomic Regulation Process of Follicular Development, Oocyte Maturation and Embryogenesis in Buffalo (T. K. Datta)	CIRB, Hisar, NIANP, Bangalore and IISC, Bangalore
Stem Cells	Characterization and Differentiation of Embryonic and Spermatogonial Stem Cells in Cattle and Buffaloes (M. S. Chauhan)	PDC, Meerut
Genomics/ Proteomics	Analysis of Mammary Gland Transcriptome and Proteome during Lactation and Involution in Indigenous Cattle and Buffalo for Identification of Probable mammary Markers (A. K. Mohanty)	NBAGR, Karnal and NCHGS&R, Punjab University, Chandigarh
Semen Cryo-preservation	Molecular basis of Capacitation Like Changes in the Assessment and Prevention of Cryodamage during Cryopreservation of Bovine Spermatozoa (Buffalo and Crossbred Bulls) (S. K. Atreja)	SKUAST, Jammu
Reproduction Augmentation	Value Chain on Zona Free Cloned Embryos for Quality Animal Production from Elite Buffaloes and Pashmina Goats' (S. K. Singla)	SKUAST, Srinagar
Functional Dairy Products	Novel Approaches for Production of Nutraceuticles from Milk and Indian Herbs for Potential use in Functional Dairy Foods (R. R. B. Singh)	NBRI, Lucknow

Value Added Dairy Products	A Value Chain on Composite Dairy Foods with Enhanced Health Attributes (A. K. Singh)	CIPHET, Ludhiana; Arpana, Karnal and M/s New Millennium Health Foods Pvt. Ltd. NOIDA
E-education	Development of e-course for B.Tech (Dairy Technology) Degree Programme (A. A. Patel)	SVVU, Triupati; AAU, Anand
	NDRI as Consortium Partner	
Biosensors	Development of Biosensors and Micro-techniques for Analysis of Pesticide Residues, Aflatoxin, Heavy Metals and Bacterial Contamination in Milk (Naresh Goel)	BITS, Pilani, Goa, IIT, Delhi and Punjab University, Patiala
Bioinformatics	Development of wireless Sensor Network for Animal Management (T. K. Mohanty)	IIT, Delhi
Policy Planning	PME Cell under Visioning, Policy Analysis and Gender (V-PAGE) (Director, NDRI/B. S. Chandel)	NCAP Delhi; IASRI, Delhi; NAARM, Hyderabad; Yes Bank, Agriwatch; NRCWA, PME Cells
Animal Nutrition	Rumen Microbial Diversity in Domesticated and Wild Ruminants and Impact of Additives on Methanogenesis and Utilization of Poor Quality Fibrous Feeds (S. K. Sirohi)	IVRI, Izatnagar; GADVASU, Panjab; CIRB, Hisar
Nano Particles	Detection and Mitigation of Dairy Pathogens and Detection of Adulterants using Chemical Biology (Y. S. Rajput)	IIT, Roorkee; BITS, Pilani (Goa)
Reproduction Augmentation	Genetic basis of Inferior Sperm Quality and Fertility of Crossbred Bulls (S. De)	PDC, Meerut; IVRI, Izatnagar
Reproduction Augmentation	Development of Potency of Parthanogenetic Goat Embryos (D. Malakar)	IVRI, Izatnagar; CARI, Izatnagar; CIRG, Makhdoom; JNKVV, Jabalpur
Environmental Physiology	Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (R.C. Upadhyay)	IVRI, Izatnagar; CIRG, Makhdoom; NRC on Camel, Bikaner; VPKAS, Almora; NEHR, Lucknow; IIT, Kanpur; NBAGR, Karnal; CIBA, Chennai; IARI, New Delhi; NBFGR, Lucknow; CIFA, Bhubneshwar; CARI, Cuttak; DRR, Tamil Nadu
Animal Reproduction	Application of Reverse Genetics: A Novel Approach to Study the Molecular Basis of Differential Immune Response in Indian Cattle Breed (D. N. Das)	II Sc, Bangalore IVRI, Bangalore
Economics	Strengthening Statistical Computing for NARS (R. Malhotra)	IASRI, New Delhi; IVRI, Izatnarar; MPUAT, Udaipur; Water Technology Centre for Eastern Region, Bhubaneshawar; ICAR Res. Complex for NEH Region, Barapani; UAS, Bangalore; NAARM, Hyderabad; CIFE, Mumbai

7 EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

Dairy Extension Division

Empowerment of Farm Women in Dairy Farming through Self Help Groups

NDRI also worked towards Empowerment of Farm Women in Dairy Farming through Vishwas Self Help Group in village Kulwehri, Dist Karnal functioning since August, 2011. Women empowerment programme in the field of dairy farming was organized through 10 trainings with 120 man hours. The women empowerment training and campaigns were organized with the objective to create awareness in the field of dairying and home science and also impart skill in these areas so that farm women could generate more income from dairying and maintain healthy atmosphere in their respective families. Technology empowerment of farm women in value added milk products through 9 trainings with 216 man hours has increased their income by adopting these milk products technologies.

The women empowerment trainings and campaigns in the field of dairying and home-science were organized with the objective to create awareness, impart skill in these areas and mobilize the farmwomen to take up vocation in the field of dairying for generating income from dairying and develop healthy atmosphere in the family.

Programmes Organised

Name of the Course	Organised at	No. of Courses	Total Participants
Capacity building of farmwomen in value added milk products.	Subri, Shahpur, Kulwaheri, Vazidpur, Nasirpur, Nasirpur Tilla	24	369
Capacity building of farmwomen in scientific dairy farming.	Shahpur, Subri, Kulwahri	6	102
Capacity building of farmwomen in clean milk production practices.	Vazidpur, Shahpur, Nasirpur	5	71
Animal health & management practices.	Shahpur, Subri, Vazidpur	3	60
Preservation of fruits & vegetables.	Kulwahri, Shahpur, Vazidpur	6	106
Child Care & nutrition practices.	Subri, Kulwahri, Nasirpur	4	60
Awareness campaign on women empowerment through self help group.	Vazidpur, Kulwahri, Kharagpur	8	92
Total		**56**	**860**

Establishment of Women Empowerment and Capacity Building Laboratory

A new initiative was taken to establish women empowerment and capacity building laboratory for imparting training to different self-help groups of NDRI, DRDA and NGO. This lab has been 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. This lab. has a small demonstration unit equipped with cream separator, butter churner, fat testing machine, weighing machine, pedestal sealing machine, cooking utensils, cooking gas, refrigerator and microwave oven.

Training Programme Organised by KVK

Name of the Course	Organised at	No. of Courses	No. of Participants
Preservation of fruits & vegetables, preparation of tomato ketchup, milk based sweets, value added milk products, low cost nutritional recipes, kitchen gardening & its importance, child care and nutrition, stitching of ladies garments and storage of food grains.	KVK adopted villages	10	196
Scientific dairy farming.	KVK, NDRI	6	200
Scientific knowledge on dairy farming, home science and allied fields.	KVK, NDRI	4	750

Vermicompost making & its importance in organic farming.	KVK, NDRI	1	21
Embroidery.	KVK, NDRI	1	39
Entrepreneurship development in block printing.	KVK, NDRI	1	15
Entrepreneurship development through value added milk products i.e. paneer making and khoa making for self employment generation.	KVK, NDRI	2	38
Entrepreneur development through preservation of fruits and vegetables.	KVK, NDRI	1	13
Food processing.	KVK, NDRI	1	17
Mahila sangoshti.	Bazida Jatan and Rasina village	2	135
Capacity building.	KVK, NDRI	1	80

- KVK celebrated "Women in Agriculture" day on 3rd December, 2011 at village Bhaini Khurd of Karnal district in which about 110 farm women participated. They were apprised of various scientific technologies in dairy farming, crop production, milk processing, bee keeping and home science. A session on open discussion was held during the celebrations. Quiz competition to assess the knowledge in the field of dairying and agriculture was also organized and prizes were given to the winning candidates.

- International Women Day was celebrated in village Dhakwala on 9th March, 2011 in which more than 500 farm/rural women/girls volunteers of NGOs and women extension workers from 12 villages of the district participated. An exhibition of KVK activities was also put up.

ERS, Kalyani

- A meeting with the farmers and Development Personnel was organized at village Emlibari in Satjelia Gram Panchayat, Gosaba block, 24 (S) Parganas on 7th September 2011. Eighty nine women attended this programme and they were made aware of the programmes relating to livestock development.

Establishment of Milk Processing Unit at Village Level under NAIP Project

Entrepreneurship development campaign was launched for transferring some of the technologies that have been developed in the field of composite dairy foods. A total 150 women were contacted and workshops were organized to promote the entrepreneurship among them with complete techno-economic feasibility and modalities of technology transfer. A group of 14 women all resource poor villagers with an average monthly income of ₹4500/- only is formed and they were trained in for the manufacture of dairy products including the value added dairy products. A processing unit has been established at Amritpur Kalan located near Karnal and commercial production of various composite dairy foods is started since October, 2010. These women have earned a monthly turnover of ₹65000/- through sale of these products and generated a profit of ₹2000 per person monthly. Another unit is established at Village Shongi near Shimla for procuring and processing of milk into various value-added products. Based on the achievements of the project, ICAR has prepared a documentary named "Kamyabi ki Dastak".

Experts from USAID being appraised of the extension activities of NDRI at Village Amritpur Kalan on 12th August, 2011

8 PUBLICATIONS

Institute Publications

Arora, Sumit, Sharma, Prateek, Singh, R. R. B., Singh, A. K., Khamrui, Kaushik and Sabikhi, Latha (Ed.) (2011) *International Conference on Functional Dairy Foods (Souvenir)*. Dairy Technology Division, NDRI, Karnal.

Arora, Sumit, Bajaj, R. K., Sharma, V., Wadhwa, B. K. and Sharma. G. S. (2011) *Milk and Dairy Waste Management: Food Processing Management* (Ed.) V. K. Joshi and S. K. Sharma *New Delhi Publishing Agency, New Delhi*.

Chakravarty, Ritu, Upadhyay, R. C., Singh, Sohan Vir and Ranga, Jyoti (2012) *Increasing Farm and Livestock Resilience to Climate Change (NICRA Project)*, NDRI, Karnal, pp. 1 - 18.

Chakravarty, Ritu, Upadhyay, R. C., Singh, S. V., Ranga, Jyoti and Ashutosh (2012) *Farmers Awareness Programme on Climate Change (NICRA Project),* NDRI, Karnal, pp. 1 - 16.

Chakravarty, A. K., Gupta, A. K. and Mohanty, T. K. (2011) *A Glimpse of Artificial Breeding Research Center (Bulletin),* NDRI, Karnal, pp. 1 – 6.

Chand, Ram, Gupta, V. K., Viz, Shilpa, Kumar, Naresh, Manju, G. (2011) *Advances in Processing and Quality Assurance of Dairy Foods (22nd March – 11th April, 2011), (Compendium),* NDRI, Karnal, pp. 1 – 378.

Chatterjee, A., Roy, P. K., Ghosh, M. K., Das, S. K. and Mondal, A. (Eds) (2012) *Nutritional Status of Dairy Cattle and Feed Resources in Eastern Himalaya Region*. (Technical Bulletin. 4), ERS of NDRI, Kalyani, West Bengal.

Chauhan, M. S, Manik, R. S., Singh, M. K., Palta, P. and Singla, S. K. (2012) *Embryonic and Spermatogonial Stem Cell Biology (Compendium).* Animal Biotechnology Centre, NDRI, Karnal, pp. 1-158.

Chauhan, M. S., Manik, R. S., Singh, M. K., Palta, P. and Singla, S. K. (2012) Recent *Advances in Reproductive Biotechnology: Retrospective and Prospective Vision (Compendium).* Animal Biotechnology Centre, NDRI, Karnal, pp 1-94.

Das, D. N., Ramesha, K. P., Kataktalware, M. A., Varalakshmi, S., Chetana, K. R., Siddaramana and Murthy, L. K. (2011) *Sub Clinical Mastitis : A Threat to Profitable Dairy Farming*. SRS Publication.

Datt, Chandra, Kundu, S. S. Upadhyay, Mridula, Singh, Sohan Vir, Meena, B. S., Sohi, D. S. and Malik, Meena (2012) *Dairy Mela Smarika-2012,* NDRI, Karnal, pp. 1-146.

Kanawjia, S. K., Khetra, Yogesh and Chatterjee, Alok (Ed.) (2011) *Technological Developments in Cheese and Dairy Foods (Compendium).* Dairy Technology Division, NDRI, Karnal.

Khamrui, Kaushik, Devaraja, H. C., Singh, R. R. B. and Sharma, Prateek (2012) *Traditional Indian Dairy Products (Manual)*, Publication No. 75/2012, NDRI, Karnal.

Kumaresan, A., Srivastava, A. K., Mohanty T. K. and Prasad, Shiv (2012) *Reproductive Disorders & their Management in Dairy Cattle & Buffaloes*. NDRI, Karnal, pp. 1-76.

Kumar, Rajesh, Sangwan, B. R. and Mann, Bimlesh (2012) *Chemical Analysis of Milk Proteins (Manual).* NDRI Publication No.

Kundu, S. S. and Datt, Chander (2011) *Net Carbohydrates and Protein Fractions Determination Animal in Feeds.* NDRI Publication No. 68/2012, pp. 65.

Malik, Meena, Rajput, Y. S. and Bharti, M. (2012) *NDRI: The Golden Quinquenium (2007-2012),* NDRI Publication No. 76/2012, pp.1 - 72.

Mandal, Ajoy, Chatterjee, A., Das, S. K., Ghosh, M. K. and Dutta, T. K. (Eds) (2012) *Infertility of Cattle and its Management.* (Technical Folder: BLTF-1), ERS of NDRI, Kalyani, West Bengal.

Mandal, Ajoy, Chatterjee, A., Roy, P. K. Das, S. K., Ghosh, M. K. and Dutta, T. K. (Eds) (2012) *How to Select Good Dairy Animals*. (Technical Folder: BLTF-2), ERS of NDRI, Kalyani, West Bengal.

Manik, R. S., Chauhan, M. S., Singla, S. K., Palta, P. and Singh, M. K. (2012) *Reproductive Ultrasonography in Bovines (our research findings) [Handbook].* Animal Biotechnology Centre, NDRI, Karnal pp. 1-48.

Mann, Bimlesh and Bajaj, R. K. (2012) *Physical Chemistry of Milk (Manual).* NDRI Publication No. 89/2012.

Meena, B. S. Mohammad, Asif, Sankhala, Gopal and Kumar, R. Senthil (2012) *Fundamental of Dairy & Animal Husbandry Extension*. NDRI Publication No.79/2012.

Meena, B. S. and Sankhala, Gopal (2012) *Shusk chhetron ke lia bahuvarshiy ghanse,* NDRI, Karnal.

Meena, B. S. and Sankhala, Gopal (2012) *Shusk chhetron ke lia chara varkash,* NDRI, Karnal.

Mohanty, A. K, Kaushik, J. K., Kumar, S. and Dang, A. K. (2012). *Transcriptomics, Proteomics and Structural Biology (Compendium).* Animal Biotechnology Centre, NDRI, Karnal, pp. 1-131.

Prakash, B. S., Singh, Avtar, Thakur, S. S., Sirohi S., Singh R. R. B., Sharma R. and Malik, Meena (Ed.) (2011) *NDRI Vision 2030.* NDRI Publication Karnal.

Raju, P. N., Sabikhi, Latha, Singh, A. K., Mann, Bimlesh and Arora, Sumit (Ed.) (2011) *National Training on Basic and Applied Approaches in Designing Dairy□based Functional Foods and Nutraceuticals (Compendium).* Dairy Technology Division, NDRI, Karnal.

Sathish, M. H., Sharma, Prateek, Singh, R. R. B., Khamrui, Kaushik and Devaraja, H. C. (2012) *Condensed and Dried Milks (Manual).* NDRI Publication No. 78/2012, NDRI, Karnal.

Sharma, R., Rajput, Y. S., Barui, A. K., Naik, L .N. (2012) *Detection of Adulterants in Milk: (Manual),* NDRI Publication No. 88/2012, pp.1 - 104.

Sharma, R., Rajput, Y. S., Bharti, M., and Barui, A. (2011) *Technologies at a Glance.* Institute Technology Management Unit, NDRI, Karnal. pp. 1 - 41.

Singh, Mahhendra, Sirohi, N. S. and Kumar, Ram (2012) *Impact Assessment of Clean Milk Production Practices in IRD Adopted Pusar Village of UP,* NDRI Publication.

Singh, Avtar, Sachdeva, G. K. and Ruhil, A. P. (2011) *Advanced Stastical Tools for Analysis of Animal Breeding Data (Compendium).* Dairy Cattle Breeding Division, NDRI, Karnal, pp. 1 - 228.

Singla, S. K., Manik, R. S., Singh, M. K., Palta, P. and Chauhan, M. S. (2011) *Cloning Research for Quality Animal Production (Manual).* Animal Biotechnology Centre, NDRI, Karnal, pp. 1-65.

Tomer, S. K., Singh, R., Singh, A. K., Arora, S. and Singh, R. R .B. (2011) *Functional Dairy Foods: Concepts and Applications.* Satish Serial Publishing House, Delhi, India.

Viz, Shilpa, Malik, R. K., Hati, Subrota (2011) *Recent Advances in Functional Dairy Foods and their Quality Assurance (9th – 29th December, 2011), Compendium,* NDRI, Karnal, pp. 1-241.

Dairy Cattle Breeding Division

Research Papers

Azad, M. S., Gupta, I. D., Datte, Sanjoy, Kour, Kawardeep, Yathish. H. M. and Chopra, Alka (2011) Identification of coagulation factor XI gene deficiency in indigenous and crossbred cattle. *Indian J. Dairy Sci.,* 64 (1) : 79 - 82.

Balasundaram, B., Gupta, A. K., Dongre, V. B., Mohanty, T. K., Sharma, P. C., Khate, Keviletsu and Singh, R. K. (2011) Influence of genetic and non-genetic factors on incidence of calving abnormalities in Karan Fries cows. *Indian J. Anim. Res.,* 45 (1) : 26 - 31.

Balasundaram, B., Gupta, A. K., Dongre, V. B., Mohanty, T. K., Sharma, P. C., Khate, Keviletsu and Singh, R. K. (2011) Influence of genetic and non-genetic factors on incidence of post partum utero-vaginal complications in Karan Fries cows. *Indian J. Anim. Res.,* 45 (3) : 192 – 97.

Debbarma, Monalisa, Gandhi, R. S., Raja, T. V., Singh, A. and Sachdeva, G. K. (2010) Influence of non-genetic factors on test day milk records in Sahiwal cattle. *Indian J. Dairy Sci.,* 63 (6) : 504 - 06.

Dongre, V. B., Gandhi, R. S., Singh, A., Raja, T. V. and Singh, R. K. (2011) Effect of non-genetic factors on weekly test day milk yields and first lactation traits in Sahiwal cattle. *Indian J. Anim. Res.,* 45(2) : 139 - 42.

Dongre, V. B., Gandhi, R. S., Singh, A. and Malhotra, R. (2011) Prediction of first lactation 305-day and fortnightly test day milk yields using lactation curve models in Sahiwal cattle. *International J. Agri. Res. and Review,* 1 (2) : 87 - 90.

Dongre, V. B., Gandhi, R. S., Singh, A., Raja, T. V. and Balasundaram, B. (2011) Genetic and phenotypic parameters of weekly test day milk yields and first lactation traits in Sahiwal cattle. *Indian J. Dairy Sci.,* 64 (4) : 310 - 14.

Dongre, V. B., Gandhi, R. S., Singh, A. and Gupta, Atul (2011) A brief review of lactation curve models for predicting milk yield and different factors affecting lactation curve in dairy cattle. *International J. Agri. Res, and Review,* 1 (1) : 6 - 15.

Dongre, V. B., Gandhi, R. S., Raja, T. V., Singh, A. and Balasundram, B. (2011) Performance of different first lactation economic traits in Sahiwal cattle. *International J. Agri. Res. and Review,* 1 (2) : 91 - 96.

Feroze, S. M., Chauhan, A. K., and Chakravarty, A. K. (2011) Microfinance and income from dairy in Haryana: An impact analysis. *Indian J. Anim. Sci.,* 81 (7) : 751- 56.

Guruprasad, J., Roy, Joyabrata, Kumar, Gulsan, Mukherjee, Ayan, Shamilk Polley, Chakravarty, A. K., Mohanty, T. K. and Sachinandan, De. (2011) Asthenozoopermia in a crossbred bull. *Indian Vety. J.,* 88 (8) : 119 - 20.

Hazra, Ritwik, Gupta, I. D., Verma, Archana, Chakrabarty, A. K., Sood, S. K. Gokul, S. and Azad, M. S. (2011) Interleukin-8 Gene polymorphism in Sahiwal Cattle. *The Indian Vety. J.* 88 (7) : 14 – 16.

Jain, Asit, Tripti, Jain, Yathish, H. M., Sachdeva, G. K., De, S., Goswami, S. L. and Datta, T. K. (2011) Headway in reproductive biotechniques for genetic improvement of buffaloes. *Current Trends in Biotechnology and Pharmacy,* 5 (3) : 1233 - 50.

Kale, D. S. and Yadav, B. R. (2011) Genetic polymorphism analysis of *Monoacyl Glycerol Transferease*2 (MOGAT2) gene in Murrah buffalo (*Bubalus bubalis*). *Buffalo Bulletin,* 30 (1) : 14 - 20.

Kale, D. S. and Yadav, B. R. (2011) Effect of DNA polymorphism in *Butyrophilin* gene on milk yield in Murrah buffalo (*Bubalus bubalis*). *Indian J. Anim. Sci.,* 81 (10) : 1068 - 72.

Kale, D. S. and Yadav, B. R. (2011) Polymorphism of leptin gene in Murrah buffalo. *Indian Vety. J.,* 88 (8) : 55 - 57.

Kokate, L. S., Singh, A., Banu, R., Gandhi, R. S., Chakravarty, A. K., Gupta, A. K. and Sachdeva, G. K. (2011) Prediction of 305-day lactation milk yield based on monthly test day values in Karan Fries cattle. *Indian J. Dairy Sci.,* 64 (1) : 83 - 85.

Kumar, A. and Gandhi, R. S. (2011) Evaluation of pooled lactation production and reproduction traits in Sahiwal cattle. *Indian J. Anim. Sci.,* 81(6) : 600 - 04.

Kumar A., Gandhi, R. S. and Haile, A. (2011) Estimation of variance components of milk yield and genetic evaluation of Sahiwal cattle using mixed linear models. *Indian J. Anim. Sci.,* 81(6) : 605 - 09.

Kumar, R., Yadav, B. R., Anand, S. K. and Singh, R. S. (2011) Molecular surveillance of putative virulence factors and antibiotic resistance in *Staphylococcus aureus* isolates recovered from intra-mammary infection of riverine buffaloes. *Microbial Pathogenesis,* 51 (1-2) : 31 - 38.

Kumar, Ravinder, Yadav, B. R., Anand, S. K. and Singh, R. S. (2011) Prevalence of adhesin and toxin genes among isolates of *Staphylococcus aureus* obtained from mastitic cattle. *World J. Microbiology Biotechnology*, 27 : 513 - 21.

Kumar, R., Yadav, B. R. and Singh, R. S. (2011) Antibiotic resistance patterns and pathogenic factors in methicillin-resistant and susceptible isolates of *Staphylococcus aureus* recovered from mastic Sahiwal cattle. *J. Biosci.,* 36 (1) : 175 - 88.

Kumar, Ravinder and Yadav, B. R. (2012). Genetic variations in immunoglobulin G3 and association with staphylococcal intra-mammary infections in cattle and buffaloes *Molecular Biology Report,* Published online: 12th Feb. 2012. (DOI 10.1007/s11033-012-1594-z)

Kumar, S., Mehla, R. K., Gupta, A. K., Sharma, V., Meena, R. K., Dandi, R. L. and Prakash, A. (2011) Effect of herbal feed supplement Shatavari (*Asparagus racemosus*) on milk production and composition in crossbred cows. *Indian J. Anim . Sci.,* 81 (4) : 420 - 23.

Kumar, Vijay, Sharma, Ashwani, Yathish, H. M. and Singh, Avtar (2011) Single nucleotide polymorphism of SLC35A3 gene in Holstein crossbred cattle. *Indian Vet. J.,* 88 (11) : 14 - 15.

Manoj, M, Gandhi, R. S., Raja, T. V. and Kumar A. (2010) Selection indices using body weights in Sahiwal cattle. *Indian J. Dairy Sci.,* 63 (6) : 502 - 03.

Manoj, M, Gandhi, R. S. and Raja, T. V. (2011) Effect of non-genetic factors on body weights at different ages in Sahiwal cattle. *J. Applied Anim. Res.,* 39 (2) : 147- 48.

Manoj, M., Gandhi, R. S., Raja, T. V. and Singh, A. and Sachdeva, G. K. (2011) Growth curves and growth bands in Sahiwal female calves. *Indian Vety. J.,* 88 (9) : 136 - 37.

Mukhopadhyay, C. S., Gupta, A. K., Yadav, B. R. and Mohanty, T. K. (2011) Exploration of Y-chromosome specific markers to discover SNP associated with sub fertility traits in dairy bulls. *Indian J. Biotechnology,* 10 : 178 - 82.

Patil, C. S., Chakravarty, A. K., Kumar, Vijay, Sharma, R. K. and Kumar, Pankaj (2011) Non-genetic factors affecting first lactation reproductive traits in Murrah buffaloes. *Indian J. Anim. Res.,* 45 (3) : 162 - 67.

Raja, T. V. and Gandhi, R. S. (2011) Heritability estimates of first lactation traits in Sahiwal cattle. *Indian Vety J.,* 88 (9) : 90 - 91.

Raja, T. V. and Gandhi, R. S. (2011) Prediction of first lactation milk yield from incomplete records in Sahiwal cattle. *Indian Vety. J.,* 88 (9) : 92 - 94.

Raja, T. V. and Gandhi, R. S. (2011) Genetic and phenotypic correlations amongst first lactation traits in Sahiwal cattle. *Indian Vety. J.,* 88 (12) : 91 - 93.

Raja, T. V., Ruhil, A. P. and Gandhi, R. S. (2012) Comparison of connectionist and multiple regression approaches for prediction of body weight in goats. *Neural Computing and Applications,* 21 : 119 - 24.

Rana, J. S., Singh, R., Singh, A., Gandhi, R. S., Chakravarty, A. K. and Gupta, A. K. (2011) Prediction of first lactation milk yield based on cumulative part lactation records in Murrah buffaloes. *Indian J. Dairy Sci.,* 64 (2) : 125 - 28.

Saha, Sujit, Joshi, B. K. and Singh, Avtar (2011) Incidence and consequences of inbreeding in Karan Swiss cattle. *Indian J. Anim. Sci.,* 81 (1) : 73 - 76.

Sentitula, Yadav, B. R. and Kumar, Ravinder (2011) Incidence of staphylococci and streptococci during winter in mastitic milk of Sahiwal cows and Murrah buffaloes. *Indian J. Microbiology,* Published on online on 9th August, 2011 pp. 1 - 7. (DOI 10.1007/s12088-011-0207-1).

Singh, Yajuvendra, Lathwal, S. S., Chakravarty, A. K., Gupta, A. K., Mohanty, T. K., Raja, T. V., Dangi, R. L. and Roy, B. L. (2011) Effect of lameness (hoof disorders) on productivity of Karan-Fries crossbred cows. *Anim. Sci. J.,* 82 : 169 - 74.

Singh, R. S., Kumar, R. and Yadav, B. R. (2011) Distribution of pathogenic factors of *S. aureus* strains isolated from mastitic cattle and buffaloes. *Indian J. Biotech.,* 10 (4) : 410 - 16.

Sharma P. C., Gupta A. K., Mohanty, T. K., Chakravarty, A. K., Singh, Avtar and Tomar, K. P. S. (2011) Genetic analysis of udder health traits in Karan Fries cattle. *Indian Vet. J.,* 88 (9) : 163 - 65.

Sharma, P. C., Gupta, A. K., Mohanthy, T. K., Chakravarty, A. K., Singh, Avtar and Chand, S. (2011) Uterine and ovarian health traits in Karan Fries cows. *Indian Vet. J.,* 88 (10) : 83 - 86.

Wakchaure, R. S., Sachdeva, G. K., Gandhi, R. S. and Gupta, J. P. (2011) Effect of non-genetic factors on economic traits in Murrah buffaloes. *Indian Vety. J.,* 88 (6) : 83 - 84.

Wakchaure, R. S., Sachdeva, G. K. and Gandhi, R. S. (2011) Studies on time series analysis of production and reproduction traits in Murrah buffaloes. *Indian J. Anim. Res.,* 45 (3) : 162 – 67.

Yathish, H. M., Sharma, Ashwani, Kumar, Vijay, Jain, Asit, Chakaraborty, D., Singh, Avtar and Tantia, M. S. (2011) Genetic polymorphism of SLC35A3 gene in Karan Fries bull calves. *Indian J. Anim. Sci.,* 81 (9) : 951 - 53.

Book Chapter

Singh, Avtar and Rashia, Banu (2011) Selection and Evaluation of Genetic Value in Domesticated Livestock" Chapter 16 of the book "An Introduction to Animal Farming Systems in India" (Chief Editor: Dr. R. Nagarcenkar) published by Dapper Creations, Rajaji Nagar, Bangalore.

Popular Articles

Dongre, V. B., Gandhi, R. S. and Singh, A. (2011) Intensifying livestock productivity by various genetic manipulation tools. *Livestock & Feed Trends,* 9 (2) : 37 - 42.

Dongre, V. B., Gandhi, R. S., Singh, A. and Gupta, A. (2012) Animal production in changing climate : Causes, adaptation and mitigation. *Agrovet Buzz,* 4 (6) : 38 – 41.

Gandhi, R. S., Dongre, V. B. and Singh, A. (2011) Embryo sexing in farm animals : Potential applications in dairy cattle. *Indian Dairyman,* 63 (12) : 50 – 54.

Jain, Asit, Tripti, Jain, Yathish, H. M., Sachdeva, G. K. De, S., Goswami, S. L. and Datta, T. K. (2011) Production and management systems of buffalo in India. *Dairy Planner,* 7 (6) : 13-16.

Mondal, A., Ghosh, M. K., Chatterjee, A. and Gandhi, R. S. (2012) Breeding strategies for genetic improvement of cattle in eastern India. *Indian Dairyman,* 64 (1) : 60 – 65.

Livestock Production and Management Section

Behera, K., Layek, S. S., Prasad, Shiv, Kumaresan, A. and Mohanty T. K. (2011) Prediction of mastitis based on electroconductivity, pH and acute phase proteins in different dairy animals in subtropical climate. *Lactation Res. in Mammals and Humans,* 01/2010.

Bhakat, M., Mohanty, T. K., Raina, V. S., Gupta, A. K., Khan, H. M., Mahapatra, R. K. and Sarkar, M. (2011) Effect of age and season on semen quality parameters in Sahiwal bulls. *Trop. Anim. Health Prod.,* 43 : 1161 – 68.

Bhakat, M. Mohanty, T. K. Raina, V. S. Gupta, A. K. Pankaj, P. K. Mahapatra, R. K. Sarkar, M. (2011) Study on suitable semen additives incorporation into the extender stored at refrigerated temperature. *Asian-Aust. J. Anim. Sci*., 24 (10) : 1348 - 57.

Bhakat, M., Mohanty, T. K., Raina, V. S., Gupta, A. K. and Khan, H. M. (2011) Frozen semen production performance of Murrah buffalo bull. *Buffalo Bulletin,* 30 (2).

Bharti, P. K. and Kamboj, M. L. (2011) Economics of feeding milk replacer and whole milk in crossbred calves. *Indian Vet. J.,* 10 : 43 – 44.

Dang A. K., Prasad, S., De, K., Pal, S., Mukherjee, J., Sandeep, I. V .R., Mutoni, G., Pathan, M. M., Manu, Jamwal., Kapila, S., Kapila, R., Kaur, H., Dixit, S., Mohanty, A. K. and Prakash, B. S. (2012) Effect of supplementation of Vitamin E, Copper and Zinc on the *in vitro* phagocytic activity and lymphocyte proliferation index of peripartum Sahiwal (*Bos indicus*) cows. *J. Anim. Phy. Nutr.,* (Article first published online: 31 JAN 2012, DOI: 10.1111/j.1439-0396.2011.01272.x).

De, K., Mukherjee, J., Prasad S. and Dang A. K. (2011) Effect of parity and stage of lactation on milk SCC and DLC in native and crossbred cows. *Indian J. Dairy Sci.,* 64 (4) : 326 - 29.

Ghai, S., Monga, R., Mohanty, T. K., Chauhan, M. S. and Singh, D. (2012) Term placenta shows methylation independent down regulation of *Cyp19* gene in animals with retained fetal membranes. *Res. Vet. Sci*., 92 (1) : 53 - 59.

Guruprasad, J., Roy, J., Das, G., Mukherjee, A., Polley, S., Chakravarty, A. K., Mohanty, T. K. and De. S. (2011) Asthenozoospermia in a crossbred bull. *Indian Vety. J.,* 88 (8) : 119 - 20.

Kalyan, De, Mukharjee, Joydeep, Dang, A. K. and Prasad, Shiv (2011) Effect of parity and stage of lactation on milk SCC and DLC in native and crossbred cows. *American J. Food and Nutr., Printed on line: ISSN 2157-1317 (//www.scihub.org/AJFN).*

Kaswan, Sandeep, Mukherjee, Joydip, Prasad, Shiv and Dang, A. K. (2011) Comparative study of milk composition and cellular parameters in high and low yielding crossbred cows during early lactation period. *Indian Vety. J.,* 8 : 92 - 93.

Kaswan, Sandeep, Mukherjee, Joydip, Prasad, Shiv Mohanty, A. K. and Dang, A. K. (2011) Alterations in hematology, neutrophilic phagocytic activity and plasma cytokine profile in relation to udder health during different days of clinical mastitis in crossbred Karan Fries cows. *Indian J. Dairy Sci*., 64 : 247 - 51.

Kalyan De, Mukharjee, Joydeep, Prasad, Shiv and Dang, A. K. (2011) Effect of different physiological stages and managemental practices on milk somatic cell counts of Murrah buffaloes. *Buffalo Bulletin,* 30 : 72 - 74.

Khan, H. M., Mohanty, T. K., Bhakat, M., Raina, V. S. and Gupta, A. K. (2011) Relationship of blood metabolites with reproductive parameters during various seasons in Murrah buffaloes. *Asian-Aust. J. Anim. Sci.,* 24 (9) : 1192 - 98.

Kishore, A., Raina, V. S., Mohanty, T. K. Gupta, A. K., Bishist, R., Singh, M. and Rao, T. K. S. (2011) Evaluation of antioxidants for preservation of cattle semen. *Indian Vet. J.,* 88 (3) : 37 - 38.

Kumar, N., Mohanty, T. K. and Chand, S. (2011) Dystocia due to lateral deviation of faetal herd and its management energy. *Intas Polinel,* 12 (2).

Kumaresan, A., Johannisson, A., Humblot, Patrice and Saravia. F. (2011) The effect of oviductal fluid on protein tyrosine phosphorylation in cryopreserved boar spermatozoa differs with the freezing method. *Theriogenology*, doi:10.1016/j. *Theriogenology*, 2011.08.035.

Kumaresan, A., Siqueira, A. P., Hossain, M. S., Johannisson, A., Eriksson, I., Wallgren M. and Bergqvist, A. S. (2011) Quantification of kinetic changes in protein tyrosine phosphorylation and cytosolic Ca^{2+} concentration in boar spermatozoa during cryopreservation. *Reproduction, Fertility and Development* - http://dx.doi.org/ 10.1071/ RD11074.

Kumaresan, A., Siqueira, A. P., Hossain, M. S., Bergqvist, A. S. (2011) Cryopreservation-induced alterations in protein tyrosine phosphorylation of spermatozoa from different portions of the boar ejaculate. *Cryobiology*, 63 (3) : 137 -44.

Kumaresan, A., Bujarbaruah, K.M., Kadirvel, G., Khargharia, G., Rumi G. Sarma, Goswami, J., Basumatary, Rantu, Palaniappan, Kavitha and Bardoloi. R. K. (2011) Early sexual maturity in local boars of Northeastern India: Age-related changes in testicular growth, epididymal sperm characteristics and peripheral testosterone levels. *Theriogenology,* 75 (4) : 687 – 95.

Layek, S. S., Mohanty, T. K., Kumaresan, A., Behera, K. Chand, S. (2011) Behavioural signs of estrus and their relationship to time of ovulation in Zebu (Sahiwal) cattle. *Anim. Reprod. Sci.,* 129 (3-4) : 140 - 45.

Layek, S. S., Mohanty, T. K., Kumaresan, A., Behera, K., Chand, S., and Raj, K. (2011) Predicting ovulation time based on estrous signs, periestrual hormone level and periestrual cervical mucus characteristics in Zebu cattle (Bos indicus).). *Reprod. Dom Anim.,* 46 (Suppl. 3), 121 (2011); (doi: 10.1111/j.1439-0531.2011.01839.x).

Mirzaei, F. and Prasad, S. (2011) Influence of dietary phytoadditive as polyherbal combination on performance of does and respective litters in crossbred dairy goats. *J. Anim. and Vety. Advances,* 10 : 1408 - 13.

Mirzaei, F. and Prasad, S. (2012) Influence of dietary phytoadditive as polyherbal combination on performance of does and respective litters in cross bred dairy goats. *Asian - Australasian J. Anim. Sci., High Beam Res.,* 29th Feb., 2012. http://www.highbeam.com

Mukhopadhyay, C S., Gupta, A. K., Yadav, B. R. and Mohanty, T. K. (2011) Exploration of Y-chromosome specific markers to discover SNP associated with sub-fertility traits in dairy bulls. *Indian J. Biotechnology,* 10 (2) : 178 - 82.

Rao, T. K. S., Mohanty, T. K., Chauhan, I. S., Singh, M., Praveen, K., Meena, R. K. and Chaurasia, S. (2011) *Freezing Protocol for Crossbred Bull Semen,* 88 (10) :71 – 73.

Singh, A. K. Singh, V.K. Narwade, B. M., Mohanty T. K. and Atreja, S. K. Comparative quality assessment of buffalo (*Bubalus bubalis*) semen chilled (5°C) in egg-yolk and soya milk extenders. *Reprod. Dom Anim.*, (doi: 10.1111/j.1439-0531.2011.01928.x).

Singh, Y., Lathwal, S.., Chakravarty, A. K., Gupta, A. K, Mohanty, T. K., Raja, T., Roy, B., Dangi, R. (2011) Effect of lameness (Hoof Disorders) on productivity of Karan Fries crossbred cows. *Anim. Sci. J.,* 82 (1) : 168 - 74.

Singh. Y., Lathwal, S. S., Tomar. S. K., Roy. B. K., Sharma. A., Raja, T. V., Dangi, R. L., Sharma, P.C., Munendra and Chandra. G. (2011) Role of biotin in hoof health and milk production of dairy cows. *Anim. Nutr. and Feed Tech.,* 11 : 293 – 302.

Popular Articles

Layek, S. S. Kumaresan, A., Behera, K., Mohanty, T. K. and Patbandha, T. (2011) Goat husbandry for livelihood security of landless, small and marginal farmers. *Livestock Line,* 5 (7) : 31 – 34.

Layek, S. S. Kumaresan, A., Behera, K., Mohanty, T. K. and Patbandha, T. (2011) Understanding and management of feeding behaviour of dairy cattle. *Indian Dairyman,* 63 (10) : 62 - 68.

Book Chapter

Srivastava, A. K., Prasad, Shiv, Singh, A. K. and Sirohi Smita (2012) Dairy Research and Development: Challenges Ahead. In Veterinary and Livestock Sector: A Blueprint for Capacity Building. Edits. Sudhir Ranjan Garg. Satish Serial Publishing House, Delhi. pp. 31-47.

Dairy Cattle Nutrition Division

Chaudhary, P. P., Sirohi, S. K. and Saxena, J. (2011) Methyl coenzyme m. reductase (mcrA) gene based phylogenetic analysis of methanogens population in Murrah buffaloes (*Bubalus bubalis*). *J. Microbiology,* 49 (4) : 558 - 61.

Datt, Chander, Reddy, G. V. N. and Kundu, S. S. (2011) Effect of feeding differently processed paddy straw based complete diets on feed intake and nutrient utilization in nellore rams. *Indian J. Anim. Nutr.,* 28 : 160 - 65.

Datt, Chander, Malik, S., Datta, M., Singh, N. P. and Kundu, S. S. (2011) Effect of probiotics supplementation on feed consumption, nutrient digestibility and growth performance in crossbred pigs under Tripura climate. *Indian J. Anim. Nutr.,* 28 : 331 - 35.

