

वार्षिक प्रतिवेदन
ANNUAL REPORT
2012-13



भाकृअनुप
ICAR

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. | 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. |
| 1936 | Renamed "Imperial Dairy Institute". | | A Guest House with two suites named as "Kamdhenu" was constructed at SRS, Bangalore. |
| 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. | | Platinum Jubilee of the Institute celebrated on 7 th - 8 th April 2000 at SRS, Bangalore. |
| 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. | | Web-site of NDRI was created and launched by the Hon'ble Union Minister for Agriculture on 23 rd December 2000. |
| 1962 | Western Regional Station established at Bombay. | 2001 | Foundation stone of the Agricultural Technology Information Centre laid on 1 st August, 2001 under NATP project at NDRI, Karnal. |
| 1964 | Eastern Regional Station established at Kalyani (W.B.). | 2002 | International Students' Hostel equipped with modern facilities and amenities constructed at NDRI, Karnal. |
| 1966 | Institute brought under the aegis of ICAR. | | Feed Quality Control Lab. set up to help keep-strict quality check on feeds being fed to bovine livestock. |
| 1975 | Operational Research Project initiated. | 2003 | State-of-the-art milking parlour system introduced in cattle section. |
| 1976 | Department of Human Nutrition and Dietetics established at NDRI, Karnal. | 2004 | First IVF goat kid born at NDRI. |
| 1979 | M.Sc., Ph.D. Programme in Dairy Engineering commenced at Karnal. | | ATIC centre at NDRI made functional. |
| 1983 | IDD (DH) started at Bangalore. | 2006 | New Animal Biotechnology Centre commissioned. |
| 1985 | "Farm Advisory Bureau" and "Industrial Consultancy Cell" set up. The Institute recognised as Centre of Excellence in Animal Biotechnology. | 2007 | Creation of Video Conferencing Lab and Mini Auditorium. |
| 1987 | Embryo Biotechnology Centre established. | 2009 | World First Cloned Buffalo Calf and second cloned calf "Garima" produced by hand-guided cloning technique at NDRI. |
| 1989 | The Institute granted "Deemed to be University" status. M.Sc. in Biotechnology started. | | DST supported Technology Business Incubator (TBI) facility made functional. |
| 1990 | Birth of Pratham, first IVF buffalo calf of the world. | | New Course Curricula for B.Tech in Dairy Technology and Masters and Doctoral Programmes introduced. |
| 1991 | 20 bedded Hospital Complex set up and made functional. National Agricultural Research Project (NARP) funded through World Bank. | | Reforms in Examination System, grading system and introduction of comprehensive exam. for Ph.D. programme introduced. |
| 1994 | The Institute got recognition as Centre of Advanced Studies in Dairy Technology & Dairy Cattle Breeding. | 2010 | 8 th Convocation of NDRI, Deemed University held in presence of Dr. A. P. J. Abdul Kalam, Former President of India. |
| 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. | 2011 | M.Sc. in Forage Production introduced National Academy of Dairy Sciences Launched. Centre of Excellence in Milk Safety established. NDRI Recognised as Centre of Advanced Faculty Training (CAFT) in the Disciplines of Dairy Production and Dairy Processing. |
| 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. | 2012 | Sahiwal Calf "Holi" through Ovum Pick up (OPU-IVF) technique born on 7 th March, 2012. |
| 1998 | A Modern Cafeteria with a seating capacity of 150 constructed in front of the Institute Hostels at the cost of 29 lakhs. | 2013 | First female calf named 'Mahima' born to a cloned buffalo on 25 th January 2013. A male cloned buffalo calf named 'Swarn' born on 18 th March 2013. Donor somatic cell used was isolated from the seminal plasma of an elite bull. |
| 1999 | Total no. of 9 NATP Projects with financial outlay of 266.25 lakhs initiated. | | |

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

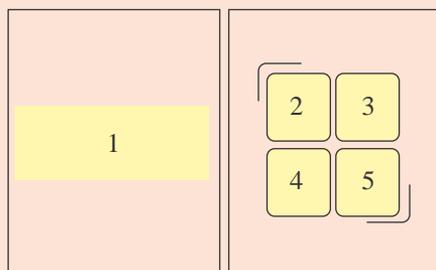
- Conducting research in the areas of Dairy Production, Processing and Marketing.
- Demand driven "Human Resource Development" to meet the requirements of Dairy Industry & R&D Institutions.
- Dissemination of innovative dairy production and processing technologies for socio-economic transformations.

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Cover Page Photos:



- 1 *Institute Administrative Block*
- 2 *'Swarn' - the cloned buffalo calf born on March 18, 2013*
- 3 *Iron fortified pearl millet biscuits*
- 4 *A new test for detection of detergent in milk*
- 5 *'Mahima' - the first female calf born to a cloned buffalo on Jan. 25, 2013*



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NDRI Annual Report 2012-13 is being presented as a comprehensive account of the most significant achievements of the Institute in the areas of Research, Education, Extension and Management, and the activities related to Infrastructure Development during the last one year.

During the preceding year, our R&D efforts got further impetus through our well-defined and well-structured research programmes comprising 72 in-house and 67 externally funded research projects, including 19 NAIP funded research projects in consortium mode wherein NDRI is either the Lead Institute or consortium partner. NDRI has been successful in getting external funding from almost all the leading national funding agencies i.e. Department of Biotechnology (DBT), Department of Science and Technology (DST), National Dairy Development Board (NDDB), National Fund for Basic and strategic Research on Agriculture (NFBSRA), Ministry of Food Processing Industries (MFPI), Department of Atomic Energy (DAE), Indian Council of Medical Research (ICMR) and Department of Animal Husbandry and Dairying (DAHD).

Through the path breaking research in the area of animal cloning, the Institute has gained unprecedented recognition and honour by producing the calf from a cloned buffalo on 25th January, 2013. This female calf was the first calf produced to a cloned buffalo in the world and was named 'Mahima'. Further, a male cloned buffalo calf named 'Swarn' was also born on 18th March, 2013. This cloned buffalo calf was born by normal parturition. In this case, the used donor somatic cell was isolated from the seminal plasma of a bull. 'Shresth',

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processed cheese spread, buffalo-milk feta cheese, functional quarg cheese, dietetic misti dahi, buffalo-milk set plain dahi and yoghurt, cow-milk set plain dahi and yoghurt, extended shelf-life functional paneer, long-life milk cake, low-fat gulab jamun mix and Arjun herbal Ghee.

Entrepreneurship development campaign was launched in collaboration with “Arpana Research and Charities Trust”, Madhuban for transferring some of the technologies that have been developed in the field of composite dairy foods. One Self Help Group (SHG) namely 'Nirmal Dhara Mahila Dugdh Samiti', was formed in village Taprana for manufacture of quality dairy products and the other SHG named as 'Shagun Bakery' was formed in village Darad for manufacture of bakery products. Further, training programmes and demonstrations on “different dairying practices” were also regularly conducted for rural women farmers and various women self help groups at regional campus Bangalore and Kalyani. Under the project on “Dairy Entrepreneurship Development of Rural Women: An Action Research”, the women SHGs were trained in dairy processing technologies and encouraged to process the raw milk into various dairy products and market these products directly to the desired customers, thus, paving the way for the economic empowerment of rural women.

NDRI as a Deemed University and a centre of excellence in frontier areas of research has been ranked at number 68 of the 100 best universities and research institutes of the country (*Careers 360*, March 2013). Initiatives were taken to start diploma course i. e. National Dairy Diploma in Dairy Technology at the Southern campus, Bangalore with effect from academic session 2013-14, with a view to bring in more employment opportunities for the youth. Under NAIP component-1, e-courses for B. Tech (Dairy Technology) degree programme were completed and uploaded for online delivery to various dairy colleges/institutions. Other educational reforms included i) e-learning, ii) web-based interactive modules and iii) development of teaching manuals. During the year 2012-13, a total no. of 15 International students was 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. NDRI instituted 'Best Teacher Award' for UG and PG Teaching and 'Best Divisional Award' for academic achievements and innovations in teaching in the year 2012-13.

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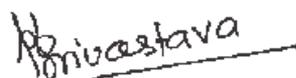
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Eleventh Convocation of NDRI Deemed University was held on 16th February, 2013. Dr. S. Ayyappan, Secretary DARE and Director General, Indian Council of Agricultural Research, New Delhi delivered the Convocation Address and gave away the Degrees, Gold Medals, Merit Certificates and Awards to the students. Academic Week was celebrated in the second week of February, 2013 to lay focus and review the academic achievements of NDRI Deemed University.

During 2012-13, a state-of-the-art Bio-safety Facility was established at Dairy Microbiology Division. Amravati wing of the Kaveri Hostel for girl students was created and made functional. Children Park facility was also created for welfare of the staff. Some of the new initiatives included construction of new hostel complex for boys, indoor sports complex at the main campus, Karnal and an auditorium with seating capacity of 200 at Southern campus, Bangalore. Foundation stone was also laid for the establishment of "National Referral Centre for Milk Quality and Safety" under NAIP at the cost of 17.43 crores.

All this could be achieved with the continued support and encouragement of Secretary DARE & Director General ICAR, Deputy Director General (AS) ICAR and also hard work of all the esteemed members of the NDRI fraternity. Here I feel privileged to acknowledge and place on record the contributions made by the Joint Directors, Heads of Divisions, Faculty, Administrative/ Finance Officers and the Staff of NDRI in the growth of the Institute. I am sure that with their continued 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 source of valuable information to the professionals of the Scientific/Academic Institutions and other Dairy Development Organizations in the country.


 (A. K. Srivastava)

EXECUTIVE SUMMARY

National Dairy Research Institute is the premier research organization of the nation dedicated for providing Research and Development (R&D) and Human Resource Development (HRD) support towards dairy development programmes in the country. Established in 1923 at Bangalore, the headquarters of the Institute 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 thirteen Research Divisions/Sections, namely, Dairy Cattle Breeding, Livestock Production and Management, Dairy Cattle Nutrition, Forage Research, 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 and Dairy Training Centre and Animal Breeding Research Centre. The Institute has infrastructure consisting of central facilities such as Livestock Farm, Forage Research and 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.) and Registrar. The Institute presently has strength of 153 scientists, 283 technicians, 155 administrative and 580 skilled supporting staff.

BUDGET OUTLAYS

The financial outlays of the Institute in terms of actual expenditure for Plan and Non-plan for the year 2012-2013 was ` 13361.52 lakhs and budget sanctioned for the year 2012-2013 was ` 13367.50 lakhs, respectively. These figures include the financial outlays for the strengthening of Deemed University/KVK and Regional Stations.

RESEARCH

A total number of 72 in-house research projects were in operation during the year 2012. 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. NDRI has been successful in getting external funding from almost all leading national funding agencies i.e. Department of Biotechnology (DBT), Department of Science and Technology (DST), National Dairy Development Board (NDDB), National Bureau of Agriculturally Important Micro-organisms (NBAIM), National Fund for Basic and strategic Research on Agriculture (NFBSRA), Ministry of Food Processing Industries (MFPI), Department of Atomic Energy (DAE), Indian Council of Medical Research (ICMR) and Department of Animal Husbandry and Dairying (DAHD). It is worth mentioning that the Institute is handling one consultancy project amounting to ` 1.85 crores.

The support from NAIP and other funding agencies has encouraged scientists to work on stem cell, buffalo cloning, transcriptome, embryogenesis, biosensors, nanotechnology, abiotic stress in farm animals, nutraceuticals and functional foods. The funds were also received for strengthening project monitoring and evaluation and computing digitization of information. The grants from NAIP have helped students to opt for modern tools and techniques in their dissertation.

- A male cloned buffalo calf named “Swarn” was born on 18th March, 2013. The calf was born by normal parturition and its weight at the time of birth was around 55 kg. This cloned buffalo calf is unique and is different from the earlier clones, because, in this case, the donor somatic cell used was isolated from the seminal plasma of a bull.
- “Mahima”, a female calf weighing 32 kg was born on 25th January, 2013 to 'Garima-II' a cloned buffalo, which had been produced by Hand-guided cloning using embryonic stem cells as donor cells. This is the first calf in the world to be born to a cloned buffalo.

- “SHRESHT”, the first male cloned buffalo calf born on 26th August, 2010 at NDRI, Karnal, is now a grown-up bull, the semen of which is being used for cryopreservation.
- Over-expression of NANOG in buffalo fetal fibroblasts and embryonic stem (ES) cells improve growth and pluripotency of ES cells.
- An *in vitro* culture system incorporating various growth factors for the short-term culture of buffalo spermatogonia.
- Vitrification in open-pulled straws was shown to be better than slow freezing for the cryopreservation of zona-free cloned buffalo blastocysts since it offered a much higher cryosurvival rate.
- Tetraploid buffalo embryos produced by electrofusion aggregated with buffalo ES cells to produce blastocysts.
- Exposure of buffalo oocytes and embryos to elevated temperatures severely compromise their developmental competence, increase apoptosis and affect stress, apoptosis and development-related genes.
- Novel non-coding RNAs were discovered in maturing buffalo oocytes, which could have determining role to impart their development competence.
- Thirteen developmentally important genes were found to be expressed in goat embryos produced by IVF and parthenogenesis.
- Oxamflatin and SAHA were found to increase the developmental potential of handmade cloned goat embryos.
- The VASA, STELLA and PUM1 germ cell-specific marker genes were shown to be expressed in germ cell-like cells produced by directed differentiation of goat iPS.
- MGP-40, a mammary gland protein protects the mammary gland from excessive loss of cells during apoptosis
- Structural modeling and estimation of energetic cost of amino acids varying between lactoferrins of cattle and buffalo were studied.
- Polymorphism in CARD 15 Gene in Sahiwal cattle is not linked with incidence of mastitis.
- PCR-RFLP using HinfI, AluI, HaeIII, MboII, EcoO1091, PvuII, BsmFI restriction endonucleases revealed monomorphic patterns in coding sequences of Calgranulin (S100A8) gene in 150 Murrah buffaloes.
- High degree of genetic variability in Heat Shock Protein 70 (HSP 70) gene in Deoni and HF crossbred cattle.
- Three SSCP patterns in Deoni cattle and two SSCP patterns in HF Crossbred cattle in promoter region of Heat Shock Protein 70 (HSP70).
- A2 casein allele in Deoni cattle is fixed. Malnad Gidda cattle is predominantly (151 out of 154) of A2 type. Frequency of A1 allele among graded HF cattle is 0.3.
- Malnad Gidda cattle was registered as a distinct breed.
- A novel method was developed for early detection of lameness in dairy animals.
- Modules for sensor based pedometer, microclimate control systems and estrus detection tools were developed.
- Bio-markers for prediction of ensuing diseases including behavioural markers for post-partum metritis and biochemical markers for metritis and mastitis were identified.
- Cleansing of frozen thawed semen facilitated separation of good quality spermatozoa and selection of better quality sperm.
- Supplementation of 10 g rumen protected choline post-rationally, increased milk yield (21%), milk fat, milk choline content and unsaturated fatty acids in milk.
- Supplementation of rumen protected methionine and lysine (7 g and 60 g, respectively) to lactating cows increased milk yield (11%) and milk fat (13%).
- Daily dietary supplementation of chromium at 1.5 ppm level, increased milk production (7.6 to 9.9 kg), milk fat, total solids along with increased dry matter intake (15%), nutrient digestibility, immune status and reproductive performance in buffaloes.
- Feeding of extruded full fat soybean in the concentrate mixture of early lactating cows enhanced milk production by 10%.

- Area specific mineral mixture was prepared for eastern region.
- Feeding of probiotic fermented milk prepared with three strains of *Lactobacillus sp.* individually improved neutrophil and macrophage functions of innate immune response.
- Dietary supplementation of probiotic (*L. casei*) containing dahi to C57BL/6/J mice reduced epididymal fat accumulation, normalizing lipid profile and modulation of cecal microflora.
- Pepsin and trypsin proteolytic enzymes are superior over other enzymes in producing ACE-inhibitory and anti-oxidative peptides from buffalo casein and whey proteins.
- Aptamers (nucleic acids based highly specific ligand molecules) were generated for their use in developing methods for aflatoxin M1 detection.
- Using combination of aspartame, sucralose, acesulfame, sorbitol and xylitol, a sweetened syrup was formulated for the preparation of sugarless khoa jalebi.
- A gulabjamun mix formulation using khoa powder as base material was developed with a shelf life of about 60 days at 30°C. The gulabjamun made from the mix possessed nutty flavour and granular texture typical of khoa-gulabjamun.
- Methodology was worked out for preparation of sugarless dietetic rabri by replacing sucrose with intense sweeteners viz. aspartame, sucralose and acesulfame.
- Casein and whey protein concentrate (WPC) films, plasticized with glycerol and sorbitol were prepared by casting method.
- Whole genome sequence of the two indigenous probiotic *Lactobacillus* strains viz. *L. plantarum* Lp91 and *L. fermentum* Lf1 was deciphered.
- Indigenous probiotic strains of *Lactobacillus reuteri* and *L. gasseri* were characterized for their health promoting attributes through *in vitro* and *in vivo* studies.
- Reuterin, a broad spectrum antibacterial compound produced by *Lactobacillus reuteri* was characterized for its application in the food system.
- A novel enzyme-substrate based bio-assay for detection of *L. monocytogenes* and *E. coli* O157:H7 in milk was developed.
- Iron and Zinc fortified Nutrimix based on pearl millet extrudate, WPC-70 and SMP was developed.
- Dietetic Shrikhand was prepared using yoghurt cultures NCDC -199 and NCDC-74, skim milk, WPC-70, Acesulfame-K and sucrose with a shelf-life of 15 days at 6-8°C.
- Herbal ghee prepared from buffalo milk using arjuna extract had a shelf life of 8 days at 80 ± 1°C as against 2 days for control.
- A whey-cereal functional beverage was prepared using probiotic *L. acidophilus* NCDC 13 and pearl millet and barley.
- A technology was standardized for preparation of functional butter containing CLA and Phytosterol.
- A technology was developed for manufacture of Mixed-Fat Chocolate Spread (MFCS) using functional dairy and non-dairy ingredients.
- A process for micronutrient fortified nutrimix based on pearl millet and milk solids for weaning purpose was developed.
- A process was standardized for the preparation of improved set-type 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.
- High hydrostatic pressure (HHP) treated samples of both cow and buffalo milks showed enhanced shelf life of 20 days under refrigeration.
- A Technology to manufacture curcumin fortified lassi having prophylactic attributes against Alzheimer's disease was developed.
- A process for the manufacture of *Aleo vera* supplemented probiotic lassi and ice cream was developed and the product's health attributes validated in animal models.
- A technology was developed to prepare ready-to-use shelf-stable dairy-fruit-cereal based composite product (smoothie).
- A process was standardized for the manufacture of *Kheer mohan* from buffalo milk.
- A process was optimized for membrane filtration for buffalo-milk set-style plain and fruit yoghurts and Dahi.

- A process was optimized for preparation of functional processed cheese spreads using plant derived ingredients viz., inulin, phytosterols and -3 fatty acid.
- Sweetened functional soft cheese from buffalo milk was developed by incorporating fructooligosaccharide (FOS), inulin and cocoa to enhance health attributes.
- Probiotic whey drink (antidiarrheal) was developed.
- Cost effective dry whey based medium was formulated for culturing and enumeration of *Lactobacillus* spp.
- A Method for the production and separation of antimicrobial peptides from skim milk using selected proteolytic *lactobacillus* strains was worked out.
- Whey protein hydrolysate exhibits preventive and curative effect against paracetamol induced hepato-nephro toxicity.
- A process for preparation of Iron and Vitamin A fortified milk was developed.
- A new test for detection of detergent in milk was developed. The method can detect presence of 20 mg of detergent in 100 ml of milk. Mother Dairy, Delhi has agreed to purchase the technology.
- A cooling system for khoa in 3 stage scraped surface heat exchanger (SSHE) was developed.
- A process was optimized for in-line production of basundi and ghee.
- Dairy Animal Health Plan was developed for the benefit of farmers.
- ITKs related to adaptation of animals to ameliorate the effects of climate change and for prevention of zoonotic diseases were identified.
- Group approach (SHGs) was found effective in income generation, leading to improved socio-economic status and empowerment.

EDUCATION

- NDRI offered B.Tech. (Dairy Technology), Masters in thirteen disciplines and Doctoral courses in twelve disciplines during 2012-2013.
- E-courses for B. Tech (Dairy Technology) degree programme were completed under NAIP component-1. The e-courses for B.tech degree programmes were uploaded for online delivery to various dairy colleges/institutions
- The academic session also attracted several international students (15 Nos.) for training and short term education in different areas of Dairying.
- **Eleventh Convocation** was organized on 16th February, 2013. Dr. S. Ayyappan, Director General, Indian Council of Agricultural Research, New Delhi delivered the Convocation Address and gave away the Degrees, Gold Medals, Merit Certificates and Awards to the students. Dr. Gurbachan Singh, Chairman Agricultural Scientists Recruitment Board, New Delhi, presided over the convocation as the Guest of Honour. As many as 32 B.Tech., 134 Master in Dairying and 38 Ph.D. students were awarded degrees during the 11th Convocation.
- In year 2012-13, NDRI organized Academic Week prior to Convocation by organizing a series of academic events such as Memorial lectures and presentation of academic achievements and innovations in teaching by different Heads of Divisions followed by deliberations by panellists and selection of students for Best Masters and Doctoral Thesis Awards. Academic Week was celebrated in the second week of February 2013. “Best Teacher Award” for UG and PG Teaching was instituted during 2012-13. “Best Divisional Award” for academic achievements and innovations in teaching was also instituted during 2012-13. “Best Thesis Awards” were given to Master's and Doctoral students to encourage spirit of competition and motivation for quality research work.
- On 11th February, 2013, 4th **Dr D. Sundaresan Memorial Oration** was held and given to Dr. Gurbachan Singh, Chairman Agricultural Scientists Recruitment Board, New Delhi. Dr. K. **K. Iya Memorial Oration Award** for the year 2013 was given to Dr. P. P. Mathur, VC Kalinga Institute of Industrial Technology Odisha and **Dr N.N. Dastur Memorial Oration Award** for the year was bestowed upon Dr K.M. Bujarbaruah, VC Assam Agricultural University, Assam.
- **Agriculture Education Day** was organised by the students and the faculty on 23rd November, 2012. Various competitions like Essay Writing, Debate and Poster Making were organised.

- The Institute hosted as many as 30 no. training programmes/workshops/seminars and symposia to promote scientific and academic interactions and exchange of new knowledge.

EXTENSION

- The pricing was finalized for initiating commercialization of the technologies viz. Functional processed cheese spread, buffalo-milk feta cheese, functional quarg cheese, dietetic misti dahi, buffalo-milk set plain dahi, buffalo-milk set plain yoghurt, cow-milk set plain yoghurt, cow-milk set plain dahi, extended shelf-life functional paneer, long-life milk cake, low-fat gulab jamun mix and Arjun herbal ghee.
- A new test for detergent detection for milk was evaluated at Punjab Biotechnology Incubator, Mohali and Mother Dairy, Delhi. The Mother Dairy purchased the technology for license fee amounting to ` 6.00 Lakhs.
- Two probiotic cultures Viz., *Lactobacillus acidophilus* (LaVK2) and *Bifidobacterium bifidum* (BbVK3) were submitted at MTCC, IMTECH, Chandigarh as a part of requirement for the grant of patent on Probiotic Dahi.
- **NDRI-Industry Meet** was held on December 1, 2012. At this Meet, 34 technologies developed at NDRI were presented before 42 participants from 32 Industrial houses and stakeholders with a focus for their commercialization. These technologies included detection tests for detergent, antibiotic residues, *Listeria monocytogenes*, *Enterococci* and aflatoxin M1 in milk. The technologies of cheese spread, Feta cheese, Quarg cheese, Misti dahi, cow plain dahi, cow plain yoghurt, buffalo plain yoghurt, buffalo plain dahi, herbal ghee, long-life milk-cake, low-fat gulab-jamun, functional milk drink, iron-fortified biscuits, reconstituted kheer, reconstituted rasmalai, reconstituted basundi, extended shelf-life of paneer, cereal based fermented beverages, whey based beverages and soups, anionic feed diet for controlling milk fever, milk protein based bajra snacks, whey-skim milk-millet based complementary food, continuous butter melter, continuous ghee making machine, supplements mixtures, mineral mixture and degcure mixture were explained/demonstrated.
- Entrepreneurship development campaign was launched for transferring some of the technologies that were developed in the field of composite dairy foods, One Self Help Group (SHG) namely Nirmal Dhara Mahila Dugdh Samiti was formed in village Taprana and the women members of the SHG were trained for the manufacture of quality dairy products. Training was also given on testing of milk and milk products. Women belonging to SHG named as Shagun Bakery, Darad were trained for the manufacture of bakery products such as biscuits, bread, buns, cakes and muffins.
- The Innovative Approach initiated by NDRI; “Dairy Education at Farmers' Door”, continued in year 2012-13. Under this programme, a team of NDRI scientists including subject matter specialists from production, processing and management group organizes Dairy Education at Farmers' Door in various villages on 2nd saturday of every month.
- KVK and DTC organized 272 training programmes (both on campus and off campus) on different aspects of dairying and allied fields of agriculture such as crop production, horticulture, bee keeping and fisheries apart from home science for the benefit of 8969 farmers, farm women, rural youth and entrepreneurs across the country.
- During 2012-13, 25375 farmers from 16 states and one union territory visited ATIC, which also included 216 delegates from 9 different countries. To improve health and productivity of dairy animals, different technological interventions in the area of nutrition, breeding, physiology and health care were suggested to 23375 farmers whereas 6478 stakeholders were suggested different technological interventions in the area of livestock production management and milk processing and 1162 cases were referred for specialized guidance to different divisions of the Institute and 2322 cases to sister institutes located at Karnal.
- Forty three women empowerment trainings and campaigns in the field of dairying and home-science were organized with the objective to create awareness and impart skill in these areas and also to mobilize farmwomen to take up vocation in the field of dairying for generating income from dairying.

- A new initiative was taken to establish laboratory for women for imparting training to different self-help groups. This lab was established with the objective to create awareness and impart skills in the field of dairy processing and fruit and vegetable preservation and also mobilize these groups to take up vocation in these areas.
- NDRI organized 57 infertility and veterinary aid campaigns, exposure visits at nearby villages viz., Nasirpur, Nasirpul Tila, Vazidpur, Kulwaheri, Budhakhera and Ganjogarhi.

INFRASTRUCTURE

- Amravati wing of the Kaveri Hostel for girl students was created.
- A state-of-the-art clean room facility was created at Dairy Microbiology Division.
- A new state-of-the-art Scanning Electron Microscope (SEM) was installed at Dairy Microbiology Division.
- Foundation stone was laid for the establishment of

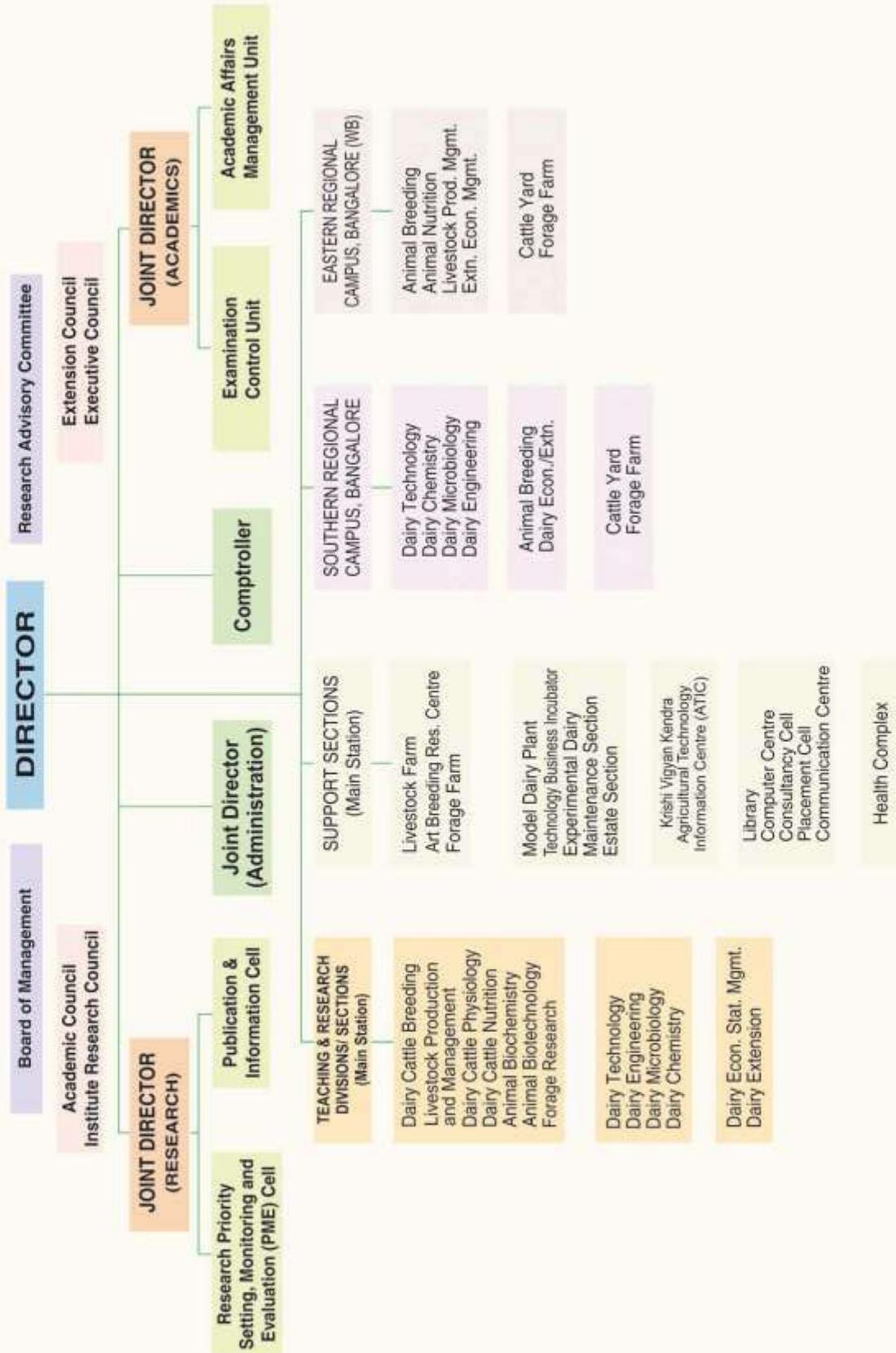
National Referral Centre. Milk Quality and Safety to be constructed at NDRI (at a cost of ` 17.43 crores).

- Children Park facility was created for staff welfare.
- Road Carpeting of whole Institute was completed.
- Construction was initiated for New Boys Hostel “Narmada Hostel” and Indoor Sports Complex.
- Wi-fi facility was established for the Southern campus, Bangalore.
- Auditorium with seating capacity of 200 was initiated at Southern campus, Bangalore.
- Sanitary lines work was completed for the hostel premises and also for the quarters at Southern campus, Bangalore.
- Canteen facility was established at Southern campus, Bangalore.
- Renovation of conference room and guest house was got done at Eastern campus, Kalyani.



Inauguration of Amravati wing of Kaveri Hostel by DDG (AS) ICAR

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

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| Chairman | Dr. A. K. Srivastava Director, NDRI |
| Member | Joint Director (Research), NDRI |
| Member | Joint Director (Academic), NDRI |
| Members (Head of Divisions/ Principal Scientists nominated By President of ICAR) | Dr. A. A. Patel, Head, DT Dr. Y. S. Rajput, Head, ABC Dr. R. C. Upadhyay, Head, DCP Dr. R. S. Gandhi, Head, DCB Dr. P. Khandekar, Principal Scientist, Agriculture Extension, NIANP, Bangalore Dr. R. K. Sethi, Ex-Director, CIRB, Hisar Dr. S. K. Agrawal, Head, Division of Animal Production, IVRI, Izatnagar Dr. D. K. Sadana, Principal Scientist, Animal Breeding, NBAGR, Karnal |
| Members Two Members of Governing Body Nominated by the President, ICAR) | Dr. Mruthyunjaya, Ex-National Director, NAIP, ICAR, A-701, Vasundhar Apartments, Plot No. 16, Sector-6, Dwarka, New Delhi Dr. Chanda Nimbkar, Director, Animal Husbandry Division, Nimbkar Agricultural Research Institute, Phaltan, Maharashtra |
| Member (VC of Agricultural University Nominated by the President, ICAR) | Dr. R. K. Mittal, Vice Chancellor, RAU, Pusa, Samastipur, Bihar |
| Member (Nominee of the DG, ICAR) | Dr. K. M. L. Pathak DDG (AS), ICAR |

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| Member (Director IVRI/IARI) | Director, IARI |
| Member (Jt. Director (Ext. Edu.)) | Head, Extension Division |
| Member (One Eminent Scientist in the Field of Research done in Institute but not employed by ICAR, Nominated by President, ICAR) | Dr. K. Pradhan, Ex- Vice Chancellor, OUAT, Bhubaneswar |
| Member (One Eminent Agril. Educationist Concerned with Nominated by President, ICAR) | Dr. S. N. Maurya, Ex-Vice Chancellor, Foot Mill City, P.O., Kamaluaganja, Haldwani |
| Member (Non Official Persons Representing Agriculture Interest to be Nominated by President, ICAR)\ | Sh. Devendra Shah, Chairman, Parag Milk Foods Pvt. Ltd., 81-A, Mittal Court, A Wing, Nariman Point, Mumbai Sh. Gurumukh Singh, Progressive Farmer, Amritsar |
| Member (FA, ICAR or his Nominee) | AS&FA, DARE |
| Member (Development Commissioner Rohilkhand Division) | Commissioner, Rohtak Division, Rohtak |
| Member Secretary | Sh. J. K. Kewalramani Joint Director (Admn. & Registrar) |

ACADEMIC COUNCIL

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| Chairman | Dr. A. K. Srivastava, Director, NDRI |
| Vice-Chairman | Dr. G. R. Patil, Joint Director (A), NDRI |
| Member | Dr. Rishendra Verma Joint Director (Research) |
| Members (Four Eminent Scientists from outside the NDRI) | Dr. B. Mishra, Former Vice Chancellor Sher-e-Kashmir University of Agricultural Sciences & Technology, Chatha-180009 Jammu (J&K) Dr. S. R. Singh, Director Institute of Agriculture, Banaras Hindu University, Varanasi-221005 (Uttar Pradesh) |

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| | Dr. B.P. Shah, Principal & Dean SMC College of Dairy Science, AAU, Anand-388001 (Guj) |
| | Dr. B. V. Venkateshaiah, Dean Dairy Science College, Karnataka Veterinary, Animal and Fisheries Sciences University, Hebbal, Bangalore-560024 |
| Member (DDG Education or his nominee) | DDG (Edn.), ICAR |
| Members (One Senior Scientist from each Division) | Dr. A. K. Dodeja, Head, DE Dr. R. S. Gandhi, Head, DCB Dr. S. S. Kundu, Head, D.Extn. Dr. Y. S. Rajput, Head, ABC Dr. K. K. Datta, Head, DES&M Dr. A. A. Patel, Head, DT Dr. R. K. Malik, Head DM Dr. Darshan Lal, Head, DC Dr. S. S. Kundu, Head, DCN Dr. R. S. Manik, I/c ABTC Dr. Shiv Prasad, I/c LPM Dr. A. S. Harika, I/c FM Dr. I. K. Sawhney, COE Dr. Satish Kulkarni, Head, SRS Dr. S.K. Kanwajra, Academic Coordinator |
| (Two Representatives from PG Faculty) | Dr. R. C. Upadhyay, Head DCP Dr. B. S. Chandel, PS |
| Students Member | Mr. Sidhartha Shankar Layek Mr. Lalatendu Keshary Das |
| Member-Secretary | Registrar, NDRI Deemed University |

RESEARCH ADVISORY COMMITTEE (TILL 31st DECEMBER, 2012)

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| | |
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| | 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, Department of Agril. Economics, IARI, Pusa, New Delhi |
| Member | Dy. Director General (AS), ICAR |
| Member | Director, NDRI |
| Member Secretary | Joint Director (Res.), NDRI |

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| Member | Dr. P. A. Shankar, Former Director, Dairy Science College, 1275, 24 th Cross, 25 th Main BSK Stage, Bangalore-560070 |

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| Member | Dr. K. L. Raheja, Ex-Dean COVAS, 634, Sector-15-A, CCSHAU, Hisar |
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| Member Secretary | Head, Dairy Extension Division, NDRI |

FINANCE

The financial outlays in terms of actual expenditure for Plan and Non-plan for the year 2012-2013 was ₹ 13361.52 lakhs and the sanctioned budget for Plan and

Non-plan in 2012-2013 was ₹ 13367.50 lakhs. These figures include the financial outlays for strengthening of Deemed University and Regional Stations.

Financial Outlays & Expenditure during 2012-13

| Head | Budget | Expenditure |
|--------------|-----------------|-----------------|
| Non-Plan | 11277.50 | 11273.64 |
| Plan | 2090.00 | 2087.88 |
| Total | 13367.50 | 13361.52 |

The Revenue Receipts of the Institute and the Regional Stations for the year 2012-2013 were ₹ 743.67 lakhs

MANPOWER

Position of Manpower at NDRI, Karnal and its Regional Stations as on 31.03.2013

| Type of Posts | Existing Approved by D/o Expenditure | Existing In position | Vacant | Additional Proposed ** | Sanctioned + Additional | Total Existing + Additional |
|----------------------------|--------------------------------------|----------------------|------------|------------------------|-------------------------|-----------------------------|
| Scientific | 194# | 153 | 41 | 20 | 194+20 | 153+20 |
| Administrative (Group A&B) | 35 | 30 | 05 | - | - | - |
| Technical | 355 | 280 | 75 | 15 | 355+15 | 280+15 |
| Administrative (Group B&C) | 127 | 125* | 2 | 04 | 127+4 | 125+4 |
| Supporting | 755 | 579 | 176 | 11 | 755+11 | 579+11 |
| Total | 1466 | 1171 | 295 | 50 | 1431+50 | 1141+50 |

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

**26 posts of UDCs are in excess from the sanctioned strength of the post of UDCs



Hon'ble Secretary DARE and Director General ICAR, Dr. S Ayyappan giving convocation address

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

Multi-trait evaluation of Karan Fries Cattle

A total of 74 Karan Fries cows (37.2%) were selected as elite cows for nominated matings with an average 305-day milk yield as 4711 kg and average EPA as 4589 kg which were 8.3% and 7.4% higher than the herd average (4348 kg) and average EPA (4272 kg). The best 305 day milk yield ranged between 4070 and 8648 kg with an average of 5553 kg. A total of 7 KF male calves were reserved on the basis of EPD and 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 305 days lactation yield of reserved KF males ranged from 5065-6150 kg.

As many as 9 Karan Fries bulls of IX set were genetically evaluated based on 305-day milk yield using BLUP. Three bulls viz. 6479, 6418 and 6558 having genetic superiority of 16.12%, 5.89% and 4.80% above the average EBV (3460 kg) were selected and declared as proven. The heritability estimates of FL305DMY, FLTMY, FLL, AFC and FCI were 0.48 ± 0.14, 0.41 ± 0.13, 0.19 ± 0.11, 0.43 ± 0.13, 0.12 ± 0.11, respectively. The heritability estimates of production traits and AFC were medium to high. (>0.40 to 0.60) indicating sufficient additive genetic variability for these traits in the herd, hence there is considerable scope for improvement by selection. The phenotypic trends for FL305DMY and TLMY were positive and significant. It revealed that FL305DMY and FLTMY increased at the rate of 20.74 kg (0.64% of HA) and 34.04 kg (0.90% of HA) per year during the period (1992-2009). The phenotypic trends for AFC, LL and CI were positive but non-significant.

A total no. of 2747 A.I were performed in KF and as a result 50.16 % conception rate was obtained under field conditions up to December, 2012. A total of 1135 (586 males and 549 females) KF calves were born in the farmers' herds and test day milk yield data on 104 Karan Fries daughters have been recorded for evaluation of bulls under field conditions.

Multiplication of Tharparkar Germplasm

Genetic analysis of productive and reproductive performance traits, lifetime and its predictability on the basis of first lactation traits revealed that the effect of season was not found significant whereas, the effect of period was found to be significant on first lactation traits. Parity effect was highly significant on all

lactation traits revealing an increase in total milk yield (TMY) and 305DMY associated with reduction in dry period (DP) and service period (SP) up to 4th parity. Overall a declining trend was observed in lactation milk yield, herd life (HL) and productive life (PL) in later periods as compared to earlier periods. The heritability was estimated using raw and adjusted data (season and period) and also by adjustment for season only. It was observed that with adjustment for period effect the reduction in sire variance was more in comparison to the reduction in error variance without adjustment. In first lactation traits (FLT), h^2 estimates were found to be lower for reproductive traits. In case of lifetime traits, the lowest h^2 (0.1-0.04) was found to be for actual lifetime milk yield per day of productive life (ALTMY/PL) and the highest (0.64-0.41) for ALTMY. The phenotypic correlations between various first lactation traits (FLT) and lifetime traits (LTT) were highly significant. The genetic correlations were not much reliable because of higher standard errors. Prediction equations were developed for prediction of life time performance on the basis of different combinations of FLT. For prediction of LTMY up to two lactations, R^2 value of 73.3% was obtained by using age at first calving (AFC) and first lactation total milk yield (FLTMY) as independent variables. For first lactation traits of AFC, FLTMY, 305DMY and MY/FLL, rank correlations (0.95, 0.99, 0.96 and 0.99) amongst rankings of sires based on breeding value estimated by using raw or adjusted data on daughters' first lactation records revealed almost similar ranking of sires.

Molecular Characterization and Identification of Polymorphism in Mastitis Related Genes

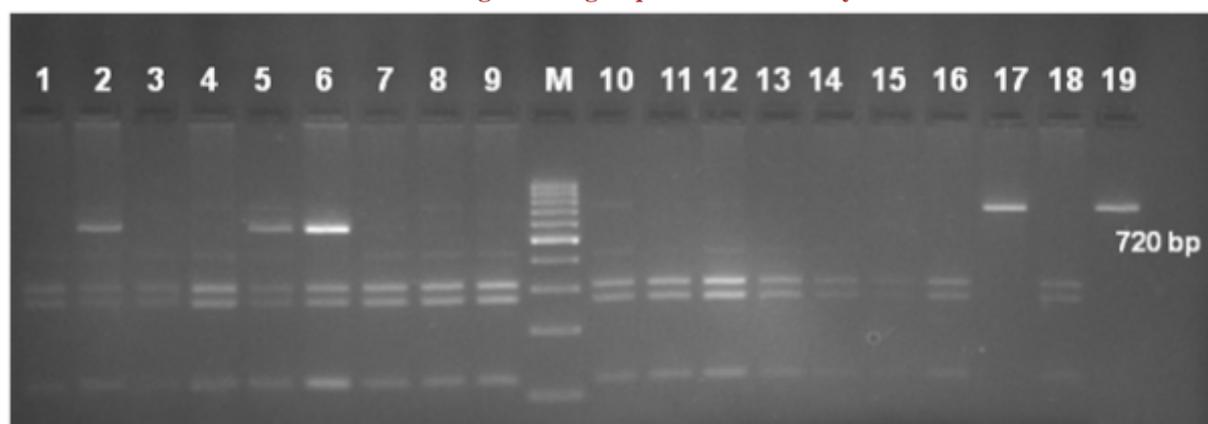
Identification of polymorphism in S100A8 (calgranulin A) gene and its association with mastitis in Murrah buffalo: Calgranulin A (S100A8) gene of Murrah buffalo was characterized using five sets of primers to obtain contigs of 449, 489, 514, 557 and 323 base pairs respectively. The changes from the reference sequence were substitutions at position 154 (G to T) and 194 (A to T) in flanking region and insertion at position 1352 (C_T to CTTT) in intron 1 of the gene making it 2069bp long. However, there was no change in the coding region, no change was found in amino acid sequence. PCR-RFLP analysis using *HinfI*, *AluI*, *MboII*, *PvuII*, *Eco0109I*, *BsmFI* and *HaeIII* restriction enzymes revealed monomorphism in all 150 Murrah animals. Due to monomorphic patterns of all the RFLP products, it was not feasible to carry out association with the incidence of mastitis in the animals

included in this study. The BLAST analysis of the complete sequence of the gene revealed 97%, 96%, 91%, 90%, 86% and 80% homology with *Bos taurus*, *Bos grunniens*, *Canis lupus familiaris*, *Equus caballus*, *Homo sapiens* and *Sus scrofa* respectively.

Molecular characterization and FEZL gene polymorphism in Murrah buffalo: One hundred lactating Murrah buffaloes were studied to characterize the coding regions and identify DNA polymorphism in FEZL gene and to analyze association between genetic variants with incidence of mastitis in Murrah buffalo. Four sets of primers were designed by using primer3 software to cover complete coding region of FEZL gene. The annealing temperatures ranged from 53°C to

58°C. PCR products were obtained with sizes of 554, 474, 685 and 720 base pairs for respective primers (I-IV). A total of 14 changes were found, out of which 6 in intron 1; 5 in intron 3 and 3 in non coding region of exon 4. The remarkable changes from the reference sequence were deletion of three bases CCA at position 2600, an insertion of three bases TCT in intron 3 at position 3152-3154, 5 bases GAAAA after nucleotide position 4365 and a stretch of 14 bases TAAACAGAATCTTA after nucleotide 4684 of *Bos taurus* sequence. The coding sequences were translated into amino acid sequence by using ExPASy translate tools and the resulting amino acid sequence was aligned with corresponding sequence of *Bos taurus* by ClustalW2. Changes at two amino acids viz glutamic

PCR RFLP of Primer 6 of FEZL gene using *MspI* Restriction enzyme in Murrah Buffaloes



| | | |
|--------------------------------|---|-------------------------------|
| Lane 17 | : | AA (720 bp) |
| Lane 1, 3-4, 7-9, 10-16 and 18 | : | BB (110, 280 and 310 bp) |
| Lane 2, 5-6 | : | AB (110, 280, 310 and 600 bp) |
| Lane 19 | : | PCR product (720bp) |
| Lane M | : | 100 bp DNALadder |

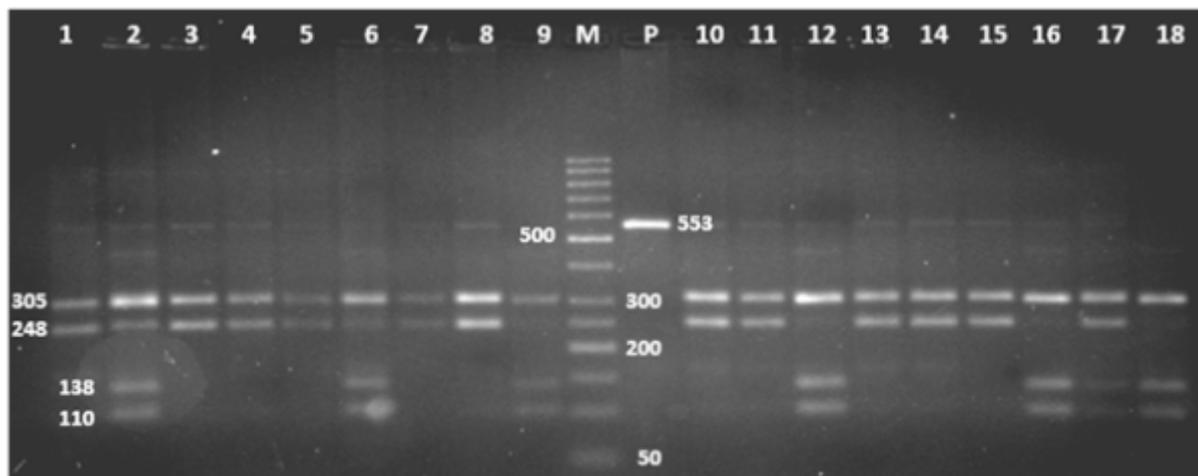
acid to valine and lysine to arginine at positions 329 and 330 respectively were observed.

PCR-RFLP analysis using *Dra I*, *Msp I* and *Taq I* restriction enzymes revealed polymorphism in three and monomorphism in four primer-restriction enzymes combinations. *TaqI* revealed polymorphism in primer 3.1 revealing AA, AB and BB genotypes, while primer 6 exhibited AA and BB genotypes with varying genotypic and allelic frequencies. *MspI* also revealed polymorphism in primer 6 having AA, AB and BB genotypes with varying genotypic and allelic frequencies. Primers 3.1, 3.2 and 4-5 did not have any restriction site with *DraI* enzyme. However, these primers have 3, 4 and 2 cutting sites with *MspI* enzyme but revealed monomorphic patterns. Polymorphisms in three primer-restriction enzymes combinations were revealed in exon 1 and 4 of FEZL gene in Murrah

buffalo. The polymorphic pattern in P6-*MspI* was found to be significantly associated with incidence of mastitis. Moreover, the animals with AA genotypes have been found to be more resistant to mastitis as compared to AB and BB genotypes.

Molecular characterization and CD14 gene polymorphism in Sahiwal cattle: Genomic DNA from 100 lactating Sahiwal cattle was subjected to PCR amplification using six sets of primers to yield overlapping fragments of 711, 553, 613, 832, 825 and 747 bp covering the complete 2630 bp of Cluster of Differentiation (CD14) gene. Sixteen nucleotide changes (SNPs) were observed in CD14 gene in Sahiwal cattle when compared with reference sequences of *Bos taurus*. Out of these SNPs four were in coding region with synonymous mutation. Two SNPs were found heterozygous at position 418 (A/C)

PCR-RFLP of contig 2 region of CD14 gene using *Hpy188I* restriction enzyme in Sahiwal Cattle



| | | |
|--------------------------------|---|-------------------------------|
| Lane 1, 3-5, 7-8, 10-11, 13-15 | : | AA (305 and 248 bp) |
| Lane 2, 6, 17 | : | AB (305, 248, 138 and 110 bp) |
| Lane 9, 12, 16, 18 | : | BB (305, 138 and 110 bp) |
| Lane M | : | 50 bp DNA Ladder |
| Lane P | : | PCR product (553 bp) |

and 2276 (C/T).

PCR-RFLP analysis was done using three restriction enzymes (*HinfI*, *HaeIII* and *Hpy188I*). *HinfI* RE showed monomorphic pattern in contig 1, 2 and 5 and polymorphic pattern in contig 4 with three genotypes (CC, CD and DD). *HaeIII* RE showed only monomorphic pattern in contig 3 and 6. *Hpy188I* RE showed polymorphic pattern in contig 2 with three genotypes (AA, AB and BB) and monomorphic pattern in contig 4. Gene frequencies of C (65.5%) and A (79%) allele were found comparatively higher in contig 4-*HinfI*. Genotypic frequencies of AA (69%) and CC (54%) genotypes were found highest in contig 2-*Hpy188I*. Chi-square analysis revealed that CC, CD and DD genotypes of Sahiwal cattle differ significantly regarding mastitis incidence. CC genotyped animals were found less susceptible to mastitis incidence. AA, AB and BB genotypes were also found significantly different for the incidence of mastitis using chi-square analysis. AA genotyped animals were also found less susceptible as compared to AB and BB genotypes.

Cytogenetical screening of pre-pubertal animals of cattle, buffaloes and goats for early detection of reproductive disorders: Chromosomes were evaluated of young calves (81) comprising of different breeds of pure and crossbred cattle and riverine buffalo (both male and female) with cytogenetical and molecular techniques. Chromosome preparations were made by short term lymphocyte cultures set up from Sahiwal (24), Tharparkar (17), Karan Fries (20) and

Murrah (20) calves using RPMI-1640 media with aphidicolin. The presence of fragile sites was confirmed by R-banding and PCR amplification using seven fragile site specific primers: IDVGA82, F9, XIST, DMD, IL1RAPL1, FMR1 and HPRT1. Fragile sites were found in 19.36%, 18.91%, 20.95% and 20.67% of total screened metaphase plates in Sahiwal, Tharparkar, Karan Fries and Murrah groups of calves, with mean of 19.27 ± 1.63 ; 18.89 ± 2.48 ; 21.28 ± 2.21 and 20.66 ± 2.34 respectively. Further fragile X-chromosomes were found in 65.08%, 72.28%, 70.63% and 78.21% of these plates showing fragile sites, respectively. Molecular analysis of sixteen (16) calves showing fragile sites in more than 30% of metaphase plates in cytogenetic investigation using primers IDVGA82, F9, XIST, DMD, IL1RAPL1, FMR1 and HPRT1 showed PCR amplification in 56.25%, 81.25%, 68.75%, 75%, 31.25%, 12.5% and 31.25% of cases, respectively. In the study, 31 calves were found with higher than 20% gaps and breaks in their chromosomes (autosomes) besides fragile sites (in X-chromosomes) and are expected to have reproductive problems. Chromosome evaluation was carried out on 27 heterosexual twin born calves, which showed XX / XY chimaerism and the owners were informed about their sterility status. Two calves at birth had multiple anomalies, chromosomes preparations were made and detailed analysis is in progress. One amorous buffalo heifer showed 49, XO chromosomes pattern. DNA repository for all these animals has been stored at low temperature freezers.

Indigenous Breed Project on Sahiwal Cattle

The first set of 8 Sahiwal bulls has been put under progeny testing at germplasm unit and five data recording units. The dam's best 305 days or less milk yield of these bulls ranged from 2503 (first lactation) – 3704 kg. A total of 2136 semen doses have been provided to various data recording units during last year. A total of 2015 AIs have been done in all the centres including germplasm unit with the semen of these bulls till date and a total of 734 pregnancies have been recorded. The overall average conception rate of 36.43% was observed in various herds. The average conception rate was 27.96% at GADVASU, Ludhiana; 41.5% at GLF, Lucknow; 38.80% at GLF, Hisar; 25.70% at GBPUAT, Pantnagar and 26.71% at Gaushala Bhiwani. The average conception rate at the NDRI Karnal was 40.68%. A total of 138 daughters have been born at different herds, out of which 93 daughters were born at the five data recording centres and 45 daughters were born at the germplasm unit. Forty nine elite cows (26% of the Sahiwal herd) were selected during the last year having average best lactation 305 day milk yield of 2562.42 kg and average EPA of 2276.36 kg at NDRI Karnal. The overall population means for age at first calving, first lactation total milk yield, first lactation 305 day or less milk yield, first lactation length, first peak yield, first dry period, first service period and first calving interval at NDRI farm were 1190.33 ± 23.30 days, 1760.39 ± 144.99 kg, 1671.63 ± 131.46 kg, 297.32 ± 16.45 days, 9.46 ± 0.72 kg, 155.78 ± 20.97 days, 121.50 ± 16.32 days and 387.95 ± 11.32 days, respectively. Ten young male calves were selected as future bulls with their EPD ranging from 1.73 – 14.12% and dam's best 305 day milk yield ranging from 2749 – 3929 kg. The prediction equations to predict first lactation 305-day milk yield on the basis of monthly part lactation yields were developed in Sahiwal cattle. The optimum equation having monthly part lactation records for second, fifth and eighth months had the accuracy of prediction as 88.8%.

Network Project on Buffalo Improvement (Institute Unit)

The breeding programme in the Murrah herd was followed for test mating using semen of seven and two test bulls of XIII and XIV set at the institute herd and the test mating was continued up to March, 2013. The dams' best lactation 305 days or less milk yield of the test bulls of XIII and XIV set had ranged from 2510 to 4470 kg and 3567 to 4341 kg, respectively. Average age at first service of buffaloes was 30.01 months and average age at first calving of buffaloes was 41.58

months. Average age for initiating training of the young bulls and age at first collection has further reduced to 24.11 and 29.02 months. The average service period of buffaloes has been estimated as 127 days. The overall female conception rate of the herd was 43.06%. Eighty Three daughters and Fifty male calves were born in the herd. The wet and herd average was to 7.35 kg and 4.63 kg, respectively.

A total of nine Murrah male calves were reserved during the period (2012-13) on the basis of Expected Predicted Difference and dam's best 305 days 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 2557 in first lactation to 3067 kg. The EPD and superiority of reserved Murrah male calves ranged from 19 to 142 Kg and 0.90 to 6.19 %, respectively. Four bulls from NDRI centre have been included in XIV set with their dams best 305 day or milk yield ranging from 3072 to 4341.

Genetic evaluation of IX set of 15 Murrah bulls using contemporary comparison method was completed and Bull MU 5258 having sire index of 2466.2 kg and dam's best lactation 305 days milk yield of 3305 kg was declared as second best ranking proven bull with 10.52% superiority over contemporary daughters. The information on 305 days milk yield of daughters were collected and compiled for X set of bulls. A total of 57 (41.30 %) Murrah buffaloes were identified as elite animals. These 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 2991 kg which was 39.18 per cent higher than the herd average (2149 kg). The best lactation milk yield of elite Murrah buffaloes ranged between 2504 to 4341 kg. The Voluntary Waiting Period (VWP) i.e days to first service is the initial phase of lactation during which no inseminations occur, voluntarily left by the management for better pregnancy rate was considered as 63 days for Murrah buffaloes. The pregnancy rate and milk production/productivity in Murrah buffaloes showed no linear trend of milk yield/wet average in the herd as the pregnancy rate varied from 32% to 37% over the years (1993-2011). The results revealed that to achieve around 2000 kg lactation milk yield or 7.5 kg wet average the level of fertility should be in between 30% - 50 %. The increase of milk production/productivity is associated with decline in fertility (pregnancy rate). The result also showed that with the increase of 100 kg milk yield in lactation or 1 kg milk yield per day per buffalo the level of fertility (PR) declined from 1.7% to 4.4% and 0.3% to 1.4%, respectively. The decline of

milk production/productivity was found maximum with the increase of pregnancy rate in first parity and minimum in fourth parity of Murrah buffaloes.

The center has produced 60,355 doses of frozen semen of which 15,410 doses of frozen semen from five test bulls and has supplied 900 doses of frozen semen to other centers. In addition 3882 doses of semen were supplied to NDRI field unit and 22,361 doses of frozen semen to farmers and other dairy development organizations during the period. The germplasm of genetically superior progeny tested proven bulls has been 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 the Center has also been used by various dairy development agencies and dairy farmers for bringing genetic improvement of Murrah buffaloes.

Network Project on Buffalo Improvement (Field Unit)

A total of 2792 AI were performed in Murrah buffaloes under field conditions and as a result 44.53 conception rate was obtained. The highest conception rate was observed in the month of March (68%) and the lowest was in the month of September (44.62%). Across the villages, the highest conception rate was observed in Rindal (54.08%) and lowest was observed in the village Shekhpura (38.15%). A total of 1120 (573 male and 547 female) Murrah buffalo calves were born in the farmers' herds and performance data on 138 daughters have been recorded for evaluation of bulls under field conditions. As many as 15 breeding bulls belonging to the 12th set were used for AI during the year.



A daughter from Murrah bull born under field conditions

Fluorescent *in situ* hybridization (FISH) and Associated Techniques for Characterization of Chromosomes for Detection of Genetical and Reproductive Problems in Cattle, Buffalo and Goats

Investigations were carried out for identification and inheritance pattern of fecundity genes in cattle, with comparison of DNA fragment between dams bearing twin and singleton. The study involved analysis of genome related to twinning using molecular markers (PCR-RFLP and SSCP) on BMPR-1B, BMP-15 and GDF-9 genes pure (Sahiwal and Haryana) and three crossbreeds (Karan Swiss, Karan Fries, Holstein Friesian) besides other cross breeds of unknown lineage selected from field. Molecular study was carried out using 18 primers on the DNA of 51 animals out of which 20 were experimental dams, 6 were control dams and 25 were twin progenies. PCR-RFLP analysis of Exon 6 of the BMPR-1B gene using *AvaII* revealed monomorphic band pattern of the wild-type allele in the sampled animals. Two of the BMP-15 mutation alleles FecXG and FecXI investigated using *HinfI* and *XbaI* revealed monomorphic pattern of the wild type allele for dams and their twin progenies. Exon 1 of the GDF-9 gene amplified to produce 462bp fragment and was subjected to *HhaI* and *HinfI* restriction enzyme which revealed homozygous pattern of the mutant allele. PCR-SSCP analysis of the BMPR-1B gene detected monomorphic pattern for this gene mutation. The progenies inherited similar monomorphic band from their dams for this gene locus. In BMP-15 locus polymorphic band pattern were detected for one region, while two other regions showed monomorphic pattern for this gene locus. SSCP pattern analysis for bovine *Bmp-15* gene revealed monomorphism for two regions in exon 1 and exon 2, while one region in exon 2 revealed polymorphic pattern in both experimental and control dams. PCR analysis of the FecXR allele of the BMP-15 gene detected the presence of wild-type allele in the dams and their progenies. An allele specific primer used for detection of GDF-9 gene mutation, identified only wild-type and control fragment which revealed the absence of the mutant fragment for this gene locus. The study on the three fecundity genes BMPR-1B, BMP-15 and GDF-9 did not show association with twinning trait in cattle.

ANIMAL BIOTECHNOLOGY

Faster Multiplication of Superior Germplasm for Development of National Milch Herds 'Garima-II' a Cloned Buffalo Gives Birth to a Normal Calf

'Mahima', a female calf weighing 32 kg was born on January 25 to 'Garima-II' a cloned buffalo, which had been produced by Hand-guided cloning using

embryonic stem (ES) cells as donor cells. This is the first calf in the world to be born to a cloned buffalo. 'Mahima' was born through normal parturition. Garima-II, the mother, who was born on August 22, 2010 attained sexual maturity at 19 months of age, which was much earlier than the average age of around 28 months at which buffaloes attain maturity. She was inseminated with frozen-thawed semen of a progeny tested bull of NDRI (No. 1875) on March 27, 2012, which resulted in conception. She was maintained under standard scientific management system during her gestation.



Mahima' with her mother Garima-II

Cloning and Expression Analysis of NANOG in Putative Buffalo ES Cells

NANOG c-DNA (open reading frame, ORF) was characterized, cloned and over-expressed in putative buffalo ES cells. Different feeder layers were prepared and their potential was assessed by growing the ES cells on them. Two ES cell lines (S-line and M-line-II) were established which survived up to 98th (~630 days) and 97th (~624 days) passages, respectively. The relative abundance of the pluripotency genes was higher in the early passages of ES cells than in late passages. The NANOG ORF of buffalo ES cells was amplified, cloned and sequenced. The total length of buffalo NANOG ORF was 903bp. The buffalo NANOG ORF sequence was found to have nucleotide similarities with cattle (99%), goat (97%), pig (85%), human (79%) and mouse (79%). The 3'UTR region of NANOG gene was characterized, which consisted of 566bp long sequence. Buffalo NANOG ORF was further cloned in eukaryotic expression vectors CT-GFP-TOPO fusion and pCAGGS-PGKNeo. Further, LIF and FGF2 ORFs were also amplified, sequenced and then cloned in a eukaryotic expression vectors pAcGFP1N1 and CT-GFP-TOPO fusion, respectively. Initially, NANOG, LIF and FGF2 constructs were transfected to various cell types like CHO-K1, COS-1 and buffalo adult fibroblast cells for their expression. Finally, NANOG (human and buffalo), LIF and FGF2 constructs were transfected to buffalo fetal fibroblast

(BFF) feeder layers and ES cells. Results indicated that NANOG, LIF and FGF2 constructs expressed the gene of interest which was validated by RT-PCR and real time PCR. The transgenic BFF feeder layers and ES cells were generated carrying NANOG, LIF, and FGF2 gene construct(s). The colony area (μm^2) of ES cells grown on BFF feeder layers transfected with NANOG, LIF, and FGF2 construct was higher than the ES cells grown on non-transfected BFF feeder cells. Over-expression of NANOG in buffalo ES cells up regulated the expression of NANOG, LIF, c-Myc and FoxD3 and down regulated the expression of differentiation and regulatory genes (Cdx2, Gata6, Gcnf, Tcf3, p53, SMAD1 and SMAD2). The DNA methylation pattern at the 5' upstream region of buffalo NANOG gene was higher in the late passage of ES cells as compared to that in early passages.

Effects of Growth Factors on Self-Renewal and Gene Expression in Buffalo Spermatogonial Stem Cells (SSCs)

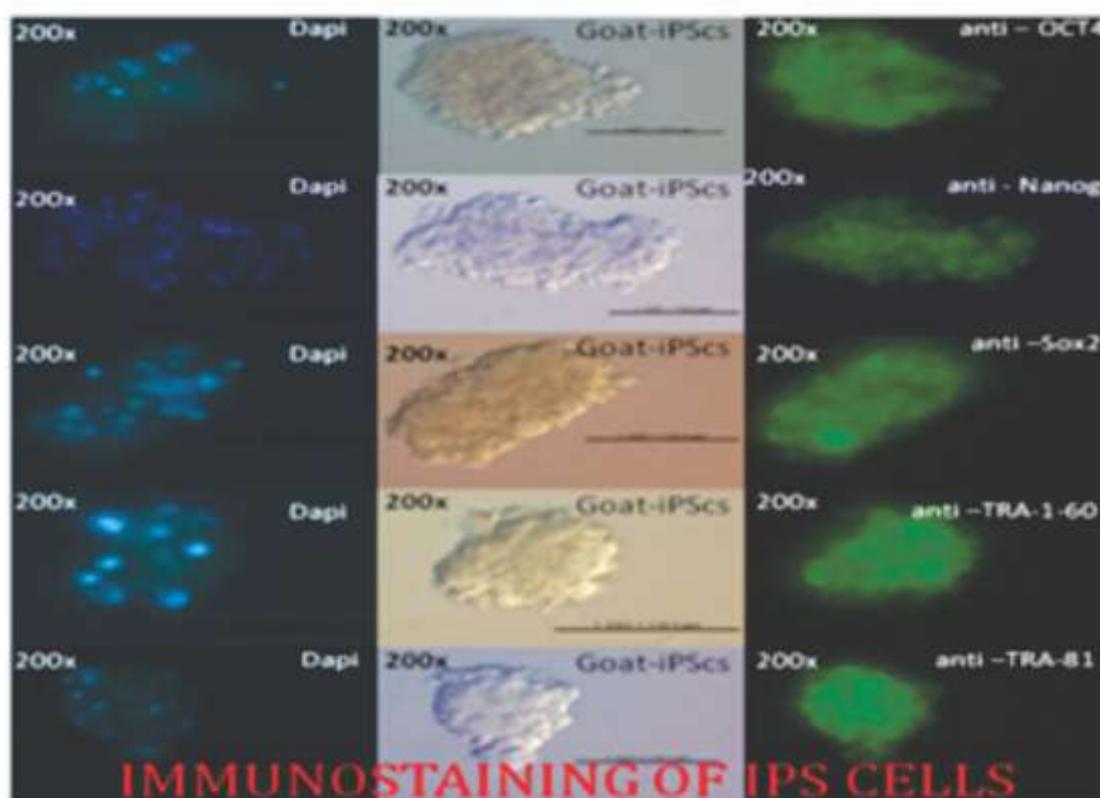
Effects of GDNF, FGF2 and EGF on self-renewal and proliferation of buffalo SSC colonies, and on gene expression in these cells were investigated. SSCs were isolated from pre-pubertal slaughterhouse buffalo testes, were enriched by filtering through nylon net filters, differential plating on lectin coated dishes and Percoll density gradient centrifugation. SSC-like cells were cultured on Sertoli cell feeder layer and characterized by examining the expression of alkaline phosphatase, pluripotent markers NANOG, OCT-4 and TRA-1-61, expression for DolichosBiflorus Agglutinin (DBA), a specific marker for type-A SSCs and absence of c-kit, a marker for differentiating spermatogonia. The effect of GDNF (40 ng/ml) or GDNF+EGF (10 ng/ml) or GDNF+FGF2 (10 ng/ml) or GDNF+EGF+FGF2 on the colony size and the expression level of some important genes in SSCs and of these growth factors individually on *ETV5* in Sertoli cells were investigated. The results of the present study suggest that i) SSC-like cells cultured on Sertoli cell feeder layer in the presence of growth factors such as GDNF, EGF and FGF2 are capable of undergoing proliferation during the course of 15-day culture, ii) the rate of proliferation is significantly higher in the presence of GDNF+EGF+FGF2 than when the medium is supplemented with EGF or FGF2 in combination with GDNF, iii) the expression level of *PLZF* in SSC-like cells is higher following supplementation with GDNF+EGF+FGF2 than when the medium is supplemented with GDNF along with EGF or FGF2, iv) the expression level of *TAF4B* is higher following supplementation with GDNF in the presence of EGF or FGF2 than with GDNF alone, v)

the expression level of *THY1* in SSC-like cells is not affected by GDNF, EGF and FGF2, together or in combination and vi) GDNF increases whereas EGF and FGF2 decrease the expression level of *ETV5* in Sertoli cells.

Production of Goat induced Pluripotent Stem (iPS) Cells

Goat iPS cells were produced by transfecting Nanog, Oct4, Sox2 and Lin28 to goat adult fibroblasts cells using lentiviruses. Characterization of iPS cells was

carried out by examining expression of alkaline phosphatase, intracellular markers Oct4, Nanog and Sox2 and, surface markers SSEA-1, SSEA-3, SSEA-4, TRA-1-60 and TRA-1-81. For directed differentiation of iPS cells to germ cell-like cells, embryoid bodies produced from iPS cells were cultured in the presence of retinoic acid and BMP-4. The germ cell-like cells generated were characterized by examining the expression of germ cell markers such as VASA, STELLA and PUM1 by immunofluorescence staining and Western blotting.



Isolation, Characterization and Differentiation of Goat Mesenchymal Stem Cells (MSCs)

MSCs were isolated from goat adipose tissue and were subjected to characterization and directed differentiation to different lineages. The Putative MSCs were examined for the expression of surface markers CD29, CD44, CD166, CD99 and CD34 by RT-PCR. Both fresh and cryopreserved MSCs were cultured to induce osteogenic, chondrogenic, adipogenic and neurogenic differentiation, which were characterized with their specific markers. Tests were performed using Alzarine dye, surface marker osteocalcin and collagen. MSCs were found to

differentiate into osteogenic cell lineages, which were further confirmed by RT-PCR analysis for osteocalcin, an osteocyte marker.

Buffalo LIF (BuLIF) was cloned, sequenced and characterized for the first time and expressed in COS-1 cell line for its stable expression. The BuLIF ORF is made of 609 nucleotides, which codes for 202 amino acids long peptide. The initial 22 amino acids represent signal peptide. The overall similarity of BuLIF with bovine, human and mouse is 92.00%, 83.38% and 72.74% at nucleic acids level and 98.52%, 89.66% and 77.45% at amino acids level respectively. Bioinformatics analysis indicates BuLIF to be a

glycosylated and phosphorylated molecule with six potential N linked glycosylation points and three Ser and three Thr phosphorylation points. LIF expression was optimized in COS-1 cells and stably transfected cells were selected which can produce buffalo recombinant LIF continuously.

Production of Cloned and IVF Embryos

A study was carried out to compare i) the post-thaw cryosurvival rate of *in vitro* produced zona-free cloned buffalo blastocysts using slow freezing and Open-pulled straw (OPS) and ii) the level of apoptosis in post-thaw cloned blastocysts cryopreserved by slow freezing or OPS vitrification. Zona-free cloned buffalo blastocysts produced by Hand-guided cloning were divided into two groups and were cryopreserved either by slow freezing in 5% ethylene glycol (EG) + 5% dimethylsulfoxide (DMSO) or by vitrification in OPS using an equilibration solution comprising 8.5% EG + 8.5% DMSO in T20 medium and a vitrification solution of 16.5% EG + 16.5% DMSO + 0.5 M sucrose. Cryosurvival of blastocysts was determined by their re-expansion rate following post thaw culture for 22–24h. The post thaw re-expansion rate was significantly ($P < 0.05$) higher following cryopreservation of zona-free cloned blastocysts by vitrification in OPS compared to that after cryopreservation by slow freezing. The total cell number was not significantly different among the fresh embryos and those cryopreserved by slow freezing or vitrification in OPS. However, the number of apoptotic nuclei, which was similar for embryos cryopreserved by slow freezing or vitrification was significantly ($P < 0.05$) higher than that for the fresh embryos. As a consequence, the apoptotic index was also similar for embryos cryopreserved by slow freezing or vitrification, and was significantly ($P < 0.05$) higher than that for the fresh embryos. The results of this study suggest that vitrification in OPS is better than slow freezing for the cryopreservation of zona-free cloned buffalo blastocysts since it offers much higher cryosurvival rate.

Procedures were standardized for *in vitro* production of tetraploid buffalo embryos and their developmental potential was examined. The *in vitro* development of aggregates of putative tetraploid buffalo embryos and buffalo ES cells was investigated. Among the combinations of pulse field strength and pulse duration examined for electrofusion of IVF or parthenogenetically generated 2-cell embryos, the highest blastocyst rate was obtained with 1.25 kV/cm pulse field strength and 99 μ sec pulse duration. Out of the 30 spreads of electrofused embryos examined, 5 (16.6%) were tetraploid whereas the rest 25 (83.3%) were not

tetraploid. Following culture of aggregates prepared from buffalo ES cells and 8- to 16-cell stage embryos derived from IVF or parthenogenesis, the blastocyst rate was 1/47 (2.1%) and 16/56 (28.5%), respectively. A study was carried out to i) determine the effect of heat stress on *in vitro* developmental competence, apoptosis and expression of some important genes was examined in a study. For each of the three experiments, the oocytes were divided into 3 groups. For controls (Group 1), IVM, IVF and IVC were carried out at 38.5°C whereas oocytes/embryos of experimental groups were exposed to 39.5°C (Group 2) or 40.5°C (Group 3) for 2 h once every day from 11.00 AM to 1.00 PM during the course of culture. In Experiment 1, the cleavage rate and the percentage of oocytes that developed to 8- to 16-cell and/or blastocyst was higher ($P < 0.05$) for Group 1 than that for Group 2 which, in turn, was higher ($P < 0.05$) than that for Group 3. In Experiment 2, the number of apoptotic nuclei was lower ($P < 0.05$) for Group 1 than that for Group 2 which, in turn, was higher ($P < 0.05$) than that for Group 3. In Experiment 3, among the heat stress-related genes, the expression level of *HSP 70.1* and *HSP 70.2* was increased and that of *HSF1* remained unaffected by heat shock in embryos. Among the genes related to development, the expression level of *ZP2* and *GDF9* was increased following heat shock. The expression level of *GLUT1* and *ZARI* remained unaffected at 8- to 16-cell stage but was increased at blastocyst stage following heat shock whereas that of *BMP15* was not affected at both stages. Among the apoptosis-related genes, the expression level of *BCL-XL*, *MCL-1*, *CASPASE-3*, *BID* and *BAX* was increased in embryos following heat shock. The results of this study suggest that embryonic development is adversely affected by heat shock induced by exposure to elevated temperatures at physiological level and that the mechanisms through which the adverse effects of heat shock are mediated include increased apoptosis and alteration in the expression of certain genes in the embryos.

In a study to examine the effects of oxamflatin and suberoylanilide hydroxamic acid (SAHA) treatment on production of Handmade cloned goat embryos, following supplementation with oxamflatin (0.5, 1 or 2 μ M), the highest yield of 8 to 16-cell stage embryos was observed at the concentration of 0.5 μ M whereas in case of SAHA (0.5, 1.0 or 2.0 μ M), the highest embryo yield was observed at 1.0 μ M concentration. Examination of the expression level of genes in morula stage embryos by qRT-PCR revealed that oxamflatin and SAHA (0.5 and 1.0 μ) significantly ($P < 0.05$) reduced the expression of pro-apoptotic genes *BAX* and

CYTOCHROME C, increased the expression of anti-apoptotic gene *BCL-2* and that of development-related genes *OCT4* and *SOX2*. Caspase-3 expression did not differ significantly among oxamflatin, SAHA and control groups. In another study, gene expression was compared between goat embryos produced by IVF or parthenogenesis. Expression of Oct4, IGF-1R, STAT3, MnSOD, DNMT1, Hsp70.1 and Cx43 was examined by RT-PCR in 2-, 4-, 8 to 16-cell, morula and blastocyst stage goat embryos. Microarray study was also performed in embryos at different stages of development. IVF embryos and data were analysed. These genes were found to be expressed in all the stages of goat embryos produced by IVF or parthenogenesis.

