NDRI

The Golden Quinquennium

2007-2012

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National Dairy Research Institute
(Indian Council of Agricultural Research)
Karnal-132001 (Haryana) India

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Preface

National Dairy Research Institute as the premier Dairy Research Institution is marching ahead with its research, teaching and extension activities with the sole aim of augmenting dairy development in the country. Being the National Institute, it continues to conduct basic and applied research with the objective to enhance animal productivity and also to develop cost effective technologies for the benefit of the consumers, the industry and the farmers. The Institute, having the status of Deemed University, is contributing significantly to the Human Resource Development through its Undergraduate and Post-graduate teaching /training programmes. Looking at the present monumental set-up of the National Dairy Research Institute, the Premier Institution of Dairying in Asia, one just cannot dispense with the historical way of looking at its pristine grandeur. The foundation stone of the edifice of National Dairy Research Institute was laid with the establishment of Imperial Institute for Animal Husbandry & Dairying at Bangalore on July 1, 1923. The Institute at its early stage at Bangalore was established primarily as a centre for Dairy Education. A two-year training course for the award of Indian Diploma in Dairying (IDD) was started at the Institute and later several other courses were added. In 1936, it was expanded and renamed as Imperial Dairy Institute.

The most important event in the history of the Imperial Institute for Animal Husbandry & Dairying was the training imparted to Mahatma Gandhi and Pandit Madan Mohan Malviya in 1927. They came to the Institute for study training and to get acquainted with modern methods of cattle management. Both of them spent two weeks discussing and learning the technicalities and complexities of problems pertaining to cows and buffaloes in India. Gandhiji was highly appreciative of the most productive crossbred cow 'Jill' of the institute. He held several discussions on the problems of Pinjrapoles, which housed low producing, mostly sterile cows and other dairy stock mainly on humanitarian grounds. Mahatma Gandhi evinced great interest in the work of the Institute and wrote several articles in `Young India' and `Harijan' on the importance of dairying and scientific cattle management. Gandhiji's

The present publication highlights some of the significant achievements of the Institute in the areas of Dairy Research, Education, Extension and Infrastructure development during the last five years i.e. from the year 2007-2012.

thinking and views had a great impact on the political leaders of the time and particularly on the policy decisions of the Government of India soon after Independence in 1947, in the formulation of Key Village Scheme, Gosamvardhana Council and intensive Cattle Development Programmes. It is not unreasonable to link the start of the cooperative movement in milk production in the area where Gandhiji and Sardar Vallabhbhai Patel were based in Gujarat and Kaira District in Gujarat with the visits of Gandhiji to Bangalore. The political support derived by Amul through stalwarts/ political leaders such as Sardar Patel, Tribhuvandas Patel and others is a matter well recognized by everyone today. Thus, the institute at Bangalore contributed the technical content through top political leadership for the sound foundations on which the dairy industry came to be gradually built.

In 1955, the Institute Headquarters were shifted to Karnal, and it was rechristened as **National Dairy Research Institute.** The Institute was brought under the wings of the Indian Council of Agricultural Research in 1966 in order to provide greater operational autonomy in research management functions. The first formal Dairy Technology course was started in India at NDRI in 1957.

An important milestone in the history of NDRI was added in 1989 when the Institute was conferred the status of Deemed University for further strengthening the academic programmes for human resource development. In 1994, The Institute got recognition as a Centre of Advanced Studies in Dairy Technology and Dairy Cattle Breeding disciplines to further strengthen the research and training components.

The Institute, with its two regional stations, Bangalore in south and Kalyani in eastern India, conducts research in the areas of dairy production, processing and management and provides high quality education in the field of dairying, which has no parallel in Asia.

The present shape and structure of this Institution owes a lot to the contributions of the great visionaries and distinguished Directors of this Institute. As the country's premier Dairy Research Institution, NDRI has developed considerable expertise over last eight decades in different areas of Dairy Production, Processing, Management and Human Resource Development. Information generated at the Institute and services offered have contributed to the growth of Dairy Industry on the whole and well being of millions of milk producers and consumers of milk and milk products. Realizing the challenging need of globalized Dairy Trade, the Institute is continuously working to develop its R&D and HRD programmes to better serve the nation in terms of food security, employment generation, and poverty alleviation.