Ebrahimi, S. H., Jha, P. and Mohini, M. (2011) Calibration of *in vitro* gas production technique using digital pressure gauge: air versus fermentative gases. *Indian J. Anim. Nutr.,* 28 (1) : 29 – 33, 87.

Ebrahimi, S. H., Mohini, M., Singhal, K. K., Heidarian Miri, V., Tyagi, A. K. (2011) Evaluation of complementary effects of 9, 10 anthraquinone and fumaric acid on methanogenesis and ruminal fermentation *in vitro*. *Archieves of Anim. Nutr.,* 65 (4) : 267 - 77.

Goel, Navneet, Sirohi, S. K. and Dwivedi, Jaya (2011) Studies on the effects of methanolic extract of *Cinnamomum zeylanicum* on *in vitro* methane inhibition and rumen fermentation patterns. *J. Chemical and Pharmaceutical Res*., 3 (6) : 609 -15.

Gupta, Arti, Singh, Sultan, Kundu, S. S. and Jha, Nisha (2011) Effect of tannin levels and pH on *in vitro* dry matter digestibility and ammonia production from oil cake – acacia catechu pellets in cattle inoculum. *Indian J. Anim. Nutr.,* 28 (11) : 1154 - 60.

Haldar, Avijit, Pal, Soumen, Pal, Rajesh, Pan, S., Biswas, C., Majumdar, D., Datt, Chander, Bujarbaruah, K. M., Datta, M. and Prakash, B. S. (2011) Immunological and physiological validation of an enzyme linked immunosorbent assay (ELISA) for the measurement of growth hormone in goat (*Capra hircus*) plasma. *Small Ruminant Res.,* Published online. (http://dx.doi.org/10.1016/j.smallrumenres. 2011.10.011).

Kamble, A. B., Puniya, Monica, Kundu, S. S., Shelke, S. K. and Mohini, Madhu. (2011) Evaluation of forages in terms of carbohydrates, nitrogen fractions and methane production. *Indian J. Anim. Nutr.,* 28 : 231 - 38.

Kumar, Vinod, Puniya, Monica and Datt, Chander (2011) Effect of heavy metals on *in vitro* rumen fermentation and use of lignosulfonate as an ameliorant. *Ind. Vet. J.,* 88: 77 - 79.

Kumar, Muneendra Kaur, Harjit Phondba, B. T., Sontakke, U. B. and Gupta, Neelam. (2011) Ameliorative effect of zinc supplementation to lead exposed goat kids on lymphocyte proliferation and superoxide dismutase (SOD) expression. *Indian J. Anim. Sci.,* 81 (8) : 35 - 37.

Madhu, Suman Rana, A., Tyagi, S. K, Asraf, Hossain, Tyagi, A. K. (2011) Effect of tanniniferous *Terminalia chebula* extract on rumen biohydrogenation, Δ9-desaturase activity, CLA content and fatty acid composition in longissimus dorsi muscle of kids. *Meat Sci.,* (Available on line)

Mohanta, R. K., Singhal, K. K., Ebrahimi, S. H., Rajput, Y. S. and Mohini, M. (2011) Comparative nutritional evaluation of transgenic cottonseeds containing Cry1C protein for ruminant feeding. *Livestock Res. for Rural Development,* 23: (14).

Ram, B. Tomar, S. K. and Karuppaiyan, R. (2011) Evaluation of sugarcane tops of Co clones for fodder quality traits. *J. Sugarcane Res*., 1(1) : 39 - 47.

Roy, Debashis, Mani, Veena, Kewalramani, Neelam and Kaur, Harjit (2011) Status of mercury in animal feeds in different districts of Haryana. *Indian J. Dairy Sci.,* 64 (3) : 1 - 5.

Sachan, C. B., Kundu, S. S., Singh, Sultan, Kushwaha, B. P. and Singh, Hari (2010) Eating pattern and milk composition of Bhadawari buffaloes on different roughage source diets. *Indian J. Anim. Nutr.,* 27 : 360 - 63.

Sachan, C. B., Kundu, S. S., Singh, S., Kushwaha, B. P, Singh, Hari. (2011) Feed intake and nutrient utilization in Bhadawari buffaloes fed sorghum, grass and *stylosanthes* hay. *Indian J. Anim. Nutr.,* 28 : 18 - 22.

Singhal, K. K., Tyagi, A. K., Rajput, Y. S., Singh, M., Kaur, H., Perez, T. and Hartnell, G. F. (2011) Feed intake, milk production and composition of crossbred cows fed with insect-protected Bollgard II® cottonseed containing Cry1Ac and Cry2Ab proteins. *Anim.,* pp. 1 - 5.

Singhal, K. K., Tyagi, A. K., Rajput, Y. S., Singh, M., Kaur, H., Perez, T. and Hartnell, G. F. (2011) Feed intake, milk production and composition of crossbred cows fed with insect-protected Bollgard II cottonseed containing Cry1Ac and Cry2Ab proteins. *Anim.,* 5 (11) : 1769 – 73.

Singh, Sultan, Kundu, S. S., Nag, S. K., Suresh, G. and Maity, S. B. (2012) Intake, eating pattern, nutrients digestibility and growth of Tharparkar heifers fed inorganic and organically produced feeds. *Indian J. Anim. Sci.,* 82 (2) : 309 - 11.

Singh, Y., Lathwal, S. S., Tomar, S. K., Roy, B. K., Sharma, A., Raja, T. V., Dangi, R. L., Sharma, P. C., Munendra and Chandra, G. (2011) Role of biotin in hoof health and milk production of dairy cows. *Anim. Nutr. Feed Technol.,* 11 : 293 - 302.

Singh, Sultan and Kundu, S. S. (2011) Comparative rumen microbial population in sheep fed *Dicantium annulatum* grass supplemented with *Leucaena leucocephala* and *Hardwickia binata* tree leaves. *Livestock Res. for Rural Development,* 23.

Sirohi, S. K. Pandey, Poonam and Goel, Navneet (2012) Response of fumaric acid addition onmethanogenesis, rumen fermentation, and dry matter degradability in diets containing wheat straw and sorghum or berseem as roughage source. *ISRN Veterinary Sci.,* Volume 2012, Article ID 496801, 9 pages doi:10.5402/ 2012/496801.

Sirohi, S. K., Mehta, Manu, Goel, Navneet and Pandey, Poonam (2012) Effect of herbal plants oil addition in total mixed diets on anti-methanogenic activity, rumen fermentation and gas production kinetics *in Vitro*. *J. Natural Product and Plant Resources,* 2 (1) : 73 - 80.

Sirohi, S. K, Pandey, Neha, Mohini, M. Puniya, A. K., Kundu, S. S. and Thube. H. (2011) Effect of monensin and anthraquinone supplementation on rumen fermentation and methane mitigation *in vitro. Indian J. Anim. Sci.,* 81 (8) : 859 -63.

Sirohi, S. K., Pandey, Neha, Singh, B., Mohini, Madhu, Puniya, A. K., Kundu, S. S. Thube, Harshala (2011) Effect of monensin and anthraquinone supplementation on rumen fermentation and methane production *in vitro. Indian J. Anim. Sci.,* 81 (8).

Sharma, A., Chaudhary, P. P., Sirohi, S. K., Saxena J. (2011) Structure modeling and inhibitor prediction of NADP oxidoreductase enzyme from *Methanobrevibacter Smithii*. *Bioinformation,* 6 : 15 - 19.

Shashikant D. Dandage, Singh, S. V., Upadhyay, R. C., Mangesh, M. Vaidya and Kundu, S. S. (2010) Thermoregulatory responses of Karan Fries cattle during thermal exposures. *Indian J. Anim. Nutr.,* 27 : 282 - 89.

Shelke, S. K. and Thakur, S. S. (2011) Effect on the quality of milk and milk products in Murrah buffaloes (*Bubalus bubalis*) fed rumen protected fat and protein. *International J. Dairy Sci.,* 6 (2) : 124 - 33.

Shelke, S. K., Thakur, S. S. and Amrutkar, S. A. (2011) Effect of rumen-protected fat and protein supplementation on milk production, composition and nutrient utilization in Murrah buffaloes (*Bubalus bubalis*) and persistence of milk production after supplement withdrawal. *Anim. Feed Sci. and Tech.,* 98 – 107.

Shelke, S. K., Thakur, S. S. and Amrutkar, S. A. (2011) Effect of pre partum supplementation of rumen protected fat and protein on the performance of Murrah buffaloes. *Indian J. Anim. Sci.,* 81(9) : 946 – 50.

Shete, S. M., Tomar, S. K., Sirohi, S. K. and Thakur, S. S. (2011) Rumen degradation kinetics of feedstuffs as estimated by *in situ* and *in vitro* gas production techniques. *Indian J. Anim. Nutr.,* 28 (1) : 34 - 38.

Shete, S. M., Tomar, S. K. and Sarma, Rijusmita (2012) Synchronization of energy and nitrogen supply to improve *in vitro* rumen fermentation. *Indian Vet J.,* 89 (2) : 97 - 98.

Shrivastava, Bhuvnesh, Nandal, Preeti, Sharma, Abha, Kavish K. Jain, Y. P., Khasa, Tapan, Das, K., Mani, Veena, Kewalramani, N., Kundu, S. S., Kuhad, R. C. (2012) Solid state bioconversion of wheat straw into digestible and nutritive ruminant feed by Ganoderma sp. rckk02. *Bioresour. Technol.,* doi:10.1016/ j.biortech.2011.12.096.

Tyagi, A., Tyagi, A. K., Singh R. R. B. and Hossain, S. A. (2011) Designing milk and meat products with enhanced conjugated linoleic acid (CLA) content. *Indian J. Anim. Nutr.,* 28 (1) : 1 – 17.

Popular Articles

Shelke, Sachin, Datt, Chander and Puniya, Monica (2011) Fields methods of quality control of feeds for livestock and poultry. *Agrovet Buzz,* 4 : 38 - 41.

Shete, S. M. and Tomar, S. K. (2011) Probiotics and prebiotics in ruminant nutrition. *Feed Trends,* 09 (3) : 50 - 54.

Tomar, S. K. and Sehgal, J. P. (2011) Feeding of pregnant cows and buffaloes in tropics. *Agrovet Buzz,* 4 (4) : 36 - 39.

Book Chapter/Review

Jha, Nisha, Kundu, S. S. Datt, Chander, Upadhyay, R. C. and Jha, Pankaj (2011) Nutritional strategies to mitigate methane from ruminants with special reference to enhancement of reductive acetogenesis. In: Veterinary Nutrition and Health (Editors: S.P. Tiwari and P.K. Sanyal). Satish Serial Publishing House. Chapter 49. pp 685-705, 724.

Kundu, S. S. Datt, Chander, Mani, Veena and Kumar, Ashoka. (2011) Livestock Productivity Enhancement with Available Feed Resources (Book on lead papers released of Animal Nutrition Society of India on "Livestock Productivity Enhancement with Available Feed Resources" held at GBPUA&T, Pantnagar, Uttarakhand, India from Nov. 3-5, 2011.). pp. 286.

Hooda, O. K., Singh, S. V., Kundu S. S. and Vaidya M. M. (2011) Follicular dynamics its Regulation and Heat Stress effect on Folliculogenesis: A Review. Wayamba Journal of Animal Science – ISSN: 2012-578x. Shete, S. M., Tomar, S. K., Sirohi, S.K. and Singh, B. Plant secondary metabolites as rumen fermentation modifiers : A review. *Agric. Review*., 32 (1) : 1-13.

Thakur, S. S. and Shelke, S. K. (2011) Bypass nutrient technology in Indian context, a book chapter page No 357-368 in book "Animal Nutrition Advancements in Feeds and feeding of Livestock, (Ed.) Lokesh Gupta and K. K. Singhal, Agrobios (India), Jodhpur, ISBN No. (13): 978 – 81 - 7754 – 447 – 3.

Dairy Cattle Physiology Division

Research Papers

Aggarwal, A. (2011) Innovative ways to keep dairy animals cool during heat stress-A Review. *Agril. Reviews*, 32 (2) : 102 - 11.

Aggarwal, A. and Chandra, G. (2011) Body condition score and lactation curve of crossbred cows supplemented with α-tocopherol acetate. *Indian Vet. J.,* 88 (12) : 27-29.

Anand Laxmi, N. and Pratheesh, M. D. (2011) Effect of exogenous progesterone treatment on quantitative expression of IFN-t in caprine fibroblast cells model. *Int. J. Genetic Engg. Biotech* ., 2 : 141- 46.

Anand Laxmi, N. and Pratheesh, M. D. (2011) Nucleofection an efficient non-viral transfection technique for IFN-t-EGFP gene expression study in Sahiwal cattle fibroblast cells. *Res. J. Agri. Sci*., 2 : 204 – 212.

Anand Laxmi, N. and Pratheesh, M. D. (2011) Recovery of transgenic cattle fibroblasts containing b IFN-t-EGFP gene, *Indian Vet. J.*, 88 : 64 – 65.

Anand Laxmi, N. and Prakash, B. S. (2011) Profile of pEGFP expression in Sahiwal cattle fibroblast cells, *Indian Vet. J.*, 66 :13 - 17.

Anand Laxmi, N., Sehgal, J. P., Prasad, Shiv, Namagirilakshmi, S. and Damoder, Shashikant (2012) Plasma IGF I and lactoferrin as biomarkers of post weaning stress and the effect of feeding probiotic to low body weight calvesfor the improvement of growth performance in cross bred KF calves. *Indian J. Anim. Sci*., 82 : 70 - 73.

Chandra, G., Aggarwal, A., Singh, A. K., Kumar, M., Kushwaha, R., Singh, A. and Singh, Y. K. (2011) Negative energy balance and reproduction: A review. *Agril. Reviews*, 32 (4) : 246 - 54.

Dang, A. K., Prasad, S., De, K., Pal, S., Mukherjee, J., Sandeep, I. V. R., Mutoni, G., Pathan, M. M., Manu, Jamwal, Kapila, S., Kapila, R., Kaur, H., Dixit, S., Mohanty, A. K. and Prakash, B. S. (2012) Effect of supplementation of Vitamin E, copper and zinc on the *in vitro* phagocytic activity and lymphocyte proliferation index of peripartum Sahiwal (*Bos indicus*) cows. *J. Anim. Phy. Nutr.,* (Article first published online: 31 JAN 2012, DOI: 10.1111/j.1439-0396.2011.01272.x).

De, K., Mukherjee, J., Prasad S. and Dang A. K. (2011) Effect of different physiological stages and managemental practices on milk somatic cell counts of Murrah buffaloes. *Buff. Bull.*, 30 (1) : 72 - 74, 99.

Hooda, O. K. and Singh, G. (2010) Effect of thermal stress on feed intake, plasma enzymes and blood biochemical in buffalo heifers. *Indian J. Anim. Nutr.,* 27 : 122 - 27.

Hooda, O. K., Singh, S. V., Kundu, S. S. and Vaidya M. M. (2011) Follicular dynamics its regulation and heat stress effects on folliculogenesis: A Review. *Wayamba J. Anim. Sci.,* (Published online Wayamba journal.com/ documents/1304195534. pdf).

Kaswan, S., Mukherjee, J., Prasad, S. and Dang, A. K. (2011) Milk composition and cellular constituents in crossbred cows during early lactation. *Indian Vet. J.*, 88 (11) : 92 - 93.

Kaswan, S., Mukherjee, J., Prasad, S., Mohanty, A. K. and Dang, A. K. (2011) Alterations in hematology, neutrophilic phagocytic activity and plasma cytokine profile in relation to udder health during different days of clinical mastitis in crossbred Karan Fries cows. *Indian J. Dairy Sci*., 64 (3) : 247 - 51.

Mirzaei, F., Prasad, S., Dang, A. K. and Sehgal, J. P. (2011) Efficacy of polyherbal feed additives on nutrient digestibility, milk yield and composition of lactating cross bred goats. *Indian J. Anim. Sci*., 81 (8) : 123.

Mishra, A., Hooda, O. K., Singh, G. and Meur, S. K. (2010) Influence of induced heat stress on HSP70 in buffalo lymphocytes. *J. Anim. Phy. Anim. Nutr.*, 95 (4) : 540 - 44.

Mukherjee, J. and Dang, A. K. (2011) Immune activity of milk leucocytes during early lactation period in high and low yielding crossbred cows. *Milchwissenschaft*, 66 (4) : 384 - 88.

Mukherjee, J., De, Kalyan and Dang, A. K. (2011) Phagocytic activity of milk neutrophils isolated from fore and rear quarters of crossbred cows. *Indian Vet. J.,* 88 (10) : 29 - 31.

Mukherjee, J., Pandita, S., Huozha R. and Ashutosh, M. (2011) *In vitro* immune competence of buffaloes (*Bubalus bubalis*) of different production potential: effect of heat stress and cortisol. *Vet. Med. Int*., Article ID 860252, doi:10.4061/2011/860252.

Sandeep, I.V.R., Shanti, M., Behera, P.S., Kapila, S., Kansal, V. K., Kapila, R., Dang, A. K., and Arora, S. (2011) Comparative evaluation of caseinophosphopeptides of cow and buffalo milk for immunomodulatory potential in mice. *Milchwissenschaft*, 66 (4) : 371 - 74.

Singh, S. P., Mehla, R. K. Singh, M., Sharma, V. and Dang, R. L. (2010) Effect of supplement feeding of Shatavari (*Asparagus resemosus*) power on mik cholesterol level in Murrah buffaloes. *Indian Buff. J.*, 8 (1&2): 46 - 47.

Singh, A. K., Pandita, S., Pampoori, Z. A. and Huozha R. and Ashutosh M. (2011) Effect of prepartum supplementation of vitamin E to Murrah buffaloes on immune functions and viability of calves. *J. Anim. Phy. Anim. Nutr*., (DOI:10.1111/j.1439-0396.2011.01264.x).

Singh, A. K. Pandita, S., Vaidya, M. M., Singh, S.V., Chandra, G., Pampoori, Z. A., Huozha, R., Pathan, M. M., Kushwaha, R. and Sharma, V. K. (2011) Bovine colostrum and neonate immunity - A Review. *Agri. Review,* 32 (2) : 79 – 90.

Singh, G., Hooda, O. K., Mahapatra, R. K., Meur S. K. and Varsheny, V. P. (2011) Effect of relative humidity on physiological responses in buffalo calves. *Indian Vet. J.*, 88 (9) : 16 - 18.

Singh, M., and Garg, A. (2011) Incidence of different pathogens and milk compositional change sin sub-clinical and sub clinical milk samples of cows. *Indian J. Anim. Res.,* 45 (1) : 51 - 55.

Singh, M., Singh, S. P. and Prakash, B. S. (2011) Effect of hand milking on haematology, energy metabolites and cortisol levels in buffaloes, *Indian Vet. J.* 88 (10):143 - 44.

Singh, S.V., Upadhyay, R. C., Hooda, O. K., Ashutosh and Vaidya M. M. (2012) Climate change : Impacts on reproductive pattern of cattle and buffaloes Review. *Wayamba J. Anim. Sci.,* (Published online:Wayamba Journal.com/documents/ 1322125457. pdf).

Singhal, K. K., Tyagi, A. K., Rajput, Y. S., Singh, M., Kaur, H., Perez, T. and Hartnell, G. F. (2011) Feed intake, milk production and composition of crossbred sows fed with insect protected Bollgard II^{R} cottonseed containing Cry1Ac and ry2Ab Proteins. *Animal,* 5 (11) : 1769 - 73.

Sonawane, P., Nikhil C. Nath and Hooda, O. K. (2011) Effect of Vitamin C supplementation on LDH activity in buffaloes exposed to thermal stress. *Indian J. Anim. Nutr*., 28 : 51 - 53.

Vaidya, M. M., Kumar, P. and Singh, S. V. (2011) Effect of temperature humidity index and heat load on physiological parameters of Murrah buffaloes and Karan Fries cattle during different seasons. *Wayamba J. Anim. Sci.* (Published online Wayamba journal. com/ documents/ 1293779969.pdf).

Vaidya, M. M., Kumar, P. and Singh, S.V. (2011) Circadian changes in heat storage and heat loss through sweating and panting in Karan Fries cattle during different seasons. *Biological Rhythm Res.,* (Published online **DOI:** 10.1080/ 09291016.2010.544938.).

Vaidya, M. M., Kumar, P. and Singh, S. V. (2011) Oxygen consumption and heat production in Karan Fries cattle during different seasons. *Indian Vet. J.,* 88 : 26 - 28.

Popular Articles

Aggarwal, A. **(**2011) Role of leptin in productivity of dairy cows. *Indian Dairyman*, 63 (5) : 50 - 54.

Chandra, V., Hooda O. K. and Singh, G. (2010) Synchronization of estrus and study of estrus behaviour in black Bengal goats. *The Blue Cross Book,* 25 : 35 - 37.

Mukherjee, J., Chaudhary, M., De, Kalyan, Dang, A. K. and Sehgal, J. P. (2011) More light equals more milk!. Effect of photoperiods on milk production in dairy cattle. *Agrovet Buzz*, 47 - 49.

Roy, P. K. and Singh, M. (2011) Dairy farming systems in rural eastern region: Status and scope. *Agriculture Today,* 4 (3) : 42 - 46.

Singh, S. V. and Vaidya, M. M. (2011) Improved housing system for sustained productivity in dairy animals. *Agrovet Buzz,* 4 : 43 - 46.

Singh, S.V., Upadhyay R. C. and Ashutosh (2011) Impacts on animal performance and mitigation strategies. *Indian Dairyman,* 60 (3) : 50 - 56.

Book Chapters

Upadhyay, R. C., Ashutosh, Singh, S. V., Rani, R., Ashraf. S. and Kumar, A. (2011) Methane emission from livestock and its mitigation. In book (Published by AICRP on Agrometeorology, CRIDA Hyderabad): Agricultural Drought: Climate Change and Rainfed Agriculture. Edited by VUM Rao; AVMS Rao; PV Kumar; S Desai; US Saikia; NN Srivastava and B Venkateswarlu). pp. 263 - 270.

Upadhyay, R.C., Rani, R., Ashraf, S., Ashutosh and Singh, S. V. (2011) Climate change impacts and adaptation strategies for Indian livestock. In Book (Published by AICRP on Agrometeorology, CRIDA Hyderabad): Agricultural Drought: Climate Change and Rainfed Agriculture. Edited by VUM Rao; AVMS Rao; PV Kumar; S Desai; US Saikia; NN Srivastava and B Venkateswarlu). pp. 194 - 202.

Animal Biotechnology Centre

Research Papers

De, S., Brahma, B., Polley, S., Singh, K. P., Singh, R., Datta, T. K. and Goswami, S. L. (2011) Simple and duplex PCR assays for species identification of cattle and buffalo milk and cheese. *Food Control,* 22 : 690 - 96.

Dutta, R., Malakar, D., Khate, K., Sahu, S., Jena, M. K., Akshey, Y., Garg, S. and Mukesh, M. (2011) Production and characterization of putative ntES cells from handmade cloned goat embryos derived from adult fibroblast donor cell. *J. Reprod. Stem Cell Biotechnol.,* 2 (1) : 64 - 76.

Dutta, R., Malakar, D., Khate, K., Sahu, S., Akshey, Y. and Mukesh, M. (2011) A comparative study on efficiency of adult fibroblast, putative embryonic stem cell and lymphocyte as donor cells for production of handmade cloned embryos in goat and characterization of putative ntES cells obtained from these embryos. *Theriogenology* 76 : 851 - 63.

Krishnakanth, G., Selokar, N. L., Saini, M., Chauhan M. S., Manik, R. S., Palta, P. and Singla, S. K. (2011) Production of nuclear transfer embryos by using somatic cells isolated from milk in buffalo (*Bubalus bubalis*). *Reprod. Dom. Anim.,* (doi: 10.1111/j.1439-0531.2011.01978.x).

Kumar, D., Anand, T., Singh, K.P., Singh, M. K., Shah, R. A., Chauhan, M..S., Palta, P., Singla, S. K. and Manik, R. S. (2011) Derivation of buffalo embryonic stem-like cells from *In vitro*-produced blastocysts on homologous and heterologous feeder cells. *J. Assist. Reprod. Genet.,* 28 (8) : 679 - 88.

Kumar, P., Verma, A., Roy, B., Rajput, S., Ojha, S., Anand, S., Yadav, P., Arora, J., De, S., Goswami, S. L. and Datta, T. K. (2011). Effect of varying glucose concentrations during *in vitro* maturation and embryo culture on efficiency of *In vitro* embryo production in buffalo. *Reprod. Dom. Anim.,* (doi: 10.1111/j.1439-0531.2011.01849.x).

Panda, S. K., George, A., Saha, A. P., Sharma, R., Manik, R. S., Chauhan, M. S., Palta, P. and Singla, S. K. (2010) Effect of cytoplasmic volume on developmental competence of buffalo (*Bubalus bubalis*) embryos produced through hand-made cloning. *Cell Reprogram,* 13 : 257 - 62.

Panda, S. K., George, A., Saha, A. P., Sharma, R., Singh, A. K., Manik, R. S., Chauhan, M. S., Palta, P. and Singla, S. K. (2012) Effect of scriptaid, a histone deacetylase inhibitor, on the developmental competence of handmade cloned buffalo (*Bubalus bubalis*) embryos. *Theriogenology,* 77 : 195 – 200.

Rameshbabu, K., Sharma, R., Singh, K. P., George, A., Chauhan, M. S., Singla, S. K., Manik, R. S. and Palta, P. Presence of nitric oxide synthase immunoreactivity and mRNA in buffalo (*Bubalus bubalis*) oocytes and embryos. *Reprod. Dom. Anim.,* (doi: 10.1111/j.1439-0531.2011.01884.x).

Roy, B., Rajput, S., Raghav, S., Kumar, P., Verma, A., Jain, A., Jain, T. Singh, D., De, S., Goswami, S.L. and Datta, T. K. (2012) Characterization of oocyte-expressed GDF9 gene in buffalo and mapping of its TSS and putative regulatory elements. *Zygote,* (doi:10.1017/S0967199411000712).

Sharma, R., George, A., Kamble, N. M., Singh, K. P., Chauhan, M. S., Singla, S. K., Manik, R. S. and Palta, P. (2011) Optimization of culture conditions to support long-term self-renewal of buffalo (*Bubalus bubalis*) embryonic stem cell-like cells. *Cell Reprogram,* 13 (6) : 539 - 49.

Singh, N., George, A., Sharma, R., Singla, S. K., Palta, P., Manik, R. S., Chauhan, M. S. and Singh, D. (2012) Characterization of POU5F1 (OCT4) gene and its promoter in buffalo ESC-like cells identifies

multiple transcription start sites and expression of four pseudogenes. *Gene,* 491 : 165 - 72.

Varshney, N., Mohanty, A. K., Kumar, S., Kaushik, J. K., Dang, A. K., Mukesh, M., Mishra, B. P., Kataria, R., Kimothi, S. P., Mukhopadhyay, T. K., Malakar, D., Prakash, B. S., Grover, S and Batish, V. K. (2012) Selection of suitable reference genes in milk somatic cells of lactating cows (*Bos indicus)* for quantitative gene expression studies. *J. Dairy Sci.,* dx.doi.org/10.3168/jds.2011-4442.

Book Chapter

Mohanty, A. K. (2011) Identification and characterization of biological macromolecules using proteomics approaches for future application in food sciences. In *'Functional Dairy Foods: Concepts and Applications'*. ISBN: 81-89304-90-9, Serial Publishing House, Delhi, pp. 241-252.

Animal Biochemistry Division

Research Papers

Arora, Tulika and Sharma, R. K. (2011) Prebiotic effectiveness of galactooligosaccharides and β-glucan in stimulation of growth of *Lactobacillus acidophilus* NCDC 13 *in vitro*. *Current Topics in Nutraceutical Res.*, 9 : 67 - 70.

Barui, A. K., Sharma, R. and Rajput, Y. S. (2012) Detection of non-dairy fat in dairy milk based on quantitative assay of anionic detergent using azure A dye. *International Dairy J.*, (24) : 44 - 47.

Duary, R. K., Rajput, Y. S., Batish, V. K. and Grover, S. (2011) Assessing the adhesion of putative indigenous probiotic lactobacilli to human colonic epithelial cells. *Indian J. Med. Res.,* 134 : 664 - 71.

Ghai, S., Monga, R., Mohanty, T. K., Chauhan, M. S. and Singh, D. (2012) Term placenta shows methylation independent down regulation of Cyp19 gene in animals with retained fetal membranes. *Res. Vet. Sci.,* 92 (1) : 53 - 9.

Gali, J. M., Kumar, R., Siddique, R. A. and Atreja, S. K. (2011) Sperm DNA fragmentation: a male infertility index. *Indian J. Dairy Sci.*, 64 (1) : 1 - 10

Kaushal, D. and Kansal, V. K. (2011) Age-related decline in macrophage and lymphocyte functions in mice and its alleviation by treatment with probiotic Dahi containing *Lactobacillus acidophilus* and *Bifidobacterium bifidum*. *J. Dairy Res.,* 26 : 1 - 8.

Kumar, R., Gali, J. M., Arvind and Atreja S. K. (2011) Assessment of cryopreservation associated DNA damage in crossbred cattle (Karan Fries) spermatozoa. *Indian J. Dairy Sci.,* 63 (3) : 243 - 46.

Mohanta, R. K., Singhal, K. K., Ebrahimi, S. H., Rajput, Y. S. and Mohini, M. (2011) Comparative nutritional evaluation of transgenic cottonseeds containing Cry1C protein for ruminant feeding. *Livestock Res. for Rural Develop.,* 23 : 2011.

Monga, R., Ghai, S., Datta, T. K. and Singh, D. (2011) Tissue-specific promoter methylation and histone modification regulate CYP19 gene expression during folliculogenesis and luteinization in buffalo ovary. *Gen Comp Endocrinol.*, 1 : 173 (1) : 205 - 15

Monga, R., Sharma, I., Datta, T. K. and Singh. D. (2011) Characterization of serum-free buffalo granulosa cell culture and analysis of genes involved in terminal differentiation from FSH - to LH-responsive phenotype. *Domestic Anim. Endocrinology,* 41 : 195 - 206.

Monga, R., Datta, T. K. and Singh, D. (2011) Validation of gene silencing using RNA interference in buffalo granulosa cells, *Asian-Aust. J. Anim. Sci.*, 24 110 : 1529 - 40.

Monga, R, Ghai, S, Datta, T. K. and Singh, D (2012) Involvement of transcription factor GATA-4 in regulation of *CYP19* gene during folliculogenesis and luteinization in buffalo ovary. *J. Steroid Biochem. and Mol. Biol.*, 130 : 45– 56

Paltra, F., Tomar, S. K., Rajput, Y. S. and Singh, R. (2011) Characterization of mannitol producing strains of *Leuconostoc* species. *World J. Microbiol. Biotechnol.,* 27 : 933 - 39.

Raja, S., Shanthi, M., Behera, P. S., Kapila, S., Kansal, V. K., Kapila, R., Dang, A. K. and Arora, S. (2011). Comparative evaluation of caseinophosphopeptides of cow and buffalo for immunomodulatory potential in mice. *Milchwissenschaft,* 66 (4) : 371 - 75.

Rafeequi, T. A. and Kaul, G. (2011) Elucidation of interaction between multiwalled carbonnanotubes and cell culture media supports biocompatibility of these nanotubes'. *Adv. Sci. Lett.,* (4) pp.1-5.

Sharma, R. and Rajput, Y. S. (2012) Rapid methods for assessing efficiency of heat treatment of milk. *J. Food Sci. and Tech.,* (DOI 10.1007/s13197-012-0635-x).

Sharma, R, Singla, S. K., Palta P, Manik R, Chauhan M. S. and Singh, D. (2012) Characterization of *POU5F1* (*OCT4*) gene and its promoter in buffalo ESC-like cells identifies multiple transcription start sites and expression of four pseudogenes. *Gene*, 491 : 165 – 72.

Dairy Technology Division

Research Papers

Basu Sandeep, Tomar S. K., Mandal, S., Hati S., Ali, B., Singh, A. K., Arora, S. and Mohanty, A. K. (2011) A study on antimicrobial activity and antibiotic susceptibility of phytate and starch degrading lactic acid bacteria isolated from indigenous cereal based fermented milk product "raabadi" *Indian J. Dairy Sci.,* 64 (1) : 27 - 32.

Chawla, R., Patil, G. R. and Singh, Ashish Kumar (2011) Sensory characterization of doda burfi (Indian milk cake) using Principal Component Analysis. *J. Food Sci. & Tech.,* (Published online)

Chawla, R., Patil, G. R. and Singh, Ashish Kumar (2011) Physico-chemical and textural attributes of Market samples of Doda barfi. *Dairy Foods International*, 1 (1).

Meena, G. S., Gupta, Suneel, Gautum, C., Majumdar and Banerjee, Rintu (2011) Growth characteristics modeling of bifidobacterium bifidum using RSM and ANN. *Brazilian Archives of Biology and Tech.*, 54 (6) : 1357- 66.

George, V., Arora, S., Sharma,V., Wadhwa, B. K. and Singh, A. K. (2011) Detection and estimation of sucrose in sweetened lassi. *Dairy Foods International,* 1(1) :17 - 19.

Khamrui, K. and Pal, D. (2011) Storage related changes in some chemical & physical properties of whey-based Kinnow juice powder. *Indian J. Dairy Sci.,* 64 (3) 198 - 204.

Kumar, J., Kumar, S., Gupta, V. K. and Kumar, B. (2012) The influence of admixing sweet cream buttermilk to buffalo milk on quality of chhana production. *Milchwissenschaft,* 67 (1) : 57 - 60.

Kumar, S. and Kanawjia, S. K. (2011) Effect of different degree of heat treatments on sensory and biochemical characteristics of buffalo Feta type cheese during ripening. *Milchwissenschaft,* 66 (3) : 290 – 93.

Kumar, S. and Kanawjia, S. K. (2011) Effect of different degree of heat treatments on textural characteristics of buffalo Feta type cheese during ripening. *Milchwissenschaft,* 66 (4) : 375 – 78.

Kumar, S. and Kanawjia, S. K. (2011) Effect of rate of addition of starter culture on textural characteristics of buffalo milk Feta type cheese during ripening. *International J. Dairy Technology,* (Online Published: DOI 10.1007/s13197-011-0565-z).

Kumar, S. and Kanawjia, S. K. (2011) The effect of type of milk on chemical composition and textural attributes of Feta type cheese during ripening. *Milchwissenschaft,* 67(1) : 26 - 29.

Kumar, S. and Kanawjia, S. K. (2011) The influence of different level of casein/fat ratio on textural characteristics of buffalo Feta type cheese. *Indian J. Anim. Sci.,* 81 (10) : 74 – 77.

Kumar, S., Kanawjia. S. K, Suryamani, K. (2011) The effect of varying casein/fat ratio on physicochemical and sensory qualities of Feta-type cheese made using buffalo milk. *International J. Dairy Tech.*, 64 : 1 – 6.

Londhe, G., Pal, Dharam and Narender Raju, P. (2012) Effect of packaging techniques on shelf life of brown peda, a milk-based confection. *LWT-Food Sci. and Tech.,* (doi:10.1016/j.lwt.2011.12.025).

Narender Raju, P. and Pal, Dharam (2011) Effect of bulking agents on the quality of artificially sweetened misti dahi (caramel colored sweetened yoghurt) prepared from reduced fat buffalo milk. *LWT-Food Sci. and Tech.,* 44 (9) : 1835 - 43.

Patange, D. D., Patel A. A., Singh, R. R. B., Patil, G. R. and Bhosle, D. N. (2011) Storage related changes in ghee-based low-fat spread. *J. Food Sci. and Tech.,* DOI: 10.1007/s13197-011-0339-7 (Published online April 13, 2011).

Ramesh, V., Kumar, R., Singh, R. R. B., Kaushik, J. K. and Mann, B. (2012) Comparative evaluation of selected strains of lactobacilli for the development of antioxidant activity in milk. *Dairy Sci. and Tech.,* 92 (2) : 179 – 88.

Sabikhi, L., Suthar, B. K. and Thompkinson, D. K. (2011) Co-encapsulation with inulin to improve the survival of probiotic *Lactobacillus acidophilus* NCDC15 for synbiotic food applications. *Milchwissenschaft,* 66 (1) :18 - 22.

Singh, Preeti and Goyal, G. K. (2011) Combined effect of refrigeration and modified atmosphere packaging on the shelf life of ready-to-serve pizza: biochemical and sensory attributes. *American J. Food Tech.*, 6 (3) : 202 - 14.

Singh, S., Kanawjia, S. K. and Gupta, V. (2011) Selection of suitable medium for growth of lactic acid bacteria. *Dairy Foods International*, 1 :36 - 40.

Yadav, D. N., Balasubramanian, S., Kaur, J., Anand, T. and Singh, A. K.(2011) Optimization and shelf-life evaluation of pearl millet based halwa dry mix. *International J. Food Sci. & Engineering*, 1 : 313 – 22.

Review Articles

Chawla, Rekha, Patil, G. R. and Singh, A. K. (2011) High hydrostatic technology in dairy processing: A review. *J. Food Sci. & Tech.,* 48 (3) : 260 – 68.

Choi, Jongwoo, Sabikhi, Latha, Hassan, Ashraf, Anand, Sanjeev (2011). Bioactive peptides in dairy products: A review. *International J. Dairy Tech.,* (DOI: 10.1111/j.1471-0307.2011.00725.x).

Hati, S., Mandal, S., Vij, S., Minz, P. S., Basu, S., Khetra, Y., Yadav, D. and Dahiya, M. (2012) Non-thermal plasma technology and its potential applications against food borne microorganism. *J. Food Processing and Preservation,* (doi:10.1111/j.1745-4549.2011.00619.x).

Hussain, S. A., Sharma, P. and Singh, R. R. B. (2011) Functional dairy foods-An Overview (Theme paper). In: Proceedings of International Conference on Functional Dairy Foods, NDRI, Karnal, Haryana, India, November 16-19, pp. vii-lii.

Khetra, Yogesh, Raju, P., Hati, S. and Kanawjia, S. K. (2011) Health benefits of traditional fermented milk products. *Indian Dairyman*, 63 (9) : 54 - 60.

Kaur, K. D., Jha, A., Sabikhi, L. and Singh, A. K. (2012) Significance of coarse cereals in health and nutrition: A review. *J. Food Sci. and Tech.,* (DOI 10.1007/s13197-011-0612-9).

Makhal, Suberna and Kanawjia, S. K. (2011) Shelf life extension of direct acidified cottage cheese using thymol. *Beverage & Food World,* 38 (8) : 38 - 48.

Sabikhi, L. and Malik, R. K. (2012) Futuristic Dairy Foods and Human Health. Souvenir. XL Dairy Industry Conference. New Delhi. Feb 2-5. Souvenir. 27-35.

Sangwan, Vikash, Tomar, S. K., Singh, R. R. B., Singh, A. K. and Babar, Ali (2011) Galactooligosaccharides -Novel components of designer foods. *J. Food Sci.,* 76 (4) : 103 – 111.

Sangwan, V, Tomar, S. K., Singh, R. R. B., Singh, A. K. and Babar, Ali (2011) Galactooligosaccharides: Novel Compounds for Designer Foods. *J. Food Sci.,* (Published online June 2011).

Tyagi, A., Tyagi, A. K., Singh, R. R. B. and Hossain, S. A. (2011) Designing milk and meat products with enhanced "Conjugated Linoleic Acid" (CLA) content-A review. *Indian J. Anim. Nutr.,* 28 : 1-7.

Popular Articles

Kanawjia, S. K. (2011) Ghee: A well designed nutraceutical dairy product. *Agrovet Buzz,* 3 (6) : 46 - 49.

Khetra, Y., Hati, S., Mandal, S. and Kanawjia, S. K. (2011) Advances in bio-functional dairy beverages. *Beverage and Food World,* 38 (8) : 54 - 57.

Khetra, Y., Raju, P. N., Hati, S. and Kanawjia, S. K. (2011) Health benefits of traditional fermented milk products. *Indian Dairyman,* 63 (9) : 54 - 60.

Nag, A., Das, S. and Khamrui, K. (2011) Dairy proteins: superior probiotics micro-encapsulation agents. *Food & Beverage Asia*. June – July 2011. 22-26.

Patel, A. A. and Sharma, Prateek (2011) Dairy processes and technologies: New avenues of product diversification. *Indian Dairyman,* 63 (3) : 64 – 66.

Book

Thompkinson, D. K. and Sabikhi, L. (2012) Quality Milk Production & Processing Technology. New India Publishing Agency, New Delhi. xxvii+ 274 pp.

Book Chapter

Raju, P. Narender and Hanumantha, Rao K. (2011). Application of Biosensors for the Quality Assurance of Dairy Products. In Biosensors in Food Processing, Safety and Quality Control, M. Mutlu (ed), CRC Press, pp. 227 - 56.