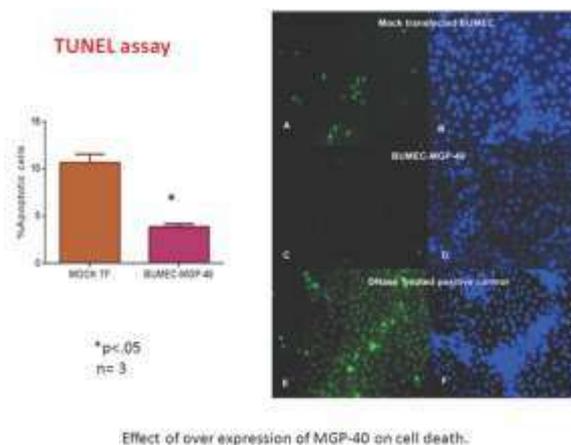
Genetic Improvement of Milch Animals through Identification and Dissemination of Superior Germplasm by Application of Emerging Reproductive and Molecular Technologies

A buffalo mammary epithelial cell (BuMECs) line was established and was maintained long-term in culture. BuMECs isolated from lactating buffalo mammary glands were cultured on a collagen matrix gel. The cells expressed significant amounts of epithelial cell-specific marker cytokeratin 18 as determined by immunohistochemistry. The BuMECs displayed monolayer, cobble-stone morphology, and formed lumen-, dome-, and duct-like structures. Furthermore, they were capable of synthesizing CSN2, BLG, ACACA, and BTN1A1, showed viability after thawing and expressed milk protein genes. The enhanced green fluorescent protein gene was transferred successfully into the BuMECs using lipofection method and the transfected cells could be maintained for long-term in culture by subculture. A hINS mammary gland specific expression vector was generated and its function was validated in BuMECs. Human pro-insulin cDNA was cloned from its genomic gene and mutated by overlap extension PCR for introducing furin consensus cleavage sequences (Arg-X-Lys-Arg). A mammary gland-specific buffalo beta-lactoglobulin promoter was used to drive expression of recombinant human insulin in BuMEC cell line. For buBLG promoter efficiency detection, one more CMV promoter regulated gene construct was also prepared for insulin expression. Both gene constructs were transferred into a BuMEC cell line by liposomal transfection and were cultured with G418 for 3 weeks to obtain positive transgene cell clones. The hINS expression in cell clones was confirmed by RT-PCR, Immunocytochemistry, Western blotting and ELISA. The pAcISC insulin-expressing clones secreted insulin at varying levels between 0.23-2.88 ng/ml/24 h/2.0x10⁶

cells whereas the pAcISUBC insulin expressing clones secreted insulin at concentrations between 0.18-1.43 ng/ml/24 h/2.0x10⁶ cells.

Functional characterization of MGP-40, a chitinase-like protein expressed during mammary gland involution

Regulation of MGP-40 expression in BuMECs was analysed by qRT-PCR which revealed significant up regulation in serum-starved conditions compared to normal cells. Prolactin induced MGP-40 expression but estrogen and progesterone had no effect. MGP-40 ORF was cloned from mammary gland and was expressed in buffalo mammary epithelial cells for over expression studies. Over expression of MGP-40 reduced development of dome and polarized acini-like structures under 2- and 3-D cultures, respectively. It also reduced both beta- and kappa- casein expression in BuMECs suggesting that MGP-40 inhibits differentiation of these cells. Current investigation also provides evidences for a protective role of MGP-40 in mammary epithelial cells by reducing apoptosis (TUNEL and Annexin V assay) and increasing proliferation (BrDU assay) under serum-starved conditions. MGP-40 activated PI3 AKT pathway, which is involved in fundamental cellular processes including protein synthesis, proliferation and survival and its over expression in BuMECs induced epithelial-mesenchymal transition like features and activated STAT 3 phosphorylation suggesting a role for this protein in maintaining the progenitor cells in the mammary gland.

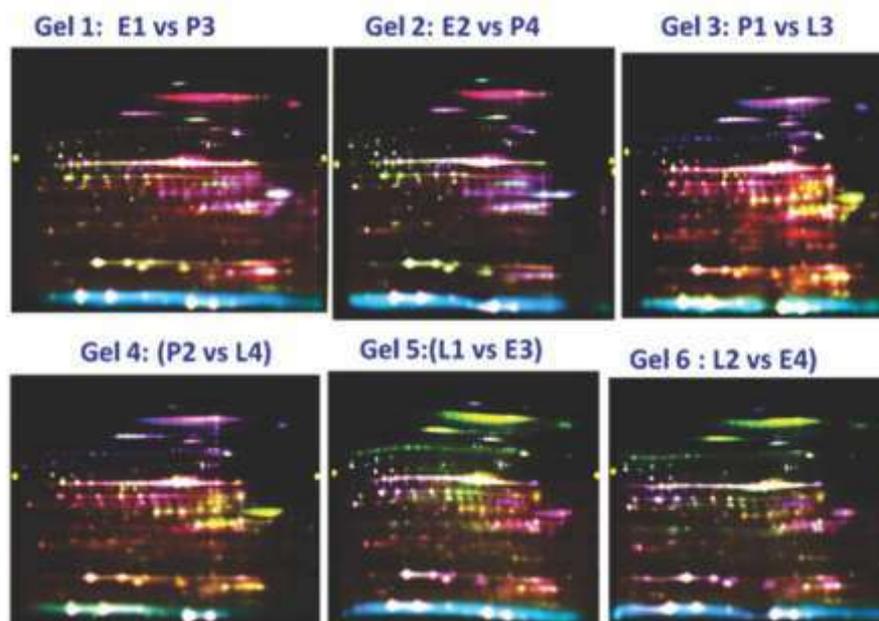


Comparative Proteome Analysis of Bovine Mammary Epithelial Cells (MEC) at Different Stages of Lactation in Cows to Understand Lactation Persistency

To understand the lactation persistency of cows, proteomic changes were studied in Bovine Mammary

Epithelial Cells (MEC) at different stages of lactation by differential gel electrophoresis (DIGE) followed by identification of the proteins by mass spectrometry. MECs were isolated from milk of 4 Sahiwal cows from each stage which constituted early, peak and late (30, ~70 and 250 days in lactation, respectively) using immunoaffinity-based methods. Protein samples were prepared from isolated MECs and subjected to isoelectric focusing in pH 4-7 gels. A total of 1523 resolved protein features, for different stages of lactation, were matched across 6 gels. These included many isoforms that resulted from charged post-translational modification and/or processing. A comparison of bovine MEC at different stages of lactation allowed identification of 44 proteins whose expression varied with the stage of lactation. The most strongly regulated proteins were cytoskeletal components, regulators of protein folding and stability, calcium-binding proteins, and regulators of cellular

metabolism. PCA was used to reduce the dimensionality of a multidimensional analysis to display the two principle components that distinguish between the two large sources of variation within the dataset. For the 44 features identified in the experiment, the first principle component distinguished 54.9 % of the variance with 40.6 % additional variation distinguished by the second principle component. Categorization of differentially expressed proteins for early, peak and late stages showed that more than one-third of identified bovine MEC proteins account for binding activity, which is essential for cell-cell interaction, cell-matrix interaction which plays role in growth, development and remodeling of mammary gland throughout the stages of lactation and rest are involved in structural molecule activity, catalytical activity, enzyme regulator activity, receptor activity and motor activity.

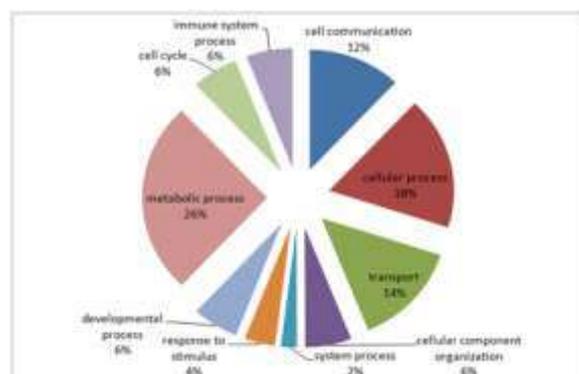


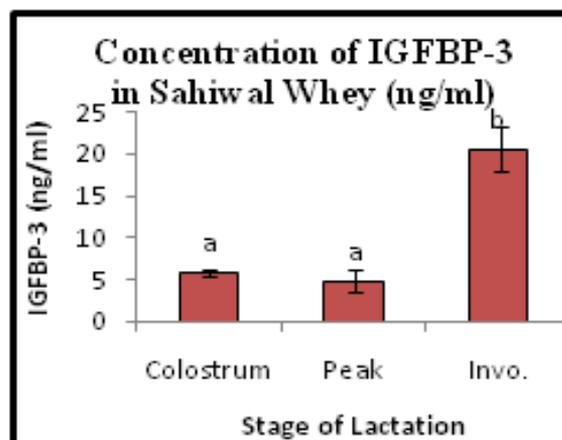
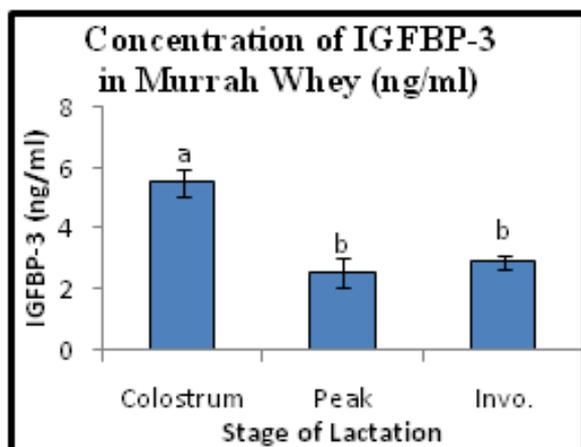
DIGE analysis of early vs peak vs late samples. DIGE images were scanned after SDS-PAGE. The gels were scanned using all the three lasers corresponding to Cy2, Cy3 and Cy5 wave lengths. The images were taken at 200 μ resolution. The green colour are down regulating and red colour spots represent up regulation.

Categorization of differentially expressed proteins at different stages of lactation based on the molecular function

Expression Analysis of Insulin-Like Growth Factor Binding Proteins (IGFBPs) in Milk of Murrah Buffaloes and Sahiwal Cows During Lactation

Expression profiling of different IGFBPs was carried out during lactation in Sahiwal cows and Murrah buffaloes to understand their role in lactation persistency and explore their source in milk. Milk





Comparison between colostrum, peak and involution stages of lactation in Murrah buffaloes and Sahiwal cows

samples were collected from lactating animals at different lactation stages (colostrums, 15, 50, 100, 150, 200, 250 and 300 days, and involution) and were used for whey preparation and RNA isolation and quantification and qRT-PCR studies. Higher IGFBP-3 expression during late lactation and involution suggested its possible role in lactation persistency. Buffalo IGFBP-2 exhibited a similar pattern suggesting that it may have a role in lactation. However, the same could not be detected at transcript level which suggests that epithelial cells may not be its site of synthesis. IGFBP-4 was predominantly expressed both at protein and transcript level, with the highest concentration at colostrum stage but its correlation with lactation persistency needs to be established. IGFBP-6 expression remained non-uniform during the whole lactation without any significant difference and was not detected at the transcript level. Increased IGF-I expression during late lactation and involution suggested another possible reason for more lactation persistency in Murrah than in Sahiwal. The overall expression of IGFBPs was higher in cattle than in buffaloes.

Research on Nutraceuticals from Milk, Functional Foods with Prebiotics, Probiotics, Micronutrients, and other Bioactive Compounds for Improved Human Health

Recombinant expression and characterization of X-prolyl dipeptidyl aminopeptidase (PepX) of *Lactobacillus helveticus* NCDC292

Aminopeptidases such as PepX are considered to be an important component of proteolytic system of probiotic *Lactobacilli*. Many proline-containing peptides are bitter and their hydrolysis by proline-specific peptidases may remove or reduce bitterness in enzyme-modified cheese. The biologically active recombinant PepX (Mol wt - 90.5 kDa) of *L. helveticus*

NCDC 292 was cloned, expressed and purified for the production of novel antibacterial and antioxidant peptides from proteins of milk and food origin. The ORFs of PepX gene were amplified and cloned in *E. coli* using pET22b+ expression vector. The PepX gene was expressed at a high level in *E. coli* BL21 and purified to homogeneity using affinity (Ni-NTA) and anion-exchange (MonoQ) chromatography. Enzyme activity was observed by using 2 mM of L-glycyl-L-prolyl p-nitroanilide (Gly-Pro-pNA) in 0.1M Tris/HCl (pH 6.5) buffer at 37°C. Optimum pH and temperature of PepX activity was 6.5 and 37°C respectively. We observed a K_m and V_{max} of PepX with the above substrate to be 0.4 mM and of 0.96 mM min⁻¹ respectively.

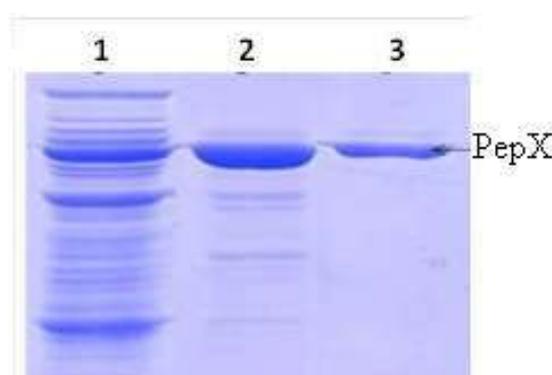
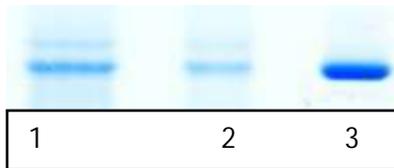


Figure: Expression and purification of PepX: SDS-PAGE shows the purified PepX protein in Unbound fraction (Lane 1), Partially purified PepX using Ni-NTA affinity chromatography (Lane 2), and PepX purified by MonoQ anion exchange column (Lane 3).

Recombinant Expression of Buffalo Sperm Acrosome-associated 3 (SPACA3) Protein

The c-lysozyme like testicular protein, SLLP1 (Sperm Lysozyme Like Protein) is encoded by SPACA3. The molecule is a potential candidate for fertility augmentation or contraception. Therefore, buffalo Spaca3/SLLP1 was cloned, expressed and purified.

Buffalo Spaca3 cDNA (Accession No. BC149686) was cloned in yeast expression system. The recombinant SLLP1 was secreted into medium from where it was purified by using a combination of chromatographic techniques. The recombinant SLLP1 protein was found to have a mol.wt. of 14-15 kDa on SDS-PAGE. Polyclonal antibodies against human SLLP1 crossreacted strongly as visualized by western blotting. The mass-spectrometric analysis also identified the expressed protein to be SLLP1. The level of expression of the recombinant protein is being optimized at fermenter level for studying the role of the protein in sperm-oocyte interaction and its localization in the pre-fusion and post-fusion events.

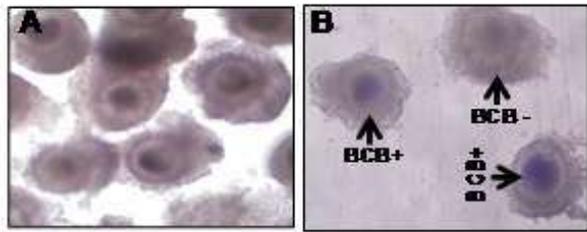


Expression and purification of buffalo recombinant SPACA3/ SLLP1 protein. Lane1 - recombinant SLLP1 concentrated by acetone, Lane2 - recombinant SLLP1 as secreted in medium, Lane3 - Hen egg white Lysozyme as a marker.

Genomics of Buffalo Follicular Cells and Oocytes

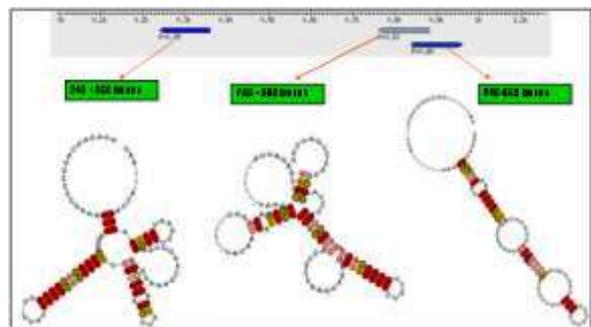
Screening good quality oocytes out of a pool of oocytes is crucial for optimum *in vitro* fertilization success. A method has been optimized where the buffalo oocytes were exposed to a cationic quinine imide dye, Brilliant Cresyl Blue for 90 minute which resulted in either the blue or white coloration of oocyte cytoplasm depending on the net transcription rate in oocytes. The results indicated that with increasing concentration of BCB the distinction rate between BCB+ and BCB- oocytes increased. This raised a possibility that up to what level of BCB it is not detrimental for the oocytes to compromise with their development ability. By comparing the M-II, Cleavage, 8 cell, Blastocyst and Hatched blastocyst percentage of control, 20µM, 26µM, 32µM of the BCB stain, it was very apparent that that BCB staining did not interfere the growth of oocyte and the embryos. The difference between BCB+ and BCB- oocytes was very significant for all oocyte development parameters. None of the blastocysts produced out of BCB- oocytes hatched. Thus the BCB screening model could clearly differentiate the competent and non-competent oocytes. There will be potential advantage of using this BCB screening method of pre-screening buffalo oocytes for augmenting IVF success rate but more importantly the current procedure puts in place a valid model for differentiating between competent and non-competent oocytes in buffalo which can be used for investigations

on molecular reasons for differential development ability of oocytes.



Buffalo oocytes before (A) and after (B) BCB Staining

We have characterized two such novel EST sequences (BOD242N and BOE177N) captured earlier from the buffalo oocyte specific subtracted cDNA library was characterized. Temporal expression pattern of these gene were also determined to assess their differential expression in buffalo oocytes screened for their competence status. BOD242N cDNA represented as a single transcript type whereas BOE177N represented as 3 alternate variants. BOD242N full length sequence was found to equivalent to the 1st intron of the SLAIN1 gene and was moderately conserved among mammalian species. BOE177N on the other hand was found matching with Intergenic part of the *Bos taurus* chromosome number 5 sharing homologies with Exon 1 and 2. For both of these ESTs very stable secondary structures could be predicted thus raising possibilities for their regulatory role on other cis/ trans genes.



Absolute Copy Number of Y Chromosomal Genes in Karan Fries and Sahiwal Bulls

The absolute copy numbers of two Y chromosomal genes *SRY* (Sex-determining region Y) and *TSPY* (testis-specific protein Y encoded) were estimated in the genomic DNA of Karan Fries crossbred and Indian Sahiwal bulls. Standard curve-based quantification of the genes was carried out by real-time PCR in *SYBR Green* chemistry. Standard concentrations (copy numbers) of plasmid carrying these gene fragments were used as template for qRT-PCR to construct the standard curve for each gene. Crossing point (Cp) values were determined from the qRT-PCR run of equal concentration of genomic DNA of test bulls and

Comparative pattern of *TSPY* gene dosage in genomic DNA of different groups of Milk

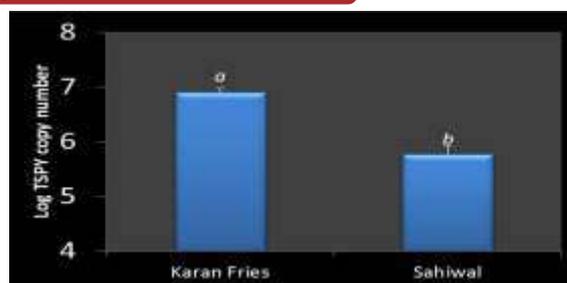


Log *TSPY* gene copy number does not vary significantly ($P=0.5$) between unit mass of genomic DNA of bulls producing superior ($n=10$) and inferior ($n=10$) quality semen

extrapolated in the corresponding standard curve to get the concentrations (genomic copy number) of the test bulls.

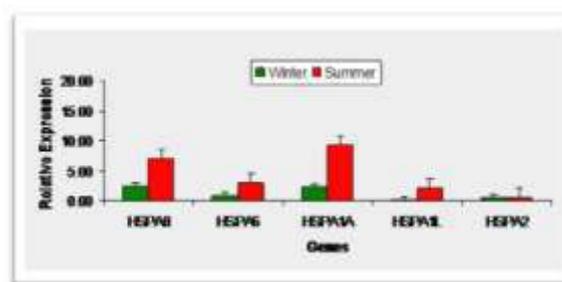
The copy number of *TSPY* gene in unit mass of genomic DNA in Karan Fries bulls producing superior and inferior quality semen and Sahiwal bulls has been shown in above. Similarly the copy number of *SRY* gene in unit mass of genomic DNA is higher in KF bulls (4.07 ± 0.02) than Sahiwal (2.78 ± 0.12) bulls.

Expression of five major HSP70 gene(s) in goat. Five important goat HSP70 genes (HSPA8, HSPA6, HSPA1A, HSPA1L and HSPA2) were cloned and sequenced from Indian goat (Barbari) and their expression pattern in blood was studied in summer and winter. HSP70 genes were expressed both during summer and winter in heat and cold adapted breeds but the expression was higher during summer. HSPA8,

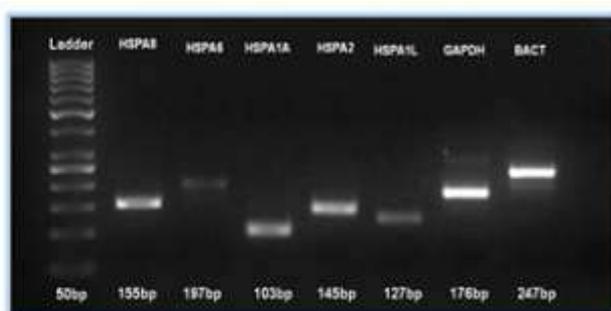
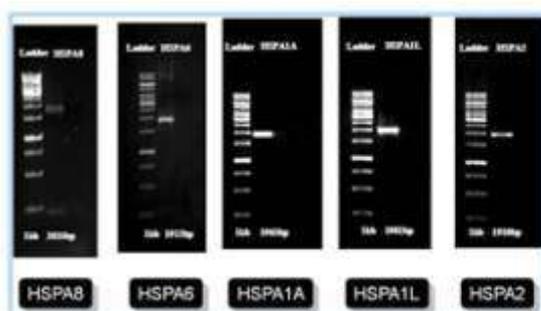


Log *TSPY* gene copy number varies significantly ($P=0.002$) between unit mass of genomic DNA of Karan Fries ($n=10$) and Sahiwal ($n=8$) bulls

HSPA1A and HSPA6 were highly expressed in blood leukocyte but the expression level of HSPA1L and HSPA2 in blood leukocyte was very low. The higher expression of HSP during summer was associated with a rise in body heat loads as reflected by increased RT, RR and PR in both heat and cold adapted goats.



Relative expression of five HSP70 genes in peripheral blood leukocytes of Barbari goat



LIVESTOCK PRODUCTION AND MANAGEMENT

Development of State-of-the-Art Dairy Production Systems Using Better Housing and Fertility Management Practices, Climate Change and its Impact on Livestock Production

Feeding Management

Effect of challenge feeding on performance and economics of milk production of crossbred cows:

The effect of 'challenge feeding' on performance and economics of milk yield of crossbred cows was studied.

For this study 10 advance pregnant crossbred cows were selected 60 days before expected date of calving and were divided into 2 groups i.e. control (T_1) and treatment (T_2) on the basis of milk yield, parity and body weight. During the prepartum period, T_1 cows were offered 2.5 kg of concentrate per day from 60th day to 22nd day prior to calving and 3.5 kg concentrate from 22nd day prior to calving till the day of parturition. The cows in T_2 were fed 3.5 kg concentrate per day from

60th day to 22nd day prior to calving and from 22nd day prior to calving till parturition 3.5 kg concentrate per day plus 250 gm concentrate till it reached 1 % of their body weight. During the postpartum period, T₁ cows were fed 2 kg concentrate per day for maintenance and 1 kg concentrate per 2.5 kg of milk production. The concentrate allowance of animals of T₂ was gradually increased by supplementation of additional 500 gm per cow concentrate mixture daily beginning from second week of parturition till it reached to free choice level. Both the groups were offered *ad libitum* green fodder during entire period of study. The mean DMI (kg) in T₁ and T₂ cows during prepartum period was 11.18 ± 0.36 and 12.01 ± 0.35 kg respectively which did not significantly differ between treatments. The postpartum DMI was significantly higher ($P < 0.05$) in T₂ (14.79 ± 0.64 kg) as compared to T₁ (12.20 ± 0.23 kg). The mean BCS during prepartum period (3.46 ± 0.03 and 3.51 ± 0.05) as well as during postpartum period (3.38 ± 0.02 and 3.45 ± 0.02) did not differ significantly between treatments. The overall mean daily milk yield per animal was significantly higher ($P < 0.05$) in T₂ (20.5 ± 1.14 kg) as compared to T₁ (17.3 ± 0.65 kg). The differences in mean calf birth weight (31.8 ± 1.28 and 34.2 ± 1.24 kg), mean daily colostrum yield (9.52 ± 0.6 and 10.90 ± 0.83 kg), days taken to achieve peak yield (25.2 ± 2.05 and 29.4 ± 1.63 days) of T₁ and T₂ groups were not significant. The differences in mean fat, SNF, lactose and protein percent and incidence of peripartum health disorders between T₁ and T₂ were also not significant. The T₂ group of cows generated an additional net income of Rs.17.9 per cow /day. It was concluded that the practice of challenge feeding of dairy animals improved the production performance during early lactation without affecting their BCS and periparturient health and was found to be economical as it generated additional income of Rs.17.9 per day during early lactation.

Influence of nutrients supplementation on lameness during transition period in KF cows: Metabolic and mineral –vitamin profiling of normal and lame Karan-Fries (KF) cows indicated that the mean plasma biotin and Zn was significantly low in lame cows. Since the levels of biotin and zinc were below critical level in lame cows, these nutrients were supplemented to 30 lame KF cows (10 each for three treatments; T1 10 mg/day, T2 20 mg/day and T3 30 mg/day) while 10 lame cows were kept as control (no supplementation). It was found that biotin and Zn significantly reduced the lameness score by 41.94%, 51.28% and 45.45% in treatment groups T1, T2 and T3 respectively compared

to the control group. Also the levels of plasma biotin, glucose and Zn increased significantly in supplemented groups compared to the control which in turn decreased the concentrations of non esterified fatty acids (NEFA) and β hydroxybutyric acid (BHBA) in lame cows compared to the control cows. The results indicated that supplementation of biotin and Zn during transition period could reduce the incidence of lameness in crossbred cows.

Effect of feeding pulse hulls in concentrate mixture on nutrient utilization and performance of dairy cows in Ethiopia: Five groups of lactating cows ($n = 6$ each) were assigned to each of the following treatment viz T₁ (control), consisted of natural hay + control concentrate mixture formulated with only conventional feed ingredients (0% pulse hulls); T₂, T₃, T₄ and T₅ were comprised of natural hay + concentrate mixture formulated by inclusion of 35% field pea hull, 50% field pea hull, 35% grass pea hull and 50% grass pea hull, respectively. Animals were fed natural hay *ad lib* while concentrate mixtures were fed @ 2 kg for maintenance requirement and 1 kg for each 2.5 kg of milk yield individually both in the morning and afternoon for 180 days. Results of the study revealed that average DM, OM, CP intake (kg/h/d) increased ($P < 0.01$) as a result of feeding field pea hull at both level of inclusion (35% and 50%) and grass pea hull at 35% inclusion in concentrate mixture as compared to the control. However, there was no variation ($P > 0.05$) in feeding of T₅ and the control. Digested nutrients intake of DM, OM, CP, NDF and ADF were significantly higher ($P < 0.01$) as a result of feeding 35% field pea hull, digested nutrients intake of OM, NDF and ADF in feeding of 50% field pea hull and digested nutrients intake of CP, NDF and ADF in feeding of 35% grass pea hull in concentrate mixture as compared to the control. All digested nutrient intake were similar in feeding of 50% grass pea hull in concentrate mixture to the control. Besides, digestibility of CP was higher ($P < 0.01$) as a result of feeding of 35 and 50% field pea hull and 35% grass pea hull and 35% grass pea hull in concentrate mixture (T₂, T₃ and T₄) and digestibility of NDF as a result of feeding 35% grass pea hull in concentrate mixture as compared to the control. The body weights of the animals did not vary significantly either at the start or end of the experimental period. Also there was no variation in body weight change among the treatment groups. Average milk yield (kg/h/d) was higher ($P < 0.01$) in feeding of T₂ and T₄ than the control. However, there was no significant variation in 4% FCM yield among the treatment

groups. In milk constituents, animals fed control concentrate mixture had better milk fat, protein and total solid contents than the treatment groups. Partial budget analysis worked out based on whole milk indicated that returns obtained from sale of milk over feed cost (Birr/cow/day) were higher ($P < 0.001$) as a result of feeding T_2 , T_3 and T_4 than both T_1 and control. Feed cost per kg of milk yield (Birr/cow/day) was significantly less ($P < 0.001$) in feeding T_2 , T_3 and T_4 than control. Besides, higher ($P < 0.001$) gross return to feed cost ratio was obtained as a result of feeding T_2 , T_3 and T_4 . On the other hand, the analysis results based on 4% FCM yield indicated that there was no significant variation ($P > 0.05$) between the control and any of the other treatments in all the above economic parameters.

Effect of Vitamin A, E, Copper and Zinc supplementation on production performance and non specific immune function of peripartum buffaloes:

Thirty six pregnant Murrah buffaloes (6 in each group) in their late gestation at 30 days before the expected date of calving were selected from the NDRI herd. The buffaloes were supplemented individually with Vitamin A, Vitamin E, Copper, Zinc and their combination from 30 days before the expected day of calving to 30 days after parturition, and group without any supplementation acted as control. Milk yield was recorded and samples were collected weekly and analyzed for milk composition. Blood samples of the buffaloes were collected on days 30, 15, 7, 3 prepartum, on the calving day and on 3, 7, 15 and 30 days of postpartum to estimate TLC, DLC, *in vitro* phagocytic activity (PA) and lymphocyte proliferation response (LPR) in periparturient buffaloes. Milk yield and composition did not vary significantly between supplemented and control buffaloes, but milk yield was significantly higher ($P < 0.05$) only in vitamin A supplemented group. Days to first estrous were lower in vitamin and mineral supplemented buffaloes. Postpartum reproductive performance was also recorded in all the buffaloes. Colostrum SCC were significantly higher ($P < 0.05$) on day-1 and decreased significantly ($P < 0.05$) on day-3. Colostrum SCC were significantly higher as compared to milk SCC. Plasma micronutrients levels estimated were significantly ($P < 0.05$) higher in supplemented buffaloes than the control buffaloes, and significantly lower at the day of calving as compared to pre and postpartum period in all the groups. Plasma cortisol levels were significantly lower ($P < 0.05$) at the day of calving in supplemented group than control group of buffaloes. *In vitro* PA activity of blood neutrophils was significantly lower

($P < 0.05$) at the day of calving as compared to pre and postpartum period in all buffaloes. Overall mean of *in vitro* PA was significantly higher ($P < 0.05$) in all supplemented groups of buffaloes than control. *In vitro* lymphocyte stimulation index (SI) for T lymphocyte was significantly lower ($P < 0.05$) at day of calving in control group as compared to combination. On day 3 postpartum, *in vitro* lymphocyte SI for B lymphocyte was significantly ($P < 0.05$) higher in combination group of buffaloes than control. Overall mean of *in vitro* lymphocyte SI for B lymphocyte were significantly higher ($P < 0.05$) in combination group of buffaloes as compared to control. For both T and B lymphocyte, *in vitro* SI was significantly lower ($P < 0.05$) on the day of calving as compared to 30 day prepartum and postpartum in all buffaloes. This study indicated that micronutrient supplementation around parturition increases the milk productivity, lowers plasma cortisol and improves the immunity of buffaloes.

Effect of satawari feeding on productive performance and health of Sahiwal cows:

Through feeding of satawari @ of 150 mg per kg prepartum and 300 mg per kg body weight post partum to high yielding Sahiwal cows increased the milk productivity by 12 per cent and feeding of 100 gram satawari resulted in an increase of 1 kg milk yield daily. The supplementation of satawari to Sahiwal heifers at the rate of 150 mg per kg body weight decreased the age at first conception by 70 days. The age at first conception in satawari fed heifers was 960 days whereas it was 1030 days in control group of heifers

Animal Behaviour and Performance

Effect of using dummy calf for milk letdown on the performance and behaviour of Murrah buffaloes:

The effect of use of dummy calf as replacement for natural suckling for milk letdown on the performance and behaviour of Murrah buffaloes was studied with 14 Murrah buffaloes randomly allotted to 2 groups of treatment (T) and control (C). The calves of buffaloes in T group were replaced with a dummy calf immediately after parturition and the calves of the C group of buffaloes were weaned at birth. The mean maternal behaviour scores of T buffaloes were 4.04 ± 0.34 and 3.14 ± 0.26 in first and second week respectively after calving on a scale of 1 to 5. The overall means of milking temperament score were 2.12 ± 0.43 and 1.87 ± 0.41 in C and T respectively which in general were lower in T buffaloes as compared to the C. The mean of milk letdown time was significantly ($P < 0.05$) lower (2.38 ± 0.36 min) in T as compared to C

(3.04 ± 0.61 min). The mean of daily milk yield over the period of 9 weeks was significantly ($P < 0.05$) higher (8.83 ± 0.37 kg) in T as compared to C (6.97 ± 0.36 kg). The mean peak yield (8.85 ± 1.25 and 10.78 ± 1.00 kg) and days to attain peak yield (33.42 ± 5.58 and 34.14 ± 6.15) did not differ significantly between C and T. The mean milking times (10.41 ± 0.99 and 10.64 ± 0.55 min) and mean values of per cent fat, protein, lactose and SNF (7.68 ± 0.06 and 7.82 ± 0.08), (3.48 ± 0.02 and 3.55 ± 0.29), (5.15 ± 0.05 and 5.06 ± 0.06) and (10.21 ± 0.10 and 10.31 ± 0.08) in C and T respectively did not vary significantly between the groups. The mean days to first heat after calving, days to first service and estrous length in the C and T were 56.00 ± 8.15 and 51.57 ± 8.15 , 76.57 ± 8.21 and 72.00 ± 8.16 and 20.57 ± 0.48 and 20.71 ± 0.52 days respectively which did not differ significantly between the two groups of buffaloes. The mean plasma cortisol levels (4.82 ± 0.058 and 4.84 ± 0.05 ng/ml) also did not differ significantly between C and T. It was concluded that the replacement of calf with a dummy calf immediately after the birth was successful in effecting maternal bonding with the dummy calf and causing normal letdown of milk and establishment of normal milking temperament in weaned buffaloes. It also improved the productive performance of weaned buffaloes without affecting the reproductive performance.

Interrelationship of vocal tract biometry with acoustic features in dairy cattle: The analysis of bioacoustics features extracted from the vocal signals of high and low yielder cows revealed that their vocal signals differed significantly ($P < 0.05$) for their various acoustic features viz. call duration, minimum amplitude, total energy, F5-Formants, and average formants dispersion. Estimation of vocal tract length (VTL) from acoustic features reflected similar trend according to the body measurements but estimated VTL value at F5 formant differed significantly ($P < 0.05$) in high and low yielder cows. The relationship between body measurements and acoustic features were correlated with each other and it was also found that formants (F5) and average formants dispersion were significantly correlated with peak milk yield and circumference of neck.

Development of Animal Management System

Soil-Plant-Animal continuum in migratory sheep of arid zone of Rajasthan: ICT application represents a major advance in data acquisition and communication for improved surveillance and delivering management inputs. In the present study real time information on

sheep migration pattern and incidence of disease and along with soil-plant-animal continuum was analysed to address the problems faced by the nomadic flock in Marwar region. For the survey, a total of 120 respondents were randomly selected from Marwar region of Rajasthan and 20 farmers through the migratory route from Pali to Rohtak. During the migration farmers faced number of problems in terms of living amenities, losses due to disease problems and other local problems. At home, the overall satisfaction of farmers regarding veterinary service was 48.52%, which during migration was only 0.92%. The lamb mortality during migration was found to be 21.68% and adult mortality was 6.02%. Although, a majority of the nomadic farmers were illiterate, it was observed that modern ICT technology can be adopted by the farmers if it is delivered through advanced smart phone with touch facilities with audio and visual way of extension communication application for sheep management.

Prediction of lameness based on the percent of body weight distributed to individual legs using artificial neural networks (ANNs) and logistic regression in Karan Fries cows: In India, lameness detection at farm level using modern techniques is in its preliminary stage and automated detection of lameness requires research and development of hardware and software. Overall incidence of lameness in KF cows was found to be 11.29% in last 12 year period. For this purpose, load cell platform (a kind of force plate) was used to record the data on individual leg weights to develop predictive models. It was found that both the front legs of healthy (28.181 ± 0.225 and 27.773 ± 0.194) as well as lame (130.252 ± 0.392 and 29.271 ± 0.345) cows bear more weight as compare to hind legs. Percent body weight distributed on the left front legs of both lame (30.252 ± 0.392) and healthy (28.181 ± 0.225) cows was higher as compared to percent body weight distributed to right front legs of both lame (29.271 ± 0.345) and healthy (27.773 ± 0.194) cows. In lame cows left hind legs (18.840 ± 0.408) bear less weight as compared to right hind legs (21.76 ± 0.424) indicating that left hind legs are more affected compared to right hind legs. It was also found that lame cows showed the greater variation in weight distribution between legs when standing as compared to healthy cows. Classification efficiency based on the percentage of correctly classified event was highest (88.14 %) in LM optimization algorithm with 5 nodes in hidden layer. LM, BP and CG optimization algorithm with 3 nodes in hidden layer had similar classification efficiency (85 %) to classify correctly a non-event.

Neuro-Fuzzy system for diagnosis of subclinical mastitis in cows and buffaloes using milk conductivity and pH:

A study was designed to find out the changes in electrical conductivity (EC) and pH of milk from mastitis affected cows in different seasons and lactation stages in organized farms and to quantify the EC and pH of milk along with the changes in certain acute phase proteins viz. serum amyloid A (SAA) and haptoglobin (Hp) from mastitis affected cows and development of ANN and fuzzy logic models for subclinical mastitis detection. Murrah and Karan-Fries showed an increase in milk pH and EC in summer while Sahiwal showed higher value in winter. Animals with more than 4 parity and high milk yield showed a considerable high milk pH and milk EC. Murrah buffaloes showed a trend of gradual increase in both SAA and Hp from healthy to subclinical and then to clinical cases. In case of cows only SAA showed similar trend and Hp was more in subclinical than in clinical cases. The ANN model of Bayesian regularization (BR) gave the maximum accuracy. ANN showed a good accuracy rate for detecting clinical mastitis from that of healthy animals. A coefficient of determination (R^2) up to 90% was obtained in BR model. Similarly fuzzy logic algorithm proved as a very good prediction engine for mastitis.

Decision Support System for productive and reproductive performance evaluation in Murrah buffaloes and Karan Fries cattle:

The possibilities of improving the performance of Murrah buffaloes with the help of decision support system (DSS) were evaluated. Based on the analysis of historical data, points of interventions were identified and DSS modules were developed. The body weight at different age, average daily gain (ADG), and age at sexual maturity (ASM) was analyzed and the association among them was studied, which revealed the body weight at 12th, 24th and 30th month of age and ADG during 6-12 month period was significantly ($P < 0.05$) associated with ASM in buffaloes. The effect of season was found to be significant ($P < 0.05$) on various reproductive traits while parity did not influence the traits significantly ($P > 0.05$). The average breeding interval was found to be 73.09 ± 4.71 days, which indicated the poor manifestation of estrus symptoms and/or low heat detection efficiency in Murrah buffaloes. The significant ($P < 0.001$) difference in the 100 days milk yield of normal and diseased animals signifies the importance of using part lactation curve for the early diagnosis of disease condition in buffaloes. Thus, performance evaluation of Murrah buffaloes using decision DSS would also assist in

identifying the potential points of intervention. DSS module for alarm list and action plan was standardized for KF animals and data were analysed in Herdman software for productive and reproductive efficiency. It was found that such modules were helpful in setting goals and monitoring the performance in the herd. In addition, the Herdman (the database management system), with integration of developed modules was found to be a valuable tool for the efficient decision making intended for precision dairy management.

Short term cooling increased the conception rate in Murrah buffaloes:

A study was conducted to find out the effect of short-term cooling on conception rate in Murrah buffalo heifers and to study the effectiveness of certain managemental tools in improving the estrus detection efficiency and accuracy in Murrah buffaloes. Short term cooling after AI significantly reduced the body temperature of buffalo heifers during hot and humid season and improved the conception rate in Murrah buffalo heifers. Buffaloes with cervical mucus having typical fern pattern had significantly ($P = 0.018$) higher conception rate (54.9%) compared to atypical fern pattern (20.0%).

Development of Wireless Sensor Network for Animal Management

- Wireless Sensor based systems like 1. “Automatic Climate Controller” 2. “Automatic Weigh Bridge”, 3. “Milk Conductivity, Temperature And Weighing System”, 4. “Activity and mounting behaviour recording system” 5. “Automatic temperature and humidity data collection system” are under validation in larger numbers of animal in different housing system. “Automatic fluid kiosk”, and “Automatic feeding systems” are being developed and testing in pilot scale is in progress.
- Android based animal tracking system and disease surveillance system are developed and are under customization for field data collection and dissemination of information through smart phone.
- Miniaturized wireless sensor nodes for “Ankle bound Pedometers” to measure activity and “Back strap for Mount Detection” were under validation for detection of heat in Karan Fries cattle.
- Final version of automatic body weight and lameness detection equipment was developed and integrated to Sensor Network.

- Artificial Neural Network (ANN) algorithm (maximum accuracy) found best suited for detection of lameness for routine screening of cows using “wireless sensor controlled four quadrant load cell platform”, based on percent body weight distribution on individual legs of Karan Fries cattle.
- Appropriate Neuro-fuzzifiers for mastitis classification was developed. Fuzzy logic algorithm once developed and standardized for a particular farming situation can be efficiently used for automated subclinical mastitis detection (Figure 1). Artificial neural network algorithm showed a good accuracy rate for detecting clinical mastitis from that of healthy animals.
- A DSS module for reproduction and production management of crossbred and Murrah buffaloes to improve accuracy and efficiency of heat detection, milking production and heifer growth was developed.

Infertility in Crossbred Bulls: Search for Spermatogenic Cell Markers for Early Prediction of Fertility (NFBSFARA–3009)

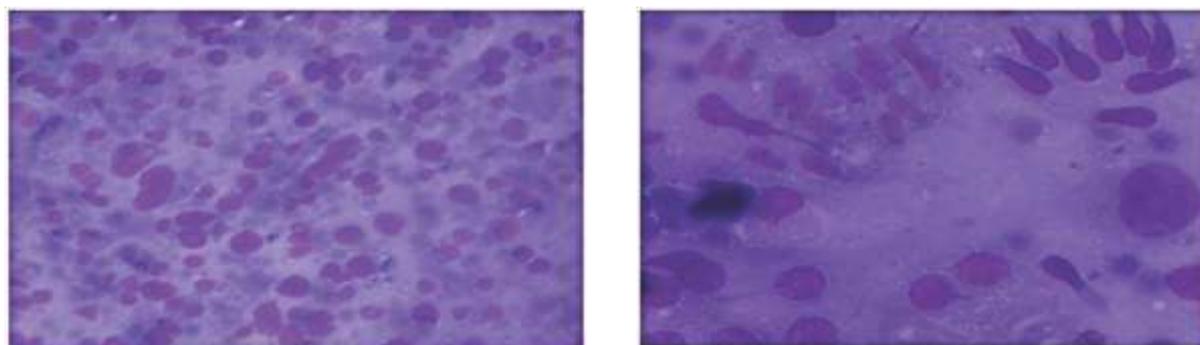
Percutaneous needle aspiration biopsy method for extraction of testicular cells from live animals: A method for extraction of testicular cells from bulls, percutaneous needle aspiration biopsy (PNAB), was standardized. The needle length, gauge and site of aspiration were standardized in morbid specimen and then in live goats, calves and then the standardized technique were applied on adult breeding bulls. The animals were restrained properly and epidural anesthesia was administered at sacro-coccygeal junction. By this procedure, desensitization of the posterior part of animals was achieved within 3-5 minutes. The testes were held tightly with hand and antiseptic solution was applied over the scrotum. A 22 gauge needle attached to 5 mL syringe was inserted into the testis through scrotum at right angle to the testis. When plunger was pulled back, the needle was moved little forward and backward within the testis two to three times for approximately 4 seconds for dislodging of cells and easy suction into the needle. It was found that the aspirates, obtained using the standardized method, were enough to study the testicular cytogram.

Effect of PNAB procedure on semen quality and testicular morphology: A preliminary study was conducted to assess the effect of PNAB technique on testicular biometry and seminal characteristics in Karan Fries crossbred bulls. Eight bulls within the age range of 4-6 years were utilized for study. Before and after fine needle aspiration, testicular parameters were measured and seminal quality was assessed as per

standard protocols. There was no significant difference observed in scrotal circumference and testicular length before and after the treatment. The testicular width was 6.59 ± 0.32 and 7.08 ± 0.27 during pre and post aspiration, while the corresponding values for testicular mass were 355.77 ± 39.20 and 427 ± 28.75 , respectively. There was no significant changes in ejaculate volume (4.63 ± 0.33 Vs 4.73 ± 0.20), mass activity (2.32 ± 0.33 Vs 2.42 ± 0.22) and individual motility (53.15 ± 4.29 Vs 58.60 ± 3.19) in bulls during pre- PNAB and post- PNAB period. Similarly, the percentage of live spermatozoa, membrane intact spermatozoa and acrosome intact spermatozoa did not differ significantly between pre- PNAB and post- PNAB period. These results indicated that percutaneous needle aspiration biopsy technique can be used as a diagnostic method to detect sub-fertility and infertility in crossbred bulls without affecting their reproductive health.

Testicular cell indices and peripheral blood testosterone concentrations in relation to age and semen quality in crossbred (KF) bulls:

The changes in peripheral blood testosterone concentration and testicular cytogram in relation to age and semen quality were studied in Karan Fries crossbred males. Three different age groups of crossbred males viz. bull calves (6 months, n = 5), young bulls (15 months, n = 5) and adult bulls (4-6 years, n = 8) were utilized for the study. Percutaneous needle aspiration biopsy technique was used to quantify testicular cytology and their indices. Peripheral blood testosterone concentrations were measured by ELISA method. Semen collected from adult bulls was evaluated for quality parameters. Mean peripheral blood testosterone concentrations in bull calves, young bulls and adult bulls were 2.28 ± 0.09 ng/ml, 1.42 ± 0.22 ng/ml and 5.66 ± 1.08 ng/ml respectively, and the difference was significant ($P < 0.01$). There was no significant difference ($P > 0.05$) between the proportion of different testicular cells in bull calves and young bulls. Between young and adult bulls, significant difference ($P < 0.01$) was observed in the proportion of spermatocytes, spermatozoa, and sperm: Sertoli cell ratio. The proportions of Sertoli cells showed significant difference ($P < 0.01$) between the three groups. The number of primary spermatocytes had positive correlation with peripheral blood testosterone concentrations in bull calves ($r = 0.719$, $P < 0.01$). Sertoli cells per 100 germ cells were negatively correlated with testosterone concentration in young bulls ($r = -0.713$, $P < 0.01$). Among different semen parameters in adult bulls, ejaculate volume ($r = 0.790$, $P = 0.01$) had positive relationship, and sperm motility had significant negative correlation ($r = -0.711$, $P = 0.048$) with testosterone concentrations. These results indicated that quantification of testicular cells and indices could be used to assess the semen production ability of bulls.



Testicular cells at 40 X (Left) and at 100 X (Right) magnifications



Sertoli cell

Spermatogonia

Spermatocyte



Early spermatids

Late spermatids

Spermatozoa

Testicular cytology of crossbred bulls using the standardized percutaneous needle aspiration biopsy technique

Protocol for peri-post-partum follow up for downsizing uterine infection in dairy animals:

A protocol for post-partum follow up of dairy animals was standardized. The protocol involves monitoring rectal temperature for at least the first 10 days post-calving to identify the possible problematic cows at an early stage. Depending upon the visual appraisal (bright and alert or dull, depressed) and body temperature, further evaluation (rectal/vaginal) is decided. If a cow's body temperature exceeds 39.5°C, then a systemic antibiotic is administered. Ceftiofur (long acting) have been found to be efficacious in reducing post-partum uterine infection. The following figure depicts the procedure followed at NDRI for post-partum follow up of calved animal for early identification of developing uterine infection so that necessary measures could be taken up at an early time.

This protocol was tested in both cattle and buffaloes and found successful in drastically reducing the post-partum uterine infection



Peri-post-partum follow up protocol for reducing uterine infection in dairy cattle and buffaloes

DAIRY CATTLE PHYSIOLOGY

National Initiative on Climate Resilient Agriculture (NICRA)

Profile of HSP70 genes in fibroblasts exposed to heat stress: Studies on dermal fibroblast of cattle were conducted to identify the major types of gene(s) under HSP70 family and to quantify major HSP70 gene(s) expression during heat stress. The real-time PCR analysis for HSP70 family genes, MMP family genes, Caspase family genes, SOD1 and iNOS along with two housekeeping genes was performed. The results revealed that HSPA1A, HSPA2 and HSPA8 were highly expressed at temperature 40°C and 44°C in cattle. At temperature 37°C and 25°C similar expression was seen in all the breeds of cattle. At temperature 40°C and 44°C the relative expressions of all the inducible HSP genes (HSPA1A and HSPA2) were higher in Karan-Fries than the heat adapted Cattle breeds (Tharparkar and Sahiwal). The expression of HSPA8 genes in heat adapted Cattle (Tharparkar and Sahiwal) was observed to be higher level than in *Bos taurus X Bos indicus* (Karan-Fries) where expression of HSPA1A and HSPA2 was of higher magnitude.

Gene expression of heat stressed leucocytes of indigenous cattle and buffalo: Gene expression profiling was done in heat exposed (42°C, 4h) cattle, Tharparkar (*Bos indicus*) by using bovine gene Microarray chip and validated the genes which were differentially expressed by Real Time PCR in Sahiwal (zebu cattle) and Murrah (water buffalo). Microarray data showed that nearly 210 genes were up regulated and 250 genes were down regulated. These genes were found to exhibit change > 2 fold in their expression profile. Besides general heat shock proteins, many non-heat shock proteins were revealed and they were functionally classified into different functional groups. The differentially expressed genes (DEGs) from microarray data were further analysed by bioinformatics. Functional annotation, pathway study of the DEGs revealed the new insights in heat stress response of indigenous cattle. The results showed that heat stress affects expression of a significant number of the genes in peripheral blood leukocytes of diverse biological functions.

Expression of genes during heat stress and recovery in lymphocytes: In an experiment on cattle, hyperthermia inhibited transcription of most genes (HSPs). However, important additional changes in gene expression were detected during recovery phase (24 and 48 hours) post exposure. The study highlighted that after return to normal state more than 50 genes not

traditionally considered HSPs have been found to undergo changes in expression during or post heat stress. Many of these genes will likely prove to be important mediators and effectors of the cell stress response in cattle and buffaloes.

Effect of heat stress on *in vitro* meiotic maturation and developmental competence of Cumulus Oocyte Complexes (COCs) in Murrah buffalo:

The study was undertaken to see the effect of heat stress on the meiotic maturation of oocytes in buffalo. The oocytes aspirated from the ovaries of buffaloes were initially matured at 40.5°C and 41.5°C in groups of 15-20 in maturation medium for first 12 hours and subsequently matured at 38.5°C for remaining 12 hours in a humidified CO₂ incubator (Relative humidity- 95%; 38.5°C). Maturation temperature of the control group of oocytes was 38.5°C during the complete 24 hours of maturation period. After 24 hrs of maturation, the oocytes were fertilized with the buffalo frozen semen (NDRI semen bank) for about 16-18 hrs. The embryos produced thereafter, were cultured *in vitro* for 9 days in culture medium comprising glucose and certain other important metabolites. Subsequently, the cleavage rate was determined on day 2 post insemination. The number of cells formed in different developmental stages i.e. 2-cell, 4-cell, 8-16 cell, morulae and blastocyst was recorded. Cleavage rate was determined on 2nd day post insemination. Similarly, 4 cell and 8-16 cell stage was recorded 4th day post insemination, respectively. No of morulae and blastocyst produced was recorded 7th and 8th day post insemination. Total cell number in blastocysts produced at control and heat stress condition was determined by Hoechst staining. The results indicated percentage of 2-cell stage, 4-cell stage, 8-16 cell stage, morulae and blastocyst production was remarkably higher in the control group (38.5°C) compared to the heat treatment groups (40.5°C and 41.5°C), thereby, indicating that the temperature of 38.5°C is most suitable for maturation of buffalo oocytes. Also, the total cell number in the blastocysts produced in the control group was higher than that in the heat stressed group as determined by Hoechst staining method. The blastocyst yield decreased remarkably compared to control group. Thus, this study concludes that heat stress or elevated temperature during oocyte maturation negatively influenced oocyte's developmental competence to significant extent, decreasing the blastocyst yield which may be due to carryover maternal RNA transcripts thereby affecting

reproductive efficiency. Expression analysis by real time PCR also indicated an increase in the expression of heat stress genes i.e. HSP 70.1 and HSP 70.2 in the heat treated oocytes. Therefore, exposure of oocytes to physiologically elevated temperature, the heat shock proteins is synthesized to the greater extent in order to combat the heat induced challenges. This study indicated the negative relationship between the physiologically elevated temperatures and oocyte developmental competence. The carry over effect was observed in the later stages of development that remain persistent up to the blastocyst stage.

Energetic efficiency and methane mitigation

studies: Encapsulated bacteriocins studies: Twelve hundred isolates of lactic acid bacteria from plant sources, dairy products and cereal products were screened for antibacterial activity using *Listeria monocytogenes* ATCC 53135 as indicator strain and also against Gram-negative bacteria, yeasts and molds. Based on the results of antibacterial activity of the isolates against the different microorganisms, 55 isolates were selected and subjected to molecular and biochemical characterization for confirmation of the genus. Partial purification of bacteriocin was done for isolate C-63 and C-70. Total activity after partial purification was C-63: 982800AU/ml; C-70: 839200AU/ml. 16sr sequencing is in progress for isolate C-63 and C-70. Trial of Microencapsulation of Nisin and Pediocin 34 (*Pediococcus pentosaceus* 34) with different combination of Alginate was conducted to study the release kinetics. The effects of bacteriocins (**Pediocin 34 and Enterocin 99**) was evaluated on methane production, on *in vitro* dry matter digestibility (IVDMD) and *in vitro* organic matter digestibility (IVOMD) in buffalo by *in vitro* gas production test (IVGPT), using 200 mg of wheat straw and concentrate mixture in equal proportion (50:50) as substrate. The results showed that methane production was found to be significantly lower compared to control and other combination of Pediocin and Enterocin. IVGPT was found significantly higher in all treatment groups compared to control. Pediocin with concentration (P1: 1.2 lakh AU/ml) has a potential for mitigation of enteric methane production in livestock. IVDMD and IVOMD were found to be higher with Pediocin concentration in P1 as compared to other combinations. Pediocin with concentration (P1: 1.2 lakh AU/ml) has a potential to increase digestibility in livestock.

Feed Supplements and Effect on Heat Stress

Studies were undertaken to investigate the

immunological and biochemical changes during thermal stress in buffaloes supplemented with vitamin C @ 10g/animal/day from 45 days before to the day of calving. Effect of Vitamin C supplementation on LPI was inconsistent, however, at day 0, the values were significantly lower ($P<0.05$) in both the groups compared to day 45 prepartum. Within the groups, the mean phagocytic activity (PA) decreased with the advancement of pregnancy and decline was significantly low on day 7 prepartum and day of calving. The SOD activity increased significantly ($P<0.01$) with the advancement of pregnancy. Increase in SOD activity was more from day 15 prepartum.

The catalase activity was significantly ($P<0.01$) higher on the day of calving compared to day 45 before parturition in both the groups. The mean plasma FRAP values decreased with the advancement of pregnancy. There was an increase in plasma albumin concentration with advancement of pregnancy. The mean plasma cortisol concentration was significantly ($P<0.01$) higher on the day of parturition compared to day 45 prepartum. Plasma T_3 and T_4 concentration decreased with advancement of pregnancy. Total Ig concentration decreased with advancement of pregnancy in both group I and group II buffaloes and the concentration of group II was significantly ($P<0.05$) higher compared to group I. RT and RR increased gradually and the differences were statistically non-significant from day 45 prepartum to the day of calving in both the groups (group I and group II). Between the groups, the RT and RR were statistically non-significant between group I and group II throughout the experiment. However, the overall mean RT and RR of group I and group II was statistically significant ($P<0.05$). PR increased gradually from day 45 prepartum to the day of calving. The study indicated a significant effect of vitamin C supplementation on biochemical parameters therefore, helps in relieving stress.

Water Footprint of Milk Production

Water use in milk production: The seasonal drinking water requirement of different breeds of dairy animals on the experimental herd at NDRI was estimated. The results are shown in Table. Data on drinking water use was also collected from the farmers' field. A sample of 120 dairy farmers from three villages in Karnal district was selected. Data were collected (partly from observation and partly through farmer interview) on the volume of bucket / water trough used and number of times in a day same was filled by the farmer. The average water use worked out to be 26 litres /animal

/day, which is somewhat lower than the average based on data from NDRI research farm. The information on water use for servicing and bathing was estimated from water use based on the observation on the diameter of water pipe, time period of water flow and number of animals in the enclosure, the average water use of servicing and bathing worked out to be 50 litres /day on

the NDRI farm and marginally lower, i.e. 40 litres /day on the farmer's field. Based on the monthly feed intake data of crossbred, buffaloes and local cows at NDRI farm and the seasonal (three seasons) data from the farmer's field the water footprint in milk production are shown in.

| Breed | Summer (March-June) | Hot-Humid/Rainy (July-Oct.) | Winter (Nov.-Feb.) | Average |
|------------------------|---------------------|-----------------------------|--------------------|---------|
| Karan Fries | 40 | 25 | 45 | 35 |
| Murrah | 45 | 30 | 50 | 40 |
| Sahiwal and Tharparkar | 30 | 20 | 35 | 30 |

Total water footprints (m³/tonne) of milk production

| Breed | Av. Milk Yield (lt./day) | CWU (m ³ /tonne) | | |
|-------------------------------|--------------------------|-----------------------------|----------------|-------|
| | | Blue (Direct+Indirect) | Green (Direct) | Total |
| <i>Organized Farm</i> | | | | |
| Karan Fries | 9.0 | 996 | 216 | 1212 |
| Murrah | 7.4 | 1031 | 238 | 1269 |
| Sahiwal and Tharparkar | 7.2 | 1279 | 304 | 1583 |
| <i>Unorganized Farms</i> | | | | |
| Cross bred | 8.3 | 1166 | 812 | 1977 |
| Buffalo | 5.2 | 1201 | 746 | 1947 |
| Local Cow | 4.5 | 981 | 563 | 1544 |

Micronutrients supplementation on hormones, milk yield, udder health and immunity in crossbred and indigenous cows: Supplementation of vitamin A and zinc, resulted in a significant difference between groups (P<0.01) and days (P<0.01) with respect to leptin, insulin and GH levels in cows. Lymphocyte proliferation index was significantly higher in cows supplemented with micronutrients between days (P<0.01). Body condition of the cows supplemented with micronutrients was significantly higher as compared to control group of cows. Milk yield was found to be significantly higher in cows supplemented with micronutrients. The SCC, decreased significantly there was significant decrease in vitamin E and Zn supplemented group. DMI was higher in cows supplemented with vitamin E and zinc. Body weight and body condition was significantly higher in cows supplemented with vitamin E and zinc as compared to control group of cows. Plasma NEFA levels began to increase from 60 days before calving and reached to

maximum on the 3rd day after calving, which was observed to be higher (P<0.05) in control as compared to cows supplemented with vitamin E and zinc. Supplementation of vitamin E and zinc increased the plasma IgG levels as compared to control cows. Oxidative stress (SOD and catalase activity) was found to improve by supplementation of vitamin E and zinc. The Plasma vitamin E level continued to decrease substantially till calving (Day 0) in all the groups. After calving, the mean plasma vitamin E concentration increased towards 120 days postpartum. Milk yield was found to increase in all supplemented groups but the highest increase was in group supplemented with combination of vitamin E and zinc. Therefore, supplementation of micronutrients in crossbred and Sahiwal cows resulted in increase in hormones, leptin, insulin and GH levels, metabolic and immune status, increase in quality and quantity of milk and health of cows.

Modulation of immunocompetence of neutrophilic function *in vivo* and *in vitro* of high producing cows and buffaloes peripartum:

The study showed that there was a decline in the plasma levels of micronutrients around calving which decreased their neutrophilic activity and expression leaving the peripartum dairy animals open to disease challenge. However, supplementation of Vitamin A (VA), Vitamin E (VE), Cu and Zn modulated the function of blood neutrophils and lymphocytes. Maximum beneficial effect was observed in the PA of blood neutrophils of VA supplemented buffaloes followed by Vitamin E, Cu and combination group. Supplementation of Vitamin E and Zn significantly ($P < 0.05$) reduced plasma cortisol levels at calving and at 30 days postcalving, whereas, Cu increased the peripartum cortisol levels. Micronutrient supplementation decreased milk SCC and improved milk yield. Significantly ($P < 0.01$) lower expression was observed in neutrophilic genes (TNF- and IL-1) at calving. Shape, viability and phagocytic activity of blood neutrophils changed as they crossed the blood mammary barrier to milk. Phagocytic activity was significantly ($P < 0.01$) higher in blood neutrophils. Significantly higher ($P < 0.01$) apoptosis of blood neutrophils was observed at calving. Under *in vitro* conditions, the response of stressed neutrophils (isolated at calving) varied with micronutrient supplementation.

Metabolic Adaptation and Early Lactation Performance of Low and High Producing Cows:

Crossbred lactating cows yielding on an average 10.0 kg were fed prilled fat @ 70g/d in early lactation for a period of 90 days. Plasma ghrelin concentration was significantly less in cows fed with prilled in comparison to control (8.03 ± 0.122 vs. 10.553 ± 0.122 ng/ml). Ghrelin concentration was more in early lactation than in late lactating cows (10.55 vs. 6.354 ng/ml). The changes in ghrelin concentration between groups and between animals was significant ($P < 0.05$). Plasma leptin varied significantly ($P < 0.01$) between groups and was less in early lactation cows fed with prilled fat than the control (1.58 vs. 1.68 ng/ml), however, leptin concentrations were higher ($P < 0.01$) during mid-lactation stage (3.91 ± 0.01 ng/ml) in KF cows. Plasma glucose increased ($P < 0.05$) and NEFA decreased in prilled fed cows.

Development of plasma catecholamines assay for evaluation of sympathetic neuronal function and milk production performance in heat stressed cows:

Epinephrine hormones were administered (@0.5 μ g and 1.0 μ g/kg body wt./day) for five days to cows. Treatment significantly decreased ($P < 0.01$) milk yield on day 1 of injection and the inhibitory effect on milk

yield was variable ($P < 0.01$) and positively correlated ($P < 0.05$) with elevated plasma epinephrine and non-epinephrine levels. The milk yield of cows was restored to pretreatment level on day 1 post treatment indicating a short term effect of treatment on milk yield. However, with 1.0 μ g/kg body wt. dose, inhibitory effect on milk yield ($P < 0.01$) persisted till day 15 post-injection. Administration of epinephrine did not influence milk composition (milk fat, SNF, lactose, SCC, protein) and plasma cortisol, T_3 and T_4 concentrations. The normal plasma epinephrine and norepinephrine levels were 0.10 to 0.25 g/ml and 0.07-0.28 ng/ml. Plasma insulin and glucose concentration increased significantly ($P < 0.01$) in experimental cows. The measured changes in circulatory epinephrine and norepinephrine levels during low ($2-5^\circ\text{C}$) and high ambient temperature (40°C) was similar to the catecholamine levels observed in epinephrine administered cows (0.5 μ g/kg body wt./d) and suggested an inhibitory role of catecholamines in milk secretion of cows during stress conditions.

Influence of guduchi supplementation on production and reproduction performance at field level:

To study the immunomodulatory effect of milk obtained from guduchi supplemented buffaloes, 16 mice were divided into two groups of 8 mice each. The first group was fed on freeze dried normal milk obtained from control buffaloes without guduchi supplementation and second group was fed on milk obtained from guduchi supplemented buffaloes @ 120 g/d/animal. The 50% of the synthetic diet was replaced with milk. The increase in weight of mice after 4 weeks of feeding was more in animals fed on guduchi milk. The phagocytic activity and lymphocyte proliferation index was also significantly higher in mice fed on guduchi milk as compared to control milk fed group.

NDRI-ILRI Collaborative Project: Dairy Development in Village Arainpura (Karnal)

Taking into account current feeding and management practices by farmers and results of the nutritional gap analysis, the work on balanced feed and mineral supplementation to reduce calf mortality was initiated.

The trials were initiated at the 40th day of lactation in buffaloes in village Arainpura feed group I (improved concentrate and 2% mineral mixture) on 25% subsidy on cost; mineral mixture group II (feed and fodder given by the farmer as per the practice) with 50% subsidy. For both the groups, 50 dairy farmers in each group were selected. The control group was maintained on feed and fodder as per the practice with no additional supplement, by 15 farmers. Data analysis was done for

different yield groups i.e. 6-8 kg, 8-10 kg and 10 kg and above. Maximum milk production was observed in 6-8 and 10 kg milk yielding buffaloes in mineral mixture group as compared to other groups. The decline in milk production was 45-50% in control group and 15-22% in mineral mixture and feed group after 160 days of lactation. The milk yield in control group declined rapidly after 2 months of experiment from 6.5 to 2.3 kg. The decline in milk production was less in both feed (6.66 to 4.56 kg/day) and mineral mixture groups (7.63 to 5.37 kg/day). The average milk yield of 6-8 kg buffaloes group was more in mineral mixture feeding (6.65 kg/day) buffaloes as compared to control group (4.69 kg/day). Body weight gain during the experiment was more in feed groups followed by mineral mixture II and control group. Rectal temperature in control group

animals was higher as compared to other groups indicating higher heat load. The conception rate in feed group buffaloes was around 70-75% as compared to 25-35% in control group animals.

To reduce calf mortality (60%), the calves were dewormed by giving fenbendazole tablets once a month up to six month of age. On adoption of this schedule, the growth rate, body condition score and body weight of calves increased significantly. Approximately 777 calves were saved that led to enhanced economic status of the farmers. Youth from village were also included in training programmes considering that more than 50 % farmers will adopt traditional livelihood. Dairy Brigade was also constituted in the village to help project team and farmers in different activities.

DAIRY CATTLE NUTRITION

Raising Productivity of Dairy Animals through Improved Feeding Strategies, Efficient Nutrient Utilization and Use of Non-conventional Feed Resources

Modification of the Procedure to Estimate Neutral Detergent Fibre (NDF) of Cereals

Neutral detergent fibre content of cereal grains was estimated using diastase (Thomas baker-12095) and thermostable α -amylase (Megazyme). Different concentrations (0, 1, 2, 4, 8, 16g/L) of diastase solutions were prepared in phosphate buffer (0.067M, pH-6) and 0.5 g ground maize was incubated in 30 ml enzyme solution at 25°C overnight. The contents were filtered and cooled to 20±0.5°C and 0.5 ml Burke's iodine solution was added quickly and colour change was recorded within 90-120 seconds. Again enzyme solutions with different concentrations showing colours from pale yellow to amber were prepared in arithmetic progression and the same procedure was followed as earlier till colour change. The enzyme concentration i.e. 8g/L resulted in complete removal of starch as evident from occurrence of pale yellow colour was used as working enzyme solution. For thermostable α -amylase, 50 ml NDS was added to 0.5g ground maize before boiling. Amylase solutions in progressive volumes (blank, 0.1, 0.2, 0.4, 0.6, 0.8) were added and after 10 minutes same volume of amylase was added again and left for 60 sec to complete the reaction. Then, the solution was filtered and similar steps followed to observe colour change. Addition of 0.2 ml enzyme solutions twice (i.e. a total 0.4 ml) yielded pale yellow colour which was taken as the

working standard volume. The standardized concentrations of the enzymes were used to analyze the NDF of maize, sorghum, pearl millet, barley, wheat and oats grains. There was significant difference ($P<0.05$) between the NDF of all samples obtained by routine method and enzyme methods, whereas no significant difference was found between two enzyme methods. Therefore, use of these enzymes is strongly recommended for estimation of NDF contents in grains used as energy sources in ruminants.

Quantitative Prediction of Indigestible Cell Wall Fraction of Tropical Forages

The present study found out alternate equation for the prediction of the quantitative cell wall content which remains indigestible in the ruminants. The cell wall components (neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent insoluble nitrogen (ADIN) and lignin) of the selected forages ($n=18$) were determined. Then the samples were incubated for 96 h *in sacco* in the rumen of fistulated animal to estimate 'C' fraction. By regressing 'C' fraction over the fiber components, following equations were developed: For all forages, $C_f = -20.0163 + 1.8498 \text{ lignin} + 0.5775\text{NDF}$, ($R^2= 85.91$); Grasses, $C_g = -85.8844 + 1.8805 \text{ lignin} - 3.5146\text{NDF} + 4.9493 (\text{NDF}+\text{ADIN})$, ($R^2= 99.86$) and legumes, $C_l = -67.5640 + 1.3779 \text{ lignin} + 2.4108\text{ADF}$, ($R^2= 94.13$). These prediction equations for determining indigestible fraction were more accurate under tropical condition than those developed for temperate conditions (lignin x 2.4).

Effect of Selected Herbal Extracts on Levels of Conjugated Linoleic Acid (CLA) Levels in Milk

Effect of the selected plant extracts on CLA enhancement and important rumen fermentation parameters viz., total gas production, individual gases, volatile fatty acid production was studied *in vitro* which was subsequently validated *in vivo*. There was 360% increase in CLA production was observed in case of supplementation with 4% of *J. palak* plant extract. Supplementation of *S. nigrum* and *J. palak*. had desirable effects on polyunsaturated fatty acids (PUFA), total volatile fatty acids (TVFA) and digestibility under *in vitro* conditions. In the rumen and milk, CLA (32 and 11.7%, $P < 0.05$, $P < 0.1$, respectively) and vaccinic acid (11 and 8%, $P < 0.05$) concentrations were increased with *C. cyminum* extract. *C. cyminum* enhanced PUFA (21%) and mono unsaturated fatty acids (MUFA) (8%) in the rumen while saturated fatty acids (SFA) (-8%, $P < 0.05$) decreased. Moreover, milk PUFA was 14% higher ($P < 0.05$) in *C. cyminum* supplemented goats with no effect on milk yield. TVFA in supplemented groups were higher than in control ($P < 0.05$). *C. cyminum* extract altered relative abundance of *Butyrivibrio*, *Prevotella* and *Fibrobacter* sp. (4, 31 and 2%, $P < 0.05$). *C. cyminum* did not inhibit growth of CLA-producing bacteria but suppressed the growth and activity of other bacteria viz., *Sterptococcus bovis*, *Peptestreptococcus anaerobios*, *Lachnospira multiparus* and decreased the biohydrogenation activity of *Butyrvibrio proteoclasticus*. Overall, *C. cyminum* increased CLA and vaccinic acid in milk by manipulation of microbial ecosystem and linoleic acid metabolism in the rumen. *Butyrvibrio fibrisolvens* was a promising direct fed microbial which can be incorporated with linoleic acid @ 200 µg/ml of rumen volume to enhance the health beneficial fatty acids including CLA in milk.

Evaluation of Different Herbal Feed Additives on Fibre Degradation Potential and Apparent Digestibility Under *In vitro* System

Eighteen different plant-based feed additives (*Albizia lebbek*, *Alstonia scholaris*, *Azadiracta indica*, *Asparagus racemosus*, *Bacopa monnifera*, *Chenopodium album*, *Cinnamomum zeylanicum*, *Dioscorea bulbifera*, *Lawsonia inermis*, *Psidium guajava*, *Terminalia arjuna*, *Eucalyptus globules*, *Morus alba*, *Murraya koenigii*, *Tribulus terrestris*, *Terminalia bellirica*, *Terminalia chebula* and *Withania somnifera*) were pre-screened (@ 5%) for their effects

on fibre degradation potential by anaerobic rumen fungi consortium *in vitro*. Anaerobic rumen fungi consortium was grown using different carbon source viz. cellobiose, glucose, avicel, carboxymethyl cellulose, xylan and wheat straw containing medium to stimulate growth of different fungal isolates. Once the consortium was grown, wheat straw (WS) was used as carbon source for fungal growth. Cultures were incubated for 96 h at 39°C in 125 mL serum bottles under strict anaerobic conditions and various rumen fermentation parameters were measured. In addition to different treatments, suitable controls viz. control 1 (+WS; + Culture; -Feed additive), control 2 (+WS; - Culture; +Feed additive) and control 3 (- WS; +Culture; +Feed additive) were also taken. Among all the feed additives tested, six feed additives (*Albizia lebbek*, *Alstonia scholaris*, *Bacopa monnifera*, *Lawsonia inermis*, *Psidium guajava*, *Terminalia arjuna*) were the most potent in enhancing the fibrolytic activities of anaerobic rumen fungi. *Albizia lebbek* was found to be the feed additive of choice as it increased the apparent fibre digestibility by anaerobic rumen fungi in pure culture as well as by total rumen microbes without increasing the methane production.

Fibre Digestion by Pure Isolates of Ruminant Fibre Degrading Bacteria in Lactating Buffaloes

A total of 42 bacterial isolates were isolated from buffalo rumen liquor and tested for their fibre degrading potential on pure neutral detergent fibre (NDF) which showed fibre digestibility ranging from 47.00 to 63.48%, respectively. Twelve potent selected fibrolytic bacterial isolates were assayed for their fibrolytic enzyme activity like carboxymethylcellulase, avicellase, -glucosidase, xylanase and acetyl esterase at 24, 48, 72 and 96 h of incubation at 39°C using pure NDF as substrate. The isolate NB-1 showed maximum mean carboxymethylcellulase, -glucosidase and xylanase enzyme activity. Based on morphological, biochemical and molecular characterization, selected potent isolates of fibrolytic bacteria were of genus *Ruminococcus*. Molecular characterization and sequencing results of 3 most potent fibrolytic isolates showed similarity with the *R. flavefaciens* strains. The three selected bacterial isolates were then tested for their ability to degrade

high fibre diet (roughages: concentrate ratio 80: 20) individually as well as in combination. The isolate NB-1 showed the highest digestibility of 57.83% among all individual isolates and combination of isolates and also

showed the highest partitioning factor and microbial biomass (mg) value of 2.11 and 69.12, respectively. On the basis of *in vitro* studies and enzyme profile, the isolate NB-1 was selected for feeding as inoculum for lactating Murrah buffaloes. The selected isolate NB-1 sequence showed 97% similarity of 16S rRNA gene sequences with *R. flavefaciens* strain FD-1. Isolate NB-1 was cultured anaerobically and 300 ml of live bacterial culture was given to treatment group of lactating buffaloes orally alternate day for one month continuously whereas, control group of animals was given the same amount of autoclaved culture. Average daily milk yield ranged from 5.91 to 6.65 kg/day/animal in the treatment group and 5.88 to 6.36 kg/day/animal in the control group, respectively. The difference in mean DM intake was significantly higher ($P<0.05$) in treatment group (11.77 kg/day) compared to control group (11.11 kg/day). There was a significant ($P<0.05$) increase in total fungal and total bacterial population as well as inoculated isolate bacterial group population in the treatment group during the dosing period. However, decreasing trend was noticed during post-dosing period except inoculated isolate bacterial group population which remained unchanged.

Rumen Escape Potential of Rumen Protected Lysine, Methionine and Choline

The total methionine content in the supplemented rumen protected methionine (RPM) was 52.68% and the fatty acid content was 44.90%. The rumen escape potential of RPM from rumen hydrolysis was 75%. The total lysine content in the supplemented rumen protected lysine (RPL) was 40.20% and the fatty acids content was 49.00%. The rumen escape potential of RPL from rumen hydrolysis was 54.97%. The total choline content in the supplemented rumen protected choline (RPC) was 25.44% and the fatty acid content was 73.95%. The rumen escape potential of RPC from rumen hydrolysis was 72.89%. The effective degradability of RPM, RPL and RPC was 24.80, 45.03 and 27.11%, respectively. Of the total, 75.20% of the RPM, 54.97% of the RPL and 72.89% of the RPC particles expected to be delivered to the duodenum.