The present publication highlights some of the significant achievements of the Institute in the areas of Dairy Research, Education, Extension and Infrastructure development during the last five years i.e. from the year 2007-2012. Here I feel privileged to acknowledge and place on record the contributions made by Joint Directors, Heads of Divisions, faculty, Officers and the Staff. I am sure that with their persistent 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.

Srivastava

(A. K. Srivastava)

NDRI At A Glance

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.

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

Main Building, National Dairy Research Institute, Karnal

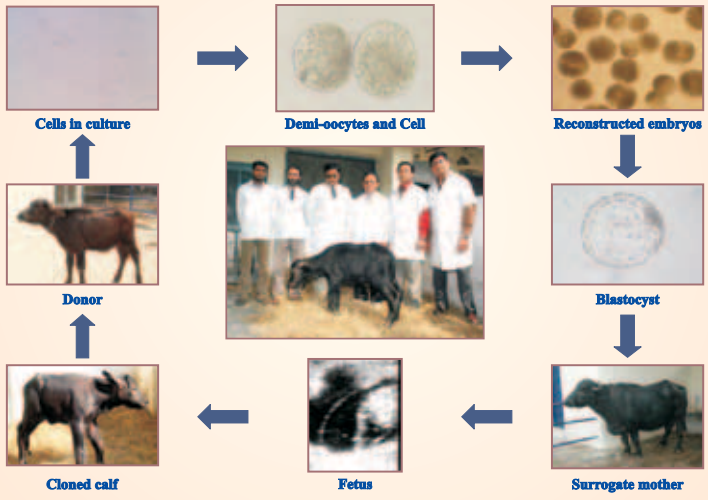
Impetus on Research and Development (R&D)

The R&D activities of the Institute mainly focus on three fundamental facets of dairying i.e. how to produce animals with better productivity, to innovate suitable milk processing technologies and equipment and to provide the dairy farmers and entrepreneurs information about existing market demands and practical management inputs for making dairying a self sustaining profitable business. Research, both in basic and applied aspects in various disciplines constitute the core activity of the Institute

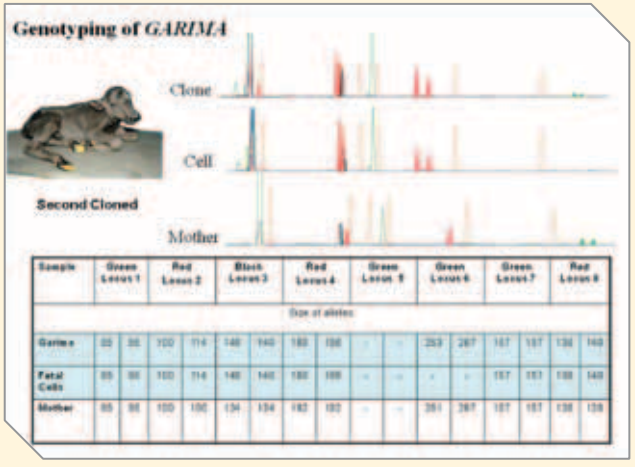
World's first cloned buffalo calf

World's first cloned buffalo calf was was born on February 6, 2009 using the somatic cell of a new-born calf whose age was only two months. The animal from which the donor cells were derived was only 12 months old when the cloned calf was born.

World's first cloned buffalo calf produced by Hand-guided cloning technique



World's second cloned buffalo calf (Garima) produced by Hand-guided cloning was born on June 6, 2009 using somatic cell of a fetus obtained from slaughterhouse. Ganotyping of Garima was established by micro-satellite markers.