Dairy Chemistry Division

Basu, Sandeep, Tomar, S. K., Mandal, S., Hati, S., Ali, B., Singh, A. K., Arora, S. and Mohanty, A. K. (2011) A study on antimicrobial activity and antibiotic susceptibility of phytate and starch

degrading lactic acid bacteria isolated from indigenous cereal based fermented milk product "raabadi". *Indian J. Dairy Sci.,* 64 (1) : 27 - 32.

George, V., Arora, S., Sharma, V., Wadhwa, B. K. and Singh, A. K (2011) Detection and estimation of sucrose in sweetened lassi. *Dairy Foods International,* 1 (1) : 17 - 19.

Kumar, Manoj, Sharma, Vivek, Lal, Darshan, Seth, Raman and Kumar, Amit (2010) A comparison of physico-chemical properties of low–cholesterol ghee with standard ghee from cow and buffalo creams. *International J. Dairy Technol.,* 63 (2) : 252 – 55.

Kumar, Arun, Lal, Darshan, Seth, Raman and Sharma, Vivek (2010) Detection of milk fat adulteration with admixture of foreign oils and fats using fractionation technique and the apparent solidification time test. *International J. Dairy Technol.*, 63 (3) : 457 – 62.

Kumar, Amit, Unikrishnan, V., Lal, Darshan and Sharma, Vivek (2010) Evaluation of the rosalic acid test for checking its suitability to detect neutralizers in milk. *Indian J. Dairy Sci.,* 63 (2) : 111 – 13.

Meena, M. K., Arora, S., Shendurse, A. M., Sharma, V, Wadhwa, B. K., Singh, A. K. (2011) Formulation optimisation of whey lemon beverage using sweetener blend aspartame / saccharin. *International J. Dairy Tech.,* (Article first published online: 8 AUG 2011 | DOI: 10.1111/j.1471-0307.2011.00712.x).

Naik, L., Sharma, R., Naik, R., Lakshmana, G. and Devi, K. (2011) Lean laboratory approaches for quality assurance in food. *International J. for Quality Res.,* 10 (10) : 611 - 18.

Raja, Sandeep, Shanthi, M., Partha, Sarathi, Kapila Suman, Kapila, Rajeev, Kansal V. K., Dang, A. K. and Arora, Sumit (2011) Comparative evaluation of caseinophosphopeptides of cow and buffalo for immunomodulatory potential in mice. *Milchwissenschaft,* 66 (4) : 371 - 75.

Ramesh, V., Kumar, Rajesh, Singh, R. R. B., Kaushik, J. K. and Mann, Bimlesh (2011) Comparative evaluation of selected strains of lactobacilli for the development of antioxidant activity in milk. Accepted for the publication in the LeLait, 2011. online published by Dairy Science & Technology (DOI: 10.1007/s13594-011-0048-z).

Sharma, R., Rajput, Y. S. and Neelima (2011) Vitamin binding proteins in milk – a review. *Indian J. Dairy Sci.,* 64 (3) : 17-184.

Yadav, Nidhi, Mann, Bimlesh, Saini, Prerna and Kumar, Rajesh (2012) Antioxidant properties of whey protein hydrolysates prepared using heat denatured whey proteins. *Milchwissenschaft,* 67 (1) : 67 - 70

Technical Articles

Nayak, S. K., Nayak, Sangeeta, Arora, Sumit and Sangwan, R. B. (2011) Functional and nutritional benefits of dietary fiber in foods. *Udyogprerna,* 8th – 19th June – August.

Shendurse, A. M., Arora, Sumit., Sharma, V., Manju, G., Mishra, S. and Thimmareddy (2011). Whey proteins: nature's wonder for mankind. *Beverage and Food World,* 38 (2) : 53 – 54.

Book Chapters

Arora, S. (2011). Vitamin fortification as dietary supplements in functional dairy products. In Functional Dairy Foods: Concepts and applications. Chap.19. Published by Satish Serial Publishing house, Delhi, India.

Sindhu, J. S. and Arora, Sumit (2011) Milk: Buffalo milk (Chapter 316) Encyclopedia of Dairy Science, 2nd Edition, pg 503-511Ed. John W. Fuquay, Patrick F. Fox and Paul L. H. McSweeney. Elsevier/Academic Press.

Dairy Microbiology Division

Research Papers

Dagar, S. S., Kumar, S., Mudgil, P., Singh, R. and Puniya, A. K. (2011) D1/D2 domain of large subunit rDNA for differentiation of *Orpinomyces* spp. *Appl. Environ. Microbiol.,* 77 : 6722 – 25.

Dahiya, M., Vij, S., Yadav, D., Hati, S. and Mann, B. (2011) Ethanol production potential of thermotolerant yeast strains isolated from dairy products and non dairy products. *Indian J. Dairy Sci.,* 64 : 21 - 26.

Das, S., Kumar, N., Raghu, H. V., Haldar, L., Gaare, M., Singh, V. K. and Puniya A. K. (2011). Microbial based assay for specific detection of β-lactam group of antibiotics in milk. *J. Food Sci. Technol.*, (DOI 10.1007/s13197-011-0609-4).

Duary, R. K., Batish, V. K. and Grover, S. (2012) Relative gene expression of bile salt hydrolase and surface proteins in two putative indigenous *Lactobacillus plantarum* strains under *in vitro* gut

conditions. *Mol. Biol. Rep.,* 39 : 2541-2552, (DOI 10.1007/ s11033-011-1006-9).

Duary, R. K., Batish, V. K., Rajput, Y. S. and Grover, S. (2011) Assessing the adhesion of putative indigenous probiotic lactobacilli to human colonic epithelial cells. *Indian J. Medical Res.,* 134 : 579 - 738.

Duary, R. K., Mache, A. B., Batish, V. K. and Grover, S. (2011) Anti-inflammatory and immunomodulatory efficacy of indigenous probiotic *Lactobacillus plantarum* Lp91 in colitis mouse model. *Mol. Biol. Rep.*, (DOI 10.1007/s11033-011-1269-1).

Goel, G., Kumar, A., Beniwal, V., Raghav, M., Puniya, A. K. and Singh, K. (2011) Degradation of tannic acid and purification and characterization of tannase from *Enterococcus faecalis. Intl. Biodet. Biodeg.,* 65: 1061- 65.

Hati, S., Gandhi, D. N., Vij, S., Mandal, S. and Dahiya, M. (2011) Process optimization for a drinkable acidophilus milk. *Indian J. Dairy Sci.*, 63 : 350- 57.

Iyer, R., Tomar, S. K., Mohanty, A. K., Singh, P. and Singh, R. (2011) Bioprospecting of strains of *Streptococcus thermophilus* from Indian fermented milk products for folate production. *Dairy Sci. & Technol.*, 91 : 237 - 46.

Iyer, R and Tomar S. K. (2011) Dietary effect of folate rich fermented milk produced by *Streptococcus thermophilus. Nutr.,* 27 : 994 - 97.

Kaur, G., Malik, R. K., Singh, T. P., Bhardwaj, A. and De, S. (2011) Antibacterial efficiency of nisin, pediocin 34 and enterocin FH99 against *Listeria monocytogenes, Enterococcu faecium* and bacteriocins cross resistance and antibiotic susceptibility of their bacteriocins resistant variant. *J. Food Sci. and Tech.*, (DOI: 10.1007/s13197-011-0500).

Kaur, Gurpreet, Singh, Tejinder Pal and Malik, R. K. (2011) Antibacterial efficacy of nisin, pediocin-like and enterocin-like bacteriocins against *L. monocytogenes E. faecium* and *E. faecalis* and bacteriocin cross resistance and antibiotic susceptibility of their bacteriocin resistant variants. *J. Food Sci. Technol.,* (DOI 10.1007/s13197-011-0500-3).

Kaur, Gurpreet, Singh, Tejinder Pal and Malik, R. K. (2011) Mechanism of Nisin, Pediocin 34, and Enterocin FH99 Resistance in *Listeria monocytogenes. Probiotic and Antimicrobial Proteins,* 4 : 11 – 20.

Kaur, G., Malik, R. K., Mishra, S. K., Singh, T. P., Bhardwaj, A., Singroha, G., Vij, S., Kumar, N. (2011) Nisin and class iia bacteriocin resistance among listeria and other food-borne pathogens and spoilage bacteria. *Microbial Drug Resistance,* 17 : 197-205. (DOI: 10.1007/s13197-011-0609-4).

Kumar, M., Verma, V., Nagpal, R., Kumar, A., Gautam, S. K., Behare, P. V., Grover, C. R. and Aggarwal, P. K. (2011) Effect of probiotic fermented milk and chlorophyllin on gene expressions and genotoxicity during AFB1-induced hepatocellular carcinoma. *Gene,* 490 : 54 – 59.

Kumar R., Grover, S and Batish, V.K. (2011) Molecular identification and typing of putative probiotic indigenous *Lactobacillus plantarum* strain Lp91 of human origin by specific primed-PCR Assays. *Probiotics and Antimicro. Prot.*, 3 : 186 - 93.

Kumar, S., Dagar, S. S. and Puniya A. K. (2011) Isolation and characterization of methanogens from rumen of Murrah buffalo. *Annals Microbiol.*, (DOI 10.1007/s13213-011-0268).

Mandal, S., Hati, S., Basu, S., Puniya, A. K., Singh, R. and Singh, K. (2011). Effect of κ-carrageenan concentrations on survival of microencapsulated *Lactobacillus casei* NCDC 298. *Indian J. Dairy Sci.*, 63 : 470 - 73.

Mandal, S., Puniya, A. K. and Singh, K. (2011) Evaluation of probiotic properties of *Lactobacillus casei*. *Beverage and Food World*, 38 : 57 - 59.

Mishra, S. K., Malik, R. K., Kaur, Gurpreet, G., Manju, Pandey, Neha, Singroha, Garima (2011) Potential bioprotective effect of reuterin produced by *L. reuteri* BPL-36 alone and in combination with nisin against food borne pathogens. *Indian J. Dairy Sci.,* 64 (5) : 406 – 11.

Nanda, D. K., Tomar, S. K., Singh, R., Mal, G., Singh, P., Arora, D. K., Joshi, B. K. and Kumar, D. (2011) Phenotypic and genotypic characterization of lactobacilli isolated from camel cheese produced in India. *International J. Dairy Tech.*, 64 : 1 - 7.

Singh, B., Ram, C. and Singh, R. (2011) Angiotensin-1 converting enzyme (ACE) inhibitory activity of peptides isolated from bovine milk fermented with *Lactobacillus helveticus* NCDC- 288. *Milchwissenschaft - Milk Sci. International*, 66 : 429 - 31.

Singh, J., Batish, V. K. and Grover, S. (2011) Molecular beacon based real time PCR assay for simultaneous detection of *Listeria monocytogenes* and *Salmonella* spp. in dairy products. *Dairy Sci. & Tech.*, 91 : 373-382. (DOI: 10.1007/s13594-011-0007).

Singh, J., Batish, V. K. and Grover, S. (2011) Simultaneous detection of *Listeria monocytogenes* and *Salmonella* spp. in dairy products using Real Time PCR-melt curve analysis. *J. Food Sci. and Technol.,* 49 : 234 - 39. DOI: 10.1007/s13197-011-0278-3.

Singh, T. P., Kaur, G., Malik, R. K., Schillinger, U., Guigas, C. (2012) Characterization of intestinal *Lactobacillus reuteri* strains as potential probiotics. *Probiotics & Antimicrobial Proteins,* 4 : 47 – 58.

Review Articles

Hati, S., Mandal, S., Vij, S., Dahiya, M. and Sarkate, S. (2011) *Lactobacillus acidophilus* – a probiotic for potential application in fermented milk products. *Indian Dairyman*, 56 - 62.

Kumar S., Dagar, S. S., Mohanty, A. K., Sirohi, S. K., Puniya, M., Kuhad, R. C., Sangu, K. P. S., Griffith G. W. and Puniya A. K. (2011) Enumeration of methanogens with a focus on fluorescence *in situ* hybridization. *Naturwissenschaften*, 98 : 457 – 72.

Rashmi, H. M., Namita Rokana, Duary, R. K., Panwar, H., Batish, V. K. and Grover, S. (2012) Management of metabolic syndrome through probiotic and prebiotic interventions. *Indian J. Endocrinol. and Metabolism,* 16 : 20 - 27.

Popular Articles

Khetra, Y., Hati, S., Mandal, S. and Kanawjia, S. K. (2011) Advances in biofuncitonal dairy beverages. *Beverage and Food World*, 38 (8) : 54 - 56 & 59.

Vij, S., Hati, S. and Yadav, D. (2011) Biofunctionality of probiotic soy yoghurt. food and nutrition science. Vol.2.502-509.[doi:10.4236/fns.2011.25073 published online July (www.SciRP.org/journal/fns)].

Dairy Economics, Statistics & Management Division

Research Papers

Chand, P., Sirohi, S. and Sirohi, S. K. (2011) Using sustainable livestock production index for development of livestock sector: case study of an arid region in India. *J. Applied Anim. Res.*, 39 : 234 - 38.

Das, G., Verma, N. K. and Jain, D. K. (2011) Consumption pattern of milk variants across different socio-economic groups of north Tripura district (Tripura). *J. Dairying, Foods and Home Sci.*, 30 : 230 – 38.

Devi, G. and Jain, D. K. (2011) Economic impact of micro finance: a comparative study of dairy Self-Help Groups (SHGs) in Jaipur district of Rajasthan. *Indian J. Agri. Eco.,* 66 : 606 – 18.

Devi, G. and Jain, D. K. (2011) Financial performance of dairy self-help groups in Jaipur district of Rajasthan: a comparative analysis. *Indian J. Dairy Sci.*, 64: 435 - 39.

Dongre, V. B., Gandhi, R. S., Singh, A. and Malhotra, R. (2011) Prediction of first lactation 305-day and fortnightly test day milk yields using lactation curves models in Sahiwal cattle. *International J. Agri. : Res. and Review*, 1 : 87 – 90.

Feroze, S. M., Chauhan, A. K. and Chakravarty, A. K. (2011) Microfinance and income from dairy in Haryana: an impact analysis. *Indian J. Anim. Sci.,* 81 : 751 – 56.

Feroze, S. M., Chauhan, A. K., Malhotra, R. and Kadian, K. S. (2011) Factors influencing group repayment performance in Haryana: application of Tobit model. *Agril. Eco. Res. Review,* 24 : 57 – 65.

Ganga and Jain, D. K. (2011) Transaction cost of dairy financing through self help groups in Jaipur district of Rajasthan. *Indian J. Social Res.*, 52 : 391 – 401.

Mahajan, S. and Chauhan, A. K. (2011) Resource use efficiency in rural and periurban dairy farms in Ludhiana district. *Indian J. Dairy Sci.,* 64 : 148 – 53.

Meena, G. L., Jain, D. K. and Chandel, B. S. (2010) Economic analysis of milk production in Alwar district of Rajasthan. *J. Dairying, Foods and Home Sci.*, 29 : 1–7.

Meena, G. L., Jain, D. K. and Dhaka, J. P. (2011) Determinants of production and marketed surplus of milk in Alwar district (Rajasthan). *Indian J. Agril. Marketing,* 25 : 51 – 65.

Raja, T. V., Ruhil, A. P. and Gandhi, R. S. (2012) Comparison of connectionist and multiple regression approaches for prediction of body weight of goats. *Neural Computing and Applications*, 21 : 119 – 24.

Ruhil, A. P., Singh, R. R. B., Jain, D. K., Patel A. A. and Patil, G. R. (2011) A comparative study of kinetic and connectionist modeling for shelf-life prediction of Basundi mix. *J. Food Sci. and Tech.,* 48 (2) : 204 - 10.

Saxena, R., Sirohi, S. and Zadeh, M. N. (2010) Aftermath of global economic crisis: impact on indian dairy sector. *Indian J. Dairy Sci.*, 63 : 491 – 96.

Sharma, A. K., Sharma, V. K., Chakravarty, A. K., Jain, D. K., Ruhil, A. P., Malhotra, R., Agrawal, R. C. and Grover, M. (2011) Web-enabled decision support system on most probable producing ability and a searchable database on herd strength for livestock farm management. *International J. Computer Sci. and Engineering*, 3 : 3628 – 33. (Published Online).

Singh, S. K., Agarwal, S. B., Singh, K. R. and Mondal, B. (2011) Economic analysis of milk production and disposal pattern of milk in Varanasi district of Uttar Pradesh. *Indian J. Dairy Sci.*, 64 : 142 – 47.

Sirohi, S. and Saxena, R. (2012) Research and development priorities for sustainable milk production in Karnataka. *Indian J. Anim. Sci.*, 82 : 209 – 15.

Popular Articles

Khetarpal, N. and Ruhil, A. P. (2012) A conceptual model of e-governance for agriculture: possibilities and challenges. *Management Vistas*, 5: 27 – 34. (Published by Guru Gobind Singh Institute of Technology and Management Studies, Yamuna Nagar, Haryana, India).

Minz, P. S., Sharma, A. K. and Raju, P. N. (2012) Automatic food quality evaluation using computer vision system – a framework. *Beverage and Food World*, 39 : 23 – 26.

Sharma, A. K. (2012). Information technology: empowering dairy entrepreneurship. *Indian Dairyman*, 64 : 52 – 58.

Book Chapters

Feroze, S. M. and Chauhan, A. K. (2011) *Microfinance in India: A Performance Evaluation*. New Century Publications, 4800/24, Bharat Ram Road, Ansari Road Daryaganj, New Delhi. ISBN 978-817708-285-2. Book Pages: 180.

Goyal, S., Sharma, A. K. and Sharma, R. K. (2011) Development of Efficient Artificial Neural Network and Statistical Models for Forecasting Shelf Life of Cow Milk Khoa – A Comparative Study. In: Mantri, A., *et al.* (Editors), *High Performance Architecture and Grid Computing*. Springer-Verlag **Series on** Communications in Computer and Information Science, vol. 169, pp. 145–149. ISBN 978-3-642-22576-5.

Khatri, I. and Sharma, A. K. (2011) *Protein Secondary Structure Prediction – Helical Transmembrane Region Prediction using Adaptive Neuro-Fuzzy Inference System*. Lambert Academic Publishing_GmbH & Co. KG, Saarbrücken, Germany. (ISBN 3844313230. EAN 978-3-8443-1323-9). Pp. 64.

Meena, B. S., Kumar, R. S., Subash, S., Ruhil, A.P. (2011) Empowering Farmers through ICTs in Changing Climate. In: Singh, K. M. and Meena, M. S. (Editors), *ICT for Agricultural Development in Changing Climate*, pp. 51–71. Narendra Publishing House, New Delhi. ISBN: 978-93-80428-45-1.

Meena, G. L., Jain, D. K. (2011) *Impact of Dairy Cooperatives on the Economy of Rural Households*. Lambert Academic Publishing AG & Co. KG Dudweiler Landstr. 99, 66123 Saarbrucken, Germany. ISBN 10:3847305077. EAN 13: 978-3-8473-0507-1. Book Pages: 124.

Sirohi, S. and Suresh, A. (2010) Impact of Climate Change on Socio-Economic Status of Small Ruminant Farmers. In: Karim, S. A., *et al.* (Editors), *Climate Change and Stress Management: Sheep & Goat Production*. Satish Serial Publishing House, New Delhi, pp. 703 - 30.

Srivastava, A. K., Prasad, S., Singh, A. K. and Sirohi, S. (2012) Dairy Research and Development: Challenges Ahead. In: Garg, S. R. (Editor), *Veterinary and Livestock Sector: A Blueprint for Capacity Building*. Satish Serial Publishing House, New Delhi, pp. 31 – 46.

Dairy Extension Division

Research Papers

Datt, R., Sujan, D. K. and Jha, S. K. (2009) Farmers' awareness about improvised agricultural technologies developed by fellow progressive farmers : An empirical study. *J. Community Mobilization and Sustainable Development,* 4 (2) : 41 - 43.

Feroze, S. M., Chauhan, A. K., Malhotra, R. and Kadian, K. S. (2011) Factors influencing group repayment performance in Haryana: Application of tobit model. *Agril. Econ. Res. Review,* 24 (1) : 57 - 65.

Gupta, Jancy and Saidur, Rahman (2011) Self help groups in India: Impact and sustainability, *International J. Extn. Edu.*, 7 : 57 – 60.

Jadoun, Y. S., Sankhala, G., Bhadauria, P. and Jaisridhar (2011) A study of consumer's acceptability of bajra lassi. *J. Dairying, Foods & H.S.*, 30 (3).

Jadoun,Y. S., Sankhala, G., Bhadauria, P. and Jaisridhar (2011) Consumer's perception regarding

dairy health foods developed at National Dairy Research Institute. *J. Dairying, Foods & H.S.,* 30 (4) : 271 - 73.

Jaisridhar, Ravichandran, Y. Jaduon and Senthil Kumar, R. (2011) Socio-economic characteristics of maize growers in Tamil Nadu. *Agril. Sci. Digest.,* 31 (4) : 305 - 07.

Jeenger, H. K., Sankhala and Meena B. S. (2011) Attitude of beneficiary farmers towards district poverty initiative project (DPIP)- Scale development. *Indian Res. J. Extn. Edu.*, 11 (2) : 65 – 67.

Maiti, Sanjit, Garai, Sanchita and Jha, S. K. (2010) Public-private partnership for artificial insemination: An experience from West Bengal". *Agril. Extn. Review,* pp. 20 - 22.

Maiti, Sanjit, Jha, Sujeet Kumar and Garai, Sanchita (2011) Performance evaluation of public-private partnership model of veterinary services in West Bengal. *Ind. Res. J. Extn. Edu.,* 11 (2).

Mohammad, Asif and Gupta, Jancy (2011) Milk disposal pattern of dairy farmers in West Bengal. *Anim. Sci. Reporter,* 5 (3) : 111 - 16.

Rahman, Saidur and Gupta, Jancy (2011) Profitability of dairy farming: A comparison between SHG members and non-members. *Indian J. Dairy Sci.,* 64 (3) : 263 - 66.

Sahu, N. C., Gupta, Jancy and Meena, B. S. (2011) Adoption of scientific dairy farming practices by the commercial dairy farmers in Haryana. *Indian J. Dairy Sci.,* 64 (1) : 63 – 68.

Sahu, N. C., Gupta, Jancy and Singh, Om Vir (2011) Status of commercial dairy farming in Haryana-An exploratory study. *Indian J. Dairy Sci.,* 64 (2) : 154 – 61.

Tak, Ata-Ul-Munim, Ckakravarty, Ritu Upadhyay, R. C., Meena, B. S., Rani, Kavita and Singh, Shyam (2011) Knowledge level of dairy farmers about udder health care practices and its relation to their socio-economic characteristics. *Indian J. Dairy. Sci.,* 64 (1) :39 - 41.

e- Publication

Kumar, Senthil, Meena, B. S., Athequalla, Subash (2011) ICT Enabled Extension Delivery System; Issues and Strategies in Agriculture. Published the popular article at Papers @ Elets e-World Forum 2011 held at International Information and Communication Technology (ICT) Conference at New Delhi.

Book

Kumar, Dileep, Kadian, K. S., Garhwal, O. P. (2012) *Mass Communication in Agricultural Extension*. Satish publishing house Delhi.

Book Chapter

Meena, B. S. Kumar, R. Senthil, Subash, S. and Ruhil, A.P. (2011) Empowering farmers through ICTs in changing climate in ICT for Agricultural Development in Changing Climate, *Edited by* : K. M. Singh and M. S. Meena published by Narendra Publishing House. pp. 161– 72.

Southern Regional Station, Bangalore

Research Papers

Amol S., Vyawahare, Pratik Nawale, Sushim, Kumar, Krushna, Papinwar, Patel, Dhinal, Kumar, H. and Jayaraj Rao, K. (2011) Psychorheological study on viscosity of milk. *J. Dairying, Foods Home Sci.,* 30 (1) : 25 - 31.

Das, D. N., Kataktalware, M. A., Ramesha, K..P. and Reddy, A. Obi (2011) Production and reproduction performances of Deoni cattle under semi intensive management. *Indian J. Anim. Sci.,* 81 : 1186 - 88.

Das, D. N., Kataktalware, M. A., Ramesha, K. P. and Obi Reddy, A. (2011) Productive and reproductive performances of Deoni cattle under intensive management system. *Indian J. Anim.l Sci.,* 81 (11) : 1186 – 88.

Karthikeyan, S., Venkateshaiah, B. V., Tulasidas, T. N., Achoth, L., Rao, K. J. and Krishnappa (2011) Process optimization for continuous microwave processing of paneer. *Dairy Foods International,* 1 (1) : 47 - 52.

Mahalingaiah, L., Venkateshaiah, B. V., Kulkarni, S. and Jayaraj Rao, K. (2011) Studies on energy requirements in manufacture of kunda – a heat desiccated Indian milk product. *J. Food Process Engineering,* 34 : 444 – 56.

Menon, Rekha Ravindra, Rao, K. Jayaraj, Nath, B. Surendra and Ram, Chand (2011) Extended shelf life flavoured dairy drink using dissolved carbon dioxide. *J. Food Sci. Technol.,* (DOI 10.1007/s13197-011-0473-2).

Navajeevan, B., Rao, K. Jayaraj, and Pagote, C. N. (2011) Studies on changes in textural properties during storage of kunda – a popular sweet product of central India. *Res. J. Engg Technol.*, 4 (3) : 11 - 18.

Pagote, C. N. and Rao, K. Jayaraj (2012) Khoa jalebi, a unique traditional product of Central India. *Indian J. Traditional Knowledge,* 11 (1) : 96 - 102.

Parmar, S. C., Sofia P. Zacharia, Jain, A. K. and Nath, B. Surendra (2010) Quality of ghee from Bangalore market. *Indian J. Dairy Sci.,* 63 : 364 – 70.

Ramesha, K. P., Kumar, Prasanna, Chandrashekar, K. V., Das, K. S., Saravanan, B. C. Pourouchottamane, R. and Kataktalware, M. A. (2011) Genetic variability of Indian yaks using random amplified polymorphic DNA markers. *African J. Biotechnology,* 10 (43) : 8558 - 61.

Ramesha, K .P., Jayakumar, S., Das, Sandeep, Biswas, T. K., Krishnan, G., Chouhan, V. S. and Kataktalware, M. A. (2012) Genetic variation of SRY gene in yak and related bovines. *International J. Pharma and Bio Sci.,* 3 (2) : 82 - 87.

Ramesha, K.P. (2011). Intellectual property rights regime for livestock agriculture in India - present status and future prospects. *J. Intellectual Property Rights,* 16 (2) : 154 - 62.

Shergojry, S. A., Ganayi, B. A., Ramesha, K. P., Rengarajan, K., Srihari, G. V., Das, D. N. and Kataktalware, M. A. (2011) Association of single nucleotide polymorphisms (SNPS) Of HSP90AA1 gene with reproductive traits in deoni cattle. IJLR Online 1 (1) : 17 - 29. www.ijlr.org.

Shilpashree, B. G., Bhavadasan, M. K., Surendra Nath, B., Ramesh, V. and Shivanand, S. (2011) Quality of high priced traditional milk sweets marketed in Bangalore. *Indian J. Dairy Sci.,* 64 : 212 – 18.

Somashekara Reddy, P. V. and B. Surendra Nath (2011) Colorimetric estimation of lactose in concentrated and lactose hydrolyzed paneer whey. *Indian J. Dairy Sci.,* 64 : 87 – 91.

Srinivas, B., Swain, N. and Singh. N. P. (2011) Quantification of nutritional sustenance and microbial protein production of sheep during different physiological stages in semi arid regions. *Indian J. Anim. Sci.,* 81(3) : 282 - 88.

Srinivas, B. and Swain, N. (2011) Seasonal dynamics in vegetation and rumen microbial nitrogen production and nutritional status of grazing sheep in a semi-arid rangeland in eastern Rajasthan. *Grassland Sci.,* 57 : 219 - 23.

Vawahare, A. S. and Jayaraj Rao, K. (2011) Application of computer vision systems in colour evaluation of kunda: a heat desiccated dairy product. *Int. J. Dairy Sci.,* 6 (4) : 252 - 66.

Wadhwa, B. K., Arora, S., Sharma, V., Surendra Nath, B., Puniya, M. and Chhabra, A. (2010) Chemical contaminants: Pesticide residues in milk and organic dairy Farming. *Indian Dairyman,* 62 : 90 - 94.

Popular Articles

Das, D. N. (2011) Control of subclinical mastitis: A way for profitable dairying published in KMF Magazine, *Ksheerasagara*, December, 2011.

Divya, K., Jayaraj Rao, K. and Pagote, C .N. (2011) Utilisation of concentrated whey in bread manufacture. *Beverage and Food World,* 38 (9) : 27 - 28.

Jayaraj Rao, K., Vyawahare, A.S. and Pagote, C. N. (2011) Colour/quality evaluation of dairy products: prospect of computer vision systems. *Indian Dairyman*, 63 (2) : 64-69.

Pagote, C. N. and Jayaraj Rao, K. (2011) Khoa Jalebi – a delicious sweetmeat of central India. *Indian Dairyman*, 63 (7) : 42 - 49.

Pankaj Madariya, Pagote, C. N. and Jayaraj Rao, K. (2011) A perspective on digital calculation system for milk standardization in automated dairy plants. *Beverage and Food World,* 38(3): 39 - 40, 44.

Srinivas, B., Surendranath, B. and Kulkarni, S. (2012) Incorporation of concentrated whey in the production of yoghurt –technological aspects. XL DIC 2nd - 5th Feb., 2012, New Delhi Souvenir, pp. 95 - 97.

Vyawahare, A. S., Reddy, K. V., Pagote, C. N. and Jayaraj Rao, K. (2011) Phytosterols: sources, applications and potential health benefits. *Beverage and Food World*, 38(12) : 57 - 60.

Book

Ramesha K. P. (2011) (Ed.) *An Introduction to Animal Farming Systems in India.* ISBN 978-81-922520-0-1.

Book Chapters

Nagarcenkar, R. and Ramesha, K. P. (2011) "Genetic Principals and Application to Animal Farming", *An Introduction to Animal Farming Systems in India.* ISBN 978-81-922520-0-1.

Ramesha, K.P. (2011) "Intellectual Property Rights Regime: An overview in Animal Farming in India", *An Introduction to Animal Farming Systems in India.* ISBN 978-81-922520-0-1.

Eastern Regional Station, Kalyani

Research Paper

Barman, K. C., Ghosh, M. K., Baruah, D. and Singh, N. D. (2011) Growth performance of local pigs under traditional system of rearing. *Ind. Vet. J.*, 88 (5) : 67-68.

Biswas, T. K., Bandyopadhyay, S., Ghosh, M. K., Jayakumar, S. K., Ramesha, P., Vikrant, C. S. and Paul, Vijay (2011) Non-infectious predisposing factors for calf mortality in yaks. *Ind. Vet. J.*, 88 (5) : 78 - 79.

Chatterjee, A., Ghosh, M. K., Roy, P. K., Das, S. K., and Santra, A. (2011) Macro and micro-mineral status of feeds and fodders in West Kameng district of Arunachal Pradesh. *Ind. J. Anim. Sci.,* 81 (10) : 1076 - 79.

Chatterjee A., De D. and Sheikh I. U. (2011) Macro and micro elemental concentrations in some locally available tree fodder of Sikkim. *Ind. J. Anim. Sci.*, 81 : 984 - 87

Chatterjee, A. and Sheikh I. U. (2011) Mineral status in Yak through hair tissue mineral Analysis: Effect of age and sex. *Vet. Sci. Res. J.,* 2 : 16 – 18.

Das, S. K., Sharma. A. K., Bhatia, V. and Mohanty, A. K. (2011) Oviductal secretory proteins as media supplement for *in vitro* embryo development in cattle. *Reprod. Fertility and Development,* 24 (1) : 164.

Ghosh, M. K. and Chatterjee, A. (2011) Nutrient digestibility and live weight change in yaks fed maize stover based complete feed block during winter. *Ind. J. Anim. Sci.*, 81 (4) : 427 - 28.

Ghosh, M. K. and Chatterjee, A. (2011) Effect of complete feed block on nutrient digestibility and live weight gain of yak. *Ind. Vet. J.*, 88 (11) : 81 - 82.

Mandal, A., Kumar, P., Rout, P.K. and Roy, R. (2011) Goat milk protein polymorphism and its effect on protein and casein content of milk. *Ind. J. Dairy Sci.*, 64 (3) : 226 - 29.

Mandal, A., Dass, Gopal, Rout, P. K. and Roy, R. (2012) Effect of environmental factors on reproductive performance of Muzaffarnagari sheep. *Ind. Vet. J.,* 89 (1) : 73 - 74.

Mandal, A., Sharma, D. K. and Roy, R. (2012) Genetic and environmental influences on faecal nematode egg counts of Jamunapari goats in India. *Vet. Rec. doi : 10.1136/vr.100287.*

Santra, A., Banerjee, A., Das, S. K. and Chatterjee, A. (2012) Effect of plants containing secondary metabolites on ruminal fermentation and methanogenesis *in vitro. Ind. J. Anim. Sci.,* 82 (2) :194 - 99.

Sharma. A. K., Mohanty, A. K. and Das, S. K. (2011) Heparin binding oviductal secretory proteins as a media supplement for *in vitro* embryo production in cattle. *Reprod. Fertility and Development*, 24 (1) : 188 - 89.

Popular Article

Mandal, A., Ghosh, M. K., Chatterjee, A. and Gandhi, R. S. (2012) Breeding strategies for genetic improvement of cattle in Eastern India. *Indian Dairyman*, pp. 60 - 65.

Book Chapter

Mandal, Ajoy (2011) "Statistical analysis of complex traits of livestock using animal model". "*Genetic Dissection of Complex Trait Analysis with Special Reference to Genetic Resistance to GIN in Goats*" held on November, 15-28, 2011 at the Central Institute for Research on Goats, Makhdoom, Mathura, Uttar Pradesh, India, pp. 71-81.

Hindi Publications

Kumar, Ajesh, Kambij, M. L., Meena, D. K. and Meena, B. S. (2011) *Navjat bacchere avan bacchrion ki Dekhbhal kaise kairen. Kheti.* Published by ICAR, New Delhi.

Meena, D. K., Kumar, Ajesh and Meena, B. S. (2012) *Swachh dugdh Utpadan kaise kairen. Kheti Duniai.* Published by Patiala Punjab. pp. 2.

Meena, D. K., Meena, B. S. and Sehagal, J. P. (2012) *Sanghthan evom shshatikaran ka swarup: swam shahayta samuh. Agovet.* (March-May, 2012) pp. 22 - 24.

9 CONSULTANCY, PATENTS & COMMERCIALISATION OF TECHNOLOGIES

Industrial Consultancy Services

The Consultancy Service Board facilitates transfer of the technologies developed on the basis of R&D work done in various laboratories for infusion of Science and Technology in areas of Dairy Production, Dairy Processing and Dairy Management on professional basis. For providing assistance to Nation's Dairy Industry, consultancy services are available in areas of (i) Products/ Processes/Equipments developed at NDRI, (ii) Engineering design support for scaling up and fabrication of dairy equipments developed at NDRI, (iii) Preparation of techno-economic feasibility reports for dairy projects on milk production and milk processing plants, (iv) R&D assistance in product manufacture and problem solving, and (v) Quality assurance and product testing services to the industry.

Revenue generated from consultancy services is utilized for strengthening the Institute's infrastructure and R&D work and also part of the money is shared among the scientists rendering such service as an incentive. Consultancy services also provide a via media for two-way communication between scientists and industry. Feedback from industry through such interactions helps the scientists to focus and fine tune their research efforts to fulfill the real needs of dairy industry. During April 2011 to March 2012, the Board provided services to 141 organizations and generated a total revenue of ₹ 23,25,667/-.

Contract Research Projects/Consultancy Projects/ Consultancy

- "Üse of Rice Bran Lecithin and Phospholipids in Dairy Cattle Feeding" Sponsored by A. P. Organics Pvt. Ltd., Dhuri (PB) (Dr. A. K. Tyagi Principal Scientist, DCN).
- "Evaluation of the Effect of the Keenan Mech Fiber System on the Lactation Performance of Buffaloes" Sponsored by Keventer Agro Ltd., Kolkatta (Dr. S. S. Thakur, Principal Scientist, DCN).
- Consultancy for Certification of Nestle, Nesvita Probiotic Dahi (Dr. V. K. Batish, Head, DM).
- SRS Bangalore provided consultancy on "Evaluation of DSM Starter Culture Performance in Dahi and other Indian Fermented Milk Products" to M/s DSM Food Specialties, Windsor House, 401, 4th Floor CST Road, Kalina, Santacruz (East), Mumbai – 400 058.
- SRS Bangalore provided consultancy for "Production of Curd" to M/s ABT Dairy Foods, Coimbatore, Tamil Nadu.
- SRS Bangalore provided consultancy on "Setting up of Dairy Plant" to M/s Vakrangree Lactisus & Hortus Ltd., Mumbai.

Institute Technology Management Committee (ITMC)

ITMC is highest decision making body at the institute level for the all mandatory decisions related to intellectual property management and commercialization, etc. ITMC/ITMU encourages inventors to submit patent applications. The pricing of technology is also decided by ITMC. During the year 2011-12, five ITMC meetings were held on 19-4-2011, 23-4-11, 2-7-11, 25-11-11 and 26-12-11. Patent applications are examined during ITMC meetings for their novelty and commercial applicability before these are being recommended for submission through NRDC.

Patent Applications Submitted to NRDC/Patent Office (2011-2012)

- Patent application titled "Method and system for automatic identification and estrous detection in buffaloes on their vocalization patterns" (Yajuvendra Singh, S. P. Lathwal, T. K. Mohanty, A. P. Ruhil and Shiv Prasad). Patent application No. 3090/ DEL/2011.
- Patent application titled "A qualitative and quantitative test for anionic detergent in milk". (Inventors: Amit Kumar Barui, Rajan Sharma and Y. S. Rajput). Patent application No. 3677/DEL/2011.
- A process of bioethanol production by immobilized thermotolerant yeast from whey" (Minakshi Dahiya and Dr. Shipa Viz). Patent application No. 3710/DEL/2011.
- An innovative approach for detection of Enterococci in milk using spore germination based bioassay" (Naresh Kumar, Gurpreet Kaur, Geetika Hakur, Raghu H.V., Namita

Ashish Singh, Vinai Kumar Singh). Patent application No. 119/DEL/2012.

- Buffalo Casein Hydrolysates Rich in Caseinophosphopeptides (Prerna Saini, Bimlesh Mann and Rajesh Kumar) (Sent to NRDC on 3-3-2012).

First Examination Report of following Patent Application Submitted to Patent Office

- HPLC method of analysis of tannin monomers present in animal feeds" (Keshab Barman and Sachchida Nand Rai).
- Estimation of tannins metabolites in blood serum and cow milk using HPLC" (Keshab Barman and Sachchida Nand Rai).
- A kit for detection of detergent in milk" (Y. S. Rajput, Rajan Sharma, Sumandeep Kaur)

NDRI Industry Meet

NDRI-Industry Meet was organized on 1st December, 2011 wherein technologies available at NDRI were presented to participants from Industries with a focus on commercial transfer. Commercial and technological aspects of thirty technologies were presented by inventors to allow one-to-one interaction and facilitation of technology transfer. Representatives from IDMC Ltd., Anand; Mother Dairy Delhi; Swarkhshit Pariwar Pvt. Ltd. Hisar; Neugen Diagnostics Delhi; Haldiram, Noida; Gururaj Engineers Varodara; Auro Foods, Vedic Creation, Milk Union (Milk Fed) Mohali; Milk Union (Milk Fed), Hosiarpur; Milk Union (Milk Fed) Patiala; Milk Union (Milk Fed) Sangrur; HAU, Hisar and National Research and Development Corporation, Delhi participated in NDRI-Industry Meet.

Display of technologies by NDRI scientists at NDRI Industry Meet - 2011

Director NDRI addressing participants from industries on the occasion of NDRI Industry Meet - 2011

10 RESEARCH PRIORITIZATION, MONITORING AND EVALUATION

Intensification of R&D activities at NDRI Karnal in recent years has necessitated introduction of professional management approach for managing research functions. Strategic Planning of research endeavours and research infrastructure development; establishment of linkages with research organizations at National and International levels; research monitoring through internal and external mechanisms; development of research database and technology bank and research documentation by undertaking publications of the Institute are the major functions existing and visualized to achieve the mandate of the Institute by R&D activities.

Research Advisory Committee (RAC)

The main functions of the RAC are i) to suggest research programmes based on national and global context of research in the thrust areas and ii) to review the research achievements of the Institute and to see that these are consistent with the mandate of the Institute.