Effect of Dietary Protein Levels on Performance in Sahiwal Male Calves

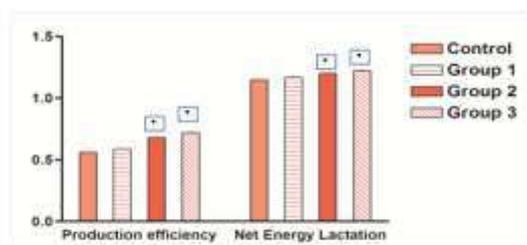
The present study was undertaken to study the effect of different dietary protein levels (15, 13.5 and 16.5% in groups T_1 , T_2 and T_3) on the growth performance, nutrient utilization, plasma enzymes and hormones in growing Sahiwal calves on isocaloric (9.71 MJ/kg total

mixed ration) diet. Digestibility of dry matter, crude protein (CP), organic matter, ether extract, neutral detergent fibre and acid detergent fibre was similar in all the groups. Crude protein digestibility was higher in T_3 than the T_1 and T_2 groups. Digestible CP (g/100 kg BW/day) intake was significantly higher ($P<0.05$) in T_3 than T_2 but comparable to T_1 . Likewise, total digestible nutrients (kg/100 kg BW) intake was also significantly ($P<0.05$) higher in T_2 than T_1 and T_3 . The intake and retention of nitrogen were similar between the treatments. The average daily gain was 0.699 ± 0.06 , 0.841 ± 0.06 and 0.830 ± 0.06 kg in calves fed T_1 , T_2 and T_3 diets, respectively. The levels of haematological parameters, blood metabolites (blood glucose, blood urea nitrogen, total plasma proteins, immunoglobulins, albumin, globulin etc.) and hepatic enzymes (aspartate amino transferase, alanine amino transferase and lactate dehydrogenase) were similar in all three groups and were within normal physiological range. Hence, the performance of Sahiwal calves in all the three groups was comparable. Therefore, 13.5% protein should be used in the ration of Sahiwal calves at current level of growth in order to minimize nitrogen excretion in the environment.

Effect of Chromium Supplementation on Nutrient Utilization, Antioxidant Status and Milk Yield in Murrah Buffaloes

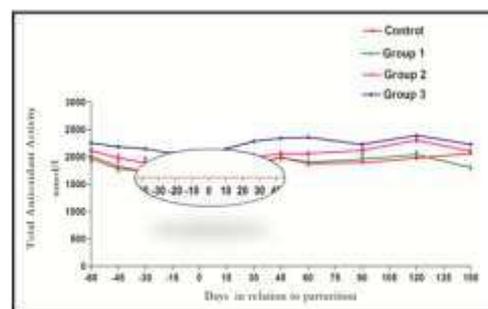
The effect of different levels chromium on immune cell function, productivity, nutrient metabolism and bioavailability of essential minerals in periparturient Murrah buffaloes were observed. The animals were distributed in four groups and supplemented with 0, 0.5, 1.0 and 1.5 ppm chromium in control, T_1 , T_2 , T_3 groups, starting from 60 days prior to the expected date of calving and continued upto 150 d post calving. There was significant higher ($P<0.05$) milk yield (22.4% and 31.7%) in T_2 and T_3 compared to control. Significant increase in dry matter intake (DMI) was recorded in 1.5 ppm Cr supplemented group. Feed efficiency for milk production in T_2 and T_3 was significantly higher ($P<0.01$) than control and T_1 . Overall average lymphocyte proliferation, phagocytic activity and antioxidant status ($\mu\text{mol/L}$) was significantly higher ($P<0.05$) in chromium supplemented group. The results indicated beneficial effects of supplementing chromium @1.5 ppm on milk yield and efficiency of nutrient utilization and antioxidant status in lactating buffaloes. The following figures show the effect of chromium supplementation on overall milk

Overall milk production efficiency net energy lactation in lactating buffaloes fed chromium supplemented ration



*P<0.001

Effect of Cr supplementation on total antioxidant activity of periparturient buffaloes



Evaluation of SX-17, SSG-080 and MFSH-4 Sudan Sorghum Grass Hybrids on Nutrient Utilization in Dairy Cows

A study was conducted for nutritional evaluation of 3 sorghum hybrids (MFSH-4, SSG-080 and SX-17) as fodder for crossbred lactating cows. Methane production (% of total gas) from MFSH-4, SSG-080 and SX-17 varieties varied from 20.51 to 25.29; 18.84 to 22.52 and 18.60 to 27.55, respectively. There was no significant difference between methane production at 50 and 65 days of harvest, however it was significantly ($P < 0.05$) higher at 85 days of harvest as compared to 50 and 65 days. Sugar content was found more in MFSH-4 hybrid whereas, digestible and slowly degradable carbohydrates were higher in SX-17 variety. *In vivo* study revealed that dry matter intake was higher in SX-17 (14.60 ± 0.87) fed group by 7.28% and 7.67% than MFSH-4 (13.82 ± 0.29) and SSG-080 (12.31 ± 0.47 kg/day), respectively. The digestibility coefficients of major of nutrients (neutral detergent fibre, acid detergent fibre, dry matter and organic matter) were higher ($P < 0.05$) in SX-17 variety as compared to MFSH-4 and SSG-080. Feeding of SX-17 sorghum hybrid to lactating crossbred cows resulted in improved DMI, digestibility of nutrients as compared to other varieties.

Characterization of Anaerobic Rumen Fungi from Murrah Buffaloes and Their Use to Improve the Nutrient Utilization of Lignified Roughages in Growing Calves

Twelve anaerobic fungal strains were isolated from the rumen liquor and faecal samples of Murrah buffaloes and identified as species of *Anaeromyces*, *Orpinomyces* and *Neocallimastix* based on their morphological and genetic (based on Internal transcribed spaces region) characteristics. Three types of fungal colonies were grown on the wheat straw agar surface between 72 to 96 h of incubation at 39°C. Type A, B and C colonies (based on morphology) were

observed mostly with *Orpinomyces spp.*, *Neocallimastix spp.*, *Anaeromyces spp.* respectively. p-coumaroyl and p-feruloyl esterase activities, *In vitro* DM and fibre digestibility were increased significantly ($P \leq 0.05$) compared to control on wheat straw alone and on total mixed ration (concentrate: wheat straw 40: 60) when incubated with different anaerobic rumen fungi. Phylogenetic results showed that *Anaeromyces* and *Orpinomyces* appear as a monophyletic sister group to the monocentric species, a feature that is supported by a Bootstrap proportion (BP) of 81-87 %. Isolate number BR9 identified as *Anaeromyces elegans* was superior and incorporated in wheat straw based total mixed ration of growing female calves as direct fed microbial @ 50 ml/day having zoospore concentration of 10^6 /ml. There was 15% and 26.42% increase in feed efficiency and growth rate of female calves compared to control. Availability of total digestible nutrients increased by 8.7 units due to incorporation of fungal zoospores while 19.82 units increase in p-coumaroyl esterase and 27.09 units increase in feruloyl esterase activity due to *Anaeromyces elegans*. The elite rumen fungi, *Anaeromyces elegans* increased the growth rate and feed efficiency of growing female calves compared to control. Thus, *Anaeromyces elegans* seems to be a promising fungi which could be incorporated in wheat straw based total mixed ration to improve the nutritive value of cereal straws.

Effect of Full Fat Extruded Soybean Seeds as a Partial Replacement of Groundnut Cake in Lactating Cows

Fifteen early lactating cross bred cows (2nd to 4th parity) were divided into 3 groups fed a basal ration consisting of wheat straw and concentrate in the ratio of 50: 50 along with 10 kg oats green fodder/animal/day. Animals in T₁ and T₂ groups were also fed same diet as that of control except that 50% of groundnut cake in their concentrate mixtures was replaced by extruded

full fat or raw soybeans, respectively. The average dry matter intake (DMI) (kg/day) was 13.3 ± 0.4 , 13.6 ± 0.3 and 14.0 ± 0.5 in C, T₁ and T₂ groups, respectively. The DMI (3.00 ± 0.05 , 3.05 ± 0.08 and 3.13 ± 0.05 kg/100 kg BW in C, T₁ and T₂ groups, respectively) and body weights were similar in all the three groups. The average milk yield (kg/d) was significantly ($P < 0.05$) higher in T₁ (14.4 ± 0.5) as compared to control (13.0 ± 0.3) and T₂ (13.0 ± 0.4) groups. The digestibility of DM, organic matter, and nitrogen free extract were significantly higher in T₁ than that of cows in group C and T₂. Crude protein digestibility was significantly higher in both the treatment groups but it was highest in T₂ group followed by T₁ group. The digestibility of nutrients was not influenced by replacing GNC with soybean (raw or extruded). Nitrogen balance (g/d) was significantly higher in T₁ (53.76) groups as compared to C (37.22) and T₂ (39.15). Net returns/income per animal /day (Rs) on 4% FCM basis was 136, 160 and 126 in C, T₁ and T₂ groups, respectively. Economics of feeding was better in ration substituted with extruded full fat soybean as a partial replacement of groundnut cake.

Effect of Feeding Fungal (*Basidiomycetes Crinipellis* Sp. and RCK-SC) Treated Wheat Straw on Nutrient Utilization and Methane Production in Sahiwal Calves

Fungal treated straws contained less amount of lignin, neutral detergent fibre and acid detergent fibre with increase in crude protein and ash contents. Digestibility of dry matter and organic matter improved

significantly ($P < 0.05$) in both the fungal treated straws along with the increase in metabolizable energy (ME), microbial protein (MBP), efficiency of microbial protein synthesis and short chain fatty acids. *In vitro* total gas production was significantly ($P < 0.05$) higher in T₂ and methane production (l/kg digestible DM and l/kg digestible OM) was lower in T₂. Digestibility of DM and OM increased significantly ($P < 0.05$) in both the fungal treated straw diets along with higher ($P < 0.05$) microbial protein. Methane production (l/kg DDM and l/kg DOM) reduced significantly ($P < 0.05$) in T₂. Among the volatile fatty acids, acetic acid and A:P were significantly ($P < 0.05$) higher in T₂. The total DMI by the Sahiwal calves was significantly ($P < 0.05$) higher in T₂ than control and T₁. Average DCP intake in T₁ and T₂ groups was significantly ($P < 0.05$) higher than control and the difference between T₁ and T₂ was significant ($P < 0.05$). Average TDN intake in T₂ group was also significantly ($P < 0.05$) higher than control and T₁. The digestibility coefficients for all nutrients except EE were significantly ($P < 0.05$) higher in T₁ and T₂ groups than control. Total body weight gain and average daily gain in T₂ group were significantly ($P < 0.05$) higher than T₁ and control. DCP and TDN percent was higher in T₂. Methane production when expressed as g/kg DMI was significantly ($P < 0.05$) lower in T₂ group as compared to control and as g/kg DDMI was also significantly ($P < 0.05$) lower in T₂ than T₁ and control. Further, methane loss as percentage of energy intake (gross energy, digestible energy and metabolizable energy) in both the treatment groups was significantly ($P < 0.05$) lower as compared to control.

ANIMAL BIOCHEMISTRY

Comparative Evaluation of Probiotic Fermented Milks

Five strains of lactobacilli belonging to three species (*L. casei*, *L. acidophilus* and *L. helveticus*) were confirmed for probiotic attributes viz. acid tolerance, bile tolerance and cell surface hydrophobicity, bile salt hydrolase and antimicrobial activities. All the strains exhibited probiotic attributes with considerable degree of variation. Three *Lactobacillus* strains selected on the basis of probiotic attributes were used for preparing three different fermented milks (PFMs). In order to evaluate the effect of feeding these probiotic fermented milks on innate and adaptive immune response, *in vivo* trials were conducted in mice for a period of one to two months. Cellular and biochemical functions of neutrophils were evaluated in terms of phagocytic

activity, chemotaxis and enzymes associated with respiratory burst (cytochrome c reductase and myeloperoxidase). In addition, the effect of oral supplementation of probiotic lactobacilli on expression of TLR2 and 4 in neutrophils were also assessed. A significant increase ($P \leq 0.05$) in neutrophil cytochrome c reductase and myeloperoxidase activities were observed in groups fed with probiotic fermented milk compared to control diet fed animals. Similarly, the percentage of phagocytosis was observed to be significantly ($P \leq 0.01$) high (54.4-63.7%) in the groups fed on PFMs after 30 days of feeding experiment. However, no significant changes in phagocytosis and respiratory burst activity were observed between 30 days and 60 days of feeding. The speed of migration of neutrophils was also improved significantly ($P \leq 0.01$) by feeding three types of

probiotic fermented milk for 30 days. Improved macrophage functionality on feeding three probiotic fermented milks was also evident from significant release ($P \leq 0.01$) of lysosomal enzymes (β -galactosidase and β -glucuronidase) and NO production in peritoneal fluid and culture supernatant of macrophages. The phagocytic activity of peritoneal macrophages increased significantly ($P \leq 0.01$) by 32.76, 30.59 and 57.75%, respectively on feeding three PFMs prepared from *L. helveticus*, *L. acidophilus* and *L. casei* respectively for 30 and 60 days to mice as compared to basal diet control group. Expression of neutrophil and macrophage TLR2 were found to be significantly ($P \leq 0.01$) up regulated in mice fed with probiotic fermented milks than control. However, non-significant changes were recorded on splenocyte proliferation index on feeding three types of PMFs in presence of LPS and ConA than control groups.

Probiotic Dahi Containing *Lactobacillus casei*

The study evaluated the effects of feeding probiotic dahi (PD) containing *L. casei* on the progression of obesity in high fat diet fed C57BL6/J mice for 8 weeks. Feeding of PD containing *L. casei* exhibited promising results in allaying the obesity complications. There was a significantly reduced gain in body weight in probiotic dahi fed group in comparison to high fat diet (HFD) fed group from 7th week onwards. The epididymal fat mass accumulation was also significantly reduced in PD group. Disturbances in lipid profile tend to normalize in PD group in terms of reduced plasma total cholesterol and LDL-C level. Modulation of gut microflora was also observed as a significant increase in bifidobacterial count ($\sim 1 \log \text{ cfu/g}$) in cecal content in PD group relative to HFD fed group. Feeding of high fat diet caused significant upregulation of PPAR and leptin, and downregulation of adiponectin in epididymal fat tissue in HFD group. Dietary supplementation of PD exhibited significant resistance to upregulation of PPAR and leptin, and downregulation of adiponectin. The dietary incorporation of probiotic dahi containing *L. casei* may have a potential antiobesity effect.

ACE Inhibitory and Antioxidative Activity of Buffalo Casein Hydrolysates

Angiotensin Converting Enzyme Inhibitory (ACEI) activity and antioxidative activity of peptides generated from buffalo casein hydrolysed by enzymes of gastrointestinal origin (pepsin, trypsin and chymotrypsin) either alone or in combination was assessed. Buffalo casein isolated from fresh milk yielded $29.61 \pm 1.16 \text{ g/l}$ of casein. Casein was hydrolysed for 3 hrs with each enzyme, in case of

combination, the casein was first digested with pepsin and then by other enzyme(s) after inactivation. The degree of hydrolysis ranges from 7 % (pepsin) to 18% (pepsin-trypsin-chymotrypsin). ACEI activity of intact casein was $2.33 \pm 0.75 \%$ per 50 μg of casein. Pepsin-trypsin hydrolysates with highest inhibitory activity ($72.55 \pm 2.23 \%$ of inhibition per 50 μg of hydrolysate), was fractioned by ultrafiltration with 10, 5, 3, and 1 kDa membrane filters. ACEI activity increased with the decrease in the molecular weight of the hydrolysate. 1 kDa permeate with highest ACEI activity ($83.0 \pm 1.53 \%$ of inhibition per 50 μg of hydrolysate) was further fractioned by RP-HPLC (C18 column). Out of 16 fractions, the 7th and 11th fraction eluted at 27 and 36% acetonitrile concentration, respectively. They showed highest ACEI activity of around 100% inhibition per 10 μg of hydrolysate.

Antioxidative activity of casein hydrolysates ranges from 1.44 ± 0.12 to 1.76 ± 0.06 TEAC ($\mu\text{mol/mg}$ of peptide) for trypsin and pepsin-trypsin hydrolysate, respectively. But the antioxidative activity of intact casein was 0.86 ± 0.11 TEAC. Antioxidative activity of casein hydrolysed by pepsin-trypsin was significantly different from that of intact casein, pepsin and trypsin hydrolysates ($P < 0.01$). Pepsin-trypsin hydrolysates was subjected to ultrafiltration through 10, 5, 3 and 1 kDa membrane filters. 1 kDa permeate showed highest antioxidative activity of 2.82 ± 0.04 TEAC ($\mu\text{mol/mg}$ of peptide) which was further fractioned by RP-HPLC (C18 column). The 11th peak eluted at 36% acetonitrile concentration showed highest antioxidative activity of 6.9 ± 0.04 TEAC ($\mu\text{mol/mg}$ of peptide).

Process Development for Large Scale Production of Purified-Pediocin for Application as Food Biopreservatives

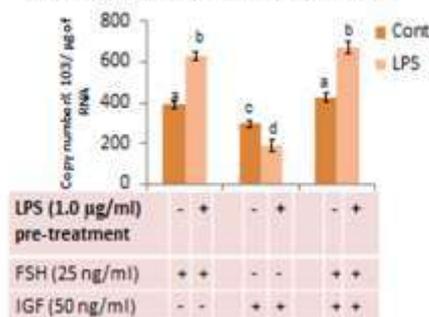
For developing pediocin as dairy food biopreservative, it is necessary to produce it in purified form on a large scale from a food grade medium. In this direction, a protocol was standardized for pediocin production from MRS broth with immobilized cells. Pediocin was purified by following ammonium sulphate precipitation at isoelectric pH and cation-exchange chromatography on SP-Sephadex in less than 2 h followed by RP-HPLC in one and an half h. A process was optimized for large-scale pediocin production using food-grade cheese whey medium in a cost-effective following 2^3 factorial design using a response surface methodology. To develop a strategy for tackling resistance issue, eight resistant variants of *E. faecalis* against pediocin were selected and characterized for their growth kinetics, cell wall sensitivity to lysozyme, cell surface hydrophobicity,

penetration of pediocin in cell membrane of resistant variants and expression levels of *mprF*, *mptA* and *dltA* upon acquisition of resistance to pediocin.

Expression Analysis 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 cows and buffaloes, leading to infertility by disrupting uterine and ovarian function. Recent reports showed that granulosa cells have a mechanism for direct action of LPS in the ovarian follicle to impair ovarian function and ovulation. Reduced *Cyp19* gene transcripts in granulosa cells and lower peripheral plasma estradiol concentrations are amongst prominent ovarian dysfunction due to LPS. However, molecular mechanism of LPS induced down regulation of *Cyp19* gene, encoding aromatase, key enzyme in estrogen biosynthesis, is not known. We have previously reported the reduced estradiol-17 β concentration in buffalo peripheral blood in animals with postpartum uterine infection can be classified based on the morphological, biochemical and clinical parameters. Similarly, evaluation of effect of LPS on *Cyp19* gene expression and estradiol-17 β production in granulosa cells *in vitro* showed the dose dependent decrease in both *Cyp19* gene expression and estradiol-17 β production. To understand the molecular mechanism of *Cyp19* gene down regulation in granulosa cells, cells were cultured in serum free conditions and cells of pre-ovulatory characteristics were treated with LPS (1.0 μ g/ml) alone or along with FSH (25 ng/ml) and IGF1 (50 ng/ml) and analysis of *Cyp19* gene was done. Result indicated the possibility of cross-talk/interaction between LPS signaling and FSH and IGF1 signaling. LPS treatment tends to increase the FSH sensitivity in *Cyp19* gene expression while LPS seems to decrease IGF1 sensitivity or increase IGF1 resistance.

FSH tend to potentiate while IGF1 resist (IGF1 resistance) the LPS action on *Cyp19* gene expression



Effect of LPS on *CYP19* transcripts in granulosa cells *In Vitro*

It has been suggested that susceptibility to LPS in granulosa cells depends on the developmental stage of follicles (depending on the FSH and IGF1 responsiveness). In conclusion, the results of the present study suggested that inhibitory effects of LPS on E2 production in granulosa cells due to decrease in IGF1 sensitivity could be one of the main causes of ovarian dysfunction in buffaloes with postpartum uterine infection.

Elucidating Molecular and Cellular Mechanisms of Ovarian and Uterine Cells Function Underlying the Infertility Associated with Postpartum Uterine Infection in Buffalo

To understand molecular and cellular mechanism of granulosa cells dysfunction associated with LPS signaling, mode of action of LPS mediated immune response was evaluated in granulosa cells *in vitro*. Granulosa cells were cultured and cells of pre-ovulatory phenotype were treated with LPS (1.0 μ g/ml) for 6 h at different intervals followed by analysis of pro-inflammatory cytokines (TNF α , IL-1 β and IL-6) using absolute quantitative real time PCR.

Result showed that all the three pro-inflammatory cytokines were significantly ($P \leq 0.01$) up regulated within 2-3 h and then after expression of all the three pro-inflammatory decreased sharply and reached to normal basal level within 6 h. CLA, ligand of PPAR γ , has been shown to be a potent anti-inflammatory and recently, elucidation of the molecular mechanism of conjugated linolenic acid (CLA) action in regulation of granulosa cells function through PPAR γ dependent pathway has been achieved. To test the hypothesis, if CLA can prevent the LPS induced pro-inflammatory cytokines expression in granulosa cells, cells were cultured and were co-treated with CLA (10 μ M) and LPS (1.0 μ g/ml) for 2 h followed by analysis of expression of pro-inflammatory cytokines. Surprisingly, CLA had no effect on pro-inflammatory cytokine expression. Further, cells were pre-treated with CLA for 12 h and then after the cells were exposed to LPS for 2 h. Result showed that pre-treatment of cells with CLA had significantly ($P \leq 0.01$) reduced the expression (almost comparable to respective control). In addition, western blot analysis of our previous study demonstrated that CLA (10 μ M) inhibit histone acetylase in granulosa cells when exposed for 12 h. PAMPs (e.g. LPS in the present study) and host cell interaction has been shown with host cell regulation through epigenetic (histone modification).

In conclusion, the present study showed that LPS induces pro-inflammatory cytokine expression in granulosa cells through TLR4 signaling. CLA pre-

treatment can prevent the LPS induced pro-inflammatory cytokines.

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

Comparative studies on apoptotic markers were made on freshly collected buffalo semen of more than +3.0 mass activity, splitted into fresh and cryopreserved in soya milk extender and in conventional egg yolk extender. The number of early apoptotic in soya vs egg yolk extender (3.0 and 3.0%); late apoptotic (30 and 32%) and necrotic cells (11 and 12%) were found to be comparable in the two extenders. The soyamilk extender proves to be better in maintaining the late apoptotic cells in comparison to egg yolk extender. Analysis of the early apoptotic, late apoptotic and necrotic cells at various stages of cryopreservation i.e. fresh cells, on dilution, cooling at 4°C, keeping cells of liquid N₂ vapour for 10 minutes and after freezing /thawing revealed significant changes by keeping cells at Liquid N₂ vapour followed by freezing and thawing.

Sperm mitochondrial membrane potential was found to be decreased in cryopreservation spermatozoa ($63.23 \pm 3.80\%$) in terms of No. of spermatozoa showing high mitochondrial membrane potential compared to fresh cells ($75.15 \pm 1.48\%$). Cryopreservation induces a significant increase ($p < 0.05$) in the proportion of spermatozoa with low mitochondrial membrane potential compared to the fresh cells as $24.96 \pm 1.49\%$ and after cryopreservation this proportion increased to $34.76 \pm 4.09\%$ in egg yolk and $31.23 \pm 1.03\%$ in soya milk extender. Similarly the spermatozoa with high mitochondrial membrane potential decreased significantly on cryopreservation in the two extenders. The soyamilk extender showed lesser effects compared to the egg yolk extender. Further studies on detection of antiapoptotic factor Bcl₂ proapoptotic factor Bax and detection of caspases by immunoblotting using specific antibodies are in progress.

Molecular Basis of Capacitation Like Changes During Cryopreservation of Bovine Spermatozoa

The Immunocytochemical localization of tyrosine phosphorylated proteins was compared in the cryopreserved spermatozoa in the presence and absence of additives like Taurine (50mM) and Trehalose (100mM). The presence of additives lowered the intensity of fluorescence at the equatorial and acrosomal region in cryopreserved spermatozoa. However, in presence of Trehalose low fluorescence was observed in mitochondrial regions in addition to the above regions. This shows the different mechanism

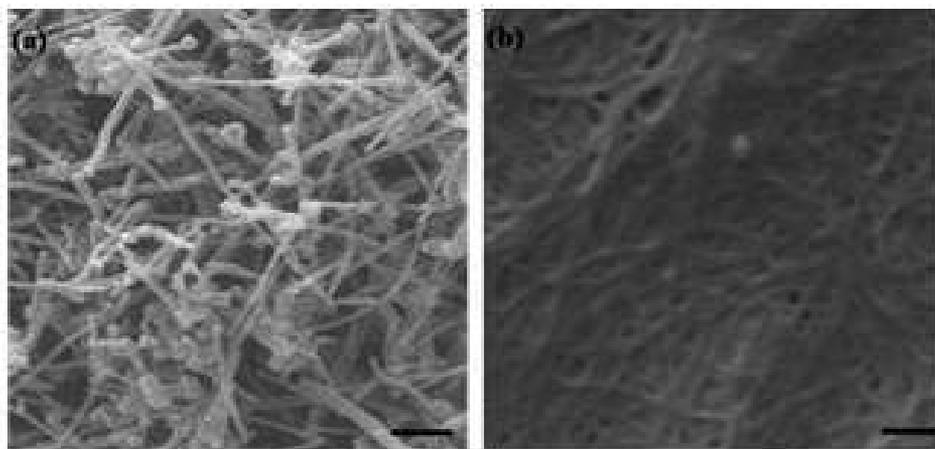
of protective action of the additive like Taurine and Trehalose in the frozen semen. The levels of glutathione an important antioxidant were found to be more in the cryopreserved spermatozoa using new soyamilk extender compared to the egg yolk extender. The addition of Taurine (50mM) and Trehalose (100mM) in the extender prior to cryopreservation further increased the glutathione levels in the buffalo and Karan Fries spermatozoa. Addition of 100mM trehalose to the extender as additives is recommended for buffalo semen cryopreservation while Taurine (50mM) is good for cattle (Karan Fries) spermatozoa. Total motility, progressive motility and percentage of rapid motile spermatozoa as analysed by Computer Assisted Semen Analyser (CASA) was found to be significantly high in cryopreserved buffalo semen extended with soyamilk extender as compared to egg yolk extender. The trials to extend the shelf life of soyamilk extender using preservatives are in progress.

Oxidative Stress Induced by Quantum Dot Nanoparticles

Oxidative stress induced by Carbon Nanotubes and Nanoparticles on a somatic cell line and ejaculated spermatozoa were studied. Despite the wide spread use of the nanoparticles, understanding of the toxicity and potential health risk associated with nanoparticle use is extremely limited. Oxidative stress is caused by an imbalance between damaging oxidants and protective antioxidants. This state of affairs can impair or destroy cell proteins, lipids and DNA, leading to the deterioration in cell function or toxicity. The quantum dot (QDs) were initially characterized by using UV-visible spectroscopy, DLS and the UV-visible spectrum of QDs showed that CdSe/Zns absorption was at 560nm, and emission spectrum at 655nm, water soluble QDs, however, showing maximum absorption spectrum at 555nm and emission spectrum at 655nm. Further particle size and distribution of the original solution and concentration of carbon nanotubes and nanoparticles in solution were measured by dynamic light scattering. Towards this we observed amongst other things primarily the zeta potential, which is the overall charge, acquired by the nanoparticle in a particular medium. The magnitude of the measured Zeta potential is an indication of the repulsive force that is present and can be used to predict the long term stability of the nanoparticle and if all the particles in the suspension have a large negative zeta potential then they will tend to repel each other and there is no tendency for the particles to come together. The hydrodynamic diameter size of CdSe/ZnS QDs was 802.2nm and width was 84.1 nm. For the water soluble QDs it was 439.7 and 59.56nm respectively. Their Zeta

potential value as assessed for CdSe/ZnS, water soluble QDs was -9.36, -10.36 respectively. After initial characterization the granulosa cells were isolated from small and medium antral follicles and cultured in DMEM media for 48hr. Granulosa cells incubated with QDs were ubiquitously showing the presence of QDs in the granulosa cells. To further study the cytotoxicity induced by QDs on granulosa cells, the cell viability was checked by MTT assay after incubating with QDs for 6h, 12h and 24h and at varying concentrations (0.1 μ g, 1 μ g, 10 μ g, 20 μ g, 50 μ g, 100 μ g). The cell viability was found to be significantly reduced at all concentrations except for at 0.1 μ g. After 6h, 12h and 24h incubation with CdSe/ZnS QDs, viability was further reduced progressively as the concentration of QDs concomitantly increased. At 100 μ g, cell viability was reduced by 32.3%, 35% and

77.4% after 6h, 12h and 24h incubation respectively. After incubation with water soluble QDs for 6h, 12h and 24h, cell viability was also significantly reduced at 10 μ g, 20 μ g, 50 μ g and 100 μ g concentrations. At 100 μ g cell viability was reduced by 30.9%, 32.6%, and 36.1% after 6h, 12h and 24h incubation respectively. These results suggested that QDs could adversely affect the granulosa cells in terms of cell viability and further CdSe/ZnS QDs are more toxic than water soluble QDs in terms of cell viability. Furthermore, oxidative stress may be a useful criterion to pinpoint which physical factors are associated with the biological insults. If carefully thought out, such studies could serve as important building blocks towards the development of more-efficient screening strategies for biosafety of new nanomaterials.

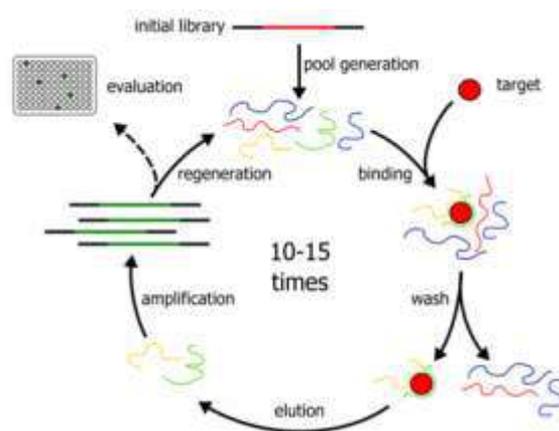


Scanning electron microscopy images of Multi walled carbon nanotube (MWNT) scaffolds (a) before and (b) after 12 hours of incubation in cell culture medium containing 5% serum

Generation of Aptamers Against Aflatoxin M1

Aptamers are single stranded oligonucleotides that bind to the target with high affinity and specificity. Aptamers are selected by an iterative process called systematic evolution of ligands by exponential enrichment (SELEX). In certain applications, aptamer technology offers several advantages over antibodies. First, high-purity aptamers can be chemically synthesized at a low cost and can be easily modified with dyes and labels without affecting their affinities. Second, aptamers are more chemically stable under most environmental conditions, have a longer shelf life, and can be reversibly denatured without loss of specificity. These properties make aptamers attractive in the development of low-cost, robust diagnostics and biosensors. Thirty seven different aptamers which recognizes aflatoxin M1 have been selected.. These aptamers have very low dissociation

constants ranging from 23nM to 1515nM indicating high level of specificity and can be utilized for developing methods for aflatoxin M1 detection.



Selection strategy for aflatoxin M1 aptamers

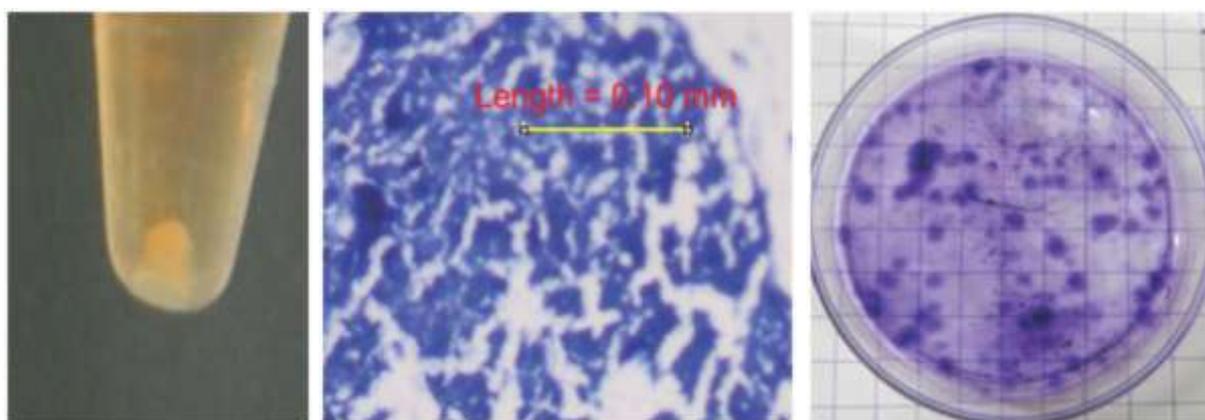
Isolation, Functionalization and Characterization of Mesenchymal Stem Cells (MSCs) from Mouse White Adipose Tissue

MSCs were isolated from white adipose tissue classically based on their ability of adherence to the plastic surfaces. The initial adherent spindle-shaped cells appeared on day 3, and further expanded mitotically. These MSCs were grown upto 70% confluency to maximize the yield and minimize their natural differentiation. MSCs were differentiated into chondrocytes by pellet culture system. Approximately 2×10^5 cells were pelleted by centrifugation at 300 g for 5 minutes followed by incubation at 37°C and 5% CO₂ in 0.5ml chondrogenic media, composed of DMEM-LG supplemented with 10ng/ml transforming growth factor β 3, 100nM dexamethasone, 50 μ g/ml ascorbic 2-phosphate and 1.25 mg/ml BSA. The cells were

of CD11b. These findings suggested the expression of Mesenchymal stem cells according to MSC standard criteria of International Society for Cellular Therapy (ISCT).

Development Genes in Mouse Brown Adipocytes

Developmental genes are now being implicated in proliferation and differentiation of adipose tissue. Brown adipose tissue (BAT) and white adipose tissue (WAT) exhibit different functions. BAT is a unique fat depot in mammals for oxidation of dietary fuel substrates without production of chemical energy. The principal role of WAT is the storage and release of triglycerides in response to energy levels. Pref1 and UCP-1 are considered stage specific markers; former for proliferation stage and later for differentiation stage. The expression of a number of development genes during proliferation and differentiation in brown



(A) MSCs differentiated into chondrocytes for 21 days in chondrogenic medium

(B) Chondrocytes stained with toluidine blue

(C) Colony forming assay by graining 1000 cells /dish

cultured for 3 weeks, changing the media every 3 days. Cells cultured in micromass adopted a morphology characteristic of chondrocytes and secreted an extracellular matrix rich in glycosaminoglycans, as evident by staining with toluidine blue.

For Colony-forming assay, 1000 cells were plated and cultured for 14 days in 60 cm² dishes. The cells were subsequently fixed with 4% paraformaldehyde, stained with 0.5% crystal violet in 4% paraformaldehyde for 5 min, and washed twice with distilled water. 45 large colony size were observed. Faintly stained or colony size less than 2 mm were ignored.

Gene expression analysis revealed high level of CD73, CD90 and CD105 expression whereas low expression

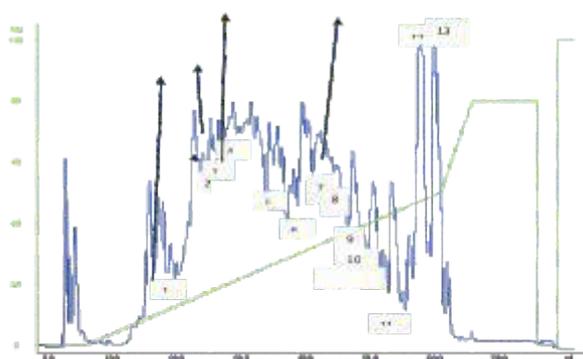
adipocytes in culture has been studied. It has been noted that more than 10 fold expression of Gpc4, En-1 and Pref1 during proliferation and Gpc4, En-1, HoxA1, HoxC8 and HoxC9 during differentiation. Shox2, UCP-1, Thbd, HoxC4, Nr2f1 and HoxA10 are expressed at very low level during proliferation. Shox2, Thbd and HoxA10 developmental genes are expressed at very low level during either proliferation or differentiation indicating these genes have no role in adipogenesis. Pref1 is 32 fold down regulated when proliferated cells are differentiated. In contrast, differentiated cells express 2655, 212, 145, 24, 18, 12.6, 12, 9.2 and 4 folds more expression of HoxC9, UCP1, HoxC8, HoxA5, Nr2f1, HoxA1, En1, HoxC4 and Gpc4 genes over proliferated brown adipocytes.

DAIRY CHEMISTRY

Research on Nutraceuticals from Milk, Functional Foods with Prebiotics, Probiotics, Micronutrients and other Bioactive Compounds for Improved Human Health

Production of antimicrobial peptides by fermentation of milk using *Lactobacillus acidophilus* NCDC 14

The exploitation of casein by LAB was initiated by principal component of proteolytic system i.e., cell-envelope proteinase (CEP) which degrades the protein into oligopeptides that are subsequently taken up by the cells via specific peptide transport systems for further degradation into shorter peptides and amino acids by a concerted action of various intracellular peptidases. For the optimum production of antimicrobial peptides from *Lactobacillus acidophilus* NCDC 14, the CEP activity was assessed using different media ranging from rich nitrogenous to minimal nitrogen sources including MRS, modified nutrient medium and skim milk. The maximum CEP activity was observed in cells grown in skim milk. Skim milk was fermented using *Lactobacillus acidophilus* NCDC 14 and assessed for degree of hydrolysis and antimicrobial activity by varying fermentation time (12-72h), inoculation level (1-3%) and temperature of incubation (37°C and 42°C). The degree of hydrolysis was observed to vary between 5.9 mM Leu to 11.5mM Leu over 72h, with corresponding peptide content 2.0 - 3.8 mg/ml. The maximum antimicrobial activity was observed against *E coli* ATCC 25922 corresponding to 3.8 mm diameter of zone of inhibition using agar well diffusion assay (Fig.1) after UF of fermentate over 10kDa membrane, by fermentation at 2% level of inoculum



RP-HPLC- Profile of *Lactobacillus acidophilus* NCDC 14 fermented skim milk

over 36h -48h period of incubation at 37°C. The method for enrichment of antimicrobial peptides following solid phase extraction over C18 was standardized. The antimicrobial peptides were separated over RP-HPLC. The fractions 1, 2, 4, and 7 showed highest antimicrobial activity over YPD agar against *E coli* ATCC 25922 resulting in 20 fold decrease in plate count as compared to control.

Ameliorative potential of whey protein hydrolysate against paracetamol-induced oxidative stress

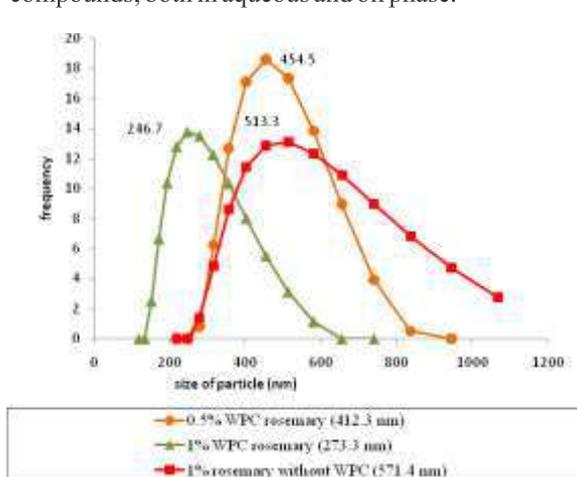
The present study was undertaken to investigate the protective effect of whey protein hydrolysate (WPH) against paracetamol-induced hepato-nephro toxicity. WPH was prepared by hydrolysing ultrafiltrated retentate of Mozzarella cheese whey with commercial food grade enzyme alcalase having an *in vitro* antioxidant activity of $1.18 \pm 0.015 \mu\text{M}$ of trolox/mg of protein. Male albino mice were treated with the WPH for 4 days (intraperitoneally-4 mg/kg body wt and orally- 8mg/kg body wt) prior or post to oral administration of paracetamol (300mg/kg body wt) for 2 days. Levels of different marker enzymes (namely, glutamate pyruvate transaminase and alkaline phosphatase), creatinine and blood urea nitrogen were measured in the experimental sera. Indices of different antioxidant enzymes (catalase, superoxide dismutase, glutathione peroxidase as well as lipid peroxidation end-products) were determined in liver homogenate. The WPH successfully mitigated the rise in the concentration of oxidative biomarkers like creatinine, alkaline phosphatase, glutathione pyruvate transaminase and thiobarbituric acid reactive substances and restored the activities of antioxidant enzymes in liver and level of blood urea nitrogen significantly with the group treated with paracetamol. But the protective effect was less in oral group compared to intraperitoneally injected groups. The seven β -Lactoglobulin derived peptides like f(96-100), f(94-100), f(123-131), f(122-131), f(124-131), f(123-134), f(122-131) were identified by RP-HPLC-MS/MS in this WPH. Therefore, it can be concluded that these WPH could be used as an effective protector against paracetamol induced hepato-nephrotoxicity and can be effectively used in formulated foods as biofunctional ingredients.

Biological properties of glycomacropeptide (GMP) derived from buffalo and cow milk

The study indicated that sialic acid content is higher in cow milk derived GMP (9%) compared to buffalo milk derived GMP (2.8%). The biological properties of isolated GMP were studied by two parameters- cholera toxin (Ctx) binding activity and the growth of *Lactobacillus rhamnosus*. The isolated GMP was able to inhibit cholera toxin and results indicated that cow GMP has better ability to inhibit cholera toxin compared to buffalo milk derived GMP. The IC_{50} value was calculated as $1 \mu\text{g/ml}$ for cow GMP vis-à-vis $1000 \mu\text{g/ml}$ for buffalo GMP. During the study, it was observed that the presence of GMP in the media promote the growth of *Lactobacillus rhamnosus*. The growth enhancing activity of GMP was found to be slightly higher than the control and bovine serum albumin.

Preparation and characterization of nanoemulsions encapsulating polyphenol extracts

Stable oil-in-water (O/W) nanoemulsions encapsulating polyphenol extracts were prepared by optimized sonication conditions. O/W nanoemulsions were prepared by using lipophilic rosemary extract as the core material and Tween 80 as surfactant along with or without WPC-70 as coating material and the particle size and zeta potential ranged from 179.3 ± 29.2 to 785.9 ± 27.4 nm and -29.9 to -48.1 mV respectively. Particle size of O/W emulsions with WPC-70 ranged from 273.3 ± 88.7 to 412.3 ± 56.8 nm and it was observed that with the addition of WPC, there was a decrease in the particle size. Turbidity (0.38 ± 0.001 – 1.45 ± 0.003) and viscosity (1.2 ± 0.03 – 2.1 ± 0.03 CP) of the emulsions also increased with the particle size of the emulsions, but in case of ionic strength the particle size (163.3 ± 43.5 - 77.6 ± 32.0 nm) decreased with increase in salt concentration (0.1 M – 1 M). Encapsulation efficiency was calculated on the basis of total polyphenol content. The O/W rosemary emulsions had an efficiency of 84-98% encapsulation efficiency. Different processing conditions (heat treatment, ionic strength and pH) had significant effect on the stability, colour and particle size of the nanoemulsions. Antioxidant activity was analyzed by using DPPH, and there was no significant difference. These nanoemulsions can be used as an effective delivery system for the poorly soluble bioactive compounds; both in aqueous and oil phase.



Particle size distribution of the emulsions having 1% rosemary O/W emulsions+WPC

Functional properties of strawberry polyphenol extract fortified stirred dahi

The growth of mesophilic mixed dahi culture (NCDC-167) was not affected in the presence of strawberry polyphenol extract at 0.25 – 1.0 mg/ml concentration. Strawberry polyphenol extract fortified stirred dahi

(SBPE dahi) was formulated with better sensory properties as compared to control and no significant difference ($p < 0.05$) was observed between control and strawberry polyphenol fortified dahi in terms of compositional and physico-chemical parameters except in case of pH and acidity. Significant differences ($p < 0.05$) in pH and acidity were observed between SBPE dahi and control dahi during storage for three weeks. SBPE dahi resulted in relatively lower pH 4.30 with corresponding acidity 0.92% LA in fresh preparation and dropped after 21 days to 3.87. Significantly higher scores were observed for flavour of SBPE dahi compared to control, which were significantly different ($p < 0.05$) till two weeks storage. Further there was no significant difference in acidity up to one week storage both for control and SBPE dahi, however, a significant difference ($p < 0.05$) occurred during 2nd week. The storage time had a statistically significant effect ($p < 0.05$) on consistency score both for control and SBPE dahi, resulting in decrease by the end of two weeks period. The total polyphenolic content showed 34% of the theoretical value of added strawberry polyphenol in aqueous dahi extract (whey portion), whereas rest (66%) was retained in the gel matrix. Further during storage of the product at 7-8^o C for 3 weeks, no change in the retention of polyphenol content in SBPE dahi was observed. Antioxidant activity of SBPE dahi was observed to be nearly seven fold as compared to control dahi. The α -amylase inhibition activity of the strawberry polyphenol extract fortified dahi was observed to be 14.2% while no inhibition was observed in the control dahi. The α -glucosidase inhibition activity of the control dahi and the strawberry polyphenol extract fortified dahi was observed to be 24.28% and 36.5%, respectively, while the corresponding angiotensin converting enzyme inhibition activity was 19.66% and 32.35%. There was no significant difference ($p > 0.05$) in terms of antioxidant activity and retention of total phenolic content, α -amylase inhibition activity, α -glucosidase inhibition activity, angiotensin converting enzyme inhibition activity throughout the storage of three weeks.

Biofunctional properties of traditional Indian lassi prepared from buffalo milk

The survey of traditional lassi from nearby villages of Karnal city was conducted with respect to method of preparation of lassi and the collected samples were analyzed for their physico-chemical and bio-functional properties. The method of preparation of lassi was optimized taking into consideration preheating temperature, incubation time, screening of *Lactobacillus* strains and the bio-functional properties.

Two NCDC cultures were selected namely, *L. acidophilus* (NCDC-15) with maximum antioxidative ($0.65 \pm 0.074 \mu\text{M TEAC} / \text{mg}$ of protein), ACE inhibitory activity IC_{50} ($26.62 \pm 0.06 \mu\text{g}$ of protein/ml) and *L. paracasei* spp. *paracasei* (NCDC-63) with maximum CPPs contents ($2.61 \pm 0.05 \text{ mg/ml}$) as an adjunct culture for the preparation of lassi with standard dahi culture (NCDC167). The products so prepared were given the name Lassi-1 and Lassi-2 respectively. The ACE inhibition and antioxidant activity of optimized Lassi-1 were $34.24 \mu\text{g}$ protein/ml (IC_{50} value) and $0.65 \mu\text{M TEAC} / \text{mg}$ of protein respectively. The caseinophosphopeptides content of lassi-2 was 2.62 mg/ml . The antioxidant activity of lassi was investigated for *in vivo* model. In *in vivo* studies, the antioxidative enzymes (AOE) viz. catalase, superoxide dismutase (SOD) and glutathione peroxidase (GPx) activities increased significantly and level of thiobarbituric acid reactive substances (TBARS) and protein carbonyl decreases significantly in blood and liver homogenate of mice group fed with lassi-1 as compared to group fed with oxidized diet. The identification and sequencing of the peptides were done by LC/MS after purification by FP-HPLC on C_{18} Column. The total 54 peptides were found in lassi-1 out of which 5, 19, 22 and 6 showing partial homology for amino acid sequencing for antioxidative, ACE inhibitory, opioid and multifunctional activity of peptides previously described by different researchers. The two new peptides which are fragments of κ casein (κ -CN66-74, κ -CN79-86) was identified in the lassi-1 samples. The major fragments of casein with which the peptides sequencing match are κ -CN (56-86), α_{s1} -CN (1-16), α_{s1} -CN (24-40), β -CN(1-7), β -CN (50-75), β -CN (76-100), β -CN (101-125), β -CN (126-150), β -CN (151-175), β -CN (176-190) and β -CN (190-209) peptides. In control lassi prepared using NCDC-167, total 24 peptides were identified out of which 16, 3, 2, and 1 partially matched amino acid sequences for ACE inhibitory, immunomodulatory, antioxidative, opioid activity respectively as mentioned by previous researchers and one new peptide sequence (κ -CN66-86).

Development of micronutrient fortified milk

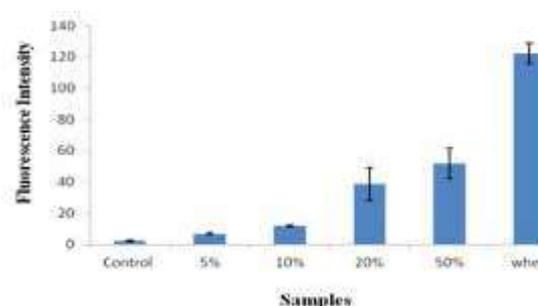
Liposomes of FeSO_4 were prepared using egg lecithin as wall material. Flavoured iron fortified milk (5, 10 and 15 ppm iron) was prepared using liposomes and sensory acceptability of fortified milk (5 ppm iron) was comparable to control. However, higher level of fortification led to a pronounced flavour defect in milk. Fortified milk samples were analysed for vitamin stability on exposure to fluorescent light and during

storage (in both polyethylene pouches and glass bottles). Vitamin D was stable to light and packaging in glass bottles whereas in polyethylene pouches significant reduction was observed. Vitamin A was stable in glass bottles where as in polyethylene pouches and under light it deteriorated significantly. Iron and calcium were stable to all these treatments. Distribution of added calcium and iron was determined and found that added calcium goes to soluble phase, whereas most of the iron goes to the colloidal phase of milk. Iron increased oxidative deterioration in milk. Non significant effect of iron and calcium on protein configuration and mobility in electrophoresis was observed. *In vitro* digestibility revealed that added calcium and iron had the same bioavailability as of control milk, whereas during multiple fortification, vitamin D enhanced bioavailability of calcium and vice versa and also vitamin A increased iron absorption, whereas iron had no significant effect on vitamin A absorption under simulated gastro-intestinal conditions.

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 and biotechnological concepts.

Detection of cheese whey in milk

Two approaches were used for developing methods for detection of cheese whey adulteration in milk. One such approach makes use of glycosylation of glycomacropeptide (GMP) which is released on action of rennet on kappa-casein during cheese preparation. The sialic acid attached to GMP was estimated using fluorimetric method for the purpose of detection of cheese whey adulteration in milk. The developed method can detect up to 10% adulteration in milk. The other approach uses derivative spectroscopy and



Relative fluorescence intensity (n = 6) of control (pure milk), milk samples adulterated with sweet whey (5, 10, 20 and 50%) and whey. Error bars represent standard error in estimation

through this concept, the difference absorption spectra of milk and milk adulterated with cheese were corresponding to area derivatized for determining of amplitude of peak and trough at characteristic wavelengths. Using this approach, 20 to 30% adulteration can be detected.

Development of strategies for detecting milk fat adulteration with admixture of animal body fats and vegetable oils

To detect the adulteration of ghee with vegetable oils/fats, RP-TLC was performed using two different stationary phases: i) RP-18 Silica gel-G F₂₅₄ TLC plates (ii) Paraffin impregnated silica gel-G and keisselghur-G plates. Many solvent systems were tried in combination with these two types of plates. It was observed that cholesterol and β -sitosterol could not be resolved on these plates. In case of paraffin impregnated plates, various permutation combination with respect to impregnation time and paraffin concentration were studied along with different solvent systems. It was observed from the chromatograms that the movement of samples was slightly better on plates impregnated with 3% paraffin solution. Since the separation of sterols was not achievable by reverse phase thin layer chromatography, therefore normal phase thin layer chromatography was also tried. Two solvent systems (i) diethyl ether: chloroform: ammonia (10:90:0.5, v/v) and (ii) heptane : ethyl acetate (1:1, v/v) were used for the development on silica gel- G plates. However, as such the bands of cholesterol and β -sitosterol were not separated in any solvent system mentioned above. But additional bands appeared in case of pure adulterant oils. The TLC approach was applied in case of adulterated samples especially adulterated with vegetable oils like coconut oil, designer adulterant oil, soy oil, groundnut oil and sunflower oil. The results showed that for coconut oil and designer oils, the level of detection was 20%, whereas the level of detection for other oils studied was 10%. TLC method was less sensitivities.

Detection and determination of extraneous thiocyanates in milk

The accuracy and precision of the IDF method was evaluated through recovery studies which showed good recovery (99.97 ± 0.36) for the added thiocyanate, indicating that the method was accurate and precise for the purpose. Using this method, thiocyanate contents in milk of different breeds of cows (Sahiwal, Tharparkar, Karan Fries and Karan Swiss) and Murrah buffaloes was established and overall average value of thiocyanate in milk was observed to be 7.81 ± 0.31 mg/l. Study was also aimed on the effect of processing

treatments (pasteurization, boiling, sterilization and chilling) on thiocyanate contents in milk. It was revealed from the study that HTST pasteurization, boiling and sterilization processes have slightly affected the estimation of thiocyanate contents in milk samples, whereas LTLT pasteurization and chilling showed no effect on the estimation of thiocyanate contents. Apart from this, the effect of various additives (adulterants, neutralizers and preservatives) on estimation of thiocyanate contents in milk was also investigated. Results indicated that all adulterants and neutralizers studied at the various levels had no effect on the estimation of thiocyanate contents both in case of cow and buffalo milks on the natural or added level of thiocyanates. Results on the effect of preservatives (formalin and hydrogen peroxide) revealed that both the preservatives (formalin and hydrogen peroxide) had lowered considerably the levels of thiocyanates in milk and it was observed that higher the level of preservative greater was the effect. Effect of natural souring on the thiocyanate contents in cow and buffalo milk samples with natural and added thiocyanate level was studied and it was revealed from the study that natural souring had no effect on the thiocyanate contents. The effect of storage of formalin preserved milk samples on the thiocyanate estimation in cow and buffalo milks was investigated and it was observed that there was significant decrease in the thiocyanate content of formalin preserved cow and buffalo milk samples after 15 days of storage. However, during subsequent storage there was only marginal decrease in thiocyanate content of formalin preserved samples. In survey of market samples, it was found that thiocyanate content of market milk samples was within the normal values of thiocyanate content of cow and buffalo milks as observed in the this study. Two types of qualitative tests were developed in the study for simple and rapid detection of added thiocyanates in milk, of which one was applicable to TCA filtrate and the other was applicable directly to milk. The test could find application at the reception dock in dairy where milk was tested for acceptance or rejection based on its quality.

Status of Bioactive Lipids in Indigenous Breeds of Cow and Murrah Buffalo

Bioactive lipids status was being measured in indigenous breeds of cow and Murrah buffalo. The total phospholipids content was higher in milk fat of Tharparkar and Sahiwal than cross bred cows and buffalo milk fat. Sahiwal also showed the highest amount of cholesterol in October 297.55 ± 1.21 mg/100g while in January and April it was highest in Karan-Fries milk fat in the range of 328.29 ± 2.07 and

321.98±2.37 mg/100g fat, respectively. Murrah buffalo milk fat showed the lowest amount of cholesterol

throughout the period of study.

DAIRY TECHNOLOGY

Value Addition to Traditional Milk Products through Application of New Processes, Biotechnological Interventions, Packaging and Mechanized Manufacturing System

Effect of Packaging Materials and Modified Atmosphere Packaging on the Shelf Life of Composite Dairy Foods

Equilibrium moisture content (EMC) of beta -glucan rich composite biscuits and complementary food at different water activities (0.103-0.950) and temperatures (28, 35 and 45C) were determined. Moisture adsorption isotherms of beta-glucan rich composite biscuits were similar to Type-II plot. Among the eight mathematical models used to fit the data BET and GAB models could closely predict the EMC of the biscuits.

Formulation of Ready-to-Serve Breakfast Smoothie

The project was envisaged with the aim to provide a nutritious and convenient 'grab-and-go' breakfast option in the form of a smoothie to consumers who do not have enough time to prepare breakfast. A breakfast smoothie based on germinated green gram flour (GGF) along with a fruit (mango), vegetable (carrot), honey and milk sources was formulated to provide adequate amount of minerals, vitamins and dietary fiber. Pre-treatments such as soaking, germination, heat treatment and dehulling reduced the phytic acid content in green gram by about 13%. Sugar, pectin and GGF levels were optimized for the product formulation using Response Surface Methodology (RSM). Shelf-life studies revealed that the smoothie remained acceptable for three, two and one months at 40°C, 30°C respectively. The cost of the developed product was estimated at Rs. 80.50 per kg and Rs. 16.10 per bottle (200 g) on the basis of prevailing prices. A serving of 200 g (per bottle) product provided approximately, 44% and 18.7% (in adult men and women respectively) of iron, 7.6% of calcium, 6.08% of vitamin A and 11.4% of dietary fibre of RDA. Attempts are also being made to formulate breakfast smoothie based on varied ingredients such as ragi (millet), sorghum (cereal) or black chickpea (legume) along with a fruit (mango) and a vegetable (carrot) and milk sources. Ragi, sorghum and black chickpea contain 3.80, 2.81 and 20.23% fibers respectively. Carrot juice (100g) contains 2.8 g dietary fiber, 320 mg potassium, 0.2 mg zinc, 0.3 mg

iron, 16705 IU vitamin A, 19.0 µg folate, 5.9 mg vitamin C and 13.2 µg vitamin K. Based on this knowledge, the current project is in progress to formulate a product, which will be a ready-to-consume breakfast option and will provide valuable nutrients and calories during the meal

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

The study was conducted to enrich the processed cheese spread (PCS) with three functional ingredients viz., inulin, phytosterols and w-3 fatty acids which have cholesterol lowering effect. In the present investigation, effect of different levels of inulin (4, 6 and 8%), phytosterols (2, 3 and 4%) and w-3 fatty acid (2, 3 and 4%) additions were investigated individually. The study revealed as the level of inulin, phytosterols or w-3 fatty acid addition were increased, some physico-chemical, rheological and sensory attributes changed significantly ($p<0.05$). At higher level of inulin (8%), phytosterols (3 and 4%) or w-3 fatty acid addition (3 and 4%) there was significant ($p<0.05$) decrease in total sensory score. So, 6% inulin added PCS (IPCS), 2% phytosterols added PCS (PPCS) and 2% w-3 fatty acid added PCS (OPCS) were optimized from this study. The optimization for the level of the three functional ingredients in combination (range – inulin: 4-8%, phytosterols: 2-4% and w-3 fatty acid: 2-4%) was carried out using Central Composite Rotatory Design of Response Surface Methodology and the addition level of inulin, phytosterols and w-3 fatty acid were optimized at 4, 2 and 4% level respectively (MPCS). The consumer acceptance study (107 consumers) revealed that the MPCS had been liked very much by the consumers due to its flavour and spreadability and the product itself was nutritionally and functionally sound. The developed functional PCSs were treated with nisin (0.04% or 400 IU nisin/g cheese) and stored for 6 months for changes in microbiological, physico-chemical, rheological and sensory attributes. To validate its hypocholesterolemic effect, developed products were fed to hypercholesterolemic rats and it was observed that serum total, LDL, VLDL cholesterol and Atherogenic index decreased and at the same time liver cholesterol and triglyceride decreased significantly ($p<0.05$). It was estimated that production cost of the nisin treated

IPCS, PPCS, OPCS and MPCS were Rs. 27.10, 30.93, 26.75 and 36.04/100 g, respectively. Thus, a technology of health promoting cheese spread developed will be useful to the consumers and industry.

Development of Sweetened Functional Soft Cheese

Sweetened functional soft cheese from buffalo milk was developed by incorporating fructooligosaccharide (FOS), inulin and cocoa as functional ingredients. Polyphenolic substances from cocoa powder contribute to reduction in LDL cholesterol, elevation in HDL cholesterol, suppression of oxidized LDL and even cancer prevention. Inulin is known as soluble dietary fiber which can also act as prebiotic. FOS is a very good prebiotic, which helps to improve immunity and is a healthy sweetener for diabetics. Based on the preliminary trials various levels of these ingredients were integrated into Response Surface Methodology (RSM) to determine their optimum levels. Central Composite Rotatory Design (CCRD) for three factors viz inulin (4-6%), cocoa (5-7%) and FOS (10-15%), as independent variables, was adapted to determine their optimum levels to elucidate effect of these variables on sensory, physico-chemical and rheological properties of the resultant soft cheese. Accordingly, optimum level of ingredients i.e cocoa (6.78%), inulin (4.16%) and FOS (13.00%) was finalized for the functional sweetened soft cheese. This optimized product was prepared and subjected to study the changes in sensory, physico-chemical, rheological and microbiological attributes during storage. The proximate composition of the product include 49.89% total solids, 12% fat, 14.29% protein, 1.83% lactose, < 250 ppm sucralose and 20.66% dietary fiber. The colour attributes of the product indicated 'L' value as 30.78, 'a' value as 11.69 and 'b' value as 16.74. The values of rheological attributes were, firmness (8.49N), Work of adhesion (36.07N.s), work of shear (121.53 N.s), and stickiness (6.19N). The changes in flavour, body and texture and colour scores were non-significant during entire storage period. However, significant changes in physico-chemical, microbiological and rheological attributes were observed throughout storage study. The product remained acceptable for 28 days without any preservatives. This product could have great potential in the fastest growing functional food market.

Enrichment of Processed Cheese Food with Functional Ingredients

The processed cheese food was enriched with three functional ingredients viz. phytosterol esters, whey protein concentrates (WPC) and inulin. Each functional ingredient level was optimized by Response

Surface Methodology (RSM). The optimum levels of addition were obtained as 4%, 2% and 6% for phytosterol esters, WPC and inulin, respectively. The optimized functional processed cheese food contained 61.55% total solids, 22.3% total fat, 24.8% protein, 3.5% ash, 2.1% salt, 1.15% lactose, 2.8% free phytosterols and 4.9% total dietary fibre. The storage study of the final product was carried out for 3 months during which changes in sensorial, rheological, physico-chemical and microbial quality were evaluated. The study revealed that the functional processed cheese food was acceptable at the end of 3 months storage period. As such, the shelf-life of the product over 3 months can be further extended by using certain natural preservatives for commercial exploitation and marketing.



Technology Development for Manufacturing of Kheer Mohan

Optimization of different process parameters taken as independent variables viz., sugar syrup conc. (° brix), semolina (% by wt. of *chhana*), cooking time and weight of *chhana* balls (g), and dependent variables (responses) was carried out using RSM. Around 60% reduction in cooking time was achieved in cooking of the optimized *kheer mohan* prepared from buffalo milk in comparison to traditional method of cooking.

Process Development for the Production of Functional Butter

Technology was developed for the production of functional butter added with functional ingredients viz. phytosterols and CLA. Functional butter with CLA added at the rate of 4% and phytosterol 12% of the butter added to cream before pasteurization 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. Animal studies are in process to evaluate

the hypocholesterolemic and anticarcinogenic effect of functional butter. Blood samples taken from experimental animals are analysed for HDL, LDL, triglycerides and total cholesterol.

Quality Improvement of Set Fermented Dairy Products Using Ultrafiltration Technology

Buffalo Milk Set Dahi: Good quality set plain *dahi* was produced from buffalo milk using ultrafiltration (UF) technique. Process of *dahi* production employing UF technique was optimized by: standardization of buffalo milk to desired level of total solids and fat with the addition of UF retentate; standardization of homogenization pressure; inoculation with desired lactic culture (NCDC-167) level and incubation at 30°C for a minimum period required for full flavour development. Desired level of titratable acidity and pH for good quality set *dahi* was optimized on the basis of better sensory and rheological parameters of the product. Chemical composition of prepared *dahi* met BIS specifications. Flavour score of optimized *dahi* was 41.58 compared to 42.68 and 39.08 of two best well established and branded market samples out of maximum possible 45, body and texture score was 28.29 compared to 25.5 and 24.83 out of maximum possible 30, acidity score was 8.41 compared to 8.75 and 7.67 out of maximum possible 10, colour and appearance score was 9.12 compared to 8.08 and 7.75 out of maximum possible 10 and overall acceptability score was much better at 92.08 compared to 90.16 and 84.13 out of maximum possible 100. Well set optimized *dahi* had firm body and smooth texture without any whey separation. Body and texture, colour and appearance and overall acceptability scores of optimized *dahi* were highly significantly ($p < 0.01$) better compared to market samples. Optimized *dahi* also had about 1.25 times higher protein content than market samples. Shelf life of optimized *dahi* was observed to be 6 days at 4°C.

Buffalo Milk Set Plain and Fruit Yoghurts: Good quality set buffalo milk plain and fruit yoghurts were produced from buffalo milk using ultrafiltration technique. Optimized yoghurt met PFA and CFR (USA) standards and possessed firm body and smooth texture with no whey syneresis compared to 0.60 ml whey syneresis in well established and branded market sample. Body and texture, acidity and overall acceptability scores of optimized yoghurt were observed highly significantly ($p < 0.01$) better compared to market sample. Firmness, stickiness, work of shear and work of adhesion of optimized yoghurt was observed to be 3.075 N, -0.508 N, 85.352 N.s and -3.377 N.s., respectively. The shelf life of

optimized yoghurt was observed to be 15 days at $4 \pm 1^\circ\text{C}$. Further, formulations for the manufacture of mango yoghurt and strawberry yoghurt were optimized by Response Surface Methodology.

Cow Milk Set Plain and Fruit Yoghurts: Formulation and processing parameters were optimized employing ultrafiltration technique to improve overall quality of set plain and fruit yoghurts. Optimized plain yoghurt had, on average, 3.31% fat, 5.44% protein, 4.15% lactose 0.84% ash and 0.86% LA and met FSSA (2006) specifications. It had 1.28 times more protein and 1.14 times more minerals than conventionally made yoghurt having similar TS. It had firm body and smooth texture with no whey syneresis compared to 5.88% whey syneresis in a reputed brand of market sample. Water holding capacity (63.44%) of optimized plain yoghurt was significantly ($p < 0.01$) higher compared to market sample (58.26%). It scored 41.4, 28.1, 8.5, 9.3 and 92 for flavour, body and texture, acidity, colour and appearance and overall acceptability out of maximum possible 45, 30, 10, 10 and 100, respectively, and was observed to be significantly ($p < 0.05$) higher than market sample. The process for the production of mango yoghurt was optimized. Optimized process for the production of strawberry yoghurt followed a similar procedure except standardization of milk to different TMS; addition of strawberry pulp:sugar mixture and addition of erythrosine before being mixed, inoculated and incubated. Optimized mango and strawberry yoghurt met FSSA (2006) specifications. According to consumer acceptability study, plain yoghurt was liked by 89% of the consumers, whereas, mango and strawberry yoghurts were liked by 99 and 100% consumers, respectively. Total cost of optimized plain, mango and strawberry yoghurts were Rs. 13.27/200 g, Rs. 7.97/100 g and Rs.8.34/100 g, respectively, whereas, the shelf lives of their products limited by growth of yeast and mould were 17, 13 and 13 days, respectively at $4 \pm 1^\circ\text{C}$.

Cow Milk Set Dahi and Misti Dahi: Processes for the production of good quality cow milk *dahi* and *misti dahi* employing ultrafiltration (UF) were optimized. Levels of UF concentration affected the quality of resultant *dahi* highly significantly ($p < 0.01$) in terms of sensory parameters, textural attributes and wheying off. Inoculum (NCDC-167) level and acidity development was optimized to give an incubation period of 12 h for preparation of *dahi*. With increasing homogenization pressures, body and texture of UF *dahi* improved highly significantly ($p < 0.01$) while whitening index improved significantly ($p < 0.05$). Heat treatment of milk and fat content of *dahi* were also optimized. The developed UF *dahi* with 1.34 times the

protein in conventional *dahi* exhibited highly significantly ($p < 0.01$) better scores for body and texture and overall acceptability and had significantly ($p < 0.01$) higher firmness than the conventionally prepared one. The optimized product had highly significantly ($p < 0.01$) firmer body and better water holding capacity (WHC) and overall acceptability than the best scored market *dahi* sample. UF *misti dahi* was optimized in terms of total milk solids and inoculum levels. Developed UF *misti dahi* possessed significantly ($p < 0.05$) better sensory and textural parameters than the best market sample of *misti dahi*. UF *dahi* was liked by 98% of the consumers with 32% of them finding it to be 'excellent', while, UF *misti dahi* was liked by 97% of the consumers. Shelf life of UF *dahi* and *misti dahi* was observed to be 13 days and 17 days, respectively, at $4 \pm 1^\circ\text{C}$ when packed in polystyrene cups. The total cost of UF *dahi* and *misti dahi* was estimated to be Rs. 14.14 and Rs. 16.26 for a pack of 200 g.

Network Project on R and D Support for Process Up-gradation of Indigenous Milk Products for Industrial Application

Aloe Vera Supplemented Probiotic Lassi Optimization of the level of milk fat, solids not fat and Aloe vera juice using response surface methodology (RSM): The central composite rotating design (CCRD) of response surface methodology was applied for optimising the levels of various ingredients for preparation of *Aloe vera* supplemented probiotic *lassi* (APL). A total of three variables in the ranges selected during preliminary trials, viz., milk fat (2-4 %), milk solids not fat (MSNF) (8-10 %) and *Aloe vera* juice (16-20 %) were considered and 20 formulations were evaluated. Based on the results of sensory, physico-chemical analysis and probiotic count of the APL, ten combinations of the ingredients with very good desirability were selected from which the formulation with highest desirability (0.804) was chosen. Verification of the quality of the optimized formulation was also done.

Consumer response study of the Aloe vera supplemented probiotic lassi: Out of 132 respondents, 68 (51.52%) rated the beverage as "excellent", 48 (36.36 %) of them rated the beverage "very good" and 12 (9.01%) rated the beverage "good". It was thus evident that the beverage had a good acceptability rating with 96.97 percent of the consumers showing their preference. Furthermore 99 percent (131 out of 132) of the respondents showed willingness to buy the APL even at premium price (25 percent higher than of the conventional *lassi*). This

suggested that the APL has a considerable market potential.

Storage study of Aloe vera supplemented probiotic lassi: Storage related changes in *Aloe vera* supplemented probiotic *lassi* were studied during its refrigerated storage ($5-7^\circ\text{C}$). The stored product was analyzed after every 3 days interval for changes in sensory and physico-chemical quality as also probiotic count. Storage study of the product showed that the samples could be stored upto 12 days without undesirable changes in sensory, physico-chemical quality and the probiotic count which remained at more than 10^7 cfu/ml.

Effect of Aloe vera supplemented probiotic lassi on specific humoral immunity in Mice: Present study revealed that combination of *Aloe vera* and probiotics was better than either of them alone in terms of immunoprotective effects against infection with enteropathogens. The protective effects of *Aloe vera* and probiotic combination against enteropathogenic infection were found to be due to enhanced production of anti-pathogen specific IgA and inhibition of translocation of the pathogen in various organs of mice.

Novel Approaches for Production of Nutraceuticals from Milk and Indian Herbs for Potential use in Functional Dairy Foods (Under NAIP component 4)

Lactobacillus isolates (25) were screened for higher proteolytic activity and cell envelope proteinase (PrtR) gene from *Lactobacillus rhamnosus* was cloned using custom synthesized primers. Restriction digestion was used to confirm positive transformation. In a separate experiment, technology for GOS production was optimized and 94.92 g/l GOS production was obtained at 30% of lactose concentration with 5.5 hr of incubation period using 35 units of α -galactosidase per liter of lactose solution. Another nutraceutical i.e. Conjugated Linoleic Acid (CLA) production by *Butyrivibrio fibrisolvens* isolate 4a was found to be highest amongst the screened isolates. Additionally seven weed extracts were screened for CLA production potential and a 372% increase in CLA production was observed in case of supplementation with 2% of *Leucas aspera* (NBD15) plant extract. Fingerprint profiles of plant extracts (methanolic) were obtained using TLC and techniques for the chemical standardization of these potential herbal bio-components were developed. HPTLC protocol for standardization of NBD-1 using Asparagine and HPTLC / HPLC protocols for NBD-3 using Puerarin as standards were also developed. In another set of experiments different milk combinations

with *Pueraria tuberosa* were prepared by homogenizing pasteurized toned milk with its ethanolic and hot water extracts and their stability with reference to pH and coagulation was studied over a period of 15 days. The Kudzu-fortified milk combinations were also analyzed for puerarin, the major isoflavone C-glucoside present in *P. tuberosa*, through HPLC. These studies will be useful for developing milk nutraceuticals fortified with Indian Kudzu which has the potential to be included as an ingredient in health and functional foods. Addition of herb extracts (Ashwagandha, Shatavari, Kudzu) to milk improved its antioxidant activity. Antioxidant potency and radical scavenging activity of ethanolic and aqueous extracts of herb shatavari were found to be significantly ($P < 0.05$) lower when compared with natural (rosemary and green tea extracts) and synthetic (BHA and TBHQ) antioxidants added to fat rich model system at the same concentration. A double layer emulsion with dairy ingredients as matrix materials were created with potential for encapsulating herb bioactives. The structure created showed 100% emulsion stability and 99-97% encapsulation efficiency. *In-vivo* studies indicated that feeding of GOS significantly ($p < 0.05$) reduced the urea and creatinine level in diabetic rats. Additionally it improved the antioxidative stress markers (SOD, Catalase and GPx) in liver and blood. The prebiotic potency score of the GOS produced was calculated as 0.54. Immunomodulatory effects of addition of herb extracts into milk were observed without affecting its processibility. Animals fed with milk containing herb extracts resulted in significantly increased phagocytic activity of peritoneal macrophage and glutathione content in liver.

Development of E-courses for B.Tech (DT) Degree Programme (Under NAIP) NDRI (Karnal), SVVU (Tirupati), AAU (Anand)

Of total 49 courses, 2 (remaining) e-courses were peer reviewed through meetings of External and internal reviewers with the respective course developers – one at NDRI and the other at SVVU. Thirty - six courses (on P-MOODLE) were reviewed by PG students (three students per course): 19 courses at NDRI and 17 at AAU. All 49 courses (i.e. the courses completed during 2012-13 plus those completed before) on the Portable Moodle (POODLE) platform were transferred to CDs (30 sets of individual course-wise CDs) and handed over to NAIP/ ICAR for off-line delivery to

SAUs. All e-courses have been uploaded on the NDRI/Sub-project Website (www.ndri.res.in, www.elearningdt.org.in). E-courses have also been submitted to IASRI/ NAIP for uploading on ICAR's DKMA Web Servers towards further dissemination to all Dairy Science institutions of the Nation.

The e-courses were delivered off-line to Deans/Principals of Dairy Science Colleges during the Sensitization Workshop organized at NDRI Karnal for effective implementation of e-courses in various institutions. The one-day **Sensitization Workshop** of Deans/Associate Deans was claimed at creating awareness about the e-courses and the need and modalities of implementation of the e-courses at dairy colleges offering B. tech. (DT) program.

A Value Chain on Composite Dairy Foods with Enhanced Health Attributes (Under NAIP, NDRI (Karnal), CIPHET(Ludhiana), Arpana (Madhuban)

A process for the development of micronutrient fortified nutrimix based on pearl millet and milk solids for weaning purpose was developed. Ammonium ferric citrate and zinc sulphate were found suitable for fortification of *Nutrimix* at 5.5 mg/100g and 3 mg/100g levels respectively. Storage stability of the iron and zinc fortified *Nutrimix* packaged in two different packaging material viz. aluminium laminates and metalized laminates was estimated under accelerated storage condition (45°C). Sensory and physico-chemical evaluation was done at fixed interval of 5 days. The present investigation revealed that the iron and zinc fortified *Nutrimix* packaged in aluminium laminates was more stable than metalized laminates at accelerated storage temperature (45°C). After 20 days of storage, all the sensory attribute of *Nutrimix* packed metalized laminates was decreased significantly and physico-chemical parameters increased significantly as compared to aluminium laminates. It revealed that the aluminium laminate can be recommended as a suitable packaging material for iron and zinc fortified *Nutrimix*. *Lactobacillus fermentum* RS-2 stain isolated from fermented milk-cereal composite was characterized for probiotic attributes and therapeutic potential and the stain exhibited very promising anti-oxidative potential which could be beneficial in enhancing the immunity. Under entrepreneurship development a milk processing unit named as “*Nirmal Dhara Mahila Dugdh Samiti*” has been established at village Taprana.