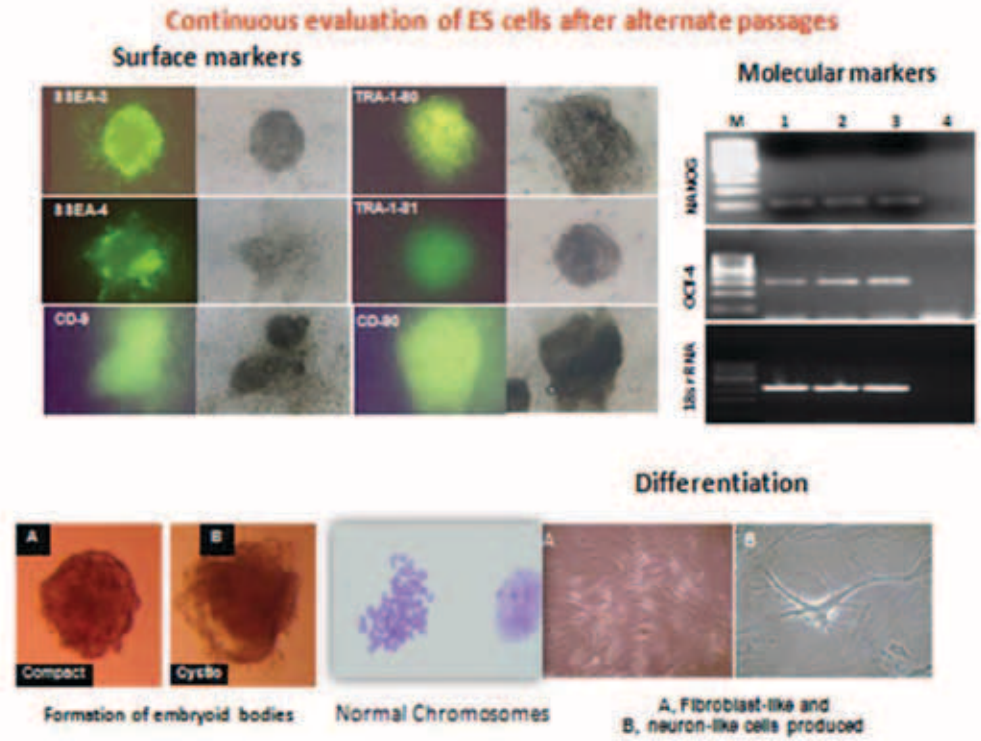


Cloned calf (Garima-II) using embryonic stem cell as donor was born on August 22, 2010.

Garima-II

A cloned calf was produced from a frozen-thawed cloned embryo. This male calf christened 'SHRESTH' was born on August 26, 2010.

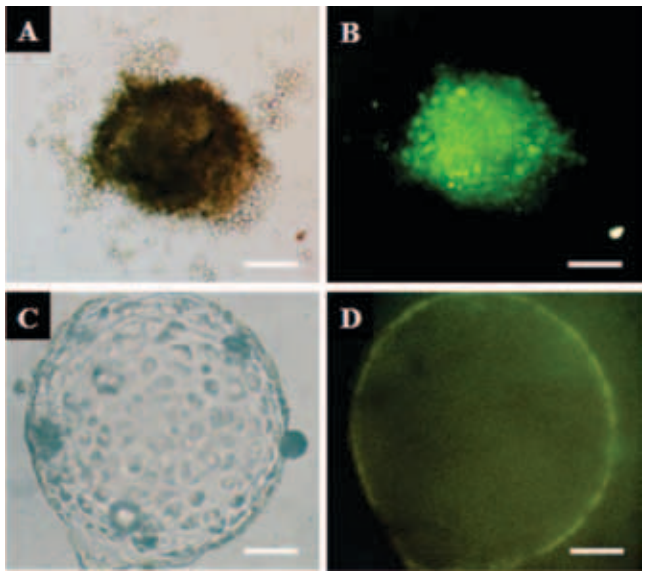
Shresth



Three cell lines of buffalo ES cells were produced, which are at 165, 125 and 115 passages and have been in culture over 34, 26 and 24 months, respectively. These are the only buffalo ES cell lines available in the world. These cell lines can now be used for transgenesis, cloning etc.

Characterization of buffalo embryonic stem cell lines

Cloned transgenic buffalo embryos were produced using buffalo somatic cells and ES cells. ES cells were derived from an adult buffalo whose productive and reproductive features were well characterized. A two-round nuclear transfer (NT) approach was applied, wherein the first round NT provided the cloned blastocysts from which NT-ES cell-like cells were derived and used as nuclear donor for a second round of NT. Buffalo adult fibroblasts and NT-ES cell-like cells of the same genotype were transfected and were further used in Hand-guided cloning for production of cloned transgenic embryos.



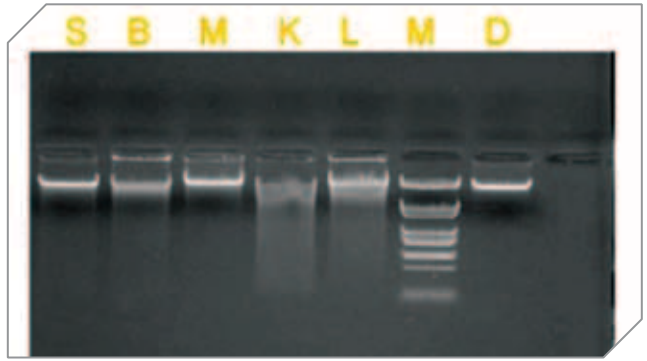
Cloned transgenic blastocysts using transfected ES cell: A, GFP tagged embryonic stem cell colony (under light microscopy); b, Expression of GFP (under fluorescent microscopy; C, Blastocyst developed using hand guided cloning and D, Expression of GFP in blastocyst (fluorescent microscopy) (Scale bar represents 50 µm).