The meetings of the Research Advisory Committee of NDRI, Karnal under the chairmanship of Dr. K. Pradhan, Ex-Vice Chancellor, OUA&T, Bhubneshwar and RAU, Bikaner was held on 17th December, 2011 at NDRI, Karnal. The other Expert members who attended the meetings were Dr. N. Balaraman, Ex-VC, TNVASU, Chennai; Dr. Suresh Pal, Head, Dept. of Agril. Economics, IARI, Pusa, New Delhi; Dr. H. N. Mishra, Head, Post Harvest Technology Centre, IIT, Kharagpur; Dr. A. K. Srivastava, Director, NDRI, Karnal; Dr. S. L. Goswami, Joint Director (Research) and Dr. G. R. Patil, Joint Director (Academic), NDRI, Karnal. The RAC Meeting specifically focused on the XII Plan proposals. All seven programmes cutting across subject matter divisions were suitably modified by incorporating the new areas such as bio-nano technology, climate change, packaging etc. Two flagship programmes, one on Fertility Management in Male and Female Cattle and Buffaloes and the other on enhancement of nutritive Value and Shelf Life of Milk and Milk Products were also presented before RAC.

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 mid-term review of IRC projects of NDRI was taken up during 8th , 10th, 12th , 25th , 30th August, 2011 at NDRI, Karnal, SRS, Bangalore and ERS, Kalyani, respectively. The final reports of the completed research projects were discussed at length during the Institute Research Council Meetings held from 6th January at ERS, 7th January at SRS, 16th – 18th January, 2012 at NDRI, Karnal, respectively. At these meetings, new proposals for research projects to be initiated from the year 2012 were also considered for approval. Based on the critical reviews at the Divisional level and subsequently at the Institute IRC meetings, certain clear-cut recommendations emerged on each research project, which were documented in the Proceedings of IRC Meetings.

National Agricultural Innovation Project (NAIP)

National Dairy Research Institute, Karnal is now active centre for executing NAIP projects. There are total twenty NAIP projects; for which NDRI is either the lead centre or consortium partner. The total budget outlay is ₹34 crore. Although major thrust of NAIP projects at NDRI is on basic and strategic research, but with the award of NAIP project on 'e-courses on Dairy Technology, dairy education will also get boost. A number of laboratories have been renovated and high costs equipments have been procured under this programme. With the availability of sophisticated equipments and budget provisions under recurring head, NDRI has become obvious preferred place for carrying out basic research. The facilities are being used by scientists and students in purusing research work in front line areas such as cloning, stem cell, nanotechnology, biosensor, proteomics and genomics.

Consortium Implementation Committee (CIC) and Consortium Advisory Committee (CAC) Meetings are regular features being utilized to (i) address administrative problems (ii) to provide technical guidance and (iii) to monitor progress. CAC is headed by renowned scientist external to ICAR system. It has provided opportunity to NDRI develop linkages with IITs and CSIR laboratories. During the period under report, CAC Meetings were held on 2nd May, 2011 and 17th March, 2012, 2010, Also CIC Meetings under NAIP were held on 9th August, 2011.

Project Information Management System (PIMS)

The PME Unit implemented On-line database/ computerization of Research Projects under PIMS introduced for the first time in collaboration with IASRI. The unit acted as a nodal agency to facilitate and coordinate with PI of the Project at IASRI, New Delhi and PIs of all the On-going and Completed Research Projects at NDRI for taking off smooth functioning of PIMS activity.

Database Management

A database of research projects was updated for all the projects in operation during the year 2011. The database of research projects containing the targets and achievements of the preceding six months and targets fixed for the next six months was updated and six monthly reports submitted to ICAR.

Research Documentation and Information

The Research Documentation and Information Cell of the Institute is responsible for documentation and dissemination of research output through Annual Reports, Six Monthly Reports, Quarterly Reports, Monthly Reports, Technical Reports/ Bulletins etc. prepared at the Institute and through various journals of National and International repute. During the period under report, **Annual Report 2010-2011** was edited and published through this cell. Research Projects of the Institute were also documented under the Research Programmmes identified by Research Advisory Committee for NDRI, Karnal. Four issues of **"NDRI News"** - a quarterly newsletter in English were also brought out during this period. The unit also prepared reports on research achievements of NDRI for inclusion in **ICAR/DARE Annual Report 2011-2012.** The unit prepared various other reports on NDRI by highlighting the significant achievements and technologies developed by the Institute; Initiatives taken by the Institute for the welfare, development and empowerment of women and other gender related issues; **Success Stories** of progressive farmers based on the extension activities of the Institute; Development of research technologies for the farming community and dairy industry; Transfer of technology in the area of animal sciences; **Quarterly Progress Reports** containing the achievements of research, finance, purchase and civil works and targets of the next month; **Monthly Progress Reports** consisting significant events; **Six Monthly Progress Reports** of the research achievements with targets of next six months. The unit also prepared comments of the Institute with respect to recommendations made by the Parliamentary Standing Committee on Agriculture. The unit also prepared information on important conferences, seminars, workshops and meetings etc. for publication in Directory of Events of ICAR; Information on NDRI for inclusion in ARIS Newsletter, ICAR; IAUA Newsletter; VCI Newsletter. The unit prepared the information regarding Tentative agenda items for Director's Conference (2011) covering relevant points relating to the Institute; Institutional performance in respect of NDRI; Establishment of linkages with various organizations; IPR issues; Provided information under Right to Information Act, 2005; Information on technologies developed, transferred and commercialized; Prepared concise report on the achievements (last 5 years) of the Institute. The unit prepared report on mid-term review of XI plan; initiated the exercise for formulation of XII plan EFC memo document of the Institute; Prepared action taken reports on recommendations emerged during the meetings of QRT/RAC/Visit of DDG (AS) at Regional Stations/Governing Body/Director's Conference/BOM of NDRI/ Regional Committee no. IV and VIII of ICAR; Consolidated information on research projects undertaken/undergoing at NDRI in the areas of food processing. Post harvest technologies, packaging, new products development, supply chain or allied fields. The unit also prepared and collated information for submission to National Director NAIP for Monitoring and Evaluation System for NAIP, ICAR with the objective to make ICAR as the Catalyst Agent for Management of Change in the Indian National Agricultural Research System. This unit prepared replies to Parliament questions and Audit (external) queries from time to time and co-ordinated with other Organisations/Institutes by sending the desired information through several questionnaires. Research papers submitted by the scientists were processed by the unit for publication in various journals of National and International repute. In addition, abstracts of papers were also processed for presentation at various Seminars/Symposia/ Workshops.

11 HUMAN RESOURCE DEVELOPMENT

Scientists/Officers/Scholars Trained Abroad

Dr. S. S. Thakur Principal Scientist, Dairy Cattle Nutrition Division participated in the Congress on Fibre in Dairy Production held from 11th - 13th May 2011 at Italy.

Dr. T. K. Datta, Principal Scientist, Animal Biotechnology Centre was deputed for training in the area of "Molecular biology techniques with mammalian oocytes/embryos" in Germany under NAIP sub-project of Component-4 from 14th May to 13th August 2011.

Dr. A. K. Srivastava, Director, NDRI and **Dr. Shiv Prasad**, Principal Scientist, & I/c Livestock Farm participated in Indo-NZ Networking Workshop on "Food & Agriculture" at Lincoin University and Riddet Institute Massey University, New Zealand from 20th to 24th June 2011.

Dr. S. K. Sirohi, Sr. Scientist, Dairy Cattle Nutrition Division participated in 4th Conference of European Mirobiologists (FEMS 2011) under NAIP project of Component-4 in Switzerland from 26th June to 30th June 2011.

Dr. M. K. Singh, Scientist, Animal Biotechnology Centre was deputed to undertake training in the area of "Stem Cell Research (Animal Sciences)" under NAIP project of Component-I from 20th June to 19th September, 2011 in USA.

Dr. S. L. Goswami, Joint Director (Res.) and **Dr. Sachinandan De**, Sr. Scientist, Animal Biotechnology Centre participated in Workshop on Comparative Genomics under NAIP project of Component-4 from 10th – 23rd July, 2011 in USA.

Dr. P. Palta, Principal Scientist, Animal Biotechnology Centre participated in "44th Annual Meeting of the Society for the Study of Reproduction" under NAIP project of Component-4 from 31st July to 4th August, 2011 in USA.

Dr. A. K. Srivastava, Director was deputed for implementing the existing MoU and finalizing implementation of ICAR's international Ph.D. scholarship programme at Kansas State Univesity Manhattan, USA from 6th – 9th September, 2011.

Dr. (Mrs.) Suman Kapila, Sr. Scientist and **Dr. Rajeev Kapila**, Sr. Scientist, Animal Biochemistry Division participated in IDF World Dairy Summit-2011 under NAIP project" Novel Approaches for Production of Nutraceuticals from Milk and Indian Herbs for Potential use in Functional Dairy Foods." under component-4 of NAIP from 15th -19th October, 2011 at Parma, Italy.

Dr. S. K. Singla, Principal Scientist, Animal Biotechnology Centre attended training programme from 9th – 12th October, 2011 at Miami, Florida.

Dr. D. Malakar, Sr. Scientist, Animal Biotechnology Centre participated in the Bit's Annual World Congress of Regeneration Medicine & Stem Cell from 11th - 13th November, 2011 at Beijing, China.

Dr. R. C. Upadhyay, Principal Scientist, Dairy Cattle Physiology Division attended the International Conference on the "Impact of Climate Change on Agriculture" (ICICCA 2011) and delivered a keynote address on "Livestock and Fisheries" from 21st - 22nd December, 2011 at the Faculty of Agriculture University of Ruhuna, Sri Lanka.

Dr. (Mrs.) Bimlesh Mann, Principal Scientist and **Dr. Rajan Sharma,** Sr. Scientist, Dairy Chemistry Division visited Dublin Institute of Technology, Ireland under Erasmus Mundus programme for teaching and research guidance to the international students of European Masters Degree in Food and Science Technology and Nutrition as Scholar (visiting professor) from 17th February to 18th March, 2012.

Dr. Gautam Kaul, Sr. Scientist, Animal Biochemistry Division availed 2012 Endeavour Research Award sponsored by Department of Education, Employees and Workplace Relation (DEEWR), Govt. of Australia for a period of six months from 2nd March, 2012.

SCIENTISTS/OFFICERS PARTICIPATION IN WORKSHOPS/SEMINARS/ CONFERENCES/TRAININGS WITHIN INDIA

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Dr. Rameshwar Singh, Head Dr. Latha Sabbiki, Sr. Sci.	National Seminar on "Recent Advances in the Development of Fermented Foods" organized by Centre of Food Science and Technology Institute of Agricultural Sciences at BHU, Varanasi.	8th - 9th April, 2011
Dr. R. S. Gandhi, Head Dr. A. K. Chakravarty, PS	Indo-Denmark Workshop on "Genomic Selection in Cattle and Buffaloes" at NASC Complex, New Delhi.	11th - 12th April, 2011
Dr. Sunita Grover, PS	Sympoisum on "Global Trends in Maternal and Pediatric Nutrition" organized by Nestle Nutrition at Sangri-La's Eros Hotel, New Delhi.	13th April, 2011
Dr. P. K. Dixit, PS	MDP on Management & Leadership Development, Centre for Disaster Management at Lal Bahadur Shastri, National Academy of Administration, Mussoorie.	18th - 22th April, 2011
Sh. Pushpannayak, CAO Sh. S. C. Tuli, AAO Sh. A. G. Barapatre, AAO	Training on "Total Quality in Purchase Function CERP/SAPE Commence & Procurement from ESCI" at Hyderabad.	25th – 27th April, 2011
Dr. A. K. Singh, Sr. Sci. Dr. P.N. Raju, Sci. Mr. Sathish Kumar, M.H., Sci.	Global Symposium on "Ready-To-Eat (RTE) Foods: Opportunities for R&D, Entrepreneurship and Markets" at Hyderabad.	25th – 27th April, 2011
Dr. D.K. Jain, PS Dr. R. Malhotra, PS	Review meeting of the NAIP (Component – 1) sub-project entitled "Strengthening Statistical Computing for NARS" New Delhi.	28th April, 2011
Mr. Prateek Sharma, Sci.	Training program on "Rapid Visco Analyser" organized by Scientific and Digital Systems at New Delhi.	9th -10th May, 2011
Mr. S. K. Kamboj, T.O.	Training Programme on "Employer Perspective on Labour Laws" at NAARM, Hyderabad.	10th-12th May, 2011
Dr. Latha Sabhiki, Sr. Sci. Dr. A. K. Singh, Sr. Sci. Dr. P. N. Raju, Sci.	Brainstorming Session on "Integration of Millets in Fortified Foods" organised at New Delhi.	13th May, 2011
Mr. Pankaj Chawala, T.O.	Training on "Recent Challenges in Power Grid Operation & Control" organized by the Department of Electrical Engineering at DBCR University of Science & Technology, Murthal, Sonepat.	16th-20th May, 2011
Dr. A. K. Chauhan, PS Dr. Surajit Mandal, Sci.	5th National Seminar on "Multisectoral innovations for rural prosperity" organized by Mobilization – Society for Community Mobilization for Sustainable Development, CATAT, IARI, New Delhi.	19th – 21st May, 2011
Dr Rajan Sharma, Sr. Sci.	ICAR-CII Industry Meet organized by ICAR, New Delhi at NASC Complex, New Delhi.	23rd May, 2011
Mr. Navdeep Singh T-3 Mr. Deepak Yadav, T-1	A.S.P. Net 4.0 at Talents Institute, Karnal	1st June, 15th August, 2011.
Dr. R. S. Gandhi, Head Dr. P. K. Roy, PS	Meeting-cum-Workshop on "Towards more Effective Role of Heads of Divisions and Regional Stations in ICAR Institutes" held at CIAE, Bhopal.	14th – 15th June, 2011
Dr. Rameshwar Singh, Head	Meeting-cum-Workshop of the HOD/ Regional Stations/Centres at CIAR, Bhopal.	15th -16th June, 2011

Mrs. Ritu Chakravarty, Sci. (SG) Dr. Bandla Srinivas, Sr. Sci.	"Technology and Innovation for Rural Development", at Centre for Disaster Management, Lal Bahadur Shastri Academy of Administration, Mussoorie.	20th June to 1st July, 2011
Dr. Narender Raju Panjagiri, Sci.	Residential Training Programme on "Packaging of Fresh and Processed Food" at NIFTEM, Kundli (Sonepat).	20th- 24th June, 2011
Dr. Satish Kulkarni, Head Dr. B.V. Balasubramanyam, PS Dr. P.K. Dixit, PS Dr. K.P. Ramesha, PS Dr. M.C.A. Devi, PS Dr. Menon Rekha Ravindra, PS Dr. F. Magdaline Eljeeva Emerald, PS Dr. B. Srinivas, Sr. Sci.	One day Brainstorming Session on "Vision & Scope for Dairy Development in Karnataka" organized jointly by Indian Dairy Association (South Zone), Bengaluru in collaboration with Deptt. of Agriculture, Govt. of Karnataka at Bangalore.	2nd July, 2011
Dr. A. K. Sharma, Sr. Sci.	International Conference on "High Performance Architecture and Grid Computing, HPAGC-2011" and Workshop on "Application of Data Mining in Software Fault Prediction" at Chitkara University, Chandigarh.	19th – 20th July, 2011
Dr. R. S. Gandhi, Head	"Interactive Workshop of Directors of Centre of Advanced Faculty Training" at IARI, New Delhi	20th - 21st July, 2011
Dr. Satish Kulkarni, Head Dr. C.N. Pagote, PS Dr. B. Surendranath, PS Dr. B. C. Ghosh, PS Dr. B. V. Balasubramanyam, PS Dr. P. K. Dixit, PS Dr. K. P. Ramesha, PS Dr. M.C.A. Devi, PS Dr. Menon Rekha Ravindra, PS Dr. F. Magdaline Eljeeva Emerald, PS Dr. B. R. Srinivasa Murthy, PS Dr. B. Srinivas, Sr. Sci.	First Endowment Lecture in Honour of Dr. K.K. Iya , Organised by Indian Dairy Association, (South Zone).	29th July, 2011
Dr. S. S. Kundu, Head	Training Programme on "Creating & Innovation" at IIM Lucknow.	1st - 3rd August, 2011
Dr. G. K. Sachdeva, PS Dr. Asif Mohammad, Sci.	Training Programme on "IT Based Decision Support Systems on Web-based Information Management for Knowledge Sharing" at NAARM, Hyderabad.	3rd - 12th August, 2011
Mrs. Ritu Chakravarty, Sci. (SG)	National Consultation on "Gender Perspective in Agriculture" organized at NASC Complex, Pusa, New Delhi.	8th - 9th August, 2011
Dr. P. Heartwin Amaladhas, PS Dr. D. N. Das, PS Dr. Mukund A. Kataktalware, PS	One-week Statistical Training Programme on "Data Analysis Using SAS", Organized by University of Agricultural Sciences GKVK, Bengaluru under the NAIP Consortium on Strengthening Statistical Computing for NARS.	8th - 13th August, 2011
Dr. S. S. Kundu, Head Dr. S. S. Thakur, PS	Expert Consultative Meet on "Utilization of Spend Mushroom Substrates and Residues" organized at Directorate of Mushroom Research, Solan.	9th August, 2011
Dr. A. K. Chauhan, PS	Workshop on "ICAR- ILRI Pilot Study on Economic Impact of Foot and Mouth Disease" at New Delhi.	9th - 10th August, 2011
Dr. Manoj Kumar, T-9 (SMO)	"Recent Advances & Controversies in Thyriod Cancer Management (CME & Live Surgical Workshop)" at RGCI & RC Centre, New Delhi.	20th - 21st August, 2011

Dr. Nishant Kumar, Sci.	Training course on "Prevention and Therapeutic Management of Peri-parturient Complications in Domestic Animals" at GADVASU, Ludhiana.	23rd August to 12th Sept., 2011
Dr. B. R. Yadav, PS Dr. R. K. Tonk, T.O.	Workshop on "Automation in Cytogenetics Lens on the use and other Operations of the Automation Functions at Hotel Siddartha, New Delhi.	24th August, 2011
Mr. G. S. Meena, Sci. Mr. Prateek Sharma, Sci.	International Conference on "Dairy: Towards Raising Milk Productivity- Sharing International Experiences" at New Delhi.	30th August, 2011
Dr. A. K. Chakravarty, PS	X Scientist Meet of Network Project on Buffalo Improvement at Bhuj, Gujarat.	2nd - 3rd Sept., 2011
Dr. Ashwani Kumar Rai, PS	Contact Classes of Post Graduate Diploma in Technology Management in Agriculture (PGD-TMA) at NAARM Hyderabad.	2nd - 8th Sept., 2011
Dr. A. Manimaran, Sci.	Short Course on "*In vitro* Toxiodynamics" at IVRI, Izatnagar.	5th - 14th Sept., 2011
Dr. R. S. Gandhi, Head	X Annual Review Meeting of AICRP on Cattle at GBPUA&T, Pantnagar.	9th - 10th Sept., 2011
Dr. K. P. Ramesha, PS	Management & Leadership Development" at Centre for Disaster Management, NIAR, LBS National Academy of Administration.	12th - 16th Sept., 2011
Dr. Sumit Arora, Sr. Sci.	Stake Holder Meeting hosted by Bel Group the World Leader in branded cheese portion segment and GAIN- GLOBAL Alliance for Improved Nutrition at New Delhi.	21st Sept., 2011
Dr. Kaushik Khamrui, Sr. Sci.	8th National Dairy Product Judging Contest and 4th National Dairy & Food Quiz Contest at SMC College, Anand, Gujarat.	22nd - 23rd Sept., 2011
Dr. P. K. Dixit, PS	MDP Workshop on "Policy and Prioritization, Monitoring and Evaluation (PME) Support to Consortia Based Research in Agriculture" at National Academy of Agricultural Research Management, Rajendranagar, Hyderabad.	22nd - 27th Sept., 2011
Dr. S. S. Kundu, Head Dr. S. N. Rai, PS	First National Conference on "The Significance of Veterinary Nutrition for Health and Production of Animal of Agro-ecological Importance" at College of Vety. Sci. & Animal Husbandry, IGKVV, Ajora Drug, Chatishgarh.	24th - 25th Sept., 2011
Dr. A. K. Singh, Sr. Sci.	Project Formulations, Risk Assessment, Scientific Report Writing and Presentation at ARI, New Delhi.	26th - 30th Sept., 2011
Dr. Sohan Vir Singh, PS	National Symposium on "Reproductive Biotechnologies for Augmentins Fertility and Conservation of Animal Species with Special reference to North Eastern Hill Region" at Central Agricultural University, Aizwal.	27th - 29th Sept., 2011
Dr. Avtar Singh, PS	Consultative meeting on "Genomics Platform for XII Plan" held at NBAGR, Karnal.	30th Sept., 2011
Dr. A. K. Singh, Sr. Sci.	Functional Foods: Managing Human Health in the Modern Age at Sardar Patel University, Vallabh Vidyanagar, Anand.	7th - 8th Oct., 2011
Dr. P. N. Raju Panjagiri, Sci.	Training Course on "Smart Packaging Techniques for Shelf-Life Enhancement and Retention of Bioactive Compounds in Food" at CIPHET, Ludhiana.	11th - 24th Oct., 2011
Dr. A. P. Ruhil, Sr. Sci.	Data Analysis for Social Sciences at IASRI, New Delhi	10th - 15th Oct., 2011

Sh. Ganga Sahay Meena, Sci.	National training on "Non-Thermal & Non-Chemical Processing and Membrane Technology in Food Systems" at CIAF, Bhopal.	12th - 21st Oct., 2011
Dr. B. R. Yadav, PS Dr. P. K. Roy, PS	Brainstorming Meet on "Livestock Fertility; and Management" at NASC Complex, New Delhi.	15th Oct., 2011
Dr. (Mrs.) Raka Saxena, Sr. Sci	Training Program on "Quantitative Methods for Agricultural policy Research" at IARI, New Delhi.	17th - 22nd Oct., 2011
Dr. Anjana Sharma, PS	Conference in "Farm to Fork: Best Practices in Agri. and Food Supply Chain" at Coronet Hall, Hotel Le-Meredian, Sankey Road, Bangalore.	19th Oct. 2011
Dr. K. P. Ramesha, PS	Management Development Programme on Leadership Development- (a pre-RMP Programme) at National Academy of Agricultural Research Management, Rajendranagar, Hyderabad.	1st - 21st Nov., 2011
Dr. R. C. Upadhyay, PS Dr. Mahendra Singh, PS	XX Annual Conference of Society of Animal Physiologists of India (SAPI) and International Symposium on "Advances in Physiologic Research for Sustainable Development of Livestock and Poultry Production" at WBFASU, Kolkata.	2nd - 4th Nov., 2011
Dr. (Mrs.) Sanchita Garai, Sci.	Winter School on "Extension Strategy on Information Communication Technology for Value Added Agriculture" at BCKV, Nadia.	2nd - 22nd Nov., 2011
Dr. S. S. Kundu, Head Dr. T. K. Datta, Head Dr. S. N. Rai , PS Dr (Mrs.) Harjit Kaur, PS Dr. S. S. Thakur, PS Dr. A. K. Tyagi, PS Dr. (Mrs.) Veena Mani, PS Dr. S. K. Tomer, PS Dr. Sohan Vir Singh, PS Dr. A. K. Puniya, PS Dr. S. K. Sirohi, Sr. Sci. Dr. Chander Datt, Sr. Sci. Dr. M. K. Ghosh, Sr. Sci. Dr. A. Chatterjee, Sr. Sci.	14th National Conference on "Livestock Productivity Enhancement with Available Feed Resources" at GBPUA&T, Pantnagar.	3rd - 5th Nov., 2011
Dr. K. K. Datta, Head Dr. B. S. Chandel, PS	71st Annual Conference of Indian Society of Agricultural Economics at Dharwad.	3rd - 5th Nov., 2011
Dr. T. K. Dutta, Head Dr. M. K. Ghosh, Sr. Sci. Dr. A. Chatterjee, Sr. Sci.	Biennial Conference of Animal Nutrition Society of India (ANSI) on "Livestock Productivity Enhancement with Available Feed Resources" at GBPUA&T, Pantnagar.	3rd - 5th Nov., 2011
Dr. Mrs. Jancy Gupta, PS Dr. R. Senthil Kumar, Sci.	International Conference on "Innovative Approaches for Agricultural Knowledge Management: Global Extension Experiences" held at NASC, Complex, New Delhi.	9th - 12th November, 2011
Mr. Narender Kumar, T-4 Mr. Lakshman, T-3	National Conference on Agricultural Libraries in Collaboration Era at Dr. Y. S. Parmar University of H&F, Nauni, Solan (HP).	17th - 19th Nov., 2011
Dr. K. Jayaraj Rao, PS	International Symposium on "Recent Trends in Processing and Safety of Specialty and Operational Foods", DFRL, DRDO, Mysore.	23rd - 25th Nov., 2011
Dr. B. R. Yadav, PS	Brainstorming Session on "Buffalo Genomics" held at NASC Complex, New Delhi.	24th Nov., 2011

Dr. K. K. Datta, Head	19th Annual Conference on "Dynamics of Supply and Demand for Labour in Indian Agriculture" at Assam Agriculture University, Jorhat, Assam.	28th - 30th Nov., 2011
Dr. A. K. Puniya, PS	Workshop on "Biotechnological Delignification of Crop Byproducts to Produce Digestible and Nutient Rich Animal Feed" organized by Lignocellulose Biotechnology Lab., Univ. of Delhi, New Delhi.	29th Nov., 2011
Dr. S.K. Atreja, PS	Conference on "Improvement of Livestock Breeding in SE Asia" at New Delhi.	29th - 30th Nov., 2011
Sh. Yogesh Khetra, Sci.	National Training on "Value Added Fermented Symbiotic Functional Foods" at SMC College of Dairy Science, AAU, Anand, Gujrat.	29th Nov. to 22nd Dec., 2011
Dr. A. Kumaresan, Sr. Sci.	Winter School on "Functional Genomic Approaches for Enhancing Fertility in Livestock" at NAINP, Bengaluru.	22nd Nov. to 12th Dec., 2011
Dr. A. K. Singh, Sr. Sci.	6th National Conference of KVK at JNKVV, Jabalpur.	3rd - 5th Dec., 2011
Dr. B. C. Ghosh, PS	International Workshop on "Recent Trends in Food Processing – The Global Scenario", Institute of Food and Dairy Technology, Chennai.	8th - 9th Dec., 2011
Mr. Yogesh Khetra, Sci.	Development of Value Added Fermented Symbiotic Functional Foods SMC College of Dairy Science, Anand.	9th - 12th Dec., 2011
Dr. Sunita Grover, PS	Symposium on "Health Impact of Probiotics – Vision and Opportunities" organized by Yakult India Microbiota and Probiotic Science Foundation at Hotel, Leela Kempisnki, Mumbai.	10th - 11th Dec., 2011
Dr. A. P. Ruhil, Sr. Sci.	5th Indian International Conference on "Artificial Intelligence" at Siddganga Institute of Technology, Tumkur (Bangalore).	14th - 16th Dec., 2011
Dr. B. Surendra Nath, PS Dr. M.C.A. Devi, PS Dr. Anjana Sharma, PS Dr. Veena, N., PS Dr. Madhumita Majumdar, PS Dr. Menon Rekha Ravindra, PS Dr. F. Magdaline Eljeeva Emerald, PS	National Conference on "Recent Trends in Food Science & Nutrition Research" held at Center for Management Studies, Jain University, Bangalore.	15th Dec., 2011
Mr. Sathish Kumar, M.H., Sci.	5th International Conference on "Fermented Foods Health Status and Social Well Being: Challenges and Opportunities" organized by Sweedish South Asian Studies Network (SASNET) CFTRI, Mysore.	15th - 16th Dec., 2011
Dr. Sohan Vir Singh, PS	International Congress of "Environmental Research" at Sardar Vallabh Bhai National Institute of Technology (SVWIT), Surat.	15th - 17th Dec., 2011
Dr. A. K. Sharma, Sr. Sci.	International Conference on "Soft Computing in Solving (SocProS–2011)" at Roorkee.	20th - 22nd Dec., 2011
Sh. Yogesh Khetra, Sci.	National Training Programme on "Value Added Fermented Symbiotic Functional Foods" at AAU, Anand, Gujrat.	21st - 22nd Dec., 2011
Dr. R. Senthil Kumar, Sci.	National seminar on "Attracting Farm Youth to Sustainable Agriculture" organized by Indian Society of Extension Education (Karnataka Chapter), at UAS, GKVK, Bangalore.	26th - 28th Dec., 2011
Sh. Ganga Sahay Meena, Sci.	CAFT Training Programme on "Online Content Creation and Manage in E-learning Environment" at IASRI, New Delhi.	3rd - 23rd Jan., 2012

Dr. S. S.Kundu, Head Dr. S. S. Thakur, PS	National Seminar on "Genetically Modified Foods- Current Scenario" at Department of Biotechnology, Punjab University Patiala.	19th Jan., 2012
Dr. S. Kulkarni, PS Dr. Raghu H.V., Sci.	XXI ICFOST Convention on "Innovations in Food Science and Technology to Fuel the Growth of the Indian Food Industry" organized by AFSTI at Pune.	20th - 21st Jan., 2012
Dr. A. K. Sharma, Sr. Sci.	National Symposium on "Bioinformatics: Challenges in the Post-Genomic Era", Jammu.	2nd Feb., 2012
Dr. A. S. Harika PS Dr. B. R. Yadav, PS Dr. I. D. Gupta, PS	40th Dairy Industry Conference "Indian Dairying: Perspective 2020" organized by Indian Dairy Association (NZ) at New Delhi.	2nd - 5th Feb., 2012
Dr. S. Kulkarni, Head Dr. R. K. Malik, PS Dr. D.K. Jain, PS Dr.(Mrs.) Jancy Gupta, PS Dr. Gopal Sankhala, PS Dr. Parveen Kumar, PS Dr. R. C. Upadhyay, PS Dr. Sohan Vir Singh, PS Dr. I. D. Gupta, PS Dr. P.K. Dixit, PS Dr. K. P. Ramesha, PS Dr. Naresh Kumar, Sr. Sci. Mr. Yogesh Khetra, Sci. Mr. Devaraja, H.C., Sci. Mr. Sathish Kumar, M.H., Sci. Dr. Raghu H.V., Sci. Mr. B. K. Rajashekharaiah, T.O. Mr. B. R. S. Murthy, T.O. Mr. K. L. Samapath, T.O. Mr M. Nanjunda Swamy, T.O. Mr. A. K. Sharma, T.O Mr. A. P. Dabas, T.O.	XL Dairy Industry Conference at New Delhi.	2nd - 5th Feb., 2012
Dr. A. K. Sharma, Sr. Sci.	XXIII Annual Bioinformatics Coordinators Meeting with Focal Theme: Bioinformatics in 21st Century – Looking Ahead at Katra.	3rd - 4th Feb., 2012
Dr. S. S. Kundu, Head Dr. (Mrs.) Madhu Mohini, PS Dr. Chander Datt, Sr. Sci.	International Conference on "Climate Change, Sustainable Agriculture and Public Leadership" at NASC Complex, New Delhi.	7th - 9th Feb., 2012
Dr. Meena Malik, Associate Prof.	National Seminar on "Diasporic Writing" at Kumari Vidyavti DAV College, Karnal	18th Feb., 2012
Dr. S. K. Atreja, PS Dr. Dheer Singh, PS	International Conference on "Reproductive Health with Emphasis on Strategies for Family Planning" & 22nd Annual Meeting of the Indian Society for the Study of Reproduction and Fertility (ISSRF) "ICMR Centenary Celebrations" (1911-2011) at Indian Council of Medical Research, New Delhi.	19th - 21st Feb., 2012
Dr. P. K. Roy, PS	Interactive workshop on "Face to Face Interactive Farmers Workshop" at Kalyani Field Station of CIFA.	21st Feb., 2012
Dr. A. K. Chauhan, PS	National Seminar on "Agribusiness Management: New Initiatives, Challenges and Strategies" at Nagpur	21st - 22nd Feb., 2012
Dr. B. R. Yadav, PS	National Symposium on "Energy Trends in Biotechnology" at Multani Mal Modi College, Patiala.	24th Feb., 2012

Dr. Mahendra Singh, PS Dr. Sohan Vir Singh, PS Dr. Ashwani Kumar Rai, PS Dr. G. K. Sachdeva, PS	National Symposium on "Role of Indigenous Animal Genetic Resources in Rural Food Security vis-à-vis Climate Change" at BAIF Pune Campus, Pune.	24th - 25th Feb., 2012
Dr. Archana Verma, PS	National Conference on "Biotechnology, Bioinformatics and Bioengineering" at Kolhapur, Maharashtra.	24th - 25th Feb., 2012
Dr. Dheer Singh, PS	Conference on "Biotechnology, Bioinformatics and Bioengineering - 2nd National Meeting of Society For Applied Biotechnology" at Maharashtra.	24th - 25th Feb., 2012
Mr. Prateek Sharma, Sci.	Technical Seminar on "Advanced Rheological Methods for Polymers, Inks & Coatings" organized by Anton Paar India at IIT Delhi.	29th Feb., 2012
Dr. A. K. Chauhan, PS	Peer-Review Meeting of e-course "Entrepreneurship Development and Indus Consultancy at Anand.	1st - 2nd March, 2012
Dr. A. K. Sharma, Sr. Sci.	Sensitization-cum-Training Workshop on "Online Software for Half Yearly Progress Monitoring (HYPM) of Scientists in ICAR" (for Officers-in-charge (Nodal Officers) of PME Cell). New Delhi.	3rd March, 2012
Mr. A. P. Dabas, T.O.	Advanced Statistical Tools for Analysis of Animal Breeding Data at IDA (NZ), New Delhi.	10th - 30th March, 2012
Dr. Bandla Srinivas, Sr. Sci.	Gender Pay Gap for on Farm Dairying Activities. Global Conference on Women in Agriculture at NASC Complex, New Delhi.	12th - 13th March, 2012
Mr. Narender Kumar, T-4 Mr. Lakshman, T-3	National Conference on Agricultural Libraries Perspectives, Empowerment and Advocacy (2011-12) at Department of Library & Information Science, University of Kashmir, Kashmir.	13th - 14th March, 2012
Dr. (Mrs.) Jancy Gupta, PS	Global Conference on "Women in Agriculture" at NASC Complex, New Delhi.	13th - 15th March, 2012
Mr. B.P. Singh, T.O.	National Conference on Agricultural Libraries and User Community 2012 on "Role of Agricultural Libraries in Knowledge Management" at Acharya N. G. Ranga, Agricultural University, Hyderabad.	13th - 16th March, 2012
Mr. Devaraja H.C., Sci.	7th Nutra India Summit 2012 on "Nutracueticals, Functional Foods and Dietary Supplements" at Bangalore.	15th - 17th March, 2012
Dr. B. R. Yadav, PS Dr. R. K. Tonk, T.O.	Chromosome Banding to Demonstrate the Practical Work at KVA-DAV College, Karnal.	17th March, 2012
Dr. B. R. Yadav, PS	National Seminar on "Recent Advancements in Application of Genetics", held at MDU, Rohtak.	20th March, 2012
Dr. R. C. Upadhyay, PS Dr. Sohan Vir Singh, PS	National Symposium on "Indian Agriculture Preparedness for Climate Change" at National Agriculture Science Complex, New Delhi.	24th - 25th March, 2012

12 CONFERENCES/ SEMINARS/ SYMPOSIA/ WORKSHOPS/ TRAINING PROGRAMMES/ FIELD DAYS ORGANISED

During the past one-year (April 2011-March 2012), the Institute hosted quite a good number of Seminars, Workshops and Short Courses with the participation of delegates from India and abroad. Some of the important ones are listed as under:

Model Dairy Plant certified under ISO: 22000: 2005.	23rd April, 2011
World Veterinary Day.	30th April, 2011
National Training on Mitigation Strategies for Methane Production from Dairy Animals.	2nd to 16th May, 2011
National Seminar on Multi-Sectoral Innovations for Rural Prosperity.	19th to 21st May, 2011
SAARC Countries Meet on Dairy Sector.	25th – 26th May, 2011
1st Convocation of National Academy of Dairy Science (India) and National Symposium on Probiotic Dairy Foods for Human Health.	1st June, 2011
Training Programme on Technological and Safety Aspects of Dairy Processing.	13th – 17th June, 2011
Silver Jubilee (25th Course) National Training Program on Technological Developments in Cheese and Fermented Dairy Foods.	5th – 25th July, 2011
National Training Programme on Basic & Applied Approaches in Designing of Dairy Based Nutraceuticals and Functional Foods.	18th – 27th July, 2011.
National Workshop on Visioning and Strategic Planning for Dairy Sector in India.	2nd - 3rd Sept., 2011
Short Course on Basic and Technological Aspects of Milk and Milk Products.	5th - 9th Sept., 2011
Training Programme on Data Analysis using SAS.	12th -17th Sept., 2011
Training Programme on Commercial Dairy Farming.	12th -17th Sept., 2011
National Seminar on Integration of Indian Dairy and Food Industry for Future Sustenance.	23rd-24th Sept., 2011
Farmers-Industry-Scientist Meet.	28th Sept., 2011
International Conference on Functional Dairy Foods-2011.	16th -19th Nov., 2011
Dairy Conclave: Connecting with the Dairy Farmer.	26th Nov., 2011
NDRI-Industry Meet.	1st Dec., 2011
Conference on Statistics and Informatics in Agricultural Research.	3rd - 5th Dec., 2011
Awareness Workshop on Foot and Mouth Disease in Dairy Animals.	15th Dec., 2011
Winter School on Recent Advances in Functional Fermented Dairy Foods and their Quality Assurance.	9th - 29th of Dec., 2011
National Training Programme on Strategic Use of Cryopreserved Semen for Assisted Reproductive Technologies.	2nd – 15th Jan., 2012
National Symposium on Recent Advances in Reproductive Biotechnology : Retrospective and Prospective Vision.	30th– 31st Jan., 2012
Dr. D. Sundaresan Mememorial Lecture Award 2012	10th Feb., 2012
Dr. K. K. Iya Oration Award	14th Feb., 2012
Tenth Convocation of NDRI Deemed University.	21st Feb., 2012
Dairy Mela-2012.	25th -27th Feb., 2012
N. N. Dastur Oration Award 2012.	27th Feb., 2012
Training Programme on Precision Dairy Farming.	3rd -23rd March, 2012
National Training Programme on Advanced Stastical Tools for Analysis of Animal Breeding Data.	10th -30th March, 2012
Annual Review Workshop on Production to Consumption – A Value Chain Approach.	26th March, 2012

13 DISTINGUISHED VISITORS

17.3.2011 Six member delegation from Life Science and Material Sciences, Netherlands led by **Sh. Sanjay Kumar Bhattacharya**, Market Development Manager, Dairy and Infant Nutrition, South Asia:

23.03.2011 Delegation from Ethiopian Agricultural Research, Ethopia. High Level Management Group and Pastoral Agro-pastoral Research group.

07.04.2011 Five members from Dept. of Genetic & Bio-technology, faculty of science and technology, Aarhus University DK-8830, Tjele, Denmark.

10.05.2011 Two member delegation from U.K. and Finland.

19.05.2011 **Shri Harish Rawat Ji**, Hon'ble MoS For Agriculture & Parliamentary Affairs, Govt. of India, visited NDRI.

16.06.2011 Three member delegation from Republic of Kazakhstan.

19.07.2011 Six member delegation from Korea (Kangwon National University, Kangwon, Korea.

19.08.2011 **Sh. Giri Raj Singh**, State Animal Husbandry & Fisheries Minister, Bihar state

13.09.2011 **Mr. Antoine Pfister** and **Ms. Juliette Drion**, French Trade Commission, French Embassy in India.

20.09.2011 Seven member delegation led by **Mr. Francisco Mayorga**, Minister of Agriculture, Livestock Rural Development, Fisheries and Food of Maxico.

27.09.2011 **Mrs. Imelda** Quibranza-Dimaporo, Member of Parliament, Republic of the Phillippines accompanied by Mr. Abdullah D. Dimapora, a former Congressman

10.10.2011 Seven member French delegation from Association for Development of International Exchange in Agricultural Products and Technologies (ADEPTA), France.

3.12.2011 Two member delegation from the Embassy of France to India.

22.12.2011 Eight member delegation from Afghan Ministry of Agriculture, Irrigation & Livestock (Mail).

28.01.2012 **Dr. John Hendricks**, Dean of Veterinary Medicine and Dr. Narayan Avadhani, Chairman, Department of Animal Biology of School of Veterinary Medicine, University of Pennsylvania, USA.

03.02.2012 Five member Hungrian delegation led by Mr. Gyorgy Czervan State Secretary, Government of Hungry.

14.03.2012 Delegation from Europeon Union of India.

21.03.2012 Ten member farmer delegation from Kandhar, Afghanistan with one liaison officer from the Embassy of India, Kabul, Afghanistan.