Investigation on High Pressure Induced Effect on Quality Characteristics of Buffalo Milk (Under National Fund for Basic, Strategic and Frontier Application Research in Agriculture)

High pressures significantly decreased the microbial load of HP treated buffalo milk which was subjected to pressure treatment in the range of 100MPa to 300MPa, however at 400MPa/10 min, the total viable count of buffalo milk reduced by 3 log cycles. A drastic reduction was noticed in coliform counts upon pressurization of 300MPa. Pressure treatment of 200MPa/10 min completely eliminated the yeast and molds. However microbial reduction was found to be related to initial microbial load. Isolation and characterization of bacteria survived pressure treatment indicated that cocci and bacilli were present in the colonies. The HHP treated samples were analyzed for microbiological parameters including pathogenic microbes. Whole and skim Buffalo milk samples, were spiked with two pathogenic strains *L. monocytogenes* (ATCC 15303) and *E. coli* (ATCC-25922) along with one lactic starter *S. thermophilus* (NCDC-459). *L. monocytogenes* count decreased by 2 log cycle upon pressure treatment of 300MPa /10min. No *Listeria* colony was observed in Buffalo milk treated at 400MPa/10min. In case of *E. coli* complete elimination was noted on pressure treatment of 200MPa/10min. Buffalo milk fat was found to have protective effect on indicator microorganisms. Milk samples were also analyzed for pathogenic indicator strains after an interval of 7 days but no growth was observed on plates. Isolation and identification on the basis of gram staining depicted higher survival as compared to cocci.

Development of Geriatric Dairy Food Having Prophylactic Attribute Against Alzheimer's Disease (2011-2014)

Curcumin, the biologically active pigment found in Indian spice turmeric, possesses numerous functional attributes e.g., anti-inflammatory, anti-Alzheimeric, antioxidant, anticarcogenic, antidiabetic, hypotensive, hypocholesteremic etc. A protocol for incorporation of curcumin in lassi and ensuring its stability during storage was developed. As curcumin is insoluble in water, two suitable matrix materials viz., β -cyclodextrin (β -CD) and Tween-80 was tried for binding of curcumin. Curcumin, when added as such resulted in approximately 50% retention of the component in lassi. Curcumin when added with Tween-80 in the ratio of 1:4, 92% retention of curcumin was observed in the product. However, when added

with β -cyclodextrin in the ratio of 1:3 resulted in 93% retention of curcumin and the product was sensorially better than the product that contained Tween-80 as binding material. The chemical composition of the optimized product was total solids 20.56%, total carbohydrates 13.8%, fat 3.48%, protein 2.73%, ash 0.52 %, pH 4.5 and contained 233 ppm curcumin. The developed product had a shelf life of 20 days at $4 \pm 1^\circ\text{C}$ at 90-95% RH when packed in low density polyethylene (LDPE) pouches or in poly ethylene terephthalate (PET) bottles, where as the control lassi had storage life up to 12 days.

Technology and Evaluation of a Whey-Cereal Functional Beverage

The project involves the development of a whey-cereal functional beverage, which can be a refreshing and cost-effective nutritious drink. A base model has been established for fermented formulations containing dairy and cereal ingredients to achieve quick fermentation of the dairy-cereal substrate using *L. acidophilus* NCDC 13, high viable counts of the probiotic organisms and a suitable pH range for acceptability of the fermented foods in which these organisms would be incorporated. The ingredients and process parameters for the probiotic beverage containing pearl millet and barley, fermented by probiotic organisms were optimised. The product was evaluated for its sensory, physico-chemical, probiotic and nutritional attributes. The efficacy of the probiotic beverage containing the beneficial organisms using animal models was investigated.

Production of Milk with Enhanced Protein Content

Demand of protein enriched food products is increasing with increasing consumer health awareness. Cow and buffalo milk with enhanced protein contents (5, 6 and 7%) have been prepared using ultrafiltered retentate. In cow milk, maximum sensory score was obtained at 7% protein level, whereas in buffalo milk, sensory score was maximum at 6% protein level. High protein milk had a shelf life of 6 days at $4 \pm 1^\circ\text{C}$ when packed in low density polyethylene (LDPE) pouches.

Evaluation of Quality of Market Samples of Dahi

This study investigated the quality and storage related changes in the market samples of dahi. Samples of five different brands viz. A, B, C, D and E were collected and analyzed for various attributes. From the results of physico-chemical parameters it transpired that compositional variation between different brands were not significant. There was small variation in pH (3.99-

4.54) and acidity (0.89-1.06% LA) of the various brands. One of the parameters where large variation was observed was syneresis (2.00% in 'B' and 15.66% in 'C'). In terms of biochemical parameters, highest L+ Lactic acid content (90.08 $\mu\text{g/g}$) was found in 'C' *dahi* and the lowest L+ value (42.46 $\mu\text{g/g}$) was found in the E *dahi*. The lowest D-Lactic content was found in 'C' product (4.51 $\mu\text{g/g}$) and the highest in the 'B' sample (52.90 $\mu\text{g/g}$). 'B' *dahi* samples had maximum acetaldehyde concentration (39.64 $\mu\text{g/g}$) and the lowest acetaldehyde content was found in 'C' *dahi* (28.08 $\mu\text{g/g}$). Degree of proteolysis did not vary significantly among the brands (8.23-9.46 $\mu\text{g/g}$). Microbiologically, 'A' *dahi* samples had highest SPC (6.58 log cfu/ml), YandM (3.63 log cfu/ml) and coliform counts (2.61 log cfu/ml) whereas the lowest SPC (5.43 log cfu/ml) was found in 'C' *dahi*. Colour characteristics were also determined but no remarkable variation was observed. In terms of sensory quality, the samples of different brands were comparable. However, 'A' samples scored high in flavor attribute (34.28) as against 28.00 for 'B'. Among rheological parameters, 'B' *dahi* had highest viscosity value (2643.82 cP), firmness (9.09 N) and work of shear (191.38 Ns). The highest stickiness (-3.96 N) was observed in 'D' samples whereas the lowest (-1.29 N) was observed in 'A' *dahi*. During storage, significant changes were observed in only a few parameters like acetaldehyde content and syneresis. Microbiological quality was affected to a very limited extent during storage.

Studies on Hardening of Rice Grain in *Kheer* During Storage

The study was aimed at minimizing the textural changes, especially hardening of the rice grains in refrigerated *kheer*. Effect of food additives such as sodium stearoyl lactylate (SSL), sorbitan monostearate (SMS), and beta-cyclodextrin (BCD), on the hardening characteristics of cooked Basmati rice was studied. The results indicated that the intactness of grain did not allow the food grade additives to penetrate into the grain. The simulated rice prepared from basmati rice flour was used as rice grain analogue in *kheer*. Based on preliminary studies, use of SSL or SMS made the grains in freshly prepared *kheer* too soft. It was, however, observed that *Kheer* prepared from the simulated rice without these additives, although soft in the beginning of refrigerated storage, had normal grain hardness after 30 days of storage and the product was comparable to the freshly prepared *kheer* using native rice.

Processing Elephant Foot Yam to Make it Compatible with Milk

Acridity, itchy sensation felt in mouth and throat is a major problem associated with the consumption of elephant foot yam. The problem is apparently related to the presence of needle-like crystals (raphides) of calcium oxalate. The effect of various treatment viz. soaking in alkali (NaOH), salt water (2, 6 and 10%) and acidulated saline (pH-3.5) for 60, 90 and 120 min on the oxalate content, acridity sensation score and whiteness index was determined. Different soaking solutions were found not much effective in decreasing either acridity score or oxalate content and no significant difference was observed in oxalate content of elephant foot yam treated with various pre-soaking solutions for varying periods. However, increase in alkali concentration was found to be significantly ($P<0.01$) decreasing the hand sensed acridity score. Whiteness index was found to be significantly decreasing ($P<0.01$) with increasing alkali concentration. Increasing salt concentration and time was found to be significantly ($P<0.01$) increase acridity score. Whiteness index value was significantly ($P<0.01$) affected by salt concentration of acidulated salt water; it increased with increasing concentration. Salt concentration in acidulated saline significantly affected the acridity score of yam milk mix. Next, the effect of time and temperature on alkali pre-soaking treatment of elephant foot yam was evaluated using response surface methodology. Responses studied were oxalate content (total and soluble), sensory acridity score, Hunter colour parameters (L^* , a^* and b^*), whiteness index and total solids in soak water. At linear level, both the soaking time and temperature had a negative effect ($P<0.01$) on the total and soluble oxalate content. The quadratic term was significant only in case of total oxalate for both time and temperature of soaking ($P<0.01$). The interaction effect of time and temperature on oxalate content was found to be non-significant. Sensory acridity score was not influenced by the soaking treatment. Thus, the linear regression model ($P<0.01$) was valid for pH, soak water total solids and soluble oxalate content of elephant foot yam, whereas the quadratic model was valid for the total oxalate content ($P<0.01$). The soaking time and temperature had a generally darkening effect in terms of Hunter L^* , a^* and b^* values as well as the whiteness index derived therefrom, the relevant regression representing quadratic model for a^* value ($P<0.01$) and linear models for the remaining parameters ($P<0.01$).

DAIRY MICROBIOLOGY

Research on Nutraceuticals from Milk, Functional Foods with Prebiotics, Micronutrients and Other Bioactive Compounds for Improved Human Health

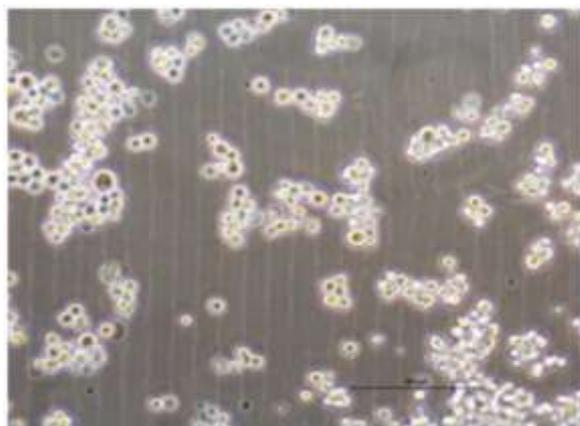
Development of Probiotic Enriched Traditional Fermented Dairy Products

Out of a total of forty indigenous isolates of probiotic lactobacilli, four viz. Lp9, Lp91, Lp65 and S7 were found to down regulate TNF- expression significantly in HT-29 cells by RT-qPCR on stimulation with LPS. On the other hand, Lp9, Lp91, Lp90 and CH4 resulted into a high level of 'IL-10' expression in HT-29 cells. Lp91 also showed a significant ($P < 0.001$) down regulation of 'TNF- ' expression by -1.45 relative to the control in THP-1 cells. Lp91 was shortlisted for product development since it possessed antibacterial and antiinflammatory property. Initially, dahi starters for the preparation of long and short set dahi were selected which included NCDC 60, 74, 159, 160, 167 and 261. The inter-compatibility with probiotic *Lactobacillus* strains was examined by determining their antibacterial activity against each other to select the best combination for producing the desired probiotic product of acceptable quality similar to that of standard dahi. The probiotic *L. plantarum* Lp91 was compatible with one of the *S. thermophilus* strains NCDC 74 which will be used for preparation of dahi. All the forty isolates were also identified by 16S rRNA as well as house keeping genes 'rpoA' and 'pheS'. Thirteen of the *Lactobacillus* isolates belonged to *L. plantarum* group (*L. plantarum*, *L. paraplantarum* and *L. pentosus*) which could be differentiated with 'pheS' into all the three species suggesting the usefulness of house keeping genes for identification. Multilocus sequence typing for *L. plantarum* strains was also

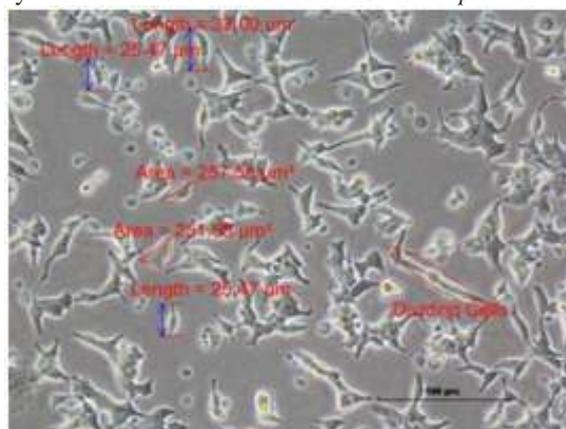
carried out using eight house keeping genes. The dendrogram and split decomposition analysis revealed that all the 14 *L. plantarum* strains including 10 indigenous and 4 reference differed in various loci excepting strains Lp-9, -65, Lp-90 and CSCC5276, MTCC 2621 which shared the same sequence types ST-2 and ST-9 respectively also clustered together. Split decomposition analysis indicated the interconnecting network or a parallelogram which points towards the involvement of recombination in the evolution of the analysed genes.

Screening Probiotics and Prebiotics for Expression of Glucagon like Peptide-1 (GLP-1)

NCI-H716 cell line procured from ATCC, USA and maintained as suspension cells in RPMI-1640 medium supplemented with 10 % FBS, 100 U/ml Penicillin and 100 µg/ml of Streptomycin at 37°C/5 % CO₂. NCI-H716 cells were differentiated into adherent human entero-endocrine cells by growing them over mouse fibroblast layer in 6 well plates. Mouse Secretin tumor cell line (STC-1pGIP Neo) was maintained in DMEM-Glutmax (Gibco) medium supplemented with 10% FBS, 100 U/ml Penicillin, 100 µg/ml of Streptomycin and geneticin (G418) as adherent entero-endocrine cells. STC-1 cells were suspended in six well plate at 4×10^6 cells/well and allowed to adhere for overnight at 37°C and 5% CO₂. Cells were treated with Berberine (100 µM) and probiotic lactobacilli (Lp9, Lp91, Lp5276, LGG) for studying their possible effect over expression of GLP-1 under induced conditions. Berberine, taken as positive control was found to significantly upregulate expression of GLP-1 gene by around three fold as compared to control. All the four *Lactobacillus* strains tested were too found to up regulate GLP-1 expression by varied levels. Reference strains viz. *L. plantarum*



A microscopic view of NCI H716 cells



A microscopic view of STC-1pGIP Neo cells

5276 and *L. rhamnosus* GG significantly upregulated GLP-1 expression by 2.7 and 1.22 fold respectively. A comparative up regulation was recorded with indigenous strains *L. plantarum* 9 (2.15) and *L. plantarum* 91 (1.33) also.

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. Incorporation of basal supplements in reconstituted whey (6% total solids) significantly improved the growth of *Lactobacillus casei* NCDC 298. The 4 and 6% total solids in reconstituted whey yielded comparable growth of *L. casei* NCDC 298, but significantly higher than 2% total solids. Reconstituted whey (4% TS) was selected for the preparation of basal medium which was further supplemented with yeast extract and casein hydrolysates individually or in combination. The 0.25% of yeast extracts (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, comparable to MRS. Growth performance of ten different species of lactobacilli in the three types of whey based media were comparable to MRS broth. *L. casei* NCDC 298 has been cultured in all the three types of whey based media at fermenter scale (2.0 l) by external neutralization (pH 5, 6, 7) and without controlling of pH. At pH 6.0, growth rates were higher ($\mu \sim 0.45$) and comparable for all the whey based media as well as MRS broth. The viable counts reached stationary phase (~ 9.5 log cfu/ml) after 12 hr at 37°C in all the media from an initial inoculation of ~ 7.0 log cfu/ml. The cell biomass was concentrated from the culture media 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 also remained unchanged in kulfi during storage upto 30 days. The performance of whey based agar medium formulation was comparable to MRS agar in enumeration of *L. casei* (NCDC 298).

Development of Synbiotic Tulsi Dahi

A total of ten lactic cultures were evaluated for bile salt hydrolase, cholesterol assimilation activity and probiotic attributes. *L. bulgaricus*-2, *S. thermophilus*-

1, *L. plantarum*-7 and *L. plantarum*-4 exhibited intense precipitation of bile salts (sodium taurocholate and taurodeoxycholic acid) suggestive of their BSH activity. These cultures also possessed highest cholesterol assimilation of 43.88 ± 0.21 , 38.05 ± 0.25 and 36.75 ± 0.40 and $20 \pm 0.13\%$. *L. bulgaricus*-2, *S. thermophilus*-1, *L. plantarum*-7 showed the least reduction of <2 log cfu/ml in total viable counts at 2% bile salt concentration after 3h exposure time. The above strains can survive at pH 2 for 3 hrs. *L. bulgaricus*-2 exhibited highest adhesion ability i.e. 54 ± 1.28 , 46.09 ± 1.21 and $30.71 \pm 0.42\%$ to hexadecane, xylene and octane, respectively. The tulsi essential oil revealed maximum inhibition of *L. monocytogenes* ATCC 15303 followed by *S. typhi* NCDC113, *Geotrichum candidum* NCDC 288, *Candida pseudotropicalis* NCDC 44, *E. coli* ATCC 25922, *S. aureus* NCDC 110 and *B. cereus* ATCC 13061. The *L. bulgaricus*-2, *Streptococcus thermophilus*-1 and *L. plantarum*-7 also exhibited inhibition of the above food spoilage and pathogenic microflora. Compatibility studies of probiotic cultures indicated their compatibility with inulin and tulsi essential oil at 3% and 0.5 μ l/ml concentration. The inoculum level from 1% to 3% reduced the curd setting time and improved acidity. However, inoculum levels from 1% to 2 and 3% gave less overall acceptability sensory score of 84.77 and 81.33. The increased levels of inulin and incubation period marginally improved probiotic counts and overall quality attributes of synbiotic dahi. Increments in inulin concentrations upto 3% and incubation period to 10 hr improved cholesterol assimilation ability of *L. bulgaricus*-2 in synbiotic dahi i.e. $69.75 \pm 0.45\%$. Shelf life studies revealed marginal difference in quality parameters and cholesterol assimilation activity of probiotic culture in synbiotic dahi upto 15 days of storage as it could maintain the probiotic counts as per WHO requirement.

Antibiotic Resistance in Commercially Probiotic Bacteria

During the initial phase of the project, Indian market was extensively scanned for probiotic preparations both in the form of pharmaceutical and food products. As many as 90 different products have been identified to be used for the isolation and characterization of probiotic organisms. Isolation was carried out from the 15 samples and the isolates characterized by microscopic, biochemical and molecular methods were identified as *Lb. reuteri*, *Lb. acidophilus*, *Lb. rhamnosus*, *Lb. sporogenes*, *Lb. plantarum*, *S. faecalis*, *Lb. casei*, and *S. thermophilus*.

Lactobacillus reuteri for their Potential Use As Biopreservatives

On screening *L. reuteri* isolates from 14 different samples of infant feces for antimicrobial activity, all 40 were found to inhibit the indicator organism *E. faecalis* NCDC 114. Two of the isolates LR BPL-36 and 38 tested positive for glycerol dehydratase '*gdh*' gene for reuterin production. *L. reuteri* BPL-36 strain was selected for further studies based on broad antimicrobial spectrum of activity and presence of '*gdh*' gene. The purified PCR products of 16S-23S rRNA and '*gdh*' gene were sequenced and submitted to Genbank with Accession No. JQ897938 and JQ897939, respectively. The production of reuterin from BPL-36 strain was optimized in MRS-glycerol and water glycerol medium both using Response Surface Methodology taking pH, temperature, incubation time and glycerol content as independent variables. The responses taken were pH, O.D. and reuterin concentration (mM). Optimum level of pH (5.50), incubation temperature (36°C), incubation time (24h) and glycerol content (325 mM) were used for maximum reuterin production (89.6 mM) in MRS-glycerol medium. Optimum level of pH (6.0), incubation temperature (37°C), incubation time (2.5h) and Glycerol content (267 mM) were used for maximum reuterin production (58.69 mM) in water-glycerol medium. Reuterin was stable at pH 4-6, 80°C for 30 min and not degraded by proteolytic enzymes. Viability of all the tested pathogens decreased with increasing contact time with the reuterin. *S. typhi* was observed to be the most susceptible among the tested organisms. Microencapsulation of Reuterin to enhance long term efficacy against food-borne pathogens was done. Our work demonstrated a novel antimicrobial delivery system that had much better capability of inhibiting the growth of *L. monocytogenes* during long-term storage at 37°C. Reuterin (16 AU/ml) exhibited bactericidal activity against both Gram-positive and Gram-negative organisms ($p < 0.01$). Similarly, reuterin (80 AU/ml) exhibited bactericidal activity against both Gram-positive and Gram-negative organisms in Quarg cheese at refrigeration condition ($p < 0.01$). Antifungal packaging system for paneer with reuterin (100 AU/mL) showed a new direction to this study. Safety aspects of the strain BPL-36 were also evaluated. Production of biogenic amines and degradation of mucin by the reuterin producing BPL-36 strain was not detected.

Alpha-glucosidase Inhibiting Lactobacilli for Controlling Postprandial Hyperglycemia (PPG)

More than 200 lactobacilli isolated from different sources (human faeces/milk, cheese, dahi, lassi and raw milk) were genetically characterized, where nearly 23% were non- α -glucosidase and α -amylase producers. These non-producers were further screened for varying levels of inhibition, wherein isolate HAF109 showed highest inhibition (85%), followed by HAF108, HAF106 and HAF19. Variations in inhibition pattern against rat α -glucosidase were recorded. Isolates showing best inhibition against α -glucosidase (yeast and rat) did not yield strong inhibition for α -amylase. Ten best isolates were further characterized at species level, where, two isolates were confirmed as *L. salivarius*, four as *L. plantarum*, three as *L. fermentum* and one as *L. casei*. *L. salivarius* HAF106 and *L. plantarum* HAF109 showed appreciable potential probiotic attributes. Effect of three different prebiotic carbohydrates on inhibitory potential of selected isolates revealed assorted responses for all the three enzymes. Overall, supplementation of β -glucan increased the inhibition against α -glucosidase and had no significant impact on α -amylase activity. In contrast, supplementation of inulin increased α -glucosidase inhibition but at the same time also increased α -amylase inhibition, therefore, may increase side effects. *L. plantarum* HAF109 was further assessed for its efficiency in controlling PPG in experimental diabetic rats by *in vivo* feeding. Acarbose and probiotic-fermented milk feeding significantly attenuated the peak glucose release during sucrose loading tests and attenuation improved during the experimental period. Probiotic-fermented milk yielded no significant impact on fasting blood glucose levels, while with acarbose feeding fasting blood glucose level improved after 9 weeks. However, probiotic feeding had significant impact on the level of lactobacilli, coliforms, plasma lipids and expression of inflammatory cytokines.

Galacto-oligosaccharides Production from Whey Using *Streptococcus thermophilus*

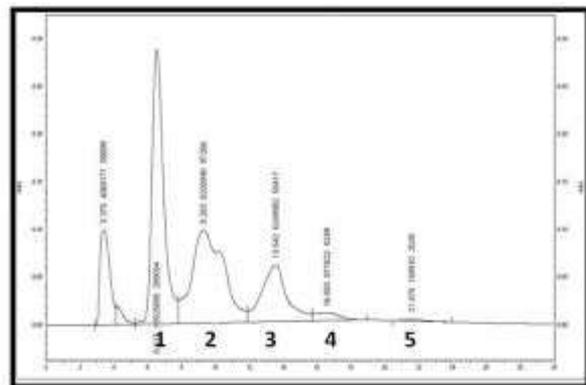
β -galactosidase which catalyzes galacto-oligosaccharides (GOS) production, was extracted from 30 (prolific enzyme producing) strains of *Streptococcus thermophilus* using different methods of cell disruption. Strain ST61 was found to be the highest enzyme producer (78.85 U/mg protein) and microfluidizer method was selected as a method of cell disruption for this study. The reaction conditions for GOS production were optimized (time-5 h; lactose conc.-30%; enzyme units-30 units/ml; temperature-55°C pH-6.8) which produced more than six fold

increase in GOS production. The crude GOS was partially purified for *in vitro* studies by microbial intervention using *Saccharomyces cerevisiae* NCDC 50, *Kluyveromyces lactis* PL2 and *Lactobacillus helveticus* NCDC 288. In an *in vitro* trial, prebiotic potency score of GOS was calculated as 0.54. Further, *in vivo* studies were carried out to see the effect of GOS on immune system of mice and reduction in pathogens when challenged with *Listeria monocytogenes* ATCC 15303. Up regulation of total IgA (4.09-5.94 μ g/ml) levels in the intestinal tissue extracts and IgG (4.74-6.47 μ g/ml) levels in serum was found in GOS fed groups of mice. A fewer densities of *L.monocytogenes* in the intestine, liver and spleen were observed in GOS fed groups as compared to pathogen control group. To assess the role of prebiotics on diabetes, a rat trial was carried out with commercial GOS. Feeding of GOS to diabetic rats ameliorated the diabetes associated markers including fasting blood glucose (GOS-183mg/dL; Diabetic-431.17 mg/dL), Hb (GOS-12.3g/dL; Diabetic- 8.3 mg/dL), triglycerides, total cholesterol (GOS-201.87 mg/dL; Diabetic- 245.41 mg/dL), LDL (GOS-79.70 mg/dL; Diabetic-98.54 mg/dL), creatinine (GOS-1.50 mg/dL; Diabetic-3.51 mg/dL), and urea. GOS was also found to improve the antioxidative stress markers (SOD, Catalase and GPx) in liver and blood of diabetic rats. Higher number of lactobacilli (5.1 log cfu/g) and lower number of coliforms (3.56 log cfu/g) were observed in GOS fed diabetic group as compared to diabetic control group (lactobacilli - 2.90 log cfu/g; coliforms - 6.02 log cfu/g).

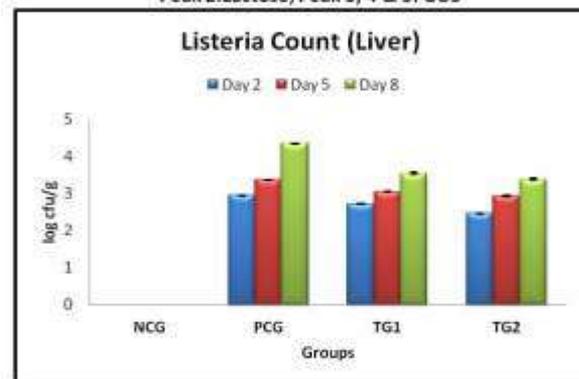
Purification of microbe Associated Molecular Patterns from *Lactobacillus plantarum* Lp91:

Current study was designed to purify the cell wall associated bacterial surface molecules (MAMPs) namely lipoteichoic acid, bacterial lipoproteins and peptidoglycan from a putative *Lactobacillus plantarum* Lp91 isolated from human gut. The isolation of LTA was performed by n-butanol extraction followed by purification with hydrophobic interaction chromatography. Three different column matrices *viz.* Phenyl-Sepharose, Octadecyl-Sepharose and Octyl-Sepharose CL4B were tried, out of which Octyl-Sepharose chromatography worked. The yield of LTA was found to be 33.6 mg and 30.4 mg from 2 L of broth culture of Lp91 and LGG. Structural study for the isolated and purified LTA using ¹H-NMR and FTIR revealed presence of unsaturated fatty acids in the glycolipid anchor of LTA isolated from Lp91 while saturated fatty acids were found to be present in case of LGG which were linked to glycerol by ether linkage. LTA from Lp91 was found to possess acetyl

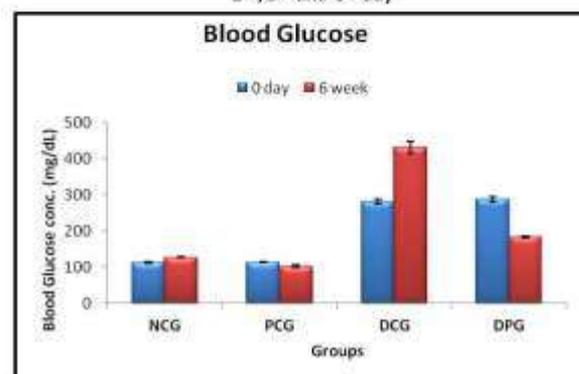
groups in the glycolipid which were absent in LGG. Isolation of Lipoproteins was done by Triton X-114 phase partitioning and 5.02 and 5.32 mg of lipoproteins were recovered from 500 ml of broth culture of Lp91 and LGG respectively. Five proteins were found prominent in Lp91 while three were found to be prominent in case of LGG. Isolation of peptidoglycan was carried out by SDS-lysis method which yielded 75 mg of this cell wall component from 100 ml broth culture of Lp91 and 31 mg from 50 ml culture LGG. All the three purified preparations of cell surface components were found to be free from endotoxin contamination and these purified cell wall components can serve as the resource material for demonstrating their immunomodulatory properties.

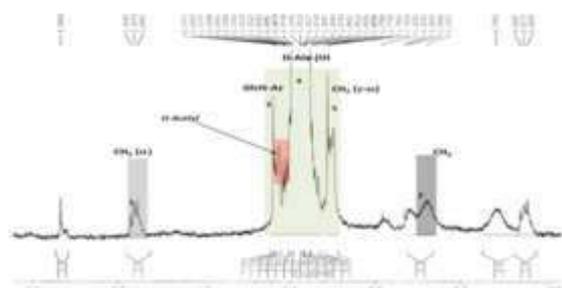


Peak 1: Combined peak of glucose and galactose; Peak 2:Lactose; Peak 3, 4 & 5: GOS



Difference in *L. monocytogenes* counts in liver of different groups of mice fed with different experimental diets after 2nd, 5th and 8th day

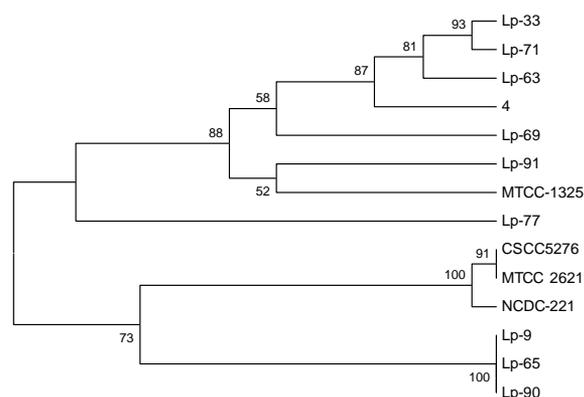




¹H-NMR Spectrum of LTA

Multilocus Sequence Typing for Differentiation Indigenous Probiotic Lactobacilli

Multilocus Sequence Typing (MLST) scheme using housekeeping genes was used for identification of 41 lactobacilli including 29 indigenous probiotic *Lactobacillus* strains and 12 reference type strains. The analysis of 16S rRNA sequencing identified almost all the isolates and reference strains mainly into *L. plantarum* group (18), *L. fermentum* (7), *L. reuteri* (8) and *L. casei* (8) groups. Ten indigenous probiotic *Lactobacillus plantarum* strains of Indian gut origin namely Lp-4, Lp-9, Lp-33, Lp-63, Lp-65, Lp-69, Lp-71, Lp-77, Lp-90 and Lp-91 and four reference strains CSCC5276, NCDC- 221, MTCC-1325 and MTCC-2621 identified as above using 16S rRNA, *pheS* and *rpoA* genes were selected for developing MLST scheme using eight housekeeping genes. The highest polymorphism was found in *gdh* gene (9 Allelic types) followed by *tkf4* (7), *purK1* (5), *pgm* (4), *gyrB* (3), *mutS* (4), *ddl* (4) and lowest being in *pheS* (3). Based on the polymorphism recorded at the nucleotide sequences of eight housekeeping genes, all the fourteen strains of *L. plantarum* were placed into eleven sequence types. Three of the indigenous isolates Lp-9, Lp-65 and Lp-90 turned out to be isogenic and belonged to the same sequence type ST-2. One interesting observation recorded in this study was that two of the reference strains MTCC2621 and CSCC5276 procured from two separate culture collection centres showed same sequence type which was traced to a single ATCC origin. These results indicate the reliability of MLST scheme as a powerful molecular technique with high discriminatory power to identify *L. plantarum* strains even at strain level. The MLST scheme developed in this study for differentiation of *L. plantarum* at strain level could be a remarkable and valuable tool which will help us in tracking the strain in *in vivo* animal models as well as in the gut of human subjects in the clinical trials besides inter-laboratory exchange and can be use as a molecular identity card.



Phylogenetic relationship amongst *L. plantarum* strains based on concatenated sequences (4789bp) of MLST loci

Evaluation of Probiotic Properties of *Lactobacillus reuteri* Strains:

A total number of 8 *Lactobacillus reuteri* isolates (previously isolated and identified in our lab) were selected and reconfirmed as *L. reuteri* on the basis of physiological, biochemical and molecular characterization. Most of the isolates precipitated sodium taurocholate and sodium tauroglycholate indicating good bile salt hydrolase activity. Molecular identification revealed the presence of *bsh* gene in one isolate i.e. *L. reuteri* LR6. LR6 was also found to exhibit maximum hydrophobicity for xylene (48.83%) and n-octane (36.37%). All the isolates exhibited good spectrum of antimicrobial activity against selected pathogens and have moderate antioxidative activity. In *in vitro* cholesterol assimilation studies, LR9 exhibited maximum cholesterol assimilation followed by LR6. Hypocholesterolemic activity of LR6 was studied *in vivo* using rats as an animal model. After 60 days of feeding, significant reduction in serum cholesterol level was noticed in probiotic fed group, with reduction in total cholesterol by 33.36% (79.24mg/dl), enhancement of HDL cholesterol by 29.30% (46.33mg/dl), reduction in triglycerides level by 25.25% (59.24 mg/dl), reduction in LDL cholesterol by 68% (21.06 mg/dl), reduction of VLDL by 25.23% (11.85mg/dl) and reduction in Atherogenic index by 79.93% (0.45). During immune-modulatory studies, feeding of LR6 caused significant increase in IgA oncentration on 5th day. Maximum decrease in *S. typhi* counts was noticed in group IV on 8th day in different organs like liver, spleen and large intestine. The overall investigation showed that LR6 can be used to develop functional foods to control hypercholesterolemia.

Production and Characterization of Exopolysaccharides from Lactobacilli for Prebiotic Attributes

Out of a total of 7 isolates of *L. gasseri* and 37 isolates of *L. reuteri* and one isolate of *L. helveticus* screened for the EPS production, *L. gasseri* Lg62 and *L. helveticus* V3 were selected for the further study. The highest EPS production of 652 ± 0.56 mg/L (crude) was observed for the *L. helveticus* V3 in the presence of sucrose (7%) when inoculated at the rate 2% and incubated at 42°C for 24 hours and 324 ± 0.68 mg/L was observed for the *L. gasseri* Ls62 in the presence of fructose (7%) when inoculated at the rate of 3% and incubated at 37°C for 24 hours incubation. The EPS from deproteinised whey (DPW) was isolated and partially purified by repeated ethanol precipitation. The hydrolyzed EPS fractions were analyzed for the monosaccharide composition by HPLC and EPS fractions comprised of heteropolysaccharides containing glucose, galactose and fructose at the ratio of 2:1:1. The growth and EPS utilisation by two probiotic organisms were evaluated in carbohydrate free basal medium containing 1% EPS (2% glucose as a positive control at 37°C for 72 hrs). Both the probiotic organisms exhibited significant results in the presence of 2% glucose along with 1% EPS (especially SV3) as well as in the presence of EPS as a sole carbon source. NCDC 17 (*L. casei*) was able to utilize more EPS as compared to the NCDC 15 (*L. acidophilus*). While estimating the short chain fatty acids (SCFAs) by gas chromatography, it was found that in comparison to media C (control) propionic acid was produced in higher concentration in both media A (carbohydrate free medium + glucose +EPS) and media B (carbohydrate free medium + EPS) by NCDC15 culture and butyric acid was produced in higher concentration in both media A and media B by NCDC 17. Thereby, the *in vitro* tests show that the EPS of *L. gasseri* Lg62 and *L. helveticus* V3 may serve as prebiotic although further *in vivo* study is required to establish its prebiotic potential fully.

Probiotic Potential of *Lactobacillus fermentum* RS-2

Probiotic potential of *Lactobacillus fermentum* RS-2, a strain isolated from a traditional cereal-based fermented milk product (Raabadi) was evaluated both by *in vitro* and *in vivo* methods using *L. fermentum* ME-3 as a reference. The *in vitro* tests included acid tolerance, bile tolerance, antioxidative activity test, cell surface hydrophobicity, antimicrobial activity, antioxidative activity and sensitivity to antibiotics. The *in vivo* evaluation

consisted of the study of effect of strains on the Alloxan induced diabetes in rats and its complications. Both the strains invariably showed appreciable tolerance during *in vitro* evaluation and RS-2 was observed to perform little bit similar. During *in vivo* evaluation, after 9 weeks, the haemoglobin content of normal control, diabetic control group, ME-3 fed group and RS-2 probiotic fed groups were $14.135 \pm 1.06\%$, $6.848 \pm 0.68\%$, $11.110 \pm 0.07\%$ and $10.300 \pm 0.31\%$ 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 levels of super oxide dismutase evaluated in probiotic fed groups after 9 weeks were significantly increased in liver such as 5.525 ± 0.99 , 2.3153 ± 0.14 , 4.198 ± 0.27 , 3.441 ± 0.32 (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 RS-2 as observed to be probiotic was used further for development of a functional fermented milk product along with *S. thermophilus* ST20 as a co culture with acceptable sensory quality. The study established potential probiotic attributes of RS-2 and development of a functional fermented milk product.

Development and Functional Evaluation of Tea Fortified Synbiotic lassi

The antioxidant and prebiotic activity of green and black tea was determined and a fortified fermented milk beverage was developed. Green tea showed higher antioxidant activity compared to black tea. The total polyphenolic contents (mg/ml of gallic acid equivalent) of green tea were higher than black tea. The different concentrations of green and black tea (5 to 20% extracts) were evaluated for their impact on the growth of three *Lactobacillus* spp. and an increase in counts was found with increasing concentrations of tea compared to control. The low calorie polyphenol enriched lassi was prepared by incorporating 0.5 mg/ml of tea extract and 800 ppm of aspartame cultured with NCDC167 and selected *Lactobacillus* culture. The developed product had a better flavor (7.60 ± 0.56) and appearance (7.86 ± 0.36) with comparable compositional and physico-chemical parameters. Antioxidant activity and total polyphenol content of developed product were significantly higher than control. Present results also showed that the tea extract fortified lassi had marked per cent inhibition (30.84 ± 0.04) against α -amylase, whereas lassi without tea extract had less inhibitory activity.

Production of Bioactive Peptides using Yeast and Lactic Acid Bacterial Proteolytic Systems in Whey Based Medium

Proteolysis of two lactic acid bacteria namely *Lactobacillus helveticus* NCDC 292, *L. helveticus* NCDC 288 and three yeasts namely *Kluyveromyces marxianus* NCDC 39, *K. marxianus* NCDC 46 and *K. lactis* NCDC 257 was studied on skim and calcium caseinate agar and in whey medium supplemented with whey protein concentrate. ACE-inhibitory activity, α -glucosidase inhibitory activity and antimicrobial activity against *E. coli* were studied. Addition of WPC increased the inhibitory peptides formation. *L. helveticus* NCDC 292 yielded the highest ACE inhibitory activity (67.05%) on supplementation of 0.5% WPC and higher antimicrobial activity was observed for *L. helveticus* NCDC 292 under similar conditions. *L. helveticus* NCDC 292 resulted in higher α -glucosidase inhibitory activity (75.44%) in whey supplemented with 0.25% WPC. The highest activities were observed in 24-48 h of incubation. *K. marxianus* NCDC 39 showed maximum ACE inhibition (53.89%) and *K. marxianus* NCDC 46 yielded the maximum α -glucosidase inhibition (70.62%) at 24 h. Antimicrobial activity was higher in *K. lactis* NCDC 257. Finally, *Lactobacillus helveticus* NCDC 292 and *Kluyveromyces marxianus* NCDC 39 were selected for co-culturing in whey medium supplemented with 0.5% WPC. ACE inhibition was found to be higher (84%) than the individually fermented whey, however, α -glucosidase inhibition was lower than individual fermentation both in flask and fermenter. The activities were higher in fermenter and on ultra-filtration fraction of peptides, the maximum activities were found in 3 kDa filtrate as compared to other fractions. Thus, the combination of *L. helveticus* NCDC 292 and *K. marxianus* NCDC 39 can be used for production of bioactive peptides using whey based medium.

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

A total number of 1435 strains of LAB isolated from different dairy and cereal products were screened for their antibacterial activity and out of which 68 isolates were selected. Amongst these 68 selected isolates, 13 showed antimicrobial activity against wide range 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 faecium* (DSM 20477 and NCDC 124), *Lactobacillus plantarum* (NCDC 021) *Lactobacillus rhamnosus* (NCDC 24), *Lactobacillus casei* (NCDC 117), *Lactobacillus paracasei* (NCDC 22), *Enterococcus faecalis* (ATCC 29212), *S. aureus* NCDC 110 as well as against Gram-negative organisms viz., *E. coli* O157:H7, *Enterobacter cloacae* (NCDC 222), *Proteus vulgaris* (NCDC 259) and *S. typhi* (NCDC 113). The activity units of these isolates were determined using *Pediococcus acidilactici* LB42 as an indicator strain. The bacteriocinogenic nature of the antimicrobial principle was also determined by treating the culture supernatants of these isolates with different proteases. Four strains of LAB isolated from milk and millet fermentate showed antifungal activity. The selected 13 isolates were characterized by biochemical tests and also by genus specific PCR. Five isolates belonged to the genus *Lactobacillus* and eight 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. Two isolates, viz., M63 and C70 showing relatively higher bacteriocin activity and also wider spectrum of activity were selected for further studies. Their bacteriocin production was optimized with different media. Bacteriocins were encapsulated using the newly fabricated machine and the release kinetics for these bacteriocins was tested in broth against *Listeria monocytogenes*. Bacteriocins of these strains are quite 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.

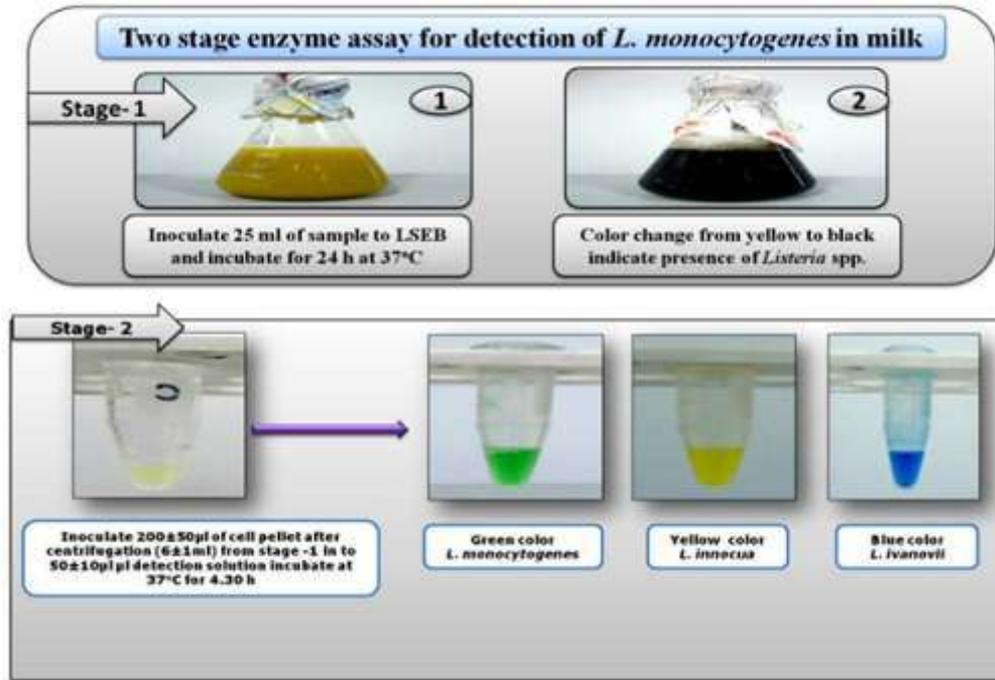
Clean Milk Production with a Focus on Emerging Health Concerns and Development of New Generation Tools for Ensuring Quality Control through Application of Newer Chemical and Biotechnological Concepts

Development of Biosensor and micro techniques for bacterial contamination (*Enterococci* / Coliform/ *Listeria* / *E. coli* / *E. coli* O157:H7/ *Campylobacter*) in milk

Technology on novel enzyme-substrate based bio-assay for real time detection of *L. monocytogenes* in milk: The technology works on the marker enzymes and can confirm the presence of *Listeria monocytogenes* with in real time of 4.30 ± 0.10 h after initial pre-enrichment of food samples in LSEB for 18

/ or 24 hrs as against 5 days protocol following conventional method (IS: 14988 (Part-2): 2002/ ISO: 11290-2: 1998). Patent has been filed dated 5/07/2012 through ITMU at NDRI. The technology has been validated at M/s SGS India PVT, Gurgaon and its

prototype development and licensing is under progress.



A real time enzyme substrate assay for detection of *E. coli* O157:H7 in milk : Despite the great strides that have been made in the improvement of real-time detection of *E. coli* O157:H7, there are still no satisfactory methods in terms of time, cost, sensitivity and selectivity. The GAL-GUD-ATPC assay developed for detection of *E. coli* O157:H7 in milk can be extremely valuable and robust diagnostic tool for rapid detection, identification and enumeration of *E.*

coli O157:H7, the most important high risk pathogen in dairy and food sector. This investigation reveals that GAL-ATPC medium as such can be used as a novel screening medium for selective recovery of *E. coli*/*E. coli* O157:H7 from food matrix without going for further biochemical tests but needs further validation work with wide range of contaminants and food matrix.

Confirmation of *E. coli* O157:H7 based on GUD-ATPC assay



| | Organism | Enzyme reaction |
|----------------|------------------------|-----------------|
| GAL-ATPC assay | <i>E. coli</i> | ++ |
| | <i>E. coli</i> O157:H7 | ++ |
| GUD-ATPC assay | <i>E. coli</i> | ++ |
| | <i>E. coli</i> O157:H7 | - |

Interpretation:

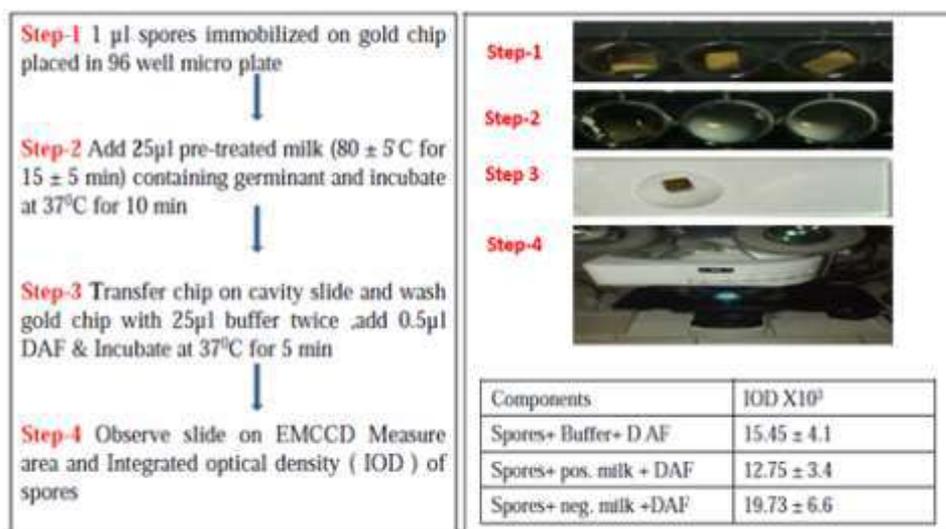
>Positive reaction for GUD enzyme with GAL positive reactions gives the confirmation of *E. coli* in the developed test method

>Negative reaction for GUD enzyme with GAL positive reaction gives the confirmation of *E. coli* O157:H7 in the developed test method

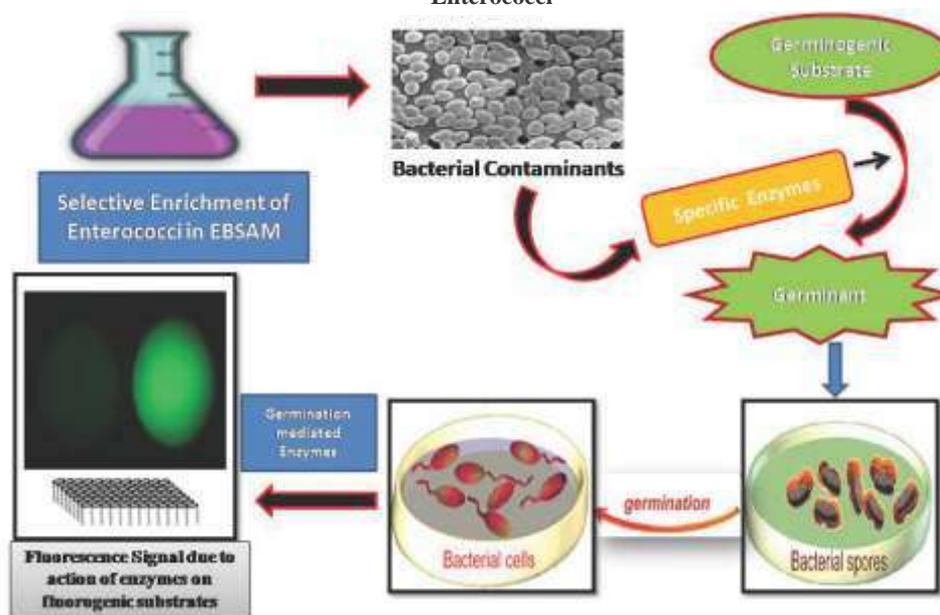
Miniaturized Spore Based assay on Biochip for Aflatoxin M1 and Enterococci in milk:

A miniaturized spore based assay for detection of aflatoxin M1 and Enterococci in milk on functionalized gold chip with minimal quantity of milk and other reagents with enhanced sensitivity has

been achieved. The developed assay needs to be transformed into commercial products after its integration with other consortia partners to have multianalyte high throughput put analysis for dairy applications.



Spore Germination Based Assay on 96 Assay on 96 micro well Plate for Detection of Enterococci



Validation of Technology : SGS Referral Laboratory, M/s SGS India Pvt. Ltd., Gurgaon, validated the technology on “Novel enzyme substrate based assay for real time detection of *Enterococci* in milk”. The technology was validated by spiking of contaminants namely *E. coli* in EBSAM medium in 5 different trials which did not interfere with the growth pattern of *Enterococcus* spp. The appearance of colour was observed after 18.45 ± 0.15 and 24 hr indicating

enterococci counts more than 1000 and 100 CFU/ mL respectively. No black colour appearance after 24 hr indicates enterococci counts in the range of 10-100 cfu/ mL of the food sample. The working performance of enzyme based bioassay for detection of more than 100 cfu/ mL for *Enterococcus* count within 24hr was compared with IS: 5887 Party-2 (3-days protocol) and results were found in accordance with the claims of the developed enzyme based assay.

R And D Support for Process Up-gradation of Indigenous Milk Products for Industrial Application (network Dt 2001/2502) – Network Project on Antibiotic Residues and Aflatoxins M1 in Milk

Aflatoxin M1 in milk: A total of 111 milk samples comprising of raw and pasteurised, were collected and analyzed by ROSA reader and CHARM assay. Aflatoxin M1 was detected in 14 (2 raw + 12 pasteurized) milk samples with a total incidence of 12.61 % \geq above 0.5 ppb (Codex MRL) by ROSA reader, and 14 (1 Raw + 13 Pasteurized) milk samples were found positive at 0.25 ppb by ROSA reader with an incidence of 12.61 %. Results showed high correlation (94.0%) with Charm assay.

Antibiotic residues in milk : A total of 111 milk samples comprised of raw and pasteurised, were collected from Rajasthan and Delhi area and analyzed by ROSA reader and CHARM assay. Fifty samples were analyzed using MDR test kit for the presence of antibiotic residues. Eight samples (1 raw and 7 pasteurized) were found positive with antibiotic residues \geq MRL level specified by Codex. Over all 10 milk samples with an incidence of 16.39% were found positive for drug residues of which 6 samples (9.83%) were detected for the presence of multiple drugs residues which includes β -lactam, Erythromycin and Sulpha drugs. The scientific data was validated by using MDR kit developed in our laboratory.

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 : More than 100 different strains of *Lactococcus* spp., and *Leuconostoc* spp., *Lactobacillus* spp. and *Streptococcus thermophilus* have been isolated from different sources such as fermented milks, vegetables, fruits, etc. across India and deposited at culture bank (NCDC/VTCC). The cultures will be used for manufacturing of various fermented dairy products with improved technological qualities.

Rumen Microbes : The different groups of rumen microbes, anaerobic fungi (i.e. *Orpinomyces joyonii*, *Orpinomyces intercalaris*, *Anaeromyces* sp., *Piromyces* sp. 1 and 2, and *Neocallimastix* sp.) and bacteria (i.e. *Bacillus licheniformis*, *Butyrivibrio* sp., *Eubacterium limosum*, *Megasphaera elsdenii* (2), *Olsenella* sp., *Prevotella* sp., *Streptococcus bovis*, *Streptococcus equinus*, *Streptococcus gallolyticus*, *Streptococcus lutetiensis*, *Streptococcus sanguinis*, and *Veillonella parvula*) were isolated, characterized and submitted to NIANP, Bangalore having the accession numbers of VTCCRM000001F to VTCCRM000006F (6 strains) and VTCCRM000007B to VTCCRM000019B (13 strains).

DAIRY ENGINEERING

Scale up Design of Continuous Khoa Making Machine

Cooling studies were made on third stage of three stage Scraped Surface Heat Exchanger (SSHE) during khoa manufacture. Inlet and outlet lines of second half jacket of third stage SSHE were provided for chilling/tap water temperature and flow measurement. Since vapours outflowing from khoa were condensing into the product during cooling, an exhaust fan of 12" size was provided at product inlet of third stage SSHE for smooth withdrawal of vapours into atmosphere. The parameters for cooling studies were a. Coolant media temperature 4, 15, 22°C b. Third stage rotor speed- 20, 30, 40 rpm c. Flow rate of coolant media- 150, 200, 250 kg/h. The cooling performance was studied in terms of overall heat transfer coefficient, cooling coefficient, cooling rate, final outlet temperature of khoa and quality of product in terms of textural and sensory attributes. Overall heat transfer coefficient was found in

range of 180 to 190 W/m² °C. Maximum cooling efficiency was 80% at 4°C coolant water temperature and flow 250 kg/h. Maximum cooling rate was found to be 6.6°C/min at 4°C coolant water temperature and flowrate 250kg/h. Minimum final outlet temperature of khoa was found to be an average of 42°C at 4°C coolant water temperature and flowrate 250 kg/h. Sensory scores were comparable with that of control sample which was not cooled.

Studies on In-Line Production of Indian Dairy Products

For in-line production of basundi, milk was preheated to 90°C for 10 min in SSHE and was concentrated upto 20% TS. Concentrated milk was transferred to CPV and sugar was added. Heating was continued till concentration of 2.5 times of initial milk solids (including sugar) was achieved. Variable parameters were SSHE speed (50 to 200 rpm), SSHE steam pressure (2-4 kg/cm²) and CPV steam pressure (0.5 to 3

kg/cm²). Optimized parameters were SSHE speed 165 rpm, SSHE steam pressure 4 kg/cm² and CPV steam pressure 3 kg/cm². Predicted sensory score viz. Flavour (45), body and texture (35), colour and appearance (15) and packaging (5) were 42.97, 33.6, 13.24 and 4.87 respectively. Viscosity of the optimum sample was 67.58 mPas. Experiments were conducted for in-line production of ghee from butter and cream. The optimized parameters for ghee from butter were SSHE 200 rpm, 2.5 kg/cm² SSHE steam pressure and 3 kg/cm² CPV steam pressure. Sensory score viz.,

flavour (45), body and texture (10), colour (10), and freedom from suspended particles (5) were 42.2, 8.44, 9.25 and 3.49 respectively. Moisture content, BR reading and FFA were 0.28 %, 40.5 and 0.69 respectively. The optimum operating parameters for making ghee from cream were SSHE 100 rpm, 4 kg/cm² SSHE steam pressure and 2.5 kg/cm² CPV steam pressure. Sensory score viz., flavour (45), body and texture (10), colour (10), and freedom from suspended particles (5) were 40.9, 8.2, 8.0 and 4.76, respectively. Moisture content, BR reading and FFA were 0.31 %, 40.8 and 0.77, respectively.

DAIRY ECONOMICS, STATISTICS AND MANAGEMENT

Promoting Dairy Enterprise through Transfer of Technologies, Improved Farm Financing, Supply Chain Management for Better Market Access

Importance of Dairy Sector in Indian Plan Documents

Plan-wise report on Five Year Plans (I-XI) vis-à-vis Animal Husbandry and Dairying were studied. It was found that the planning lacked uniformity in terms of both pattern and in measures taken for the development of each of the sub-sectors in animal husbandry and dairying. In the first four Plans, planning was found to be comparatively exhaustive, while in the successive Plans it got more “general” in terms of steps-to-be-taken. Even in the Tenth and Eleventh Plans, a lot of instructive measures, rather than concrete measures were seen. The sub-sectors were found to be missing altogether in some of the Plans. There has been a tremendous improvement in animal husbandry and dairying since the inception of the first Plan, but there is no denying the fact that we lacked consistency and timely checks.

Determinants of Veterinary Services in Punjab – Empirical Results and Policy Implications

The study has shown the importance of identifying factors that determine the likelihood of using veterinary services by dairy farmers in Punjab. Descriptive analysis revealed that, for the majority of dairy farmers the principal source of income was agriculture and they possessed small landholding. Dairy farming offers an opportunity to these marginalised farmers to diversify farming business and to secure livelihood. The proportional relationship between veterinary services available within the village and use of veterinary services implied that distance of veterinary service availability positively influenced the farmer decision to use the veterinary services. Therefore, the number of veterinary

institutions delivering veterinary services should be increased at village level. The positive relationship was observed between literacy levels of family head and use of veterinary services. It implied that improving the literacy level of dairy households increased the likelihood to use veterinary services. The principal source of income from agriculture positively influenced the likelihood of veterinary service use by dairy farmers. It is indicated that as the income from agriculture activity increased the dairy farmers more likely used veterinary services. Those dairy farmers who were self employed in agricultural activities were more potent to the use of veterinary services in the Punjab. The predictive model developed showed that 71% of the farmers used the veterinary services as one of the important input in order to commercialise dairy farming

Value Chain, Food Security and Rural Livelihood through Dairy Sector

The proportional expenses on dairying to total production expenditure at the household level is inversely related to land ownership and income from dairying to total family income of the households is also inversely related to land ownership. Therefore, dairying has the capacity to reduce poverty at the household level and it should be an integral part of poverty alleviation programmes. This study revealed that 1 per cent incremental increase in crop income will trigger total income inequality by 1.38 per cent with a caveat that other things are unchanged. On the other hand, 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 other livestock farming compared to distribution of incomes through crop. Promotion of economic development and reduction of poverty will

depend on the capacity of dairy farming to contribution to smallholder income and employment.

One way with which food insecurity in Indian context could be explained is through the seasonality of agricultural production. It was found that nearly 52% of households were food insecure nationally. The analysis suggests that around 27-40% households could not produce enough food for their self-sufficiency, while about 12-25% of the rural households who could produce enough food lacked in calorie intakes.

The food accessibility and food availability at the household level differs across the regions and even within the states in a given region. This study found that stable and regular sources of income especially from livestock sector acts as a conduit against food insecurity in some arid and semi-arid states like Rajasthan. Higher household incomes do not always ensure higher food accessibility-the sources of income and their frequency of accrual are determinants of food security. This probably creates a canvas for further analysis on different attributes of income sources by type of employment, asset ownership, agricultural practices and livelihood dependence. The income from livestock activities, and wages and salaries are more inclusive in ensuring food security at the household level.

Operation Flood programme emphasis on developing smallholder-based dairy sector in the pre-liberalised era is justified on the ground that it realised the needs of the production base by the masses. Need of the day is to provide quality of efficient input and output support services as provided by the co-operatives (Amul model at Gujarat, Nandani Milk Federation at Karnataka Model), private sector (*Nestlé*) and contract dairy farming. In the recent years, some new dairy development models have been implemented and scaled up by cooperative sector like New Generation Cooperatives (Dairy Producer Companies) in Junagadh (Gujarat) initiative taken by NDDDB and Punjab Progressive Dairy Farmers Association started by a group of progressive farmers. In the liberalised economy, the replication and scaling up of these models largely depends on the governance, institutional support and market forces.

Costs and Returns in Milk Production: Developing Standardised Methodology and Estimates for Various production Systems

Estimation of cost of milk production is a complex exercise because production of milk is largely scattered over innumerable small units of production throughout

the country. These milk producers are not in a position to maintain any detailed or systematic records and are generally ignorant about the quantitative aspects of the enterprise. The cost of milk production varies across agro-climatic regions, seasons, species and breeds of animals. Further, disparities in resource endowments of different categories of milk producers with varying degree of commercial and non-commercial orientation also leads to variations in costs. In contrast to the standardised methodology used uniformly throughout the country for working out cost of cultivation of various crops, a similar tool for estimating cost of milk production is lacking and has been taken up by this study. Several revisions and additions have been made in the existing estimation framework. The notable changes/additions are: (i) Formulation of Standard Animal Units (SAU) for different geographical regions (North, South, East, West and Hills) based on animal body weight and labour utilisation instead of uniform SAU based only on labour use; (ii) Redefining productive life of milch animals; (iii) Using capital recovery cost method in estimation of fixed cost; (iv) Including rental value of land used for dairying as cost item; and (v) Valuation of fodder intake from grazing. User friendly software is being developed for the working out economics of milk production for different herd-size categories and animal type.

Sustainability of Smallholder Dairy Production System in Under-developed Production Environments

Sustainability of livestock production system is the ability of the system to maintain or enhance its performance, i.e., output and services for long time, through linkage with other systems, which are economically viable, socially acceptable and ecologically secure. The evaluation of sustainability is to be based on construction of Sustainable Dairy Farming Index, encompassing all the three economic, social and ecological dimensions of sustainability, for each of the 900 sample farms in Chhattisgarh and Uttarakhand. The indicators to be used in each dimension are as follows: (i) Economic Dimension: cost of milk production and input (labour, capital and feed) productivity; (ii) Social dimension: family labour income, women empowerment and drudgery of work; and (iii) Ecological dimension: animal waste management practices, animal breeding practices, enteric methane emissions and water footprints of milk production.

Study of Structure, Conduct and Performance of

Selected Wholesale Markets of Indigenous Dairy Products in India

There is a wide range of indigenous dairy products like ghee, khoa and channa and the sweets made from these products, paneer, etc. With the increase in milk production, the wholesale marketing of these products is continuously increasing. The efficient working of these markets has long term repercussions on welfare of the large number of stakeholders associated with it. In this background, the present study was taken with following objectives: (i) To determine the market structure of selected markets; (ii) To analyse conduct of the markets; (iii) To estimate the performance of selected markets; and (iv) To examine the major constraints of wholesale of indigenous dairy products. To achieve these objectives, three important wholesale markets of indigenous dairy products namely Paneer market in Rohtak, khoa market in Delhi and channa market in Kolkata were purposely selected. The study concluded that the numbers of wholesalers in all the three markets were lesser in number but they were selling the product more close to their proportionate share. The overall structure of markets was slightly to moderately concentrated oligopolistic. The major barriers of entry to the market were observed to be the low profit margin and perish ability of the products. In the study of market conduct, it was found that all the markets lack in using the fair means of price determination except the khoa market where open auction method of sale was followed between the producer and wholesaler. The products were sold unpacked. Quality of the products was determined subjectively on the basis of texture, colour and flavour. In the absence of perfect competition, the market margin charged was higher and producer's share in consumer's rupee was lower. The marketing efficiency estimated was experienced to be the highest in both channa (6.0) and khoa market (11.5) in producer-wholesaler-consumer marketing channel. The study has highlighted the need for formulating market policy for easy operation and regulation of these wholesale markets.

Economics of Milk Production and Utilisation Pattern in Malwa Plateau of Madhya Pradesh

Two districts, i.e., Indore and Rajgarh from the Malwa Plateau were selected randomly for this study. From each district, two tehsils and further two villages from each tehsil were selected randomly. Thus in all total four villages, viz., Bhagora, Pedmi, Budakheda and Laltalai were selected randomly. A sample of 160 milk producing household were selected from these four villages consisting 70 small, 61 medium and 29 large

milk producing households. The average herd size was observed 1.47, 3.0 and 5.10 for small, medium and large category of households, respectively. Average land holding was 4.55, 4.69 and 5.08 acres and average family size of small, medium and large category was 6.5, 6.78 and 6.85, respectively. 23.13% of heads of the sampled households were illiterate and 4.38% were graduates or post graduates. On an average a milking buffalo produced 5.43 litres of milk per day, which ranged from 4.99 litres (small) to 5.85 litres (large) and a milking crossbred cow produced 7.36 litres of milk per day, which was highest (7.89 litres) for large and lowest (6.89 litres) for small category. The net maintenance cost per day per milking buffalo was ` 136.59 ranging from ` 122.19 (small) to ` 147.63 (large) and per milch buffalo it was ` 123.60 ranging from ` 115.67 (small) to ` 134.76 (large). Net return from milking buffalo was ` 23.78, which was highest for large (` 32.87) and lowest for small (` 19.28) categories. Cost/litre of milk was worked out to be ` 25.16 and ` 29.09 for milking and milch buffalo, respectively. The cost/litre of milk for milking and milch crossbred cow was ` 20.38 and ` 21.88, respectively. The green fodder for local cow, cross bred cow and buffalo was found negative and significant indicating over utilisation of this input, therefore, green fodder feeding can be reduced without affecting milk production. The concentrate for local cow was found to be positive and significant indicating underutilisation of this input and increase in this input will further increase milk production while for buffalo it was found negative and significant indicating it's over utilisation; thus, feeding of concentrates can be reduced in case of buffaloes without affecting milk production. Out of total quantity of milk disposed off per day by the sample households 18.64% was disposed to co-operative society, 38.86% to Milk vendor 14.35% to consumer and 28.13% was disposed to Tea stall and Halwai/private dairies.

Price Behaviour and Market Integration Analysis of Selected Dairy Products in India

Prices are the language of market. Beyond a mere medium of exchange, prices transmit signals of the demand, supply, deficits, consumer preferences and taste. Future shape and size of production will be determined by the extent price signals are transmitted among products and markets. Prices measure marketing efficiency and decide the marketing system to be followed in a particular product. Thus, study of commodity prices is crucial to the decision making and policy analysis regarding its production and marketing. This study was taken up with the objectives: (i) To determine growth rate and inter commodity price

causation in milk and selected milk products in major markets of the country; (ii) To analyse the trends in price variation across products and markets; and (iii) To examine the extent of market integration of milk and selected milk products in the country.

The deseasonalised price data of wholesale and retail prices of milk and butter, ghee and SMP were used in this study to investigate the compound monthly growth rate (CMGR), variations in MMP prices and trends in variability. The entire study period (1988-2007) was divided into two sub period (1988-1997 and 1998-2007) to study the growth rate, variations in MMP prices and trends in variability. The higher CMGR was observed during 1988-1997 and lower CMGR was observed during 1998-2007 for all wholesale and retail markets of milk, butter, ghee and SMP except Patna milk wholesale and Mathura SMP wholesale market and Bhopal SMP retail market. A study on inter-product causality, bilateral causality was observed between butter and milk prices in Mumbai wholesale market while unidirectional causality was observed between milk and ghee wholesale prices in Chennai market while it was unidirectional causality between Kanpur and Kolkata, Delhi and Chennai, Kanpur and Delhi, Chennai and Kanpur milk wholesale markets and in Chennai and Kolkata milk retail markets was observed. The price variability in wholesale and retail prices of milk, butter, ghee and SMP were found decreasing from first to second sub period except Anand butter wholesale price, Patiala SMP wholesale price; Kanpur milk retail price, Delhi butter retail price, Indore ghee retail price and Bhopal SMP retail price. In market integration analysis, all wholesale and retail markets of milk, butter, ghee and SMP product was found integrated except retail SMP markets, which establishes the better marketing and information

linkages among milk and milk product markets.

An Economic Analysis of Dairy Farming in Tribal Areas of Dhar District (MP)

This study was taken up with the specific objectives to study the socio-economic characteristics of tribal dairy farmers, to work out cost and returns from milk production, to study the production and disposal pattern of milk of the sample households, to examine the resource use efficiency in milk production and to study the dairy farming practices and identify the constraints faced by the tribal dairy farmers. Households were selected from four villages, two tehsils and one district. A list of households having at least one lactating animal from the four selected villages was prepared and then the households were further classified into three categories, i.e., small, medium and large on the basis of milch animals by using cumulative frequency square root method. A predetermined sample of 160 households was drawn according to the proportion of population in each herd size category. The primary data were collected during January-February, 2012. The resource use efficiency of green fodder for buffalo was found positive and significant indicating under utilisation of this input. Concentrate for buffalo and local cow found positive and significant indicating underutilisation. Dairy farm practices followed by tribal dairy farmers such as Breeding, Feeding and Health care management practices were followed more frequently by large and medium category as compared to small category. Major constraints faced by sample household were lack of green fodder availability throughout the year, low availability and high cost of concentrates, non availability of dry fodder throughout the year, low productivity of animals, etc.

DAIRY EXTENSION

Entrepreneurship Development Based on Dairy Innovations

Entrepreneurial behavior on scientific dairy farming among youth of Manipur was conducted and found that the highest (79.12%) entrepreneurial Index was found in self-confidence attribute and the overall entrepreneurial index was 57.91 %. The overall knowledge was 58.31 % on scientific dairy farming practices.

Knowledge Management of Dairy Innovations

A study on perception and adaptation of dairy farmers on climate change revealed that the climate parameters in 2001-2010 period shows that 53.28 %, 21.44 % and

25.88 % perceived by respondents were increasing trend, decreasing trend and no effect, respectively in the study areas. Subsequently in 1991-2000 period, 7.54 %, 14.32 % and 78.14 % respondents were perceived increasing trend, decreasing trend and no effect, respectively.

As concerned to the productive and reproductive performances of dairy animals in Faizabad district of Uttar Pradesh it was found that the average milk peak yield of buffalo, crossbred cow, indigenous cow was 8.56 ± 0.85 , 10.42 ± 1.42 and 5.51 ± 0.53 litre/animal, Age at first calving 1288 ± 122 , 1170 ± 88 and 1517 ± 131 days/animal, service period was 189 ± 16 , 197 ± 12 and 268 ± 18 days/animal, and calving interval was 505 ± 39 ,

485±32 and 558±55 days/animal respectively. The overall knowledge index of the dairy farmers on productive and reproductive traits/practices was 66.79 %. In time A.I. facilities are less available at the village and incompetence of para veterinary staff engaged in A.I. and related diagnostic were serious.

In case of farmers knowledge analysis about major bovine zoonotic disease in Kerala, about half (50%) of the respondents had high knowledge on anthrax, leptospirosis, bovine tuberculosis and fungal dermatitis. Trans-boundary transmission of disease through imported bovines from other states was ranked first as the major constraint in adopting preventive and control measures of anthrax and brucellosis, in case of leptospirosis. The major constraint in treatment management of anthrax and fungal dermatitis was inexperience to manage the treatment of disease whereas, for brucellosis, leptospirosis and bovine tuberculosis it was costly treatment of disease. A participatory animal health plan for dairy farmers in district Karnal was developed as the majority (89.0%) of the dairy farmers were having low to medium knowledge level. Nearly 11.00 % of the respondents were not getting their low producing animals vaccinated. Only 57.89 % were practicing parasite control measures whereas, 67.78 % were not isolating sick animals and 37.76 % were feeding fungi infested feed and fodder. Developed participatory animal health plan was found feasible for adoption by a majority (81.25 to 100.00%) of the dairy farmers.

Demand-Driven Extension Approaches

Assessment of 'livelihood security' among farmers of Vidarbha region of Maharashtra resulted that the value of overall livelihood security of the farmers was 47.20 % and extent of livelihood diversification was 51 % in the study area. Farmers with 'Livestock-included' diversification were having higher livelihood security than others. Lack of assured sources of irrigation, natural calamities affecting the agriculture and lack of availability of credit to start any new enterprise were the major constraints as perceived by the farmers.

A study of animal health care and management practices followed by tribal dairy farmers of Ranchi district (Jharkhand) revealed that about 45 % respondents practiced vaccination of animals. About 57 % of the respondents having large herd size, did not practice deworming. The major risk factor identified

was "use of same pond by both animals and humans", followed by no isolation of diseased animals (mean score 82.58). The most serious constraint was found as lack of fodder and scarcity of clean drinking water, with a mean score of 63.21.

Women Empowerment

Two milk processing units were established successfully in Karnal district under the study on extension strategies for promoting value addition in milk among farming community. *Anmol Mahila Dugdh Samiti* (Amritpur Kalan): The processing unit is presently handling 400-500 litres/day of milk, which is being converted into milk products (Curd, Paneer, Whey drinks, Khoa, Gulab Jamun mix powder, Kulfi, etc.); and the earning is Rs. 5000/- per month/member. A documentary film '*Kamyabi Ki Dastak*' on Anmol Mahila Dugdh Samiti is available on ICAR-web site. Whereas *Nirmaldhara Mahila Dugdh Samiti* (Taprana) is processing 200 litres of milk/day, which is being converted into Paneer, Dahi, Khoa, Cream etc; and the earning is Rs.1000/- per month/member.

Organizational Management and Communication Networks in Dairy Organizations

A study on problems and prospects in the performance of Jammu and Kashmir milk producers' cooperative limited revealed that overall mean performance of societies was 51.83 % in Jammu and 44.00 % in Kashmir. Co-operative societies in Kashmir were performing better with respect to indicators like yearly increase in membership and percentage of households covered by a cooperative societies with performance percentage of 66.67 and 66.12 compared to performance percentage of 50.83 and 35.45 in Jammu; respectively. It was observed that around 76 per cent of the respondents perceived that the organizational climate prevailing in the department of animal husbandry of Andhra Pradesh in India was favorable. Leadership, teamwork and trust had significant contribution towards perception of organizational climate as favourable. Work motivation, persistence disposition, participativeness, job satisfaction, physical facilities availability and timeliness of availability of facilities were found to have substantial significant positive influence while job stress had significant negative influence on perceived organizational climate.

SOUTHERN REGIONAL STATION, BANGALORE

HSP70 Gene and its Association with Thermo Tolerance and Reproductive Performance in Cattle

PCR-SSCP analysis of promoter region of HSP 70 gene

showed three SSCP patterns in Deoni cattle and two SSCP patterns in HF crossbred cattle were observed. The PCR-SSCP analysis of HSP70 revealed three genotypic combinations viz., AA, AB and BB in the

frequencies of 0.034, 0.254 and 0.712 in Deoni, 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 age at first calving (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. PCR-SSCP analysis of HSP 70 coding region revealed 2 unique patterns in Exon 1, showed 4 patterns in Exon 2 (3 patterns each in Deoni and HF Crossbreds), Exons 3 showed 4 patterns (4 patterns in Deoni and 2 patterns in HF crossbreds), Exon 4 was monomorphic and Exon 5 showed 3 unique patterns (3 patterns in Deoni cattle, 2 pattern in HF cattle). Unique SSCP patterns were further analyzed by direct sequencing. Sequence data were analyzed using Bioedit software (Hall, 1999) CLUSTAL W multiple alignments for detecting Single Nucleotide Polymorphisms (SNPs). The analysis of coding region revealed 13 band patterns in Deoni cattle while 8 band patterns were detected in HF crossbred cattle out of which 8 bands were found in both the breeds while 5 bands were unique to Deoni breed of cattle. Eleven SNPs were detected in the coding region of HSP70 gene in cattle which included six transitions (G456A, G480A, A972G, A1098G, T1766C and A1788G) and two transversion (C312G and G2033C) in Deoni and two insertions (C at positions 574-575 and 624-625), two transition (A480G and A1098G) and one transversion (C312G) in HF Crossbred cattle indicating high degree of genetic variability in HSP70 gene in the breeds under study. In fragment 5, the observed SNP at base position 2033 (G→C) results in amino acid change from glycine to alanine in peptide chain. Among the observed Single Nucleotide Polymorphisms (SNP) of the HSP 70 gene, base change at G2033C of the HSP 70 gene that results in an amino acid change from Glycine to Alanine in the translated product had an effect on milk yield and heat tolerance as indicated by high rectal temperature after exposure to sun as well as high HTC (heat tolerance coefficient). Thus, the study clearly indicated that there is high variability in HSP 70 gene in Deoni and HF crossbred cattle which suggest that HSP 70 could be used as a candidate gene for identifying markers for heat tolerance.

Evaluation and Improvement of Indigenous Cattle of Malnad Region of Karnataka

The Malnad Gidda cattle is unique dwarf (small sized) cattle and distributed predominantly in Malnad and adjacent costal districts of Karnataka. Studies indicated that Malnad Gidda cattle has the reproductive

uniqueness of regular calving (inter calving period of 396± 33 days) under low input regime. They play a major role in the rural economy of this region by providing milk, manure and draft power. Based on the breed descriptor, Malnad Gidda has been registered as a breed recently with Accession Number INDIA_CATTLE-0800MALNADGIDDA-03037. Phenotypic characterisation, haematological, and milk composition studies were carried out. Elite Malnad Gidda cows were identified weighing less than 120 kg and giving up to 7 kg of milk per day. Training programme for the improvement of Malnad Gidda cattle and inauguration of the Malnad Gidda conservation and improvement trust were successfully arranged at Igalakoppa, Thalaguppa, Sagar, Shimoga district, Karnataka during 26-27th October 2012.