Pregnancy established using oocytes collected from live Sahiwal cattle by Ovum-Pick-up

Oocytes were collected from the ovaries of Sahiwal cattle by follicular aspiration using an ultrasound machine with a transvaginal convex transducer with a needle guide, single lumen 18-gauge 55 cm long sterile needle with an ultrasound echo tip and a vacuum pressure of 80 mmHg. Oocytes were then subjected to in vitro maturation, in vitro fertilization and in vitro culture for development of embryos. When the embryos developed to transferable stage i.e., the blastocyst stage, these were transferred to the recipient i.e., the surrogate mother. Using this OPU and IVF technique, a pregnancy was established.

A non-invasive DNA isolation methodology in dairy animals developed

This is an innovative process for the isolation of Genomic DNA from fecal /epithelial tissue in cattle and buffalo. The invention relates to a process for purifying and/or isolating nucleic acids from domestic animal feces (cattle and buffalo),

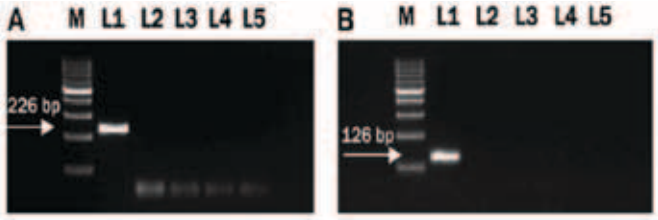


Agarose (1%) gel elctrophoresis of genomic DNA isolated from buffalo fecal tissue (7) Genomic DNA sample (3 µl of each) electrophoresed in a 1% agarose gel with Lambda marker (M), (S) Skin, (K) Kidney, (B) Brain, (L) Liver, (M) Muscle

which may contain impurities and inhibitors. The invention describes a detailed procedure and reagents for carrying out the said method. The basis of the invention is a method of disrupting the dead fecal epithelial tissue, selectively protecting the nucleic acids and finally purifying them. The isolated nucleic acids were found to be considerably intact (not broken / sheared while in the process of isolation). The isolated DNA was processed further for use in PCR and restriction endonuclease digestion methods.

PCR (Polymerase Chain Reaction) based method of differentiating cow and buffalo milk developed

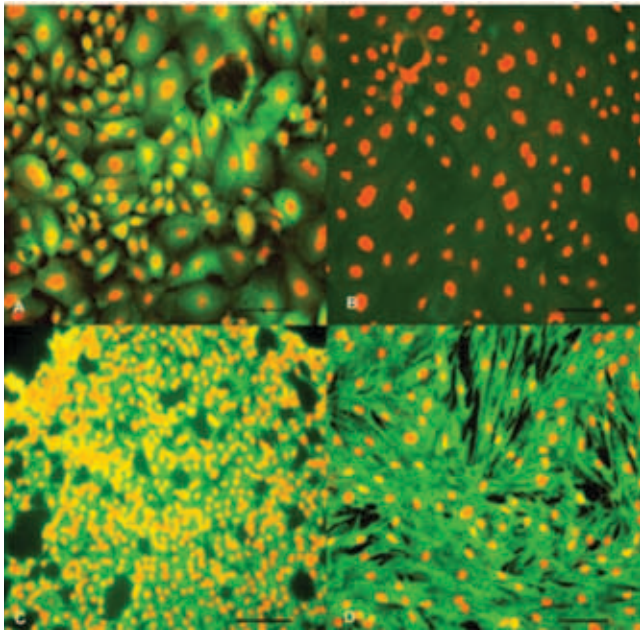
This invention provides a method for detecting segments of the mitochondrial D-loop gene from a milk sample. This invention includes: extracting genomic DNA from a milk sample as a template and carrying out a general PCR test with two sets of self designed primers in terms of the optimized reaction conditions. Milk contains a large but highly variable number of somatic cells, ranging from 10^4 to 10^7/ml, depending on the status of the cow / buffalo (parity, season, stage of lactation, and health). These cells are predominantly leukocytes but also include a small proportion (<2%) of epithelial cells. Use of these cells would facilitate obtaining DNA samples from cows (cattle and buffalo). The DNA samples obtained from the milk were used for PCR based differentiation of cattle and buffalo DNA by using species-specific PCR primers. This work describes the isolation of DNA from milk samples and their use by species specific PCR reactions.