Director NDRI interacting with Mr. Francisco Mayorga

A Delegation from Afghan with the Director of the Institute

14 PERSONNEL

INSTITUTE STAFF

As on 31st March, 2012

General Administration

A. K. Srivastava, Ph.D.	Director
G. R. Patil, Ph.D.	Joint Director (Academic & Research)
J. K. Kewalramani, B.Sc., M.B.A.	Joint Director (Admn.) & Registrar
Rameshwar Singh, Ph.D.	Registrar
I. K. Sawhney, Ph.D.	Controller of Exams
Pushpnayak, M.Sc.	Chief Admn. Officer
R. C. Meena, M. Com.	Sr. Admn. Officer
S. George, M.A., PGDLA	Chief. Fin. & Account Officer
Mithlesh Kumar, M.Sc., PGDCFA	Sr. Fin. & Account Officer
Ram Shankar, M.A., P.G.D.T.	Deputy Director (Off. Lang.)
Vishal Acharya, MA	Asstt. Fin. & Account Officer
Kuna Ram Kisku	Asstt. Admn. Officer (ERS, Kalyani)
S. C. Tuli, B.A.	Asstt. Admn. Officer
A. G. Barapatre	Asstt. Admn. Officer
R. K. Bansal, M.A.	Asstt. Admn. Officer
Ram Niwas, B.A.	Asstt. Admn. Officer
Ishwar Diyal, B.A.	Asstt. Admn. Officer
S. Shashi Kala	Asstt. Admn. Officer (SRS, Bangalore)
S. S. Meena, B.A.	Asstt. Admn. Officer
Saroj Khurana, M.A.	Asstt. Admn. Officer
Neelam Bala	Asstt. Admn. Officer
N. K. Verma	Asstt. Admn. Officer
Jagdish Kumar, B.A.	Asstt. Admn. Officer
Rajbir, B.A.	Asstt. Admn. Officer
Braham Prakash, B.A.	Asstt. Admn. Officer
Deepak Chopra, B.A.	Security Officer
Sunita Chaudhary	Private Secretary
Shukla Vermani, B.A	Private Secretary
Prem Kumari, B.A	Private Secretary
Parvesh Lata, B.A	Private Secretary
Nirmala Kumari, B.A	Private Secretary
Simita Roy , B.A	Private Secretary (ERS, Kalyani)
Shukantla Rani, B.A	Private Secretary

RTI Cell

J. K. Kewalramani, B.Sc., M.B.A.	Appellate Authority
Y. S. Rajput, Ph.D.	Public Information Officer
Meena Malik, Ph.D.	Asstt. Pub. Information Officer
P. K. Dixit, Ph.D.	Asstt. Pub. Information Officer
R. A. Dey, Ph.D.	Asstt. Pub. Information Officer

Scientists and Technical Officers

Dairy Cattle Breeding Division

R. S. Gandhi, Ph.D.	Head
G. K. Sachdeva, Ph.D.	Principal Scientist
B. R. Yadav, Ph.D.	Principal Scientist
A. K. Gupta, Ph.D.	Principal Scientist
A. K. Chakravarty, Ph.D.	Principal Scientist
Archana Verma, Ph.D.	Principal Scientist
I. D. Gupta, Ph.D.	Principal Scientist
Avtar Singh, Ph.D.	Principal Scientist
A. P. Dabas, B.Sc.	Technical Officer
Om Bir Singh	Technical Officer
Vinod Kumar, B.Sc.	Technical Officer
Y. K. Panwar, M.A.	Technical Officer
Rakesh Kumar Tonk, Ph.D.	Technical Officer
Ashwani Kumar, M.Sc.	Technical Officer
Mool Chand	Technical Officer
Shisha Singh	Technical Officer
Vikram	Technical Officer
Y. P. Singh, B.Sc.	Technical Officer

Livestock Production and Management Section

Shiv Prasad, Ph.D.	Principal Scientist & Incharge
R. K. Mehla, Ph.D.	Principal Scientist
T. K. Mohanty, Ph.D.	Sr. Scientist
M. L. Kamboj, Ph.D.	Sr. Scientist
S. S. Lathwal, Ph.D.	Sr. Scientist
A. Kumaresan, Ph.D.	Sr. Scientist
Ramesh Chandra, Ph.D.	Sr. Scientist
A. Manimaran, M.Sc.	Scientist
Prasant Kumar, M.Sc.	Scientist
Shiv Kumar, M.Sc.	Technical Officer

Dairy Cattle Nutrition Division

S. S. Kundu, Ph.D.	Head
Amarjit Singh, Ph.D.	Principal Scientist
Harjit Kaur, Ph.D.	Principal Scientist
J. P. Sehgal, Ph.D.	Principal Scientist
D. S. Sohi, Ph.D.	Principal Scientist
Neelam Kewalramani, Ph.D.	Principal Scientist
S. S. Thakur, Ph.D.	Principal Scientist
Madhu Mohini, Ph.D.	Principal Scientist
Veena Mani, Ph.D.	Principal Scientist
S. K. Tomar, Ph.D.	Principal Scientist
A. K. Tyagi, Ph.D.	Principal Scientist
P. S. Oberioi, Ph.D.	Principal Scientist
S. K. Sirohi, Ph.D.	Sr. Scientist
Chander Datt, Ph.D.	Sr. Scientist
Raj Bahadur, B.Sc.	Technical Officer
Karan Singh, M.Sc.	Technical Officer

Dairy Cattle Physiology Division

R. C. Upadhayay, Ph. D.	Head
O. K. Hooda, Ph.D.	Principal Scientist
Sujata Pandita, Ph.D.	Principal Scientist
Parveen Kumar, Ph.D.	Principal Scientist
Mahendra Singh, Ph.D.	Principal Scientist
Sohanvir Singh, Ph.D.	Principal Scientist
N. Anand Laxmi, Ph.D.	Sr. Scientist
A. K. Dang, Ph.D.	Sr. Scientist
Anjuli Aggarwal, Ph.D.	Sr. Scientist
Manju Ashutosh, Ph.D.	Sr. Scientist
Ashutosh, Ph.D.	Sr. Scientist
Ashwani Kumar Roy, Ph.D.	Sr. Scientist
Bhagwat Swroop	Technical Officer

Animal Biotechnology Centre

R. S. Manik, Ph.D.	Officer-in-charge

Prabhat Palta, Ph.D.	Principal Scientist
S. K. Singla, Ph.D.	Principal Scientist
M. S. Chauhan, Ph.D.	Principal Scientist
T. K. Datta, Ph.D.	Sr. Scientist
D. Malakar, Ph.D.	Sr. Scientist
S. De, Ph.D.	Sr. Scientist
J. K. Kaushik, Ph.D.	Sr. Scientist
A. K. Mohanty, Ph.D.	Sr. Scientist
Manoj Kumar Singh, Ph.D.	Scientist
Sudarshan Kumar, Ph.D.	Scientist

Animal Biochemistry Division

Y. S. Rajput, Ph.D.	Head
S. K. Atreja, Ph.D.	Principal Scientist
R. K. Sharma, Ph.D.	Principal Scientist
Gautam Kaul, Ph.D.	Sr. Scientist
S. K. Sood, Ph.D.	Sr. Scientist
Dheer Singh, Ph.D.	Sr. Scientist
Rajeev Kapila, Ph.D.	Sr. Scientist
Suman Kapila Ph.D.	Sr. Scientist
Ms. Suneeta Meena, M.Sc.	Scientist
Ravi Kant, M.Sc.	Technical Officer
Karam Singh, B.A. LLB	Technical Officer

Dairy Technology Division

A. A. Patel, Ph.D	Head
Vijay Kumar, Ph.D	Principal Scientist
S. K. Kanawjia, Ph.D	Principal Scientist
D. K. Thompkinson, Ph.D	Principal Scientist
R. R. B. Singh, Ph.D	Principal Scientist
Latha Sabikhi, Ph.D	Sr. Scientist
A. K. Singh, Ph.D.	Sr. Scientist
Kaushik Khamrui, Ph.D.	Sr. Scientist
Narender Raju Panjagari, Ph.D.	Scientist
Prateek Sharma, M.Sc.	Scientist
Yogesh Khetra, M.Sc.	Scientist
Ganga Sahay Meena, M.Sc.	Scientist
Sathish Kumar, M. H., M.Sc.	Scientist
Devaraja, H.C. M.Sc.	Scientist
Vinod Kumar, B.Sc.	Technical Officer
Ram Swarup, M.A.	Technical Officer
Lehri Singh, M.Sc.	Technical Officer
S. K. Kharb, M.A.	Technical Officer
Savitri Jhamb, B.Sc.	Technical Officer
G. K. Goyal, Ph.D.	Emeritus Scientist

Experimental Dairy

A. K. Sharma, B.Sc.	Technical Officer (DS)
Hari Ram Gupta, M.Sc.	Technical Officer
A. K. Kohli, Dip. (Mech. Engg.)	Technical Officer
D.P. Verma, Intermediate	Technical Officer
T. L. Jaggi, Dip. (Refrigerator)	Technical Officer
Probir Mondal, B.Sc.	Technical Officer
Subhash Chander, Dip. (Electrical)	Technical Officer
Sanjeev Kumar, M.A.	Technical Officer
Prathvi Raj	Technical Officer
Balvir Singh	Technical Officer

Dairy Engineering Division

A. K. Dodeja, Ph.D.	Head
I. K. Sawhney, Ph.D.	Principal Scientist
Bikram Kumar, M.Tech.	Principal Scientist
Prashant Saurabh Minz, M.Tech.	Scientist
Om Prakash, Diploma (Agri. Engg.)	Technical Officer
Sunil Kumar, M.Sc.	Technical Officer
S. K. Chaudhary, A.M.I.E.	Technical Officer
S. S. Bhinder, Diploma (Mech. Engg.)	Technical Officer
J. K. Dabas, M.Tech.	Technical Officer
Pawan Kumar	Technical Officer

Dairy Chemistry Division

B. K. Wadhwa, Ph.D.	Head
Darshan Lal, Ph.D.	Principal Scientist
Raman Seth, Ph.D.	Principal Scientist
Bimlesh Mann, Ph.D.	Principal Scientist
Sumit Arora, Ph.D.	Sr. Scientist
Vivek Sharma, Ph.D.	Sr. Scientist
Rajan Sharma, Ph.D.	Sr. Scientist
Rajesh Kumar, Ph.D.	Sr. Scientist
P. C. Singh, M.Sc.	Technical Officer

Dairy Microbiology Division

Rameshwar Singh, Ph.D.	Head
R. K. Malik, Ph.D.	Principal Scientist
Sunita Grover, Ph.D.	Principal Scientist
A. K. Puniya, Ph.D.	Principal Scientist
S. K. Tomar, Ph.D.	Sr. Scientist
Shilpa Vij, Ph.D.	Sr. Scientist
Naresh Kumar, Ph.D.	Sr. Scientist
Chand Ram, Ph.D.	Sr. Scientist
Surjit Mandal, Ph.D.	Scientist
Raghu H.V., M.Sc.	Scientist
Rashmi H. M., M.Sc.	Scientist
P. V. Behare, Ph.D.	Scientist
R. P. Singh, Ph.D.	Technical Officer
Inder Kumar, B.Sc.	Technical Officer
Chamela Ram	Technical Officer
V. K. Batish, Ph.D.	Emeritus Scientist

Dairy Economics, Statistics and Management Division

K. K. Datta, Ph.D.	Head
D. K. Jain, Ph.D.	Principal Scientist
B. S. Chandel, Ph.D.	Principal Scientist
A. K. Chauhan, Ph.D.	Principal Scientist
Smita Sirohi, Ph.D.	Principal Scientist
Ravinder Malhotra, Ph.D.	Principal Scientist
A. K. Sharma,Ph.D.	Sr. Scientist
A. P. Ruhil, Ph.D.	Sr. Scientist
Raka Saxena, Ph.D.	Sr. Scientist
Uditya Chaudhary, Ph.D	Scientist
Rishi Kanta Singh, M.Sc.	Scientist
Tara Chand, B.Sc.	Technical Officer
J. P. Dhaka, Ph.D.	Emeritus Scientist

Dairy Extension Division

Ram Kumar, Ph.D.	Head
Jancy Gupta, Ph.D.	Principal Scientist
Khajan Singh, Ph.D.	Principal Scientist
K. S. Kadian, Ph.D.	Principal Scientist
S. K. Jha, Ph.D.	Sr. Scientist

Gopal Sankhala, Ph.D.	Sr. Scientist
B. S. Meena, Ph.D.	Sr. Scientist
Ritu Chakravarty, M.Sc.	Scientist (SG)
R. Senthil Kumar, Ph.D.	Scientist
Asif Mohammad, Ph.D.	Scientist
Sanchita Garai, Ph.D.	Scientist
N. S. Sirohi, Ph.D.	Technical Officer
Parvinder Sharma, Ph.D.	Technical Officer
Mridula Upadhayay, M.A.	Technical Officer
Jai Bhawan Sharma, Dip. In (AH)	Technical Officer

Agricultural Technology Information Centre (ATIC)

D. S. Sohi, Ph.D.	Principal Scientist & Incharge
Kumar Bharat, M.A.	Technical Officer
Rajpal Sharma, B.A.	Technical Officer
Pramod Kumar, M.Sc.	Technical Officer

Krishi Vigyan Kendra/Dairy Training Centre

Dalip K. Gosain, Ph.D.	Progam Coordinator
C. J. Juneja, Ph.D.	Technical Officer
Surender Gupta, Ph.D.	Technical Officer
Saroj Mehta, M.Sc., B.Ed.	Technical Officer
Satya Pal, M.V.Sc.	Technical Officer
Rajeshwar Dayal, B.Sc.	Technical Officer
Mohar Singh, M.Sc.	Technical Officer
Kulvir Singh, M. Sc.	Technical Officer
D. V. Sharma	Technical Officer
Prem Singh	Technical Officer

Forage Section

A. S. Harika, Ph.D.	Principal Scientist & Incharge
D. S. Sohi, Ph.D.	Principal Scientist
Magan Singh, Ph.D.	Sr. Scientist
Satish Kumar, M.Sc. (Horti.)	Technical Officer
Uttam Kumar, Ph.D.	Technical Officer
Ramesh Chand, B. Sc. (Agri.)	Technical Officer
Anil Kumar Dagar, M.Sc.	Technical Officer
Sohan Lal	Technical Officer
Satrughan Mehto	Technical Officer
Jagpal Singh, B.Sc.	Technical Officer
Sukhdev Singh	Technical Officer
Ravi Rawat, M.Sc. (Entomology)	Technical Officer

Livestock Farm

Shiv Prasad, Ph.D.	Principal Scientist, Incharge
T. K. Mohanty, Ph.D.	Sr. Scientist
M. L. Kamboj, Ph.D.	Sr. Scientist
Ramesh Chandra, Ph.D.	Sr. Scientist
A. Kumaresan, Ph.D.	Scientist
A. Manimaran, M.Sc.	Scientist
Nishant Kumar, M.Sc.	Scientist
Chaman Lal, Dip. (Motor Mechanic)	Technical Officer
S. K. Sharma, B.A.	Technical Officer
S. Raju, M.V.Sc	Technical Officer

Animal Health Complex

M. K. Srivastava, M.V.Sc.	Technical Officer
K.P.S. Tomar, M.V.Sc.	Technical Officer
Praveen Kumar, M.V.Sc.	Technical Officer
Harpal Singh	Technical Officer
Sahdev, M.Sc.	Technical Officer

Artificial Breeding Research Centre

A. K. Chakravarty, Ph.D.	Principal Scientist, Incharge
A. K. Gupta, Ph.D.	Principal Scientist
T. K. Mohanty, Ph.D.	Sr. Scientist
J. K. Pundir, B.V.Sc.	Technical Officer
R. T. Bansode, M.Sc.	Technical Officer
Nihal Singh	Technical Officer
Jintendra Rana, M.Sc.	Technical Officer
Subhash Chand, B.V.Sc.	Technical Officer
Amarpal Singh, M.Sc.	Technical Officer

University Office

G. R. Patil, Ph.D.	Joint Director (Academic)
Rameshwar Singh, Ph.D.	Registrar (A)
I. K. Sawhney, Ph.D.	Controller of Examinations
A. K. Tyagi, Ph.D.	Chief Hostel Warden
Gopal Sankala, Ph.D.	Hostel Warden
S. V. Singh, Ph.D.	Hostel Warden
Madhu Mohini, Ph.D.	Hostel Warden
Ritu Chakravary, M.Sc.	Hostel Warden
A. K. Singh, Ph.D.	Hostel Warden
Latha Sabikhi, Ph.D.	I/c Placement Cell
S. C. Tuli	Asstt. Admn. Officer
Yogesh Sharma	Technical Officer

Research Prioritization, Monitoring and Evaluation Cell

G. R. Patil, Ph.D.	Joint Director (Academic & Research)
Meena Malik, M.Phil., Ph.D.	Associate Prof. (English)
Braj Kishor, M.A., B.Lib Sci. &MSS, Post M.A. Dip. in Translation	Technical Officer

Library Services

B. R. Yadav, Ph.D.	Incharge
Pushpa Rani, B. Lib. Sci.	Technical Officer
B. P. Singh, M.A., M. Lib.& Info. Sci.	Technical Officer

Computer Centre

A. P. Ruhil, Ph.D.	Incharge
A. K. Sharma, Ph.D.	Sr. Scientist
Anirudha Kumar M.Sc., PGDCA, NHT Diploma	Technical Officer
Gian Singh, M.Sc.	Technical Officer

Communication Centre

Gopal Sankhala, Ph.D.	Incharge
G. D. Joshi, M.A.	Technical Officer
S. K. Talwar, M.A., P.G.D.	Technical Officer
Dharmbir, B.A.	Technical Officer
Ganpat Rai, ITI	Technical Officer
Gulshan Kumar, B.A.	Technical Officer

Vehicle Maintenance Section

R. K. Mittal, B. E. (Mechanical)	Incharge
Ram Chander	Technical Officer

Press Unit

Dr. S. K. Kanawjia, Ph.D.	Incharge
Mehi Lal	Technical Officer

Official Language Unit

Ram Shankar Gautam, M.A. P.G.D.T.	Deputy Director (Off. Lang.)
Kanchan Choudhary, M.A.	Technical Officer

Security Section

Ashutosh, Ph.D.	Incharge
Deepak Chopra, B. A.	Security Officer
Rajvir Singh, M.A., PGDCA	Security Supervisor

Maintenance Section

R. M. Chayal, Dip.Civil Engg.	Technical Officer, Incharge
R. K. Bansal, B.E. (Civil)	Technical Officer
Pankaj Chawala, M.Tech. (Electrical)	Technical Officer
Sarwan Kumar	Technical Officer
S. K. Saini	Technical Officer
Tek Chand (ITI Electrical)	Technical Officer
Bhagwat Singh (ITI Workshop)	Technical Officer
Devinder Kumar (ITI Wireman)	Technical Officer
Raj Kumar (ITI Electrical)	Technical Officer
Sohan Lal, M.A.(Eco.) (ITI Electrical)	Technical Officer
Khem Chand (ITI Electrical)	Technical Officer
Naresh Kanyana (ITI Electrical)	Technical Officer
Balbir Singh	Technical Officer
Ranbir Singh	Technical Officer

Hospitality Cell

D. Sherpa	Technical Officer

Health Complex

R. K. Malik, Ph.D.	Principal Scientist, Incharge
Rekha Sharma, M.B.B.S.	Sr. Medical Officer
Manoj Kumar, M.B.B.S.	Medical Officer
Richa Walia, Diploma Nursing	Technical Officer
Saroj Kathuria, Diploma Nursing & Mid Wifery	Technical Officer
Shishan Pal	Technical Officer
Shish Pal Gupta	Technical Officer

Estate Section

Sushil Kumar Kamboj, M.Sc.	Incharge
Prem Singh, M.A.	Technical Officer
P. M. Meena	Technical Officer

Southern Regional Station, Bangalore

Satish Kulkarni, Ph.D.	Head
C. N. Pagote, Ph.D.	Principal Scientist
B. Surendra Nath, Ph.D.	Principal Scientist
B. C. Ghosh, Ph.D.	Principal Scientist
B. V. Balasubramanyam, Ph.D.	Principal Scientist
P. K. Dixit, Ph.D.	Principal Scientist
K. P. Ramesha, Ph.D.	Principal Scientist
B. Srinivas, Ph.D.	Sr. Scientist
M. C. Arunmozhi Devi, Ph.D.	Sr. Scientist
K. Jayaraja Rao, Ph.D.	Sr. Scientist
D. N. Das, Ph.D.	Sr. Scientist
P. Heartwin Amala Dhas, Ph.D.	Scientist (SS)
Rekha Ravindra Menon, M. Tech.	Scientist (SS)
F. Magdaline Eljeeva Emerald, ME (Agri.)	Scientist (SS)
Mukund Amritrao Kataktalware, Ph.D.	Scientist (SS)
S. Varalakshmi, M.V.Sc.	Scientist
S. Subhash, Ph.D.	Scientist
P. Murugananthan, M.Lib. Sci.	Technical Officer
M. Nanjundaswamy, M. Lib.Sci.	Technical Officer
V.R.V. Surendranath Naik, M.D.	Medical Officer
M. Sreenath, M.Sc.	Technical Officer
Sarwar, M.Sc.	Technical Officer
L. Krishna Murthy, M. Sc.	Technical Officer
P. Aravindakshan, M.Sc	Technical Officer
M.A. Usha, B.Sc.	Technical Officer
M. K. Vedavathi, B.Sc.	Technical Officer
B. K. Rajeshekaraiah, B.Sc.	Technical Officer
J. Nageshwara Rao, Dip.(Mech)	Technical Officer
Thivija Kumari, M.A.	Technical Officer
Siddaramanna, M.V.Sc.	Technical Officer
Veeraju, B.E. (Civil)	Technical Officer
K. L. Sampath, B.Sc.	Technical Officer
P. G. Satisha, B.V.Sc.	Technical Officer
K. P. Lakshminarayanappa DME (Mech.)	Technical Officer
Meganathan, Dip. (Elect. Engg.)	Technical Officer
R. Keshvamurthy, B.Sc.	Technical Officer
Gurunath Gouda Patil, B.Sc.	Technical Officer
M. S. Nagarajaiah, Dip. (Civil Engg.)	Technical Officer
B. R. Srinivasamurthy, B.Sc.	Technical Officer
K. Geetha Kumari	Technical Officer
K. Ningaraju, M.V.Sc.	Technical Officer
Janakshi, M.C.A.	Technical Officer
A. Louis, B.Sc.	Technical Officer
Vimala, B.Sc.	Technical Officer
Sreekanta	Technical Officer

Eastern Regional Station, Kalyani

T. K. Datta, Ph.D.	Head
P. K. Roy, Ph.D.	Principal Scientist
R. A. Dey, Ph.D.	Sr. Scientist
Lotan Singh, Ph.D.	Sr. Scientist
S. K. Das, Ph.D.	Sr. Scientist
Anupam Chatterjee, Ph.D.	Sr. Scientist
M. K. Ghosh, Ph.D.	Sr. Scientist
Ajoy Mandal, Ph.D.	Sr. Scientist
V. P. Verma, M.A., B.Lib.Sci.	Technical Officer
Alokesh Goswami, M.Sc.	Technical Officer
Amitava Ghosh, M.V.Sc.	Technical Officer
Somnath Dutta, M.V.Sc.	Technical Officer
Prabir Saha, M.Sc.	Technical Officer
H. C. Yadav, M. Tech.	Technical Officer
N. K. Daihya, M. Tech.	Technical Officer

Personnel Milestones

Joining

- Sh. Vishal Achrya Joined as AF&AO at NDRI, Karnal w.e.f. 14.03.2011 on transfer from CSSRI, Karnal
- Dr. Ram Kumar, Principal Scientist, nominated as Acting Head, Dairy Extension Division, w.e.f. 22.03.2011.
- Sh. Mithlesh Kumar joined as Sr. Finance & Accounts Officer on 01.04.2011 on transfer from ICAR Research Complex, Patna
- Dr. Ashwani Kumar Roy, Sr. Scientist (Animal Physiology) joined at NDRI, on his transfer from NRC, Camel, Bikaner on 26.05.2011.
- Dr. Pawan Singh, Principal Scientist (LPM) joined at NDRI, Karnal on 18.07.2011 from CIRB, Hisar on transfer.
- Ms. Sunita Meena joined as Scientist at Animal Biochemistry Division, NDRI, Karnal on 30.08.2011.
- Dr. P. S. Oberoi Principal Scientist (Animal Nutrition) joined at NDRI, Karnal on 01.11.2011 from CIRB, Hisar, Nabha Centre on transfer.
- Dr. Magan Singh, Sr. Scientist (Agronomy) joined at NDRI, Karnal on 08.11.2011 from ICAR, Research Complex for N.E.H. Region, Arunachal Pradesh Centre, Basar, on transfer.
- Ms. Rashmi H.M. joined as Scientist (Dairy Microbiology) at NDRI Karnal on 14.12.2011.
- Sh. Pradip Vishnu Behare, joined as Scientist (Dairy Microbiology) at DM, Division, NDRI Karnal on 24.12.2011.
- Dr. A. K. Mathur joined as Admn. Officer at NDRI, Karnal w.e.f. 26.12.2011 from IARI, Pusa, New Delhi on promotion.
- Sh. R. C. Meena, joined as Sr. Admn. Officer at NDRI, Karnal w.e.f. 27.01.2012 on transfer from NIRJAFT, Kolkata.
- Dr. T. K. Dutta appointed as Head ERS of NDRI Kalyani and jointed w.e.f. 01.02.2012 from CIRG, Makhdoom, Mathura, UP.
- Dr. Ramesh Chandra, Sr. Scientist (LPM) joined at NDRI, Karnal on 16.02.2012 from ICAR, Research Complex for N.E.H. Region, Sikkim Centre, Tadong, Gangtok (Sikkim) on transfer.
- Dr. R. S. Manik, Principal Scientist nominated as Incharge, Animal Biotechnology Centre, NDRI, Karnal w.e.f. 16.01.2012.
- Dr. R. C. Upadhyay, Principal Scientist nominated as Acting Head, Dairy Cattle Physiology Division, NDRI, Karnal w.e.f. 16.01.2012.

Promotions

- The tenure of G. R. Patil, Joint Director (Academic) renewed for the period w.e.f. 24.05.2011 to 31.01.2015.
- Dr. (Mrs.) Meena Malik, Assistant Prof. (English) promoted to the post of Associate Professor (English) w.e.f. 08.07.2005.
- Dr. Brajendra Singh Meena, Scientist (Sr. Scale) (Agril. Extension) promoted to the post of Sr. Scientist w.e.f. 19.11.2008.
- Sh. Braj Kishor, Technical Officer T-5 (P&E) promoted as T-6 (P&E) w.e.f. 04.05.2011.
- Sh. Jagdish Kumar Assistant and Sh. Rajbir Assistant promoted as Asstt. Admn. Officer w.e.f. 18.07.2011.
- Ms Usha, M.A. Technical Officer T-6(L/T) promoted as T-7/8 (L/T) w.e.f. 01.07.2010.
- Sh. A. K. Kohli, Technical Officer T-6 (W/S) promoted as T-7-8 (W/S) w.e.f. 24.02.2011.
- Sh. B. P. Singh, Technical Officer T-5 (Library) promoted as T-6 (Library) w.e.f. 31.10.2010.
- Ms. Kanchan Choudhary, Technical Officer T-5 (P&E) and Ms. T. R. Thivijakumari, Technical Officer, T-5 (P&E) promoted as T-6 (P&E) w.e.f. 29.06.2011.
- Sh. Brahm Parkash, Assistant promoted as Asstt. Admn. Officer w.e.f. 02.01.2012.

- Smt. M. K. Vedavathi, Technical Officer, T-6 (L/T) promoted to the post of Technical Officer, T-7/8 (L/T) w.e.f 01.01.2010.
- Sh. B.K. Rajashekaraiah, Technical Officer, T-6 (F F/T) promoted to the post of Technical Officer, T-7/8 (F F/T) w.e.f 01.01.2010.
- Dr. Siddaramanna, Technical Officer, T-5 (F F/T) promoted to the post of Technical Officer, T-6 (F F/T) w.e.f 07.06.2011
- Ms. Janakshi, T-4 (L/T) promoted to the post of Technical Officer, T-5 (L/T) w.e.f 12.07.2010.
- Sh. Sreekanta, T-4 (W/S) promoted to the post of Technical Officer, T-5 (W/S) w.e.f 03.02.2011.
- Sh. Shish Pal Gupta, T-4 (L/T) and Sh. Yogender Pratap Singh, T-4 (L/T) promoted to the post of Technical Officer, T-5 (L/T) w.e.f 01.01.2010.
- Sh. Karm Singh, T-4 (L/T), Sh. Prithvi Raj, T-4 (L/T), Sh. Balbir Singh, T-4 (L/T), Ms. Sudesh Kumari, T-4 (L/T), Sh. Hukam Chand, T-4 (L/T), Ms. Prabha Sharma, T-4 (L/T), Sh. Ved Parkash Kalra, T-4 (L/T), Sh. Vikrama, T-4 (L/T), Sh. Bhagwar Sarup, T-4 (L/T), Sh. Chamela Ram, T-4 (L/T) and Sh. Yogesh Kumar Sharma, T-4 (L/T) promoted to the post of Technical Officer, T-5 (L/T) w.e.f 03.02.2010.
- Mr. Pramod Kumar T-5 (F/FT) promoted to the post of T-6 (F/FT) w.e.f. 24.5.2011.
- Mr. Jitender Rana, T-5 (L/T) promoted to the post of T-6 (L/T) w.e.f. 1.5.2011.
- Mr. P.M. Meena T-5 (F/FT) promoted to the post of T-6 (F/FT) w.e.f. 27.4.2011.
- Mr. Shiv Kumar, T-5 (F/FT) promoted to the post of T-6 (F/FT) w.e.f. 27.1.2011.

Retirement/Transfer

- Dr. S. L. Goswami, Joint Director (Research) appointed to the post of Director at NAARM, Hyderabad & relieved from NDRI, on 20.12.11.
- Dr. B. S. Prakash, Head, Dairy Cattle Physiology appointed to the post of Assistant Director General (Animal Nutrition & Physiology) at Hqrs. ICAR, Krishi Bhawan, New Delhi & relieved from NDRI on 29.12.11.
- Dr. Ashok Santra, Sr. Scientist (Animal Nutrition) relieved on transfer from ERS of NDRI, Kalyani on 25.04.2011 A.N. to join at NRC on Yak, Dirang, Arunachal Pradesh.
- Sh. A. K. Mathur, Admn. Officer relieved from NDRI, Karnal w.e.f. 21.03.2012 to join at Directorate of M.R. New Delhi.
- Sh. Khub Chand Private Secretary retired from Council's service on superannuation on 31.03.2011.
- Dr. D. K. Sharma, PS & Head, ERS of NDRI, Kalyani (WB) compulsorily retired from the services vide Council order No.4(9)/09-Vig. (D) dated 13.04.2011.
- Dr. K. K. Kalra, Principal Scientist (Agril. Economics) retired from Council's service on superannuation on 30.04.2011.
- Dr. V. K. Kansal, Principal Scientist (Biochemistry Animal Scientist) and Sh. D. K. Arya, Finance & Accounts Officer retired from Council's service on superannuation on 30.09.2011.
- Dr. S. Subash Scientist (Vety. Extension Education)) relieved from NDRI, Karnal 06.09.2011 to join at SRS of NDRI, Bangalore.
- Mrs. Saroj Kumari, AAO retired from Council's service on superannuation on 31.12.2011.
- Dr. S. N. Rai, Principal Scientist (Animal Nutrition) retired from Council's services on superannuation on 31.03.2012.
- Dr. Siddaramanna, T.O. T-6 (F/FT) was relieved of his duties from SRS of NDRI, Bangalore on 29.02.2012 to join as Associate Professor at Veterinary College, KVAFSU, Hebbal Bangalore.
- Sh. P. S. Shivaprasad, T.O. T-7/8 (W/S) SRS, Bangalore retired on superannuation on 31.01.2012.
- Sh. K.H. Rangappa, T-5 (F F/T) retired on superannuation on 31.05.2011
- Dr. A. Obi Reddy, Principal Scientist retired on superannuation on 31.10. 2011

15 MAIN STATION

Research Divisions

Dairy Cattle Breeding Division

The Division has been instrumental for conducting research in the areas of animal genetics and breeding including cytogenetics and molecular genetics. The main thrust research areas are genetic improvement of crossbred, Sahiwal and Tharparkar cattle and Murrah buffaloes by progeny testing of breeding males and judicious selection of males and females, faster multiplication of superior germplasm, evolving selection criteria, development of optimum breeding plans, genetic polymorphism studies at molecular level and its association with production/reproduction traits, disease resistance and thermo-tolerance, screening of young males for genetic disorders and assessment of male fertility.

Another important mandate of the Division is the development of skilled human resources in the field of animal genetics and breeding. The Center of Advanced Studies (Animal Genetics & Breeding) was established in 1995 at Division of Dairy Cattle Breeding during eighth plan. It has been renamed as Center of Advanced Faculty Training (CAFT) in Animal Genetics and Breeding in 2010 imparting training to scientists/teachers from Research Institutes, State Agricultural/Veterinary Universities and Livestock Development Organizations in advanced areas of Animal Genetics and Breeding. Till date, a total of 28 National Training Programs have been organized under the aegis of CAFT (AG&B) at the Division.

The Division also assists KVK and TBI (SINED) in training programs, consultancy services to farmers and various organizations, supplies superior germplasm in the form of frozen semen and breeding males to farmers, livestock developmental agencies, state governments and other stake holders.

The Division has Animal Breeding Lab., Biometrical Genetics Lab., Sire Evaluation Lab., Molecular Genetics Lab., Livestock Genome Analysis Lab., Livestock Record Cell and Artificial Breeding Research Complex. Besides this, breeding herds of cattle (Karan Fries, Karan Swiss, Sahiwal and Tharparkar) and Murrah buffaloes are also the integral part of the research component of Dairy Cattle Breeding Division.

Livestock Production Management Section

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. However, separate faculty of LPM alongwith 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 practices 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 Animal Breeding Research Center of Institute besides supporting the training and extension activities of the Institute. The objectives of the section are: To maintain elite germplasm repository of dairy animals of the identified breeds; Development of state-of-art dairy animal management facilities and infrastructure for high yielding dairy animals; To carry out research in collaboration with different divisions, in the upstream areas of dairy animal production; To standardize the package of management practices and to demonstrate the state of the art dairy animal production system to clients and to provide consultancy to the needy farmers and entrepreneurs for establishment of commercial dairy farms.

Dairy Cattle Nutrition Division

The major objectives of the Dairy Cattle Nutrition Division are to conduct basic, applied and anticipatory research, to undertake post-graduate programme in Animal Nutrition and to participate in the process of extension education through various training programmes. The Division was accorded the status of Center of Excellence by UNDP/IAEA for conducting post-graduate education and research. The faculty of this Division has been working in the frontline research areas such as mitigation of methane release from rumen of cattle and buffalo, mineral mapping, pesticide, insecticide and mycotoxin contamination of feeds and its amelioration, development of feed additives including herbal ones to enhance animal productivity, bypass nutrients, technological aspects for the improvement of feed utilization.

The Division has excellent facilities including Central Fine Instrumentation Laboratory, Laboratory for Anaerobic Rumen Microbial Work, Post Graduate Teaching Lab, Environrnental Laboratory, Quality Control Laboratory and Feed Manufacturing Unit besides the well equipped animal sheds for conducting the animal experiments.

Dairy Cattle Physiology Division

The discipline of Animal Physiology functioned as a section of erstwhile Dairy Husbandry Division and subsequently of Dairy Cattle Nutrition Division till the end of the 6th Five Year Plan. In the year 1984, it received the status of an independent Division. The objectives of the Division are: To conduct basic and applied research and impart training in various aspects of Animal Physiology; To undertake post graduate programmes of education in Animal Physiology at Master's and Doctoral levels and Development and application of field level technologies.

Presently, the Division is focusing its research thrust in 3 main areas namely Growth and Reproductive Physiology, Lactation Physiology and Environmental Physiology. The Division has also undertaken research projects funded by the BARC, World Bank, Department of Biotechnology, NDDB and DST-DAAD. A Network project on impact, adaptation and vulnerability of Indian agriculture to climate change with emphasis on livestock has been initiated and will continue during the current plan period. Linkages have also been established for collaborative research ventures with other ICAR Institutes viz. NRC on Yak, Arunachal Pradesh and NRC on Mithun, Nagaland.

Animal Biotechnology Centre

Biotechnology was initiated at NDRI, Karnal during mid eighties under a UNDP 'Centre of Excellence on Biotechnology' program. The urgent need for application of recent biotechnological advances in reproduction and production to superior females of dairy breeds of ruminants for improving animal productivity in our country formed the basis for the establishment of a state-of-art Embryo Biotechnology Centre (EBC) by financial support from the Department of Biotechnology. Biotechnology was further strengthened by establishment of Livestock Genome Lab and Molecular Biology Unit under National Agricultural Research Project-II. Animal Biotechnology Centre was reorganized in June 1999 by consolidating all the infrastructure facilities created under various programs on biotechnology. Besides research on areas relevant to biotechnology in dairy production and processing, the Centre also offers the M.Sc. 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 M.Sc. and Ph.D. programmes in biotechnology for the NDRI Deemed University. Recognizing its strength in genomics research ICAR recognized the centre as a niche area of excellence in buffalo production and reproduction genomics.

The centre has Embryo Biotechnology Lab, Animal Genomics Lab and Proteomics Lab. A state-of-the-art biotechnology research facility was created in 2007 to consolidate the biotechnology research at NDRI. The new lab facility offers a working space of more than 20,000 sq. ft. and have specialized laboratories on Embryo Biotechnology, Regenerative Biotechnology, Animal Genomics and Proteomics Research.

Animal Biochemistry Division

The Division of Animal Biochemistry came in to being in September 1984 with the merger of the discipline of Animal Biochemistry of Dairy Chemistry Division and the section of Human Nutrition and Dietetics. Research endeavors 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; Nutrigenomics; Characterization of buffalo fertility genes; Sperm functions and cryopreservation of seman; Spermatogonial stem cells research and Bioinformatics in dairy processing and production.

The Division has instrument rooms with modern equipments viz. Alpha- and Beta- counters, Ultra-centrifuge, High speed centrifuges, Micro-centrifuges, UV-Visible spectrophotometers, Spectrofluorometer, PCR, ELISA Plate readers, High Pressure Liquid Chromatography, Gas Liquid Chromatography, Inverted and fluorescent microscopes, Ice flaking machines, Freeze dryer, Gel documentation (Imaging) systems, ultra

filtration unit, Ultra-low temperature freezers and Carbon dioxide incubators. Division has a cold room for carrying out research at low temperature. Cell culture facilities are also available in the Division.

The Division has the laboratories for Nutregenomics, functional foods and therapeutics; Prebiotics and probiotics; Bioactive peptides and immunology; Bioinformatics; Molecular Endocrinology, Reproductive Biochemistry and Stem cell research. Division manages "Small Animal House" that caters to the need of students and scientists for laboratory animals viz. rat, mouse, rabbit and hamster.

Dairy Technology Division

The Dairy Technology Division is one of the first Divisions set up at this Institute. It is involved in teaching, research, training and consultancy activities. Over the years, the Division has made significant contributions to development of technological know-how for the dairy industry.

The Indian Council of Agricultural Research has, since 1994, recognized the Division as Centre for Advanced Studies (CAS) in Dairy Technology (now, Centre for Advanced Faculty Training [CAFT]) in Dairy Processing. Through these efforts a large number of teaching faculty and research scientists of the State Agricultural Universities and other institutions have been exposed to the latest developments in the field of Dairy Processing. The Division has thus far organized 25 training courses under this programme.

Three NAIP projects granted to NDRI as lead centre have their core in the Dairy Technology Division: (1) A value chain in composite dairy foods with enhanced health attributes, (2) Novel approaches for production of Nutraceuticals from milk and Indian herbs for potential use in functional dairy foods and (3) Development of E-course content for B.Tech (Dairy Technology) degree programme. One DST funded project on 'Development of geriatric dairy food having Prophylactic Attribute against Alzheimer's Disease' and another project on investigation on 'High Pressure Induced Effect on Quality Characteristics of Buffalo Milk' funded by ICAR under National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA) was also granted to faculty of Dairy Technology Division.

Dairy Technology Division at NDRI spearheads the nation's most prestigious under-graduate programme in Dairy Technology and provides elite human resource for various managerial positions in the industry. Dairy Technology Division at this Institute also took an initiative to establish the Dairy Technology Society of India (DTSI), which is a scientific and academic body representing the processing component of the dairy sector. It was registered on May 31, 2005. Recently DTSI organized International Conference on 'Functional Dairy Foods' held at NDRI, Karnal during November 16-19, 2011. There were 40 international delegates representing from 11 countries.