Glutathione s-transferase Pi (GSTP1) Gene Polymorphism in Deoni Cattle by Single Strand Conformation Polymorphism

Genetic variation in GSTP1 gene using PCR-SSCP technique in Deoni cows were studied. Entire coding region of GSTP1 gene was amplified by PCR using a total of six sets of primers. The genetic variants were determined by PCR-SSCP technique. Two unique SSCP patterns (A and B) were observed in fragment 1, 3, 5 and 6 of GSTP1 gene. Sequence analysis with reference to GenBank Acc. No AC_000186.1 revealed polymorphisms at position 210, 746, 2439, 2438, 2443, 2507, 2695 and insertions between positions 707 and 708, 2700 and 2701 and, 2775 and 2776 respectively. All the observed variations in the coding regions were silent mutations. The cows with SSCP pattern B of fragment-5 had higher age at first calving while the cows with pattern A had higher lactation length and lactation yield as compared to pattern B ($P \leq 0.05$). The animals with pattern A of fragment 6 in GSTP1 gene had higher lactation length and lactation yield as compared to animals with pattern B. There was no difference in enzyme activity and calving interval in cows with different patterns in different SSCP fragments.

Screening of Males for Genetic Diseases and Karyotypic Abnormalities (Consultancy Project)

Two hundred sixty two males were screened belonging to *Bos Taurus* (Holstein Friesian, Jersey), *Bos indicus* (Deoni, Amrithmahal, Khillar, Hallikar) and buffaloes (Surti and Murrah) either under semen collection or intended for semen collection from 4 semen stations in Karnataka for genetic diseases (BLAD, Dumps, Citrullinaemia and Factor X1) using molecular genetic tools and for karyotypic abnormalities. BLAD carrier Holstein Friesian males

from one of the semen station were identified.

Management of Breeding Bulls in Semen Stations

One commercial semen production station located in Kerala, maintaining 83 breeding bulls was visited personally and information on genetic merit, performance, and management of breeding bulls collected and analysed. Karyotyping and breeding soundness examination were done for all the breeding bulls. The old-sheds where crossbreds, indigenous and buffalo bulls were kept, bulls were tethered round the clock, had no access to loafing / open area and the average floor space in covered area was 2.69 m² which was found to be grossly inadequate. However, in newly constructed shed where HF and Jersey crossbreds were kept, bulls had access to loafing area, the average floor space in covered and open area was 16.22 m² and 18.22 m² respectively. On an average the quantity (kg) of green fodder, hay, concentrate, and mineral mixture fed to breeding bulls were 35, 5, 2 and 0.02, respectively. The semen collection yard facilities, hygiene followed for bull preparation, sexual preparation of bulls, technique of semen collection, cleaning of AV, rubber wares, glass wares, collection tubes, etc., quality of AV and preparation of AV, were found to be very good. However, due to lack of manpower bull exerciser was not used. The lay out of semen labs, cleanliness of lab, lab temperature maintained, semen cooling protocol, precautions taken while handling semen, maintenance of equipments, labeling of straw, print quality were satisfactory. The frozen semen doses of 23 breeding bulls were procured from two commercial semen stations. The post-thaw evaluation of AI doses indicated desirable semen quality of semen procured from both the commercial semen stations. However, Semen Station 1 had significantly higher ($P<0.05$) total motility (%), HPAP (%), HP (%), significantly lower ($P<0.05$) static and immotile spermatozoa (%), total abnormality (%), head abnormality (%) as compared to Semen Station 2.

Effect of Cleansing Methods on Qualitative Attributes of Frozen Thawed Bull Semen

The study reports the effect of cleansing methods on quality of frozen thawed bull semen and to evaluate the influence of cleansing methods on sire age dependent changes in quality of frozen thawed bull semen. The experiments were performed on procured frozen semen corresponding to four different ejaculates of each of 24 Holstein Friesian breeding bulls maintained at commercial semen production stations. In swim-up treatment, the mean percentage of total motility, progressive forward motility, live spermatozoa, functional membrane integrity, acrosome integrity and

sperm subpopulation positive for both functional membrane integrity and acrosome integrity and normal morphology spermatozoa obtained were significantly higher ($P<0.05$) than Percoll density gradient centrifugation and control samples. Type A spermatozoa harvested was significantly higher ($P<0.05$) in the Percoll density gradient centrifugation and swim-up as compared to the control samples. In control samples and after Percoll treatment, the total motility percentage significantly increased ($P<0.05$) from <2 year to 2-7 year age group and declined in >7 year age group. The percentage of total motility and progressive forward motility, live spermatozoa, acrosome integrity, functional membrane integrity and normal morphology spermatozoa were significantly higher ($P<0.05$) in swim-up treatment as compared to Percoll and control samples in all age groups. It was concluded that the cleansing of frozen thawed semen facilitates separation of good quality spermatozoa from the ejaculate and in addition permits selection of better quality sperm from the rejected ejaculate of the elite bulls and the bull semen-processing centres may explore the utility of swim up treatment in a larger bull population in due course to adopt this technique to improve frozen semen quality and fertility.

Bovine Sub Clinical Mastitis in Crossbred Dairy Cattle, Early Diagnosis and Control for Enhancement of Milk Production Under Field Conditions: An Integrated Approach: NABARD, RIF

Efforts were made for the *on the spot* diagnosis and control mastitis especially subclinical mastitis through testing of milk by electrical conductivity meter, assessing somatic cell counts by California Mastitis Test (CMT) and automated digital reader for high yielding HF graded/crossbreds cows under the project “Bovine sub clinical mastitis in crossbred dairy cattle, early diagnosis and control for enhancement of milk production under field conditions: an integrated approach” (sponsored by NABARD) at various areas of Bangalore urban, rural and Kolar districts. The results revealed that 58.24 per cent animals were normal and 30.86 per cent were affected with subclinical mastitis (somatic cells with a range from 200,000 to 120,000). Whereas, clinical mastitis was manifested in 10.86 % of animals (somatic cells above 120,000). The results of these tests to detect the infection and occurrence of subclinical mastitis in each quarter were 14.85, 17.99, 17.80 and 13.71 per cent in front left, front right, hind left and hind right quarters, respectively. While, the occurrence of clinical mastitis based on above mentioned quarters were 4.0%, 2.84%, 3.4% and 4.76%, respectively.

Characterization of *BTN1A1* Gene and Association with Somatic Cell Score and Fat Per Cent in Deoni and HF Crossbred Animals

The genetic polymorphism of *BTN1A1* gene Exon 3 and Exon 8 were studied in 150 HF crossbred (*Bos taurus* X *Bos indicus*) and 51 Deoni (*Bos indicus*) cattle breeds by PCR – RFLP analysis utilizing *NciI* and *HaeIII* restriction enzymes, respectively. The polymorphisms in *BTN1A1* Exon 3 and 8 were associated with fat percent in milk and SCC values of milk in Deoni purebred and HF crossbred cattle breeds. AA, AC and CC in the frequencies of 0.12, 0.32 and 0.56 respectively. Statistical analysis using GLM procedure of SPSS 17 software revealed that the heterozygotic genotype AC was associated with lower SCC values in both the studied breeds, whereas AA genotype was significantly ($P \leq 0.05$) related to higher SCC. The Exon 8 of *BTN1A1* gene in Deoni cattle revealed three genotypes, viz, AA, AB and BB with frequencies of 0.72, 0.24 and 0.04, respectively. The frequencies of A and B alleles were 0.823 and 0.176 respectively. Similarly in HF crossbred cattle, 3 genotypes viz. AA, AB and BB were observed with the frequencies of 0.80, 0.16 and 0.02 respectively. Thus the allelic frequencies of A and B alleles were 0.883 and 0.116 respectively. In HF crossbreds, significantly ($P \leq 0.05$) higher SCC was observed during mid lactation stage, whereas in Deoni cows, no significant variations were observed in SCC values in relation to stage of lactation. The results indicated that in Exon 8, Genotype AA and allele A were related to more milk fat percent in both the studied breeds. The results also indicated that Genotype AA (Allele A) in Exon 3 of *BTN1A1* gene was related to an increased milk SCC content in both breeds, whereas the Genotype AA was related to more fat content in both the breeds. Thus the genetic variation in the bovine *BTN1A1* gene could be exploited as a marker for QTLs controlling milk yield and fat percentage as well as SCC.

Studies on Culling Patterns in Crossbred Cattle Under Field Conditions in Tamil Nadu

The study assessed the culling patterns in crossbred cattle under field conditions in Trichy, Salem and Erode districts of Tamil Nadu. Most (62.11%) of the farmers practiced cultivation of green fodder and opted for purchasing cattle feed ingredients from the open markets and the farmers (60.00%) practiced stall feeding of animals. The farmers (88.42%) practiced 'intermittent milking' method for drying of cows. The BCS indicates energy status of the animal and in the present study 35.64% of cows scored BCS of 2.0. In the study area, on an average 36.07% of crossbred cows

were pregnant in farmers' herds and took 2.42 ± 0.76 mean number of services per conception. With respect to culling, farmers culled higher percentage (54.04%) of young stock males from their herds. As male calves were not used for agriculture or any other work 98.19% of the disposed male calves went to butcher. Farmers preferred selling crossbred heifers as and when money was needed. Among the crossbred cows in farmers' herds, 28.86% of cows were found to be pregnant during sale. Farmers culled crossbred cows due to various reasons such as economic reasons (41.35%), health disorders (30.77%), poor reproductive performance (19.23%) and other reasons (8.65%) such as old age, etc. Reasons for selling cows at cattle markets were economic reasons (35.40%), other reasons (28.50%) such as old age, etc, health disorders (21.59%), reproductive problems (11.68%) and productive problems (2.83%). Similar trends on BCS and udder characteristics as that of farmers' herds were noticed in crossbred cows at cattle markets. It was concluded that most of the farmers were culling crossbred cows due to economic reasons, health disorders and poor reproductive performance.

Developing Protocol to Formulate Designer Concentrate Supplement for Synergistic Affect on Microbial Protein Production in Rumen, Nutrient Utilization and Milk Production in Cattle

Concentrate supplements (CS) were categorised into 6 types based on fermentation kinetics of the feedstuffs in order to make heterogenous group of ingredients to homogenous with their fermentation kinetic characteristics. These categories included rapid to slow fermentation with varying levels of rate kinetics. Kinetic rate of fermentation of feedstuffs is necessary to design CS to suit different productivity levels of the dairy animals. Formulation of CS based on homogenous fermentation characteristics resulted in positive associate effect. *In vivo* studies were conducted to differentiate impact of two types of CS formulated based on fermentation characteristics with the type –II standard pellet feeds (M/s Karnataka Milk Federation, Bangalore).

Diversity in the Protein Fractions of Edible Oilseed Meals and Their Effect on Rumen Microbial Protein and Milk Production in Deoni Cows

Protein properties of popularly used edible oil seed meals/cakes (OSM) in dairy rations viz., ground nut cake (GNC). Soy meal (SOY), cotton seed cake (CSC), mustard cake (MUS), sunflower meal (SFM), copra cake and palm cake indicated significant difference in CP content, cell wall (NDF) and non fibrous carbohydrates (NFC). CP of OSM consisted of 8 to 16

% NPN, 6 to 17 % globular proteins (B1), 55 to 60 % albumin+glutelin proteins (B2), 5 to 12 % NDF bound or denaturated proteins (B3) and, 5 to 9 % indigestible proteins (C). About 80 % of OSM had potentially digestible fraction. Extent of fermentation of OSM based on *In vitro* gas production (IVGP) was in the order of [SOY = GNC] > MUS = COPRA > PALM > [CSC = SFM]. Globulin fraction of OSM was more negatively related to Y asymptote, Y_a and, k while positively related to τ and $T^{1/2}$. Microbial nitrogen (MBN) flow from rumen in cows fed with concentrate supplement (CS) consisted maize grain and NPN as source of nitrogen (CG) or GNC (T1), CSC (T2), copra cake (T3) or MUS (T4) showed was 137, 165, 145, 108 and 143 g N/d, respectively. Maize grain along with NPN had better effect on MBP production than copra cake. Copra meal improved milk fat, protein and lactose but not MBN flow from rumen or milk yield thus, copra meal was optional for improving the milk composition. CSC improved milk yield, lactose, and MBN flow but milk fat was less. Milk yield, fat and MBN flow would increase with GNC but less influence on SNF. MUS had average effect of above type of OSM. Fat content of milk would be lesser like CSC while SNF would also lesser. The study revealed that the albumin protein fraction of OSM had negative impact on the MBP production while positive impact on total solids and SNF. Different OSM had variable influence of milk yield (GNC, CSC) and composition (copra cake) while OSM like MUS had a balanced impact.

Development of Khoa-Jalebi using Non-Conventional Sweeteners

A technology for preparation of sugarless khoa jalebi using non-conventional sweeteners including intense sweeteners and bulk sweeteners was developed. During the soaking process, sugar diffuses into the fried units and imparts sweetness to whole product. The available options for preparation of sugar-free syrup are: use of permitted intense sweeteners like aspartame, acesulfame and sucralose, and bulk sweeteners such as sorbitol, xylitol and maltitol which have GMP status. The quality of sweetness and threshold values of the intense sweeteners have been evaluated along with sweetness of the bulk sweeteners. Preliminary trials evaluated the sweetness quality and pleasantness of a few non-conventional sweeteners namely aspartame, acesulfame and sucralose dissolved in water at a concentration between 100 and 1000 ppm. Aspartame at 500 ppm level gave sweet perception but slightly unpleasant flavour. Sucralose gave clean sweetness up to 1000 ppm. Acesulfame gave sweetness without undesirable after taste up to 300 ppm. With

regard to bulking agents, it was found that 70% sorbitol and 60% xylitol solutions gave sweetness level equivalent to 60% sugar syrup, These bulk sweeteners not only provided sweetness to the soaking solution but also imparted viscosity i.e. consistency to the solution. However, their consistency was yet thinner than the sugar syrup. The desired level of consistency could be achieved by using maltodextrin. The effect of heat treatment on the stability of the sweetness was also studied qualitatively. Based on the sweetness perceptions and the viscosity results, a soaking syrup consisting of sorbitol/xylitol along with aspartame/sucralose/acesulfame was formulated which had sweetness perception equivalent to that of 60% sugar solution.

Enhance Functional Attributes of Cheddar Cheese

Cheddar cheese was manufactured using standardized mixed cow milk. Two per cent soluble starch, maltodextrin and resistant starch were incorporated into the each 5 kg of milled curd at the time of salting. Cheese were pressed, surface dried, paraffined and kept in the cold room for ripening. Preliminary observation revealed that the soluble starch did not mix well with the curd which resulted in some white patches on the surface. All the experimental cheeses were harder than control cheese. pH of all the experimental cheeses were more than that of control. 2% and 4% resistant starch and inulin were added to the each 5 kg of milled curd at the time of salting. Cheese were pressed, surface dried, paraffined and kept in the cold room for ripening. Both samples are progressing well and sensory quality is better than the control sample. However, inulin did not mix well and it formed lump.

Effect of Incorporation of Flax Seeds on Quality of Khoa

The study reports the effect of incorporation of flax seeds (best source of the omega-3 fatty acids) on rheological and sensory qualities of khoa, and optimize the addition of flax seeds for khoa based sweets preparation in functional foods. Flax seeds in the form of powder could be incorporated into milk itself before converting the milk into khoa. Khoa prepared this way was found to have good quality comparable to that of control sample. Among the different levels of flax seeds incorporation in milk for khoa production, 2% flax seeds incorporation (on khoa basis) was found to produce khoa having sensory and rheological values similar to control khoa. The values of all the rheological parameters were positively correlated to the amount of flax seeds incorporation. The chemical analysis of experimental sample with 2% flax seeds

resulted in higher fat content. The fat, protein, carbohydrate and ash content of khoa with 2% flax seeds were 23.72, 18.90, 18.59 and 3.29% respectively. The corresponding values for control khoa samples were 22.92, 18.52, 20.63, 3.22%, respectively. The experimental khoa had 0.41% fibre which was absent in control khoa. The water activity of experimental and control khoa were 0.934 and 0.941, respectively. The experimental khoa at 37°C had a shelf life of 3 days when packed in polyethylene pouches and 4 days in parchment paper, which were comparable to control khoa samples. The most acceptable peda and chocolate burfi could be produced from khoa with 3% flax seeds which was statistically similar to control samples.

Incorporation of Whey Proteins in Cheddar Cheese to Enhance the Functionalit

Whey protein was incorporated in the form of whey solids and whey protein concentrate (WPC) each @ 1% and 3% level of fresh milled cheese. Incorporation of 3% whey solids showed maximum yield and minimum moisture loss, whereas control cheese showed maximum moisture loss during ripening. pH of the cheeses decreased throughout the ripening period. All the experimental cheeses showed significantly higher increase in titratable acidity than control during ripening and the increase was maximum in cheese with 3% whey solids. Free fatty acid content in all the cheeses was significantly higher than that of control cheese. Tyrosine content during ripening showed maximum increase in cheese with 3% whey solids followed by cheese with 3% WPC and minimum was in control cheese. Electrophoretic study revealed a considerable breakdown of a-casein in cheeses with incorporated whey protein during ripening and the extent of breakdown was more in 3% level compared to 1%. Texture profile analysis showed a decrease in hardness of all cheese types except in control whose hardness was found to increase towards the end of ripening. Springiness and cohesiveness decreased throughout the ripening time irrespective of cheese types. Sensory evaluation showed that addition of whey solids resulted in deterioration of sensory quality of cheese while addition of WPC improved the sensory attributes during ripening. No coliform was detected in all the cheeses.

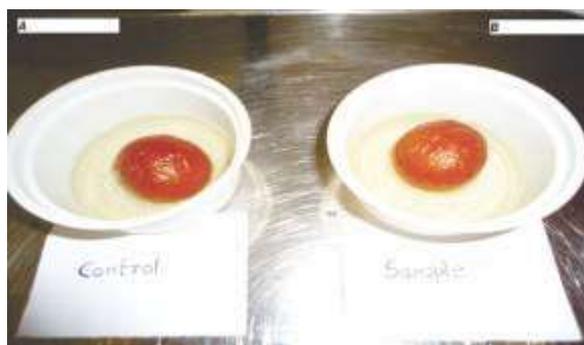
Development of Tea Whitener Using Concentrated Whey and Milk Solids

Suitability of whey as ingredient for dairy whitener was studied. Cheese whey from the experimental dairy plant with pH 6.2 ± 0.1 was concentrated to 12.0% solids in a vacuum evaporator, pasteurized at $72\pm 2^\circ\text{C}/15$ sec and stored for 16-18 hours at $5-7^\circ\text{C}$. Diluted whey was

cold blended with toned milk of 11.5% solids. Decoction was prepared from 2.5 g tea powder per 100 ml water. The whitener with 25% whey and subsequently homogenized was of acceptable quality. The final tea beverage was evaluated for sensory parameters and physico-chemical quality attributes. Tea prepared from blends containing 25% whey and which was homogenized was found to give good mouth feel and flavour. Among the treatments, tea prepared from homogenized 25% blend had the highest reflectance value and lowest browning index. Tea prepared from 50% blends also scored high on sensory aspects but fared poorly with respect to colour. The viscosity results indicated that homogenization had a positive impact on the viscosity. Coffee stability test was done to assess the stability of whitener under acidic conditions and it was observed that blend with 25% whey was comparable to toned milk. Standard plate count, coliform count and presumptive coliform test were done to assess the microbiological quality of the whitener. The whitener was observed to have a shelf life of 2 days at $7\pm 2^\circ\text{C}$. Prominent whey flavour was noticed beyond 2nd day storage which limited its shelf life. It was concluded that a satisfactory tea whitener can be prepared by blending whey with toned milk in 25:75 proportion and homogenization as one of the processing parameters.

Development of Khoa Powder based Gulabjamun Mix

The present investigation was carried out for the development of a gulabjamun mix which has khoa powder as a main ingredient instead of skim milk powder. The other ingredients used were maida and baking powder. The effect of levels these ingredients in khoa powder based gulabjamun mix (KP-GMP) on the sensory and textural characteristics of the gulabjamun was studied. Different ratios of khoa powder and maida were tried: 80:20, 70:30 and 60:40. Out of these, use of 30 parts of maida in the KP-GMP gave best body and texture, flavour and highest overall acceptability of gulabjamun. Incorporation of baking powder at 0.5 parts level gave the best quality of



gulabjamun with soft and uniform granular texture which was preferred among 0, 0.5, 1 parts levels tried. The average composition of KP-GMP was: moisture 9.43 %, fat 18.94 %, protein 14.03 %, ash 3.97 % and total carbohydrates 53.63 %. During storage, the moisture content and reflectance values of KP-GMP decreased whereas FFA and TBA values increased irrespective of packaging material and treatment during storage. The textural characteristics of gulabjamun prepared from the KP-GMP during storage also increased. The shelf-life of the KP-GMP was found to be more than 60 days at 30°C when packed in LDPE or metalized pouch.

Development of Dietetic Rabri

A technology for preparation of rabri from cow milk and replace its sugar with non-conventional sweeteners like aspartame, sucralose and acesulfame-k. Sucralose @ 350 ppm, acesulfame-k @ 1400 ppm and aspartame @ 1600 ppm were found to have equivalent sweetness to sugar in rabri. Conforming to FSSAI (2012), it was possible to replace sugar in rabri by about 12.5, 30 and 100% using aspartame, acesulfame-k and sucralose, respectively. Irrespective of legal implications, it was possible to replace the sugar with sucralose up to 100% without any major drawbacks but only up to 50 % replacement was possible by aspartame and acesulfame-k. There was variation in the gross composition, which ranged as follows: TS 50.00-40.19%, fat 12.82-15.15%, protein 9.91- 11.71%, lactose 10.27-12.14%, sucrose 0 – 15.38% and ash 1.61-1.90%. Rabri behaved as shear thinning fluid i.e. the viscosity decreased as shear rate increased. Casson's equation was best suited model (R^2 value 0.9939) followed by Herschel Bulkley (R^2 value 0.9925). Shelf-life of control sample and 100% sugar replaced rabri sample was about 15 and 10 days at 5°C. Cost of full sugar rabri sample (control) and dietetic rabri prepared by using sucralose as sweetener (100% replacement) was estimated to be ₹ 106.92 per kg and ₹ 133.93 per kg. These figures show that the cost of production of dietetic rabri was about 25% higher than the cost of control rabri sample. Studies revealed that sucralose is the best non-conventional sweetener compared to aspartame and acesulfame-k for the production of dietetic rabri. It can be used to completely replace sugar in rabri well within the FSSAI limits.

Studies on the Rheological Properties of Batter in Relation with Characteristics of Khoa Jalebi

The effect of moisture level in batter on its rheological quality as well as quality of khoa jalebi was investigated. Moisture was found to have the

significant influence on the rheological behaviour of jalebi batter. The viscosity was found to decrease with increasing shear rate, indicating pseudoplastic behaviour with yield stress. The yield stress of jalebi batter was found to lie between 83.96 to 654.34 Pa. The optimum level of moisture in jalebi batter, in terms of rheological characteristics, was found as 45%. There was gradual decrease in flow behaviour index with increase in moisture content from 40 to 50% in jalebi batter. The rheological properties of jalebi batters were also measured by Textural Analyzer (TA-XT). The firmness of jalebi batter was 32.24, 19.01 and 6.5 N for 40, 45 and 50% moisture, respectively. There was a wide variation in consistency of batter from 62 to 316.34 N.s for variation in moisture from 50 to 40%. Also, the stickiness was observed to decrease with increase in moisture in batter. Further, there was gradual decrease in all rheological properties viz. hardness and consistency of jalebi with increase in moisture of batter. It indicates the significant effect of moisture in batter on the rheological properties of khoa jalebi. There was 7-8% and 9-10% increase in coil-rod thickness of jalebi after frying 40% as well as 45 and 50% moisture batters, respectively. Further, there was 1.5 and 2.0 times increase in weight of jalebi coil after soaking for 40% and 45 and 50% moisture batters, respectively. There was gradual increase in moisture and sucrose content of jalebi with increase in moisture of batter. Sensory analysis of khoa jalebi showed that moisture in batter had a marked effect on the overall acceptability, with khoa jalebi made from 45% moisture batter securing highest sensory score.

Process Upgradation of Indigenous Milk Products for Industrial Application (Network)

Shelf life studies of foxtail millet-milk solids products: Procedure for the preparation of dry mix incorporating foxtail millet powder, skim milk powder and sugar was standardized. The dry mix on reconstitution produced a beverage of acceptable quality. The dry mix packed in LDPE pouches and stored at 37°C was observed to keep well for 4 months based on sensory and physico-chemical analysis. The total bacterial, coliform and yeast and mould of dry product observed to decrease from 37300 to 26100, 27 to 0 and 10 to 0 cfu/g, respectively after 4 months of storage. The reconstituted beverage was free from coliform and yeast and moulds.

Preparation of foxtail millet halwa: The fox tail millet halwa was prepared. Fox tail millet (100 g) soaked overnight was ground to a fine suspension. The suspension was filtered using muslin cloth. The filtrate was kept for settling for 24 h. The watery supernatant

was discarded. The thick suspension settled in the bottom was mixed again with fresh water was kept overnight. The process was repeated for three days. The thick suspension was cooked along with toned milk (250 ml), ghee (100 g) and sugar (150 g) till a halwa like consistency was obtained. The product was spread on a greased plate and cut into pieces. Upon sensory evaluation, it was observed that the product had good taste and desired body but had a greasy texture. Trials were conducted to prepare foxtail millet halwa with desired texture. The proportion of the ingredients was changed to foxtail millet (200 g), sugar (300 g), milk (500 ml) and ghee (100 g) and the product was prepared by the above described method. The product was spread on greased plate and cut into pieces. It was observed that the texture improved considerably by the change in the proportion of the ingredients. The product packed in LDPE pouches kept well for a week at room temperature and about one month in refrigerator. The product had 67.0% total solids and 11.2% fat.

Preparation of ragi-milk beverage: In continuation to the work previously reported on ragi milk beverage, 4 batches of product were prepared. Ragi grains were soaked in water for overnight. The water was removed and the soaked grains were ground to extract ragi-milk. The suspended solids of the extract were removed to get a clear ragi-milk. This extract (600 ml) was diluted with water and was brought to boil (1:1). To this extract, 600 ml boiled toned milk (fat: 3%, SNF: 8.5%) and sugar (8%) were added. The contents were brought to boiling with constant stirring. The ragi-milk beverage thus obtained was evaluated for sensory evaluation by a panel of judges. The product was observed to have good sensory properties. The product had 85.4% moisture, 1.1% fat, 0.3% ash, 1.4% protein and 11.8% total carbohydrate (By difference). The product was packed in glass bottles, crown capped and heat sterilized. On autoclaving at 15 lbs pressure for 15 min, the product attained a slight brown colour due to Maillard browning and a higher viscosity due to concentration of the product. The autoclaved beverage was observed to be acceptable on sensory evaluation. The product kept well at 38°C for 2 months.

Isolation of Antagonistic Lactic Acid Bacteria and their Use in Extending the Shelf Life of Fermented Dairy Foods

The lactic isolates which have exhibited antagonistic activity were tested for their ability to control the test organisms in milk medium and a *dahi* based food product. 70 lactic acid bacterial isolates were isolated from *dahi* obtained from different sources. 9 isolates

exhibited medium to strong inhibitory activity against *I. aureus* subsp *aureus* and *Escherichia coli* AB 1157 organisms. Attempts were also made to isolate lactic acid bacteria from vegetable sources. The isolates obtained from vegetable sources were heterofermentative in nature and not coagulate milk hence these isolates were not maintained. Attempts were made to prepare *raitha*, a *dahi* based product prepared by mixing *dahi* and cut vegetables such as carrot, cucumber and onion. *dahi* prepared by using selected antagonistic cultures was mixed with the cut vegetables and inoculated with the test organisms. The result showed 3 isolates could able to control the growth of *E. coli*, while other isolates exhibited weak inhibitory effect. Similarly, 3 isolates could completely inhibit the growth of *S. aureus* while other isolates exhibited poor inhibitory effect against the test organisms. The *dahi* prepared by using the antagonistic lactic isolates were subjected to sensory evaluation. The studies indicate no significant difference in the sensory parameters among the *dahi* samples. The 9 lactic isolates were tested for their antagonistic activity against isolated yeasts and molds and observed that none of 9 isolates were able to inhibit the yeasts and molds.

Heat and Mass Transfer Phenomena during Manufacture of Gulabjamun and Pantoa

Optimization of frying conditions was carried out using face-centered central composite response surface design. Three temperatures namely 125, 135 and 145°C were tested. Frying temperature and time were optimized based on the four responses *viz.*, yellowness index, core temperature, fat content and chewiness. The quality attributes of fried *pantoa* such as moisture content, fat content, crust colour, dimensional changes, textural and thermal properties were measured periodically as frying progressed. The crust colour in terms of lightness, yellowness index and total colour difference and texture in terms of hardness and chewiness were modeled using zero-, first- and fractional conversion first-order reaction kinetics. After an initial lag, the core temperature increased linearly till it attained 102±0.5°C, and stabilized thereafter. A negative correlation was observed between moisture and fat contents of the product. The dimensional and thermal properties of *pantoa* varied during frying. The changes in lightness followed first order reaction kinetics ($R^2 > 0.95$) whereas yellowness index ($R^2 > 0.96$) and total colour difference ($R^2 > 0.97$) followed fractional conversion first order reaction kinetics. Similarly, the changes in hardness ($R^2 > 0.98$) and chewiness ($R^2 > 0.99$) of *pantoa* at different stages

of frying were best explained by fractional conversion first order reaction kinetics. The time-temperature combination for frying of *pantao* was optimized as 142°C for 330 s. The experimental values of the responses at the optimum frying conditions were 142.9±2.27, 100.74±0.67°C, 29.66±0.97% (w.b.) and 2.97±0.24 N for yellowness index, core temperature, fat content and chewiness, respectively. The second order polynomial regression models predicted the responses and were close to the experimental data.

Development, Characterization and Evaluation of Edible Films and Coatings for Selected Dairy Products

Casein and whey protein concentrate (WPC) films, plasticized with glycerol and sorbitol independently at different concentrations, were prepared by casting. The film thickness, tensile, water vapour, oxygen permeation and moisture sorption properties of the casein and WPC films were studied. The biopolymer to plasticizer (w/w) ratios evaluated were 1:0.25, 1:0.5, 1:0.75 for glycerol and 1:1, 1:1.25, 1:1.5 for sorbitol. Higher quantities of sorbitol (1:0.75 or more) were required for the formation of brittle-free casein and WPC films. The film properties were influenced by biopolymer and plasticizer types and the amount of plasticizer used in film formation. The three-way interaction effects of biopolymer, plasticizer type and concentration on film thickness, tensile and water vapour permeability (WVP) properties were significant, indicating that the effect of one factor on film properties was dependent on the levels of the remaining two factors. With increasing level of plasticizer, the film thickness increased significantly ($p < 0.05$) from 0.168 to 0.328 mm. Sorbitol-plasticized films had relatively higher thickness and WVP than glycerol-plasticized films. The tensile strength of the films ranged from 0.734 to 4.585 MPa, percent tensile strain from 19.22 to 66.63 % and elastic modulus from 2.051 to 6.930 MPa. Increasing the plasticizer concentration, increased the film thickness, % elongation (% E) and WVP, but decreased the tensile strength (TS) and elastic modulus. Casein films showed superior tensile properties as compared to WPC films. The WVP ranged from 3.874 to 13.968 g mm/(m² h kPa). WPC films and sorbitol-plasticized films were found to have higher WVP than casein films and glycerol-plasticized films, respectively. The experimental moisture sorption behaviour of the films was fitted adequately by the GAB model. The equilibrium moisture content of the films was influenced by biopolymer, plasticizer type and its concentration. WPC films adsorbed more moisture than casein films during equilibration. The oxygen

permeability of casein films was relatively lower than that of WPC films, regardless of the plasticizer used.

Modeling the Heat and Mass Transfer Phenomena during Deep-Fat Frying of Pantao

Heat and mass transfer studies on *pantao* during deep-fat frying was carried out with the objectives that include determination of quality attributes, evaluation of the kinetics of quality changes, optimization of frying conditions and modeling of heat and mass transfer. *Pantao* was prepared by blending *khoa* (40% w.b.) and *chhana* (58% w.b.) in the ratio of 4:5 along with other ingredients such as refined wheat flour (3%), semolina (3%), arrowroot powder (3%), ground sugar (0.7%) and baking powder (0.3%) to a homogeneous and smooth dough. The dough was rolled into balls weighing 15 g each, and fried in sunflower oil at temperatures of 125, 135 and 145°C for 8 min. The heat transfer coefficient increased from 100.57 to 211.46 W/m²K while, the moisture transfer coefficient increased from 7.80×10⁻⁶ to 9.05×10⁻⁶ ms⁻¹ with increase in frying temperature from 125 to 145°C. The moisture diffusivity increased from 5.55×10⁻⁸ to 38.8×10⁻⁸ m²s⁻¹ when the frying temperature increased from 125 to 145°C. From the Lewis number obtained at three temperatures, the thermal diffusion was found prominent at lower temperature of frying, which was superseded by the effect of moisture diffusion at higher frying temperatures.

Characterization and Application of Milk Protein Films for Packaging of Selected Dairy Products

The casein and whey protein concentrate films prepared with 1:0.5 and 1:1 glycerol and sorbitol plasticizers respectively were evaluated for packaging of dairy products such as Cheddar cheese and milk sweet. While determining moisture sorption behavior the glycerol-plasticized films were found to adsorb more moisture and had higher equilibrium moisture content (EMC) than sorbitol-plasticized films, similarly the WPC films found to adsorb more moisture than casein films at all a_w investigated. A good agreement between experimental and predicted data was found with the GAB models by the coefficient of determination (R^2) of 0.97 to 0.98 and the P% value below 10 % ($P% < 10%$), regardless of the type of plasticizer used. The initial SN content (125.72 mg N₂/100gm) increased in control and sample wrapped in films was 151.2 mg N₂/100gm and 151.1 mg N₂/100gm respectively after 30 days storage. Initial TBA value of cheddar cheese sample was 0.01 (OD at 532 nm) which increased to 0.051 for control and 0.031 to 0.04 for samples wrapped in edible films after 30 days storage. The soluble nitrogen content, thiobarbituric acid

(TBA) value and titratable acidity increased in all cheese samples during storage. Total bacterial count and yeast and mould counts of both control and experimental samples of the products increased during storage at stipulated temperatures. However, the microbial quality of samples wrapped in edible films was found to be superior to control samples packed in LDPE pouches. The sensory data revealed that the organoleptic quality of both products was not significantly affected by edible film packaging.

Prediction of Shelf-Life of Gulabjamun Mix Using Simulation and Mathematical Modeling –Based on Moisture Gain

A mathematical model to predict the shelf-life of *gulabjamun* mix based on moisture-induced spoilage by stickiness (caking) and non-enzymatic browning (NEB) was developed. The moisture adsorption isotherms of *gulabjamun* were determined at 10, 25 and 40°C. The water vapour permeabilities of the packaging materials also were calculated. The critical moisture contents for stickiness and NEB to occur were determined and the moisture-limiting shelf-life was predicted. Validation of the prediction model was done by accelerated shelf-life testing at 38°C and 90% RH. At 4.8% moisture content, the experimental shelf-life of *gulabjamun* mix based on stickiness and NEB was observed respectively as 41 and 54 days in LDPE and 280 and >360 days in PET/Al foil/PET/LDPE pouches. The corresponding predicted values were 34 and 46 days in LDPE and 247 and 342 days in PET/Al foil/PET/LDPE, respectively. The simulation model was fairly accurate and reliable in predicting the shelf-life of this product.

Smallholder Dairy Production Systems in Southern Region

During the period under report data collection was carried out in the selected villages viz, Mallur and Abbani of Chikkaballapur, Kolar district of Karnataka, the study area selected under progressive dairy farming are in the state. In Mallur, fifty small farm households were selected as respondents by random sampling method and data collection was done by personal interview technique with the standardised interview schedule developed for the study. The profile of the study area revealed that Mallur had 800 household with 250 households practicing dairy farming, with 900 share members in the Dairy Cooperative Society with milk procurement of 1500 litres/day from 150 members with 3-4 cows as average number of dairy cows per household. The socio-personal profile of small dairy farmers revealed that, majority of the respondents (66.00%) were under middle age category,

more than half (56.00%) with secondary level of education, majority with farming and dairying as their occupation (76.00%), with small family, upto 5 members (62.00%), with socio-economic profile of the selected respondents under study included more than half of the respondents/with a small farm holding of 1-2 hectares, (56.00%) a herd size of 3-5 animals (62.00%), with a milk production of upto 15 litres per day in most of the households (60.00%) with an annual income from dairying in the range of Rs.51,00 to 1,00,000 in case of majority (72.00%) of the respondents. Case study analysis of selected successful dairy farmers was conducted in the study area. Two successful dairy farmers were studied following case study approach, in Mallur village under Kolar Milk Union.

Dairy Entrepreneurship Development of Rural Women: An Action Research

An “Action Research” is primarily focused on developing two successful dairy based women self help groups in scientific dairy farming practices and also dairy processing activities through institute interventions. The SHG members were motivated to start small dairy enterprises through processing dairy products and market it their own marketing channel, thus securing higher profit. In order to establish the dairy based women SHG, the project team has identified the two SHG groups in association with local NGOs. The preliminary survey about their activities and their expectations and constraints in doing dairy based activities were discussed at village level meetings and motivated group members to start dairy based activities and two SHGs expressed their willingness to take up the dairy based activity. After mobilizing the SHG members, the preparations for the entrepreneurship training packages are being taken at present. The Motivational training programme for the members was conducted in association with the local NGOs viz., AIRD and Peoples Trust.

Dairy Service Delivery Systems in Namakkal District of Tamil Nadu – An Exploratory Study

The study was carried out in Tamil Nadu. Most of the respondents were in middle age group and possessed a medium herd size with an average of five animals per household. The important dairy service providers identified in the area were dairy cooperatives, private integrators, public departments, private vets paravets, educational institutes, pharmacies and commercial agencies. The respondents predominantly availed health services and AI services from different service providers in the study area, whereas the supply of fodder seeds and slips, concentrate feed and mineral mixture were moderately availed by the respondents.

The training and extension services, credit and insurance facilities of different service delivery systems were least used by the respondents except the members of dairy cooperatives. Overall, it was perceived that the public departments were effective in delivering health and AI services, insurance and mineral mixture and other supplements to the dairy farmers while the dairy cooperatives were perceived to be

effective in supplying fodder seeds and slips, credit facilities and extension and training activities. Commercial cattle feed agencies were perceived to be effective in supplying concentrate feed to the dairy farmers than dairy cooperatives and private integrators. Non-remunerative milk price was the predominant constraint faced by the farmers followed by poor supply and non availability of inputs for dairying.

EASTERN REGIONAL STATION, KALYANI

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

The overall means for 305 days milk yield, total milk yield, lactation length, milk yield per day of lactation length, calving interval and milk yield per day of calving interval under organic management system were 2386 kg, 2668 kg, 359 days, 7.46 kg, 425 days and 6.26 kg, respectively. The 305 d milk yield in the 1st, 2nd, 3rd and 4th year under organic production management system (OPMS) were 2569 kg, 2317 kg, 2288 kg and 2365 kg, respectively. The performance of cows under organic management system has been reduced considerably in the second year as compared to the first year, and thereafter, reduction rate was very low in the third year. In the 4th year, the decreasing milk production trend has been partially recovered and showed increasing trend. The milk yield per day of lactation length in the fourth year showed an increasing trend than second and third year performance (7.55 kg, 7.28 kg and 7.37 kg, respectively). Similar trend was observed in case of milk yield per day of calving interval (6.23 kg, 6.12 kg and 6.10 kg, respectively). Based on four years performance data, the average 305 days milk yield per cow under organic management system was 2386 kg which was about 4% less than the average conventional production of 2488 kg per cow. Organic roughage is produced without chemical fertilizer and consequently has lower energy and protein content. Interval from calving to 1st AI, Service period, No. of AI per conception and Calving Interval were found less for organic cows than conventional cows (104 days, 142 days, 1.4 and 425 days vs. 115 days, 171 days, 1.8 and 458 days, respectively). This showed comparatively better reproductive performance of cows maintained under organic management system than cows maintained under conventional management system.

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

Feeds, fodder, blood and soil samples were collected from different AERs of West Bengal. Feeds, fodder and soil samples collected from Arunachal Pradesh,

Nagaland, Sikkim and Meghalaya through ICAR centers of those states. The major feed resources 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 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. The mineral composition of feeds and fodder are being analyzed. It was found that mainly Ca, P, Zn, Cu, Co and Mn were limiting in this areas. To ameliorate this mineral deficiency, an area-specific mineral mixture (KALMIN-ERS) for livestock was prepared at ERS-NDRI, Kalyani with di-calcium phosphate (DCP), zinc sulphate (ZnSO₄), copper sulphate (CuSO₄), cobalt sulphate (CoSO₄) and manganese sulphate (MnSO₄) in the ratio of 3000:40:20:2:1 and the formulation was tested and validated both at the Institute and village level. The requirement of KALMIN-ERS is 20-30g/day for an adult cow and buffalo having body weight of 350-400 kg and 2-3 g/day for adult goats and sheep. The expenditure incurred for the same is Rs. 1.0-1.25/animal/day for large animals and Rs. 0.20-0.25/animal/day for small animals. This mineral mixture was very effective to correct the reproductive problems of cattle/buffalo and goats and to maintain the sustainable production of animal.

Establishment and Characterization of Cattle Embryonic Stem Cells (cESC)

Cattle ovaries collected in normal saline supplemented with strepto-penicilline at 30-35C from Kolkata slaughterhouse. Immature oocytes were collected from ovaries by aspiration method using 19 gauge needle, washed thoroughly in washing media and kept in the CO₂ incubator with maximum humidity for *in vitro* maturation in the maturation media for 24 h. After maturation oocytes were fertilized with capacitated sperms and allowed for fertilization in Fert-BO media for 14-18 h. After 24 h of incubation, COCs were co-incubated with *in vitro* capacitated sperms for

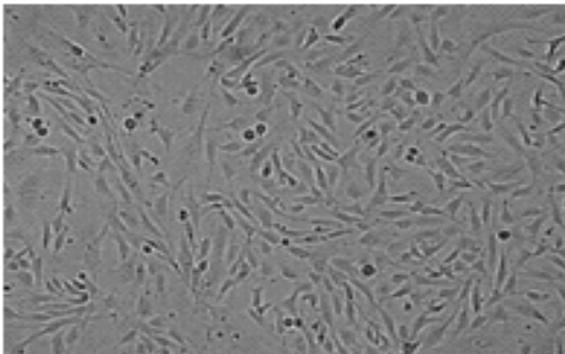
fertilization in Fert-BO media at 38.5 °C in 5% CO₂ in air with maximum humidity. At the end of 18 h presumptive zygotes were washed and transferred in embryo development medium and incubated in the 5% CO₂ incubator at 38.5 °C for 48 h with maximum humidity. The medium were replaced every 24 h with replacement media.

Fetal Skin Fibroblast Cells Monolayer for Feeder Layer

Fetal skin samples were collected from fetus (15 cm). Samples were cut into small pieces and washed 6-7 times in PBS. After washing put into the digestion



Different stages of cattle embryos



Fetal fibroblast cell monolayer after 48 h of culture

solution containing 0.5% trypsin and 0.05% collagenase in PBS. Cells were isolated by stirring on a magnetic stirrer for 30 min. After settling down the cell suspension, supernatant was collected and centrifuged at 600 rpm/5 min. The pellet was washed 3-4 times in PBS. The isolated cells were inoculated in T-25 flask containing DMEM +10% FBS and incubated at 38.5°C in CO₂ incubator.

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

Lactation performance of Jersey crossbred animals, maintained at the ERS Kalyani, were evaluated. This farm was located at an average altitude of 9.75 meters above the mean sea level on 22.59' N latitude and 88.29'

E longitude. The climatic condition of this location was hot humid having the average highest temperature of 31C during summer and the lowest of about 20C in winter. The annual rainfall was around 1250 mm, with maximum precipitation was between July to October (83%). The cows were managed in a loose housing system and fed *ad lib.* green fodder (berseem, maize, oats etc.) and paddy straw. Data on 731 lactation records which comprises of first to thirteen lactations of 274 Jersey crossbred animals extended over 39 years (1974-2012) were used. Data on the entire duration was divided into 8 periods comprising 5 years each where differences would be sizeable enough to be detected. The year was delineated into 3 seasons based on prevalent climatic conditions viz. winter (Nov. to Feb.), summer (March to June) and rainy (July-Oct.) seasons. The data was distributed in nine genetic groups, having different levels of Jersey inheritance in animals. The lactation traits analyzed for this study were 305-days milk yield (MY305D), total milk yield (TMY) and lactation length (LL) of animals. The days of lactation (milking) were considered in the model as linear covariate for total milk yield (TMY) of animals. Data were analyzed using the mixed model least-squares analysis of variance for fitting constants (Harvey 1990) including all main effects. The genetic composition of animals revealed that majority of animals fell in 3-breed cross (41%) followed by 2-breed (33%) cross. The overall least-squares means for MY305D and TMY of crossbred animals were 2727.70±52.74 and 3306.36±68.57 kg, respectively with average lactation length of 403.02±9.24 days. Different environmental factors like period and season of calving, lactation number and genetic group of animals significantly affected the most of the lactation traits. The genetic group of animal had significant (P<0.01) influence on all the lactation traits under study except lactation length of animals. Among the different crosses, the halfbreds of Jersey and Tharparkar crosses produced higher 305-days milk (2981.65±51.14kg) and total milk yield (3636.09±66.86 kg) as compared to animals of other genetic groups. The animals having less than 50% Jersey inheritance produced lowest 305DMY (2495.35±92.44 kg) and TMY (2948.68±121.01 kg) among all crosses. The lactation number of animals had significant (P<0.01) effect on 305DMY and TMY of animals but the effect was found non-significant (P>0.05) for LL. The period of calving had highly significant (P<0.01) effect on MY305D, TMY and LL of animals. The significant differences in milk yields among crossbred cattle calved in different periods/years may be attributed to differences in management, selection of sires, and environmental conditions such as ambient temperature, humidity, rainfall etc. Significant (P<0.01) differences in 305 days milk yield and TMY existed among cows calved

in different seasons but the season of calving had non-significant ($P>0.05$) effect on lactation length of animals. Cows calved in winter season produced significantly higher milk than the cows calved in rainy and summer season. Days of lactation (milking) were found statistically significant ($P<0.01$) as linear covariate for TMY in this study.

Nutritional Evaluation of Sun Dried Brewer's Spent Grain Meal and its Utilization in Ruminant Ration

The chemical composition and *in vitro* evaluation of sun dried *Brewer's Spent Grain* meal (BSG meal) and its effect on growth performance of cross bred cattle was studied. The wet brewer's spent grain was procured from local breweries in Kalyani. Wet BSG was dried under sun to remove the moisture for 3-4 days and frequently turned thrice a day for complete removal of moisture. A representative sample of wet BSG was dried in hot air oven to determine the dry matter. Proximate analysis indicated that it was a fair source of crude protein (213.2 to 278.1 gk g⁻¹ DM). The mean concentration (% of DM) of organic matter, crude protein, crude fibre, ether extract, total ash, NFE, NDF, ADF and ADL in BSG meal were 96.87±0.04, 24.13±0.26, 17.35±0.21, 7.08±0.07, 3.18±0.05, 48.26±0.40, 58.18 ±0.41, 24.91 ±0.29 and 1.84 ±0.04, respectively. *In vitro* rumen fermentation pattern and nutritive value of BSG meal was evaluated using *in vitro* gas production technique (IVGPT). Paddy straw: BSG ratios comprised of 100:0, 75:25, 50:50, 25:75 and 0:100 on DM basis were subjected to incubation and cumulative gas production was recorded at 2, 4, 6, 8,12, 18, 24, 48, 72 and 96 hour. Evaluation parameters included total gas production (GP), Digestible organic matter (DOM), Metabolizable energy (ME), IVDMD and IVTDMD. The effect of incorporation of sundried BSG Meal in the ration of cross bred calves was studied in a growth trial of 105 days. The animals in control group (T₀) were fed with paddy straw (around 45 %) green fodder (around 15 %) and concentrate mixture (around 40 %). In the treatment group (T₁) dried *Brewer's Spent Grain* was 20 % of concentrate mixture fed to the calves. There was no significant difference in total dry matter intake, CP intake and TDN intake between the two groups. There was no significant difference in digestibility of nutrients between two groups. The average daily live-weight gain (ADLG) was higher in T₁ (452.2 ± 14.9/d) than in T₀ (389.9 ± 17.1g/d), the difference was statistically significant. The Feed conversion efficiency (kg live weight gain/100 kg DMI) was significantly ($P<0.05$) higher in T₁ (15.54 ± 0.88) than in T₀ (13.84 ± 0.99). It can be concluded from the growth and digestibility study of dried Brewer's Spent Grain meal that replacing 20 per cent of concentrate mixture has no adverse effect on intake and



digestibility of nutrients. Rather the growth rate significantly improved by around 16 % and feed conversion efficiency also improved significantly indicating its potential use as an alternative feed for cattle.

Nutritional Evaluation of Azolla Meal and its Effect of Supplementation in the Ration of Growing Crossbred Cattle

The different methods of Azolla cultivation have been explored and an Azolla production cum demonstration unit was established at ERS-NDRI, Kalyani and the package of practices for Azolla cultivation has been standardized. The harvested azolla was dried under shade for two days, and thereafter, in oven at 40-50°C for 24 h and then ground to pass 1 mm sieve to form Azolla meal.

Proximate analysis of *Azolla* indicated that it was a fair source of plant protein (210.7-296.7 g kg⁻¹ DM). The mean concentration (% of DM) of organic matter, crude protein, crude fibre, ether extract, total ash, NFE, NDF, ADF and ADL in *Azolla microphylla* meal were 80.53±0.59, 24.06±0.35, 13.44 ± 1.20, 3.27 ± 0.18, 19.47±0.59, 37.71 ± 1.83, 45.52 ± 1.93, 30.16 ± 1.12 and 8.96±0.56, respectively. *In vitro* rumen fermentation pattern and nutritive value of *Azolla microphylla* was evaluated using *in vitro* gas production technique (IVGPT). Paddy straw: *Azolla* ratios comprised of 100:0, 75:25, 50:50, 25:75 and 0:100 on DM basis were subjected to incubation and cumulative gas production was recorded at 2, 4, 6, 8,12, 18, 24, 48, 72 and 96 hour. Evaluation of parameters included total gas production (GP), Digestible organic matter (DOM), Metabolizable energy (ME), IVDMD and IVTDMD. Some common feeds and fodder namely maize grain, mustard cake and oat fodder were also evaluated for the above *in vitro* parameters for comparison. The effect of *A. microphylla* meal supplementation in cross bred calves was studied in a growth trial of 105 days. This experiment was conducted in 10 cross bred male calves distributed into two groups (T₀ and T₁). The animals in control group (T₀) were fed with paddy straw (around 45%), green fodder (around 15%) and concentrate mixture (around 40%). In the treatment group (T₁)



dried *Azolla microphylla* meal was supplemented @ 60 g/animal (equivalent to 1 kg fresh *Azolla*) replacing 10% of concentrate mixture fed to the calves. There was no significant difference in total dry matter intake, CP intake and TDN intake between the two groups. There was no significant difference in digestibility of nutrients between two groups. The average daily live-weight gain (ADLG) was higher in T_1 (423.6 ± 14.0 g/d) than in T_0 (389.9 ± 14.9 g/d). The difference was statistically significant ($P < 0.05$). The feed conversion efficiency (kg live weight gain/ 100 kg DMI) was also significantly ($P < 0.05$) higher in T_1 (15.06 ± 1.01) than in T_0 (13.84 ± 0.99). It can be concluded that supplementation of *Azolla* meal @ 60 g/ animal/d replacing 10% of concentrate mixture could significantly enhance the growth performance and the feed conversion efficiency of male cross-bred calves.

Role of Women Dairy Cooperatives in Nagaland

The 25 member households and 10 non member households were interviewed in Nagaland. It was seen from the data that majority of the households belonged to tribal community in both types of households (members and non members) and keeping Jersey and local Tho Tho cattle at the farm. The ratio of earners and non earner was estimated 50% in the both situation. The average land size of the member households was estimated 1.648 hectares which is less than the state average land holding i.e. 1.789 hectares. Cropping intensity has been estimated higher in the sample households which are higher than the state cropping intensity. Overall average number of milch animal is estimated 3.83 cattle which indicated interest of member households in dairy farming. Over all animal milk productivity on member household was estimated 4.72 litres per day. While, it was higher in case of small farmers (5.79 litters). Jersey cross-bred cattle produced more milk than local Tho-Tho cattle.

The 75-95% milk is marketed by member household to the society. They are feeding concentrate mixture to their dairy animals, which is prepared with wheat bran (30%), rice polish (25%), wheat crush (30%), pulse (5%) and maize (10%). The Dimapur Feed Plant preparing concentrate feed and supplying to the society at the rate of 12.65/kg per kg which is cheaper than the home made concentrate at farmer's level. Dairy farmers



supplying their milk to the Dimapur milk union and getting Rs.28/- per litres. Farmers' facing the problem of fodder seed. It is the opinion of the majority of the farmers that concentrate feeding is not economic while some of them are in favour of it. This may be due to quality of the concentrate feed fed to the animals from particular lot of the feed. It is further analysed that among available technologies, majority of the farmers are having knowledge of the quality fodder seeds followed by artificial insemination and type of quality cattle breeds. It is seen from the estimates that the fodder seed and artificial insemination and exotic breeds of cattle were adopted by the majority of the member households. The overall cost benefit ratio of the crossbred cattle rearing was estimated 1:1.24. During the survey it has been seen that livestock in Nagaland is considered a major sector which contributes significantly towards the rapid economic growth of this state. Animal husbandry is a prime occupation of the local people of Nagaland. Poultry, fishery, piggery, dairy and cattle farming are the areas considered as major economic household activities in the state.

The livestock in Nagaland has huge possibilities of further growth. In fact the livestock of the state plays an important role in enhancing the economy of the state. Also, there is a ready market for dairy, poultry and fish products.

Upliftment of Socio-economic Condition of Tribal People through Integrated Livestock Farming in North Eastern Hill Region/Eastern Part of India

The project was initiated at this station in 2012 under Tribal Sub Plan funded by ICAR, New Delhi. Initially, the survey of different tribal villages in eastern part of India was carried out for selection of villages to implement this project. One health and farmers' awareness camp was organized in one tribal village of Birbhum district. Different dairy production technologies were demonstrated to the tribal farmers. Some fodder seeds (maize and cowpea) and rooted slips of some fodder grass were also distributed to tribal farmers who rear livestock. The survey of different blocks/villages will be done for appropriate selection of tribal villages in northern-eastern region of India as per the recent guidelines for TSP projects.

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 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 and improved management practices.

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

Activities Conducted in Adopted Villages from April, 2012 – March, 2013

| Sr. No | Activities Conducted | Nos. of Cases |
|--------|-------------------------------|---------------|
| 1 | A.I. in Cows | 1830 |
| 2 | Conception Rate | 43.50 |
| 3 | A.I. in Buffaloes | 1325 |
| 4 | Conception Rate | 30.00 |
| 5 | No. of Cross-bred calves born | 390 |
| 6 | No. of buffalo calves born | 246 |
| 7 | General Treatment | 2904 |

Infertility and Veterinary Aid Campaigns

A total of 57 Veterinary Camps were organized. In all, 2901 cases were treated for reproductive disorders and various veterinary ailments. Ecto- and Endo-parasite control programmes were conducted.

Fodder Demonstration

To maintain the year round supply of green fodder at farmers' fields, demonstrations of high yielding

varieties of berseem (BL-42) oats, (JHo-822), maize (Vijay Composite) fodder crops were organized.

Kissan Sanghosthis

Forty eight Kisan Sangosthis were organized at the village level. In all, 190 farmers and 130 farmwomen attended and were educated on dairy farming innovations. Question/answer sessions were also arranged in these sessions, which provided excellent opportunities to the farmers. The solutions were offered to their day-to-day problems and the feedback was collected on the extension programmes.

Dairy Education at Farmers' Door

A team of NDRI scientists including subject matter specialists from production, processing and management group organized Dairy Education at Farmers' Door in various villages on 2nd Saturday of every Month.

Scientist and Resource Poor Farmer' Interaction

An Institute level programme entitled an interaction between scientists and resource poor dairy farmers was organized. Forty one resource poor dairy farmers from four villages (Vazidpur, Kharajpur Kulwahri, and Mehmadpur) actively participated in this interaction. The interaction was focused on dairy animal breeding, feeding, animal health care practices and animal management & marketing practices.

Farmer Awareness Programme on Climate Change

A Farmer Awareness Programme on Climate Change was organized (under NICRA Project) at village Manglora, district Karnal, on 15th September, 2012. Protection of the animals from effects of heat stress, possible impact of extreme weather conditions and climate variability, importance of nutritional supplementation during challenging climatic conditions and controlling environmental pollution were some of the aspects covered during the programme. Importance of maintaining the health of the animals for sustainable milk production during adverse weather conditions was specially emphasized. An exhibition for enhancing the level of awareness of the farmers towards climate change and variability, was also arranged at the venue, Middle School, Gram Panchayat, Manglora.

KRISHI VIGYAN KENDRA (KVK)

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

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

Training Programmes Organized by KVK (April, 2012 to March, 2013)

| Title of the course | Duration (days) | No. of courses | No. of beneficiaries | Mandays Trained |
|--------------------------------------|-----------------|----------------|----------------------|-----------------|
| On Campus | | | | |
| Dairy Production (KVK) | 5 | 5 | 359 | 1795 |
| Sponsored | 3-5 | 65 | 1869 | 9129 |
| Dairy Processing | 5 | 7 | 113 | 565 |
| Sponsored | 5 | 4 | 39 | 195 |
| Crop Production | 3 | 2 | 39 | 117 |
| Crop Diversification | 5 | 1 | 20 | 100 |
| Vermiculture | 3 | 3 | 48 | 144 |
| Bee-keeping | 4 | 3 | 81 | 324 |
| Fish Farming | 4 | 2 | 37 | 148 |
| Home Science | 1-5 | 12 | 241 | 760 |
| Horticulture (Sponsored) | 5 | 1 | 20 | 100 |
| Short Integrated Training Programmes | 1-2 | 112 | 4194 | 4496 |
| Total (A) | | 217 | 7060 | 17873 |
| Off Campus | | | | |
| Dairy Production | 1-4 | 8 | 460 | 1120 |
| Dairy Processing | 1 | 5 | 97 | 97 |
| Crop Production | 1 | 9 | 160 | 160 |
| Vermiculture | 1 | 2 | 47 | 47 |
| Bee-keeping | 1 | 4 | 55 | 55 |
| Fish Farming | 1 | 4 | 55 | 55 |
| Home Science | 1-32 | 23 | 1035 | 2295 |
| Total (B) | | 55 | 1909 | 3829 |
| Grand Total (A) + (B) | | 272 | 8969 | 21702 |

Sponsored Courses Conducted (April, 2012 to March, 2013)

| 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 Pradesh | 5 | 1 | 30 | 150 |
| Scientific Dairy Farming for farmers sponsored by Agricultural Technology Management Agency (ATMA) and AH & Vety. department Rajasthan | 5-7 | 10 | 301 | 1573 |
| Scientific Dairy Farming and Horticulture crops for farmers sponsored by different agencies and deptt. of Himachal Pradesh | 3-5 | 10 | 279 | 1171 |
| Scientific Dairy Farming, Clean Milk Production and Scientific cultivation sponsored by ATMA from Bihar | 5 | 28 | 786 | 3930 |
| Scientific Dairy Farming sponsored by IFFCO for rural youth of Haryana State | 5 | 1 | 19 | 95 |
| Scientific Dairy Farming for dairy farmers sponsored by various departments of Jharkhand | 5 | 7 | 241 | 1205 |
| Scientific Dairy Farming & Refresher course in dairying for Extension functionaries and sponsored by various departments of Assam | 5 | 11 | 202 | 1010 |
| Scientific Dairy Farming for Farmers sponsored by state departments Utrakhand | 5 | 1 | 30 | 150 |
| Scientific Dairy Farming for Farmers sponsored by state department Gujarat | 3 | 1 | 30 | 90 |
| Scientific Dairy Farming for Farmers sponsored by state department Maharashtra | 5 | 1 | 30 | 150 |
| Total | | 71 | 1948 | 9524 |

(Revenue generated from sponsored courses = Rs.13,99,206/-)

Front-line Demonstrations on Oilseeds and Pulses

| S. No | Crop | Variety | Total No. of Demonstrations | Area (ha.) | Av. Yield q/ha Demonstrations |
|-------|--------------|-----------|-----------------------------|------------|-------------------------------|
| 1 | Mustard | Pusa Bold | 6 | 2.0 | 17.68 |
| | | CS-56 | 6 | 2.0 | 18.35 |
| 2 | Gram | H.C-1 | 2 | 0.8 | 18.5 |
| | | BG-1103 | 7 | 1.6 | 25.0 |
| 3 | Summer Moong | SML-668 | 26 | 10.0 | 4.28 |

On-Farm Trials

| Sr. No. | Crop | Variety | Total Number of Farmer s | Area (ha.) | Av. yield qt./ha |
|--------------|---------|----------------|--------------------------|------------|------------------|
| 1 | Wheat | HD-2851 | 2 | 0.8 | 60.50 |
| | | HD-2932 | 2 | 0.8 | 54.96 |
| | | HD-2733 | 2 | 0.8 | 54.00 |
| Total | | | 6 | 2.4 | |
| 2 | Mustard | Pusa Jay Kisan | 7 | 2.8 | 17.00 |
| | | Pusa Bold | 8 | 3.2 | 16.00 |
| Total | | | 15 | 6.0 | |
| 3 | Berseem | BL-42 | 2 | 1.2 | 1131.0 |
| | | Mescavi | 16 | 3.2 | 1080.0 |
| Total | | | 18 | 4.4 | |
| 4 | | Pusa-1121 | 4 | 1.0 | 45.70 |
| | | PB-1(1460) | 4 | 1.2 | 51.56 |
| Total | | | 8 | 2.2 | |

Front-line Demonstrations on Fodder Crops

| Sr. No. | Crop | variety | No. of Demo. | Area(ha.) | Av. yield qt./ha |
|--------------|-----------------|---------------|--------------|------------|------------------|
| 1. | Maize | African Tall | 5 | 2.0 | 627.0 |
| 2. | Jowar(multicut) | Sudax chari-1 | 11 | 4.0 | 597.0 |
| Total | | | 16 | 6.0 | |

Extension Activities of KVK

- KVK through its four stockman centres in the adopted villages, namely: Taprana, Kailash, & Phusgarh and Jundla Gate, Karnal attended 12611 cases, out of which, 148 cases were for general treatment, 98 for infertility treatment, 161 for dehorning, 2604 for pregnancy diagnosis, 3550 A.Is in dairy animals and 6050 cases were for FMD vaccination. Through Artificial Insemination 1585 calves were born.
- Subject Matter Specialists of KVK organized 13 one day camps on fertility, deworming, tick control, general treatment and pregnancy diagnosis and attended 2,313 cases in adopted villages to create awareness among farmers about animal infertility problems and dairy management aspects.
- KVK concentrated its efforts in increasing the Moong cultivation area in the district. Moong variety SML-668 was promoted and the farmers having different categories of land holding were encouraged to grow summer Moong for getting Moong pulse as well as to increase the soil fertility.
- Zero Tillage technology in Wheat crop production was demonstrated to various groups of farmers and farm women of Karnal district and also to other states. It was also promoted in different villages.

- KVK under the Cereal System Initiative for South Asia programme organized various experiments and front line demonstrations on direct seeding of rice.
- KVK in association with IFFCO, KRIBHCO, Rashtriya Chemical Fertilizers Limited, organized a series of programmes on capacity building of pesticides and fertilizer dealers in which nearly 450 participants participated.
- National Nutrition Week was organized in KVK adopted village Shamgarh on 4th November 2012 in which 65 women participated.
- KVK organized a programme on World Health day in village Palnagar on 12th April 2012 in which 40 farm women participated.
- KVK in association with the Haryana kisan Ayog organized Kisan Divas on 23rd December, 2012 in which more than 5000 farmers from different districts of the Haryana participated.

Revenue Generated

Total revenue generated at KVK through various activities during **April 2012 to March, 2013** was ₹ **40,11,738/**

AGRICULTURE TECHNOLOGY INFORMATION CENTRE (ATIC)

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

During 2012-2013, 25375 farmers from 16 states and one union territory visited ATIC which included 216

delegates from 9 different countries. To improve health and productivity of dairy animals, different technology interventions in the area of Nutrition, Breeding, Physiology and Health Care were suggested to 25375 farmers whereas 6478 stakeholders were suggested different technological interventions in the area of livestock production management and milk processing and 1162 cases were referred for specialized guidance to different divisions of the institute and 2322 cases to sister institutes located at Karnal. During the same period centre generated revenue of ` 1,80,485/- from sale of publications and ` 1,46,7748/- from sale of seed and culture. ATIC also provided on-line guidance to 3499 stakeholders through e.mail and telephone (toll free No. 1800-180-1199) whereas 823 video shows were organized for the visitors.



Dr. R. S. Paroda, Chairman of Haryana Kisan Ayog, giving his inaugural address at the seminar



Hon'ble Chief Minister Haryana, Sh. Bhupinder Singh Hooda on the occasion of Kisan Divas



4. DAIRY EDUCATION

Academic Programmes

The following courses were offered by NDRI Deemed University during the academic session 2012-13.

• B.Tech. (Dairy Technology)

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

• Master's and Doctoral Degree Programmes

The institute offers Master's degree programme in the following disciplines: 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) Agricultural Economics; xii) Agricultural 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/- per month for two years plus ` 6000/- per annum as contingency.

Ph.D. ` 10,500/- per month for three years and ` 10,000/- per annum as contingency.

Ph.D. (In-service) ` 1000/- per month for three years and ` 10000/- per annum as contingency.

ICAR Junior Research Fellowship

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

ICAR Senior Research Fellowship

Ph.D. ` 12000/- per month (for non veterinarians) for 1st and 2nd year and ` 14,000/- for 3rd year; and 10000/- per annum as contingency.

Ph.D. ` 14,000/- per month (for veterinarians) for 1st and 2nd year and ` 15000/- for 3rd year; and ` 10000/- per annum as contingency.

Ph.D. (In-service) ` 1000/- per month 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 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 for employment in Dairy/ Food Industry (Govt./Cooperative/ Multinationals). Salary ranges from ` 20,000 to 60,000/- per month. Students also opt for higher studies in India and abroad. The major functions of the Placement Cell are as follows:

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

Counseling for Admissions

Counseling for admission to UG and PG programme was held by the Education Division of ICAR on 15th June, 2012 and 27th, 30th June and 1st July, 2012, respectively at NASC Complex, New Delhi.

Entrance Examination

An all India competitive entrance examination for admission to Ph.D. programme for the session 2012-13 was conducted by NDRI on 21st June, 2012 at three centers i.e. Karnal (486 candidates), Bangalore (85 candidates) and Kalyani (16 candidates).

Admissions

During academic session 2012-13 a total of 30 students joined B.Tech. (Dairy Technology), 124 students including one foreign national from Ghana joined Masters' programme, 103 students including three foreign nationals from Mauritius, Bangladesh and Ethiopia joined the Ph.D. programme.

Degrees Awarded during the 11th Convocation.

| | | |
|----------------------------|---|-----|
| B.Tech. (Dairy Technology) | : | 32 |
| Master in Dairying | : | 134 |
| Ph.D. | : | 38 |

Meetings

- 71st and 72nd meeting of the Standing Committee on Course Curricula and Academic Affairs was held on 28th September, 2012 and 28th March, 2013.
- 49th, 50th & 51st meetings of the Standing Committee on Faculty, Students Problems and Discipline were held on 29th September, 3rd November, 2012 and 22nd February 2013.
- 33rd and 34th Meeting of Academic Council

Gold Medals for Best Ph.D. Thesis

| Group | Name of the Student | Name of the Guide | Discipline |
|-----------------------------|--------------------------|-------------------|----------------------|
| Processing | Mr. Santosh Kumar Mishra | Dr. R. K. Malik | Dairy Microbiology |
| Social Science & Management | Mr. Ram Datt | Dr. S. K. Jha | Dairy Extension Edn. |
| Production | Ms. Isha Sharma | Dr. Dheer Singh | Animal Biochemistry |

Best Thesis Awards for Master's theses (one each in Production, Processing and Management Groups) carrying a citation, a certificate and Rs. 5000 were

were held on 9th October, 2012 and 14th February, 2013.

Eleventh Convocation of NDRI Deemed University

Eleventh Convocation of NDRI Deemed University was held on 16th February, 2013. Professor (Dr.) S. Ayyappan, Secretary, DARE and Director General, Indian Council of Agricultural Research delivered the Convocation Address. Dr. A. K. Srivastava, Director & Vice Chancellor, NDRI Deemed University presented the Convocation Report. A total of 204 students (including 45 girls) were conferred different degrees i.e. B.Tech. (Dairy Technology) -32, Master's - 134 and Doctoral - 38. Three topper students each in B. Tech. (DT), Master's and Doctoral programmes were awarded Gold, Silver and Bronze Medals for overall performance in Course work. Merit Certificates to 20% of the total pass out students in B. Tech. (DT) Programme based on performance in course work were also awarded. Merit certificates to toppers of each discipline in Master's and Ph.D. degree programme for performance in course work as per the eligibility criteria were also awarded.

Award of Honorary Degrees

Honorary degree of Doctor of Science-D.Sc. (*Honoris Causa*) was conferred on Dr. K. Pradhan, Ex-VC, OUA&T, Bhubaneswar and RAU, Bikaner in recognition of his contribution in dairy education, research and development sector.

Best Thesis Award

Gold Medals for best thesis research work in Ph.D. Programme of Production, Processing and Management Group were awarded. The award carries Gold Medal, Citation and Certificate. The students presented their theses before the Award Committee. Two theses in each programme were recommended by committees in each discipline.

awarded. The students presented their theses before the Award Committee. Two theses in each programme were recommended by committees in each discipline.

Best Master's Thesis Awards

| Group | Name of the Student | Name of the Guide | Discipline |
|-----------------------------|----------------------|--------------------|----------------------|
| Processing | Ms. Athira S. | Dr. Bimlesh Mann | Dairy Chemistry |
| Social Science & Management | Mr. Sajad Ahmed Wani | Dr. Gopal Sankhala | Dairy Extension Edn. |
| Production | Arpita Mahapatra | Dr. Ajay Dang | Animal Physiology |

Dr. D. Sundaresan Memorial Lecture Award-2013

Dr. D. Sundaresan Memorial Lecture Award-2013 was bestowed on Dr. Gurbachan Singh, Chairman, Agricultural Scientists Recruitment Board, New Delhi. Dr. Singh delivered the lecture on 11th February, 2013 on the topic “Food, Nutrition, Livelihood and Environmental Security in India: Issues Opportunities and Strategies”. The award carries an amount of Rs. 20,000, a citation, shawl and a certificate.

Dr. N. N. Dastur Oration Award-2013

Dr. N.N. Dastur Oration Award-2013 was bestowed on Dr. K. M. Bajurbaruah., Vice Chancellor, AAU, Jorhat. Dr. Bajurbaruah delivered the oration on 22th February, 2013 on the topic “Towards a Technology Driven and not Animal Number Driven Agriculture in India”. The award carries an amount of Rs. 20,000, a citation, shawl and a certificate.

Dr. K. K. Iya Oration Award-2013

Dr. K. K. Iya Oration Award-2013 was bestowed on Dr. P.P. Mathur, Vice Chancellor, KIIT, Bhubaneswar. Dr. Mathur delivered the lecture on 23rd February, 2013 on the topic “Effects of Endocrine Disruptors on Male Reproduction”. The award carries an amount of Rs. 20,000, a citation, shawl and a certificate.

Best Divisional Award for Academic Achievements and Innovations in Teaching

The Heads of Divisions presented the innovations and significant achievements during 2012-13 in

education/research and consultancy “Best Divisional Award” was presented to Dairy Technology Division and Livestock Production and Management Division jointly.

Best Teacher Award for Excellence in Teaching

Best Teacher Awards at under-graduate teaching and post-graduate levels at NDRI, Karnal to recognize and promote teaching excellence and motivate the faculty to adopt high standards for content preparation, delivery of lectures, motivation of students and overall development of students were conferred upon at the 11th Convocation.

NDRI Signed Memorandum of Understanding with the following Universities for collaboration in areas of mutual interest

- Sam Higginbottom, Institute of Agriculture Technology and Sciences (Deemed University) Allahabad, Uttar Pradesh.
- Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana

Agriculture Education Day

Agricultural Education Day was organized and celebrated by NDRI (Deemed University) with full fervor and enthusiasm by the students, faculty akin, on 23rd November, 2012. Various competitions like Essay Writing, Poster Making and Debate were organized during 20-23 November, 2012.



Fresher'Day Fiesta at NDRI, Karnal

5. HONOURS/AWARDS

• A project entitled “**Characterization and Differentiation of Embryonic and Spermatogonial Stem Cells in Cattle and Buffaloes**” was awarded, under National Agricultural Innovation Project, in Component-4, in July 2009. Under this project 'GARIMA-II', a cloned buffalo calf, produced through the new and advanced 'Hand-guided Cloning Technique' was born at National Dairy Research Institute (NDRI), Karnal under Indian Council of Agricultural Research (ICAR) on 22nd August, 2010. This cloned buffalo calf was unique in the sense that the donor cell used for producing this calf was from embryonic stem cell. On this achievement, National Agricultural Innovation Project, Secretary (DARE) and Director General (ICAR), New Delhi awarded certificate of appreciation on 14th December, 2012 to the Project at NDRI, for outstanding contribution in model translational research in buffalo to establish developmental competence of embryonic stem cells, having produced GARIMA-II.

• NAIP project entitled “**A value chain on composite dairy foods with enhanced health attributes**” under component-2 was awarded with “**Certificate of Appreciation**” by the National Agricultural Innovation Project for outstanding contribution in development of technological packages for milk and pearl millet based innovative composite dairy foods. The NAIP also complemented the activities related to popularization and commercialization of developed technologies among the stakeholders and consumers. Secretary DARE and Director General (ICAR) presented the certificate on December 14, 2012 during the Inauguration Ceremony of Regional Committee Meeting of ICAR.

• National Dairy Research Institute, Karnal, Consortium Leader (**Dr. A. K. Srivastava**),



Chairman, Consortium Advisory Committee (**Dr. C. P. Puri**) and Consortium Research Team (**Dr. M. S. Chauhan, Dr. P. Palta, Dr. R. S. Manik, Dr. S. K. Singla, Dr. Dheer Singh, Dr. Manoj Kumar and Dr. S. L. Goswami**) were felicitated by Secretary, DARE and Director General, ICAR and awarded certificate of recognition for model translational research carried out under NAIP project on stem cell entitled “**Characterization and Differentiation of Embryonic and Spermatogonial Stem Cells in Cattle and Buffaloes**” that has produced GARIMA-II.

• **Dr. Raj Kumar Duary** was awarded “**Jawaharlal Nehru Award**” for P. G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2011 held on 16th July 2012 at NASC Complex ICAR, Delhi. He has done his Ph.D. under the guidance of Dr. Sunita Grover on “*Modulation of gene expression by indigenous probiotic lactobacilli under simulated in vitro gut environment.*”

• **Dr. Dheer Singh**, Principal Scientist, Animal Biochemistry Division was bestowed with the prestigious **Labhsetwar Award-2013** of the Indian Society for the Study of Reproduction and Fertility (ISSRF) on 7th-9th February, 2013 at Thiruvananthapuram.

• **Dr. A. K. Singh**, Senior Scientist, Dairy Technology Division got “**NDRI Best Teacher Award**” for undergraduate teaching (2012) during 11th convocation of the NDRI deemed university held on 16th February, 2013.

• **Dr. Bimlesh Mann**, Principal Scientist, Dairy Chemistry Division got “**NDRI Best Teacher Award**” for postgraduate teaching (2012) during 11th convocation of the NDRI deemed university held on 16th February, 2013.