PCR amplification result with buffalo specific (A) and cow specific (B) primers. Samples are: (A)= Marker (M), buffalo (L1), cattle (L2), sheep (L3), goat (L4), negative control (L5); (B)= Marker (M), cattle (L1), buffalo (L2), sheep (L3), goat (L4), negative control (L5).

Buffalo mammary epithelial cell line established

Buffalo mammary tissue collected from slaughter house was processed enzymatically to obtain a heterogenous population of cells containing both epithelial and fibroblasts cells. Epithelial cells were purified by selective trypsinization and were grown in plastic substratum. The purified mammary epithelial cells (MECs) were characterized for mammary specific functions by immunocytochemistry, RT-PCR and western blot. The established buffalo mammary epithelial cell line (BuMEC) exhibited epithelial cell characteristics by



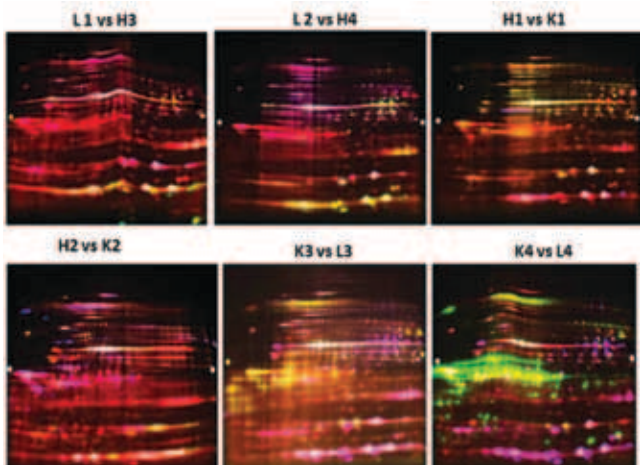
Immunostaining for cytoskeletal markers in BuMECs

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

immunostaining positively with cytokeratin 18 and negatively with vimentin. The BuMEC maintained the characteristics of its functional differentiation by expression of κ-casein, κ-casein, butyrophilin and lactoferrin. BuMEC had normal growth properties and maintained diploid chromosome number (2n=50) before and after cryopreservation. A spontaneously immortalized buffalo mammary epithelial cell line was established after 20 passages and was continuously subcultured for more than 60 passages without senescence. This cell line can be used as model system for studying mammary gland functions.

Differentially expressed proteins in lactating cows having different lactation potential (High vs low producing cows) identified

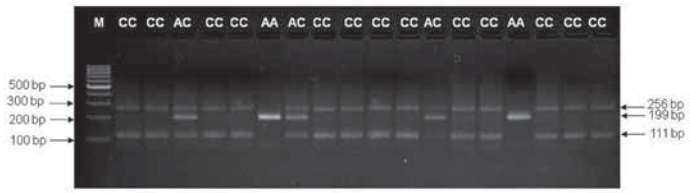
Probable biomarkers of lactation potential in lactating cows were identified by differential expression analysis of proteins in mammary epithelial cells in high vs low producing Sahiwal cows, performed by differential in gel electrophoresis (DIGE) techniques within a pI range of pH 4-7 followed by Mass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



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

PCR-based method for differentiating A1 and A2 beta casein containing milk developed

The DNA samples obtained from the milk were used for presence of A1 and A2 beta-casein by using allele-specific PCR. Four different allele specific PCR based primers were designed and simple PCR was optimized to distinguish the A1 and A2 type of beta casein. This process can be applied to milk and all products processed from that milk for identification of A1 and A2 milk type. A mutation in the DNA sequence coding for the beta casein protein at nucleotide position 200 has resulted in the replacement of a cytidine base with adenine base. Thus, the triplet codon affected by this change codes for histidine (CAT) rather than for proline (CCT) at the amino acid position 67 of the protein. Thus, the histidine at position



Agarose (2%) gel electrophoresis of allele specific A1A2 PCR product

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

67 results in the cow producing beta casein A1 while the proline results in the cow producing beta casein A2.