Physically, the Division comprises the Traditional Dairy Products Cell, Infant and Dietetic Foods Cell, Cheese and Fermented Dairy Products Cell, Convenience and Health Foods Cell, By-products and Membrane Technology Laboratory, Under-graduate/ Post-graduate Laboratory, Sensory Evaluation Laboratory, Food Technology Laboratory, Packaging Laboratory and Quality Control Laboratory.

Dairy Engineering Division

Dairy Engineering Division was established as one of the major research divisions since the inception of the Institute. It is contributing in teaching, research, training and industrial consultancy. The Division has research laboratory facilities to cater to the needs of specific areas and programmes such as process engineering, process equipment design, unit operations 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 breakthrough in developing a number of process equipment for manufacturing indigenous milk products. Many of these equipments 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 developed equipments. The Division has developed prototypes for the manufacture of khoa, paneer, rasgolla, malai laccha, etc. on the industrial scale and paneer gadget and cream separator attachment for small scale applications. Recent research achievements include improvisation of butter melter for higher capacity, manufacture of ghee using three stage SSHE and in-line production of rabri. Three stage SSHE is fully automatic state-of-the-art system for continuous manufacture of khoa, basundi, burfi, rabri and ghee. The Division also conducts specialized training to the graduate engineers during summer.

Dairy Chemistry Division

The mandate of the 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.

The Division has state-of-the-art Seminar room, Lecture room, Quality control lab, Undergraduate and Postgraduate labs, Instrument room, Research labs (lipids, proteins, minerals, enzymes, functional foods/neutraceuticals and nanotechnology).

Dairy Microbiology Division

The Division of Dairy Microbiology has been contributing significantly in both basic as well as applied aspects of dairy microbiology. The DM faculty has been extensively involved in development of human resource and imparting educational programmes for both undergraduate and postgraduate level courses. The Division offers contractual and consultancy services such as supply of starter cultures and microbiological analysis of milk and milk products and organizes short term specialized training programmes for dairy industry personnel and students from other universities/colleges.

The Division is currently engaged in research covering the areas related to molecular biology and genetic engineering, starter cultures and fermented milk products, probiotics, prebiotics and bioactive peptides, quality assurance and public health, biopreservatives, ultrastructure of dairy organisms/products and rumen microbiology. National Collection of Dairy Cultures (NCDC) is a singular facility of its kind in the country. The NCDC caters to the requirement for cultures from dairy industry and research organizations. At present, the main focus of the Division is on probiotics, food safety, bioactive peptides and value added dairy products.

Dairy Economics Statistics & Management Division

The Division of Dairy Economics, Statistics and Management was created during the IV Five Year Plan. In the early stage, the focus of research in the Division was on conducting research in economics of milk production and processing, with thrust on cost-returns studies. During subsequent periods, the research programmes of the Division enveloped more intricate and broader aspects of dairy enterprise encompassing backward and forward linkage factors for facilitating technology evaluation and transfer. The Division, over the years, has developed good infrastructure in terms of scientific manpower, teaching and training aids, divisional library and computer unit.

In response to the research demands of the clientele systems, the Division has been orienting its research priorities and conducting the research accordingly. From simple economic analysis of milk production, the Division envisaged to work on advanced aspects of value chain management, implication of economic reforms on dairy sector, climate change and economic impact assessment through the staff research projects and post-graduate research programmes of the scholars.

Dairy Extension Division

Dairy Extension Division was established at NDRI, Karnal in May, 1961 to undertake extension activities, besides teaching and research in extension education. Research endeavors of the Division are in the areas of information and communication technologies, organizational behaviour, information management, participatory technology development and impact studies of dairy innovations. The faculty has also been engaged in human resource development through post graduate and doctoral programmes of NDRI.

The main extension programme of the institute such as Dairy Mela and demonstrations, field days, etc. are organized by the Division. Research-Extension-Industry-Farmer Interface is also organized by the Division to provide an opportunity for the convergence of all stake holders working together for dairy development. Interface not only helps the dairy organizations to find solutions for today's problems, but also to realize the vision for the future. The Division also organizes technology transfer campaigns, infertility and veterinary aid campaigns, *Kisan 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" was initiated in February, 2009, to strengthen the effective dissemination of dairy production and processing technologies among farming community.

Livestock Farm

The total milk production of the herd during the year (2011-12) was 1260486.2 kg. The production performance of the two crossbred strains developed by the NDRI viz. Karan Swiss and Karan Fries was 11.3 and 12.4 kg per head per day, respectively as compared to 10.6 and 12.0 kg per animal during the previous year (2010-11). The milking average of Sahiwal cows and Murrah buffaloes was 6.6 and 6.4 kg per animal per day, respectively. One Sahiwal cow (SW-1876) produced best milk yield of 20.5 kg in peak lactation. Best yield in Murrah buffalo (MU- 498) was 17.0 kg per day during the current year. The peak milk yield by the KF and KS crossbred cows was 40.0 kg (KF-6791) and 27.0 kg (KS-4395), respectively.

Bovine Strength of Cattle and Buffaloes as on 31.03.2012

Age group	Cattle						Buffaloes	Total Bovines
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	Local	Total	Murrah	
Calves upto 6 months								
Male	25	04	04	26	-	59	22	81
Female	24	03	03	35	-	65	17	82
Heifers	130	35	13	138	-	316	132	448
Cows	131	19	21	195	-	366	140	506
Male stock (young)	18	-	-	13	-	31	14	45
Bullocks/ Teaser	-	-	-	01	01	02	03	05
Total	**328**	**61**	**41**	**408**	**01**	**839**	**328**	**1167**

Flock Strength of Goats as on 31.03.2012

Age Group	Alpine x Beetal	Sannen x Beetal	Total
Female			
Kids upto 6 months	29	15	44
6-12 months	--	--	--
Yearling	42	08	50
Goats	23	12	35
Male			
Kids upto 6 months	07	01	08
Bucks	08	04	12
Total	**109**	**40**	**149**

Milk Production at NDRI, Karnal during the year 2011-12 (01.04.2011 to 31.03.2012)

Total Milk Production (kg)		1260486.2 kg
Average Number of Animals in Milk per day:		
	Cattle	290
	Buffalo	65
	Goats	47

Sale of Livestock during the year 2011-12 (01.04.2011 to 31.03.2012)

Mode of Disposal	Cattle	Buffaloes	Goats	Total
Public Auction	869800.00 (365)	1521600.00 (106)	673200.00 (258)	3064600.00 (729)
On Book Value	953872.00 (87)	587955.00 (52)	135620.00 (77)	1677447.00 (216)
Grand Total	**1823672.00 (452)**	**2109555.00 (158)**	**808820.00 (335)**	**4742047.00 (945)**

- Auction of animals was conducted on 27th & 28th May and 16th & 17th September, 2011 and 16th & 17th March, 2012.
- Figure in parentheses indicates the total number of animals sold.

Performance of Dairy Animals during the year 2011-12 (01.04.2011 to 31.03.2012)

Particulars	Genetic Groups				
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	Murrah
Average number of animals in milk per day	96	11	18	165	65
Average number of dry animals per day	71	21	07	64	87
Milking average (kg) per day	6.6	6.1	11.3	12.4	6.4
Overall average (kg) per day	3.8	2.1	8.1	8.9	2.7
Best yield (kg) in a day	20.5	17.0	27.0	40.0	17.0
Animal number	SW-1876	TP-1208	KS-4395	KF-6791	MU-498

Flock Performance of Goats during the year 2011-12 (01.04.2011 to 31.03.2012)

Particulars	Genetic Groups	
	Alpine x Beetal	Sannen x Beetal
Average number of animals in milk per day	36	11
Average number of dry animals per day	21	07
Milking average (kg) per day	1.3	1.1
Overall average (kg) per day	0.8	0.8
Best yield (kg) in a day	3.9	2.7
Animal number	AB-918	SB-126

Month-wise Milking Average (kg) of Cows, Buffaloes and Goats Maintained at NDRI, Karnal 2011-12 (01.04.2011 to 31.03.2012)

	Cows								Buffaloes		Goats			
Months	Sahiwal		Tharparkar		Karan Swiss		Karan Fries		Murrah		Alpin x Beetal		Sannen x Beetal	
	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day	No of animals in milk/ day	Milk yield (kg)/ animal/ day
April	96	7.1	11	5.2	20	12.7	204	11.7	74	6.2	59	1.5	14	1.1
May	108	7.2	12	4.9	22	11.6	199	11.5	71	6.1	56	1.4	13	1.1
June	107	7.3	08	7.0	20	11.7	181	12.0	64	6.0	48	1.3	10	1.0
July	116	7.0	10	6.1	20	10.9	181	11.7	59	6.0	45	1.1	11	0.8
August	114	6.7	13	5.2	18	10.1	172	10.9	59	5.3	32	0.7	06	0.5
September	108	6.8	12	4.4	17	9.8	166	11.0	57	5.7	16	0.7	02	0.5
October	96	6.4	09	5.9	17	9.7	152	11.7	61	6.0	11	0.8	02	0.7
November	89	5.7	09	6.3	14	10.9	145	12.7	64	6.7	24	1.2	06	1.3
December	77	6.1	09	8.7	15	12.2	145	14.0	65	6.8	38	1.3	17	1.1
January	83	5.6	11	8.1	16	11.2	140	14.0	62	6.7	39	1.4	20	1.2
February	83	6.1	12	7.7	15	13.9	142	14.2	72	7.5	37	1.2	08	2.6
March	72	6.4	12	6.4	17	14.1	149	14.7	75	7.2	31	1.2	17	1.0
Average	**96**	**6.6**	**11**	**6.1**	**18**	**11.3**	**165**	**12.4**	**65**	**6.4**	**36**	**1.3**	**11**	**1.1**

Fat and SNF Percentage of Cattle and Buffaloes during the year 2011-12 (April 2011 to March 2012)

Particulars	First Lactation				
	Cows				Buffaloes
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	(Murrah)
No of observations	284	22	96	684	214
Average Fat%	4.58	4.57	4.42	4.36	8.16
Range	3.69-5.69	3.94-5.54	3.53-5.14	3.50-5.21	6.07-10.17
No. of observations	284	22	96	684	214
Average SNF%	8.79	8.75	8.74	8.75	9.68
Range	8.52-9.13	8.57-9.16	8.52-9.09	7.98-9.14	9.27-10.53

Particulars	All Lactations				
	Cows				Buffaloes (Murrah)
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	
No. of observations	1131	122	209	1989	750
Average Fat%	4.50	4.48	4.35	4.34	819
Range	3.58-5.99	3.59-5.54	3.50-5.41	3.05-5.81	5.99-10.82
No of observations	1131	122	209	1989	750
Average SNF%	8.78	8.79	8.76	8.75	9.72
Range	8.47-9.15	8.47-9.16	8.50-9.09	7.98-9.14	9.12-10.53

Protein and Lactose Percentage of Cattle and Buffaloes during the year 2011-12 (April 2011 to March 2012)

Particulars	First Lactation				
	Cows				Buffaloes (Murrah)
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	
No of observations	144	17	60	369	59
Average protein	3.36	3.29	3.26	3.29	3.88
Range	2.97-3.68	3.13-3.49	2.87-3.50	2.72-3.72	3.39-4.24
No. of observations	144	17	60	369	59
Average lactose	5.01	4.92	4.92	4.93	5.79
Range	4.51-5.36	4.56-5.29	4.31-5.43	4.45-5.39	5.45-6.11

Particulars	All Lactations				
	Cows				Buffaloes (Murrah)
	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	
No. of observations	531	49	99	941	316
Average protein	3.30	3.27	3.22	3.27	3.88
Range	2.29-3.68	2.54-3.49	2.54-3.50	2.72-3.96	3.27-4.51
No of observations	531	49	99	941	316
Average lactose	4.98	4.96	4.86	4.91	5.80
Range	4.00-5.59	4.56-5.32	3.36-5.48	3.65-5.84	5.08-6.31

Month-wise Milking Average (kg) as Fat Corrected Milk of Cows and Buffaloes Maintained at NDRI, Karnal (April 2011 to March 2012)

Month	Sahiwal 4% Fat		Tharparkar 4% Fat		Karan Swiss 4% Fat		Karan Fries 4% Fat		Murrah 6% Fat	
	Av. No. of Animals in milk/ day	Av. FCM yield (kg.)/ Animals/ day	Av. No. of Animals in milk/ day	Av. FCM yield (kg.)/ Animals / day	Av. No. of Animals in milk/ day	Av. FCM yield (kg.)/ Animals/ day	Av. No. of Animals in milk/ day	Av. FCM yield (kg.)/ Animals/ day	Av. No. of Animals in milk/ day	Av. FCM yield (kg.)/ Animals/ day
Apr. 2011	96	7.67	11	5.80	20	13.48	204	12.24	74	7.44
May 2011	108	7.85	12	5.14	22	12.52	199	12.32	71	7.57
June 2011	107	7.99	8	7.39	20	12.71	181	13.11	64	7.43
July 2011	116	7.67	10	6.77	20	12.11	181	12.82	59	7.56
Aug. 2011	114	7.37	13	5.63	18	10.64	172	11.98	59	6.34
Sept. 2011	108	7.13	12	4.45	17	10.29	166	11.35	57	6.88
Oct. 2011	96	6.63	9	6.22	17	9.74	152	11.91	61	8.11
Nov. 2011	89	5.94	9	6.60	14	11.19	145	12.83	64	8.61
Dec. 2011	77	6.33	9	9.05	15	12.47	145	14.17	65	8.83
Jan. 2012	83	6.26	11	8.96	16	11.58	140	14.45	62	8.05
Feb. 2012	83	6.49	12	8.40	15	14.38	142	14.57	72	9.36
Mar. 2012	72	6.94	12	7.00	17	14.65	149	15.34	75	9.40
Average	96	7.02	11	6.78	18	12.15	165	13.09	65	7.96

Production and Reproduction Performance of Cattle Initiating their Lactation during 2010 and Completing in 2011

Traits	Sahiwal	Tharparkar	Karan Swiss	Karan Fries	Murrah
First Lactation					
Age at 1st calving (Months)	39.13(31)	37.94(5)	35.50(12)	36.93(68)	42.13 (24)
Total milk yield (kg)	1760(23)	1698(5)	3707(12)	4039(63)	2228 (13)
305 or less days milk yield (kg)	1671(23)	1395(5)	3174(12)	3499(69)	2151 (13)
Lactation length (days)	297(23)	236(4)	358(12)	358(63)	310 (13)
Dry period (days)	156(23)	182(4)	77(9)	82(35)	85 (11)
Service period (days)	121(24)	128(4)	117(9)	180(38)	106 (24)
Calving interval (days)	388(21)	419(4)	402(9)	451(36)	406 (11)
All Lactations					
Total milk yield (kg)s	1810(108)	1457(17)	3634(20)	3893(193)	2344 (67)
305 or less days milk yield (kg)	1772(109)	1348(17)	3271(20)	3457(206)	2191 (67)
Lactation length (days)	270(108)	246(17)	323(20)	331(186)	332 (67)
Dry period (days)	114(65)	191(8)	92(16)	95(97)	111 (56)
Service period (days)	113(71)	118(8)	112(16)	178(102)	121 (87)
Calving interval (days)	393(65)	379(8)	398(16)	455(94)	428 (56)
Average number of lactations	3.03(109)	3.88(17)	2.84(19)	2.67(205)	2.92
Best Lactation (305 or less days)					
Milk yield (kg)	3962	2649	6042	6775	3353
Animal number	1695	1257	4344	6791	5605
Lactation number	2	1	7	3	1
Best Lactation					
Milk yield (kg)	4377	3587	6863	10417	4619
Animal number	1695	1257	4344	6732	5517
Lactation number	2	1	7	3	3
Lactation length (days)	377	457	393	767	417

Figures in parentheses indicate number of animals

Artificial Breeding Research Center

The Artificial Breeding Research Center (ABRC) at present with a capacity of 131 bulls (Sahiwal, Tharparkar, Karan-Fries breeds of cattle and Murrah breed of buffalo), is the largest Institute Breeding Bull Center in the country.

Proven KF Bull at ABRC

Proven Murrah Bull at ABRC

The centre has a state-of-the-art seminar-cum-class room, semen quality control and germplasm information laboratory, long range open bull exercising zone, mist cooling system for reducing and heat stress to breeding bulls.

Long range open bull exercising zone

Mist cooling system for reducing heat stress to breeding bulls

The center has also strengthened the facilities for scientific management of male animals/ dairy bulls, cryopreservation facility for storage of germplasm, semen processing laboratory, advance training facility on animal breeding / reproduction management and frozen semen technology and dissemination of superior germplasm of cattle and buffaloes.

Research Achievements

- Eighth Set of Murrah bulls was evaluated and Bull No. 4813 of NDRI Center was declared as second best proven bull with sire index of 2101 kg and 12.59 per cent superiority out of 16 Murrah bulls under Network Project on Buffalo Improvement. The germplasm of proven bull is being used for developing elite Murrah herd. Murrah bulls of XIII set were selected and test mating was initiated.
- Karan Fries, Sahiwal & Murrah bulls with sub-fertility problems viz., poor libido, poor semen quality and poor semen freezability, were found to have significantly higher percent fragile sites on X chromosomes than those in normal breeding bulls.
- The ejaculate rejection rate is very high (>45%) in Karan Fries bulls as compared to Sahiwal and Murrah bulls. Poor semen quality traits in crossbred bulls are transferred from one generation to the other. Research planning has been made for generating parameters related to libido for identification of poor libido bulls.

Management of Breeding Bulls

During the period, Six Murrah bulls for XII and XIII set under 'Network project on Buffalo improvement', 15 Sahiwal bulls for IX and X set under 'Associated herd progeny testing programme in Sahiwal' and 17 Karan Fries crossbred bulls for XI and XII set under Progeny Testing of KF bulls were maintained in the center. The center also maintained nine Tharparkar bulls for multiplication of Tharparkar breed of cattle.

Artificial Insemination and Reproduction Management

The center performed the test and elite mating of breeding bulls and monitored the reproductive health and reproductive efficiency of the NDRI herds. The centre also screened the breeding bulls for sexually transmitted bacterial and viral diseases. All the bulls and semen samples were found to be negative in sexually transmitted diseases.

Reproductive Status of NDRI Herd for the year 2011

	Breeds				
Particulars	**Sahiwal**	**Tharparkar**	**Karan Swiss**	**Karan Fries**	**Murrah**
Cows/ Buffaloes					
No. of observations	113	25	15	125	66
Service period (days)	110.63	104.08	125.4	154.12	148.19
No. of service/conc.	1.47	1.52	1.66	1.7	1.68
Heifers					
No. of observations	28	6	4	36	39
Age at maturity (mo)	29.7	28.5	28.25	28	38.89
Age at conception (mo)	31.5	29.25	29.25	28.63	40.56
No. of service/conc.	1.64	2.00	1.75	1.19	1.35
Conception Rate (%)					
Conc. rate by 1st service	43.87	35.13	42.85	41.03	40.28
Conc. rate by 3rd service	76.53	91.89	85.71	76.50	80.56
Overall conception rate	40.04	37.5	42.62	39.32	33.33

Production and Dissemination of Superior Germplasm

During the period, the center produced 92,984 doses of frozen semen and disseminated 34,029 ml doses liquid semen of Sahiwal, KF and Murrah bulls to farmers of different states and also disseminated/ supplied 69,587 doses frozen semen of Sahiwal, KF, KS and Murrah bulls to farmers and various dairy development organizations/agencies.

Distribution of Breeding Bulls

The center distributed 13 breeding bulls (Karan Fries -5, Sahiwal-4 and Murrah -4) to Bihar through Bihar Livestock Development Agency. The center also distributed nine breeding bulls to farmers through auction.

Production and Dissemination of Male germplasm

Breed	Frozen Semen Produced	Frozen Semen Deseminated		Liquid Semen Deseminated
		Sale	Others	Sale
KF/Exotic	37417	15773	17641	19106
KS	160	2195	150	-
SW	17500	5255	4233	5469
TP	4824	260	100	-
MU	33083	6729	17251	9454
Total	**92,984**	**30212**	**39375**	**34029**

₹ 9,44,530 generated through sale of liquid and frozen semen.

Forage Research and Management Centre

Forage Research and Management Centre produces adequate quantity of good quality green fodder to meet the nutritional requirements of institute herd. After meeting the day to day requirement of fodder, some area is utilized for production of fodder seed and other grain crops to meet out the requirements for transfer of technology programes of the Institute and partial fulfillment of the grain component of feed.

Allocations of the Farm Land to Different Units

Production Unit	Area (hectare)
Farm Section	297.18
Seed Production Scheme/Forage Research Farm	40.25
Dairy Demonstration Unit (KVK)	13.52
Dairy Mela Ground	3.44
Hostel, Power House, Play Ground	2.83
Total land	**357.22**

Fodder/Seed/Feed Production and Supply

A total of 2,06,187 quintal good quality green fodder was produced from high yielding varieties of fodder crops of maize, sorghum, sorghum x sudan hybrids and cowpea during kharif season and lucerne, berseem, oats Chinese cabbage, turnip and winter maize in rabi season. Similarly, grain crops of oats, wheat and paddy were also grown. During the period under report, a total of 2,06,187.00 q of fodder including 1,97,980.00 q. green fodder 522.00 q silage and 6168.25 q. dry fodder was supplied to cattle yard. A total of 311.00 q green fodder (berseem and oats) was supplied in Live Stock Show in Feb. 2011 and 142.52 q. green fodder was supplied to DCN Division in March-2011 to May-2011. Total production of grains of wheat, barley and oats was 1858.00 q.

Production and Productivity of Forage Crops in terms of Green Fodder

Crop	Area (ha)	Average Yield (q/ha)	Production (q)
Berseem + mustard	63.57	641.38	41927.25
Berseem + oats	0.40	607.50	243.00
Oats/oats + mustard	78.72	311.99	24560.50
Turnip	18.70	649.71	12149.75
Lucerne	10.12	492.66	4985.75

Maize	238.37	274.81	65508.75
Maize + oats	16.43	362.75	5960.75
Jowar (multi-cut)	18.25	622.36	11358.25
Jowar (single-cut)	74.13	366.22	27148.50
Cowpea	11.84	110.13	1304.00
Bajra	6.07	740.60	4495.50
Makchari	9.37	456.77	4280.00
Maize + mustard	9.45	239.76	2265.75
Total	**555.42**	**-**	**2,06,187.00**

Production and Productivity of Grain Crops

Crop	Area (ha)	Average Yield (q/ha)	Production (q)
Wheat	19.23	35.11	675.00
Oats	63.09	11.19	706.25
Barley	18.40	25.91	476.75
Total	**100.72**	**-**	**1,858.00**

Dry Fodder

A total of 734.75 q of dry fodder as wheat, barley and oats straw in the form of by- product of these crops was produced. To fulfill the nutritional requirements of the herd during lean period and to provide required dry matter during winter months, when DM content in the lush green forages is very low silage and wheat/oats straw were supplied.

Revenue Generation

Through sale of farm produce and providing tractors on lease an amount of ₹ 3,67,363.00 was realized and an amount of ₹ 14.99,353.00 was saved by the use of Farm Produce as Seed/Feed.

Revenue Generation by the Sale of Farm Produce

Item sold	Quantity (q)	Rate (₹/q)	Amount (₹)
Wheat grain	177.00	1120	1,98,240.00
Wheat seed	41.08	1400	57,512.00
Sewage sludge	843.00	12	10,116.00
Farm yard manure	260.50	10	2605.00
Tractors/ machinery leasing out	-	-	98,890.00
Total	**-**	**-**	**3,67,363.00**

Budget Saved by the use of Farm Produce as Seed/Feed

Produce	Quantity (q)	Rate (₹/q)	Amount (₹)
Wheat feed	489.15	1120	5,47,848.00
Oats seed	121.23	3500	4,24,305.00
Oats feed	37.50	900	33750.00
Barley seed	7.60	3000	22800.00
Barley feed	470.65	1000	4,70,650.00
Total	**1126.13**	**-**	**14,99,353.00**

Revolving Fund Scheme on Seed Production

Unavailability of good quality seeds of improved varieties of fodder crops is the biggest constraint in increasing the production of fodder crops. Thus, a Revolving Fund Scheme on Seed Production of Fodder Crops was initiated at NDRI, Karnal in 40 hectare area to produce the seeds of improved varieties of fodder crops for cultivation at Institute farm and sale to farmers, ICAR Institutes and other agencies. During the year under the report, 468.05 q seeds of improved varieties of fodder crops, 191.25 q undersized grains and 15565.00 q green/ dry fodder were produced.

Production of Seeds under RFS Seed Production

Name of crop	Quantity of Seeds (q)	Rate (₹/q)	Amount (₹)
Maize (V.C)	195.55	3000	586650.00
Jowar (PC-9/HJ-513)	20.00	5000	100000.00
Oats (OS-6/Kent)	61.00	2600	158600.00
Mustard (Chinese Cabbage)	3.50	5000	17500.00
Turnip	0.80	15000	12000.00
Paddy P-44	187.20	3000	561600.00
Total	**468.05**		**1436350.00**

Production of Grains under RFS Seed Production

Name of crop	Quantity of Grains (q)	Rate (₹/q)	Amount (₹)
Maize	76.00	1000	76000.00
Oats	65.00	90	58500.00
Mustard	0.25	1500	375.00
Paddy Screen	50.00	600	30000.00
Total	**191.25**	**-**	**1,64,875.00**

Green/Dry Fodder Supplied to Cattle Yard (q) under RFS, Seed Production

Fodder	Quantity	Rate/qntl.	Amount in (₹)
Green fodder	5448.00	100	544800.00
	1211.50	145	175667.00
	7711.50	140	1079610.00
Maize Kadbi	741.50	20	14830.00
Jowar Kadbi	315.75	125	39468.00
Paddy Straw	136.75	20	2735.00
Total	**15565.00**	**-**	**18,57,111.25**

Experimental Dairy Plant

Experimental Dairy Plant provides 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 training to the students in the operation of dairy plants. After meeting the requirements of research and teaching, the plant is used for converting the surplus milk into variety of dairy products such as, Milk Powder, Pasteurized Butter, Ghee, Paneer, Burfi, Kalakand, Lassi, Ice Cream, Processed Cheese etc. These products are sold through the Milk Parlour located at the Institute's main entrance. A total no. of 54 students from several institutions were also provided training during the year 2011-2012. Experimental Dairy, self sustaining dairy has been running under Revolving Fund Scheme since 1989-90. Revenue generated through scheme is being utilized for development of infrastructure of Experimental Dairy. Experimental Dairy is certified under Quality management system ISO 9001-2008 and HACCP-15000 by BIS Chandigarh. The revenue generated during the year January to December, 2011 was ₹ 3,60,31,198/-.

Sale of the Dairy Products during (January 2011 to December 2011)

Item	Qty.	Amounts (₹)
Cow Ghee (kg)	20814	6978350
Mix Ghee (kg)	601	196160
Pasteurized Butter (kg)	2645	153540
Paneer 500 gm (kg)	14406	2745240
Paneer 250 gm (kg)	12664.25	2192870
Paneer (kg)	14022	2426000
Ice-cream (Cup)	70684	1199305
Flavoured Dairy Drink (200 ml)	286787	3494740
Lassi (200 ml)	138961	1691885
Dahi (200 ml)	7557	84250
Kalakand (kg)	13588	2655130
Pro. Cheese Slices (200 g)	1118	83030
Skim Milk Powder (R) (kg)	34433.5	8198125
Gulab Jamun Mix (kg)	10877	2041250
Pizza Cheese 200 g	4049	241630
Carry Bag (No)	5838	29190
Cheddar Cheese (kg)	411.2	88811
Khoa (kg)	182.5	39570
Cooking Butter (kg)	67	19400
Mozzarella Cheese (kg)	0.5	100

Burfi (kg)	6707	1421150
Table Cream (kg)	31	1550
Skim Milk Powder (Spray Dried) (kg)	0	0
Jaljeera (200 ml)	720	6570
Skim Milk (kg)	0	0
Tomato Soup (Cup)	5096	43352
Total		**3,60,31,198**

Computer Centre

The Computer Centre is engaged in academic and service providing activities such as teaching Computer Science courses to under-graduate and post-graduate students in Dairying; scientific data processing including software development; monitoring management information; maintenance of the Institute Website and databases; and imparting software training to Institute staff and sponsored students from other academic institutions.

Agricultural Research Information System

The Agricultural Research Information System (ARIS) Cell worked effectively during the year with regard to LAN management in order to provide round-the-clock network services. The bio-data of Institute staff is being regularly updated as part of PERMISNET. Intelligent Reporting System (IRS) of ICAR is also operational in which Institute information is being uploaded quarterly.

The up-to-date information is also being maintained online about academic and related aspects under NISAGENET. A Statistical Cell is also functioning in the Centre, which provides up-to-date information and statistics related to Institute students and faculty, to various organizations such as UGC, State Department of Higher Education and similar other departments.

Online Examination Centre

An Online Examination Centre with 120 nodes has been established under the NAIP sub project "Developing, Commissioning, Operating and Managing an Online System for Net/ARS - Preliminary Examination by ASRB, ICAR" for conducting NET/ARS Preliminary Examination for ASRB, ICAR.

Wi-Fi Facilities in Hostels

Institute LAN facilities have been extended to connect the students' hostels (including Boys Hostels, International Hostel and Kaveri Hostel) through Wi-Fi networking to enable the students to access the Internet and Library Resources from their hostels, round-the-clock. A new UTM system with 4.5 Gbps capacity to accommodate 1500 licensed users has been procured and commissioned.

National Knowledge Network

NDRI is connected with NKN with a bandwidth of 1 Gbps network that seamlessly interconnects the leading Scientific and Technological institutions, which are pursuing world –class research and development. NKN management is capable of handling provisioning for the central services such as Multimedia Conferencing, e-access, digital library and central data centre to all users.

Institute Website

The Institute Website is dynamic with role-based security features in place. Its Web-content is regularly being updated by the Computer Centre as well as dynamically by the faculty members, divisions and the Purchase Section so as keep the information up-to-date.

Library

The Institute Library has an impressive collection of literature on Dairy Science and related subjects. More than 200 periodicals are subscribed to keep track of the current scientific/technical developments. Currently, there are 94,730 volumes, which include 50,395 books 31,210 bound journals, 8,200 bulletins, 3,357 theses, 268 microfiches and 1,300 CDs. Library has an excellent computer section having 50 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 is adequately equipped with facilities such as Internet, Email, Documentation, Reference, Current Awareness Services and CD-ROM Literature scanning services. Library has various CD-ROM Databases i.e. CAB Abstract, Food Science Technology Abstract, AGRIS, Derwent Biotechnology Abstract, Indian Standards on CD-ROM and ISO Standards of milk and dairy products on CD-ROM. The Library also provides Photocopying, Document Scanning and Printing facility. Computerized Issue-Return and reservation of books is done by using LIBSYS Library software Packages with Web OPAC. Library is a major partner of NAIP sub-project 'Strengthening of Digital Library and Information Management under NARS (e-Granth)'. The project has a major mandate to have a union catalogue of

participating libraries on OCLC platform. In this project, the participating libraries are to upload their database/ information of all the available books, journals and other resources on OCLC platform in MARC-21 format. In addition of above, library is also contributing in other NAIP subprojects "Krishiprabha' and 'CeRA'.

Communication Centre

Exhibition Unit

During the period, Exhibition Unit organised eight number of exhibitions at in around Karnal. Exhibitions were also arranged at NASC Complex, New Delhi on 13.5.2011; Kisan Mela, Haridwar on 30.9.2011to 1.10.2011; IVRI Izatnagar on 18-20.10-2011 and CIRB, Hisar on 1.2.2012. A sum of ₹ 6.70 lakhs was generated from renting of Exhibition Ground during the year.

Video Lab.: The facility of audio-video recording, editing were provided to the scientists, staff & students for their research work. Video coverage of 41 events of the institute consisting of National and Inter-national seminars, workshops, meetings, conferences, convocations, cultural programmes, cattle shows, scientific assignments & researches, kisan sanghostis, exhibitions, Dairy Mela, calf rallies & other functions of the institute was carried out. The production of two new films "NDRI at a Glance" in Hindi & English was also completed. In view of the great demand for processing these films by various state development, Agriculture universities & development agencies, 154 nos. of DVD/VCD were supplied. " seven' DVD's on clean milk production were sold to the prestigious organization.

Photo Lab.: Photo Lab. of the Institute covered research activities of scientists and students, national and international seminars, workshops, conferences, cultural programmes, extension activities and visit of high dignitaries. The photo lab also supplied photographs to various organizations in the country, Agril. universities, KVK and other NGO etc. A sum of ₹ 16818/- was realized through supply of photographs.

Technology Business Incubator

Technology Business Incubator (TBI) has been established with the support of DST. During the year, TBI organized three Entrepreneurship Development Programmes, one on Dairy Processing & two on Commercial Dairy Farming, & Eight short Training Programs in the area of Breeding, Artificial Insemination, Reproduction Management in Farm Animals. Short term training program for 150 Veterinarians from Chhattisgarh State was also organized in six batches on "Breeding & Health Management in Dairy Animals" from Mar – Apr'12. Revenue of ₹ 31 lakhs was generated by TBI through EDPs, Training Programs & Incubation Program.

An Incubatee Company, M/s. Agati Healthcare Pvt. Ltd. also operated under the guidance of TBI to manufacture colostrum powder. Besides, advisory support was extended to a couple of entrepreneurs in setting up of dairy farm.

Maintenance Section

Since 1979, Maintenance Section has been providing the services related to mechanical, electrical, civil, refrigeration & air conditioning etc.; new works addition/alterations required in the labs/Institute; maintenance of the Sub-Station, overhead lines, street lights, service connections maintenance of electric supply to the office area as well as residential area of the Institute; providing generator supply to office area in case of power failure; Liaison works with HSEB, CPWD, Haryana State Pollution Control Board and Local Authorities; maintenance of the water supply & sewage disposal system in the Institute; planning and inspection of new buildings in the Institute; maintenance of STP & Bio Gas Plants and other miscellaneous works of the Institute.

Human Health Complex

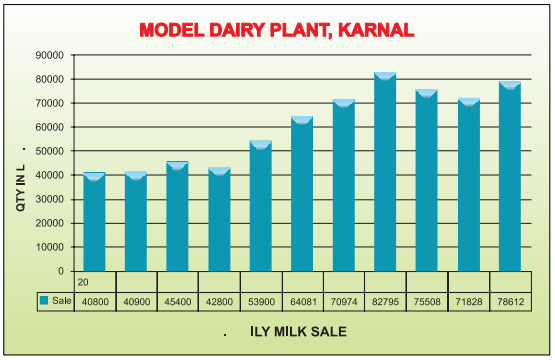
The Human Health Complex was established in 1991. It is catering to the health needs of the employees and students of at NDRI as well as to the other sister ICAR Institutes situated at Karnal. Medical Officers render medical aid in Allopathy, Ayurveda & Homoeopathy systems of medicine. Well qualified & trained nursing staff, laboratory technicians and pharmacists assist the Doctors in providing the desired medical facilities.

The HHC is continuously upgrading its medical facilities. A Physiotherapy Unit was started in the complex premises in June, 2010 for the benefit of the patients suffering from various chronic ailments such as Lower back-ache, Cardiac ailments, Hypertension and various types of Arthritis etc. Diagnostic clinical lab is well equipped with a fully automatic Haematolyzer and a semi-auto Biochemical analyzer.

HHC also organized various health awareness programmes in the year 2011-12 for educating the Staff and their dependents for better health care.

Model Dairy Plant

A state-of-the-art Commercial Dairy Plant with the capacity to handle 60,000 liters of milk per day was established during 1995 at NDRI, Karnal through the financial assistance and installed on turnkey basis by the National Dairy Development Board. As an autonomous unit of ICAR, this is independently managed by a committee, whose Chairman is the Director of NDRI. MDP is presently processing/ packing 70000 - 80000 lpd of polypack milk in all the varieties for Mother Dairy, Delhi.



Special Features

- Model Dairy Plant (MDP) provides one year in-plant training to the students of B.Tech. (DT) of the N.D.R.I. Deemed University during the 4th year of the course curriculum. This helps them in gaining sufficient experience in managing the modern commercial Dairy Plant and instills confidence in handling real life problems in production management. A total of 387 no. of students have been trained so far.

- It also provides infrastructure facilities to the scientists of NDRI for scaling up R & D concepts from laboratory to industrial scale under commercial environment.

- MDP also processes/packs Ice-cream for Mother Dairy to the tune of 7000 liters per day thereby utilizing the full capacity of the unit. The ice cream manufactured at MDP is of different varieties i.e. vanilla, strawberry, shahi malai, kewra, thandai, butter scotch, etc. and as per the requirements of Mother Dairy.

- MDP manufactures cow ghee from cow butter purchased from different State Federations and its production is not taken as per demand. All the ghee manufactured at MDP is being sold through the MDP sale counter.

- MDP is also engaged in training students in manufacturing of cottage cheese, processed cheese, paneer on trial basis.

- Model Dairy Plant is presently certified under the Food Safety Management System (FSMS) **ISO 22000:2005.**

Model Dairy Plant

16 REGIONAL STATIONS

Southern Regional Station, Bangalore

The National Dairy Research Institute was started at Bangalore 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 Nation's dairy industry. Upon shifting of the Institute Head Quarters to Karnal in 1955, the establishment at Bangalore 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 Station functions with the following mandate and objectives.

Mandate

- Identify the region specific problems of dairy production, processing and management on continuing basis and evolve suitable solutions.
- Establish centers for technology development, assessment and dissemination.
- Establish centers of advanced studies for R & D and HRD with the Station as the Southern Campus of NDRI Deemed University.

Infrastructure

The Campus is endowed with necessary infrastructure in terms of qualified staff, farmland, dairy herd, laboratories, library, staff dispensary, hostel facilities, etc. The Campus envelopes a land area of 46.3 hectares. About 21 hectares of land is utilized for the cultivation of various forage crops for meeting the feeding requirement of the dairy herd of the Institute. About 200 zebu cattle of Deoni breed, constitutes the dairy herd of the Institute.

The Campus has good laboratory and infrastructural facilities for carrying out research work on molecular genetics, screening of microbes, chemical and microbiological analyses of dairy products, testing of dairy equipments, manufacturing of various dairy products, effluent analysis, etc. There are network connected computer facilities to facilitate data analysis, documentation, e-mail communication and programming packages for students.

A LAN with a modern web server networks the computers of different sections and Internet facilities are provided to all the sections through the server. An effluent treatment plant and effluent-testing laboratory are established and are functioning at the campus. A sensory evaluation laboratory for evaluation of dairy products has also been established.

The library is stocked with 12375 books, 10691 bound volumes of journals , 1789 theses and 1295 reprints. Library subscribes to 125 Indian / Foreign Journals relevant to various disciplines of Dairy Science. In addition, few journals were also received on gratis basis from different Institutions / organizations of the country and abroad. Library Automation Software procured for facilitating the automation of library functions and 8312 Bibliographical details about the book have been updated into the software. Library also provides Internet services, photo copying facility, News Paper Clipping Services, Reference Services and Inter Library Loan facilities to readers. The Library serves as a referral centre for many students and professionals in the field of dairying and food science across the country.

There is a good hostel and guest house facility for the stay of students and visitors. The staff dispensary at the Campus caters to the medical needs of students, staff and retired employees. The clinical laboratory of the dispensary also has facilities for taking up preliminary investigations. For facilitating conduct of meetings, seminars, conferences etc a seminar hall and a mini auditorium with very good facilities have been developed recently.

The research, training and transfer of technology programmes at the Campus are carried out through different sections viz., Animal Breeding & Artificial Insemination, Cattle yard & Forage Production, Dairy Technology, Dairy Chemistry & Bacteriology, Dairy Engineering, Dairy Economics & Management, Dairy Extension and Dairy Education. The Campus has staff strength of 181 including 16 Scientific and 43 Technical staff.

Education and Training

Educational Programmes

Ph.D Programmes are being offered in the disciplines of Dairy Technology, Dairy Chemistry, Animal Genetics & Breeding, Livestock Production and Management and Dairy Economics. In addition to conducting M.Tech Programme in

Dairy Technology, guidance is being provided to the PG students in the disciplines of Dairy Chemistry, Dairy Engineering, Animal Genetics and Breeding, Livestock Production and Management, Animal Nutrition, Dairy Extension and Animal Biotechnology for carrying out their dissertation work. Short term Training Programmes are being imparted in Processing, Quality Assurance, Dairy Production and Extension for the students, dairy farmers/ entrepreneurs and personnel from Co-operative Federations and Private Organisations.

Apart from this, in-plant training and in-lab training are given to the UG and PG students of other Colleges/Universities. PG students of other Colleges/Universities also conduct project work in the Campus.

The Station has proposed a course on "Regulatory Affairs for Foods and Beverages". The course has been approved as Non-credit course for PG and Ph.D students by Academic Council.