• **Dr. A. Kumaresan**, Senior Scientist, Livestock Production Management; **Dr. Rajan Sharma**, Senior Scientist and **Dr. Darshan Lal**, Principal Scientist Dairy Chemistry, **Dr. Rajeev Kapila** and **Dr. Suman Kapila**, Principal Scientists, Animal Biochemistry, **Dr. Ravindra Malhotra**, Principal Scientist, Dairy Economics, **Dr. S. K. Tomer**, Principal Scientist, Dairy Microbiology and **Dr. P. N. Raju**, Scientist, Dairy Technology received “**Appreciation Certificates for Outstanding Contributions in Teaching**” at NDRI, Karnal.

- **Dr. Isha Sharma**, Ph.D. Scholar got “**Best Ph.D. Thesis Award 2012-13**” (Production Group) for her Ph. D dissertation entitled, “Regulation of steroidogenesis in buffalo ovary by *peroxisomal* proliferator- activated receptor γ ” Dr. Sharma worked under the guidance of **Dr. Dheer Singh**, Principal Scientist Animal Biochemistry Division, NDRI, Karnal.
- **Dr. Santosh Kumar Mishra**, Ph.D. Scholar got “**Best Ph.D. Thesis Award 2012-13**” (Processing Group) for his Ph. D dissertation entitled, “Isolation and Characterization of Reuterin Producing Strains of *Lactobacillus Reuteri* for their Potential Use as Biopreservatives”. Dr. Mishra worked under the guidance of **Dr. R. K. Malik**, Principal Scientist & Head Dairy Microbiology Division, NDRI, Karnal.
- **Ms. S. Athira**, M.Tech. Scholar got best “**M. Tech. Thesis Award 2012-13**” in the processing group on dissertation work “Process Optimization for the Production of Bioactive Peptides Enriched Ingredients from Cheese Whey” during 11th Convocation of the NDRI deemed university held on 16th February, 2013. She completed her dissertation under the guidance of Dr. Bimlesh Mann, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal.
- **Dr. R. K. Malik**, Principal Scientist **Ms. Gurpreet Kaur**, **Mr. Tejinder Pal Singh** and **Mr. Santosh Mishra** got “**Best Paper Award**” for the paper entitled “Health-enhancing Functional Dairy Foods Bioactive Peptides” published in Indian Dairyman during 41st Dairy Industry Conference organised by IDA during 14th – 16th March, 2013 at Mumbai.
- **Mr. K. N. Papinwar**, **Dr. B. Surendra Nath**, Principal Scientist and **Mr. D. H. Patel** got “**Best Paper Award**” for the paper entitled “Antimicrobial Packaging for Food Preservation” published in Indian Journal of Dairy & Biosciences Vol. 20 in the category of Dairy Processing for the years 2009 & 2010.
- **Dr. Vikram Singh** and **Dr. Jancy Gupta**, Principal Scientist (2012) “**Best Paper Award**” for Clean Milk Production: The Path for Milk quality Improvement. 6th National Seminar on Emerging Challenges and Paradigm for Sustainable Agriculture Rural Development at YSPUHF, Solan 18th – 20th December, 2012.
- **Mr. Nirish Chandra Sahu**, **Dr. Jancy Gupta**, Principal Scientist and **Dr. Om Vir Singh**, Principal Scientist got “**Best Paper Award**” for Status of commercial dairy farming in Haryana: An exploratory study at 41st Dairy Industry Conference-2013 organised in Mumbai from 14th – 16th March, 2013.
- **Dr. S. Jeyakumar** was awarded “**Best Oral Paper Presentation**” on the paper entitled “Sustainable dairy production through reproductive and management technological interventions to boost milk production in Andaman Islands” by the Indian Society of Animal Production and Management during XX Annual Convention and National Seminar on “New Paradigms in Livestock Production: From Traditional to Commercial Farming and Beyond” 28th - 30th January, 2013 at NDRI Karnal.
- **Dr. Archana Verma**, Principal Scientist got “**Best Oral Paper Award**” entitled “Effect of surplus colostrum feeding on growth and immunity status of crossbred calves” during the National Seminar of ISAPM from 28th - 30th January, 2013 at NDRI, Karnal.
- **Dr. S. S. Lathwal**, Senior Scientist, Livestock Production Management was awarded with “**Smt. Kadambini Devi Award for Best Oral Presentation on Domestic Animal Behavioural Science**” by ISAPM during its XX annual convention and National Seminar on “New paradigms in livestock production: From traditional to commercial farming and beyond” held at NDRI from 28th - 30th January, 2013.
- **Mr. Mukesh P. Singh**, **Dr. S. K. Kanawjia**, Principal Scientist, **Ms. Apurba Giri** and **Dr. Y. Khetra**, Scientist bagged “**Best Research Paper Award**” entitled “Moisture Sorption Isotherms and Thermodynamic Properties of Mozzarella Cheese Added with Microcrystalline Cellulose” during the International Conference on “Food Technology for Health Promotion” organized by International Institute of Food and Nutritional Sciences (IIFANS), from 27th-28th December, 2012 at Jawaharlal Nehru University, New Delhi.
- **Ms. Apurba Giri**, **Dr. S. K. Kanawjia**, Principal Scientist, **Mr. Mukesh P. Singh** and **Dr. Y. Khetra**, Scientist bagged “**Best Research Paper Award**” entitled “Effect of Phytosterol on the Quality of

- Processed Cheese Spread and its Hypocholesterolemic Study” during the International Conference on “Food Technology for Health Promotion” organized by International Institute of Food and Nutritional Sciences (IIFANS), from 27th-28th December, 2012 at Jawaharlal Nehru University, New Delhi.
- **Dr. R. K. Malik**, Principal Scientist & Head Dairy Microbiology Division, NDRI, Karnal and Editor of **Indian Journal of Dairy Science** was honoured and awarded a certificate of commendation for his outstanding contribution to the journal as Editor during 41st Dairy Industry Conference 2013 from 14th-16th March, 2013 at Mumbai (Maharashtra).
 - **Dr. S. K. Sirohi**, Principal Scientist, DCN Division honoured as “**Fellow of Animal Nutrition Association for 2010-12**” by Animal Nutrition Association during its conference held at RAJUVAS, Bikaner on 28th - 30th November, 2012
 - **Dr. J. K. Kaushik**, Senior Scientist, Animal Biotechnology Centre, was awarded “**Erasmus Mundus Scholar Grant, 2012**”.
 - **Dr. Shiv Prasad**, I/C LPM & LRC was awarded “**Fellowship (FISAPM)**” by the Indian Society of Animal Production and Management during its XX Annual Convention and National Seminar on “New paradigms in livestock production: From traditional to commercial farming and beyond” held at NDRI from 28th - 30th January, 2013.
 - **Dr. Shiv Prasad**, I/C LPM & LRC was nominated and selected as “**Vice-President**” of Indian Society of Animal Production and Management for North Zone.
 - **Dr. A. Kumaresan**, Senior Scientist, Livestock Production Management was awarded with “**Eight Sisters NE Best LPM Research Award**” by ISAPM during its XX Annual Convention and National Seminar on “New paradigms in livestock production: From traditional to commercial farming and beyond” held at NDRI from 28th - 30th January, 2013.
 - **U R Mehra Lifetime Achievement Award** conferred on **Dr. S. S. Kundu**, Head, DCN Division for his contribution in Animal Nutrition for 2010-12 by Animal Nutrition Association during its conference held at RAJUVAS, Bikaner on 28th - 30th November, 2012
 - **Mr. Umesh Kr. Shandilya**, pursuing Ph.D. under the supervision of **Dr. Rajeev Kapila**, Senior Scientist, Animal Biochemistry Division, delivered oral presentation entitled “**Orally induced tolerance to caseins and whey proteins in mice with cow milk allergy**” at International Conference on Frontiers in Immunology Research-2012 organised FIRN, USA from 1st – 4th July in Salzburg, Austria.
 - **Dr. Priti Devi**, Ph.D. Scholar of **Dr. A. K. Puniya**, Principal Scientist was awarded “**Department of Science and Technology**”, Travel Grant, to present a paper during “12th International Nutrition and Diagnostic Conference”, 27th - 30th August, 2012, Prague, Czech Republic.
 - **Dr. Sumit Singh Dagar**, Ph.D. Scholar of **Dr. A. K. Puniya**, Principal Scientist was awarded “**Stapledon Travelling Fellowship - 2012**” for six months by “The Stapledon Memorial Trust” to visit 'Institute of Biological, Environmental and Rural Sciences', Aberystwyth University, Aberystwyth, UK.
 - **Dr. Sumit Singh Dagar**, Ph.D. Scholar of **Dr. A. K. Puniya**, Principal Scientist was selected for “**FEMS Young Scientist Meeting Grant (YSMG)**” for participating in 8th INRA-RRI Symposium on Gut Microbiology; Gut Microbiota: Friend or Foe?; Clermont-Ferrand, France, 17th – 20th June, 2012.
 - Two M.Sc. students, **Mr. Renjith Sebastian** and **Mr. Vivek Phani Varma D.** under **Dr. Rajeev Kapila**, Senior Scientist, Animal Biochemistry Division, were awarded “**First Prize**” in immune response therapy session for presentation of paper entitled “*Lactobacillus helveticus* fermented milk modulates innate immunity by activating macrophages and neutrophils” in Biotech-2012 “Current Advances in Biotechnology and Medicine” organized by Institute of Liver and Biliary Sciences, New Delhi from 24th - 25th February, 2012.
 - **Mr. Harsh Panwar**, Doctoral student of **Ms. Sunita Grover**, Principal Scientist was selected to make an “**Oral Presentation**” on 'Anti-diabetic potential of probiotic lactobacilli: inhibition of alpha-glucosidase and DPP-4 and stimulation of incretin hormone secretion' at 'International conference on probiotics and prebiotics, IPC-2012) held at Kosice, Slovakia (12th – 14th June, 2012).

- **Ms. Neha Pandey**, Ph.D. Scholar, Dairy Technology, **Mr. Parvin Sarkar** and **Ms. Richa Singh** Ph.D. Scholar, Dairy Chemistry and **Mr. Tapas K. Patbandha**, Ph.D. Scholar, Livestock Production & Management were awarded with “**DST-INSPIRE**” fellowship by the Department of Science and Technology (DST), Ministry of Science and Technology, Govt. of India, for pursuing full time doctoral programme at National Dairy Research Institute, Karnal.
- NDRI got “**Second Rajshree Tandon Award-2011**” for its outstanding work done in Official Language Hindi. The award was presented to NDRI at Director's Conference held on 19th March, 2013.
- Annual In-house journal in Hindi “**Dugdh Ganga**” published by NDRI was awarded “**Consolation Prize**” under “**Ganesh Shankar Vidyarthi Hindi Krishi Patrika Puruskar Yozna**” of ICAR for the year 2011-2012 during Director Meet of ICAR held on 19th March, 2013.
- **Mr. Santosh Mishra**, **Dr. R. K. Malik**, **Ms. Gurpreet Kaur**, **Ms. Manju G.**, **Ms. Neha Pandey** and **Ms. Garima Singroha** got “**Second Best Paper Award**” for the paper entitled “Potential bioprotective effect of reuterin produced by *L. reuteri* BPL-36 alone and in combination with nisin against food borne pathogens” published in Indian Journal of Dairy Science during 41st Dairy Industry Conference organised by IDA during 14th – 16th March, 2013 at Mumbai.
- **Dr. Raka Saxena**, **Dr. Samita Sirohi**, **Ms. Kavita Pal** and **Mr. Puneet Aggarwal** were awarded "Best Research Paper Prize" for train article in Hindi entitled Bharat Mei Asangathit Dairy Sangathano Ki Sarachana, Pranli Evam Samasyain during Hindi Divas at NDRI, Karnal
- **Dr. Chander Datt**, Sr. Scientist and **Dr. S. S. Kundu**, Head, Dairy Cattle Nutrition awarded “**Second Best Paper Prize**” for the article in Hindi “*Khees Ek Atyant Avashyak Ahar*” Published in Dairy Mela Samarika-2013 (A compilation of articles in Hindi on various aspects of animal husbandry and dairying released during National Dairy Mela-2012 held at NDRI, Karnal from 25th – 27th February, 2013.
- **First Prize for Best Stall Award** was given to Dairy Cattle Nutrition Division for exhibition of nutritional technologies to the farmers during National Dairy Mela held at NDRI, Karnal from 25th – 27th February, 2013.
- **Dr. Raj Kumar Duary** awarded “**Best Young Researcher Award (Second Prize)**” for his paper on “Potentiality of two promising putative indigenous strains of probiotic lactobacilli for boosting gut health and immunity” presented in 1st Annual conference of Probiotic Association of India (PAI) and International Symposium on probiotics for human health on 28th-29th August, 2012.
- **Ms. K. C. Neethu**, **Dr. F. Magdaline Eljeeva Emerald**, **Dr. Pushpadass Heartwin A.**, **Dr. Rekha Ravindra Menon**, **Dr. K. Jayaraj Rao**, and **Dr. B. Surendra Nath** got “**Poster Award - Second Prize**” for the poster entitled “Modeling the moisture transport of *pantofa* during deep-fat frying”. Subhiksha Dairy and Food Industry Conference, Thrissur during 11th - 13th April, 2012.
- **Mr. A. Giri**, and **Dr. S. K. Kanawjia**, Principal Scientist were awarded “**2nd Best Prize**” for the oral presentation entitled “Enrichment of processed cheese spread with functional ingredients” at International conference on 'Food and Nutrition Technology for Public Health Care', organized by International Institute of Stress Management and Allied Sciences, at Jawaharlal Nehru University, New Delhi, on 4th - 5th May, 2012.
- **Mr. A. Kumar**, **Dr. S. K., Kanawjia**, Principal Scientist **Dr. Y. Khetra**, Scientist, **Mr. A. Giri**, and **Mr. R. Kumar** were awarded “**2nd Best Prize**” for their research poster presentation entitled “Development of functional chocolate soft cheese” at International Conference on 'Food and Nutrition Technology for Public Health Care', organized by International Institute of Stress Management and Allied Sciences, at Jawaharlal Nehru University, New Delhi, on 4th - 5th May, 2012.
- **Ms. Apurba Giri** and **Dr. S. K. Kanawjia**, Principal Scientist, bagged “**Second Best Oral Paper Award**” entitled “Effect of Inulin on the Quality Processed Cheese Spread and its Hypocholesterolemic Study” during the International Conference on “Food Technology for Health Promotion” organized by International Institute of Food and Nutritional Sciences (IIFANS), from 27th-28th December 2012, at Jawaharlal Nehru University, New Delhi.
- **Dr. Bharat Kumar**, **Dr. Archana Verma**, Principal Scientist, **Dr. I. D. Gupta**, Principal Scientist and **Dr.**

- Mahesh V. Chaudhary** got “**Best Poster Award**” for the poster “Nucleotide sequence variability and association of FEZL gene polymorphism with incidence of clinical mastitis in Murrah buffalo” presented during 41st Dairy Industry Conference & IIDE 2013 from 14th-16th March, 2013 at Mumbai (Maharashtra).
- **Ms. Minaxi, Mr. T. P. Sari, Mr. D. Divya, Dr. Bimlesh Mann, Principal Scientist, Dr. Rajan Sharma, Principal Scientist, Dr. Rajesh Bajaj, Principal Scientist and Dr. R. R. B. Singh, Principal Scientist** got “**Second Prize**” for the poster presentation on topic “Stability of nanoemulsions encapsulating clove oil prepared using milk proteins and non-ionic emulsifiers” in the 41st dairy industry conference by Indian Dairy Association held Mumbai 14th-17th March, 2013.
 - **Dr. Bimlesh Mann, Principal Scientist, Dr. Shilpa Vij Principal Scientist and Ms. Prerna Saini** got “**First Prize**” for the Hindi article published in “Dairy Mela Samarika” on “Swachh Dugdh Utpadan: Labh va Tarike” for the year 2011-2012.
 - **Dr. Mukesh Bhakat, Senior Scientist** was awarded with “**Third Prize for Oral Presentation**” by ISAPM during its XX Annual Convention and National Seminar on “New paradigms in livestock production: From traditional to commercial farming and beyond” held at NDRI from 28th-30th, January 2013.
 - **Dr. S. K. Tomar, Principal Scientist, Dr. Nitin Tyagi, Principal Scientist, Dr. Chander Datt, Sr. Scientist and Dr. S. S. Kundu, Head, Dairy Cattle Nutrition** awarded “**Third Prize for Poster Presentation**” on “*Gabhin Gai Va Bhains Ka Poshan*” during Hindi Divas held on 8th November, 2012.
 - **Ms. M. Puniya, Mr. A. Kumar, Ms. Renuka Devi R., Mr. K. Ahlawat, Mr. T. S. Goud, Mr. P. Srinivasulu, Dr. A. K. Puniya, Principal Scientist and Dr. R. C. Upadhyay, Principal Scientist** were awarded “**Second Best Poster Award**” Climate change associated challenges and mitigation strategies during livestock production systems. In: National Seminar and XX Annual Convection on 'New Paradigms in Livestock Production: From Traditional to Commercial Farming and Beyond' 28th - 30th January, 2013 organized by 'Indian Society of Animal Production and Management', at NDRI, Karnal.
 - Recognition of the Most Cited Paper of 2009 published in Journal of Food Science **Mr. Ramya Iyer and Dr. S. K. Tomar** 2009. Folate: A Functional Food Constituent. J. Food Sci. 74 (9): R114-122; awarded by The Institute of Food Technologists during their Annual Meeting on 26th June, 2012 in Las Vegas, USA.
 - “**Agricultural Leadership Award – 2012**”, for **Dr. (Mrs.) Jancy Gupta**, by Agriculture Today-The National Agriculture Magazine.
 - **Neethu, K.C., Magdaline Eljeeva Emerald, F., Heartwin A. Pushpadass, Menon Rekha Ravindra, Jayaraj Rao, K. and Surendra Nath, B.** got “**2nd Prize Poster**”. Modeling the moisture transport of *pantoa* during deep-fat frying. Subhiksha Dairy and Food Industry Conference, Thrissur. 11th - 13th April. P-123. (APT-1).
 - **Dr. Jancy Gupta, Principal Scientist Mr. Prahlad Gupta and Mr. Nirish Chandra Sahu** got “**Best Poster Prize**” at 41st Dairy Industry Conference held from 14th – 16th March 2013 at Mumbai.
 - **Ms. K. Jayalakshmi and Dr. B. V. Balasubramanyam** won the “**Best Poster Paper Award (Third Prize)**” for the poster paper entitled “Effect of use of concentrated and lactose hydrolysed whey on sensory quality of bread” presented at Seminar on “Subhiksha – 2012” organized by Kerala Chapter of Indian Dairy Association (SZ) and Kerala Agril. Univ., Mannuthy, during 13th - 14th April, 2012.
 - **Ms. K. C. Neethu, Dr. F. Magdaline Eljeeva Emerald, Dr. B. Surendra Nath, Dr. M. K. Vedavathi, Dr. Rekha Ravindra Menon, Dr. P. Heartwin Amaladhas and Dr. B.V. Balasubramanyam** got “**Poster Award – Third Prize**” for the poster entitled “Sensory evaluation modeling of buttermilk drinks using fuzzy-logic approach” presented in the National Conference on Appropriate Technologies for Indian Food Processing Industries during 5th – 6th March, 2012.
 - **Ms. Aparna Sudhakaran V., Dr. V. K. Batish and Dr. (Mrs.) Sunita Grover** were awarded the “**Best Paper Award (Third Prize)**” for the poster entitled “Modulation of anti-inflammatory response in LPS stimulated cell line and mouse model with indigenous putative probiotic lactobacilli”

presented in '1st Annual conference of Probiotic Association of India (PAI) and International Symposium on probiotics for human health on 28th-29th August, 2012.

- Neethu, K.C., Magdaline Eljeeva Emerald, F., Surendra Nath, B., Vedavathi, M. K., Menon Rekha Ravindra, Heartwin Amaladhas, P. and Balasubramanyam, B.V. got **“3rd Prize Poster”**. Sensory evaluation modeling of buttermilk drinks using fuzzy logic approach. Poster abstract. In: National conference on Appropriate technologies for Indian food processing industries, Bangalore. 5th - 6th March. (P-93 No.IICPT/NCOFTECH/2012/PT1138).
- **Dr. Archana Verma**, Principal Scientist got **“Certificate of Felicitation for Oral Presentation”** entitled **“Molecular analysis of candidate genes for mastitis in Murrah buffaloes (*Bubalus bubalis*)”** during the World Congress on Biotechnology from 13th -15th September, 2012 at Hyderabad International Convention Centre, Hyderabad.
- **Dr. V. K. Batish**, Former Head and Emeritus Scientist was elected **“Fellow of National Academy of Agricultural Sciences”** for the year 2012-2013 for his outstanding contributions in the area of Biotechnology and Microbiology.
- **Dr. B. S. Meena**, Sr. Scientist, Dairy Extension was awarded **“Fellow of Range Management Society of India”**, Jhansi on the occasion of National Symposium on Sustainable production of forages from arable and non-arable land and its utilization held on 2nd - 3rd November, 2012 at Indian Grassland & Fodder Research Institute, Jhansi
- **Dr. Dheer Singh**, Principal Scientist received **“11th AJAS/CAPI Outstanding Research Award”** (C/o Korean Society of Animal Science & Technology). The award includes 1,000 US\$ (donated by CAPI in Korea) and a Plaque.
- **Dr. A. K. Puniya**, Principal Scientist was awarded the **“Certificate of Appreciation”** from 'The Annual Bio-medical Research Conference for Minority Students', 7th - 10th November, 2012, San Jose, California, USA, in recognition of his outstanding contribution in reviewing undergraduate, postbaccalaureate and graduate student abstracts.
- Certificate awarded to **Dr. Naresh Kuamr**, Principal Scientist for presenting NAIP technologies on Aflatoxin M1/Enterococci/*Listeria monocytogenes* during National Dairy Mela -2012 held during 25th - 27th February, 2012 at NDRI, Karnal.
- **Mr. Sukanta Basak**, II Year M.V.Sc. (AGB) was awarded **“Consolation Prize for Poster Presentation”** entitled **“Genetic Characterization of Exon 3 of TLR4 gene in Deoni and HF crossbred cattle”** (S. S. Chauhan, D.N. Das, S. Basak, P.V. Jadhav) during the Annual Conference of the Indian Society of Animal Genetics & Breeding 2012' held at College of Veterinary Science, Sri Venkateswara Veterinary University, Hyderabad from 22nd - 23rd November, 2012.



Dr. K. M. L. Pathak giving away merit certificate to passing out graduates at 11th convocation of NDRI on 16th February, 2013

6. RESEARCH COLLABORATIONS

The scientists of the Institute maintained close liaison with various organizations 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

| Sl No. | Title of the Project | Name of PI/ Co-PI | Funding Agency | Duration | Total Cost (in Lakh) |
|--------|---|--|----------------|----------|----------------------|
| 1 | National initiative on climate resilient agriculture | R. C. Upadhyay | CRIDA | 2010-17 | 986.50 |
| 2. | Cost and returns in milk production: Developing standardized methodology and estimates for various production system. | Smita Sirohi | DAHD | 2012-14 | 61.58 |
| 3. | Fluorescent <i>in situ</i> hybridization (Fish) and associated techniques for characterization of chromosomes for detection of genetical and re-productive problems in cattle, buffalo and goat. | B. R. Yadav | DBT | 2011-14 | 43.11 |
| 4. | Elucidating molecular and cellular and mechanisms of ovarian and uterine cells function underlying the infertility associated with post-partum uterine infection in buffalo. | Dheer Singh | DBT | 2011-14 | 59.79 |
| 5. | Genetic diversity and haplotyping of innate immune genes in Indian cattle and buffalo | S. De | DBT | 2012-15 | 42.46 |
| 6. | Application of probiotics in alleviating allergic responses and immuno-seneescene. | Rajeev Kapila | DBT | 2011-14 | 53.72 |
| 7. | Molecular basis for modulation of immuno-competence of neutrophilic function <i>in vivo</i> and <i>in vitro</i> of high producing cows and buffaloes peri-partum. | A. K. Dang | DBT | 2010-13 | 42.05 |
| 8. | Developing & evaluation of multiple micro-nutrient (mineral & vitamins) fortified milk for consumer market. | Sumit Arora | DBT | 2010-13 | 42.59 |
| 9. | Buffalo genome information resource | S. De | DBT | 2012-14 | 27.47 |
| 10. | Anti-Mullerian hormone profile, its characterization and expression for using as diagnostic marker for fertility assessment in farm animals. | Avijit Haldar NER Tripura/ S. De | DBT | 2012-15 | 27.97 |
| 11. | Establishment of facilities for research and training in stem cell technology in pigs. | M. S. Chauhan | DBT | 2012-16 | 37.38 |
| 12. | Development of transgenes for <i>in vitro</i> expression in buffalo mammary gland epithelial cells. | M. S. Chauhan | DBT | 2011-13 | 43.06 |
| 13. | Diversity study of CLA producing indigenous <i>Butyrivibrio spp.</i> its subsequent utilization as a probiotic for animals and genes expression pattern of enzymes involved in biohydrogenation of fatty acids. | A. K. Tyagi | DBT | 2011-14 | 50.00 |
| 14 | Digestive enzymes (a-glucosidase and a-amylase) probiotics lactic acid bacteria for controlling postprandial hyperglycemia | A.K. Punia | DBT | 2012-15 | 22.60 |

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|-----|---|-----------------|--------------------------------------|----------|--------|
| 15. | Improvement in fertilizability of cryopreserved buffalo bull semen by minimizing cryo capacitation and apoptosis like changes”(Collaboration with GADVASU, Ludhiana) | M. S. Chauhan | DBT | 2012-14 | 17.77 |
| 16. | Bioacoustics tool: A novel non-invasive approach for efficient monitoring of health and productivity in dairy animals | S. S. Lathwal | DBT | 2013-16 | 64.09 |
| 17. | Effect of micronutrients supplementation on hormones, milk yield, udder health, immunity in cross- bred and indigenous cows | Anjali Aggarwal | DBT | 2009-12 | 70.00 |
| 18. | Development of geriatric dairy food having prophylactic attribute against Alzheimer's disease. | Kaushik Khamrui | DST | 2011-14 | 22.00 |
| 19. | Diversity of exopolysaccharides produced by lactic acid bacteria | Pradip Behare | DST | 2013-16 | 21.96 |
| 20. | Phylogenetic study of ruminal bacteria and its potential for CLA production and gene expression pattern of linoleic acid isomerase and reductase with different\ dietary supplementary supplementation and its subsequent utilization as probiotics for animals | A. K. Tyagi | DST | 2012- 14 | 5.00 |
| 21. | Understanding role of micro RNA (mRNA) mediated gene regulation during folliculogenesis and lutinization: a comparative study in buffalo and cow. | Dheer Singh | DST-DAAD | 2011-14 | 8.25 |
| 22. | Confirmation of lactation performance and animal safety of dairy animals of <i>Bos</i> species treated with recombinant bovine samatotropin. | A. Manimaran | Eli Lilly Asia Inc. ELANCO Bangalore | 2012-14 | 185.00 |
| 23. | Evaluation and improvement of indigenous cattle of Malnad region of Karnataka-DAH&VS | K. P. Ramesha | Govt. of Karnataka Bangalore | 2011-13 | 64.72 |
| 24. | Network programme on veterinary type culture (VTC)-Rumen Microbes. | A. K. Punia | ICAR | 2010-13 | 13.80 |
| 25. | Indigenous breed program (Sahiwal cattle) | R. S. Gandhi | ICAR | 2010-12 | 25.00 |
| 26. | Upliftment of socio-economic condition of tribal people through integrated livestock farming in north eastern hill region/eastern part of India –ICAR | T. K. Dutta | ICAR | 2012-17 | 75.00 |
| 27. | Monitoring of drug residues and other environmental pollutants-outreach project of ICAR | N. K. Goel | ICAR Fund | 2009-13 | 71.00 |
| 28. | Screening probiotics and prebiotics for expression of glucagon like peptide-1 (GLP)-1), a satiety inducing hormone, as prophylactics against diabetes mellitus-2. | Sunita Grover | ICMR | 2012-15 | 54.06 |
| 29. | Status of antibiotic resistance among commercially available probiotic bacteria. | S. K. Tomar | ICMR2 | 012-15 | 43.00 |
| 30. | Characterization of colostrum Bio-active components from different spices (camel, sheep and goat) and their application in the formulation of novel dairy products. | Raman Seth | MFPI | 2012-14 | 87.26 |

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|-----|--|-----------------|--------------------------|------------------|--------|
| 31. | Development of traditional fermented dairy products enriched with an indigenous probiotic strain for promoting the health and well being of consumers. | Sunita Grover | MFPI | 2010-12 | 67.83 |
| 32. | Evaluating corn hybrid on the quality of silage and growth performance in crossbred calves. | A. K. Tyagi | Monsanto India Pvt. Ltd. | 2012 - 13 | 8.5 |
| 33. | Dairy Extension education and services at Farmers' door through mobile extension unit: Action research. | Jancy Gupta | NABARD | 2010-13 | 14.36 |
| 34. | Elucidating the physiological and genomic regulation process of follicular development, oocyte maturation and embryogenesis in buffalo. | T. K. Datta | NAIP | 2008 March 13 | 332.01 |
| 35. | Characterization and differentiation of embryonic, adult and spermatogonial stem cells in cattle and buffaloes. | M. S. Chauhan | NAIP | 2008 March - 14 | 371.91 |
| 36. | Analysis of mammary gland transcriptome and proteome during lactation and involution in indigenous cattle and buffalo for identification of probable mammary biomarkers. | A. K. Mohanty | NAIP | 2008 March-14 | 330.02 |
| 37. | Genetic basis of inferior sperm quality and fertility of crossbred bulls. | S. De | NAIP | 2009 March-13 | 119.35 |
| 38. | Development potency of parthenogenetic goat embryos. | D. Malakar | NAIP | 2009 March-13 | 55.74 |
| 39. | Value chain on zone free cloned embryos for quality animal production from elite buffaloes and pashmina goats. | S. K. Singla | NAIP | 2009-13 | 793.84 |
| 40. | Development of wireless sensor network for animal management. | T. K. Mohanty | NAIP | 2008-13 | 213.06 |
| 41. | Rumen microbial diversity in domesticated and wild ruminants and impact of additives on methanogenesis and utilization of poor quality fibrous feeds. | S. K. Sirohi | NAIP | 2008-1 | 378.89 |
| 42. | Development of e-courses for B. Tech. | A.A. Patel | NAIP | 2009-13 | 140.85 |
| 43. | Novel Approaches for the production of nutraceuticals from milk and Indian herbs for potential use in functional dairy foods. | R. R. B. Singh | NAIP | 2009-17 | 230.38 |
| 44. | A value chain on composite dairy foods with enhanced health attributes by ICAR. | A. K. Singh | NAIP | 2009-14 | 357.98 |
| 45. | Development of biosensors and micro-techniques for analysis of pesticide residues aflatoxin, heavy metals and bacterial contamination in milk. | N. K. Goel | NAIP | 2008-13 | 276.21 |
| 46. | Detection and mitigation of dairy pathogens and detection of adulterants using chemical biology. | Y. S. Rajput | NAIP | 2009 March-13 | 125.96 |
| 47. | Strengthening statistical computing for NARS. | R. Malhotra | NAIP | 2010-March-14 | 55.24 |
| 48. | Bio-prospecting of genes and allele mining for abiotic stress tolerance. | R. C. Upadhyay | NAIP | 2009- 13 | 44.60 |
| 49. | Molecular basis of capacitation like changes in the assessment and prevention of cryodamage during cryopreservation of bovine spermatozoa (buffalo and crossbred bulls | Dr. S.K. Atreja | NAIP | upto June - 2013 | 272.12 |

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|-----|--|--|----------|------------------|--------|
| 50. | Strengthening of digital library and information management under NARS (e GRANTH) | Dr. B.R. Yadav | NAIP | upto March 2014 | 38.41 |
| 51. | Developing commissioning operating & managing an online system for NET/ARS Prelim examination by ASRB ICAR | Dr. A.K. Srivastava | NAIP | upto March 2014 | 32.45 |
| 52. | Implementation of management information system (MIS) including financial management system (FMS) in ICAR | Sh. J.K Kewaramani | NAIP | upto March 2014 | 31.41 |
| 53. | Impact adaptation and vulternability of Indian agriculture of climate change. | R. C. Upadhyay | Network | 2004-2012 | 61.95 |
| 54. | Adaptation of livestock to impending climate change through shelter management. | R. C. Upadhyay | Network | 2009-12 | 23.00 |
| 55. | Network project on buffalo Improvement-Field Unit (CIRB Hisar-125001). | R. S. Gandhi | Network | 2007-17 | 60.20 |
| 56. | Network project on buffalo improvement-institute herd (CIRB Hisar-125001). | A.K. Chakravarty | Network | 2007-17 | - |
| 57. | Scheme on dairy microbes under network mode. | R. K. Malik | Network | 2010-13 | 95.00 |
| 58. | Network project on R&D support for process upgradation of indigenous milk products for industrial application. | G. R. Patil (NDRI) Satish Kulkarni (SRS) | Network | 1999 March, 2013 | 51.11 |
| 59. | Rumen microbial manipulations for mitigation of methane emission and productivity enhancement in dairy animals. | S. K. Sirohi | NFBSFARA | 2007-12 | 70.88 |
| 60. | Micro-encapsulation of bacteriocins for their controlled release. | R. K. Malik | NFBSFARA | 2011-14 | 52.75 |
| 61. | Investigations on high pressure induced effect on quality characteristics of buffalo milk | A. K. Singh | NFBSFARA | 2011Dec.-12 | 66.02 |
| 62. | Deciphering the mechanism of aberrant maternal recognition of pregnancy events in sheep and buffalo under heat and nutritional stress. | T. K. Datta | NFBSFARA | 2010-15 | 77.11 |
| 63. | Early detection of pregnancy in cow and buffalo by pregnancy associated proteins (PAPs). | A.K. Mohanty | NFBSFARA | 2012-15 | 200.39 |
| 64. | Infertility in crossbred bulls:Search for spermatogenic cell markers for early prediction on fertility. | A.Kumaresan | NFBSFARA | 2012-162 | 41.30 |
| 65. | Development of transgenic goat for production of human lactogerrin. | M. S. Chauhan | NFBSFARA | 2012-16 | 253.68 |
| 66. | Countering gastrointestinal tract pathogens by adhesion-promoting probiotic surface proteins. | J. K. Kaushik | NFBSFARA | 2012-15 | 123.68 |
| 67. | Enhancing development competence of oocytes for better <i>in vitro</i> fertilizing ability. | T. K. Datta | NFBSFARA | 2013-16 | 107.17 |

7. EMPOWERMENT OF WOMEN & MAINSTREAM OF GENDER ISSUES

DAIRY EXTENSION DIVISION

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.

| Name of the Course | Organised at | No. of Courses | Total no. of Participants |
|---|--|----------------|---------------------------|
| Capacity Building of farm-women in scientific dairy farming | Subri Kulwehri Shahpur Bazidpur | 13 | 212 |
| Capacity building of farm women in animal health and management. | Bazidpur Kulwahri | 2 | 24 |
| Capacity building of Farm women in fruits and vegetables preservation | Kulwehri | 1 | 15 |
| Capacity building of farm women in value added milk products | Kulwaheri, Bazidpur Subri Shahpur | 17 | 221 |
| Awareness campaign in women empowerment through formation of dairy SHGs dairy | Bazidpur Khirajpur | 8 | 96 |
| Awareness campaign in child care nutrition practices | Khirajpur | 2 | 25 |
| Total | | 43 | 593 |

Salient Achievements

Initiative were taken to form a new self-help group in village Bazidpur. The self-help group was formed on the name of Sidak Self-Help group on 9th August 2012. This group has 14 members and has deposit of Rs.8400. This group has already been trained in scientific dairy farming and value added milk products. By adopting scientific dairy farming practices, they have increased the milk production and also adopted the technology for preparation of milk products, which has indirectly increased their income by making paneer and other sweets at home.

KRISHI VIGYAN KENDRA (KVK)

- Twenty two training programmes were organized particularly for rural women/girls and extension functionaries in the areas of 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 participated by 495 women from KVK adopted villages, NDRI, Karnal.
- Nine sponsored training programmes were organized by KVK & DTC, NDRI in Scientific Dairy Farming and Clean Milk Production for 195 farm women from Utrakhand, Bihar, Rajasthan, and Himachal Pradesh. They were explained and

demonstrated the relevant dairy production and processing technologies.

- In the short training cum exposure visits, more than 350 farm women from Himachal Pradesh and Rajasthan were provided scientific knowledge on dairy farming, home science and allied fields.
- One training programme of ten day on Entrepreneurship Development in Food Processing was organized for 10 rural women by KVK, NDRI, Karnal.
- A training programme for five days was organized on entrepreneurship development in Block Printing for 11 rural women of Karnal district at KVK, NDRI, Karnal.
- One training programmes in entrepreneurship development through value added Milk Products i.e. paneer making and khoa making for self employment generation were organized for 10 extension functionaries of Self Help Group at KVK, NDRI. Karnal.
- National Nutrition Week participated by 65 women was organized in KVK adopted village on 4th November 2012 in village Shamgarh.
- World Health day was celebrated in village Palnagar on 12th April 2012. Forty farm women participated in this programme.

- Three training programmes on clean milk production were organized for 78 rural women at KVK, and in KVK adopted villages NDRI, Karnal.
- Two training programmes on “Preparation of Low Cost Balanced Diet and Nutrition” for all age groups were organized in KVK adopted villages in which 113 women participated.
- Two training programmes of one month duration each on “Stitching of Ladies Garments” were organized in KVK adopted villages in which 40 rural women were imparted training.
- KVK organized four *Mahila Sangoshtis* on the topic “Economic Activities for Women Empowerment” for 324 extension functionaries from district Karnal, Kurukshetra, Mahindergarh and Bhiwani at Rajiv Gandhi Swarajgor Institute of Panchayati Raj and Community Development Center, Nilokheri, Dist Karnal.
- KVK in association with IFFCO organized a programme on capacity building for about 30 rural women from village Kulwehri Distt. Karnal on 31st July, 2012 at KVK NDRI Karnal.

DAIRY TECHNOLOGY DIVISION

Entrepreneurship development campaign was launched for transferring some of the technologies that have been developed in the field of composite dairy foods. Under the project one Self Help Group (SHG) namely Nirmal Dhara Mahila Dugdh Samiti, was formed in village Taprana and the women members of the SHG were trained for the manufacture of quality dairy products. Training was also given on testing of

milk and milk products. The samiti is processing around 100 liters of milk per day and manufacturing various dairy products including paneer, curd and khoa. Eight women belonging to SHG named as Shagun Bakery, Darad have been trained for the manufacture of bakery products such as biscuits, bread, buns, cakes and muffins. The training programme is continuing and SHG will establish the bakery in village Darad. All these activities have been carried out in collaboration with Arpana Research and Charities Trust, Madhuban.

SOUTHERN CAMPUS, BANGALORE

The Extension activities were primarily focused on empowering rural women through knowledge dissemination and creating awareness programmers on modern dairy farming practices to augment their income through profitable dairy farming. Various Training programmes and demonstrations on different dairying practices were conducted for rural women farmers and also for various women self help groups. An Extension Research Project on “Dairy Entrepreneurship Development of Rural Women: An Action Research” was under taken under the thematic research programme of “Promoting Dairy Enterprise through Transfer of Technologies, improved farm financing, supply chain management and better market access”. Under this project, the women SHGs are trained in dairy processing technologies and encouraged to process the raw milk into various dairy products and market them directly to the desired customers so that a huge share of profit is secured by the group only and thus paving the way for the economic empowerment of rural women.



Women self help group displaying the milk products during Dairy Mela-2013

8. PUBLICATIONS

INSTITUTE PUBLICATIONS

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DAIRY CATTLE BREEDING

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**SOUTHERN REGIONAL STATION,
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9. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGIES

INDUSTRIAL CONSULTANCY SERVICES

In year 2012-13, the consultancy services helped many prospective dairy entrepreneurs by providing project reports, which enabled them to secure loans/financial assistance from different organizations. Revenue generated from consultancy services was utilized for strengthening the Institute's infrastructure and R&D work and also part of the money was shared among the scientists rendering such service as an incentive. Consultancy services also provided a via media for two-way communication between scientists and industry. Feedback from industry through such interactions helped the scientists to focus and fine-tune their research efforts to fulfil the real needs of dairy industry. During **2012-13**, the Institute provided services to 119 organizations and generated a total revenue of **Rs.1, 13, 23, 720/-**.

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 2012-13, five ITMC meetings were held on 13-4-12, 1-5-2012, 30-7-12, 5-10-12 and 24-11-2012. Patent applications were examined during ITMC meetings for their novelty and commercial applicability before these were recommended for submission through NRDC.

Patent applications submitted to NRDC/Patent office (2012-2013)

1. Buffalo casein hydrolysates rich in Caseinophosphopeptides. (Patent Application No. 331/DEL/2013)
2. An innovative approach for detection of *Enterococci* in milk using spore germination based bioassay (Patent Application No. 119/DEL/2012)
3. A novel enzyme substrate based rapid assay for detection of *L. monocytogenes* in milk. (Quote No. IPR/FA/12037-L/2012)
4. Application of a mammary gland specific glycoprotein-40 (MGP-40) as a biomarker for detection of sub-clinical mastitis in cows and buffaloes.
5. Development of a *Bubalus bubalis* (Indian water buffalo) mammary epithelial cell for *in vitro* gene expression studies.
6. Iron fortified biscuits from a composite dairy-cereal mix.
7. A milk-protein based nutritive antacid and method of making the same.

First examination report of following patent applications submitted to patent office

1. A process for instant rasmali mix (Patent Application No. 2738/DEL/2006)
2. Formulation of ready to use cheese poori mix (Patent Application No. 1984/DEL/2004)
3. A mechanized system for continuous production of Chhana Balls (Patent Application No. 1402/DEL/2004)
4. Process for shelf-stable low-fat tomato-whey soup (Patent Application No. 1714/DEL/2006)
5. Process for coconut cream filled gouda cheese (Patent Application No. 2737/DEL/2006)
6. A process for preparation of acido-bifidus probiotic Dahi (Patent Application No. 639/DEL/2007)
7. A process for long life milk cake (Patent Application No. 641/DEL/2007)
8. A non-invasive DNA isolation methodology in dairy animals (Patent Application No. 1366/DEL/2007).

Commercialization of Technologies

Pricing of the technologies viz. Functional processed cheese spread, buffalo-milk feta cheese, functional quarg cheese, dietetic misti Dahi, buffalo-milk set plain Dahi, buffalo-milk set plain yoghurt, cow-milk set plain yoghurt, cow-milk set plain dahi, extended shelf-life functional paneer, long-life milk cake, low-fat gulab jamun mix and Arjun herbal Ghee were finalized for initiating commercialization process.

The following technologies were evaluated and commercialized:

A new test for detergent detection for milk was evaluated at Punjab Biotechnology Incubator, Mohali and Mother Dairy, Delhi. The Mother Dairy has been purchased the technology for license fee amounting to Rs- 6.00 Lakhs.

Submission of microbial cultures

Two probiotic cultures Viz., *Lactobacillus acidophilus* (LaVK2) & *Bifidobacterium bifidum* (BbVK3) were submitted at MTCC, IMTECH, Chandigarh as a part of requirement for the grant of patent on Probiotic Dahi.

NDRI Industry Meet

NDRI-Industry Meet was held on December 1, 2012. At this Meet, 34 technologies developed at NDRI were presented before 42 participants from 32 Industrial houses and stakeholders with a focus for their commercialization. These technologies included detection test for detergent, antibiotic residues, *Listeria monocytogenes*, *Enterococci*, aflatoxin M1 in milk, cheese spread, Feta cheese, Quarg cheese, Misti dahi, cow plain dahi, cow plain yoghurt, buffalo plain yoghurt, buffalo plain dahi, herbal ghee, long-life milk-cake, low-fat Gulab-jamun, functional milk drink, iron-fortified biscuits, reconstituted kheer, reconstituted rasmalai, reconstituted basundi, extended shelf-life of paneer, cereal based fermented beverages, whey based

beverages, and soups, anionic diet for controlling milk fever, milk protein based bajra snacks, whey-skim milk-millet based complementary food, continuous khoa making machine, continuous butter melter, continuous ghee making, supplements mixtures, mineral mixture and Degcure mixture. Forty two personnel from thirty two industrial-houses or sweet manufacturers participated in NDRI-Industry Meet. This awareness programme helped in sensitization of available technologies for their commercial transfer. At this meet, the participants were shown live demonstration on dairy equipments viz. khoa making machine, butter melter and ghee making machine. Big industrial-houses viz. Healcraft Pharma Pvt. Ltd. Baddi, Zytex Biotech Pvt. Ltd., Mumbai, Qabool querensees Pvt. Ltd. Delhi, The Hershey Company, USA, Westfalia Surge India, IDMC Pvt Ltd. Gujrat, North and South Kenth Ind South Asia Pvt. Ltd. Chennai and Modern Dairy, Karnal and sweet manufacturers showed interest in technologies.



Participants being shown live demonstration on dairy equipments



In-line system for production of Indian Dairy products



Milk-whey-cereal based complementary food

10. RESEARCH PRIORITIZATION, MONITORING AND EVALUATION (PME)

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 meeting of the RAC of NDRI, Karnal were held on 14th May 2012 and 19th December 2012 under the chairmanship of Dr. K. Pradhan. New RAC of the Institute has been constituted vide ICAR letter F.N. 12-24/12-IA-1 dated 16th November 2012. The first meeting under the chairmanship of Dr. B. N. Mathur, Former Director, NDRI Karnal was convened on 4th February 2013.

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 9th, 13th, 14th and 16th August, 2012 at NDRI, Karnal, 20th July, 2012 SRS, Bangalore and 13th September ERS, Kalyani, respectively. The final reports of the completed research projects were discussed at length during the Institute Research Council Meetings held on 11th December 2012 at SRS, Bangalore on 10th April 2013 at ERS, Kalyani and on 1st - 2nd March 2013 at NDRI, Karnal. At these meetings, new proposals for research projects to be initiated from the year 2013 were also considered for approval. IRC meetings were chaired Dr. A. K. Srivastava, Director/or Dr. Rishendra Verma Joint Director (Res.), NDRI Karnal.

National Agricultural Innovation Project (NAIP)

There are **twenty** NAIP projects; in which NDRI is either a lead centre or consortium partner. The total budget outlay is Rs. 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 cost equipments have been procured under this programme. The facilities are being used by scientists and students in pursuing 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 were held regularly 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 to develop linkages with IITs and CSIR laboratories.

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 2012. 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 2011-2012** was edited and published through this cell. Research Projects of

the Institute were also documented under the Research Programmes 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 2012-2013**. 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 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 (2012) 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 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.



Dr. S. Ayyappan, Hon'ble Secretary DARE and Director General ICAR giving insights on the PME functioning at ICAR

11. HUMAN RESOURCE DEVELOPMENT

SCIENTISTS/OFFICERS/SCHOLARS TRAINED ABROAD

- **Dr. A. K. Srivastava**, Director NDRI participated in the Workshop for CGIAR, Research Programme on Dryland System, Integrated Agricultural Production System for the Poor and Vulnerable in Dry Area from 25th – 28th June, 2012 at Dubai.
- **Dr. Anil Kumar Puniya**, Principal Scientist, Dairy Microbiology Division participated in the 1st International Conference in Animal Nutrition and Environment from 13th – 18th September, 2012 at Khon Kaen, Thailand.
- **Dr. Magan Singh**, Sr. Scientist, Forage Research & Management Centre was deputed for exposure visit Training and Up-gradation of Technical Knowledge in Administration & Management at Japan from 29th – 30th September, 2012 (including journey period).
- **Dr. S. S. Thakur**, Principal Scientist, Dairy Cattle Nutrition Division participated in the Science Symposium, Elanco Animal Health at Chicago Illinois USA from 1st October – 5th October, 2012.
- **Dr. V. P. Singh**, Joint Director (Academic) was deputed for consortium meeting of Indo-UK Collaborating Programme on Development of HS Vaccine held at UK from 29th – 30th October 2012.
- **Dr. Satish Kulkarni**, Head, SRS Bangalore participated in “India – New Zealand Business Forum 2012” and delivered a talk on “The Indian Dairy Industry – Opportunities & Challenges” on 28th November 2012 at University of Waikato, Hamilton, New Zealand.
- **Dr. A. K. Tyagi**, Principal Scientist and **Dr. Sumit Arora**, Principal Scientist were deputed to Teagasc Moorpark Food Research Centre Moorpark Fermoy Ireland from 3rd to 11th February, 2013 under Indo Ireland Research Project.
- **Dr. A. K. Tyagi**, Principal Scientist visited KaHo Sint-Lieven Gent Belgium under Erasmus Mundus programme from 28th October to 18th November 2012.
- **Dr. Vivek Sharma**, awarded Erasmus Mundus Fellowship of European Union for the year 2011- 12. to take part in the European M.Sc. Degree in Food Science, Technology and Nutrition as a scholar (Visiting Professor) from 30th April to 26th May, 2012 at Katholieke Hogeschool, Gent Belgium and Dublin Institute of Technology, Ireland.

Scientists/officers Participation In Workshops/ Seminars/ Conferences/trainings Within India

| Name & Designation | Title of Workshop/Seminar/ Conferences Training | Period |
|--|--|---|
| Name & Designation | First Indo-US International Conference on “Polymers for Packaging Applications” Mahatma Gandhi University, Kottayam, Kerala. | 31 st March to 2 nd April, 2012 |
| Dr. B. R. Yadav, PS | National Conference on “Current Trends in Biotechnology - 2012 (CTBT-2012)”, at DAV College for Women, Karnal. | 3 rd April, 2012 |
| Dr. T. K. Dutta, Head Dr. P. K. Roy, PS Dr. M. K. Ghosh, PS | National Seminar on “Dairy Development in Eastern India – Constraint and Remedies”, Institute of Engineers Complex, Kolkata. | 7 th April, 2012 |
| Dr. T. K. Dutta, Head Dr. P. K. Roy, PS Dr. M. K. Ghosh, PS | National Seminar on “Dairy Development in Eastern India – Constraint and Remedies”, Institute of Engineers Complex, Kolkata. | 7 th April, 2012 |
| Dr. Subrata K. Das, PS Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci. | Engineers Complex, Kolkata. | |
| Dr. R. R. B. Singh, PS | National Seminar on “Dairying in Eastern India” at Hotel Maurya, Patna. | 15 th -16 th April 2012 |

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| Dr. S. K. Kanawjia, PS | National Seminar on “Dairying in Eastern India” at Hotel Maurya, Patna | 16 th April 2012 |
| Dr. Shiv Prasad, PS Dr. S. S. Lathwal, PS Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci | 5 th IFIP World IT Forum 2012 and present the paper entitled” Development of Wireless Censor Network for Animal Management” at Vigyan Bhawan, New Delhi. | 16 th – 18 th April, 2012 |
| Dr.(Mrs.) Jancy Gupta, PS | World IT Forum (WITFOR 2012) on “Sustainable Human Development in four the Matic Areas E-governance Agriculture Health and Education”, New Delhi. | 16 th – 18 th April, 2012 |
| Dr. Bandla Srinivas, PS | Food Safety Management Systems (ISO 22000:2005): Alumni Association, Southern Regional Station, National Dairy Research Institute, Bangalore. | 17 th - 21 st April, 2012 |
| Dr. D. K. Gosain, PS Mr. Mohar Singh, TO | Multi Stock Holder Consultation on Spring Maize organized by CSISA at Ladwa, Kurukshetra. | 19 th April, 2012 |
| Dr. Rameshwar Singh, Head Dr. R. K. Malik, PS Dr. Mahendra Singh, PS Dr. Parveen Kumar, PS | Seminar on “Food Safety and Standard Act and Dairy Industry of IDA” (North Zone), New Delhi. | 27 th – 28 th April, 2012 |
| Sh. Pushpanayak, CAO Sh. Mithlesh Kumar, Sr. F&AO Sh. Vishal Acharya, AF&AO Sh. Brahm Parkash, AAO Sh. A. G. Barapatre, AAO | Implementation of Management Information System (MIS) including Financial Management System (FMS) at IASRI, New Delhi. | 30 th April to 5 th May, 2012 |
| Dr. R. S. Gandhi, Head Dr. A. A. Patel, Head | Workshop on “Systematic Approach to Training” at IASRI, New Delhi. | 3 rd – 5 th May, 2012 |
| Dr. A.K. Sharma, Sr. Sci. | Workshop on “All India Survey on Higher Education (AISHE) for Nodal Officers from the Universities located in Haryana and Punjab states including Chandigarh, UT” at Govt. College for Girls, Sector-14, Panchkula. | 5 th May, 2012 |
| Dr. D. K. Gosain, PS Mr. Kulvir Singh, TO | Zonal KVKs Workshop at CSKHKW, Palampur (H.P). | 20 th - 22 nd May, 2012 |
| Dr. M. K. Singh, PS | Summer Short Course on “Genomic and Phenomic Tools for the Analysis of Livestock Gaenome” at NBAGR, Karnal. | 14 th – 23 rd June, 2012 |
| Dr. Rajan Sharma, PS | National Seminar on “Food Safety – Role of Standards” organized by Bureau of Indian Standards at Chennai. | 20 th June, 2012 |
| Dr. R. Malhotra, PS | Project Completion Workshop & Installation Training –cum–Workshop of Nodal Officers of NAIP project on Strengthening Statistical Computing for NARS. IASRI, New Delhi | 25 th -26 th June, 2012 |
| Dr. Archana Verma, PS Dr. Avtar Singh, PS | International Workshop on “Innovative Teaching for Improved Learning” organized by USAID, University of Illinois, USA and Cornell University, USA under the auspices of Agricultural Innovation Partnership (AIP) at Sheraton Hotel, New Delhi. | 16 th -18 th July, 2012 |

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| Dr. K. K. Datta, Head Dr. Rishikanta Singh, Sci. | International Workshop on “Innovative Teaching for Improved Learning” ITC Sheraton, New Delhi. | 17 th –18 th July, 2012 |
| Dr. D. K. Gosain, PS Mr. Mohar Singh, TO Mr. Kulvir Singh, TO | Seminar on “Green Revolution-White Revolution” organized by Amrik Singh Cheema Foundation Trust at Chandigarh. | 18 th July, 2012 |
| Dr. S. K. Tomar, PS | 2 nd Annual Review Workshop of “National Fund for Basic Strategies & Frontier Application Research in Agriculture” at NASC, New Delhi. | 23 rd -24 th July, 2012 |
| Dr. D. K. Gosain, PS Dr. Satya Pal, TO | Seminar on “Infertility Management of Livestock in Gujrat” organized by Zonal Project Director, ICAR, CAZRI Campus, Jodhpur (Rajasthan) at Anand Agriculture University, Anand (Gujrat). | 27 th July, 2012 |
| Dr. D K Gosain, PS Mr. Mohar Singh, TO Mr. Kulvir Singh, TO | State Level Review Workshop of KVKs Haryana and Delhi on Drought Mitigation at CCSHAU, Hisar organized by ZPD, Ludhiana. | 30 th July, 2012 |
| Dr. S. Subash, Sci. | National Consultation on “Integrated development of Uttara Kannada District of Karnataka” organized by CMFRI (RS), Karwar at Karwar. | 1 st August, 2012 |
| Dr. S. Subash, Sci. | Workshop on “Institutional Innovations in Agri-Extension for Inclusive Growth” organized by NAARM at Hyderabad. | 1 st – 7 th August, 2012 |
| Mrs. Ritu Chakarvarty, Sr. Sci. | Review and Planning Workshop of Core Institutes for TDC Component of NICRA Project, held at IIHR, Bangalore. | 7 th -8 th August, 2012 |
| Dr. D. K. Gosain, PS Dr. Satya Pal, TO | Seminar on “Strategies to Improve Productivity of Infertile Animals in Rajasthan” organized by Zonal Project Director, ICAR, CAZRI Campus, Jodhpur (Raj.) at A.R.S., Durgapur, Jaipur (Rajasthan). | 9 th August, 2012 |
| Dr. Dheer Singh, PS | INSIRE Camp at IFS College of Pharmacy, Moga. | 20 th -25 th August 2012 |
| Dr. Mukund A. KataktaIware, PS | National Training Programme on “Assessment of microbial diversity by New Generation Sequencing (NGS) for taxonomic and Metabolic Reconstruction of the Gut Microbes” at NIANP, Bangalore. | 22 th August to 4 th September, 2012 |
| Mr. Yogesh Khetra, Sci. | NDRI, Karnal and Punjab Halwai Association Meet CIPHET, Ludhiana | 27 th August, 2012 |
| Dr. Y.S. Rajput, Head Dr. A. K. Mohanty, PS Dr. J. K. Kaushik, PS Dr. Latha Sabiki, PS Dr. Surjit Mandal, PS Dr. Rajeev Kapila, PS Dr. Suman Kapila, PS Dr. Sumit Arora, PS Dr. Bimlesh Mann, PS Dr. Vivek Sharma, PS Dr. Rajan Sharma, PS Dr. R. R. B. Singh, PS Dr. R. K. Malik, PS Dr. Sunita Grover, PS Dr. A. K. Puniya, PS | 1 st Annual Conference of PAi (Probiotic Association of India) and the “International Symposium on Probiotics for Human Health”, New Delhi. | 27 th - 28 th August, 2012 |

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| Dr. Chand Ram, PS Dr. Surjit Mandal, PS Ms. Rashmi. H.M, Sci. Dr. P. N. Raju, Sci. Mr. Sathish Kumar, M.H. Sci. | | |
| Mr. B. P. Singh, T.O. | Workshop on “Strengthening of Digital Library and Information Management under NARS (e-Granth)” organised at Madras Veterinary College Library, Tamil Nadu Veterinary and Animal Sciences University, Chennai. | 27 th -28 th August 2012 |
| Dr. Rameshwar Singh, Head Dr. A. A. Patel, Head Dr. R. K. Malik, PS Dr. Sunita Grover, PS Dr. A. K. Puniya, PS Dr. Shilpa Vij, PS Dr. Chand Ram, PS Dr. Surjit Mandal, PS Dr. J. K. Kaushik, PS Dr. Latha Sabikhi, PS Dr. Pradip V. Behare, Sci. Dr. Satish Kumar M.H, Sci. Mr. Raghu H.V., Sci. Ms. Rashmi. H.M, Sci. | 1 st Annual Conference with National Symposium on “Probiotics for Human Health-New Innovation and Emerging Trends” at India Habitat Centre, Pusa, New Delhi. | 28 th – 29 th August, 2012 |
| Dr. A.K. Sharma, Sr. Sci. | Content updating meeting for the Web Page of Animal Science Division at ICAR Head Quarters. Krishi Bhawan, New Delhi. | 29 th August, 2012 |
| Dr. S. K. Kanawjia, PS Sh. R. C. Meena, Sr.AO Sh. Ram Niwas Panchal, AAO Sh. Ishwar Diyal, AAO | Non-Residential Workshop on “Reservation Policy for Scs, Sts, OBC, Ex-Servicemen and Persons with Disabilities” being organized by the Sansadhan Vikas Tatha Prabandhan Sanstha, Jaipur Rajasthan and Regional Office of the National Commission for Scheduled Tribes, Jaipur at Hotel Jaipur Palace, Near Laxmi Mandir, Tonk Road, Jaipur (Rajasthan). | 6 th - 8 th September, 2012 |
| Dr. A.K. Puniya, PS | XXVI Annual Convention of “Indian Association of Vety. Microbiologists, Immunologists and Specialists in Infectious Diseases” & International Seminar on Future of Livestock Health, T.N. Vety. & Ani. Sci. Univ., Madras Vety. Collge, Chennai. | 6 th - 8 th September, 2012 |
| Dr. P. K. Roy, PS | Hindi Workshop at NIRJAFT, Kolkata. | 10 th -11 th September, 2012 |
| Dr. Archana Verma, PS Dr. A. Mandal, Sr. Sci. | 3 rd World Congress on Biotechnology at Hyderabad International Convention Centre, Hyderabad. | 13 th -15 th September, 2012 |
| Dr. A. K. Dodeja, Head, Dr. I. K. Sawhney, PS Dr. K. Jayaraj Rao, PS Dr. P. S. Minz , Sci. Mr. Raghu H.V. Sci. | 7 th Convection of Indian Dairy Engineering Association and National Seminar on “Automation in Dairy and Food Industry” at Shri Venkateshwara Veterinary University, Tirupati (AP). | 24 th -25 th September, 2012 |
| Dr. Bimlesh Mann, PS Dr. Rajan Sharma, Sr. Sci. Dr. Naresh Kumar, Sr. Sci. | Technical workshop on “Risk based Approaches on Food Safety Management,” New Delhi. | 26 th -27 th September, 2012 |

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| Dr. A. S. Harika, PS Dr. D. S. Sohi, PS Dr. Magan Singh, Sr. Sci. | Third International Congress on “Agricultural Diversification, Climate change Management and Livelihoods” at IARI, New Delhi. | 26 th -30 th September, 2012 |
| Dr. I. K. Sawhney, PS Dr. S. Kulkarni, PS Dr. B. Surendranath, PS | National Workshop on “Revamping Education and Research in Dairy Processing to Meet Global Challenges” and to deliver a lecture at College of Dairy Sciences and Technology, Kerala Veterinary and Animal Science University, Thirsur. | 27 th – 29 th September, 2012 |
| Dr. Bimlesh Mann, PS | Meeting of the Nanotechnology Platform at CPRI, Shimla. | 29 th September, 2012 |
| Dr. Vivek Sharma, PS Dr. Rajan Sharma, Sr. Sci. Dr. Naresh Kumar, PS Dr. Shilpa Vij, PS | NAIP-NDRI-CIPHET- Punjab Halwai Association Interface on “Milk Quality Assurance and Dairy based Health Foods” at CIPHET Ludhiana. | 3 rd October, 2012 |
| Dr. R. C. Upadhyay, Head | Conference on “Veterinary Resulting Reforms in India: Current Status and the Road Ahead and Meeting of IVA” at New Delhi. | 6 th October, 2012 |
| Dr. K. K. Datta, Head Dr. B. S. Chandel, PS Dr. A. K. Chauhan, PS Dr. Rishikanta Singh, Sci. Dr. Udit Chaudhary, Sci. | 20 th Annual Conference of the Agricultural Economics Research Association (Indian) at IARI, New Delhi. | 9 th -11 th October, 2012 |
| Dr. K. K. Datta, Head Dr. Rishikanta Singh, Sci. | Workshop on “Supply Chain Management in Agriculture” at NAARM Hyderabad. | 15 th - 19 th October, 2012 |
| Mrs. Rashmi H. M., Sci., | Short Course on “Moteogronics Role of at Anand Agriculture University Anand. | 15 th - 24 th October, 2012 |
| Dr. M. C. A. Devi, Sr. Sci. | Seminar on “Word Food Day – 2012” on “Agricultural Cooperatives: Key to Feeding the World” organized and to be held at Institution of Agricultural Technologists (IAT), Bangalore. | 18 th October, 2012 |
| Dr. K.P. Ramesha, PS | “Lead Auditor course ISO14001” at BIS, NOIDA, Delhi. | 19 th - 23 rd October, 2012 |
| Dr. D. Malakar, Sr. Sci. | International Conference on “Natural Polymers & Bio polymers, Biomaterials, their Composites, Blends, IPNs, Polyelectrolytes and GTels” at Mahatma Gandhi University, Kottayam Kerela. | 26 th - 28 th October, 2012 |
| Dr. Ravinder Kumar Malik, Head Dr.(Mrs.) Meena Malik, Associate Professor (English) | Training programme on “Hands on Training On-Line Processing of Articles” at DKMA, New Delhi. | 30 th - 31 st October, 2012 |
| Dr. B. R. Yadav, PS Dr. A. K. Chakravarty, PS | Brainstorming session on “Mastitis Management in Dairy Animals” at NAAS, New Delhi. | 31 st October, 2012 |
| Dr. A. K. Chakravarty, PS | Farmars-Scientist Interaction on “Agriculture and Allied Departments” at Raipur, Chattisgarh. | 4 th November, 2012 |
| Dr. R. C. Updadyay, Head Dr. O. K. Hooda, PS Dr. Sohan Vir Singh, PS Dr. Ashwabni Kumar Roy, Sr. Sci. | National Symposium on “Physiological Research in changing Environmental Scenario for Sustainable Livestock and Poultry Production and Present the Paper” at Navsari Agriculture for University, Navsari (Gujarat). | 6 th -8 th November, 2012 |

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| Dr. S. K. Singla, P.S. | Workshop on “An Action Planning for Conservation of Sild Water Buffaloes in Central India” at Nagpur, Maharashtra State. | 5 th -7 th November, 2012 |
| Dr. Dheer Singh, PS | Symposium on “Chemistry & Biology, Two Weapons against Disease and 81 Annual Meeting of SBC(1)” at Science City, Kolkatta. | 8 th -11 th November, 2012 |
| Dr. Rajan Sharma, Sr. Sci. | ASEAN India Expo & Meet organized by ICAR at NASC Complex, New Delhi. | 17 th November, 2012 |
| Sh. Sudershan Kumar, Sci. | Short Course on “Recent developments in epigenetic, structural and functional genomics for animal genetic resource conservation viz a viz augmentation of productivity in poultry and livestock species at PDP, Hyderabad. | 17 th -26 th November, 2012 |
| Dr. Dheer Singh, PS Dr. S. De, PS Dr. T. K. Datta, PS Dr. A. K. Mohanty, PS Dr. M.K. Singh, Sci. | Workshop on “Exploring recombinant bone morphogenetic protein receptor protein BMPR-1B) as a fecundity vaccine for improving the prolificacy of non-prolific sheep breed of India” at NAARM Hyderabad. | 19 th - 21 st November, 2012 |
| Dr. D. K. Gosain, PS | Project Development Workshop at NAARM Hyderabad. | 19 th - 21 st November, 2012 |
| Dr. D. K. Gosain, PS Dr. C. J. Juneja, TO Dr. Satya Pal, TO Mr. Kulvir Singh, TO Ms. Saroj Mehta, TO Mr. Mohar Singh, TO | Seventh National Conference on KVKs held at PAU, Ludhiana, (Punjab). | 20 th – 22 nd November, 2012 |
| Dr. M. S. Chauhan, PS Dr. Pawan Singh, PS Dr. Mukesh Bhagat, Sr. Sci. | National Symposium on Addressing Animal Reproductive Stress through Biotechnological Tools at College of Vety. Science, Assam Agricultural University, Khanapara, Guwahati | 21 st -23 rd November, 2012 |
| Dr. B. R. Yadav, PS | Brainstorming session on 'Research Priorities in Animal Biotechnology for Augmentation of Productivity' by 'Agri Biotech Foundation- National Institute of Animal Biotechnology (NIAB)', at Hyderabad. | 22 nd November, 2012 |
| Dr. R. S. Gandhi, Head Dr. B. R. Yadav, PS | National Symposium on “Conventional Breeding and Emerging Technologies in Changing Global Scenario – Challenges, Prospects and Retrospects” organized at College of Veterinary Science, Sri Venkateshwara Veterinary University, Hyderabad. | 22 nd - 23 rd November, 2012 |
| Dr. A. K. Mohanty, PS | International Symposium on Proteomics beyond IDs and Fourth Annual meeting of proteomics Society (India) at NCL Pune. | 22 nd - 24 th November, 2012 |
| Dr.(Mrs.) Shilpa Vij, Sr. Sci. | Workshop on accepted Project Concept note under “National Fund for Basic, Strategic and Frontier Application Research in Agriculture” at NAARM, Hyderabad. | 22 nd - 24 th November, 2012 |
| Dr. B. R. Yadav, PS | National Symposium on “Improvement of Livestock Productivity through Conventional Breeding and Emerging Technologies ...Retrospective and XII Annual Conference” at College of Veterinary Science, Hyderabad. | 23 th November, 2012 |

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| Dr. M. Manjunatha, Sr. Sci. | Attended the training on “Spectroscopy methods and data analysis for food quality evaluation” held at CIPHET, Ludhiana. | 26 th November to 1 st December, 2012 |
| Dr. Mukund A. Kataktalware, PS Dr. M. C. A. Devi, Sr. Sci. | Model Training Programme on “Dairy Entrepreneurship Development” sponsored by Directorate of Extension, Ministry of Agriculture, Govt. of India organized by Dept. of Dairy Economics and Business Management of Dairy Science College, Hebbal, Bangalore. | 26 th November to 3 rd December, 2012 |
| Dr. S.S. Kundu, Head Dr. S.K. Tomer, PS Dr. S.K. Sirohi, PS Dr. A.K. Puniya, PS Dr. Chander Datt, SS Dr. Nitin Tyagi, SS | 8 th Biennial Animal Nutrition Association Conference on “Animal Nutrition Research Strategy for Food Security” held at RAJUVAS, Bikaner. | 28 th -30 th November, 2012 |
| Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci. | 3 rd International Conference on “Emerging Applications of Information Technology” held at Indian Statistical Institute, Kolkata. | 30 th November to 1 st December, 2012 |
| Dr. Bimlesh Mann, PS Dr. K. Jayaraj Rao, PS Dr. M.C.A. Devi, Sr. Sci. Dr. S. Varalakshmi, Sr. Sci. Smt. M. K. Vedavathi, Sci. Smt.Vimala, Sci. | National Convention on “Safety Assurance of Foods through Emerging Science and Technology” at CFTRI, Mysore. | 30 th November to 1 st December, 2012 |
| Dr. J. K. Kaushik, Sr. Sci. | Conference on “International Interdisciplinary Science” at Jamia Millia, Islamia, New Delhi. | 8 th - 10 th December, 2012 |
| Dr. Rajan Sharma, Sr. Sci. | National Seminar on “Food Safety – Role of Standards” organized by Bureau of Indian Standards at New Delhi. | 12 th December, 2012. |
| Dr. A. Manimaran, Sci. | XI Annual Conference of Indian Society of Pharamocology and Toxicology and National Symposium at Bangalore. | 12 th - 14 th December, 2012 |
| Dr. Risherdra Verma, Joint Director (Res.) Dr. Dheer Singh, PS | National Conference on “Use of Animals and Alternatives in Biomedical Research with Empasis on Dairy Development (NUAAB-2012) at Centre for Advances Studies”, Department of Zoology, Jaipur. | 14 th - 16 th December, 2012 |
| Dr. K. K. Datta, Head | Workshop on “Indian Agri. Food System and the World Market” at New Delhi. | 14 th December, 2012 |
| Dr. Dheer Singh, PS | Refresher course is “Challenges and Opportunities in Life Sciences”, Department of Botany and Zoology, Rajsthan University, Jaipur, Rajasthan | 15 th December, 2012 |
| Dr.(Mrs.) Sunita Grover, PS Dr. B.V. Balasubramanyam, PS Dr. B. Surendra Nath, PS Dr. S. Varalakshmi, PS | Probiotic Symposium at Hotel Sheraton Bengaluru. | 15 th – 16 th December, 2012 |
| Dr. A. K. Chakravarty, PS | Conference for promotion of Dairy Sector organized by J & K Cooperative Union Ltd. at Rajouri, Jammu & Kashmir. | 18 th December, 2012 |
| Dr. I. K. Sawhney, PS Dr. Ravinder Malhotra, PS Dr. A. K. Sharma, PS | 66 th Annual Conference (International Conference) of the Indian Society of Agricultural Statistics (ISAS), IASRI, New Delhi. | 18 th - 20 th December, 2012 |

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| Dr. Bimlesh Mann, PS Dr. S. K. Atreja, PS Dr. A. Mandal, Sr. Sci. | National Seminar on “Future Challenges and Opportunities to Improve Health and Production of Ruminants” organized at Central Institute for Research on Goats, Makhdoom. | 22 nd - 23 rd December, 2012 |
| Dr. Ajay Mandal, Sr. Sci., ERS, Kalyani | International Conference on Indian Statistical a CIRG, Makhdoom, Mathura (UP). | 22 nd - 23 rd December, 2012 |
| Dr. S. K. Kanawjia, PS | Conference on Food Processing and Development of Uttar Pradesh at University of Allahabad (UP). | 27 th - 28 th December, 2012 |
| Dr. G. K. Sachdeva, PS Dr. Archana Verma, PS Dr. Bandla Srinivas, PS Dr. Subrata K. Das, PS Dr. D. Malakar, Sr. Sci. Dr. S. K. Dass, Sr. Sci. | 100 th Indian Science Congress on the theme “Science for Shaping the Future of India” in Kolkata. | 3 rd -7 th January, 2013 |
| Dr. Kaushik Khamrui, Sr. Sci. | Refresher Course in “Agricultural Research Management” NAARM, Hyderabad | 7 th – 20 th January, 2013 |
| Dr. R. K. Malik, PS Dr. P.S. Minz, Sci. Dr. Vijay Kumar Gupta, PS Sh. Devaraja H.C., Sci. Dr. P. N. Raju, Sci. | International Conference at “National Institute of Food Technology Entrepreneurship Management” at Kundli, Sonapat. | 10 th -11 th January, 2013 |
| Dr. Rajan Sharma, Sr. Sci. | Workshop 1 st International Conference on “Innovation in Food Processing” at NIFTEM, Kundli. | 12 th January, 2013 |
| Dr. K. K. Datta, Head Dr. Rishikanta Singh, Sci. | Government's 1 st ICT for Development Conference New Delhi. | 14 th -15 th January, 2013 |
| Dr. Gautam Mandal, Sr.Sci. | Winter School on “Sustainable fish foods and Nutra Courticals to Grow Heats Promoting” at Bhubaneshwar, Odisha | 15 th January, 2013 |
| Dr. R. S. Gandhi, Head | Executive Development Workshop on “Educational Policy and Planning for Promoting Innovation in Agriculture” organized by NAARM, Hyderabad. | 16 th - 19 th January, 2013 |
| Dr. Smita Sirohi, PS | National Seminar on “Prospects of Livestock and Dairying in India under Changing Global Economic Era” at AAU Anand. | 17 th -18 th January, 2013 |
| Dr. A. K. Sharma, Sr. Sci. | Present technical paper in Plenary Section of the “International Conference at Ganpati Institute of Technology & Management, Bilaspur, Jagadhari. | 18 th January, 2013 |
| Dr. Chand Ram, Sr.Sci. | Conference on “Food Safety and Environment” at Indian Habitat Centre, Lodhi Road, New Delhi | 20 th – 21 st January, 2013 |
| Dr. M. S. Chauhan, PS Dr. A. K. Mohanty, Sr. Sci. Dr. S. Dey, Sr. Sci. | International Symposium on “Genomics in Aquaculture” at CIFA Bhubaneshwar. | 22 nd - 23 rd January, 2013 |
| Dr. Sohan Vir Singh, PS | Symposium on “Climate Change and Indian Agricultural”: Slicing Down the Uncertainties and Present the paper entitled “Impact of Temperature Variabilities on Physiological, Hematological and Biochemical Profile of Growing and Adult Buffaloes” at CRIDA, Hyderabad. | 22 nd - 23 rd January, 2013 |

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| Dr. Gopal Sankhala, PS | Meeting of Extension Council of IVRI at IVRI Izatnagar. | 24 th January, 2013 |
| Dr. P. N. Raju, Sci. | International Summit for Packaging Industry (ISPI-2013), Hotel The Leela, Mumbai | 29 th -30 th January, 2013 |
| Dr.(Mrs.) Sunita Grover, PS | International Seminar entitled “Synergistic effect of Beneficial Micolives with Multi-disciplinary Approache”, Hindustan College of ARB, Coimbtore. | 30 th January to 1 st February, 2013 |
| Dr. D. K Gosain, PS Dr. C.J. Juneja, TO Dr. S.K. Gupta, TO Mr. Kulvir Singh, TO Ms. Saroj Mehta, TO Dr. Satya Pal, TO Mr. Mohar Singh, TO | National seminar on Hi-tech vegetable production, post harvest management and marketing organized by KVK and NHRDF Salaru, District Karnal. | 2 nd - 3 rd February, 2013 |
| Dr. A.K. Sharma, PS Dr. J. K. Kaushik, PS | 24 th BTISnet Annual Coordinator Meeting at Lucknow. | 3 rd - 4 th February, 2013 |
| Sh. S. George, Comptroller | Training Course on “Project Formulation and Appraisal” at ISTM, New Delhi. | 4 th - 5 th February, 2013 |
| Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci. | 1 st International Conference on “Bio-Resources and Stress Management” at Bose Institute, Kolkatta. | 6 th -9 th February, 2013 |
| Dr. Nitin Tyagi, Sr. Sci. | 21 days short course on “Clinical Nutrition Approaches for Health and Productivity of Farm Animals” at IVRI, Izatnagar. | 6 th - 24 th February, 2013 |
| Dr. R. S. Gandhi, Head, DCB | National Symposium on “Integrated Development of Vast Biodiversity of Indigenous Livestock for Long Term Rural Livelihood Security” organized at GBPUA&T, Pantnagar. | 7 th - 8 th February, 2013 |
| Dr. D. K. Gosain, PS Dr. Dheer Singh, PS | International Conference on “Repronics-Omics in Reproduction and Development” at AAU, Anand. | 7 th -9 th February, 2013 |
| Dr. D. Malakar, Sr.Sci. | National Conference on “Endo-orinology and Reproduction” at Karnatka University, Dharwar | 11 th -13 th February, 2013. |
| Dr. A. K. Chakravarty, PS | Workshop on “Enhancement of milk productivity of Dairy Cattle-Scope and Challenges” organized by Rajasthan Livestock Development Board at Jaipur. | 19 th -20 th February, 2013 |
| Dr. Chand Ram, PS | Conference on “Food Safety and Toxins” organized by Centre for Science and Environment, New Delhi. | 20 th -21 st February, 2013 |
| Dr. (Mrs.) Madhu Mohini, PS | International Conference on “Recent Advances in Chemical Sciences” and Present the paper entitled “Impact of Livestock on Global Warming through Methane Emission” at Arya P.G. College, Panipat (Haryana). | 24 th -26 th February, 2013 |
| Dr. Rishikanta Singh, Sci. | National Seminar on “Sustainable Development of Rural India” by 2022, NITTTR, Chandigarh | 7 th – 8 th March, 2013 |
| Dr. A. K. Singh, PS | National Training Programme on “Application of High Pressure in Food Processing” Central Institute of Fisheries Technology (CIFT), Kochi. | 12 th March, 2013 |

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| Dr. R. K. Malik, Head Dr. I. K. Sawhney, PS Dr. S. K. Kanwjia, PS Dr. Jancy Gupta, PS Dr. S. K. Singla, PS Dr. I. D. Gupta, PS Dr. Rajan Sharma, Sr. Sci. Dr. Meena Malik, Associate Prof. Dr. G. K. Sachdeva, PS | 41 st Dairy Industry Conference on “Global Dairy Industry & Food Security” at Mumbai. | 14 th – 16 th March, 2013 |
| Dr. R. S. Gandhi, Head Dr. Avtar Singh, PS | National Seminar on “Technological and Policy Interventions for Sustainable Cattle Breeding in India” on organized by Project Directorate on Cattle, Meerut | 14 th March, 2013 |
| Dr. A. K. Singh, PS Dr. T. K. Dutta, PS Dr. P. K. Roy, PS Dr. M. K. Ghosh, PS Dr. Subrata K. Das, PS Dr. R.A. Dey, Sr. Sci. Dr. Lotan Singh, Sr. Sci. Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci. | Scientists-Dairy Industry Partners Interface Organized by ERS of NDRI, Kalyani. | 25 th March, 2013 |
| Dr. A. K. Chakravarty, PS Dr. T. K. Dutta, PS Dr. P. K. Roy, PS Dr. M. K. Ghosh, PS Dr. Subrata K. Das, PS Dr. R.A. Dey, Sr. Sci. Dr. Lotan Singh, Sr. Sci. Dr. A. Mandal, Sr. Sci. Dr. A. Chatterjee, Sr. Sci. | Brainstorming session on “Management of Infertility in Dairy Animals”, at NDRI, Eastern Regional Station, Kalyani, West Bengal. | 26 th March, 2013. |



Sh. Arvind R. Kaushal, Secretary ICAR addressing the farmers during National Dairy Mela-2013 organised at NDRI

12. CONFERENCES/SEMINARS/SYMPOSIA/WORKSHOPS/ TRAINING PROGRAMMES/FIELD DAYS ORGANISED

The Institute hosted 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 :

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| SAARC Regional Training Programme. | 10 th April, 2012 |
| Lead Auditor Course on Food Safety Management | 17 th - 21 st April, 2012 |
| Systems at SRS of NDRI, Bangalore. | |
| Training Programme on Scientific Dairy Farming. | 25 th April – 9 th May, 2012 |
| World Veterinary Day at NDRI, Karnal and ERS, Kalyani. | 28 th April, 2012 |
| Indo-New Zealand Workshop. | 25 th - 26 th May, 2012 |
| World Milk Day at NDRI, Karnal and ERS, Kalyani. | 1 st June, 2012 |
| Interface Meeting on Detection of Adulterants in Milk. | 22 nd June, 2012 |
| Teachers' Day at NDRI, Karnal and SRS, Bangalore | 5 th September, 2012 |
| Engineers' Day Celebration at SRS of NDRI, Bangalore. | 15 th September, 2012 |
| Hindi Week. | 15 th - 21 st September, 2012 |
| Personality Development Lecture on Stress Management. | 17 th September, 2012 |
| National Seminar on Global Opportunities and Concerns in Dairy and Food Sector. | 28 th - 29 th September, 2012 |
| NAIP-NDRI-CIPHET-Punjab Halwai Association Interface. | 3 rd October 2012 |
| International Training Programme on Milk and Dairy Products Processing. | 3 rd - 9 th October, 2012 |
| National Training on Innovative Trends in Dairy and Food Products Formulation. | 10 th – 30 th October, 2012 |
| ICAR Institute- SAU-Development Departments and Stake-holders Interface. | 19 th October, 2012 |
| Farmers' Training Programme on Malnad Gidda Cattle at SRS of NDRI, Bangalore. | 26 th October 2012 |
| Agriculture Education Day. | 23 rd November, 2012 |
| NDRI-Industry Meet. | 1 st December, 2012 |
| Winter school on Advanced Molecular Techniques in Gene Regulation and Functional Genomics. | 3 rd – 23 rd December, 2012 |
| Review Workshop of PME Cells of ICAR. | 8 th December, 2012 |
| National Seminar on Prosperity through Diversification in Agriculture. | 22 nd December, 2012 |
| Kisan Divas. 23 rd December, 2012 ICAR-DARE Informal Retreat. | 28 th - 29 th Dec., 2012 |
| National Training Program on <i>In Vitro</i> Fertilization Technology. | 10 th - 30 th Jan., 2013 |
| National Seminar on New Paradigms in Livestock Production : From Traditional to Commercial Farming and Beyond. | 28 th - 30 th January, 2013 |
| Sensitization Workshop on “B. Tech. (DT) E Courses under National Agricultural Innovation Project (NAIP). | 31 st January, 2013 |
| CAFT Training Programme on “Molecular Genetic Data Generation, Analysis and Utilization on Animal Breeding”. | 5 th - 25 th March, 2013 |
| Scientist – Dairy Industry Partners Interface Meet on “Issues and Challenges of Dairy Industry in the Eastern Part of India” at ERS, Kalyani. | 25 th March, 2013 |
| Brainstorming Session on “Management of Infertility in Dairy Animals” at ERS, Kalyani. | 26 th March, 2013 |

•National Dairy Mela was organized on 25th -27th February, 2013.

13. DISTINGUISHED VISITORS

12.04.2012 Two member delegation from Ministry of Agriculture, Irrigation and Livestock, Kabul Afghan led by Dr. Khuswant Singh Sethi, Capacity Development Advisor, UNDP, Kabul.

- **Mr. Humayun Nawabi, OSD, to Deputy Minister.**
- **Ms. Muzaghan Sadat, Director, Ministry of Agriculture, Irrigation and Livestock.**

20.04.2012 US experts from American Embassy, India for interactive meeting with NDRI, Scientists.

- **Dr. R. Thomson Wright, Attache for Agriculture Affairs, India, Bangladesh, Sri Lanka.**
- **Dr. Ritambhara Singh, Agriculture Specialist.**

25.04.2012 Thirty four member delegation from Australia led by **Mr. Gregory Thomas Cahill.**

02.05.2012 A group of 24 farmers, industry representatives and academicians sponsored by Texas Agricultural Leadership Program (TALL), USA led by **Mr. Jim Mazurkiewicz, Leadership Program Director and Professor.**

09.05.2012 A four member high level delegation from Afghanistan:

- **Mr. R. Osmani, Director General,**



Afghanistan delegation being explained about processing and evaluation of semen in Animal Biotechnology Centre

GDPDM, Independent Administrative Reforms and Civil Service Commission (The Afghan Counterpart of DoPT).

- **Mr. Sultan Hajiyevev, Project Manager, NIBP, UNDP.**
- **Mr. Khushwant S. Sethi, Capacity Development Advisor, Afghan Ministry of Agriculture.**
- **Ms. Serwat Parwaiz J.D., Advisor of the Director General.**

11.05.2012 **Sh. K. Chandramouli, Chairman, FSSAI (Food Safety and Standards Authority of India) Ministry of Health & Family Welfare, Govt. of India, FDA Bhawan, Kotla Road, New Delhi.**

14.05.2012 Seven member delegation from Bhutan, Ministry of Agriculture Forest led by **Mr. Sithar Dorji, Project Director.**

18.05.2012 Six member delegation from FONTERRA Cooperative Group Ltd., New Zealand and IFFCO.

22.05.2012 Four member delegation from University of Abadan (Nigeria) led by **Prof. H. S. Gaur, Dean & Joint Director, (Edn). IARI, New Delhi.**

15.06.2012 Four member delegation from Ministry of Agriculture, Government of the Republic of Mozambique.

20.06.2012 Members of the Parliamentary Standing Committee on Agriculture:

- **Sh. Basudeb Acharya, MP & Chairman**
- **Sh. Nirpendra Acharia, MP**
- **Sh. Narendra Budania, MP**
- **Sh. Shashi Bhushan Behera, MP**
- **Sh. Rajpal Singh Saini, MP**
- **Sh. Ashwamedh Devi, MP**
- **Sh. Narayan Singh Amlabe, MP**
- **Sh. S. Thangavelu, MP**
- **Sh. Naranbai Kachhadia, MP**



12.07.2012 Five member delegation from High Commission of the Republic of Mozambique University of Zambeze

- **Prof. Dr. Bhangy Cassy**, Vice Chancellor, Uni. Of Zambeze.
- **Prof. Dr. Daniel Chongo.**
- **Prof. Dr. Custodio Boane.**
- **Prof. Dr. Fabiao Cumbe.**
- **Mr. Lourenco Lazaro Magaia**, Director for Cooperation

22.08.2012 **Mr. Adriaan Vernooij**, Agriculture Counsellor, Agriculture Department of the Embassy of the Kingdom of Netherlands, New Delhi with **Mr. Mukanjay Singh**, Delhi Embassy.

6.11.2012 Sixteen member delegation from France.



Hon'ble members of the Parliamentary Committee on Agriculture being shown the dairy products developed at NDRI

27.11.2012 Thirteen member delegation from Ministry of Agriculture and Forestry, Bhutan.

10.12.2012 Study visit of 15 member delegation from Afghan Dairy Nationals with **Mr. K. L. Arora**, IDA (NZ), New Delhi

23.01.2013 Minister of Agriculture, Rawanda (Africa) and a Ambassador of Rawanda to Govt. of India with WAPCOS team.

01.02.2013 Eleven member delegation from Bhutan.

20.02.2013 Twenty Seven member delegation from Canada under California Agriculture Leadership Program.



ILRI delegation at Village Arianpura

14. PERSONNEL

INSTITUTE STAFF

As on 31st March, 2013

General Administration

| | |
|-------------------------------|---------------------------------------|
| A. K. Srivastava, Ph.D. | Director |
| Rishendra Verma, Ph.D. | Joint Director (Research) |
| V. P. Singh, Ph.D. | Joint Director (Academic) |
| J. K. Kewalramani, MBA | Joint Director (Admn.) & Registrar |
| S. K. Kanawjia, Ph.D | Academic Coordinator |
| I. K. Sawhney, M. Tech. | Controller of Exams |
| R. C. Meena, M. Com. | Sr. Admn. Officer |
| Ashok Mallick, B. Com. | Sr. Admn. Officer |
| S. George, M.A., PGDLA | Comptroller |
| Mithlesh Kumar, M.Sc., PGDCFA | Sr. Fin. & Account Officer |
| Sarita Yadav, B.P.T., PGDPMIR | Admn. Officer |
| Ram Shankar, MA | Deputy Director (Off. Lang.) |
| Vishal Acharya, MA | Asstt. Fin. & Account Officer |
| Kuna Ram Kisku | Admn. Officer |
| 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 |
| S. S. Meena, B.A. | Asstt. Admn. Officer |
| Saroj Khurana, M.A. | Asstt. Admn. Officer |
| N. K. Verma | Asstt. Admn. Officer |
| Rajbir, B.A. | Asstt. Admn. Officer |
| Braham Prakash, B.A. | Asstt. Admn. Officer |
| Mukesh Kumar Dua, B.A. | Asstt. Admn. Officer |
| Dharam Singh Meena, B.A. | Asstt. Admn. Officer |
| Nirmal Kumar Jain, 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 |
| 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, M. Phil. Ph.D | Asstt. Pub. Information Officer |
| P. K. Dixit, Ph.D. | Asstt. Pub. Information Officer |
| R. A. Dey, Ph.D. | Asstt. Pub. Information Officer |

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 |
| Om Bir Singh, M.V.Sc. | 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. | Principal 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 |
| J. P. Sehgal, Ph.D. | Principal Scientist |
| Neelam Kewalramani, Ph.D. | Principal Scientist |
| S. S. Thakur, Ph.D. | Principal Scientist |
| Madhu Mohini, Ph.D. | Principal Scientist |
| S. K. Tomar, Ph.D. | Principal Scientist |
| Veena Mani, Ph.D. | Principal Scientist |
| A. K. Tyagi, Ph.D. | Principal Scientist |
| S. K. Sirohi, Ph.D. | Principal Scientist |
| Chander Datt, Ph.D. | Sr. Scientist |
| Nitin Tyagi, | Sr. Scientist |
| Goutam Mondal | 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. | Principal Scientist |
| A. K. Dang, Ph.D. | Principal Scientist |
| Anjuli Aggarwal, Ph.D. | Principal Scientist |
| Manju Ashutosh, Ph.D. | Sr. Scientist |
| Ashutosh, Ph.D. | Sr. Scientist |
| Ashwani Kumar Roy, Ph.D. | Sr. Scientist |

Animal Biotechnology Centre

| | |
|----------------------|-----------------------------------|
| R. S. Manik, Ph.D. | Principal Scientist and In-Charge |
| P. Palta, Ph.D. | Principal Scientist |
| S. K. Singla, Ph.D. | Principal Scientist |
| M. S. Chauhan, Ph.D. | Principal Scientist |
| T. K. Datta, Ph.D. | Principal Scientist |
| S. De, Ph.D. | Principal Scientist |
| J. K. Kaushik, Ph.D. | Principal Scientist |
| A. K. Mohanty, Ph.D. | Principal Scientist |
| D. Malakar, Ph.D. | Principal Scientist |
| M. K. Singh, Ph.D. | Scientist |
| S. 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. | Principal Scientist |
| Dheer Singh, Ph.D. | Principal Scientist |
| Rajeev Kapila, Ph.D. | Principal Scientist |
| Suman Kapila Ph.D. | Principal Scientist |
| S. K. Sood, Ph.D. | Sr. Scientist |
| Sunil Kumar Onteru Ph.D. | Sr. Scientist |
| Ms. Suneeta Meena, M.Sc. | Scientist |
| Ravi Kant, M.Sc. | Technical Officer |
| Karam Singh | Technical Officer |

Dairy Technology Division

| | |
|--------------------------------|---------------------|
| A. A. Patel, Ph.D. | Head |
| Vijay Kumar, Ph.D. | Principal Scientist |
| S. K. Kanawjia, Ph.D. | Principal Scientist |
| R. R. B. Singh, Ph.D. | Principal Scientist |
| Latha Sabikhi, Ph.D. | Principal 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 |

| | |
|----------------------|--------------------|
| Savitri Jhamb, B.Sc. | Technical Officer |
| G. K. Goyal, Ph.D. | Emeritus Scientist |

Experimental Dairy

| | |
|------------------------------------|----------------------|
| A. K. Sharma, B.Sc. | Dairy Superintendent |
| Hari Ram Gupta, M.Sc. | Technical Officer |
| A. K. Kohli, Dip. (Mech. Engg.) | Technical Officer |
| Probir Mondal, B.Sc. | Technical Officer |
| Sanjeev Kumar, M.A. | Technical Officer |
| T. L. Jaggi, Dip. (Refrigerator) | Technical Officer |
| Subhash Chander, Dip. (Electrical) | Technical Officer |
| Balvir Singh | Technical Officer |
| Prathvi Raj | Technical Officer |

Dairy Chemistry Division

| | |
|---------------------|---------------------|
| Darshan Lal, Ph.D. | Head |
| Raman Seth, Ph.D. | Principal Scientist |
| Bimlesh Mann, Ph.D. | Principal Scientist |
| Sumit Arora, Ph.D. | Principal 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

| | |
|----------------------|---------------------|
| R. K. Malik, Ph.D. | Acting Head |
| Sunita Grover, Ph.D. | Principal Scientist |
| A. K. Puniya, Ph.D. | Principal Scientist |
| S. K. Tomar, Ph.D. | Principal Scientist |
| Naresh Kumar, Ph.D. | Principal Scientist |
| Shilpa Vij, Ph.D. | Sr. Scientist |
| Chand Ram, Ph.D. | Sr. Scientist |
| Surjit Mandal, Ph.D. | Scientist |
| Raghu H.V., M.Sc. | Scientist |
| P. V. Behare, Ph.D. | Scientist |
| Rashmi H. M., M.Sc. | Scientist |
| R. P. Singh, Ph.D. | Technical Officer |
| Chamela Ram | Technical Officer |
| V. K. Batish, Ph.D. | Emeritus Scientist |

Dairy Engineering Division

| | |
|-------------------------------------|---------------------|
| A. K. Dodeja, Ph.D. | Head |
| I. K. Sawhney, M.Tech. | 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 Economics, Statistics and Management Division

| | |
|----------------------|---------------------|
| K. K. Datta, Ph.D. | Head |
| 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 |
| 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

| | |
|---------------------------------|---------------------|
| S. S. Kundu, Ph.D. | Acting 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. | Principal Scientist |
| Gopal Sankhala, Ph.D. | Principal 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 Upadhyay, 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/Trainers' Training Centre

| | |
|---------------------------|---------------------|
| Dalip K. Gosain, Ph.D. | Program 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 Research 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 |
| Satrugan Mehto | Technical Officer |
| Sukhdev Singh | Technical Officer |
| Ravi Rawat, M.Sc. (Entomology) | Technical Officer |

Livestock Farm

| | |
|-----------------------------------|-------------------------------|
| Shiv Prasad, Ph.D. | Principal Scientist, Incharge |
| R. K. Mehla | Principal Scientist |
| S. S. Lathwal | Sr. Scientist |
| T. K. Mohanty, Ph.D. | Sr. Scientist |
| M. L. Kamboj, Ph.D. | Sr. Scientist |
| Ramesh Chandra, Ph.D. | Sr. Scientist |
| A. Kumaresan, Ph.D. | Sr. 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 |
| Deepa Kumari, B.Sc. (HSc), MA | 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 |
| Pawan Singh | Principal Scientist |
| T. K. Mohanty, Ph.D. | Principal Scientist |
| Mukesh Bhakat, 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) |
| S. K. Kanawjia, Ph.D. | Academic Coordinator |
| 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 |
| Dheer Singh, Ph.D. | Hostel Warden |
| Bimlesh Mann, Ph.D. | Hostel Warden |
| Ritu Chakravarty, M.Sc. | Hostel Warden |
| A. K. Singh, Ph.D. | Sports Coordination |
| Latha Sabikhi, Ph.D. | I/c Placement Cell |
| Sarita Yadav, B.P.T., PGDPMIR | Admn. Officer |
| S. C. Tuli, B.A. | Asstt. Admn. Officer |
| Yogesh Sharma | Technical Officer |



Research Prioritization, Monitoring and Evaluation Cell

| | |
|-----------------------------|---------------------------|
| Rishendra Verma, Ph.D. | Joint Director (Research) |
| Meena Malik, M.Phil., Ph.D. | Associate Prof. (English) |
| Braj Kishor, M.A., | Technical Officer |

Library Services

| | |
|--------------------|-----------------------|
| B. R. Yadav, Ph.D. | Incharge |
| B. P. Singh, M.A., | Sci.Technical Officer |
| M. Lib.& Info. | |

Computer Centre

| | |
|------------------------------|-------------------|
| A. K. Sharma, Ph.D. | Incharge |
| Anirudha Kumar M.Sc., PGDCA | Technical Officer |
| Gian Singh, M.Sc. | Technical Officer |
| Naresh Kumar Dahiya, M.Tech. | 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 |
| Dharambir, B.A. | Technical Officer |
| Ganpat Rai, ITI | Technical Officer |

Vehicle Maintenance Section

| | |
|----------------------------------|----------|
| R. K. Mittal, B. E. (Mechanical) | Incharge |
|----------------------------------|----------|

Vehicle Maintenance Section

| | |
|-------------|-------------------|
| Ram Chander | Technical Officer |
|-------------|-------------------|

Press Unit

| | |
|---------------------------|-------------------|
| Dr. S. K. Kanawjia, Ph.D. | Incharge |
| Mehi Lal | Technical Officer |

Official Language Unit

| | |
|-------------------------|------------------------------|
| Ram Shankar Gautam, | Deputy Director (Off. Lang.) |
| M.A. P.G.D.T. | |
| Kanchan Choudhary, M.A. | Technical Officer |

Security Section

| | |
|---------------------------|---------------------|
| Ashutosh, Ph.D. | Incharge |
| Deepak Chopra, B. A. | Technical 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 |
| Vinod Kumar | 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 | Technical Officer & Mid Wifery |
| 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. | Principal Scientist |
| K. Jayaraja Rao, Ph.D. | Principal Scientist |
| D. N. Das, Ph.D. | Principal Scientist |
| M. C. Arunmozhi Devi, 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 Katakataware, Ph.D. | Scientist (SS) |
| S. Varalakshmi, M.V.Sc. | Scientist |
| S. Subhash, Ph.D. | Scientist |
| Manjunatha M., Ph.D. | Scientist |
| S.Jeyakumar, 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. Rajeshkaraiah, B.Sc. | Technical Officer |

| | |
|---|-------------------|
| Veeraju, B.E. (Civil) | Technical Officer |
| J. Nageshwara Rao, Dip.(Mech) | Technical Officer |
| K. L. Sampath, B.Sc. | Technical Officer |
| Thivija Kumari, M.A. | 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 |
| Janakshi, M.C.A. | Technical Officer |
| Sreekanta | Technical Officer |
| K. Ningaraju, M.V.Sc. | Technical Officer |
| A. Louis, B.Sc. | Technical Officer |
| Vimala, B.Sc. | 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. Manjunath M., Scientist (AS&PE) joined at SRS of NDRI, Bangalore on 28.05.2012 after transfer from CIPHET, Ludhiana.
- Ms. Sarita Yadav, joined as Admn. Officer at NDRI, Karnal w.e.f. 12.06.2012.
- Dr. Jeyakumar, Scientist (SS) (Animal Science) joined at SRS of NDRI, Bangalore on 18.06.2012 after transfer from CARI, Port Blair.
- Dr. V. P. Singh Joint Director (A) joined on 13.07.2012 after transfer from IVRI, Izatnagar.
- Dr. Rishendra Verma, Joint Director (Res.) joined on 16.07.2012 after transfer from IVRI, Izatnagar.
- Dr. Nitin Tyagi, Sr. Scientist (Animal Nutrition) joined NDRI on 17.08.2012.
- Dr. Mukesh Bhakat, Sr. Scientist (LPM) joined on 29.08.2012.
- Dr. R. C. Upadhyay Principal Scientist (Acting Head) Dairy Cattle Physiology joined as regular Head Dairy Cattle Physiology Division NDRI on 30.08.2012.
- Sh. Ashok Malik, Sr. Admn. Officer joined on 01.09.2012.
- Dr. R. K. Malik, Principal Scientist joined as Acting Head, Dairy Microbiology Division on 04.09.2012.

- Dr. Gautam Mandal, Sr. Scientist (LPM) joined on 07.09.2012.
- Dr. Sunil Kumar Onter, Sr. Sci. joined Animal Biochemistry Division on 20.12.2012.
- Dr. Darshan Lal, Principal Scientist joined as Acting Head, Dairy Chemistry Division on 01.01.2013.
- Mrs Deepa Kumari, T-5 joined at NDRI, Karnal on 30. 4.2012 after transfer from ICAR Research Complex for NEH Region, Sikkim Centre Gangtok.

Promotions

- Sh. S. George, CF&AO promoted as comptroller at this Institute on 26.07.2012.
- Dr. (Mrs.) Meena Malik, Asstt. Prof. (English) promoted to the post of Associate Prof. (English) w.e.f. 08.07.2005.
- Following Senior Scientists were promoted to Principal Scientist from 01.01.2009.
 - Dr. (Mrs.) Anjali Aggarwal, Sr. Sci. (Animal Physiology)
 - Dr. Ajay Kumar Dang, Sr. Sci. (Animal Physiology)
 - Dr. K. Jayaraj Rao, Sr. Sci. (Dairy Technology) SRS, Bangalore
 - Dr. Bandla Srinivas, Sr. Sci., SRS, Bangalore
 - Dr. (Mrs.) Latha Sabikhi, Sr. Sci. (Dairy Technology)

- Dr. Naresh Kumar, Sr. Sci. (Dairy Microbiology)
- Dr. Sudhir Kumar Tomer, Sr. Sci. (Dairy Microbiology)
- Dr. S. K. Sirohi, Sr. Sci. (Animal Nutrition)
- Dr. Manoj Kumar Ghosh, Sr. Sci. (Animal Nutrition)
- Dr. Tushar Kumar Mohanty, Sr. Sci. (Animal Reproduction)
- Dr. Sujeet Kumar Jha, Sr. Sci. (Agricultural Extension)
- Dr. Sachdanandan De, Sr. Sci. (Bio-technology)
- Dr. Gautam Kaul, Sr. Sci. (Bio-Chemistry) (AS)
- Dr. (Mrs.) Anand Laxmi, Sr. Sci. (Animal Physiology) promoted to Principal Scientist from 01.01.2010.
 - Dr. Dayal Nitin Das, Sr. Sci. (Genetics Breeding) SRS, Bangalore promoted to Principal Scientist from 22.03.2012.
 - Dr. Sumit Arora, Sr.Sci (Dairy Chemistry) promoted to Principal Scientist from 26.8.2011.
 - Dr. Gopal Sankhala, Sr. Sci. (Agricultural Extension) promoted to Principal Scientist from 25.07.2009.
 - Dr. Ashok Kumar Mohanty, Sr. Sci. (Bio-technology) promoted to Principal Scientist from 11.12.2009.
 - Dr. Jai Kumar Kaushik, Sr. Sci. (Bio-technology) promoted to Principal Scientist from 28.07.2009.
 - Dr. Subrata Kumar Das, ERS, Sr. Sci. (Bio-technology) promoted to Principal Scientist from 01.01.2010.
 - Dr. D. Malakar, Sr. Sci. (Bio-technology) promoted to Principal Scientist from 01.01.2010.
 - Dr. D. K. Gosain, Sr. Sci. (Agricultural Extension) promoted to Principal Scientist from 03.02.2011.
 - Dr. Suman Kapila, Sr. Sci. (Bio-Chemistry) (AS) promoted to Principal Scientist from 27.09.2010.
 - Dr. Rajeev Kapila, Sr. Sci. (Bio-Chemistry) (AS) promoted to Principal Scientist from 13.02.2010.
 - Dr. Dheer Singh, Sr. Sci. (Bio-Chemistry) (AS) promoted to Principal Scientist from 27.07.2009.
 - Sh. K.R. Kisku, AAO promoted to AO at ERS Kalyani from 26.11.2012.
 - Sh. Mukesh Kumar Dua, Asstt. promoted to AAO from 05.11.2012.
 - Sh. Dharam Singh Meena, Asstt. promoted to AAO from 01.12.2012.
 - Sh. Nirmal Jain, Asstt. promoted to AAO from 07.02.2013.
 - Mrs. Maridula Upadhyay, T-7/8 (P&E) (Dairy Extension) and Sh. G. D. Joshi, T-7/8 (Photo Lab.) were promoted to T-9 w.e.f 3.2.2012.
 - Mr. Kumar Bharat, T5 (P&E) (ATIC) was promoted to T-6 w.e.f 1.1.2010.
 - Sh. Braj Kishor, Technical Officer T-5 (P&E) promoted as T-6 (P&E) w.e.f. 04.05.2011.
 - Sh. Anirudha Kumar, T-7/8 (L/T) (Computer Centre) was promoted to T-9 w.e.f 1.1.2012.
 - Sh. Sarwar, T-7/8(L/T) and Sh. Krishana, T-7/8(L/T) were promoted to T-9 w.e.f 3.2.2012.
 - Sh. V. P. Verma, T-7/8(L/T) (ERS, Kalyani) was promoted to T-9 w.e.f 3.2.2012.
 - Sh. Rajeshwar, T-6(L/T) (KVK) was promoted to T-7/8 w.e.f 1.1.2012.
 - Sh. Ramesh, T-6(L/T) (ARBC) was promoted to T-7/8 w.e.f 1.1.2012.
 - Sh. Sahadev Singh, T-5(L/T) (Cattle Yard) was promoted to T-6 w.e.f 21.08.2012.
 - Sh. Probir Mondal, T-5(L/T) (Exp. Dairy) was promoted to T-6 w.e.f 22.02.2012.
 - Sh. Hari Ram Gupta, T-7/8(F/FT) (Exp. Dairy) was promoted to T-9 w.e.f 3.2.2012.
 - Dr. Raghendra Pal, T-7/8(F/FT) (Dairy Microbiology) was promoted to T-9 w.e.f 3.2.2012.
 - Sh. Satya Pal, T-7/8(F/FT) (KVK) was promoted to T-9 w.e.f 3.2.2012.
 - Sh. Alokesh Goswami, T-7/8(F/FT) (ERS, Kalyani) was promoted to T-9 w.e.f 3.2.2012.
 - Sh. Amitava Ghosh, T-7/8(F/FT) (ERS, Kalyani) was promoted to T-9 w.e.f 15.5.2012.
 - Dr. Uttam Kumar, T-7/8(F/FT) (Farm Section)



was promoted to T-9 w.e.f 20.4.2012.

- Sh. Subhash Chand, T-5(F/FT) (ABRC) was promoted to T-6 w.e.f 14.1.2012.
- Sh. Balraj Singh, T-4(F/FT) (KVK) was promoted to T-5 w.e.f 1.7.2012.
- Sh. A. C. Mondal, T-4(L/T) (ERS, Kalyani) was promoted to T-5 w.e.f 1.1.2012.
- Sh. P. S. Shiva Parsad, T-7/8(W/S) (SRS, Bangalore) was promoted to T-9 w.e.f 1.1.2012.
- Sh. R. K. Mittal, T-7/8 (W/S) (Veh. & Aud.) was promoted to T-9 w.e.f 1.7.2011.
- Sh. Rishi Pal T-5(W/S) (Hostel) was promoted to T-6 w.e.f 1.1.2012.
- Sh. Sarwan Kumar T-5(W/S) (M.E.) was promoted to T-6 w.e.f 1.1.2012.
- Sh. Arun Kumar T-4(W/S) (M.E.) was promoted to T-5 w.e.f 2.9.2011.
- Ms. Manju Bala T-4(W/S) (Dairy Engineering) was promoted to T-5 w.e.f 10.7.2011.
- Sh. Vinod Kumar T-4(W/S) (Vehicle Pool) was promoted to T-5 w.e.f 1.6.2012.
- Sh. Sanjiv Kumar T-4(W/S) (M.E.) was promoted to T-5 w.e.f 13.10.2011.
- Sh. Govind Raju T-4(W/S) (SRS, Bangalore) was promoted to T-5 w.e.f 1.7.2010.
- Sh. M. Sreenath, T-7/8, SRS, Bangalore was promoted to T-9 w.e.f 3-2-2012.
- Sh. Veeraju, T-6, SRS, Bangalore was promoted to T-7/8 w.e.f 24-2-2012.
- Mrs Janakshi, T-4 SRS, Bangalore was promoted to T-5 w.e.f 12-07-2009.

Transfers

- 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.
- 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.
- Dr. A. P. Ruhil, Sr. Scientist (Computer Application)

relieved from NDRI, Karnal to join at ICAR, H.Q., New Delhi w.e.f. 09.04.2012.

- Sh. Pushpanayak, Chief Admn. Officer relieved from NDRI, Karnal to join at ICAR Research Complex, Patna w.e.f. 21.05.2012.
- Dr. S. Jeyakumar, Scientist (SS) (Animal Science) joined at SRS of NDRI, Bangalore on his transfer from CARI, Port Blair w.e.f. 18.06.2012.
- Sh. Manjunath M., Scientist (AS&PE) joined at SRS of NDRI, Bangalore on his transfer from CIPHET, Ludhiana w.e.f. 28.05.2012.
- Sh. Naresh Kumar Dahiya, Technical Officer T-6 (Computer) joined at NDRI, Karnal after transfer from ERS, Kalyani on 11.06.2012.
- Dr. G. R. Patil, Joint Director (A) relieved from NDRI, Karnal w.e.f. 13.07.2012 to join at IVRI, Izatnagar.
- Dr. Rameshwar Singh, Head, Dairy Microbiology relieved from NDRI, Karnal w.e.f. 04.09.2012 to join as Project Director DKMA, ICAR Hqrs, New Delhi.
- Dr. J. S. Jeyakumar, Scientist (SS) joined SRS of NDRI, Bangalore after his transfer from Central Agricultural Research Institute, Port Blair to SRS of NDRI, Bangalore. on 18.06.2012
- Dr. Harjeet Kaur, Principal Scientist (Nutrition) relieved on 15.12.2012 to join at ICAR Headquarters New Delhi.
- Dr. Raka Saxena, Sr. Scientist, Dairy Economics relieved on 15.12.2012.

Retirements

- Dr. S. N. Rai, Principal Scientist (Animal Nutrition) retired from Council's services on superannuation on 31.03.2012.
- Sh. P. S. Shivaprasad, T.O. T-7/8 (W/S) SRS, Bangalore retired on superannuation on 31.01.2012.
- Sh. Satnam Singh, T-7-8 (W/S) Dairy Engineering Division retired from Council's service on superannuation on 31.03.2012.
- Sh. Sohan Lal, T-5 (W/S) Farm Section retired from Council's service on superannuation on 31.05.2012.



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— Personnel —

- Sh. Anand Prakash Dabas, T-9 (F/FT) Dairy Cattle Breeding Division retired from Council's service on superannuation on 30.06.2012.
- Sh. Jagpal Singh, T-5 (F/FT) Farm Section, Mrs. Pushpa Rani, T-5 (Library) and Sh. S. C. Haldar, T-5, ERS, Kalyani retired from Council's service on superannuation on 30.06.2012.
- Sh. Kailash Rabidas, T-5 (F/FT), ERS, Kalyani retired from Council's service on superannuation on 30.04.2012.
- Dr. D. K. Jain, Principal Scientist, DES&M retired from Council's service on superannuation on 30.9.2012.
- Dr. Balbir Kaur Wadhwa, Head, DC and Dr. D. K. Thompkins, Principal Scientist, DT retired from Council's service on superannuation on 31.12.2012
- Dr. Ram Kumar, Acting Head, Dairy Extension retired from Council's service on superannuation on 28.02.2013.
- Smt. Neelam Bala, AAO retired from Council's service on superannuation on 31.10.2012.
- Sh. Jagdish Kumar Wadhawa retired from Council's service on superannuation on 30.11.2012.
- Ms. M. A. Usha, T-7/8, SRS, Bangalore retired from Council's service on superannuation on 31.10.2012.



Sahiwal Breed



Murrah Buffalo Breed

Livestock Research Centre at NDRI

15. MAIN STATION

RESEARCH DIVISIONS

Dairy Cattle Breeding Division (DCB)

The division has been actively involved in conducting research and teaching in the areas of animal genetics and breeding including cytogenetics and biotechnology related to molecular genetics. The main thrust research areas are genetic improvement of crossbred and Sahiwal 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. The Center of Advanced Studies in Animal Genetics and Breeding established at Division of Dairy Cattle Breeding during eighth plan and renamed as Centre of Advance Faculty Training (CAFT) in 2010 continued its activities on imparting training to scientists/teachers from Research Institutes, State Agricultural/Veterinary Universities and Livestock Development Organizations in advanced areas of Animal Genetics and Breeding. A total of 29 National Training Programs have so far been organized under the aegis of CAFT (AG&B) in the Division. The division also assists KVK/DTC 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 Genomic 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 is also the integral part of the research component of the division.

Livestock Production Management Section (LPM)

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: (i) to maintain elite germplasm repository of dairy animals of the identified breeds; (ii) development of state-of-art dairy animal management facilities and infrastructure for high yielding dairy animals; (iii) to carry out research in collaboration with different divisions, in the upstream areas of dairy animal production; (iv) to standardize the package of management practices and to demonstrate the state of the art dairy animal production system to clients and to provide consultancy to the needy farmers and entrepreneurs for establishment of commercial dairy farms.

Dairy Cattle Nutrition Division (DCN)

The division undertake basic and applied research, post-graduate programmes of education and participate in the process of extension education through various training programmes and field level technology development and refinement in the discipline of animal nutrition and forage production. The division has a well-knit team of highly qualified and experienced scientists occupying different positions. The faculty members have been adequately trained in various priority areas and have visited advanced institutions of repute in European countries, Canada and United States of America to gain expertise and exposure in the respective aspects. The research laboratories are equipped with modern analytical instruments for chemical and physical analysis. The division has built up excellent laboratory facilities, which are central facilities for research and education not only for the Institute but also for various sister organizations seeking such support from time to time. The central facilities include (1) central fine instrumentation laboratory (2) laboratory for anaerobic rumen microbial work (3) laboratory for environment related studies including methanogenesis (4) quality control laboratory (5) feed processing unit (6) nutritional biotechnology laboratory. Some of the sophisticated instruments available include GC-mass spectrophotometer, atomic absorption spectrophotometer, gas-liquid chromatography, HPLC system, ¹⁵N- Analyzer, methane analysis equipment

using SF₆ technique, spectrophotometer, PCR machine etc. The division is likely to receive HFT test gas equipment shortly to study rumen fermentation kinetics. Under the WTO conditions, the quality of the feed should be as per Codex Alimentarius Commission to obtain good quality products. Quality evaluation of feeds is, thus, very important not only for balanced nutrition of livestock but also for obtaining quality product for Human being. The system for ruminants has been developed at Cornell University and named as Cornell Net Carbohydrates and protein system (CNCPS). This system characterizes the feeds into different protein fractions (A, B₁, B₂, B₃ and C) and carbohydrate fractions (sugar, fructans; fast degradation – starch pectin, oligosaccharides; slow degradable starch; fast degrading fiber; and lignin). This method helps to rank the feeds precisely as per their net feeding value and consequently will assist in optimization and in efficient utilization of feeds/forages for higher productivity in livestock. For the last few years precision nutrition and nutrient gene interaction studies are full swing in the division to observe the study of a particular gene/ *loci* on nutrient utilization and *vice versa*.

Dairy Cattle Physiology Division (DCP)

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: (i) to conduct basic and applied research and impart training in various aspects of Animal Physiology; (ii) to undertake post graduate programmes of education in Animal Physiology at Master's and Doctoral levels and Development and application of field level technologies. The notable salient achievements of the division are: development of temperature humidity index (THI) maps of India, development of sensitive radio-immunoassays for several protein and steroid hormones; development and validation of sensitive enzyme immunoassays for progesterone, oxytocin, GH, LH, FSH, cortisol, testosterone, prolactin, estradiol-17 and PGFM; application of progesterone measurement in body fluids for fertility improvement viz. estrus confirmation, pregnancy/non pregnancy detection, monitoring cyclicity and identification of ovarian disorders, application of estrone sulphate determination in milk for confirmation of pregnancy and fetal viability; indigenous production of progesterone antiserum and anti-rabbit IgG (second antibody) and their application in hormone

immunoassays; parturition induction, superovulation and embryo transfer; neonate physiology; temporal endocrine interrelationships during different phases of growth, reproduction and lactation; application of endocrine techniques for growth enhancement and fertility improvement, optimum frequency of feeding and milking; induction of lactation, augmentation of lactation through growth hormone administration, estimates of udder capacities, residual milk and milk secretion rates; somatic cell counts in milk of bovines during different stages of lactation; draught evaluation system, work efficiency of crossbred and indigenous bovine and buffalo bullocks and optimum work-rest cycle for working bullocks. Presently, its research thrust in three main areas is 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. National Initiative on Climate Resilient Agriculture (NICRA) has been initiated for basic and strategic research to identifying unique traits in cattle and buffaloes for resilient livestock production system. A Network Project on impact, adaptation and vulnerability of Indian agriculture to climate change with emphasis on livestock was taken up. Linkages have also been established for collaborative research ventures with other ICAR Institutes viz. IVRI, Izatnagar and CIRB, Hisar and SAU's for strengthening research on climate resilient livestock.

Animal Biotechnology Centre (ABTC)

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-the-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. The Centre also offers the M.Sc. Animal Biotechnology program. The objectives of the proposed Division are: i) 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, ii) to train manpower in application of Biotechnology in Dairy Production and Dairy Processing and iii) 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 specialized laboratories on Embryo Biotechnology, Regenerative Biotechnology, Animal Genomics, Proteomics Research etc.

Animal Biochemistry Division (ABC)

The Division of Animal Biochemistry came into being in September 1984 with the merger of the discipline of Animal Biochemistry of Dairy Chemistry Division and the section of Human Nutrition and Dietetics. Research endeavors 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 semen; 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. The 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 Nutragenomics, functional foods and therapeutics; Prebiotics and probiotics; Bioactive peptides and immunology; Bioinformatics; Molecular Endocrinology, Reproductive Biochemistry and Stem cell research. The Division manages Small Animal House that caters to the need of students and scientists for laboratory animals *viz.* rat, mouse, rabbit and hamster, etc.

Dairy Technology Division (DT)

The Dairy Technology Division is one of the first divisions set up at National Dairy Research Institute, Karnal. It is involved in teaching, basic and applied research, training and consultancy activities in the area of dairy processing and dairy product manufacture. At present the Division has got nine well-equipped laboratories *viz.*, sensory evaluation laboratory, packaging laboratory, indigenous milk products laboratory, cheese and fermented milks laboratory, infant food laboratory, concentrated and dried milk products laboratory, food technology laboratory, dairy by-products laboratory and e-Learning laboratory. The labs house a range of advanced analytical instruments e.g., micro-fluidizer, food texture analyzer, colour meter, water activity meter, viscometer, rapid visco analyser, laminar air flow units, automatic Soxhlet extractor, vacuum packaging system, ultrafiltration and reverse osmosis units, MAP analyser etc., which are necessary for undertaking cutting edge research in dairy. Another unique feature of the infrastructure available to the Division for undertaking R & D work for scaling up of the laboratory concepts to the pilot/semi-commercial scale is a well equipped Experimental Dairy capable of processing 10,000 liters of milk into a diverse range of dairy products. The dairy is equipped with all modern equipments like pasteurizer, homogenizer, cheese and fermented product manufacturing units, butter and ghee manufacturing equipments, ice cream-manufacturing unit, multistage evaporator and spray dryer. Pilot-scale vacuum dryer, membrane processing units, rotary oven, extrusion cookers, etc. are also available in the division. The prominent research achievements of the division include development of technologies and innovative processes for improved traditional dairy products as well as certain western products such as cheese, milk powders and yoghurt. Convenience formulations such as instant ready-to-reconstitute *gulab jamun* mix powder, *rasmalai* mix, *khoa* powder, extended shelf-life *milk-cake*, *kheer* mix, *dalia* dessert mix, *basundi* mix, *kulfi* mix powder. Technology of milk and cereal based composite foods e.g., *bajra* and *sorghum lassi*, *Bajra* biscuits, dairy-fruit-cereal based composite product like smoothie, dietetic products like low calorie burfi, *Misthi dahi*, arjuna herbal *ghee*, ultrafiltration (UF) based *shrikhand*, different varieties of cheese from cow, buffalo and goat milks and their admixtures, low fat cheeses, a variety of table spreads *viz.*, *chhana* based dairy spread, vegetable-fat based spreads, soya-based spread, etc. are some other important accomplishments of the division. Ready-to-reconstitute whey-kinnow juice mix and a range of

whey-based formulations such as whey-mango beverage, whey-*Jaljeera* drink, whey-tomato soup and whey-mushroom soup, egg-less cake mixes have also been developed. The division has developed strong expertise in the area of membrane processing and biotechnological applications to utilize modified microorganisms and enzymes for production of cheese and fermented milk with improved sensory, biochemical, textural and probiotic attributes. The current emphasis is on functional dairy-foods using various health related nutraceutical interventions. Recently developed quarg type fresh cheese with low fat and high fiber content, omega-3-fatty acid enriched milk, functional *chhana murki*, fiber-enriched milk, *doda burfi*, kheer, yoghurt and *paneer*, functional butter, curcumin fortified *lassi*, functional ice-cream and fiber and iron fortified biscuits, probiotic cheeses and infant formula with microencapsulated probiotic organisms are the examples of efforts in this area.

The Indian Council of Agricultural Research (ICAR) 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 so far organized 26 training courses under this programme.

Three NAIP projects were 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) also granted to faculty of Dairy Technology Division.

DT Division spearheads the nation's most prestigious under-graduate programme in Dairy Technology and provides elite human resource for various managerial positions in the industry. The Division has received a number of National and International Awards in recognition of the outstanding

scientific contributions made by the scientists and students, some of which include Rafi Ahmed Kidwai Awards, Jawaharlal Nehru Awards for P.G. Agricultural Research, Hari Om Ashram Trust Awards, DAAD Fellowships, Humboldt Fellowships, Rishab Shree Award, CSIRO Dairy Research Jubilee Award, Nestle' Young Scientist Award, UGC Research Award, Fellowship of NAAS, Vijay Shree Award, Fellowship Award of the Bioved Research Society, Hari Krishan Shastri Memorial Award for outstanding research in Agriculture, Borlaug Award, International Professional Women Opportunity Award, Dr. P.G. Nair Award, Dr. J.R. Patel Memorial Trust Award for teaching & research in Dairy Processing and ICAR Team Research Award and NDRI Best Teacher (UG) Award besides several others including Best Research Paper awards. Dairy Technology division received the institute's best division award for 2012-13

DT Division established the Dairy Technology Society of India (DTSI), which is a scientific and academic body representing the processing component of the dairy sector.

Dairy Chemistry Division (DC)

The mandate of division is to conduct fundamental and applied research for understanding chemistry of milk and milk products, to impart educational programmes for undergraduate and postgraduate courses and to provide R&D support towards chemical-quality control related problems of the dairy industry. The division has contributed significant knowledge on the chemistry of milk and milk products. The salient achievements are: evaluation of physico-chemical properties of buffalo milk and alteration in its calcium and casein levels and micellar stability enabling manufacture of satisfactory products like cheese, condensed milk and rasogolla; humanization of buffalo milk and glyceride structure of buffalo milk fat; evaluating role of phospholipids in stability of dairy products; revealing chemistry of ghee and ghee residue flavour; antioxidant properties of ghee residue; chemical makeup and structural integrity of milk fat globule membrane; influence of various processing parameters on the major minerals and trace elements and their partitioning; rapid and simple methods for the determination of SNF in milk; formulation of quality standards of milk and milk products now prescribed by the Central Committee of Food Standards under the Ministry of Health as well as Bureau of Indian Standards; modification of Gerber test for simultaneous estimation of milk fat and availability of fat for detection of adulteration; simple tests for the detection of adulteration of milk and milk products;

methods of manufacturing of butter and cheese colour from annatto seeds; preparation of rennet from fistulated calves and vegetable sources; structure and bacteriostatic role of lactoferrin; characterization and crystallization of buffalo lactoperoxidase; functional properties of WPC; renovation of rancid ghee and role of antioxidants in enhancing the shelf life of fat rich dairy products; effect of processing treatments on vitamins; status of pesticides and antibiotic residues in milk and milk products; methodologies for non-dairy whitener, low fat frozen dessert, calcium fortified milk, coconut filled Gouda cheese and low cholesterol ghee; a platform test for detection of detergent in milk; a colour based test to detect adulteration of milk with 2.5 to 10% soya milk; a multi-purpose device for dialysis; buffer exchange and concentration.

The recent achievements of the Division include standardization of a method for the production of antimicrobial peptides from skim milk by fermentation using selected proteolytic *Lactobacillus* strains; method for the preparation of casein hydrolysates rich in caseinophosphopeptides from buffalo milk; method for the preparation of strawberry polyphenols fortified stirred dahi; process for Iron and Vitamin A fortified milk; preparation of antioxidant whey protein hydrolysate using mozzarella cheese whey with commercial food grade enzyme alcalase; a new test for detection of detergent in milk; a method for detection of coconut oil and designer vegetable oil in ghee; method for detection of adulteration of vegetable oils in milk using specially designed dual purpose Gerber butyrometer; method for detection & estimation of neutralizer in milk/khoa/paneer using flame emission / atomic absorption spectrophotometer; a rapid method for sialic acid determination in milk and milk products and a method for the qualitative detection of extraneous thiocyanates in milk. The division has state of the art air conditioned Seminar room, Lecture room equipped with interactive board, LCD projectors, Visualiser, Podium etc., Quality control Lab, Undergraduate and Postgraduate labs, Instrument room, Research labs (lipids, proteins, minerals, enzymes, functional foods/ nutraceuticals, nanotechnology).

Dairy Microbiology Division (DM)

The Division of Dairy Microbiology has been contributing significantly in both basic as well as applied aspects of Dairy Microbiology. The faculty of the Division 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 handling research and teaching activities in the field of Dairy Microbiology and Biotechnology. Broadly, the research work of the Division covers 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 Engineering Division (DE)

Dairy Engineering Division was established as one of the major research divisions from 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 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 Economics Statistics & Management Division (DES&M)

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 (D. Extn.)

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 Sanghoshthi and field workshops at the adopted villages regularly. 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.



Hon'ble Director General, ICAR Dr. S. Ayyappan addressing the farmers during Kisan Divas

SUPPORT SECTIONS

LIVESTOCK RESEARCH CENTRE (LRC)

The total milk production of the herd during the year 2012-13 was 1362769.4 kg. The production performance of the two crossbred strains developed by the NDRI viz. Karan Swiss and Karan Fries was 13.1 and 13.5 kg per head per day, respectively as compared to 11.3 and 12.4 kg per animal during the previous year

(2011-12). The milking average of Sahiwal cows and Murrah buffaloes was 6.5 and 7.2 kg per animal per day, respectively. One Sahiwal cow (SW-1783) produced best milk yield of 23.5 kg in peak lactation. Best yield in Murrah buffalo (MU- 490) was 19.0 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 29.0 kg (KS-4402), respectively.

Bovine Population of Cattle and Buffaloes as on 31.03.2013

| Age group | Cattle | | | | | Local | Total | Buffaloes Murrah | Total Bovines |
|-----------------------------|------------|----------------|----------------|----------------|-----------|------------|------------|---------------------|------------------|
| | Sahiwal | Tharpa rkar | Karan Swiss | Karan Fries | | | | | |
| Calves upto 6 months | | | | | | | | | |
| Male | 18 | 03 | 02 | 23 | - | 46 | 22 | 68 | |
| Female | 14 | 12 | 01 | 29 | - | 56 | 16 | 72 | |
| Heifers | 138 | 29 | 13 | 128 | - | 308 | 125 | 433 | |
| Cows | 125 | 32 | 23 | 177 | - | 357 | 157 | 514 | |
| Male stock (young) | - | - | - | - | - | - | 36 | 36 | |
| Bullocks/ Teaser | - | - | - | 01 | 01 | 02 | 01 | 03 | |
| Total | 295 | 76 | 39 | 358 | 01 | 769 | 357 | 1126 | |

Goats as on 31.03.2013

| Age Group | Alpine x Beetal | Sannen x Beetal | Total |
|--------------------|-----------------|-----------------|------------|
| Female | | | |
| Kids upto 6 months | 35 | 08 | 43 |
| 6-12 months | - | - | - |
| Yearling | 28 | 16 | 44 |
| Goats | 28 | 06 | 35 |
| Male | | | |
| Kids upto 6 months | 04 | 01 | 05 |
| Bucks | 12 | 04 | 16 |
| Total | 107 | 35 | 142 |

Milk production at NDRI, Karnal during the year 2012-13 (01.04.2012 to 31.03.2013)

| | | |
|--|---|---------------------------------|
| Total Milk production (kg) | : | 1362769.4 kg |
| Average Number of Animals in Milk per day: | | |
| | | Cattle 252 |
| | | Buffaloes 87 |
| | | Goats 31 |

Sale of livestock during the year 2012-13 (01.04.2012 to 31.03.2013)

| Sale Value (₹) | | | | |
|--------------------|------------------------|-----------------------|-----------------------|-------------------------|
| Mode of Disposal | Cattle | Buffaloes | Goats | Total |
| Public Auction | 264500.00 (106) | 310900.00 (12) | 98800.00 (33) | 674200.00 (151) |
| On Book Value | 678972.00 (56) | 364757.00 (26) | 36020.00 (20) | 1079749.00 (102) |
| Grand Total | 943472.00 (162) | 675657.00 (38) | 134820.00 (53) | 1753949.00 (253) |

- Auction of animals was conducted on 21st & 22nd September, 2012 and 22nd & 23rd March 2013.
- Figure in parentheses indicates the total number of animals sold.

Performance of dairy animals during the year 2012-13 (01.04.2012 to 31.03.2013)

| Particulars | Genetic groups | | | | |
|---|-----------------|-----------------|-----------------|-----------------|----------------|
| | Sahiwal | Tharparkar | Karan Swiss | Karan Fries | Murrah |
| Average number of animals in milk per day | 67 | 13 | 17 | 155 | 87 |
| Average number of dry animals per day | 60 | 13 | 06 | 42 | 51 |
| Milking average (kg) per day | 6.5 | 5.9 | 13.1 | 13.5 | 7.2 |
| Overall average (kg) per day | 3.4 | 2.9 | 9.7 | 10.6 | 4.6 |
| Best yield (kg) in a day | 23.5 | 17.0 | 29.0 | 40.0 | 19.0 |
| Animal Number | SW -1783 | TP -1183 | KS -4402 | KF -6791 | MU -490 |

Flock performance of goats during the year 2012-13 (01.04.2012-31.03.2013)

| Particulars | Genetic Groups | |
|---|-----------------|-----------------|
| | Alpine x Beetal | Sannen x Beetal |
| Average number of animals in milk per day | 24 | 07 |
| Average number of dry animals per day | 04 | 02 |
| Milking average (kg) per day | 1.3 | 1.1 |
| Overall average (kg) per day | 1.0 | 0.8 |
| Best yield (kg) in a day | 3.1 | 2.8 |
| Animal Number | AB -950 | SB -185 |

Month-wise milking average (kg) of cows, buffaloes and goats maintained at NDRI, Karnal 2012-13 (01.04.2012 to 31.03.2013)

| Months | Cows | | | | | | Buffaloes | | | | Goats | | | |
|----------------|----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|------------------------------|
| | Sahiwal | | Tharparkar | | Karan swiss | | Karan Fries | | Murrah | | Alpine 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 | 62 | 6.0 | 13 | 5.5 | 16 | 15.0 | 158 | 14.2 | 84 | 8.1 | 22 | 1.5 | 11 | 1.1 |
| May | 64 | 6.1 | 18 | 5.6 | 18 | 14.4 | 167 | 13.8 | 83 | 7.7 | 22 | 1.4 | 10 | 1.2 |
| June | 66 | 6.7 | 21 | 5.4 | 20 | 15.0 | 158 | 14.2 | 80 | 7.4 | 22 | 1.3 | 09 | 1.1 |
| July | 71 | 7.0 | 21 | 5.6 | 19 | 13.8 | 156 | 13.3 | 80 | 7.3 | 21 | 1.1 | 07 | 1.1 |
| August | 77 | 6.9 | 18 | 4.7 | 19 | 12.1 | 162 | 12.4 | 88 | 6.3 | 16 | 0.7 | 05 | 0.9 |
| September | 76 | 6.6 | 11 | 6.0 | 21 | 11.4 | 160 | 12.3 | 89 | 6.5 | 06 | 0.6 | 04 | 0.7 |
| October | 74 | 6.0 | 10 | 5.7 | 19 | 11.4 | 151 | 13.1 | 91 | 6.4 | 03 | 0.8 | 02 | 0.7 |
| November | 65 | 5.8 | 11 | 4.8 | 17 | 11.1 | 152 | 13.0 | 89 | 6.7 | 36 | 1.1 | 08 | 1.1 |
| December | 61 | 6.1 | 08 | 4.8 | 16 | 12.7 | 151 | 13.0 | 84 | 7.5 | 40 | 1.1 | 09 | 1.0 |
| January | 58 | 6.5 | 08 | 8.3 | 15 | 13.2 | 143 | 13.9 | 81 | 7.9 | 38 | 1.2 | 08 | 1.0 |
| February | 61 | 6.9 | 09 | 7.3 | 14 | 12.1 | 149 | 14.9 | 85 | 7.2 | 35 | 1.4 | 05 | 1.3 |
| March | 66 | 6.9 | 12 | 6.8 | 13 | 12.7 | 154 | 13.9 | 105 | 8.0 | 33 | 1.5 | 05 | 1.0 |
| Average | 67 | 6.5 | 13 | 5.9 | 17 | 13.1 | 155 | 13.5 | 87 | 7.2 | 24 | 1.3 | 07 | 1.1 |

Fat and SNF percentage of cattle and buffaloes during the year 2012-2013 (April 2012 to March 2013)

| Particulars | First lactation | | | | |
|---------------------|-----------------|------------|----------------|----------------|---------------------|
| | Sahiwal | Cows | | | Buffaloes Murrah |
| | | Tharparkar | Karan Swiss | Karan Fries | |
| No. of observations | 120 | 32 | 57 | 582 | 248 |
| Average fat % | 4.77 | 4.74 | 4.41 | 4.34 | 8.09 |
| Range | 3.50 -5.50 | 3.83 -5.50 | 3.77 -5.30 | 3.44 -6.12 | 5.95 -9.97 |
| No. of observations | 120 | 32 | 57 | 582 | 248 |
| Average SNF% | 8.83 | 8.88 | 8.78 | 8.75 | 9.66 |
| Range | 8.50 -9.10 | 8.65 -9.15 | 8.50 -9.02 | 8.09 -9.29 | 9.04 -10.50 |

| Particulars | All lactations | | | | |
|---------------------|----------------|------------|----------------|----------------|---------------------|
| | Sahiwal | Cows | | | Buffaloes Murrah |
| | | Tharparkar | Karan Swiss | Karan Fries | |
| No. of observations | 791 | 154 | 206 | 1929 | 1010 |
| Average fat % | 4.76 | 4.78 | 4.39 | 4.32 | 8.17 |
| Range | 3.50 -5.95 | 3.65 -5.65 | 3.54 -5.52 | 3.33 -6.12 | 5.17 -10.50 |
| No. of observations | 791 | 154 | 206 | 1929 | 1010 |
| Average SNF% | 8.83 | 8.86 | 8.75 | 4.32 | 9.70 |
| Range | 8.48 -9.23 | 8.53 -9.27 | 8.40 -9.07 | 8.09 -9.68 | 9.04 -10.50 |

**Protein and lactose percentage of cattle and buffaloes during the year 2012-2013
(April 2012 to March 2013)**

| Particulars | First lactation | | | | |
|---------------------|-----------------|------------|----------------|----------------|---------------------|
| | Sahiwal | Cows | | | Buffaloes Murrah |
| | | Tharparkar | Karan Swiss | Karan Fries | |
| No. of observations | 24 | 5 | 12 | 155 | 64 |
| Average protein | 3.11 | 3.19 | 3.26 | 3.17 | 3.74 |
| Range | 2.63 -3.39 | 2.98 -3.38 | 2.93 -3.60 | 2.81 -4.04 | 2.97 -4.25 |
| No. of observations | 24 | 5 | 12 | 155 | 64 |
| Average lactose | 4.71 | 4.83 | 4.67 | 4.73 | 5.56 |
| Range | 4.33 -5.10 | 4.64 -5.11 | 4.36 -5.30 | 4.16 -5.32 | 4.44 -6.25 |

| Particulars | All lactations | | | | |
|---------------------|----------------|------------|----------------|----------------|---------------------|
| | Sahiwal | Cows | | | Buffaloes Murrah |
| | | Tharparkar | Karan Swiss | Karan Fries | |
| No. of observations | 245 | 35 | 59 | 647 | 339 |
| Average protein | 3.16 | 3.19 | 3.19 | 3.15 | 3.81 |
| Range | 2.63 -3.71 | 2.69 -3.84 | 2.93 -3.60 | 2.46 -4.04 | 2.97 -4.47 |
| No. of observations | 245 | 35 | 59 | 647 | 339 |
| Average lactose | 4.73 | 4.77 | 4.75 | 4.72 | 5.65 |
| Range | 4.33 -5.40 | 4.40 -5.15 | 4.36 -5.38 | 3.72 -6.10 | 4.44 -6.69 |

Month-wise milking average (kg) as fat corrected milk of cows and buffaloes maintained at NDRI Karnal (April 2012-March 2013)

| 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. 2012 | 62 | 6.66 | 13 | 6.13 | 16 | 15.60 | 158 | 14.71 | 84 | 10.31 |
| May 2012 | 64 | 7.03 | 18 | 6.36 | 18 | 15.39 | 167 | 14.91 | 83 | 9.94 |
| June 2012 | 66 | 7.65 | 21 | 5.85 | 20 | 15.65 | 158 | 14.82 | 80 | 9.02 |
| July 2012 | 71 | 8.33 | 21 | 6.67 | 19 | 14.61 | 156 | 14.61 | 80 | 9.42 |
| Aug. 2012 | 77 | 7.77 | 18 | 5.77 | 19 | 13.09 | 162 | 13.45 | 88 | 8.26 |
| Sep t. 2012 | 76 | 7.43 | 11 | 6.61 | 21 | 12.62 | 160 | 12.78 | 89 | 7.94 |
| Oct. 2012 | 74 | 6.96 | 10 | 6.75 | 19 | 12.17 | 151 | 13.83 | 91 | 8.39 |
| Nov. 2012 | 65 | 6.78 | 11 | 5.66 | 17 | 11.48 | 152 | 13.55 | 89 | 8.29 |
| Dec. 2012 | 61 | 7.18 | 8 | 5.51 | 16 | 13.87 | 151 | 14.58 | 84 | 9.57 |
| Jan. 2013 | 58 | 6.90 | 8 | 8.68 | 15 | 14.43 | 143 | 15.76 | 81 | 9.73 |
| Feb. 2013 | 61 | 7.17 | 9 | 7.39 | 14 | 12.18 | 149 | 14.34 | 85 | 8.53 |
| March 2013 | 66 | 7.50 | 12 | 7.62 | 13 | 13.69 | 154 | 14.95 | 105 | 10.82 |
| Average | 67 | 7.28 | 13 | 6.58 | 17 | 13.76 | 155 | 14.36 | 87 | 9.19 |

Production and reproduction performance of cattle initiating their lactation during 2011 and completing in 2012

| Traits | Sahiwal | Tharparkar | Karan Swiss | Karan Fries | Murrah |
|------------------------------------|------------|------------|-------------|-------------|------------|
| First lactation | | | | | |
| Age at 1st calving (Months) | 42.21(34) | 49.13 (9) | 43.21 (4) | 40.44 (47) | 41.58 (29) |
| Total milk yield (kg) | 1778 (22) | 2134 (1) | 2854 (5) | 3932 (43) | 2283 (45) |
| 305 or less days milk yield (kg) | 1710 (22) | 2134 (1) | 2229 (5) | 3215 (47) | 2212 (50) |
| Lactation length (days) | 276 (22) | 276 (1) | 381 (4) | 382 (43) | 296 (45) |
| Dry period (days) | 86 (18) | 114 (1) | 71 (3) | 49 (29) | 98 (34) |
| Service period (days) | 102 (22) | 107 (1) | 220 (3) | 165 (26) | 106 (37) |
| Calving interval (days) | 389 (18) | 390 (1) | 510 (3) | 438 (26) | 430 (34) |
| All lactations | | | | | |
| Total milk yield (kg) | 1806 (135) | 1695 (15) | 3015 (22) | 4215 (150) | 2356(78) |
| 305 or less days milk yield (kg) | 1678 (136) | 1643 (20) | 2855 (23) | 3696(161) | 2205(85) |
| Lactation length (days) | 250 (135) | 241 (15) | 286 (19) | 346 (147) | 319(85) |
| Dry period (days) | 109 (83) | 134 (9) | 68 (11) | 76(79) | 113(57) |
| Service period (days) | 105 (98) | 105 (9) | 129 (11) | 159 (80) | 127(51) |
| Calving interval (days) | 384 (83) | 384 (9) | 415 (11) | 433 (79) | 431 (57) |

| | | | | | |
|--|------------|-----------|-----------|------------|-----------|
| Average number of lactations | 3.02 (136) | 3.87 (15) | 3.87 (23) | 2.79 (160) | 2.81 (85) |
| Best lactation (305 or less days) | | | | | |
| Milk yield (kg) | 3624 | 2887 | 5024 | 6244 | 4341 |
| Animal number | 1820 | 1228 | 4402 | 6751 | 5517 |
| Lactation number | 3 | 3 | 2 | 4 | 2 |
| Best lactation | | | | | |
| Milk yield (kg) | 4933 | 3684 | 5063 | 8806 | 4619 |
| Animal number | 1820 | 1228 | 4402 | 6751 | 5517 |
| Lactation number | 3 | 3 | 2 | 4 | 3 |
| Lactation length (days) | 536 | 461 | 310 | 448 | 417 |

Figures in parentheses indicate number of animals

ARTIFICIAL BREEDING RESEARCH CENTER

The Artificial Breeding Research Center (ABRC) with a capacity of 107 bulls (Sahiwal-31, Tharparkar-17, Karan-Fries-27, Karan Swiss-2 and Murrah- 30), is the largest Institute Breeding Bull Center in the country. ABRC is playing a proactive role in achieving genetic improvement of dairy cattle and buffalo and reproduction management of male animals/breeding bulls, production, processing, evaluation and preservation of superior male germplasm, teaching of post-graduate students, training and consultancy on male animal reproduction and dissemination of superior germplasm of cattle and buffaloes. The ABRC maintained the linkages with ICAR institutes and state agencies for vertical growth of the center.

Physical Infrastructure

The following physical infrastructure facilities were developed at ABC

- Infrastructure for maintaining cloned buffalo bull.
- Semen quality control laboratory
- Semen parlour for distribution of germplasm

The center has also taken initiative for developing storage for dry fodder and chaff cutter shed. 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. The center proposed ten bulls for final selection under 14th set of Network Project on Buffalo Improvement.
- The semen of cloned buffalo bull(Shresth)was frozen for the first time in the world and 4948 doses of frozen semen with more than 60 % PTM are available at ABRC.

Research Collaboration Programme

The collaborative project “*Ex Situ* Conservation of Important Indigenous Cattle and Buffalo Breeds” has been implemented between NBAGR, Karnal and ABRC, NDRI, Karnal. Eight high pedigree young Tharparkar bulls from Govt. Livestock Farm, Jaisalmer, Rajasthan and Central Cattle Breeding Farm, Suratgarh, Rajasthan were added at ABRC. The dam's milk yield of young Tharparkar bulls ranged from 2319 to 2903 kg during the period, 17,207 doses of frozen semen from five Tharparkar bulls were preserved and 3000 doses were transferred to NBAGR, Karnal for conservation.

Reproduction Management

The center performed 1302 artificial insemination of breeding bulls and monitored the reproductive health and efficiency of the NDRI herds.

Reproductive Status of NDRI Herd for the Year 2012

| Particulars | Breed | | | | |
|---|--------|--------|-------|--------|--------|
| | SW | TP | KS | KF | MU |
| Cow/ Buffalo | | | | | |
| No. of observation | 107 | 27 | 13 | 101 | 77 |
| Service period (days) | 106.27 | 106.85 | 95.61 | 130.17 | 122.28 |
| No. of service/conception | 1.44 | 1.44 | 1.23 | 1.62 | 1.40 |
| Heifer | | | | | |
| No. of observation | 49 | 13 | 3 | 42 | 36 |
| Av. age at maturity (Month) | 29.61 | 30.30 | 26.66 | 29.92 | 34.33 |
| Av. age at conception (Month) | 32.02 | 30.69 | 27 | 30.64 | 36.52 |
| No. of service/conception | 1.61 | 1.15 | 1.33 | 1.40 | 1.5 |
| Conception rate (%) | | | | | |
| Conception rate ^{1st} service. | 50 | 58.33 | 46.42 | 41.61 | 40.69 |
| Conception rate ^{3rd} service | 81.81 | 83.33 | 71.42 | 66.37 | 70.93 |
| Overall conception rate | 46.89 | 53.16 | 41.07 | 36.29 | 42.27 |

Management and Cryopreservation of Semen of Breeding Bulls

During the period, the center collected and preserved the frozen semen of eight Murrah bulls of XII, XIII and XIV set under “Network Project on Buffalo Improvement”, ten Sahiwal bulls of IX, X and XI set under Sahiwal project and fifteen Karan Fries crossbred bulls for XI, XII and XIII set under Progeny Testing of KF bulls are maintained at ABRC. The center also preserved the semen of seven Tharparkar bulls for multiplication of Tharparkar breed of cattle.

Screening of Sexually Transmitted Diseases (STD) of Breeding Bulls

The ABRC has screened sexually transmitted bacterial and viral diseases viz., TB, JD, Brucellosis, IBR, Campilobacteriasis and Trichomoniasis of all breeding bulls and semen of breeding bulls using ELISA & Real Time PCR Test from Regional Disease Diagnostic Laboratory (North Zone), Jalandhar, Punjab. All the bulls and semen samples were found negative from the above sexually transmitted diseases.

Production and Dissemination of Male Germplasm during 2012

| Breed | Frozen Semen Produced | Frozen Semen | | Disseminated | |
|--------------|-----------------------|--|-------------------------------|-------------------------------|---------------------|
| | | Frozen Semen doses to Dairy Development Agency (DDA) | Frozen Semen doses to Farmers | Liquid semen doses to Farmers | Total Dissemination |
| KF | 61789 | 1800 | 20625 | 13,912 | 36337 |
| KS | 120 | - | 220 | - | 220 |
| SW | 31775 | 1805 | 7951 | 2685 | 12441 |
| TP | 23832 | 85 | 2770 | - | 2855 |
| MU | 60355 | 8970 | 26137 | 8067 | 43174 |
| Total | 1,77,871 | 12,660 | 57,703 | 24,664 | 95,027 |

The ABRC generated ` 10,80,865/- for the institute through sale of liquid and frozen semen during 2012.

FORAGE RESEARCH AND MANAGEMENT CENTRE

Economic milk production can only be achieved, if nutritious fodder is made available throughout the year to the dairy herd. The cost of feeding constitutes about 65% of the total cost of production of milk. Thus, it is essential to economise the feeding cost. It has been established that cost of milk production is the lowest and animal performance is better if adequate green fodder in the form of cereal and legume mixture and high energy silage is made available for feeding to the

dairy animals.

The foremost responsibility of Forage Research and Management Centre is to produce adequate quantity of good quality green fodder to meet the nutritional requirements of the institute herd. After meeting the day to day requirement of fodder, some area is utilized for production of fodder seed and other grain crops to meet out the requirements for transfer of technology programmes of Institute and partial fulfillment of the grain component of feed.

Allocations of the Farm Land to different Units

| Production Unit | Area (ha) |
|---|---------------|
| 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

In all, 1,48,721.50 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 175578.25 q of fodder including 1,62,923.25 q green fodder, 8858.25.00 q silage and 3798.75 q dry fodder was supplied to cattle yard. Total production of grains of wheat, barley, paddy, berseem and oats was 2206.67 q.

Production and Productivity of Forage Crops in terms of Green Fodder

| Crop | Area(ha) | Average Yield (q/ha) | Production (q) |
|-------------------|---------------|----------------------|--------------------|
| Berseem+Mustard | 50.98 | 778.41 | 39683.75 |
| Oats+ Maize | 7.71 | 342.93 | 2644.00 |
| Oats | 64.51 | 422.18 | 27,235.25 |
| Turnip | 11.01 | 596.45 | 6,567.00 |
| Lucerne | 5.26 | 454.84 | 2,392.50 |
| Maize | 180.95 | 221.96 | 40163.75 |
| Jowar (multicut) | 41.74 | 395.86 | 16523.25 |
| Jowar(single cut) | 34.51 | 196.29 | 6774.00 |
| Cowpea+Bajra | 8.38 | 86.10 | 721.50 |
| Bajra | 8.06 | 159.93 | 1289.00 |
| Makchari | 10.73 | 333.64 | 3580.00 |
| Mustard | 3.44 | 333.57 | 1147.50 |
| Total | 427.28 | - | 1,48,721.50 |

Production and Productivity of Grain Crops

| Crop | Area(ha) | Average Yield (q/ha) | Production (q) |
|--------------|---------------|----------------------|-----------------|
| Wheat | 18.48 | 44.75 | 827.00 |
| Oats | 66.32 | 11.62 | 770.50 |
| Barley | 8.30 | 27.33 | 226.81 |
| Paddy | 10.53 | 34.92 | 367.75 |
| Berseem | 17.21 | 0.84 | 14.61 |
| Total | 120.84 | - | 2,206.67 |

Forage Conservation

Sufficient quantity of green fodder of oats was conserved as silage 10212 q and 1379.25 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 Rs. 15,09,680.00 was realized and an amount of Rs. 15,42,570.00 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 seed | 824.50 | 1600/- | 1319200.00 |
| Wheat grain | 2.50 | 1285/- | 3213.00 |
| Barley seed | 8.26 | 1225/- | 10,118.50 |
| Sewerage sludge | 113.00 | 12/- | 1,356.00 |
| Farm yard manure | 263.50 | 10/- | 2,635.00 |
| Tractor leasing out | - | - | 1,04,460.00 |
| Timber wood | | | |
| i) Sheesham/kikar | 241.50 | 275/- | 66,412.50 |
| ii) Misc. wood | 12.50 | 180/- | 2,285.00 |
| Total | | | 15,09,680.00 |

Budget saved by use of farm produce as seed/feed.

| Produce | Quantity(q) | Rate(₹/q) | Amount(₹) |
|--------------|-------------|-----------|---------------------|
| Oats seed | 148.67 | 2000/- | 2,97,340.00 |
| Oats feed | 698.00 | 1200/- | 8,37,600.00 |
| Barley feed | 204.55 | 1100/- | 2,25,005.00 |
| Berseem seed | 14.61 | 12500/- | 1,82,625.00 |
| Total | | | 15,42,570.00 |

Revolving Fund Scheme (RFS) 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 Institute and other agencies. During the year under the report 213.95 q seeds of improved varieties of fodder crops, 138.0 q undersized grains and 12085.50 q green/dry fodder were produced.

Production of Seeds under (RFS) Seed Production

| Name of Crop | Quantity of seed(q) | Rate(` /q) | Amount (`) |
|-------------------------|---------------------|------------|---------------------|
| Maize VC | 135.00 | 3000/- | 4,05,000.00 |
| Jowar PC-9 | 3.00 | 5000/- | 15,000.00 |
| Oats OS-6/Kent | 65.00 | 2000/- | 1,30,000.00 |
| Mustard chinese cabbage | 5.50 | 5000/- | 27,500.00 |
| Turnip | 0.45 | 15000/- | 6,750.00 |
| Berseem | 5.00 | 12500/- | 62,500.00 |
| Paddy P-44 | 245.00 | 3000/- | 7,35,000.00 |
| Total | 458.95 | - | 13,81,750.00 |

Production of Grains under RFS Seed Production

| Name of Crop | Quantity of seed (q) | Rate (` /q) | Amount (`) |
|--------------|----------------------|-------------|--------------------|
| Maize | 25.00 | 1000/- | 25,000.00 |
| Oats | 12.00 | 1000/- | 12,000.00 |
| Mustard | 1.00 | 1500/- | 1,500.00 |
| Paddy | 100.00 | 650/- | 65,000.00 |
| Total | 138.00 | - | 1,03,500.00 |

Green/Dry Fodder Supplied to Cattle Yard (q) under RFS, Seed Production during January 2012 to December 2012.

| Fodder | Quantity (q) | Rate (` /q) | Amount (`) |
|--------------|-----------------|-------------|-------------------|
| Green fodder | 4460.25 | 145/- | 646736.25 |
| | 5555.00 | 120/- | 666600.00 |
| Maize kadbi | 1173.50 | 20/- | 23470.00 |
| Jowar kadbi | 595.25 | 125/- | 74406.25 |
| Paddy straw | 301.50 | 20/- | 6030.00 |
| Total | 12085.50 | - | 1417242.50 |

EXPERIMENTAL DAIRY PLANT

Facilities in the milk processing

A well equipped dairy plant for handling 10,000 liters milk per day was installed in 1962 and renovated in the year 1984. Basic equipments are available for processing different types of milk, fat rich products, indigenous milk products, condensed and dried milk products, various types of cheese and fermented milk products. Facilities are available for the product development and to give practical training to the students familiarizing them with the operational aspects of a commercial dairy. During the year 1989, a Revolving Fund Scheme was introduced in

Experimental Dairy under AP cess Fund Project by the Ministry of Agriculture. In the year 2004, Experimental Dairy was granted International Standards Certification for its quality and food Safety Policy i.e. ISO 9001 2000 HACCP-15000. In March 2010, Experimental Dairy was certified for ISO 9001-2008 & HACC-15000.