Training Programmes

Name of the Training Programmes	No. of Batches	No. of Participants
Dairy Cattle Feed Analysis and Feed Formulation	03	06
Commercial Dairy Production	05	62
Production of Cheese and Related Products	01	04
Preparation of Ice-cream and Indigenous Dairy Products	02	11
Training on Livestock Genomics and IP Protection in Livestock Biotechnology	01	02
Scientific Dairy Farming Practices for Dairy Farmers	02	67
Calibration of Dairy Glassware	01	05
Summer Placement Training	02	27
In-plant Training (DT)	02	10
In-lab Training (Microbiology)	01	01
Project Work	05	12
Total	25	207

A total revenue of ₹ 3,08,400/- was collected towards the training fees for the above training programmes during April 2011 to February 2012.

Extension Activities

- During the period under report, 1085 visitors in 31 batches comprising of students from various educational institutes of southern region, farmers, entrepreneurs and trainees visited the institute. The visitors were taken around the Institute to various units/labs as per their needs and were explained about the ongoing activities.
- Advisory services and technical advice were rendered to the needy clientele, during their personal visits to the institute and through mail response also.
- An Orientation Programme was organized for fifty progressive farmers / milk producers from Salem, Coimbatore, Nilgiris and Dindugal milk unions of Tamil Nadu on study tour in National Agricultural Development Programme.
- Participated in JKM Mela 2011 (Januvaru, Kukkuta and Matsysa Mela) held at Dairy Science College, KVAFSU, Hebbal, Bangalore from 12th-13th February, 2011 organized by Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU), Bidar.
- Participated in exhibition for the programme under NAIP Project "Mobilizing Mass Media Support in Sharing Agro Information" organized by IIHR and held at National Institute of Animal Nutrition & physiology (NAINP), Adugodi, Bangalore on 26th February 2011, showcasing the technologies developed by the regional centers of ICAR institutes for the benefit of the farming community.
- A farmer-scientist interaction meet and a media meet was organized, which was well attended by the beneficiaries and media personnel, respectively. NDRI stall depicted innovative and educative information on dairy production and processing technologies, indigenous breeds of South India and traditional dairy products.

- Participated in the Bharat Nirman Exhibition, a Public Information Campaign (PIC) organized by Press Information Bureau, Ministry of Information and Broadcasting, Government of India in association with other media units of Information & Broadcasting Ministry and respective District Administration and Zilla Panchayat in Karnataka, the Exhibition held at Town Municipal Ground, Sirsi in Uttar Kannada district, Karnataka during 20th – 22nd March 2011.
- Participated in Dairy Tech India 2011 International Exhibition on Dairy Products & Technology held during 9th to 11th September 2011 at Palace ground, Bangalore.
- Participated in Rashtriya Krishi Mela 2011 organised by University of Agricultural Sciences, Bangalore, a national event to showcase new farm technologies benefiting the clientele group from 16th to 20th November 2011 at GKVK Campus, Bangalore.
- Extension literature on dairy production and processing aspects were distributed to the visitors and needy clients for dissemination of needed technical information to the needy clientele group. A dairy product catalogue was prepared for the benefit of the clientele groups especially in view of participation in various dairy melas / exhibitions.
- Regular weekly visits were made to the adopted villages for providing needed technical advice to clientele groups on scientific dairy farming practices and veterinary extension services to the needy clientele group.

Type of veterinary service	No. of cases treated in Adopted Villages
Artificial Insemination	405
Re-insemination	215
Calves born. Male	120
Female	103
First-aid Cases	1736
Infertility Cases	610
Deworming	1590
Dehorning	144
Castration	204
Tattooing	144
Pregnant Animals	117
Sale of Born Calves	55
Abortion	12

Awareness creation and training cum demonstration on diagnosis and control of subclinical mastitis.

Programmes under NABARD sponsored research project were undertaken on detection and control of subclinical mastitis under field conditions. The efforts were made towards achieving quality milk production by educating the dairy farmers through training and demonstration benefitted more than 500 farmers belonging to Karnataka and Andhra Pradesh under NABARD sponsored project. The training cum demonstration programmes on detection of subclinical mastitis in the milking cows by using electrical conductivity meter, California Mastitis Test kit and digital somatic cell counter were arranged both on campus and off campus i.e. at farmers' door step. Efforts resulted in awareness creation about subclinical mastitis. Hence, they have started to implement the detection and control of subclinical mastitis. After demonstration, Karnataka Milk Federation (KMF) both in Bangalore and Kolar districts have initiated steps to control subclinical mastitis at their collection centres. This clearly indicates that the possibility of using techniques for qualitative analysis of milk immediately after milking as well as from bulk milk cooler becomes more useful.

Livestock Farm

The total milk production of Deoni herd during current year was 470778.5 kg. The milking average was 4.5 kg/day. Best yield of Deoni cow was 11.5 kg/day. The details of herd strength and performance are mentioned below.

Performance of Deoni Animals

Average no. of animals in milk	38
Average no. of animals in dry	47
Milking average(kg/day)	4.5
Herd average (kg/day)	2.0
No, of calves born (M + F)	49 (28+21)
No, of animals died	02
Mortality percent	0.71

Herd Strength

	Deoni Animals			Cross-bred Animals		
Age group	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Calves up to 6 months	08	08	16	-	01	01
6 months to 1 year	15	17	32	01	06	07
1 to 2 years	01	17	18	-	-	-
Above 2 years	11	31	42	-	-	-
Milch animals	-	16	16	-	08	08
Dry animals	-	48	48	-	02	02
Breeding bulls	04	-	04	-	-	-
Bullocks	08	-	08	-	-	-
Total	**47**	**137**	**184**	**01**	**17**	**18**

Performance of Animals

	Deoni Cows	Cross-bred Cows
Total milk yield (kg)	34,400/-	36,894/-
Best individual milk yield/day	11.5	24.0
Average no. of animals in milk	29	10
Average no. of animals in dry	50	Nil
Milking average(kg/day)	4.0	11.9
Herd average (kg/day)	1.5	11.9
No, of calves born(M + F)	(22+22)=44	(0+3)=03
No, of animals died	05	Nil
Mortality percent	2.7	Nil
No. of animals disposed	78	Nil

Revolving Fund Scheme

The revolving fund scheme was started to sustain the activities of the experimental dairy without much burden on the institute for the funds. Required amount of milk over and above the milk received from the farm was purchased from Bangalore Dairy - a unit of Karnataka Milk Federation. Various products like cheese, milk sweet, flavoured dairy drink, ice cream, chhana podo, cheese puri mix, curds, butter, ghee, etc. were prepared for sale under this scheme through the milk parlour.

Milk and Milk Products Sale (January to December, 2011)

Product	Quantity sold	Amount (₹)
Milk sweet, kg	251.5	48288
Flavoured milk, pkt	3480	38280
Process cheese, pkt	4182	267648
Paneer, kg	536.5	87986
Butter, kg	552	138000
Ghee, kg	399	111720
Gulabjamun mix, pkt	252	9576
Cheese puri mix, pkt	265	10070
Chhana podo, pkt	704	33792
Kunda, cups	1522	30440
Ice cream (S), cups	660	9240
Ice cream (O), cups	1757	21084
Ice cream (FP)	28	3220
Yoghurt, cups	4299	51588
Curd, pkt	2075	18675
Khoa, kg	16.5	3498
Milk, lit	25714	540000
Total		1423105

Eastern Regional Station, Kalyani

The Eastern Regional Station was established at the Central Dairy in Kolkata. in 1964 and was shifted to Kalyani during 1966, Nadia district, about 50 km north of Kolkata 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 E.R.S. of N.D.R.I. with effect from June 1, 1968. In 1978 the Government of West Bengal granted 100 acres of land at Kalyani where cattle sheds, forage unit, staff quarters, etc. were gradually built up. The Station built its own laboratory building and the entire station started functioning within the same campus from May, 1987.

The 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 region 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 Station has infrastructure facilities like Research Laboratories, Cattle Herd, Fodder Farm, Library, Computer section, Guest House, etc. The station has staff strength of 49 including 8 scientists, 16 technical, 6 ministerial and 19 skilled supporting staff.

Keeping in view the enormous demand for milk in the eastern region, low milk production potential of the native stock, shortage of feed and fodder resources and diversified agro-climatic and socio-economic conditions; this research station has a great role to play in the field of dairy development in this region.

Support Sections

Livestock Farm

Different Breeds: Jersey cross and Tharparkar

Livestock section at ERS, Kalyani.

Reproductive Performance of ERS-NDRI herd (2011)

Particulars	Jersey Cross	Tharparkar	Over all
Herd strength as on 31-12-2011	143	2	145
Total milk production (kg)	116932.5	303	117235.5
Av. no. of cow's in milk/day	48.8	0.9	49.7
Av. no. of cow's in dry/day	16	1.6	17.6
Wet average (kg)/day	6.6	0.6	7.2
Herd average (kg)/day	4.9	0.3	5.2
Age at first calving (month)	39.9	0	39.9
No. of inseminated	111	8	119
No. of pregnant	42	2	44
Conception rate (%)	37.8	25	37
Service period (days)	97	117	98
Inter calving period (days)	453	386	451
Mortality (%)	11.7	0	11.6

Milk Production Performance at ERS-NDRI Herd (January to December, 2011)

Months 2011	Milk Production (kg)	Wet Average (kg)	Herd Average (kg)	Average FAT %	Average SNF %
January	9493.5	6.15	5.00	4.86	8.73
February	9506.5	6.67	5.26	4.96	8.73
March	9867.0	6.38	4.90	4.92	8.70
April	9396.0	6.43	4.67	4.91	8.71
May	10159.0	6.88	4.60	4.67	8.69
June	10195.0	6.88	4.64	4.66	8.68
July	9977.0	7.14	4.42	4.84	8.71
August	9491.5	6.88	4.93	4.91	8.67
September	10169.0	6.81	5.34	4.96	8.71
October	10472.5	6.31	5.00	4.94	8.70
November	9440.0	5.89	4.53	5.12	8.39
December	9068.5	5.48	4.17	4.94	8.70
Overall Average	**117235.5**	**6.49**	**4.79**	**4.89**	**8.68**

Forage Farm

Forage Farm section is engaged in cultivation of quality fodder crops in about 27 hectares area and manages harvesting and supply of fodder crops either chaffed or unchaffed to the Cattle Yard.

Besides cultivation of fodder crops, the Forage Section also has a mini workshop for regular servicing of agricultural machineries including tractors, chaffcutter, etc. There is a small vermicompost unit used for production of vermicompost and also for training and demonstration purpose. There is an agri-meteorological observatory where regular observations are taken for various meteorological parameters like relative humidity, max. and min. air temperature, soil temperature at different depth, wind speed and direction, rainfall, etc.

There are about 700 plants of teak, shesham, etc. growing around the Institute premises. Besides, there is a fodder herbarium for training and demonstration purpose. The Forage Section has necessary facility for covering the theoretical and practical part of training in fodder crop production.

Land Development

ERS of NDRI was assigned to develop 30 acres land at Kalyani owned by Eastern Regional Station of Indian Veterinary Research Institute (IVRI), Kolkata. The land was kept barren and unutilized for long. The land was developed and brought under cultivable condition. Presently fodder crops are grown for animal feeding.

Land development

Fodder Cultivation

Production of different fodder crops at ERS fodder farm during 2011(Jan-Dec)

Type of fodder	Production (Quintals)
Berseem/Berseem + Mustard	920.60
Maize/Maize + Cowpea	2036.67
Oats/Oats + Mustard	2193.65
Sorghum/Sorghum + Maize	1246.35
Sorghum + Cowpea	1199.35
Hybrid Napier	1086.90
Guinea grass	175.90
Para grass	231.05
Total	**9090.47**

Library

The Library contains 1505 books, 3360 volumes of bound journals and other periodicals in the field of dairying. Besides, annual reports of different Institutes and proceedings of various workshops and seminars are also available for reference. Presently 20 journals are subscribed.

Computer Section

The computer center facilitates the maintenance of huge database and analysis of experimental data of various research projects. The Institute has Internet connectivity through VSAT, which is useful for searching literature and references.

Extension Activities and Trainings

Trainings Courses

Two 15 days training programme were organized at ERS of NDRI, Kalyani on *Scientific Dairy Farming* for unemployed rural youth and dairy farmers. One course was conducted from 16th -31st May 2011 in which 7 trainees from 4 districts (Nadia, 24 (N) Pgs., Purulia and Hooghly) participated. Another course from 1st - 14th February 2012 was conducted in which 9 trainees from 4 districts participated.

Off Campus Extension Programmes

One Animal Health Camp was organized on 10th April, 2011, at Sandeshkhali, the Aila affected area in 24 (S) Parganas of West Bengal on the request of an NGO in collaboration with the Jadavpur University, Kolkata.

Rural Exhibition

- The station organised an exhibition at Sahabajipur in Balasore district of Odisha from 14th - 20th August, 2011.
- The Station set up an exhibition stall in Agricultural and Livestock Fair organised by Chaltaberia Krishak Sangha, an NGO in Barasat of 24 (N) parganas 16th February, 2012.
- One Animal Health Camp and Livestock show was organized in Panchuriya village, under Barasat-I Block on 18th February, 2012.
- ERS-NDRI has set up one Exhibition Stall at 'Regional Agricultural Fair 2012' organized by the Central Rice Research Institute and I.C.A.R. at Cuttack, Odisha on 21st- 23rd February, 2012.

Awareness Programmes

- A meeting with the farmers and Development Personnel was organized at village Emlibari in Satjelia Gram Panchayat, Gosaba block, 24 (S) Parganas on 7th September, 2011. Eighty nine women and rural youth participated in this programme.
- An interface meeting was arranged for members of the Balaram Dairy Association on 8th September, 2011.

हिन्दी सारांश

राष्ट्रीय डेरी अनुसंधान संस्थान राष्ट्र का एक अग्रणी एवं प्रतिष्ठित अनुसंधान संस्थान है जो कि देश मे डेरी विकास कार्यक्रमों के लिए अनुसंधान एवं विकास तथा मानव संसाधन विकास में सहयोग के लिए पूर्ण रूप से समर्पित रहा है । वर्ष 1923 में स्थापित इस संस्थान के मुख्यालय को वर्ष 1955 में करनाल से स्थानान्तरित कर दिया गया। इस संस्थान के दो क्षेत्रीय केन्द्र हैं जो कि बंगलौर एवं कल्याणी में स्थित है । दक्षिण व पूर्वी क्षेत्रीय केन्द्र स्थानीय क्षेत्र में कृषि वातावरण के अनुरूप डेरी विकास के लिए अनुसंधान एवं सहयोग प्रदान करने में लगे हुए हैं। शैक्षिक कार्यक्रमों के संचालन हेतु संस्थान को मान्य विश्वविद्यालय का दर्जा प्राप्त है।

संगठनात्मक स्वरूप

संस्थान की प्रबन्ध प्रणाली भारतीय कृषि अनुसंधान परिषद् के मान्य विश्वविद्यालय की प्रशासनिक पद्धति के अनुरूप ही है। संस्थान के अनुसंधान, शिक्षण, प्रशिक्षण, विस्तार शिक्षा और प्रशासनिक कार्यकलाप के क्षेत्र में नीति–निर्धारण और निर्णय का दायित्व प्रबंध मडंल, अनुसंधान सलाहकार परिषद, विद्या परिषद एवं विस्तार परिषद, समितियों को सौंपा गया है। निदेशक इस संस्थान का कार्यपालक अधिकारी है। दोनों संयुक्त निदेशक, निदेशक को अनुसंधान, शिक्षण एवं विस्तार कार्यकलापों को संपन्न कराने में सहयोग प्रदान करते है। संस्थान के अनुसंधान और विकास के तीन मुख्य क्षेत्र (1) डेरी उत्पादन (2) डेरी प्रसंस्करण तथा (3) डेरी प्रसार प्रबन्ध है। सभी अनुसंधान एवं विस्तार कार्यक्रम संस्थान के मुख्यालय तथा इसके दो क्षेत्रीय केन्द्रों पर संस्थान के ग्यारह प्रभागों/अनुभागों डेरी पशु प्रजनन, डेरी पशुपोषण, डेरी पशु शरीर क्रिया विज्ञान, पशु जीवरसायन, पशु जैवप्रौद्योगिकी, डेरी प्रौद्योगिकी, डेरी इंजीनियरी, डेरी सूक्ष्मजीव विज्ञान, डेरी विस्तार तथा डेरी अर्थशास्त्र सांख्यिकी एवं प्रबन्धन प्रभाग के अन्तर्गत संपन्न होते है। संस्थान में एक कृषि प्रौद्योगिकी सूचना केन्द्र (एटिक), कृषि विज्ञान केन्द्र तथा डेरी प्रशिक्षण केन्द्र भी है। संस्थान में पशुधन फार्म, चारा फार्म, एवं प्रबंधन केन्द्र, पशु स्वास्थ्य परिसर, मॉडल डेरी संयंत्र, टेक्नोलोजी बिजनस इनक्यूबेटर, प्रयोगात्मक डेरी संयंत्र, परामर्श एकक, पुस्तकालय सेवा एंव राष्ट्रीय जैवसूचना केन्द्र, कंप्यूटर केन्द्र, संपदा अनुभाग तथा अनुरक्षण इंजीनियरी अनुभाग जैसी केन्द्रीय सुविधाएं उपलब्ध हैं। प्रशासनिक कार्यकलाप जैसे वित्त, क्रय, भंडार, स्थापना, राजभाषा एकक तथा सुरक्षा के कार्यकलाप संयुक्त निदेशक (प्रशासन) एवं कुलसचिव के नियंत्रण में है। संस्थान में इस समय 154 वैज्ञानिक 300 तकनीशियन, 130 प्रशासनिक तथा 618 निपुण सहायक कर्मचारी सेवारत हैं ।

बजट

संस्थान का वर्ष 2011–2012 में योजना और गैर–योजना शीर्ष में वास्तविक व्यय बजट 12576.42 लाख रूपए था तथा वर्ष 2011–12 के लिए कुल बजट 12578.28 लाख रूपए स्वीकृत किया गया। इसमें मान्य विश्वविद्यालय तथा कृषि विज्ञान केन्द्र तथा क्षेत्रीय केन्द्रों का बजट भी सम्मिलित है।

अनुसंधान

वर्ष 2011 के दौरान कुल 70 अन्तः संस्थान अनुसंधान परियोजनाओं का कार्य चल रहा था। मूल एवं महत्वपूर्ण अनुसंधान कार्यों को सुदृढ़ करने के लिए एन.ए.आई.पी. के द्वारा विश्व बैंक ने संयुक्त रूप से कुछ अनुसंधान परियोजनाओं को वित्तीय सहायता देना स्वीकार किया है जिनमें राष्ट्रीय डेरी अनुसंधान संस्थान या तो नेतृत्व करेगा अथवा सहायक सहयोगी होगा। राष्ट्रीय कृषि नवप्रवर्तन परियोजना (एन.ए.आई.पी.) परियोजना के अन्तर्गत वर्ष 2011–12 के दौरान 20 परियोजनाओं के लगभग 34 करोड़ रूपए की राशि जारी रहेगी। कई अनुसंधान कार्यक्रमों के राष्ट्रीय स्तर पर जैव प्रोद्योगिकी विभाग (डी.बी.टी.), राष्ट्रीय कृषि उपयोगी सूक्ष्मजीव ब्यूरो (एन.बी.ए.आई.एम) नैशनल कम्यूनिकेशन टू यूनाइटेड नेशन्स फ्रेमवर्क कनैक्शन ऑन क्लाइमेंट चेंज (एन.ए.टी.सी.ओ.एम–यू.एन.एफ.सी.सी.) इंडो–यू.एस–एग्रीकल्चरल नोलेज इनीशिएटिव (ए.के.आई) खाद्य प्रसंस्करण उद्योग मंत्रालय, राज्य कृषि विश्वविद्यालयों तथा राज्य विकास विभागों के साथ अन्तः संस्थानिक संबंध थे।

अनुसंधान

* साहीवाल गो–पशुओं में ओव्यूम पिक–अप तकनीक द्वारा जीवित गाय से एकत्रित डिम्बाणुजनकोशिकाओं का प्रयोग करके गर्भस्थापन किया गया एवं इस तकनीक से दिनांक 07 मार्च, 2012 को उत्पन्न गाय की प्रथम बछड़ी का नाम 'होली' रखा गया।
* दूध से वियोजित सोमेटिक कोशिकाओं को दाता कोशिकाओं के रूप में प्रयोग भैंस के क्लोन्ड भ्रूण उत्पन्न किए गए। हैंड मेड–केक्लोनिंग तकनीकी द्वारा ब्लास्टोसिस्ट से भ्रूणीय स्टैम कोशिकाओं के उत्पादन के लिए बकरी में एक प्रोटोकोल संस्थापित की गई। हैंड गाइडिड क्लोनिंग एवं अनिषेक जनन (पार्थनोजेनेसिस) द्वारा उत्पन्न भ्रूणों के प्रयोग से भैंस की भ्रूणीय स्टैम कोशिकाएं उत्पन्न की गई।

* परखनली निषेचन (आई.वी.एफ), हैंडमेड क्लोनिंग एवं अनिषेकजनन (पार्थनोजेनेसिस) तकनीकियों द्वारा उत्पन्न ब्लाटोसिस्टस से व्युत्पन्न भैंस के भ्रूणीय स्टैम कोशिकाएं उनकी बहुप्रजननक्षम चिन्हक अभिव्यंजना के लिए समसंयोजकता प्रदर्शित करने हेतु दिखाए गए।

* भैंस के नैनोजी तथा ओक्टपजीनों को क्लोन्ड किया गया तथा भैंस के भ्रूणीय स्टैम कोशिकाओं में अभिलक्षित किया गया।

* आई.वी.एम., आई.वी.एफ. तथा आई.वी.सी. 20% से 5% के दौरान O_2 सान्द्रण को निम्नतर करने के लिए अथवा सिस्टामाइन के साथ आई.वी.एम. तथा आई.वी.सी. माध्यम के सम्पूरण, एक प्रति आक्सीकर ब्लास्टोसिस्ट उत्पादन को संशोधित करने के लिए, एंटी–एपोपटोटिक जीनों की अभिव्यंजना में वृद्धि तथा प्रो–एपोपटोटिक जीनों की अभिव्यंजना में कमी को प्रदर्शित करने के लिए दिखाया गया।

* इन–विट्रो तकनीक द्वारा गाय के भ्रूण पूर्वी क्षेत्रीय केन्द्र, कल्याणी पर उत्पन्न किए गए।

* एक स्वतः परिवर्तित भैंस की स्तनीय विशेषक कोशिका लाइन प्राप्त एवं संस्थापित की गई।

* एम.जी.पी–40, एक स्तनीय ग्रन्थि प्रोटीन थनैला रोग के लिए जैव चिन्हक के रूप में प्रस्तुत किया जाता है।

* ए–I तथा ए 2β केसीन युक्त दूध में अन्तर करने के लिए एक पी.सी.आर. आधारित विधि विकसित की गई।

* प्रथम ब्याँत 305 दिन दुग्ध उत्पादन के पूर्वानुमान के लिए स्वतन्त्र परिवर्तकों के रूप में विभिन्न आयु पर शारीरिक भार का प्रयोग करके तथा एफ.एल.305 डी.एम.वाई का अवलम्बित परिवर्तकों के रूप में बहुगुणन रेखीय परावर्तन (एम.एल.आर) तथा कृत्रिम तंत्रिकीय नेटवर्क (ए.एन.एन.) मॉडल विकसित किए गए तथा दोनों मॉडलों की फिटिंग की परिशुद्धता की तुलना की गई।

* सन्तति परीक्षण के लिए वर्ष (2007–2011) के दौरान कुल 119 करन फ्रीज, 78 साहीवाल तथा 80 मुर्राह युवा नर पशु आरक्षित रखे गए। सम्भावित पूर्वानुमानित अन्तर (ई0पी.डी.:) तथा डैम की श्रेष्ठ 305 दिन दुग्ध उत्पादन की श्रेणी तीनों नसलों का क्रमशः 1.57–18.44, 0.24–23.10 तथा 1.69–18.63% तथा 2330–4341 कि0ग्रा0 था।

* सर्वश्रेष्ठ पशु समूह का अनुपात वर्ष 2007–2011 के दौरान करन फ्रीज में 23–41%, साहीवाल में 21–26% तथा मुर्राह भैंसों में 34–38% के बीच था। सर्वश्रेष्ठ करन फ्रीज तथा साहीवाल गायों एवं मुर्राह भैंसों का औसत ई.पी.ए. क्रमशः 4492 तथा 5520 कि0ग्रा0 के बीच, 2199 तथा 2440 कि0ग्रा0 के बीच तथा 2339 एवं 2371 कि0ग्रा0 के बीच था।

* इस अवधि के दौरान साहीवाल नसल के (11 सांडो) तथा करन फ्रीज के (17 सांडो) प्रत्येक के दो सैटो तथा मुर्राह झोटों (43 झोटों) के तीन सैटों का मूल्यांकन किया गया। इन सांडों में से 4 साहीवाल, 5 करन फ्रीज तथा 3 मुर्राह सांडों को सन्तति परीक्षण हेतु सिद्ध सांड चयनित किया गया। इनका ई.बी.वी. क्रमशः 1641–1917 कि0ग्रा0, 3228–4144 कि0ग्रा0 तथा 1972–2116 कि0ग्रा0 के बीच था, जबकि उनकी पशु में औसत श्रेष्ठता क्रमशः 9.33–27.73%, 12.00–16.70% तथा 8.41–17.26% के बीच थी। वर्ष 2007–2011 के दौरान, परिणामस्वरूप क्षेत्रीय परिस्थितियों के अन्तर्गत रखे गए सांडों से कुल 2152 करन फ्रीज तथा 2325 मुर्राह मादा सन्तति उत्पन्न हुई।

* इस अवधि के दौरान करन फ्रीज, साहीवाल एवं मुर्राह सांडों के प्रशीतित वार्य की कुल 3,72,770 डोज़ उत्पन्न की गई तथा इन तीन नसलों के प्रशीतित वीर्य की 4,70,134 डोज़ पशु प्रजनन अनुसंधान केन्द्र राष्ट्रीय डेरी अनुसंधान संस्थान द्वारा विभिन्न विकास एजेन्सियों/संस्थाओं एवं कृषकों को प्रसारित (बेची तथा आपूर्ति) की गई।

* ब्याँत वक्र के श्रेष्ठ मॉडल को विकसित करने के लिए करन फ्रीज गायों में प्रथम दुग्ध उत्पादनों का प्रयोग करके क्वाडरेटिक कम लाग माडल (क्यू सी एल एम), गामा फंक्शन (जी.एफ) , को बि.ली.डू.माडल (सी.एल.डी.एम.), पोलिनोमिएल रिग्रेशन फंक्शन (पी.आर.एफ) तथा मल्टीफेसिक लोगिस्टिक फंक्शन (एन.एल.एफ) का आंकलन किया गया।

* विभिन्न सैम्पल विधियों अर्थात् सेन्टरिंग डेट विधि (डी.सी.एम.), परीक्षण अन्तराल विधि (टी.आई.एम.) एवं सैम्पल दिवस उत्पादन विधि (एस.पी.एम.) का प्रयोग करके 305 दिन अथवा कम दुग्ध उत्पादन के पूर्वानुमान के लिए प्रथम दुग्ध–स्त्रवण मासिक परीक्षण दिवस उत्पादन का प्रयोग किया गया।

* करन फ्रीज गो पशुओं में 305 दिन अथवा कम दुग्ध उत्पादन के लिए सैम्पल दिवस उत्पादन विधि श्रेष्ठ विधि पाई गई तथा क्षेत्रीय परिस्थितियों में इसका प्रयोग किया जा सकता है।

* फ्रोरब्रेन एम्ब्रयोनिक जिंक फिंगर–लाइक जीन (एफ.ई.जेड.एल.) परपोषी रोग प्रतिरोधक शक्ति को प्रभावित करते है। मुर्राह भैंसों में एफ.ई.जेड.एल.जीन के आर.एफ.एल.पी.

विश्लेषण एक्जो़न 3 में पोलिमारफिज्म प्रदर्शित करते हैं, जो कि थनैला रोग के साथ महत्वपूर्ण ढंग से सम्बद्ध थे।

* डिओनि गोपशुओं में हीट शॉक प्रोटीन 90 ए ए। (एच.एस. पी.90 ए ए 1) जीन के पी.सी.आर–एस.एस.सी.पी. विश्लेषणों ने एक्जोन 8 में क्रमशः 0.250, 0.638 तथा 0.111 जीनोटाइप आवृत्ति के साथ तीन अद्वितीय एस.एस.सी.पी. पैटर्न प्रदर्शित किए एक्जोन 9 में एस.एस. सी.पी पैटर्न तथा एक्जोन 10 में दो अद्वितीय एस.एस. सी.पी पैटर्न क्रमशः 0.236 तथा 0.764 जीनोटाइप आवृत्ति के साथ देखे गए।

* असक्रिय एफ.एम.डी. वायरस के साथ प्रचुर मात्रा में उत्पन्न औसत सूचकांक डिओनि में 3.7 तथा मलनाद गिदा देशी गोपशुओं में 5.7 तक पहुंच गया। डिओनि नसल की अपेक्षा मलनाद गिदा ने एफ.एम.डी.डब्ल्यू एंटीजन तथा सब वायरल प्रक्रियाओं से उच्चतर कोशिकीय प्रतिक्रिया प्रदर्शित की। BOLA किस्म के अध्ययनों ने प्रदर्शित किया कि लोकस डी.आर.बी3 ' डिओनि गोपशुओं की अपेक्षा मलनाद गिदा में अधिक प्रचलित थे। मलनाद गिदा गोपशु अन्य जीनोटाइप की अपेक्षा अधिक प्रतिरोधी पाए गए।

* मदकाल अधिष्ठापन अचक्रीय भैंस के ओसरों में प्राप्त किया है। बहिर्जात हार्मोनों के अनुप्रयोग से यह भैंस के ओसरों की अनुकूलन (कीड़े निकालना, खनिज एवं विटामिन सम्पूरण) से मदकाल प्रतिक्रिया एवं जननक्षमता में सुधार हुआ।

* कठोर परिस्थितियों, वियोजन, विलम्ब से दुग्ध दोहन, एवं मदकाल के अन्तर्गत भैंसों में स्वर पैटर्न की पहचान की गई।

* शुक्राणुओं में टायरोसाइन फास्फोराइलेशन स्तरों तथा सी. ए.एम.पी.की समकालिक जाँच के लिए प्रवाह साइटोमीटरी का प्रयोग कर एक नवीन विधि विकसित की गई।

* एक नर पशु की जनन क्षमता से संबंधित शुक्राणुओं में टायरोसाइन फास्फोरराइलेश्न के एक विशेष पैटर्न की जांच की गई।

* क्रायोपरिरक्षण के दौरान अन्तःकोशिकीय केल्सियम तथा टायरोसाइन फास्फोराइलेशन के गतिमूलक के बारे में प्रथम बार अध्ययन किया गया।

* संकर नसल के साडों में परिष्कृत सुई चूषण कोशिका विज्ञान मानकीकृत किया गया।

* प्रतिध्वनि आवृत्ति श्रेष्ठ उपयुक्त ध्वनिक लक्षण सिद्ध हुआ जो कि डेरी पशुओं की स्थिति की पहचान के लिए पैटर्न अभिज्ञान प्रणाली में उपयोग किया जा सकता है।

* संकर गोपशुओं में प्रसव पश्चात गर्भाशय शोथ की संभावना के लिए कुछ प्रसव पूर्व जैव चिन्हकों (व्यावहारिक एवं जैव रासायनिक) की पहचान की गई।

* चार चतुर्थांश नसल कोशिका आधारित तोल प्रणाली वायरलैस संवेदी आधारित आटो पहचान एवं डैटा अर्जन प्रणाली डेरी पशुओं में लंगड़ेपन के शीघ्र निदान के लिए डिजाइन की गई एवं विकसित तथा मान्य की गई।

* वायरलैस संवेदी आधारित स्वचालित, पंखा एवं निर्वात्तक पखां संचालन बंद पशु गृह में बसे एल्गोरिदम के रूप में टी.एच.आई के साथ विकसित किया गया।

* ओवसिन्च प्रोटोकोल के अनुप्रयोग के बाद जननक्षमता एवं उपचार प्रतिक्रिया में संशोधन के लिए भैंसों के ओसरों के लिए एक 'पूर्व अनुकूलन' नवीन विधि विकसित की गई।

* भैंस के नकली कटड़े का मॉडल विकसित किया गया तथा भैंसों में दूध घटाने में सफल पाया गया।

* उष्णकटिबन्धीय जलवायु पशु प्रबन्धन प्रणाली में पशु स्वास्थ्य प्रबन्ध तथा उच्च दुग्ध उत्पादन वाले संकर पशुओं के लिए प्रारंभिक जोखिम भरे तत्वों के लिए खनिज एवं उपापचय रूप रेखा की पशु समूह स्तर मानकित किया गया।

* पेरी पार्टम अवधि के दौरान सूक्ष्मपौषणिक सम्पूरण से प्रति गर्भस्थापन में सर्विस की संख्या हुई है तथा दुग्ध उत्पादन में सुधार हुआ है।

* साहीवाल ओसरों मे लैंगिक परिपक्वता पर प्रगामी आयु के लिए एक प्रोटोकाल मानकित की गई।

* एन.ई.एफ.ए, बी.एच.बी.ए तथा एन.ई.एफ.ए का उत्थानः कुल कोलस्ट्रोल अनुपात तथा ग्लूकोज का अल्प सान्द्रण एवं कुल कोलस्ट्रोल पिछले 2–3 सप्ताह से पोस्ट–पार्टम विकास से संबंधित रहा।

* अध्ययन किए गए तीन दुग्ध पैरामीटरों (पी.एच.ई.सी. तथा एस.सी.सी.) में से उप–नैदानिक थनैला के लिए एस.सी.सी. श्रेष्ठ संकेतक है। सूक्ष्मपौषणिक के सम्पूरण ने दूध एस.सी. सी. में कमी करके तथा दूध के प्रतिशत न्यूट्रोफिलस द्वारा अयन के स्वास्थ्य में सुधार किया।

* पशुओं में भारी धातुओं (सीसा तथा अरगजी) के प्रदर्शन आक्सीकारण दाब में वृद्धि हुई।

* बकरी के बच्चों (मेमनों) पर 50 पी पी एम पी बी के अनुप्रयोग से रक्त पैरामीटरों पर कोई महत्वपूर्ण प्रतिकूल प्रभाव नहीं हुआ। जिंक (जेड एन) के सम्पूरण का पी बी का प्रतिकूल प्रभाव को कम करने में लाभप्रद प्रभाव था।

* भैंसों में पुराने सिलीनोसिस को कम करने में 100 कि0ग्रा0 शरीर भार पर 9 ग्राम की दर से पेंटासल्फेट मिश्रण तथा आहार का 40 पी.पी.एम. की दर से संखिया प्रभावी थे।

* संकर गायों में प्रजनन क्षमता तथा दुग्ध उत्पादन में सुधार के लिए तथा थनैला रोग को कम करने के लिए असंक्राम्यता स्तर में सुधार करने तथा आक्सीकारक दाब को कम करने के लिए संधिकाल के दौरान विटामिन ई 1000 आई0यू0/डी0 की दर से जेड एन (पी.पी.एम.) तथा सी यू (20 पी.पी.एम) सम्पूर्ण लाभप्रद पाए गए।

* भैंस के कटड़ों के आहार में 0.22% की दर से गंधक मिला कर गेहूँ की भूसी से आधारित सम्पूर्ण आहार पिण्ड जिनमें निओकैलीमेसटिक्स स्पै.जी.आर.–1 के फंगर्ल जूस्पोरस सम्मिलित हैं खिलाने से वृद्धि दर, अनुमानित सिद्धान्तों तथा रूमेन किण्वन की ग्राह्मता में सुधार हुआ है।

* उच्च सूक्ष्मजैवीय प्रोटीन संश्लेषण तथा रूमेन किण्वन पैटर्न के लिए इन–विट्रो अध्ययनों ने उच्च समक्रमिक आहारों के प्रति सकारात्मक प्रतिक्रिया प्रदर्शित की है।

* सान्द्रण मिश्रण में 4.5% की दर से बबूल की फलियों से टेनिन्स खिलाने के क्षेत्रीय प्रयोग चरने वाली भेड़ों में जठरीय आन्त्रीय गोलकृमियों की संख्या को कम करने में लाभप्रद सिद्ध हुए है।

* मध्यम में उच्च शारीरिक परिस्थिति अंकों (बी.सी.एस.) वाली गायों ने एस.ओ.डी. तथा कैटालेस किण्वकों के स्तर द्वारा इंगित प्रसवकालीन के दौरान आक्सीकरों में अन्तर प्रदर्शित की।

* गायों के दूध में आक्सीटोसिन के लिए एक संवेदी ई.आर.ए. विधि विकसित की गई।गायों ने आक्सीटोसिन की 25 आई. यू0 अथवा 50 आई0यू0 (दुग्ध निष्कासन के लिए 250 से 500 बार अपेक्षित डोज़) मात्रा के अनुप्रयोग ने दुग्ध आक्सीटोसिन में न्यूनतम वृद्धि (प्रयुक्त डोज़ का 0.3–0.6%) प्रदर्शित की। दुग्ध आक्सीटोसिन पास्तुरीकरण पर 43% तथा ऊष्मा उपचारित परिस्थितियों में 130^{o} से0 तक स्थिर पाया गया।

* ग्रीष्म एवं शीत ऋतुओं दोनों में गर्भस्थापन दर एवं अण्डोत्सर्ग का समय, एंडोक्राइन परिवर्तनों की स्थिति में मदकाल समक्रमण एवं नियतकालिक गर्भाधान के लिए 'हीटसिन्च प्रोटोकाल' नामक एक नवीन प्रक्रिया मूल्यांकित की गई।

* दुग्ध न्यूट्रोफिलस के भक्षक कोशिका सामर्थ्य शीघ्र दुग्धस्त्रवण के दौरान न्यूनतम थी उसके पश्चात प्रौढ़ एवं मध्यम दुग्ध स्त्रवण का स्थान रहा। लिम्फोसाइट प्रचुरउद्भवन के माप तथा एन.ओ.उत्पादन का प्रयोग मुर्राह भैंसों में कोशिका मध्यस्थता असंक्राम्यता के क्रियात्मक स्तर को इंगित करने के लिए किया जा सकता है।

* दूध देने वाली भैंसों को खनिज मिश्रण एवं उच्च कोटि का राशन खिलाने से जुलाई, अगस्त तथा सितम्बर मास के दौरान पर्यावरणीय दाब में कमी हुई।

* एलोवीरा के साथ स्किम दूध सम्पूरण के परिणामस्वरूप किण्वित दूध में ए.सी.ई. निरोधक गतिविधियों में वृद्धि होती है तथा इससे किण्वित दूध में प्रतिजैवियों (प्रोबायोटिक) के जीवनक्षम काऊण्ट को बढ़ाने में भी प्रभावकारी पाया गया।

* गाय तथा भैंस केदूध की भापसह पात्रता से कुल तथा प्रोटीन विशिष्ट आई.जी.ई, स्तरों विशेषकर (पीढ 0.01) कच्चे दूध प्रोटीन सुग्रहित चूहों की तुलना में कम हो गया। एलर्जी की प्रतिक्रियाओं पर अध्ययन करने के लिए मस्तूल कोशिकाओं में बोन मैरो कोशिकाओं को पहचानने के लिए विधि मानकित की गई।

* क्रायोपरिरक्षित भैंस के शुक्राणुओं में प्रोटीन टायरोसाइन फास्फोरिलेशन के दौरान सी.ए.एम.पी., ई आर के तथा पी–आई चक्र आश्रित एवं अनाश्रित संकेतन मार्ग सम्मिलित थे।

* परम्परागत अंडपीतक विस्तारक की तुलना में क्रायोपरिरक्षण पर प्रोटीन टायरोसाइन फास्फारिलेशन तथा आक्सीकर दाब के विरूद्ध सोया दुग्ध विस्तारक (नवीन) ने भैंस के शुक्राणुओं को महत्वपूर्ण रूप से बचाया।

* ग्लूटाथयोन–एस–ट्रांसफिरेज तथा डाईहाइड्रोलियोपोएल डिहाइड्रोजिनेज जैसे किण्वकों के आइसोजाइमिक रूप भैंस के शुक्राणुओं के क्रायोपरिरक्षण पर तथा संधारिता के दौरान विशिष्ट टायरोसाइन फास्फोरिलेटिड थे।