It also provides training facilities to outside students of various universities and colleges in the Dairy field. A total no. of 70 students from several institutions were provided training during the year 2012-2013. The revenue generated during the year January - December, 2012 was ` 3,75,31,613.00

Sale of the Dairy Products during January 2012 to December 2012

| Products Name | Qty. | Amounts (`) |
|--------------------------------|---------|-----------------|
| Cow Ghee (kg) | 20146 | 7454020 |
| Mix Ghee (kg) | 949 | 332150 |
| Pasteurized Butter (200 gm) | 2512 | 150720 |
| Paneer 500 gm (kg) | 21398.5 | 4279700 |
| Paneer 250 gm (kg) | 9117 | 1823400 |
| Paneer (kg) | 8994 | 1798800 |
| Ice-cream (Cup) | 81573 | 1631460 |
| Flavoured Dairy Drink (200 ml) | 240070 | 3601050 |
| Lassi (200 ml) | 153958 | 2309370 |
| Dahi (200 ml) | 5646 | 84690 |
| Kalakand (kg) | 22734 | 5001480 |
| Pro. Cheese Slices (200 gm) | 1304 | 104320 |
| Skim Milk Powder (R) (kg) | 13792.5 | 3448125 |
| Gulab Jamun Mix(kg) | 17279.5 | 3455900 |
| Pizza Cheese (200 gm) | 3561 | 249270 |
| Carry Bag (No.) | 12148 | 60740 |
| Cheddar Cheese (kg) | 1052.95 | 252708 |
| Khoa (kg) | 366.5 | 87960 |
| Cooking Butter (kg) | 120 | 36000 |
| Mozzarella Cheese (kg) | 35.8 | 7160 |
| Burfi (kg) | 6005 | 1321100 |
| Table Cream (kg) | 184 | 9200 |
| Tomato Soup (Cup) | 3229 | 32290 |
| Total | | 37531613 |

COMPUTER CENTRE

Computer Centre is a central facility to provide computational support to the scientists and administration; and training to students/scholars. The Computer Centre offers two Computer Science courses to under-graduate students and one course to post-graduate students. There is a well established Computer Laboratory for students' teaching, equipped with state-of-the-art 64 bit i5 computer systems together with multi-function laser printers. The Institute has a well established Local Area Network (LAN) connecting all the divisions/sections through optical fiber/UTP cabling to cover the main buildings and ADSL switches for distantly located buildings, thereby providing connectivity to all the scientists, technical/administrative officers/students. Student hostels are also connected to Institute LAN through Wi-Fi network to enable the students to access the internet and library resources round the clock. The

computer systems support FORTRAN, C, C++ and Visual Programming languages compilers.

Scientific Data Processing

The Centre processed scientific data pertaining to research projects of the Institute as submitted by the scientists and also the data for dissertation/thesis work submitted by the research scholars. The sophisticated SAS statistical computing software (recently acquired under the aegis of the NAIP funded subproject: SSCNARS) is extensively utilised for the purpose.

Management Information Service

The Computer Centre prepared daily fortnightly and monthly reports relating to milk production, supply of feeds and fodders, herd performance, animal management system, etc., for decision support to the appropriate authorities. The processing of pay bills and GPF transactions of different categories of staff as well as generation of various reports was also carried out by the Centre. A new module has been added to the

existing in-house developed Medical Bill Generation software (operational in C&B Section) to find out the individual monthly/yearly claimed total medical amount.

Agriculture Knowledge Management Unit (AKMU)

The Agriculture Knowledge Management Unit (AKMU) established with the help of ICAR is fully functional with the Internet and e-mail connectivity through National Knowledge Network node (1 Gbps) provided by the National Informatics Centre (NIC) Govt. of India and through leased line (2 Mbps) provided by ERNET India Ltd., via Unified Threat Management (UTM) System. AKMU is also undertaking the implementation of ICAR sponsored programs like Personnel Management Information System (PERMISNet), National Information System for Agriculture Education Network (NISAGENet), and Project Information Management System (PIMSNet), Half Yearly Progress Monitoring System (HYPM), Intelligent Reporting System (IRS), etc.

Website

The Institute Website is dynamic with role based security features in place. The web content is regularly updated to keep the information up-to-date.

ASRB Online Examination Centre

An online examination lab 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 by ASRB, ICAR.

LIBRARY

The Institute Library has made an impressive collection of literature on Dairy Science and related subjects. More than 125 periodicals have been subscribed to keep track of the current scientific/technical developments. Currently, there are 94,550 volumes, which includes 51,155 books, 32,457 bound journals, 5,252 gratis-books/bulletins, 4,186 theses and 1,500 CDs. Library has an excellent computer section having fifty workstations for students and staff of the institute. The Library provides Internet, Email, Documentation, Reference, Current Awareness Services, CD-ROM Literature scanning through CD-ROM of CAB Abstract, Food Science Technology Abstract, AGRIS, Derwent Biotechnology Abstract,

Indian Standards on CD-ROM and ISO Standards of Milk and Dairy Products on CD-ROM. The Library also provides photocopying, Document Scanning and Printing facility. Computerised Issue-Return and reservation of books was done by using LIBSYS Library Software Packages with Web OPAC. The Library, NDRI has been an active partner of NAIP Sub-project “Strengthening of Digital Library and Information Management under NARS (eGranth)”. The project has major mandate to have a union catalogue of all participating libraries with integration/collaboration of Online Computer Library Center (OCLC)”. In this project all the available books, journals and other resources information has been uploaded on OCLC platform in MARC21 format. Presently, 45,390 catalogue records of Library, NDRI are available on WorldCat. Library has transferred successfully all the catalogue records of books, theses, standards, annual reports and bound periodicals, etc. from Libsys-Library Management System to Koha-Library Management System.

TECHNOLOGY BUSINESS INCUBATOR

Technology Business Incubator (TBI) established with the support of DST and registered as a society in the name of “Society for Innovation & Entrepreneurship in Dairying” during the financial year 2012-13, organized four Entrepreneurship Development Programmes, one on Dairy Processing and three on Commercial Dairy Farming and eight short Training Programs in the areas of Breeding, Artificial Insemination, Reproduction Management in Farm Animals and Health Management in Dairy Animals. Four Incubatee Companies also joined TBI under Incubation Programme, two for processing of milk for different milk products, one for mineral mixtures & one for Bakery products.

COMMUNICATION CENTRE

Audio-Video and Photo Lab

The facilities of audio video recording and photos editing were extended to the scientists, staff and the student for their research projects, video coverage of 52 events of the Institute consisting of National and International seminars, workshops, conferences, cultural programmes, Dairy Mela, Cattle Shows, Kisan Sangoshties, Exhibitions and other functions of the Institute were carried out and a total No. of 205 DVD on the above programmes were made.

Exhibitions Organised

| | | |
|-----|---|---|
| 1. | 12 th May, 2012. | Awareness cum treatment of animals Khanpur Block, Dist., Haridwar (UK). |
| 2. | 13 th May, 2012 | Awareness cum treatment of animals at Gandhi Khat Gujjar, Dist., Haridwar (UK). |
| 3. | 20 th June, 2012 | Study visit of Parliamentary Standing Committee on Agriculture at NDRI, Karnal. |
| 4. | 9 th September, 2012 | "Foundation Day of DWR", Karnal. |
| 5. | 21 st September, | 2012 "Foundation Day of NBAGR," Karnal. |
| 6. | 22 nd September, 2012 | "Fish Festival" at Lahli Centre CIFE, Rohtak. |
| 7. | 28 th - 29 th September, 2012 | 6 th National Seminar on "Global opportunities and concerns in dairy and food sector" organised by graduate association, NDRI, Karnal. |
| 8. | 17 th - 19 th October, 2012 | ASEAN India Expo & meet, NASC, Delhi. |
| 9. | 19 th October, 2012 ICAR | Institutes- SAU -Development & stake holder interface at NDRI, Karnal. |
| 10. | 31 st October, 2012 | "Innovators Day" at DWR, Karnal. |
| 11. | 4 th November, 2012 | Visit of Board of Trustees of ILRI at NDRI, Karnal. |
| 12. | 26 th - 30 th November, 2012 | 3 rd International Agronomy Congress at IARI, Delhi. |
| 13. | 8 th December, 2012 | NAIP Meeting at NDRI, Karnal. |
| 14. | 23 rd December, 2012 | Kisan Sammellan at NDRI, Karnal. |
| 15. | 28 th - 30 th January, 2013 | New paradigms in livestock production from traditional to commercial farming and beyond at NDRI, Karnal. |
| 16. | 2 nd - 3 rd February, 2013 | Seminar on "Hi-tech vegetable production, post harvest management and marketing held at NDRI, Karnal. |
| 17. | 25 th - 27 th February, 2013 | "National Dairy Mela" at NDRI, Karnal. |
| 18. | 1 st March, 2013 | "Rabi Kisan Mela" at CSSRI, Karnal. |
| 19. | 9 th March, 2013 | Buffalo Mela and Exhibition at CIRB, Hisar. |

Revenue Generation

| | | |
|---------------------|---|----------------------|
| 1. | Hiring rent from Dr. D. Sundaresan Auditorium | ₹ 2,75,282.00 |
| 2. | Photography | ₹ 5,878.00 |
| 3. | VCD on Clean Milk Production | ₹ 1,521.00 |
| Total Amount | | ₹ 2,81,160.00 |

MAINTENANCE SECTION

Since 1979, Maintenance Section has been providing the services related to mechanical, electrical, civil, refrigeration and 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 and

sewage disposal system in the Institute; planning and inspection of new buildings in the Institute; maintenance of STP and Bio Gas Plants and other miscellaneous works of the Institute.

HUMAN HEALTH COMPLEX

The Human Health Complex (HHC) was established in 1991. It is catering to the health needs of the employees and students 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 and trained nursing staff, laboratory technicians and pharmacists

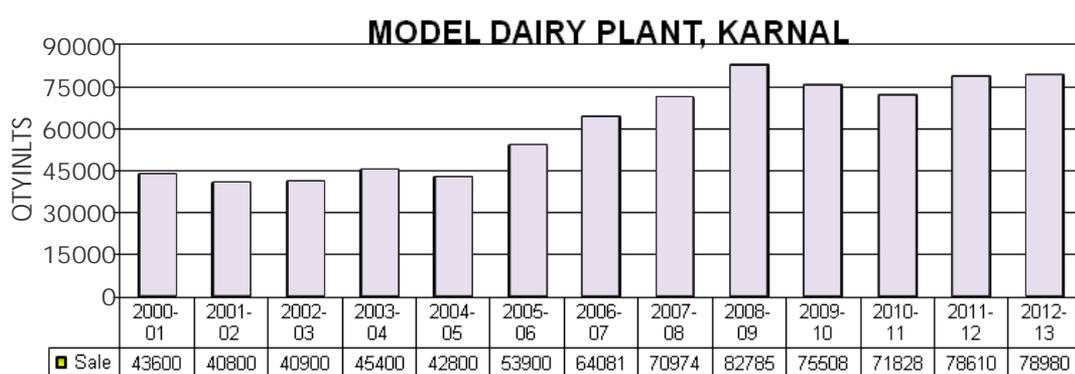
assist the Doctors in providing the desired medical facilities. A Physiotherapy Unit exists at the complex premises for the benefit of the patients suffering from various chronic ailments such as lower back-ache, cardiac ailments, hypertension and various types of muscular, arthritis and ailments etc. Diagnostic clinical lab is well equipped with a fully automatic haematolyzer and a semi-auto biochemical analyzer.

Model Dairy Plant (MDP)

Model Dairy Plant is presently certified Under the Food Safety Management System (FSMS) ISO

22000:2005.

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 the committee, whose Chairman is the Director of NDRI. MDP is presently processing/packing 75000-80000 lpd of polypack milk in all the varieties for Mother Dairy, Delhi



AV. DAILY MILK SALE

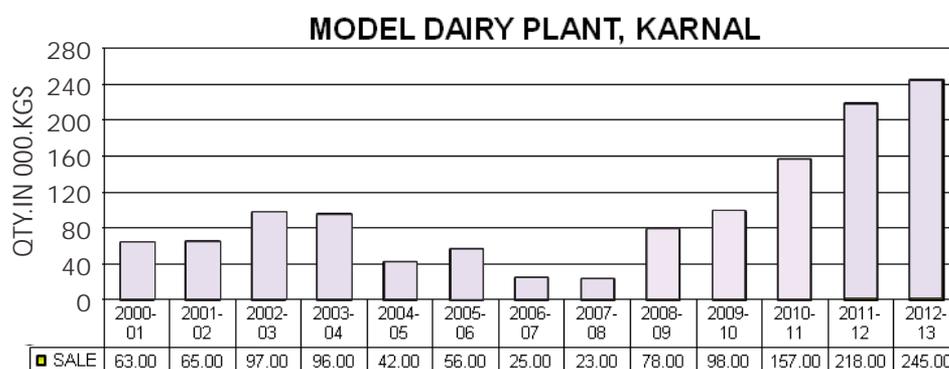
Activities of Model Dairy plant (MDP)

1. Model Dairy plant (MDP) provides one year in-plant training to the students of B.Tech. (DT) of the NDRI Deemed University during the 4th year of the course curriculum. A total of 411 No. of students have been trained so far.
2. It also provides infrastructure facilities to the scientists of NDRI for scaling up R& D concepts from laboratory to industrial scale under commercial environment.
3. 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.

4. 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



GHEE SALES (M.Tons)

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 and 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 250 zebu cattle of Deoni breed and 50 crossbred cattle constitute 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 12402 books. 10691 bound volumes of journals, 1808 theses and 1295 reprints. Library subscribes to 125 Indian / Foreign Journals relevant to various disciplines of Dairy Science. In addition, a few journals are also received on gratis basis from different Institutions / organizations of the country and abroad. Library Automation Software has been procured for facilitating the automation of library functions and 9258 Bibliographical details about the book have been updated in to the software. The 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. The Library has also facility for online journal referral.

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 and Artificial Insemination, Cattle yard and Forage Production, Dairy Technology, Dairy Chemistry and Bacteriology, Dairy Engineering, Dairy Economics and Management, Dairy Extension and Education. The Campus has staff strength of 173 including 19 Scientific and 39 Technical staff.

Education and Training

Educational Programmes

Ph.D Programmes for carrying out dissertation work are being offered in the disciplines of Dairy Technology, Dairy Chemistry, Dairy Engineering, Animal Genetics and Breeding, Livestock Production and Management and Dairy Economics. In addition to conducting the course work for Ph.D in Dairy Engineering and M.Tech Programme in Dairy Technology and Dairy Engineering, guidance is being provided to the PG students in the disciplines of Dairy Technology, Dairy Chemistry, Dairy Engineering, Animal Genetics and Breeding, Animal Nutrition, Dairy Economics, 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.

Training programmes

| Name of the Training Programmes | No. of Batches | No. of Participants |
|---|----------------|---------------------|
| Commercial Dairy Production | 05 | 48 |
| Scientific Dairy Farming Practices for Dairy Farmers | 01 | 40 |
| Preparation of Ice-cream and Indigenous Dairy Products | 01 | 05 |
| Calibration of Dairy Glassware | 01 | 05 |
| In -plant Training (DT) | 03 | 10 |
| Summer Placement Training | 01 | 15 |
| Training on Livestock Genomics and IP Protection in Livestock Biotechnology | 01 | 04 |
| Project Work | 01 | 01 |
| Total | 08 | 128 |

A total revenue of ` 1,81,000/- was collected towards the training fees for the above training programmes during January 2012 to January 2013.

- The Ph.D. and M.Tech Students are awarded with NDRI Fellowship/ and external fellowship as shown below:

| Scholarship/Fellowship | Ph.D. | M.Tech. |
|------------------------|-------|---------|
| NDRI Fellowship | 10 | 23 |
| ICAR-SRF/JRF | 01 | 02 |
| RGNF-JRF | 01 | - |
| INSPIRE (SRF) | 01 | - |

- Guidance and counseling were imparted to the PG students for their career advancement and Campus recruitment was conducted by the various organizations like M/s. Wrigley India Pvt. Ltd., GCMMF, Anand, Gujarat and ITC Foods Division, Bangalore, Mother Dairy New Delhi, Food Safety and Standard Authority of India and Academic Institutions.
- Literary and Cultural activities are conducted for the students of our Campus during the Hindi Day and National Festival Celebrations. Sports were also conducted during the Independence Day and Republic Day Celebrations.
- Campus Recruitment was organised for the students by M/s. Wrigley India Pvt. Ltd. On 24.02.2012, ITC Foods Division, Bangalore on 03.04.2012, GCMMF, Anand, Gujarat on 23.03.2012, GOMA Engineering Ltd., at Thane on 03.05.2012, FERRERO India Ltd., Baramati on 16.05.2012 and Mother Dairy, New Delhi on 28.05.2012.

Extension Activities

- A total no. of 1705 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 round the institute to various units/labs as per their needs and were explained about the ongoing activities.
- Technical /Advisory services were rendered to the needy clientele, during their personal visits to the institute and through mail correspondence. The profile of information needs included feasibility of modern and mechanised mega dairy project, availability of high yielding dairy breeds, information regarding hand operated milk machines, dairy processing technologies and scientific dairy farming aspects, know-how on preparation of indigenous dairy products, training programmes in dairying for rural women and farmers, preparation of project reports for dairy business, export potential for dairy products, packaging and marketing of milk and milk products, availability of dairy cultures for food industry and on knowhow to start up a commercial dairy farm.



Hon'ble Dr. S. Ayyappan, Secretary DARE and Director General, ICAR visited Southern Campus, Bangalore

- Training programmes were organised at the adopted villages on Scientific Dairy Farming for 162 rural women from eight self-help-group (SHGs)
- Participated in GIM EXPO-2012, Global Investors Meet, held at Bangalore International Exhibition Centre (BIEC), Bangalore from 6th -8th June 2012 organised by Government of Karnataka.
- Participated in Dairy Tech India 2012, International Exhibition on Dairy Products and Technology held during 25th – 27th August, 2012 at Palace ground, Bangalore.
- Extension literature on dairy production and processing aspects was distributed to the visitors and needy clients for dissemination of technical information to the needy clientele group. An extension folder on 'Clean Milk Production' was prepared in English and Kannada for the benefit of dairy entrepreneurs and dairy farmers of the locale.
- 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.

New Initiatives

- A new cluster of villages was identified to implement Rural Extension Programme
- A study was initiated through in-house project on small holder dairy production systems of all the southern states to elucidate the present dairy farming trend/status in the region, which included the constraint analysis of the small dairy farming systems.
- Empowerment of rural women SHGs through implementation of IRC project Dairy Entrepreneurship Development of Rural Women: An Action Research. This project involves association of NDRI with interested NGOs working in the field of dairying and rural development.

Success Story

Package of practices for effective control of sub clinical mastitis under field conditions:

Training cum demonstration programmes on detection and control of subclinical mastitis in lactating cows by using electrical conductivity meter, CMT kit and digital somatic cell counter were arranged for the benefit of the dairy farmers of Shivajinagar, Koramangla, Adegodi and Dhoddanekkundi areas *etc.* under Bangalore urban. Farmers in the areas under Kumbalgarh village and two adopted villages *viz.*, Sriramnahalli, Rajanukunte and Honnenahalli in Doddaballapur taluk under Bangalore rural district were also trained. In these areas women dairy farmers have shown special interest.

Similarly, demonstration cum training programmes were also arranged at Chkkaballapur and Boppanahalli villages of Mallur taluk under Kolar Milk Union, Kolar dist. Similar training programme was also arranged at NDRI Cattle Yard where

farmers belonging to Andhra Pradesh, Karnataka and Kerala participated. More than 650 farmers were provided *on-farm* and *off-farm* training on implementation, detection and control of subclinical mastitis. They started using this practice at their own for further use at their herds. After these 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. So, the efforts made by the NDRI SRS team helped in quality improvement of milk production in the region.

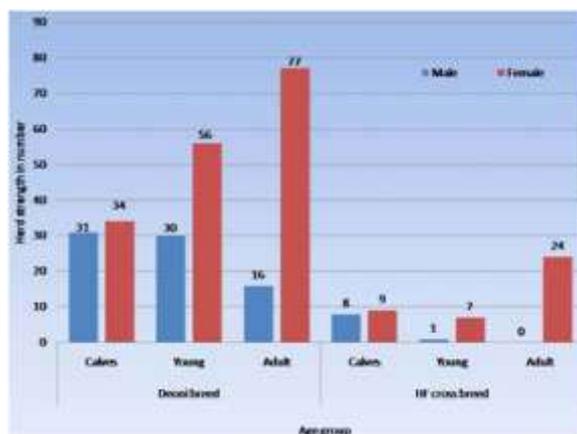
Awareness about subclinical mastitis was also created among dairy farmers and entrepreneurs during National Krishi Mela/Exhibitions *etc.* organized by UAS, Bangalore at GKVK, Bangalore. Nearly 1000 dairy farmers were benefitted out of this demonstration.

LIVESTOCK FARM

Breeds maintained

Cattle Yard located at NDRI-SRS, Bangalore maintains 'Deoni, an important dual purpose indigenous breed, which is generally found in Maharashtra, northern part of Karnataka and some parts of Medak district in

Andhra Pradesh. This breed is hardy and well adapted for tropical draught prone areas. At present (as on 31.12.12), the station maintains highest herd strength of 244 Deoni cattle and 49 HF crossbred cows for research and propagation. Various research activities including students' dissertation programmes were taken up on Deoni and HF crossbred cattle.



Herd strength of Dairy cattle at NDRI-SRS

Herd Performance

The total milk production from Deoni and HF cross bred cattle was 43679 and 64968.5 kg, respectively. The best individual cow's milk yield per day was 13.5 and 35.0 kg in Deoni and HF cross bred cattle. Lactation performance (Jan.12-Dec.12) of Deoni cows showed that mean no. of cows on lactation per month, mean monthly production and wet average was 27.3 ± 3.8 , 3640.0 ± 370.7 and 4.7 ± 0.2 , respectively. Lactation performance of HF crossbred cows showed that mean no. of cows on lactation per month, mean monthly production and wet average was 18.3 ± 1.3 , 5414.0 ± 405.3 and 10.1 ± 0.3 , respectively. Herd

| Parameters | Deoni cattle | HF cross breed |
|-----------------------------------|--------------|----------------|
| Total milk yield (kg) | 43679 | 64968.5 |
| Best individual milk yield kg/day | 13.5 | 35 |
| Average no.of cows in milk | 31 | 20 |
| Milking average kg/day | 4.7 | 9.8 |
| Herd average | 1.8 | 8.3 |
| Total no.of calves born | 67 | 17 |
| Mortality rate (per cent) | 2 | 6 |

average was 1.8 and 8.3 kg for Deoni and HF cross bred cattle. A total of 67 Deoni and 17 HF cross bred calves were born during this period.

Revolving Fund Scheme

The experimental dairy of the institute has all the

facilities for manufacturing various milk and milk products. The section is involved in regular training programmes and also providing in-plant training to the students from various institutions. Training is also imparted to the entrepreneurs. The excess of milk is being sold as market milk and some quantity of milk is

| Product | Quantity Sold | Amount (₹) |
|----------------------|---------------|----------------|
| Milk sweet, kg | 460.25 | 99984 |
| Flavoured milk, pkt | 5009 | 60530 |
| Process cheese, pkt | 4942 | 339688 |
| Paneer, kg | 1158.5 | 193801 |
| Butter, kg | 453.5 | 116965 |
| Ghee, kg | 8.5 | 2380 |
| Gulabjamun mix, pkt | 256 | 10140 |
| Cheese puri mix, pkt | 434 | 17174 |
| Chhana podo, pkt | 1092 | 57981 |
| Kunda, cups | 1931 | 40340 |
| Ice cream (S), cups | 52 | 780 |
| Ice cream (O), cups | 1236 | 15407 |
| Ice cream (FP) | 53 | 6670 |
| Yoghurt, cups | 4631 | 58624 |
| Curd, pkt | 2421 | 23000 |
| Khoa, kg | 40 | 8784 |
| Milk, lit | 40630.5 | 957121 |
| Total | | 2009369 |

also converted to different dairy products for sale through the parlour of the institute.

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, 2012)

The Experimental Dairy has processed and sold milk and milk products as per details given below:

Revenue Generated through Consultancy

- A revenue of Rs. 1, 07,050/- (Rupees one lakh seven thousand two hundred fifty only) was generated by the Dairy Chemistry Unit by providing analytical services to outside agencies.
- A revenue of Rs 14,400 (Rupees fourteen thousand and four hundred only) was generated by providing starter cultures by the Dairy Bacteriology Unit.
- A revenue of Rs 4,000 (Rupees four thousand only) was generated by providing analytical services by the Dairy Bacteriology Unit.

Patents Applied

- S. Isloor, D. Rathnamma, B. M. Veeregowda, K.P. Ramesha *et al.* “Development of Biofilm Based Mastitis Vaccine” was submitted to the Indian Patent Office, Chennai vide Application No.3658/CHE/2012 A, International classification :A61K39/00 and published in the Patent Office Journal on 28/09/2012. No. of Pages: 27 No. of Claims: 10.
- Patent application on “Development of Real Time PCR based Antigen Detection Kit for diagnosis of Bovine Herpes Virus-1” by B. M. Chandranaiik, D. Rathnamma, S.S. Patil, S. Isloor, K.P. Ramesha, B. M. Veeregowda and C. Renukprasad was submitted to the Indian Patent Office, Chennai vide application No: 778/CHE/2012 with CBR No 2365.

EASTERN REGIONAL STATION, KALYANI

The Eastern Regional Station (ERS) was established at the Central Dairy in Calcutta, in 1964 and was shifted to Kalyani during 1966, Nadia district, about 50 km north of Calcutta and was located in the Administrative Building of Kalyani University. The Regional Animal Nutrition Research Centre of the ICAR till then located at Haringhata, West Bengal, was merged with the ERS of NDRI with effect from 1st June, 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 and north eastern regions of the country for transfer of technology developed at the Institute and provides appropriate feedback after trial for perfection. The research work undertaken at this station is mainly strategic and applied in nature and the thrust of research is to improve the socio-economic conditions of dairy farmers of this region.

The research work during the period 1964-1972, was mainly related to Animal Nutrition. During the period of 1972-1976, it was related to Animal Nutrition and Dairy Chemistry and Bacteriology, and during 1977-1985, related to Animal Nutrition, Animal Breeding, Soil Science, Dairy Economics and Dairy Extension. Since 1986, research is mainly focused on Animal Nutrition, Livestock Production and Management, Animal Breeding, Forage Production, Dairy Economics and Statistics and Dairy Extension. Animal Biotechnology section started functioning during 2005. The station of has infrastructure facilities like Research Laboratories, Cattle Herd, Fodder Farm, Library, Computer section, Guest House *etc.*

Keeping in view the enormous demand for milk in the eastern region, low milk production potential of the native stock, shortage of feed and fodder resources and diversified agro-climatic and socio-economic conditions; this research station has a great role to play in the field of dairy development in this region.

Livestock Farm

| Particulars | Jersey Cross | Tharparkar | Overall |
|--------------------------------|--------------|------------|----------|
| Herd Strength as on 31-12-2012 | 146 | 02* | 146 |
| Total milk production (kg) | 118080.0 | 407.5 | 118487.5 |
| Av. no. of cow's in milk/day | 49.0 | 0.3 | 49.3 |
| Av. no. of cow's in dry/day | 19.7 | 1.2 | 20.9 |
| Wet Average (kg)/day | 6.6 | 0.3 | 6.6 |
| Herd Average (kg)/day | 4.7 | 1.2 | 4.6 |
| Age at First Calving (month) | 39 | 0 | 39 |
| No. of Inseminated Cows | 131 | 0 | 131 |
| No. of Pregnant Cows | 53 | 0 | 53 |
| Conception Rate (%) | 40.5 | 0 | 40.5 |
| Service period (days) | 49 | 0 | 49 |
| Inter calving period (days) | 424 | 0 | 424 |
| Mortality (%) | 3.4 | 0 | 3.4 |

* Two animals were in the herd up to 03/10/12 and then auctioned on 04/10/12

Milk Production Performance at ERS-NDRI Herd (January to December, 2012)

| Months | Milk Production (kg) | Wet Average (kg) | Herd Average (kg) | Average FAT % | Average SNF % |
|------------------------|----------------------|------------------|-------------------|---------------|---------------|
| 2012 | | | | | |
| January | 10470.0 | 6.14 | 4.74 | 4.9 | 8.68 |
| February | 10213.5 | 6.91 | 4.96 | 4.79 | 8.64 |
| March | 10424.0 | 6.73 | 4.82 | 4.69 | 8.70 |
| April | 9730.5 | 6.74 | 4.57 | 4.75 | 8.77 |
| May | 10416.5 | 6.96 | 4.65 | 4.75 | 8.80 |
| June | 10286.5 | 6.91 | 4.70 | 4.71 | 8.77 |
| July | 9879.0 | 6.49 | 4.37 | 4.56 | 8.46 |
| August | 8724.0 | 5.92 | 3.86 | 4.56 | 8.48 |
| September | 8802.0 | 6.14 | 4.00 | 4.67 | 8.68 |
| October | 10283.5 | 6.94 | 5.05 | 4.67 | 8.65 |
| November | 9118.0 | 6.54 | 4.75 | 4.66 | 8.63 |
| December | 10140.0 | 6.38 | 5.09 | 4.61 | 8.63 |
| Overall Average | 118487.5 | 6.58 | 4.62 | 4.69 | 8.66 |

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 depths, 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.

Production of different fodder crops at ERS fodder farm during 2012-13

| Type of fodder | Production (Quintals) |
|---|-----------------------|
| Berseem / Berseem+ Mustard | 1957.85 |
| Maize / Maize+Cowpea | 2976.45 |
| Oats/ Oats + Mustard | 2188.95 |
| Sorghum/ Sorghum+cowpea | 6159.00 |
| Hybrid Napier+ Guinea grass +Para grass | 55.55 |
| Total | 13337.80 |

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 database. The institute has Internet connectivity through VSAT, which is useful for searching literature and references.

Technology Assessed and Transferred to Farmers at ERS-NDRI, Kalyani

- **Area-specific Mineral mixture (KALMIN-ERS) developed for livestock of lower Gangetic regions of West Bengal**

Micro-nutrient mapping of lower Gangetic region of West Bengal revealed that the soil, feed and fodder of cattle rearing areas in this region are mainly found deficit in certain macro- and micro minerals. To ameliorate this mineral deficiency, an area-specific mineral mixture (KALMIN-ERS) for livestock was prepared and the formulation was tested and validated both at the Institute and village level. The requirement of KALMIN-ERS is 20-30g/day for an adult cow and buffalo having body weight of 350-400 kg and 2-3 g/day for adult goat and sheep. The expenditure incurred for the same is Rs. 1.0-1.25/animal/day for large animals and Rs. 0.20-0.25/animal/day for small animals. This mineral mixture is very effective to correct the reproductive problems of cattle/buffalo and goats and to maintain the sustainable production of animal.



- **Azolla meal: a potential feed supplement for ruminants**

Azolla is a small free floating aquatic fern native to Asia, Africa, and the America. The fern Azolla has a symbiotic blue green algae *anabaena azollae*, which is responsible for the fixation and assimilation of atmospheric nitrogen. This fact makes Azolla an attractive protein source for animal feed. Azolla is also a very good source of essential mineral elements and vitamins. Package of practices of low cost Azolla production was developed. The fresh biomass of Azolla was harvested at regular interval. The harvested material was washed to remove the extraneous materials and dried under shade for two days and thereafter in oven at 40-50°C for 48 h and then ground to form Azolla meal.

Chemical analysis indicated that Azolla meal was a fair source of plant protein. The concentration of some other micro nutrients was also studied. The results of *in vitro* and *in vivo* evaluation of Azolla meal in cross bred cattle indicated that it can be utilized as good alternative green supplement of protein and other essential nutrients in ruminants.



• **Development of improved calf feeder device to minimize feed wastage**

To minimize the feed/fodder wastage, a feeding device/appliance was developed at ERS-NDRI, Kalyani, which is much more effective as compared to earlier trough. Materials like angle iron, G.I.



sheets, iron bars *etc.* are needed for fabrication which are locally available. One device is sufficient for 6-8 calves (upto 6 months of age) at a time for all types of feeding materials. This will eliminate contamination of feed/fodder through urine and faeces and reduced feed/fodder wastage (no wastage in pelleted feed, < 10 percent wastage in case of dry and green fodder). Further, the calves can consume feed/fodder easily from trough with comfort.

DG Visited ERS-NDRI, Kalyani on 4th January 2013

Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE, Govt. of India visited ERS of NDRI, Kalyani on 4th Jan. 2013. The honourable DG took round the institute, visited different laboratories, interacted with scientists and addressed the staff members of ERS. He also interacted with farmers during his short visit.

Extension Activities and Trainings

- Four training programmes of 15 days duration were organized at ERS of NDRI, Kalyani on *Scientific Dairy Farming* for unemployed rural youth and dairy farmers. Thirty participates from seven districts attended the training programme.

ERS-NDRI attended the Titumir Rural Fair



organized by the SEVA an N.G.O. in 24 (N) Pgs; on 19th, Nov. 2012. Forty-six men and one woman attended the session. The issues highlighted were the participatory role of farmer's in monitoring the health and feeding practices of their livestock, and breeding system to be adopted in Goats.

Five off campus infertility camps were conducted at different districts of west Bengal

| Place | Date | Total cases attended |
|---------------|----------------|--|
| a) 24(N) Pgs. | 18 Feb.'12, | 37 (15 Cows, 8 Heifers, 11calves, 03 Buffaloes and 23 Goats) |
| b) Nadia, | 28 April'12. | 108 (56 Cows, 34 Heifers, 1 Buffalo and 27 calves) |
| c) Nadia | 12 October'12. | 89 (19 Cows, 15Heifers, 11calves, 20 goats and 24 poultry birds) |
| d) 24(N) Pgs. | 19 Nov. '12. | 92 (18 Cows, 26 Heifers, 8 calves, 22 Goats and 8 kids) |
| e) 24(N) Pgs. | 23 Feb'13. | 107 (18 Cows, 26 Heifers, 23 calves and 30 Goats.) |



- Total 433 livestock cases were attended during the camp for repeat breeding, pregnancy diagnosis, digestive disorders, metabolic disorders and deworming etc.
- The demonstration of annual rabi fodder was carried out on the fields of four selected farmers in Haiderpur village of Baduria Block. Berseem (Wardan) + Mustard (Chinese cabbage) and Oats (Kent) + Mustard (Chinese cabbage) were the selected crops; which have been sown by using only bio-fertilizers and farm yard manure.
Follow up programmes for the selected farmers were conducted in 4 different districts of West Bengal (viz. Burdwan, Nadia, 24 (N) Pgs. and Hooghly) to review the progress of fodder crops on 12th, 14th and 16th February 2013
- Total four Visits/ Orientation programme were held during the period. Total 41 Farmers in 2 batches of 9 (24 N Pgs.) and 33 (Burdwan), 26 BVSc students from the WBUA and FS, and 3 State Veterinary officials from I.V.R.I (E.R.S.) attended the visits.
- Two rural seminars were conducted. 52 Farmers attended the Seminar organized by the E.R.S. at Muratipur village, 24(N) Pgs. on the occasion of World Veterinary Day on 28th March 2012. Thirty four farmers attended another rural seminar organized by SEVA (NGO), at Atghara 24(N) Pgs. on 19th Nov. 2012. Lectures were delivered on 'Farmers Role in Dairy Development' and 'Breeding Strategies for Goats under Rural Conditions for Enhanced Productivity'.
- A Total Nine Rural Exhibition/Fairs were attended by ERS, NDRI at different places of eastern India.

SUCCESS STORY

Successful overcoming of postpartum anoestrus in cattle under village condition

The impact analysis of transfer of technology on reproductive performance of cattle was conducted in four villages (Pipli-II, Beri-II, Dackbunglow and Natungram) in 24 parganas district of West Bengal. Anoestrus cows were treated with three different types of treatments (viz. T1: massage of ovary + iodine tamponing; T2: massage of ovary + iodine tamponing + deworming and T3: massage of ovary + iodine tamponing + deworming + mineral mixture +

vitamin-A + Tonophosphan). The result revealed that only reproductive stimuli (ovary massage, iodine tamponing) helps to obtain 42% conception rate, whereas, vitamin A, tonophosphan and mineral mixture supplementation along with ovary massage, iodine tamponing and deworming to animals may help to obtain 77% conception rate among treatment responded animals. The cost incurred per animal in group III to bring them cyclic condition and conception stage was Rs. 200 followed by Rs. 150 in group II and Rs. 100 in group I animals.

हिन्दी सारांश

राष्ट्रीय डेरी अनुसंधान संस्थान राष्ट्र का एक अग्रणी एवं प्रतिष्ठित अनुसंधान संस्थान है जो कि देश में 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 में स्थानान्तरित कर दिया गया। इस संस्थान के दो क्षेत्रीय केन्द्र हैं जो कि बंगलौर एवं कल्याणी में स्थित हैं। 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 परिषद के मान्य विश्वविद्यालय की प्रशासनिक प)ति के अनुरूप ही है। संस्थान के अनुसंधान, शिक्षण, प्रशिक्षण, विस्तार शिक्षा और प्रशासनिक कार्यकलाप के क्षेत्र में नीति-निर्धारण और निर्णय का दायित्व प्रबंध मंडल, 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 हैं। संस्थान के अनुसंधान और विकास के तीन मुख्य क्षेत्र ढूपपत्र डेरी उत्पादन ढूपपत्र डेरी प्रसंस्करण तथा ढूपपत्र डेरी प्रसार प्रबन्ध है। सभी अनुसंधान एवं विस्तार कार्यक्रम संस्थान के मुख्यालय तथा इसके दो क्षेत्रीय केन्द्रों पर संस्थान के तेरह प्रभागों/अनुभागों डेरी पशु प्रजनन, पशुधन उत्पादन एवं प्रबंधन, डेरी पशुपोषण, चारा अनुसंधान, डेरी पशु शरीर क्रिया विज्ञान, पशु जीव रसायन, पशु जैव प्रौद्योगिकी, डेरी प्रौद्योगिकी, डेरी इंजीनियरी, डेरी रसायन, डेरी सूक्ष्म जीव विज्ञान, डेरी विस्तार तथा डेरी अर्थशास्त्र सांख्यिकी एवं प्रबंधन प्रभाग के अन्तर्गत संपन्न होते हैं। संस्थान में एक कृषि प्रौद्योगिकी सूचना केन्द्र ढूपटिकत्र कृषि विज्ञान केन्द्र तथा डेरी प्रशिक्षण केन्द्र एवं पशु प्रजनन अनुसंधान केन्द्र भी हैं। संस्थान में पशुधन फार्म, चारा अनुसंधान एवं प्रबंधन केन्द्र, पशु स्वास्थ्य परिसर, मॉडल डेरी संयंत्र, प्रौद्योगिकी व्यवसाय संवर्धन ढूपटी.बी.आई.त्र, प्रयोगात्मक डेरी संयंत्र, परामर्श

एकक, क्रय, भंडार, पुस्तकालय एवं राष्ट्रीय जैवसूचना केन्द्र, कंप्यूटर केन्द्र, संपदा अनुभाग तथा अनुरक्षण इंजीनियरिंग अनुभाग जैसी केन्द्रीय सुविधाएं उपलब्ध हैं। प्रशासनिक कार्यकलाप जैसे: वित्त, स्थापना, राजभाषा एकक एवं सुरक्षा अनुभाग संयुक्त निदेशक ढूपप्रशासनत्र एवं कुलसचिव के नियंत्रण में हैं। संस्थान में इस समय 153 वैज्ञानिक, 283 तकनीशियन, 155 प्रशासनिक तथा 580 निपुण सहायक कर्मचारी सेवारत हैं।

बजट

संस्थान का वर्ष 2012-2013 में योजना और गैर-योजना शीर्ष में वास्तविक व्यय बजट 13361.52 लाख रूपए था तथा वर्ष 2012-2013 के लिए कुल बजट 13367.50 लाख रूपए स्वीकृत किया गया था। इसमें मान्य विश्वविद्यालय/कृषि विज्ञान केन्द्र तथा क्षेत्रीय केन्द्रों का बजट भी सम्मिलित हैं

अनुसंधान

वर्ष 2012 के दौरान कुल 72 अन्तःसंस्थान अनुसंधान परियोजनाओं का कार्य चल रहा है। 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 डेरी अनुसंधान संस्थान लगभग सभी अग्रणी राष्ट्रीय फंडिंग एजेन्सियों जैसे जैव प्रौद्योगिकी विभाग (डी.बी.टी.) विज्ञान एवं प्रौद्योगिकी विभाग (डी.एस.टी.), राष्ट्रीय डेरी विकास बोर्ड (एन.डी.डी.बी.) राष्ट्रीय कृषि उपयोगी सूक्ष्मजीव ब्यूरो (एन.बी.ए.आई.एन) कृषि पर मूल एवं महत्वपूर्ण अनुसंधान के लिए राष्ट्रीय फंड (एन.एफ.बी.एस. आर.ए.), खाद्य प्रसंस्करण उद्योग मंत्रालय (एम.एफ.पी.आई.), परमाणु ऊर्जा विभाग (डी.ए.ई.), भारतीय चिकित्सा अनुसंधान परिषद (आई.सी.एम.आर.) तथा पशुपालन एवं डेयरिंग विभाग (डी.ए.एच.डी.) से बाह्य वित्तीय सहायता प्राप्त करने में सफल रहा है। यहां यह उल्लेखनीय है कि संस्थान रु 1.85 करोड़ राशि की एक परामर्श परियोजना का संचालन कर रहा है।

एन.ए.आई.पी. एवं अन्य फंडिंग एजेन्सियों से प्राप्त सहायता ने



वैज्ञानिकों को स्टैम कोविका, भैंस की क्लोनिंग, ट्रांसक्रिपटोन, एम्ब्रयोजेनेसिस, बायोसेंसर, नैनोप्रौद्योगिकी, क्षेत्रीय पशुओं में एबायटिक दाब, न्यूट्रास्यूटिकतस तथा क्रियात्मक आहारों पर कार्य करने के लिए प्रोत्साहित किया है। सूचनाओं के परियोजना मानीटरिंग तथा मूल्यांकन एवं परिकलन तथा अंकीकरण को सुदृढ़ करने के लिए भी फंड प्राप्त किए गए। एन.ए.आई.पी.से प्राप्त अनुदान ने छात्रों को अपने शोध निबंधों में आधुनिक उपकरण एवं तकनीकियों के चयन के लिए भी सहायता प्रदान की है।

अनुसंधान

- भैंस का क्लोन्ड कटड़ा 'स्वर्ण' दिनांक 18 मार्च, 2013 को उत्पन्न हुआ। कटड़ा सामान्य प्रसव द्वारा उत्पन्न हुआ तथा जन्म के समय उसका भार लगभग 55 किलोग्राम था। यह क्लोनड कटड़ा श्रेष्ठ है तथा पूर्व उत्पन्न क्लोन्ड कटड़ों से भिन्न है क्योंकि इस केस में प्रदाता सोमैटिक कोशिका सांड के वीर्य प्लाज़्म से वियोजित की गई थी, जिसका कि प्रयोग इस समय राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल के पशु प्रजनन अनुसंधान केन्द्र पर वीर्य प्रदान करने के लिए किया जा रहा है।
- इस क्लोन्ड भैंस 'गरिमा-2' से दिनांक 25 जनवरी, 2013 को 'महिमा' नामक कटड़ी उत्पन्न हुई जिसका जन्म के समय शरीर भार 32 किलोग्राम था जो कि हैंड गाइडिड क्लोनिंग द्वारा उत्पन्न की गई तथा प्रदाता कोशिकाओं के रूप में एम्ब्रयोनिक स्टैम कोशिकाओं का प्रयोग किया गया।
- राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल पर दिनांक 26 अगस्त, 2010 को उत्पन्न भैंस का प्रथम क्लोनड कटड़ा 'श्रेष्ठ' अब तक विकसित सांड हो गया है, जिसका वीर्य क्रायोसंरक्षण के लिए प्रयुक्त किया जा रहा है।
- भैंस के फीटल फाइब्रोब्लास्ट तथा एम्ब्रयोनिक स्टैम (ई.एस) कोशिकाओं में एन.ए.एन.ओ.जी. की अति-अभिव्यंजना से ई.एस. कोशिकाओं के विकास तथा बहुक्षमता में सुधार हुआ।
- भैंस के शुक्राणुजन कोशिका के लघु अवधि संवर्धन के लिए विभिन्न विकास पहलुओं को समन्वित करने के लिए एक विट्रो संवर्धन प्रणाली विकसित की गई।
- जीना-मुक्त क्लोनड भैंस के ब्लास्टोसिस्ट के क्रायोपरिरक्षण के लिए धीमे प्रशीतन की अपेक्षा ओपन-पुलड स्ट्रा में काचन अधिक श्रेष्ठ दिखाया गया चूंकि इसने काफी अधिक क्रायोसंरक्षण दर प्रस्तुत की।
- वैद्युत संयोजन द्वारा उत्पन्न भैंस के टैट्राप्लायड भ्रूण ब्लास्टोसिस्ट उत्पन्न करने के लिए भैंस की ई.एस.त्र कोशिकाओं के साथ एकत्रित किए गए।
- उन्नत तापमान तक भैंस के डिम्बाणुजन कोशिकाओं तथा भ्रूणों के प्रदर्शन उनकी विकासात्मक क्षमता को अलग-अलग समाविष्ट करेंगे। एपोपटोसिस में वृद्धि होगी तथा दाब, एपोपटोसिस तथा विकास संबंधी जीनस को प्रभावित करेंगे।
- भैंस के डिम्बाणुजन कोशिकाओं के परिपक्वण में नवीन नान-कोडिंग आर-एन-ए अविष्कृत किए गए, जो कि उनके विकास क्षमता को प्रदान करने में निर्धारित भूमिका रख सकते हैं।
- आई.वी.एफ तथा पार्थेनोजेनेसिस द्वारा उत्पन्न बकरी के भ्रूण में तेरह विकासात्मक महत्वपूर्ण जीनस अभिव्यंजना के लिए पाए गए।
- हैंडमेड क्लोनड बकरी के भ्रूणों की विकासात्मक संभाव्यता वृद्धि के लिए ओक्समफ्लेटिन तथा एस.ए.एच. ए. पाए गए।
- बकरी के आई.पी.एस. के निर्दिष्ट विभेदीकरण द्वारा उत्पन्न जनन कोशिका जैसी कोशिकाओं में वी.ए.एस.ए., स्टैला तथा पी.यू.एम./जनन-कोशिका-विशिष्ट मार्कर जीनस अभिव्यंजित पाए गए।
- एम.जी.पी-40, एक स्तनीय ग्रन्थि प्रोटीन स्तनीय ग्रन्थि को एपोपटोसिस के दौरान कोशिकाओं की अत्याधिक क्षति से बचाती है।
- गोपशुओं तथा भैंसों के लेक्टोफेरिन के बीच अमीनों अम्ल की संरचनात्मक माडलिंग एवं क्रियाशील लागत में अन्तराल का अध्ययन किया गया।
- साहीवाल गोपशुओं में सी.ए.आर.डी., 15 जीन में पोलिमार्फिज़्म थनैला से संवर्धित नहीं है।



- हिन्फ1, ए.एल.यू. i एच.ए.ई iii, एम.बी.ओ. ii, ई को ओ 1091, पी.वी.यू.ii, बी.एस.एम.एफ.। प्रतिबंधित एंडोन्यूक्लीसिस का प्रयोग करके पी.सी.आर-आर.एफ. एल.पी. ने 150 मुराह भैंसों में कालग्रेन्यूलिन (एस.100 ए.8) के कोडिंग अनुक्रम में मोनोमर्फिक पैटर्नों को प्रकट किया।
- डिओनि तथा होलस्टिन फ्रीजियन संकर गायों में हीट शाक प्रोटीन 70 (एच.एस.पी.70) में आनुवांशिक परिवर्तनशील की उच्च डिग्री पाई गई।
- हीट शाक प्रोटीन 70 (एच.एस.पी. 70) के प्रवर्तक क्षेत्र में होलस्टिन फ्रीजियन संकर गोपशुओं में दो एस.एस.सी. पी. पैटर्न तथा डिओनि गोपशुओं में तीन एस.एस.सी.पी. पैटर्न।
- डिओनि गोपशुओं में ए. केसीन एलील निर्धारित की गई। मलनाद गिदा गोपशु प्रमुखता ए. किस्म (154 में से 151) की थी। श्रेणीकृत होलस्टिन फ्रीजियन (एच.एफ) गोपशुओं में ए. एलील की बारम्बारता 0.3 है।
- मलनाद गिदा गोपशु एक विशिष्ट नसल के रूप में पंजीकृत हुए हैं।
- डेरी गोपशुओं में लंगड़ेपन के शीघ्र निदान के लिए एक नवीन विधि विकसित की गई।
- संवेदन आधारित पीडोमीटर, सूक्ष्म जलवायु, नियंत्रण प्रणालियों तथा मदकाल निदान साधनों के लिए मापदंड विकसित किए गए।
- प्रसवोपरान्त गर्भाशय शोथ के लिए व्यावहारिक मार्करों सहित आगामी रोगों के पूर्वानुमान के लिए जैवमार्करों तथा गर्भाशयशोथ एवं थनैला के लिए जैवरासायनिक मार्करों की पहचान की गई।
- प्रशीतित हिमद्रवित वीर्य के शुद्धिकरण ने उच्च कोटि के शुक्राणुओं के पृथकीकरण तथा उच्चकोटि के शुक्राणुओं के चयन को सरल बना दिया है।
- 10 ग्राम रूमेन संरक्षित कोलाइन पश्च रोमन्थी के सम्पूर्ण से दुग्ध उत्पादन (21%), दुग्धवसा, दुग्ध कोलाइन अंश एवं दूध में असंतृप्त वसीय अम्लों में वृद्धि है।
- दुधारू पशुओं को रूमेन संरक्षित मीथिओनाइन एवं लाइसाइन (क्रमशः 7ग्रा0 एवं 60 ग्रा0) के संपूरण से दुग्ध उत्पादन में (11%) तथा दुग्ध वसा में (13%) वृद्धि हुई।
- क्रोमियम 1.5 पी.पी.एम. स्तर तक दैनिक आहारिय सम्पूर्ण से भैंसों में दुग्ध उत्पादन (7.6 से 9.9 कि.ग्रा.), दुग्ध वसा, कुल ठोस एवं अधिक शुष्क पदार्थ अन्तर्ग्रहण (15%), पोषणिक पाच्यता, असंक्राम्यता स्तर तथा प्रजनन क्षमता में वृद्धि हुई।
- प्रारम्भिक दुधारू गायों को सांद्रित मिश्रण में निस्त्रावित सम्पूर्ण वसा सोयाबीन खिलाने से दुग्ध उत्पादन में 10% तक वृद्धि होती है।
- पूर्वी क्षेत्र के लिए क्षेत्रीय विशिष्ट खनिज मिश्रण तैयार किया गया।
- लेक्टोबेसिलस स्पै. की तीन जातियों के साथ तैयार प्रतिजैवी किण्वित दुग्ध के आहार से अन्तजाति असंक्राम्य प्रतिक्रिया के न्यूट्रोफिल तथा मैक्रोफेज कार्यों में सुधार किया।
- सी.57बी.एल.6/जे.चूहों को प्रतिजैवीय (एल.केसी) मौजूद दही के आहारिय सम्पूर्ण से एपिडीडाइमल वसा संचयन कम होता है, लिपिड प्रोफाइल सामान्य होता है तथा सी.ई.सी.ए.एल सूक्ष्म वनस्पति का अधिमिश्रण हुआ।
- भैंस के केसीन तथा व्हे प्रोटीनों से एस-निरोधक एवं प्रति आक्सीकारक पेप्टाइड उत्पन्न करने में पेप्सिन तथा ट्राइप्सिन प्रोटियोलाइटिक किण्वक अन्य किण्वकों से श्रेष्ठ है।
- अफ्लागक्सिन एम 1 की जांच के लिए विकसित विधियों में उनके प्रयोग के लिए एप्टामर्स (न्यूक्लिक अम्ल आधारित उच्च विशिष्ट लिजेंड अणु) उत्पन्न किए गए।
- चीनी रहित खोआ जलेबी तैयार करने के लिए एस्पारटेम, सुक्रोलोज, एसीसल्फेम, सोरबिटोल तथा क्जालिटोल, मीठी चाश्नी को मिलाकर एक सूत्र तैयार किया गया।
- खोआ पाऊडर को आधारभूत सामग्री के रूप में प्रयोग करके गुलाबजामुन मिश्रण का सूत्र का विकास किया गया। इसको सुरक्षित रखने की अवधि 30° से 0 ग्रेड पर 60 दिन के लगभग थी। इस मिश्रण से तैयार गुलाबजामुन



- में विशेषकर खोआ-गुलाबजामुन की दानेदार संरचना तथा सुगन्ध पाई गई।
- एस्पार्टेम, सुक्रालोज तथा असैसल्फम जैसे तीव्र मीठे पदार्थों के साथ सुक्रोज प्रतिस्थापित करके चीनी रहित आहारिय रबड़ी तैयार करने के लिए विधि विकसित की गई।
 - केसीन एवं व्हे प्रोटीन सान्द्रण फिल्मस (डब्ल्यू.पी.सी) ग्लाइसिरोल तथा सोर्बिटोल के साथ प्लास्टिकृत कास्टिंग विधि द्वारा तैयार किए गए।
 - स्वदेशी प्रोबायोटिक लेक्टोबेसिलस जातियों अर्थात् एल. प्लानटेरम एल्क 91 तथा एल फरमेनियम निकाला गया।
 - इन विट्रो एवं इन विवो अध्ययनों के द्वारा उनके स्वास्थ्य वर्द्धक गुणों के लिए लेक्टोबेसिलस रियूट्री तथा एल. गौसेरी की स्वदेशी प्रतिजैवीय जातियों को अभिलक्षित किया गया।
 - रियूट्रीन लेक्टोबेसिलस रियूट्री द्वारा उत्पन्न एक व्यापक स्पैक्ट्रम प्रतिजैवीय संयोज्य खाद्य प्रणाली में इसके अनुप्रयोग के लिए अभिलक्षित किया गया।
 - दूध में एल.मोनोसाइटोजीनस तथा ई.कोलि 0157; एच 7 की जांच के लिए जैव-मापन आधारित एक नवीन किण्वन-आधार विकसित किया गया।
 - बाजरा निष्कासित लौह एवं जस्ता पुष्ठीकर न्यूट्रीमिश्रण आधारित, डब्ल्यू पी.सी.-70 तथा एस.एम.पी. विकसित की गई।
 - योघर्ट संवर्धन एन.सी.डी.सी-199 तथा एन.सी.डी.सी.-74, स्किम मिल्क, डब्ल्यू पी.सी.-7., एसेसल्फेम-के, तथा इक्षुशर्करा (सुक्रोज) का प्रयोग कर आहारिय श्रीखंड तैयार किया गया। इस की सुरक्षित रखने की अवधि (शेल्फ-लाइफ) 6-8^o से0ग्रेड तापमान पर 15 दिन थी।
 - अर्जुन सत्व का प्रयोग करके भैंस के दूध से तैयार हर्बल घी तैयार किया गया। इसकी शेल्फ लाइफ 80±1^o से 0 ग्रेड तापमान पर 8 दिन थी जबकि निरीक्षण के लिए तैयारी के 2 दिन थे।
 - प्रोबायोटिक एल. एसिडोफिलस एन.सी.डी.सी. 14 तथा बाजरा एवं जौ का प्रयोग कर एक व्हे अनाज सूत्रीकृत पेय पदार्थ तैयार किया गया।
 - सी.एल.ए. तथा फाइटोस्टीरोल युक्त क्रियात्मक मक्खन तैयार करने की एक प्रौद्योगिकी मानकीकृत की गई।
 - क्रियात्मक डेरी एवं गैर-डेरी संघटकों का प्रयोग कर मिश्रित-वसा चाकलेट स्ट्रैड (एम.एफ.सी.एस) के निर्माण के लिए एक प्रौद्योगिकी विकसित की गई।
 - बाजरा एवं दुग्ध ठोसों पर आधारित सूक्ष्म पौषणिक पुष्ठीकर न्यूट्रीमिक्स के लिए एक प्रक्रिया दूध छुड़ाई के उद्देश्य से विकसित की गई।
 - अति सूक्ष्मछानन (यू.एफ.) प्रक्रिया तकनीक का प्रयोग कर भैंस के दूध से संशोधित सैट-टाइप दही को तैयार करने के लिए एक प्रक्रिया मानकित की गई।
 - मधुमेह के रोगियों के लिए जौ आधारित तुरन्त पकाने योग्य तैयार सेवंई (खीर) के उत्पादन के लिए एक प्रक्रिया विकसित की गई।
 - गाय एवं दूध दोनों के एच.एच.पी. उपचारित नमूनों की रेफरीजरेटर परिस्थितियों के अन्तर्गत शेल्फ लाइफ 20 दिन तक बढ़ी हुई प्रदर्शित की।
 - एल्जहेमर रोग के विरुद्ध प्रोफाइलेक्टिक गुणों वाली हल्दी जैसी पुष्ठीकर लस्सी तैयार करने की एक प्रौद्योगिकी विकसित की गई।
 - एलोवेरा सम्पूरित प्रोबायोटिक लस्सी तथा आइसक्रीम बनाने की एक प्रक्रिया विकसित की गई तथा उत्पाद के स्वास्थ्यवर्धक गुण पशु मॉडलों में मान्य पाए गए।
 - तत्काल प्रयोग करने के लिए तैयार शेल्फ-लाइफ स्थिर डेरी-फल-अनाज आधारित सम्मिश्रित उत्पाद तैयार करने की प्रौद्योगिकी विकसित की गई।
 - भैंस के दूध से 'खीर मोहन' तैयार करने की एक प्रक्रिया तैयार की गई।
 - इन्युलिन, फाइटोस्टीरालस तथा 1-3 वसीय अम्ल जैसे संयंत्र से उत्पन्न संघटकों का प्रयोग करके क्रियात्मक प्रोसैसड चीज को तैयार करने के लिए एक प्रक्रिया विकसित की गई।



- स्वास्थ्यवर्धक गुणों को बढ़ाने के लिए फ्रूटोलिगों सैकराइड (एफ.ओ.एस.) इन्युलिन तथा कोकोआ को समाविष्ट करके भैंस के दूध से मीठी क्रियात्मक नर्म चीज़ विकसित की गई।
- प्रतिजैवीय व्हे पेय (डायरियारोधक) विकसित किया गया।
- लेक्टोबेसिलस एस.पी.पी. के संवर्धन एवं परिगणना के लिए एक मूल्य प्रभावी शुष्क व्हे आधारित विधि सूत्रीकृत की गई।
- चयनित प्रोटियोलाइटिक लेक्टोबेसिलस जातियों का प्रयोग करके स्किम मिल्क (सपरेटा दूध) से प्रति सूक्ष्मजैवी पेप्टाइडस के वियोजन एवं उत्पादन हेतु एक विधि क्रियान्वित की गई।
- व्हे प्रोटीन हाइड्रोलाइसेट ने पैरासिटामोल प्रवृत्त हेप्टो-नेफरो विषाक्तता के विरुद्ध संरक्षात्मक एवं बचावकारी प्रभाव प्रदर्शित किए।
- लौह एवं विटामिन ए पुष्टीकृत दूध को तैयार करने की एक प्रक्रिया विकसित की गई।
- दूध में डिटर्जेंट (प्रक्षालक) की जांच के लिए एक नवीन परीक्षण विकसित किया गया। इस विधि से 100 मि०ली० दूध में 20 मि.ग्रा. डिटर्जेंट की विद्यमानता की जांच की जा सकती है। 'मदर डेरी', दिल्ली इस प्रौद्योगिकी को खरीदने के लिए तैयार हो गई है।
- 3 स्टेज स्क्रैड सरफेस हीट एक्सचेंजर (एस.एस.एच.ई.) में खोआ के लिए एक शीतलन प्रणाली विकसित की गई।
- बासुंडी तथा घी के इन-लाइन उत्पादन के लिए एक प्रक्रिया प्रारंभ की गई।
- कृषकों के हित के लिए डेरी पशु स्वास्थ्य योजना विकसित की गई।
- जलवायु परिवर्तन के प्रभावों में सुधार करने के लिए पशुओं को अपनाने के लिए तथा जेनेटिक रोगों से बचाव के लिए संबंधित आई.टी.के.की पहचान की गई।

- सामाजिक-आर्थिक स्तर तथा सशक्तिकरण के सुधार के लिए अग्रणी, आय अर्जित करने में सामूहिक प्रयास (एस.एच.जी) प्रभावी पाए गए।

शिक्षण

- राष्ट्रीय डेरी अनुसंधान संस्थान ने वर्ष 2012-13 के दौरान बी.टैक (डेरी प्रौद्योगिकी), 13 विषयों में मास्टर तथा 12 विषयों में डाक्टरल पाठ्यक्रमों में शिक्षण प्रदान किया।
- बी.टैक (डेरी प्रौद्योगिकी) उपाधि कार्यक्रम के लिए ई.-पाठ्यक्रम विभिन्न कालेजों 2 संस्थानों को आन-लाइन डिलीवरी के लिए अपलोड किया गया।
- इस शैक्षणिक सत्र में डेयरिंग के विभिन्न क्षेत्रों में अल्प अवधि शिक्षण एवं प्रशिक्षण के लिए कई अन्तरराष्ट्रीय छात्रों (15 छात्रों) को यहां आकर्षित किया।
- संस्थान का 11वां दीक्षान्त समारोह 16 फरवरी, 2013 को आयोजित किया गया। डा. एस.अय्यप्पन, महानिदेशक, भारतीय कृषि अनुसंधान परिषद, नई दिल्ली ने अपना दीक्षान्त उद्बोधन प्रस्तुत किया तथा छात्रों को उपाधियां, स्वर्ण पदक, मेरिट प्रमाणपत्र तथा पुरस्कार प्रदान किए। डा. गुरबचन सिंह, अध्यक्ष कृषि वैज्ञानिक चयन मंडल, नई दिल्ली ने मुख्य अतिथि के रूप में दीक्षान्त समारोह में भाग लिया। इस 11वें दीक्षान्त समारोह के दौरान 32 बी.टैक, 134 मास्टर इन डेयरिंग तथा 38 पीएच-डी छात्रों को उपाधियां प्रदान की गई।
- राष्ट्रीय डेरी अनुसंधान संस्थान ने वर्ष 2012-13 में दीक्षान्त समारोह से पूर्व शैक्षिक सप्ताह मनाया। इस सप्ताह में स्मारक व्याख्यान तथा शैक्षिक उपलब्धियों की प्रस्तुतीकरण तथा विभिन्न प्रभागाध्यक्षों द्वारा शिक्षण में नवप्रवर्तन श्रेष्ठ मास्टर एवं डाक्टरल शोध-निबंधों (थीसिस) के लिए छात्रों का चयन आदि जैसी कई शैक्षणिक गतिविधियों का आयोजन किया गया। शैक्षिक सप्ताह फरवरी 2013 के द्वितीय सप्ताह में मनाया गया। वर्ष 2012-13 के दौरान स्नातक एवं स्नातकोत्तर शिक्षण के लिए 'श्रेष्ठ शिक्षक पुरस्कार' भी प्रारंभ किया गया। वर्ष 2012-13 के दौरान शिक्षण में नवप्रवर्तनों एवं शैक्षिक उपलब्धियों के लिए 'श्रेष्ठ प्रभागीय पुरस्कार' भी



प्रदान किया गया। 'श्रेष्ठ थीसिस पुरस्कार' भी मास्टर एवं डाक्टरल छात्रों को उच्च गुणवत्ता का शोध कार्य करने के लिए प्रतिस्पर्द्धा एवं प्रेरणा की भावना को प्रोत्साहित करने के लिए दिया गया।

- चौथा डा. डी.सुन्दरेसन स्मारक व्याख्यान दिनांक 11 फरवरी, 2013 को संपन्न हुआ। यह व्याख्यान डा. गुरबच्चन सिंह, अध्यक्ष, कृषि वैज्ञानिक चयन मंडल, नई दिल्ली द्वारा दिया गया। वर्ष 2013 के लिए डा.के.के. अइया स्मारक व्याख्यान, डा. पी.पी.माथुर, कुलपति, कलिंग औद्योगिक प्रौद्योगिकी संस्थान, ओडिसा को दिया गया तथा इस वर्ष का डा. एन.एन.दस्तूर स्मारक व्याख्यान पुरस्कार डा.के.एम बजरबरूआ, कुलपति असम कृषि विश्वविद्यालय असम को दिया गया।
- कृषि शिक्षा दिवस दिनांक 23 नवम्बर, 2012 को छात्रों एवं संकाय द्वारा आयोजित किया गया। निबंध लेखन, वाद विवाद एवं पोस्टर बनाने जैसी विभिन्न प्रतियोगिताएं आयोजित की गईं।
- संस्थान ने इस अवधि में वैज्ञानिक एवं शैक्षिक सम्पर्क को प्रोन्नत करने तथा नवीनतम ज्ञान के आदान-प्रदान के लिए 30 प्रशिक्षण कार्यक्रम/कार्यशालाएं/संगोष्ठियां एवं विचार गोष्ठियां आयोजित की।

विस्तार कार्यकलाप

- क्रियात्मक प्रसंस्कृत चीज़ स्प्रेड, भैंस के दूध से तैयार फेटा चीज़, क्रियात्मक क्वारंग चीज़, आहारीय मिस्ट्री दही, भैंस के दूध से सैट प्लेन दही, भैंस के दूध से सैट प्लेन योघर्ट, गाय के दूध से सैट प्लेन योघर्ट, गाय के दूध से सैट प्लेन दही, अधिक शैल्फ लाइफ वाली क्रियात्मक पनीर, अधिक अवधि तक सुरक्षित रखने योग्य मिल्क केक, अल्प-वसीय गुलाब जामुन मिक्स तथा अर्जुन हर्बल घी जैसी प्रौद्योगिकियों के व्यावसायीकरण को प्रारंभ करने के लिए मूल्य निर्धारित कर लिया गया है।
- दूध में डिटर्जेंट (प्रक्षालक) की जांच करने के लिए एक नवीन परीक्षण पंजाब जैव प्रौद्योगिकी इनक्यूबेटर मोहाली तथा मदर डेरी, दिल्ली पर मूल्यांकित किया गया। 'मदर डेरी' ने इस प्रौद्योगिकी को 6.00 लाख रूपए की लाइसेंस

शुल्क पर खरीद लिया है

- दो प्रोबायोटिक संवर्धन अर्थात् लेक्टोबेसिलस एसिडा-फिलस (एल.ए. वी.के.2) तथा बिफिडोबेक्टीरियम विफिडम (बी.वी.व.के.3) एम.टी. सी.सी., आई.एम.टैक., चंडीगढ़ पर प्रस्तुत किए गए, प्रोबायोटिक दही पर पेटेंट प्रदान करने के लिए इनकी आवश्यकता थी।
- राष्ट्रीय डेरी अनुसंधान संस्थान-औद्योगिक सम्मेलन दिसम्बर, 1,2012 को संपन्न हुई। इस सम्मेलन में राष्ट्रीय डेरी अनुसंधान संस्थान द्वारा विकसित 34 प्रौद्योगिकियां 32 उद्योगिक संस्थाओं एवं स्टेकहोल्डरों के 42 प्रतिभागियों के समक्ष उनके व्यवसायीकरण को केन्द्रित करने के लिए प्रस्तुत की गईं। इन प्रौद्योगिकियों में दूध में डिटर्जेंट की जांच, एंटीबायोटिक अवशेषों, लिस्टीरिया मोनोसाइटोजीनस, एन्ट्रोकोकि तथा अफ्लाटाक्सिन एम/सम्मिलित थी। चीज़ स्प्रेड, फैंटा चीज़, क्वारंग चीज़, मिस्ट्री दही, गाय के दूध की प्लेन दही, गाय के दूध की प्लेन योघर्ट, भैंस के दूध की प्लेन योघर्ट, भैंस के दूध की प्लेन दही, हर्बल घी, अधिक अवधि तक सुरक्षित रहने वाला मिल्क-केक, अल्पवसीय गुलाब-जामन, क्रियात्मक दुग्ध-पेय, लौह-पुष्टीकर बिस्कुट, पुनः संरचित खीर, पुनःसंरचित रसमलाई, पुनः संरचित बासुन्डी, पनीर की बढ़ती शैल्फ लाइफ, अनाज आधारित किण्वित व्हे, व्हे आधारित पेय एवं सूप, प्रसूति ज्वर को नियंत्रित करने के लिए एनियोनिक आहार खुराक, दुग्ध प्रोटीन आधारित बाजरा के स्नैक, व्हे-स्कम मिल्क-बाजरा आधारित सम्पूरक आहार, निरन्तर मक्खन पिघलाने का यन्त्र, निरन्तर घी बनाने की मशीन, सम्पूरक मिश्रण, खनिज मिश्रण एवं देगक्योर मिश्रण की प्रौद्योगिकियां वर्णितप्रदर्शित की गईं।
- उद्यमिता विकास अभियान का प्रारम्भ सम्मिश्रित डेरी आहारों के क्षेत्र में विकसित कुछ प्रौद्योगिकियों को हस्तांतरित करने के लिए किया गया। निर्मल धारा महिला दुग्ध समिति नामक एव स्वयं सेवी समूह (एस.एच.जी.) गाँव टपराना में गठित किया गया तथा एस.एच.जी की महिला सदस्यों को उच्च गुणवत्ता वाले डेरी उत्पादों को

तैयार करने के लिए प्रशिक्षित किया गया। दूध एवं दुग्ध उत्पादों के परीक्षण पर भी प्रशिक्षण दिया गया। एस.एच. जी. से संबंध रखने वाली महिलाओं को शगुन बेकरी, दरड़ का नाम दिया। उन्हें बिस्किट, डबलरोटी, बनस, केक तथा मफिन जैसे बेकरी उत्पाद तैयार करने के लिए प्रशिक्षित किया गया।

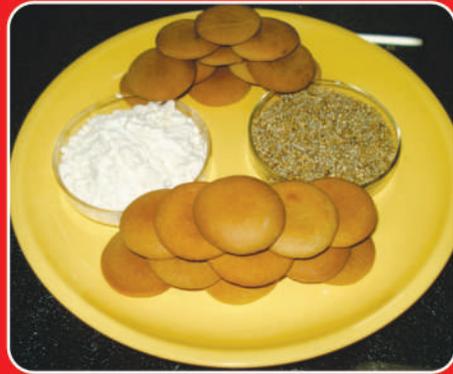
- राष्ट्रीय डेरी अनुसंधान संस्थान द्वारा प्रारंभ किया गया नवप्रवर्तित कार्य: 'कृषकों के द्वार पर डेरी शिक्षण' वर्ष 2012-13 में भी जारी रहा। इस कार्यक्रम के अन्तर्गत राष्ट्रीय डेरी अनुसंधान संस्थान के वैज्ञानिकों की एक टीम जिनमें उत्पादन, प्रसंस्करण एवं प्रबन्धन वर्ग के विषय-विशेषज्ञ भी सम्मिलित हैं प्रत्येक मास के द्वितीय शनिवार को विभिन्न गाँवों में डेरी कृषकों के द्वार पर डेरी शिक्षण आयोजित किया।
- कृषि विज्ञान केन्द्र तथा डेरी प्रशिक्षण केन्द्र ने पूरे देश के 8969 कृषकों, ग्रामीण महिलाओं, ग्रामीण युवाओं एवं उद्यमियों के हित के लिए फसल उत्पादन, बागवानी, मधुमक्खीपालन, मत्स्यपालन, गृहविज्ञान जैसे कृषि के संबंधित क्षेत्रों एवं डेयरिंग के विभिन्न पहलुओं पर 272 प्रशिक्षण कार्यक्रम (परिसर पर एवं परिसर से बाहर) आयोजित किए।
- वर्ष 2012-13 के दौरान 16 राज्यों एवं एक केन्द्र शासित प्रदेश से 25375 कृषकों ने कृषि प्रौद्योगिकी सूचना केन्द्र (एटिक) का भ्रमण किया जिनमें 9 विभिन्न देशों के 216 प्रतिनिधि भी सम्मिलित हैं। डेरी पशुओं के स्वास्थ्य एवं उत्पादकता में सुधार के लिए पोषण, प्रजनन, शरीरक्रिया एवं स्वास्थ्य देखभाल के क्षेत्र में विभिन्न प्रौद्योगिकीय मध्यस्थताओं के बारे में 23375 कृषकों को सुझाव दिए गए जबकि 6478 स्टेकहोल्डरों को पशुधन उत्पादन प्रबन्धन एवं दुग्ध प्रसंस्करण के क्षेत्र में विभिन्न प्रौद्योगिकियां सुझाई गई तथा 1162 मामलों को संस्थान के विभिन्न प्रभागों को विशेषज्ञों के निर्देशन के लिए तथा 2322 मामलों को करनाल स्थित सहयोगी संस्थानों के पास भेजा गया।
- डेयरिंग तथा गृह विज्ञान के क्षेत्र में 43 महिला सशक्तिकरण प्रशिक्षण एवं शिविर आयोजित किए गए।

इनका उद्देश्य इन क्षेत्रों में निपुणता प्रदान करने के लिए जागरूकता पैदा करना था तथा डेयरिंग से आय अर्जित करने के लिए डेयरिंग के क्षेत्र में व्यवसाय करने के लिए ग्रामीण महिलाओं को तैयार करना भी है।

- विभिन्न स्वयंसेवी समूहों को प्रशिक्षण प्रदान करने के लिए महिलाओं हेतु एक प्रयोगशाला संस्थापित करने के लिए एक नई पहल की गई। यह प्रयोगशाला जागरूकता पैदा करने के उद्देश्य तथा डेरी प्रसंस्करण एवं फल एवं सब्जियों के परिरक्षण के क्षेत्र में निपुणता प्रदान करने के लिए संस्थापित की गई तथा इन क्षेत्रों में व्यवसाय चलाने के लिए इन समूहों को तैयार करना है।
- राष्ट्रीय डेरी अनुसंधान संस्थान ने 57 बांझपन तथा पशुचिकित्सा सहायता शिविर नासिरपुर, नासिरपुर तिला, वजीदपुर, कुलवहेड़ी, बुढ़ाखेड़ा तथा गंजोगहड़ी जैसे निकटस्थ गाँवों में लगाए गए।

आधारीय संरचना

- छात्राओं के लिए कावेरी छात्रावास के अमरावती विंग का निर्माण किया गया।
- डेरी सूक्ष्म जीवविज्ञान प्रभाग में एक अत्याधुनिक क्लीन रूम सुविधा सृजित की गई।
- डेरी सूक्ष्म जीवविज्ञान प्रभाग पर एक नवीन अत्याधुनिक स्कैनिंग इलैक्ट्रान माइक्रोस्कोप (एस.ई.एम.) संस्थापित की गई।
- राष्ट्रीय डेरी अनुसंधान संस्थान में (17.43 करोड़ रूपए की लागत से) तैयार की जाने वाली दुग्ध-गुणवत्ता एवं सुरक्षा राष्ट्रीय रैफरल केन्द्र की संस्थापना के लिए नींव रखी गई।
- स्टाफ कल्याण के लिए बच्चों के पार्क की सुविधा सृजित की गई।
- पूरे संस्थान की सड़कें बनाने का कार्य पूरा किया गया।
- छात्रों के नए छात्रावास 'नर्मदा छात्रावास' तथा इनडोर खेल परिसर का निर्माण कार्य प्रारंभ किया गया।
- दक्षिण क्षेत्रीय केन्द्र, बंगलौर के लिए वाई-फाई सुविधा संस्थापित की गई।



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