* ग्लाइसिरोल–3–फास्फेट डिहाइड्रोजिनेज, ग्लूटाथाइओन–ट्रांसफिरेज तथा डाईहाइड्रोलियोपोएल डिहाइड्रोजिनेज जैसे किण्वकों के परिरक्षण स्थानीकरण पैटर्न क्रायोपरिरक्षित भैंस के शुक्राणुओं में विभिन्न शुक्राणु आरगेनीलीज पर स्थानांतरित थे।

* स्कैनिंग इलैक्ट्रान सूक्ष्मदर्शी ने भैंस के शुक्राणुओं की सतह पर सूक्ष्मकण लगे हुए देखे। Tio_2 सूक्ष्म अवयवों (एन.पी.एस) के लिए डी.एन.ए में डोज आश्रित वृद्धि थी। EU_2 O_3 एन पीएस से शुक्राणुओं में डी.एन.ए. क्षति नहीं हुई। शुक्राणु की इलैक्ट्रान माइक्रोस्कोपी प्रसारण ने शुक्राणुओं के सिर तथा पूंछ में सम्बद्ध एवं आन्तरिक एन.पी. प्रदर्शित किए।

* चूहों पर सूक्ष्म टीआई ओ2 सूत्रीकरण अनुप्रयोग के बाद एन पी. इलैक्ट्रान माइक्रोस्कोपी प्रसारण द्वारा त्वचा एवं टेस्टिस खण्डों में पाया गया।

* चूहों की वसा से मिसिन्चाइमल स्टैम कोशिकाएं वियोजित की गई तथा प्रचुरमात्रा में उत्पन्न किया गया तथा परिपक्व एडिपोसाइट, ओस्टिओसाइटस तथा कोंड्रोसाइट में विशिष्टता बनाई। एम.एस.सी. की कालोनि फार्मिंग संधारिता संस्थापित की गई।

* चूहों से ब्राउन एडीपोसाइटस के प्रचुर दी–भवन तथा विभेदीकरण संस्थापित किए गए। बहुसंख्यक बहुकोष्ठक लिपिड बिन्दुक के संचयन मं विभेदीकरण प्रक्रिया हुई। प्रचुरीदभवन के दौरान हाक्स ए1, हाक्स ए 5, हाक्स सी 4, हाक्स से 8, जी पी सी4, एस.एफ.आर.पी.2, एस हाक्स2, टी.एच,बी.डी., ई.एम.एल., टी.बी.एक्स 15, एन आर एफ। विकासात्मक एवं पी आर ई एफ। चिन्हक अभिव्यंजित किए गए। तथापि हाक्स बी, तथा हाक्स ए2 विकासशील जीनस अभिव्यंजित नहीं किए गए।

* भैंस के सवंर्धित ग्रेन्यूलोसा कोशिकाओं में आर.एन.ए.आई का प्रयोग करके जीन विकृति मानकित की गई।

* एफ.एस.एच. से एल.एच. प्रतिक्रियात्मक फेनोटाइप से विभिन्न भैंस से ग्रेनुलोसा कोशिका टर्मिनल को समझने के लिए इन विट्रो कोशिका संवर्धन मॉडल विकसित किए गए।

* फोलिक्यूलोजेनेसिस तथा ल्यूटिनाइजेशन के दौरान भैंस के सी.वाई.पी 19 (जननक्षमता जीन) के निर्धारण के लिए एक नवीन निर्धारक मार्ग पर प्रकाश डाला गया।

* क्रियात्मक डेरी एवं गैर–डेरी संघटकों का प्रयोग करके मिश्रित–वसा चाकलेट स्प्रेड (एम.एफ.सी.एस.) के निर्माण के लिए एक प्रौद्योगिकी विकसित की गई।

* अति सूक्ष्म छनन (अल्ट्राफिल्ट्रेशन) तकनीक का प्रयोग करके भैंस के दूध से उच्च कोटि का सैट 'दही' तैयार करने की एक प्रक्रिया मानकित की गई।

* मधुमेह के रोगियों के लिए तुरन्त पकाने योग्य जौं आधारित खीर मिश्रण तैयार करने की एक प्रक्रिया विकसित की गई।

* लौह पुष्टिकारक व्हे प्रोटीन से भरपूर बाजरा के बिस्किुट बनाने की प्रौद्योगिकी तैयार की गई तथा पशु मॉडल में लौह की जैव उपलब्धता के लिए मान्य ठहराई गई। इसी प्रकार दुग्ध प्रोटीन तथा अपरिष्कृत अनाज के आटे के साथ बाजरा तथा बाजरे के आटे से प्रोटीन से भरपूर, अधिक रेशे, अल्प वसा वाले निःस्त्रावित स्नैक विकसित किए गए।

* बाजरा (बाजरा लस्सी) तथा जौ की लस्सी के लिए नवीन स्टार्टर जीवाणुओं एमाइलोलाइटिक प्रोटियोलाइटिक तथा फाइटेज क्रियाकलाप युक्त प्रौद्योगिकी विकसित की गई। विकसित लस्सी की शेल्फ लाइफ भी बढ़ाई गई।

* अल्प लागत वाली सम्मिलित न्यूट्रीमिक्स बनाने की प्रौद्योगिकी विकसित की गई।

* दक्षिण क्षेत्रीय केन्द्र, बंगलौर पर खोआ, अरारोट पाऊडर तथा टोकीर का प्रयोग करके खोआ जलेबी बनाने की प्रौद्योगिकी विकसित की गई। खोआ जलेबी को सुरक्षित रखने की अवधि (शेल्फलाइफ) अनुकूल पैकेजिंग के द्वारा एक मास से अधिक समय तक बढ़ाई गई।

* गुड़, ब्रेड, बन तथा सूप स्टिकस में व्हे के उपयोग के लिए एक विधि विकसित की गई।

* जल अपघटित व्हे से एक अर्गोजेनिक पेय विकसित किया गया।

* पुनः संरचना के लिए तैयार फोक्सटेल बाजरा–दुग्ध ठोस शुष्क मिश्रण अधिक शेल्फ लाइफ के साथ विकसित किए गए।

* गाय तथा भैंस दोनों के दूध के उच्च जल द्रवस्थैतिक दाब (एच.एच.पी.) उपचारित नमूनों ने रेफरीजरेटर में 20 दिन की बढ़ी हुई शेल्फ लाइफ प्रदर्शित की।

* करक्यूमिन पुष्टिकृत लस्सी जिसमें ऐलजहेमर रोग के प्रतिकूल प्रोफाइलेक्टिक गुण विद्यमान हैं को बनाने की प्रौद्योगिकी विकसित की गई।

* संशोधित वातावरणीय पैकिंग में पैक की गई शुष्क किस्म की छैना–मुर्की की शैल्फ लाइफ 10^{o} सें0ग्रेड पर पांच सप्ताह पाई गई।

* क्रियात्मक छैना मुर्की की शैल्फ लाइफ नाइट्रोजन से भरपूर पैकेजों में 10^{o} सें0ग्रेड पर 15 दिन प्रदर्शित हुई।

* ऊष्मा उपचार पर एलोहा वीरा की असंक्रामय अधिमिश्रण में कोई महत्वपूर्ण कमी नहीं हुई।

* चयनित भारतीय औषधियों से न्यूट्रासयूटिकल संघटकों के अभिलक्षण तथा तैयारी के लिए प्रक्रियाएं मानकित की गई।

* दुग्ध उत्पादों में औषधीय न्यूट्रास्यूटिकलस के लिए हस्तांतरण प्रणालियां विकसित की गई।

* ई0 कोलि तथा स्टेफाइलोकोकस एरिस की रोगोत्पादक जातियों के प्रतिकूल प्रतिरोधी क्रियाकलापों के साथ लेक्टिक कल्चरों (जीवाणु समूहों) को दही से वियोजित किया गया।

* भिन्नात्मक परिवर्तन प्रारंभिक पद्धति प्रतिक्रिया बलगति की तथा अरेहीनियस संबंधों का प्रयोग करके तलने के दौरान गुलाबजामुन में रंग परिवर्तन की गतिक का प्रतिरूप बनाया गया।

* कुंडा एवं चार व्यावसायिक रूप से उपलब्ध गुलाबजामुन मिश्रण की आर्द्रता अवशोषण अभिलक्षण ग्रेंवीमीट्रिक विधि का प्रयोग करके 10,25 तथा 40^{o} सें0ग्रेड पर संस्थापित किए गए।

* निरन्तर मक्खन गलनक मशीन विकसित की गई। थ्री स्टेज एस.एस.एच.ई. का प्रयोग करके निरन्तर घी निर्माण की प्रौद्योगिकी विकसित की गई।

* बरफी बनाने के लिए इन लाइन उत्पादन प्रणाली विकसित की गई तथा रबड़ी के इन–लाइन उत्पादन के लिए प्रक्रिया यंत्रीकरण की गई।

* पनीर के लिए काइनमेटिक हाफटर्न नट दाब प्रक्रिया डिजाइन की गई एवं विकसित की गई।

* विस्कोस (चिपचिपा) डेरी उत्पाद के लिए हस्तांतरित प्रणाली विकसित की गई।

* चूहे आधारित में डी.एस.एस. प्रवृत बृहदान्त्रशोथ में संरक्षात्मक भूमिका प्रदर्शित करने के लिए एक स्वदेशी प्रोबायोटिक जाति एल एफ1 पाई गई।

* दूध में प्रक्षालक (डिटर्जेन्ट) की गुणवत्ता एवं मात्रात्मक मूल्यांकन के लिए एक नवीन सरल परीक्षण विकसित किया गया। दूध की गुणवत्ता सुनिश्चित करने के लिए इस विधि को प्लेटफार्म परीक्षण के रूप में प्रयोग किया जा सकता है।

* अफलाटाक्सिन एन1 को मानीटर करने के लिए एक बीजाणु आधारित जैव विधि विकसित की गई। परीक्षण का प्रयोग दूध की गुणवत्ता मानीटरिंग के लिए किया जा सकता है।

* अल्प कोलस्ट्रोल घी की प्रौद्योगिकी मैसर्ज क्वालिटी डेरी इंडिया लिमिटेड, नई दिल्ली को एन.आर.डी.सी., नई दिल्ली के द्वारा हस्तांतरित की गई। यह उत्पाद बाजार में उपलब्ध है।

* घी में विथानिया सोमनीफेरा (अवश्गंधा), एस्परेगस रेसमोसस (शतावरी), प्यूरेरिया ट्यूबरोसा (बिदारीकंड) की औषधियों के सत्व मिलाने से घी की आक्सीकर स्थिरता पर महत्वपूर्ण प्रभाव था। औषधियों के प्रतिआक्सीकर गुणों का हरी चाय के सत्व से भी अधिक प्रभावी तथा रोजमेरी सत्व के समान पाया गया लेकिन बी.एच.ए. तथा टी.बी.एच.क्यू. से कम प्रभावीकारी पाया गया।

* इन विवो अध्ययन प्रदर्शित करते हैं कि प्रतिआक्सीकर किण्वक अर्थात् केटालेस, सुपरआक्साइड डिसनुटेस तथा ग्लूटाथिओन परआक्सीडेज क्रियाकलाप आर. बी.सी लाइसेटस तथा जिगर होमोजिनेटस व्हे प्रोटीन हाइड्रोलाइइसेटस फेड वर्ग में 15 तथा 30 दिन के बाद नियंत्रण करने की तुलना में महत्वपूर्ण ढंग से वृद्धि हुई।

* केसीन पर एल.हेज्वेटिकस एन.सी.डी.सी. 288 से प्रोटीनेज् की गतिविधियों से उत्पन्न दो प्रतिआक्सीकारक पेप्टाइडों की जांच की गई। प्रथम पेप्टाइड जी.वी.एस.के. वी.के.ई.ए.एम.ए.पी.के अनुक्रम β–केसीन (94–105) के साथ अनुकूल बनाए गए तथा दूसरे पेप्टाइड आर.पी. के.एच.पी.आई.के.एच.क्यू.जी.एल.पी.क्यू. अनुक्रम सी.एन (1–13) के साथ अनुकूल पाए गए।

* पाच्य किण्वन के साथ भैंस की केसीन के जल अपघटन द्वारा α_1 टी.सी.एन (37–58) α_1 –सी.एन (35–38) α_1 –सी एन (43–58), α_2 –सी एन (2–21), β–सी एन (2–27) क्रेसीनोफास्फोपेप्टाइड के उत्पादन की एक प्रक्रिया तैयार की गई।

* एक स्वदेशी प्रोबायोटिक जाति एल.एफ1 चूहों में डी.एस. एस. अभिप्रेरित बृहदान्त्र–शोथ में संरक्षात्मक भूमिका प्रदर्शित करती पाई गई जो डी.ए.आई में सुधार ऊतकीय अंकों एम.डी.ए. स्तरों में गिरावट तथा एस.ओ.डी2 तथा टी. आर.एक्स आर–1 की अभिव्यंजना में वृद्धि पर आधारित थी।

* एल.पी.एस. चूहों मॉडलों का खिलाई गई प्रतिजैवीय (प्रोबायोटिक) एल.पी 91ने आसंजन अणुओं 'वी.सी.ए. एम.1' तथा 'आई.सी.ए.एम–1' क्रमशः–3,1.35 तथा 2.279 गुना नीचे संमजन पाया गया।

* एलपी 9, एलपी 78, एलपी 91 तथा एन.सी.एफ.एम. क्रमशः 1.34,–1.34,–1.45 तथा–1.21 गुना संमजन स्तर तक (पी<0.01) लाने में सक्षम रहे।

* लेक्टोबेसिलस एस.पी.पी. की परिगणना के लिए लागत प्रभावी व्हे आधारित आगार माध्यम सूत्रीकृत किए गए।

* टैक्सोनोमिक चिन्हक के रूप में विशाल उपयूनिट (एल.एस. यू.) राइबोसोमल डी.एन.ए.के डी1/डी2 प्रभाव क्षेत्र के आधार पर वातनिरपेक्ष फफूंद ओरपिनोमाइसिस की दो जातियों अर्थात् ओ. इन्टरकेलेरीस तथा ओ.जोयोनी को अवकलित किया जा सकता है।

* ओ.इन्टरकेलेरिस में अलुल के लिए जी0/टी0 के एक अपक्रम ने एक अतिरिक्त निर्बन्धन स्थल सृजित किया जिसके परिणामस्वरूप ओ.इन्टरकेलेरिस में 138 तथा

74 बी पी क्षेत्रों में विभाजित हुए तथा इस प्रकार अलुल का प्रयोग ओरपिनो माइसिस एस पी पी में जातियों के स्तर विभेदीकरण के लिए एक जैवचिन्हक के रूप में प्रयुक्त किया गया।

* प्रतिजैवीय (प्रोबायोटिक) लेक्टोबेसिलस डेलब्रुसकि एस.एस.पी. बलगेरिकस एल.बी–2 ने कोलस्ट्रोल में कमी, प्रतिआक्सीकारक तथा कैंसर प्रतिकूल सम्भाव्यताएं प्रदर्शित की।

* लेक्टोबेसिलस डेलब्रुसकि एस.एस.पी.बलगेरिकस एल बी–2 तथा स्ट्रेप्टोकोकस सेलिवेरियस एस.एस.पी. थर्मोफिलस एस.टी–1 की प्रतिजैवीय जातियों ने एल. मोनोसाइटोजीनस.ए.टी.सी.सी. 15303, ई–कोलि ए.टी.सी.सी. 25922, बी.सीरस,ए.टी.सी.सी. 13061 एस.टाइफि एन.सी.डी.पी.सी.ए.टी.सी.सी. 113, सी. पसीयुडोट्रोपिकेलिस एन.सी.डी.सी.44 तथा जी1 केडिडम एन.सी.डी.सी. 228 के अवरोध प्रदर्शित किए।

* इनयूलिन तथा ओ.सैंक्टम मौलिक तेलों के साथ सम्पूर्ण से सिनबायोटिक योघर्ट की प्रतिआक्सीकर क्रियाकलाप तथा अवरोध पर सहयोगी प्रभाव प्रदर्शित किए।

* बी.आई.एस. द्वारा संस्तुत मानकों के अनुसार तथा एन्टरोकोकि के विभेदीकरण तथा वियोजन के लिए चयनित माध्यम द्वारा 5–12 घंटों के बीच दुग्ध प्रणाली की विभिन्न किस्मों में एन्टरोकोकि की जांच के लिए एक परीक्षण विकसित किया गया।

* चीज से वियोजित लेक्टोबेसिलि के व्हे किण्वित पेप्टाइड विभेदीकरण एल.मोनोसाइटोजीनस, ई.कोलि, टाइफि, एस.आरियस, ई.फेकेलिस तथा पेसयुडोमोनास एस.एस. पी. पर अधिक अवरोधक थे।

* लेक्टोकोकि तथा ल्यूकोनोसटोक एस.पी.पी.की विभिन्न जातियां ओ.टाइप तथा एल.डी.–किस्म के मिश्रित प्रवर्तक जामन से वियोजित किए गए फेनोटाइपिक तथा जीनोटाइपिक विधियों द्वारा अभिलक्षित किए गए तथा उनकी प्रौद्योगिकीय गुणों के लिए मूल्यांकित किए गए। ये किस्में एन.सी.डी.सी.संवर्धन संग्रहालय में उपलब्ध है।

* डेरी निर्माण उद्योग के प्रदर्शन मूल्यांकन का अध्ययन किया गया। वर्ष 2000–2001 के बार असंगठित डेरी निर्माण यूनिटों की संख्या में कमी आई, जो कि संगठित डेरी प्रसंस्करण एवं डेरी उत्पाद निर्माण की ओर झुकाव को बढ़ाता है। असंगठित निर्माण यूनिट पश्चिमी बंगाल एवं उत्तर प्रदेश में अधिक केन्द्रित (भारत में 70% से अधिक हिस्सा) थे। रोजगार उत्पन्न करने में सकारात्मक वृद्धि पाई गई लेकिन कुल मूल्य संवर्धन में भागीदारी राज्यों में अल्प उत्पादकता के महत्वपूर्ण यूनिटों की संख्या के अनुरूप नहीं थे।

* यूरिया–अमोनिया उपचारित भूसे तथा खनिज मिश्रण सम्पूरण से ग्रीष्म ऋतु में भी दुग्ध उत्पादन के स्तर को कायम रखा जा सकता है। अपने डेरी पशुओं सामान्य लवण खिलाने से डायरिया से बचाव में सहायता मिलती है।

* कृषक समुदाय में दूध के मूल्य संवर्धन को बढ़ावा देने के लिए विस्तार नीतियां विकसित की गई।

शिक्षा

* एन.ए.आई.पी संघटक–1 के अन्तर्गत बी–टैक (डेरी प्रौद्योगिकी) उपाधि कार्यक्रम के लिए ई0–पाठ्यक्रम के विकास के लिए पहल की गई। अन्य शैक्षणिक सुधारों में (i) ई–लर्निंग (ii) आई.सी.टी.के माध्यम से ज्ञान, प्रबन्ध एवं प्रसारण (iii) वैब आधारित परस्परिक मापदंड तथा (iv) शिक्षण पुस्तिका सम्मिलित है।

* 'प्री रिसर्च सेन्सिटाइजेशन' की संकल्पना को विकसित किया गया तथा छात्रों को एक प्रयोगशाला के साथ अथवा एक वरिष्ठ छात्र के साथ उनके अनुसंधान के लिए प्रयुक्त की जाने वाली तकनीकियों पर प्रारम्भिक प्रदर्शन के लिए जोड़ा गया। छात्रों में अनुसंधान कुशाग्रबुद्धि मन में बैठाने के लिए प्रभावकारी पाई गई।

* वर्ष 2011–12 के दौरान राष्ट्रीय डेरी अनुसंधान संस्थान ने रवांड़ा, ईरान, इथोपिया, श्रीलंका आदि के अन्तरराष्ट्रीय छात्रों को आकर्षित किया है। इस समय राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय द्वारा चलाए जा रहे विभिन्न कार्यक्रमों में कुल 19 विदेशी छात्र अध्ययनरत हैं।

* उच्च कोटि के अनुसंधान कार्य के लिए प्रतिस्पर्द्धा की भावना एवं प्रेरणा के लिए प्रोत्साहित करने हेतु मास्टर एवं डाक्टरेट छात्रों के लिए श्रेष्ठ शोध प्रबन्ध पुरस्कार जारी रहा।

* राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय का दसवां दीक्षान्त समारोह दिनांक 21 फरवरी, 2012 को संपन्न हुआ। पदम् विभूषण डा. एम.एस.स्वामीनाथन सांसद (राज्यसभा) एवं अध्यक्ष एम.एल.स्वामीनाथ फांउंडेशन ने अपना दीक्षान्त भाषण प्रस्तुत किया तथा छात्रों को उपाधियां, स्वर्णपदक, मेरिट प्रमाण पत्र एवं पुरस्कार प्रदान किए।

* राष्ट्रीय डेरी अनुसंधान संस्थान, मान्य विश्वविद्यालय की शैक्षिक उपलब्धियों का पुनरावलोकन करने तथा ध्यान केन्द्रित करने के लिए फरवरी, 2012 के द्वितीय सप्ताह में शैक्षिक सप्ताह मनाया गया।

* वर्ष 2012 में डा0 के.के.आइया व्याख्यान पुरस्कार एवं डा0 एन.एन.दस्तूर व्याख्यान पुरस्कार प्रारम्भ किया गया। प्रथम डा0 के.के.अइया व्याख्यान पुरस्कार डा0 वी.के. तनेजा, कुलपति, जी.ए.डी.वी.ए.एस. विश्वविद्यालय को दिया गया तथा डा0 एन.एन.दस्तूर व्याख्यान पुरस्कार डा0 तेज प्रताप सिंह, कुलपति शेर–ए–कश्मीर कृषि विज्ञान एवं प्रौद्योगिकी विश्वविद्यालय, कश्मीर को प्रदान किया गया।

* छात्रों के प्रवेश के लिए ए.एस.आर.बी. के तत्वावधान में राष्ट्रीय डेरी अनुसंधान संस्थान पर आनलाइन परीक्षा प्रणाली सृजित की गई।

विस्तार

* संस्थान द्वारा विकसित प्रौद्योगिकियों को हस्तांतरित करने के लिए अपनाए गए गॉवों में कुल 56 किसान संगोष्ठियां आयोजित की गई। कुल 856 कृषकों को प्रजनन प्रबन्धन प्रक्रियाओं, थनैला नियंत्रण, रोग बचाव मापदण्डों एवं चारा उत्पादन के बारे में जागरूक बनाया।

* कृत्रिम गर्भाधान के द्वारा स्थानीय भैंसों में चयनित प्रजनन तथा गायों में संकर कार्यक्रम जारी रखा गया। कृत्रिम गर्भाधान में गर्भस्थापन दर गायों की 46.20% तथा भैंसों में 35% देखी गई।

* अपनाए गए गाँवों में कुल 60 पशु चिकित्सा सहायता शिविर आयोजित किए गए। कुल 1210 पशुओं का प्रौढ़ परिपक्वन, अमदकाल तथा आवृत्त प्रजनन का निदान किया गया तथा उपयुक्त उपचार दिया गया।

* वर्ष के दौरान कृषि विज्ञान केन्द्र/डेरी प्रशिक्षण केन्द्र ने 293 प्रशिक्षण कार्यक्रम (परिसर के अन्दर तथा बाहर दोनों) आयोजित किए गए। जिसमें डेरी उत्पादन, डेरी प्रसंस्करण, कृषि, वर्मी कम्पोस्ट, मधुमक्खी पालन, मत्स्यपालन तथा गृहविज्ञान में विभिन्न पहलुओं पर 26367 प्रशिक्षणार्थियों ने भाग लिया।

* कृषि प्रौद्योगिकी सूचना केन्द्र (एटिक) को और सुदृढ़ किया गया। रिपोर्टाधीन अवधि के दौरान 23200 कृषकों ने सूचना एवं परामर्श सेवा प्राप्त करने के लिए एटिक का भ्रमण किया। एटिक हेल्पलाइन सेवाएं प्रदान करने, प्रकाशनों की बिक्री, बीजों, जैव–उर्वरकों तथा वर्मी कम्पोस्ट की बिक्री, प्रदर्शनी, फिल्म प्रदर्शन तथा आमने–सामने परस्पर सम्पर्क स्थापित करने में लगा हुआ था।

* भूटान, डेनमार्क, नेपाल, संयुक्त राष्ट्र अमरीका, फिनलैंड, कजाकिस्तान आदि से कई विदेशी प्रतिनिधियों ने एटिक का भ्रमण किया। उन्हें अनुसंधान एवं विकास एजेन्सियों/संस्थाओं के साथ सम्पर्क, कार्यों तथा लक्ष्यों, सूचना एवं प्रौद्योगिकी हस्तांतरण की भूमिका तथा सिंगल विंडो प्रणाली प्रस्ताव का प्रभाव के बारे में विस्तार से बताया गया जो कि उत्पादकता तथा स्टेकहोल्डरों की आय में वृद्धि के लिए एटिक द्वारा अपनाए गए।

* देश भर से कई कृषकों ने पशुशाला की उत्पादन प्रक्रियाओं एवं सुविधाओं के लिए पशुशाला का भ्रमण किया तथा डेरी पशुओं में उत्पादन एवं प्रजनन को अनुकूलतम बनाने के लिए पैकेज आफ प्रेक्टिसिस के बारे में सुग्राही बनाया गया।

* विभिन्न राज्यों से कृषकों तथा पशु चिकित्सकों के लिए टी.बी.आई. के समन्वय से व्यावसायिक डेरी पालन, डेरी पशु प्रजनन प्रबन्धन तथा बकरियों में कृत्रिम गर्भाधान पर प्रशिक्षण कार्यक्रम आयोजित किए गए।

आधारीय संरचना

* उच्च उत्पादन वाली स्वदेशी, संकर गायों एवं भैंसों के लिए तीन अत्याधुनिक आवास प्रणालियां निर्मित की तथा पशु कल्याण एवं आराम के लिए चालू की गई।

* पशुओं के प्रयोग के लिए वायरलैस संवेदी आधारित जलवायु नियंत्रण कक्ष विकसित किया गया।

* उष्ण कटिबन्धीय परिस्थितियों में डेरी पशुओं में विभिन्न व्यावहार्य अध्ययनों के लिए पशुशाला में एक व्यवहार्य मानीटरिंग प्रणाली संस्थापित की गई।

* पशुशाला में ओसरों, दूध देने वाले दुधारू पशुओं तथा शुष्क एवं गाभिन पशुओं के लिए शैडों का निर्माण।

* पशुप्रजनन प्रयोगशाला; लिपिड विश्लेषण प्रयोगशाला; परिशुद्ध पोषण एवं पोषण जीवरसायन प्रयोगशाला; आहार प्रसंस्करण एवं गुणवत्ता नियंत्रण प्रयोगशाला; दाब एवं पर्यावरणीय शरीरक्रिया प्रयोगशाला तथा कोशिका संवर्धन प्रयोगशाला का नवीकरण।

* अतिथिगृह/प्रशासनिक खंड का नवीकरण।

* पुस्तकालय के सन्दर्भ अनुभाग का नवीकरण।

* सुरक्षा अनुभाग का नवीकरण।

* क्रीड़ा मैदान/सतलुज छात्रावास/कृष्णा छात्रावास में बिजली के कार्य का नवीकरण।

* राष्ट्रीय डेरी अनुसंधान संस्थान के पूर्वी क्षेत्रीय केन्द्र ने आई.वी.आर.आई., कोलकता की कल्याणी में स्थित पूर्वी क्षेत्रीय केन्द्र की 30 एकड़ जमीन विकसित की। यह जमीन काफी समय से बंजर थी तथा उपयोग मे नहीं लाई जा रही है। इस भूमि को खेती के लिए प्रयोग किया गया तथा पशु आहार के लिए चारे की फसलें उगाई गई।

* संस्थान राजभाषा कार्यान्वयन समिति की तिमाही बैठकें नियमित रूप से आयोजित की जाती हैं। इस वर्ष में भी चार तिमाही बैठकें आयोजित की गई तथा बैठकों में सर्वसम्मति से लिए गए निर्णयों पर अनुवर्ती कार्रवाई सुनिश्चित की गई।

* उच्च विशेषाधिकार प्राप्त संसदीय राजभाषा समिति (कमेटी ऑफ पार्लियामेंट ऑन ऑफिशयल लेंग्वेज) के निर्देशानुसार करनाल नगर में नगर राजभाषा कार्यान्वयन समिति गठित है। इस समिति के अन्तर्गत करनाल स्थित 70 केन्द्र सरकार के कार्यालय, उपक्रम, निगम, बैंक आदि हैं। संस्थान के निदेशक डा. ए.के.श्रीवास्तव जी को राजभाषा विभाग, गृह मंत्रालय के आदेश अनुसार इस समिति के अध्यक्ष एंव श्री आर.एस. गौतम, उपनिदेशक (राजभाषा) को सचिव नियुक्त किया गया है। इस समिति की छःमाही बैठक 29/12/2011 को निदेशक महोदय की अध्यक्षता में संपन्न हुई।

* राजभाषा (हिंदी) में कार्य करने की झिझक को दूर करने के उद्देश्य से संस्थान में तकनीकी वर्ग (टी–1 से टी–4) के कार्मिकों हेतु 27/9/2011 को एक दिवसीय प्रशासनिक कार्यशाला का आयोजन किया गया जिसमें लगभग 120 तकनीकी कार्मिकों ने भाग लिया इसमें तीन अतिथि वक्ताओं के व्याख्यान कराए गए।

* संस्थान द्वारा विगत कई वर्षो से मूल हिंदी वैज्ञानिक तकनीकी आलेख लेखन पुरस्कार योजना चलाई जा रही है। वर्ष 2010–11 के अन्तर्गत 26 वैज्ञानिकों एवं तकनीकी कार्मिकों को पुरस्कृत किया गया।

* संस्थान के पशासनिक कार्मिकों को राजभाषा (हिंदी) में कार्य करने के लिए प्रोत्साहित करने हेतु मूल रूप से हिंदी में टिप्पण/मसौदा लेखन प्रोत्साहन योजना गत कई वर्षो से चालू है। इस योजना के अन्तर्गत वर्ष 2009–10 के लिए संस्थान के 12 कार्मिकों को पुरस्कृत किया गया।

* संस्थान की वार्षिक गृह पत्रिका 'दुग्ध–गंगा' के द्वितीय अंक का सफल प्रकाशन एकक द्वारा किया गया। इस पत्रिका में कृषि व डेरी विज्ञान से संबंधित लगभग 25 आलेख तथा राजभाषा खंड भी प्रकाशित किया गया। संस्थान में विगत वर्षो की भांति इस वर्ष भी राजभाषा मास 14 सितम्बर–30 अक्टूबर–2011 तक आयोजित गया।

* संस्थान के वैज्ञानिक, तकनीकी कार्मिकों तथा छात्रों हेतु शोध–पत्र पोस्टर–प्रदर्शन प्रतियोगिता आयोजित की गई। इस प्रतियोगिता में वैज्ञानिकों, तकनीकी अधिकारियों, छात्रों ने सोलह नवीनतम शोध विषयों पर पोस्टर प्रदर्शित किए। प्रतियोगिता के बाद विश्व हिन्दी दिवस समारोह आयोजित किया गया।

* संस्थान के सभी कार्मिकों के दैनिक पत्राचार बढ़ाने के उद्देश्य टिप्पण एवं मसौदा लेखन प्रतियोगिता दिनांक 20.9.2011 को आयोजित की गयी।

* इसी क्रम में संस्थान के कार्मिकों ने रा0भा0(हिन्दी) के प्रति जागरूकता पैदा करने के प्रयोजन से 23 सितम्बर,2011 गीत–गायन प्रतियोगिता आयोजित की गई। इस प्रतियोगिता में संस्थान के साथ करनाल स्थित भारत सरकार, उपक्रम निगम वि0वि0 अनुसंधान संस्थानों तथा राष्ट्रीयकृत बैंकों आदि के कार्मिकों ने योगदान दिया।

* इस मास के अन्तर्गत राजभाषा हिन्दी में मूल वैज्ञानिक एवम् तकनीकी लेखन को प्रोत्साहित करने के उद्देश्य से संस्थान के वैज्ञानिकों, तकनीशियन तथा अन्य कार्मिकों द्वारा लिखित आलेख/शोधपत्र, फोल्डर, बुलेटिन तथा पुस्तकों के भी मूल्यांकन समिति द्वारा पुरस्कार निर्धारित किए है। इस दो वर्ष की प्रविष्टियों में लगभग 36 वैज्ञानिकों एवं तकनीकी अधिकारियों का सराहनीय योगदान रहा।

* 22 अक्टूबर,2011 को मुख्य राजभाषा एवं पुरस्कार वितरण समारोह आयोजित किया गया। इस समारोह में डा0 एम.एल.रंगा, कुलपति गुरू जम्भेश्वर विज्ञान एवं प्रौद्योगिक विश्वविद्यालय, हिसार, (हरियाणा) ने मुख्य अतिथि के रूप में भाग लिया एवं समारोह की अध्यक्षता संस्थान के निदेशक डा. ए.के.श्रीवास्तव ने की।

GUIDE MAP OF NDRI, KARNAL

ADMINISTRATIVE BLOCK

DIRECTOR'S OFFICE (Ist. Floor)	1
JOINT DIRECTOR (ACADEMICS)	1
JOINT DIRECTOR (RESEARCH)	1
JOINT DIRECTOR (ADMN.) (Ist Floor)	1
UNIVERSITY OFFICE	1
COMPUTER CENTER	1
RESEARCH PRIORITIZATION, MONITORING AND EVALUATION CELL	1
OFFICIAL LANGUAGE CELL	1
MINI AUDITORIUM	1
RECEPTION CELL	1

DIVISIONS, SECTIONS AND SUPPORTING UNITS

DAIRY MICROBIOLOGY	2
LIBRARY	3
DAIRY TECHNOLOGY (Ground & Ist. Floor)	4
DAIRY ECONOMICS, STATISTICS & MANAGEMENT (Ist. Floor)	4
EXPERIMENTAL DAIRY	5
ANIMAL BIO-CHEMISTRY (Ground Floor)	6
DAIRY CHEMISTRY (Ist. Floor)	6
DAIRY CATTLE NUTRITION (Ground Floor)	7
DAIRY CATTLE PHYSIOLOGY (Ist. Floor)	7
DAIRY CATTLE BREEDING (2nd Floor)	7
LIVESTOCK PRODUCTION & MANAGEMENT	7
DAIRY ENGINEERING (Ground, Ist & 2nd Floor)	8
DAIRY EXTENSION (2nd Floor)	8
LIVESTOCK FARM	9
GENERATOR HOUSE	10
TECHNOLOGY BUSINESS INCUBATOR (TBI)	11
ANIMAL HEALTH COMPLEX	12
SMALL ANIMAL HOUSE	13
KENDRIYA BHANDAR	14
FEED PLANT	15
MAINTENANCE SECTION	16
FORAGE RES. & MGMT. CENTRE	17
BIO - GAS PLANT	18
SEWAGE TREATMENT PLANT	19
ARTIFICIAL BREEDING RES. CENTRE	20
KRISHI VIGYAN KENDRA	22
DAIRY TRAINING CENTRE	23

RESIDENTIAL

DIRECTOR'S BUNGALOW	33
JOINT DIRECTOR'S RESIDENCE	34
F-TYPE QUARTERS	35
E-TYPE QUARTERS	36
D-TYPE QUARTERS	37
C-TYPE QUARTERS	38
B-TYPE QUARTERS	39
A-TYPE QUARTERS	40

OTHERS

AUDITORIUM	40
MODEL DAIRY PLANT	41
HEALTH COMPLEX	42
STAFF CLUB	43
BADMINTON HALL	44
NURSERY	45
GOVT. PRIMARY SCHOOL	46
COMMUNITY CENTER	47
ELECTRICAL SUB-STATION	48
SHOPPING CENTER	49
CAFETERIA	50
COMMUNICATION CENTER	51
SECURITY SECTION	52
MILK PARLOUR	53
ATIC BUILDING	54
ANIMAL BIOTECHNOLOGY CENTRE	55
STUDENTS' PLAY GROUND	56

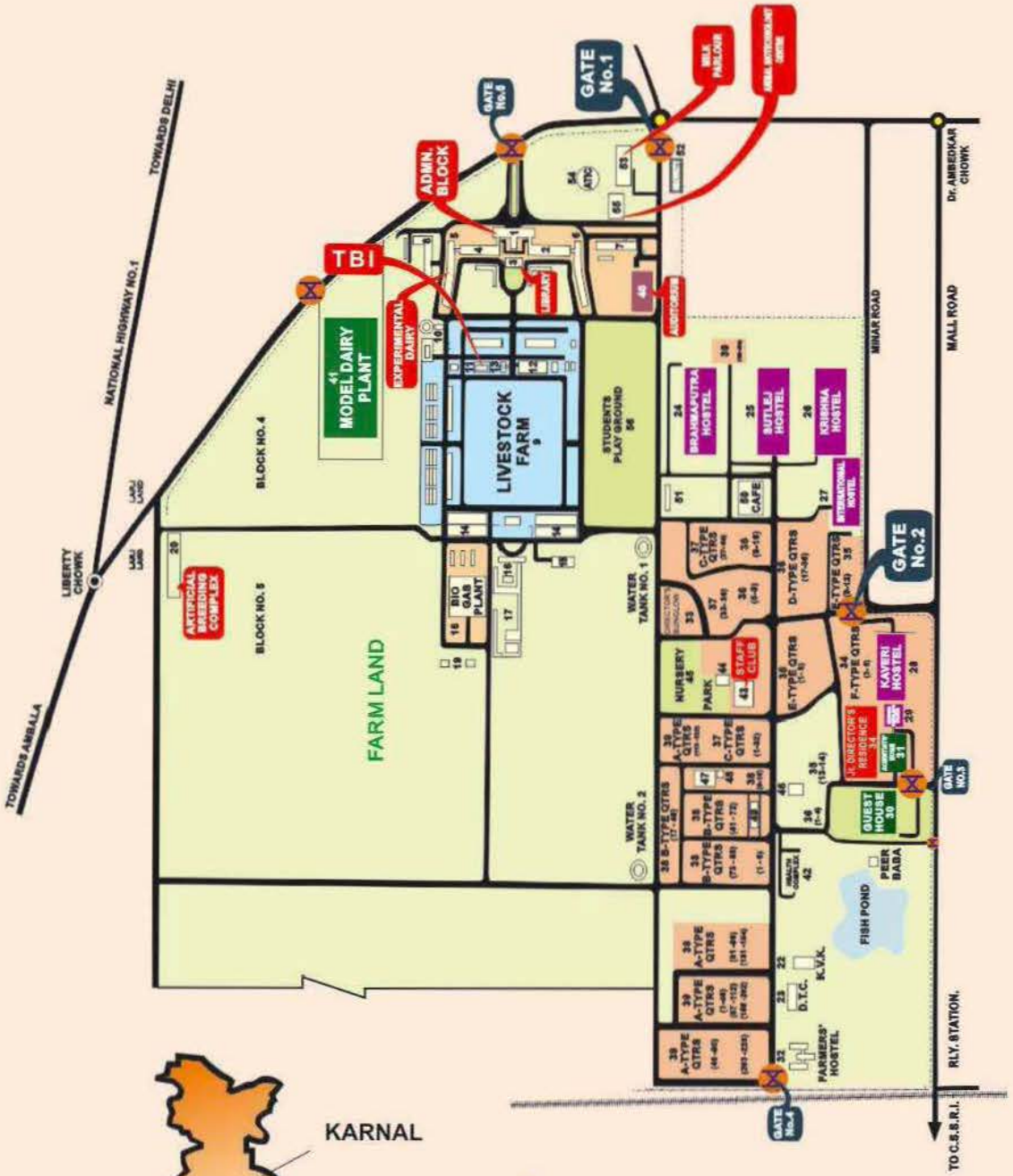
STUDENT HOSTELS

BRAHMAPUTRA	24
SUTLEJ	25
KRISHNA	26
INTERNATIONAL HOSTEL	27
KAVERI	28
MARRIED SCHOLARS'	29
ALAKHNANDA	40

GUEST ACCOMMODATION

GUEST HOUSE	30
SCIENTISTS' HOME	31
FARMERS' HOSTEL	32

GUIDE MAP OF NDRI, KARNAL



LOCATION AND TRAVEL

Location

Karnal is 250 mt above mean sea level, latitude 29.43 N and longitude 77.2 E.

Air

Domestic and international flights to and from Indira Gandhi Airport, Delhi are available.

Rail/Bus

Karnal is 133 km from Delhi and Institute is 1 km from Railway Station/Bus Stand

Climatic Information

Min. Temperature in winter : 10°C
Max. Temperature in summer : 45°C
Annual Rainfall : 70 cm

NATIONAL DAIRY RESEARCH INSTITUTE
(Deemed University)
(ICAR) Karnal - 132 001 India
Tel.: 0184-2252800 | Fax : 0184-2250042 | E-mail : dir@ndri.res.in
Website : www.ndri.res.in