Biotechnological Reproductive and Molecular Technologies...

- Interspecies blastocyst stage embryos were produced by Handguided cloning using buffalo cytoplasts and differentiated somatic cells from cattle and goat.
- Zona-free buffalo oocytes were successfully activated for parthenogenetic development for producing blastocyst stage embryos using chemical or electrical stimulation.
- Cloning efficiency was shown to be improved by increasing cytoplasm volume or by treatment of embryos with an epigenetic modifier scriptaid.
- Some developmentally important genes viz. Bcl-xl, Bax, Glut-1 and HSP 70.1 were found to be differentially expressed in cloned and IVF-derived embryos.
- Cloned buffalo embryos were produced by using somatic cells isolated from milk as donor cells.
- Cardiomyocytes, which exhibited rhythmic beating, were generated from IVF goat ES cells.
- An efficient protocol was established in goat for production of embryonic stem cells from blastocysts produced by handmade cloning.
- Development of 3 buffalo embryonic stem cell lines achieved.
- *In vitro* culture system capable of supporting long term self-renewal of buffalo embryonic stem cells was developed.. Buffalo embryonic stem cells were characterized by a battery of markers such as SSEA-1, SSEA-3, SSEA-4, TRA-1-60, TRA-1-81, CD9, CD90, *OCT4*, *SOX2*, *FOXD3*, *REX-1* and *NUCLEOSTEMIN*. Embryoid bodies were formed by spontaneous differentiation of buffalo embryonic stem cells, which contained cells from all three germ layers i.e., ectoderm, mesoderm and endoderm, as confirmed by expression of markers specific to these cell types.
- Neurons and muscle cells from buffalo embryonic stem cells by directed differentiation were produced. Buffalo embryonic stem cells were produced using embryos produced by Hand-guided cloning and parthenogenesis. Buffalo embryonic stem cells derived from blastocysts produced by IVF, Handmade cloning and parthenogenesis were shown to exhibit equivalency in terms of their pluripotent marker expression. There exists a crosstalk between JAK-STAT and MAPK pathway and that inhibition of LIF signaling caused inhibition of pluripotency in buffalo embryonic stem cells. WNT3A works together with exogenous FGF-2 and LIF, resulting in proliferation of undifferentiated buffalo ES cells and that WNT3A resulted in formation of scaffold like structure and inhibition of neural cell differentiation in differentiated buffalo ES cells. Buffalo (*Bubalus bubalis*) OCT4 ortholog expressed in buffalo embryonic stem cells and its promoter region were cloned and characterized. Buffalo *NANOG* gene was cloned and characterized and alternative transcription start cSites, splicing and polyadenylation was examined in buffalo embryonic stem cells.
- During the course of *in vitro* culture, buffalo oocytes and embryos were found to suffer from DNA damage, which could be partly ameliorated by supplementation of culture media with cysteamine. Nitric oxide was shown to be necessary for optimal embryo development in buffalo. Lowering the O_2 concentration during IVM, IVF and IVC from 20% to 5% or supplementation of IVM and IVC media with cysteamine, an antioxidant, was shown to improve blastocyst yield, increase the expression of anti-apoptotic genes and decrease that of pro-apoptotic genes.
- Single blastomere sexing of goat embryos was carried out by PCR amplification of the SRY gene.

- Expression profiling of genes related with transcription initiation helped in defining the Maternal to Embryonic transition event in developing Buffalo embryos to take place at 8 cell stage was studied. Development ability of buffalo follicular oocytes and early embryos characterized in terms of gene expression events was studied. GDF9 emerged as a potential oocyte competence marker.
- Important deviations identified in chronology of embryo development between cattle and buffaloes. Generated information will help in formulating better ART protocols for buffalo.
- More than 40, so far unknown, genes identified to be expressed in buffalo oocytes. Some of them have been found to be expressed distinctly differently in more competent oocytes. These could emerge as potential oocyte determinant for fertility.
- New polymorphic alleles isolated for buffalo κ-casein gene. Buffalo κ-casein exists in two different polymorphic forms. Type B was found to be a predominant (85%) allele over A (15%).
- Bovine Y chromosomal haplotyping method was developed based on Y chromosome based SNPs and indel markers.
- A PCR-based method for differentiating A1 and A2 κ-casein containing milk was developed.
- Buffalo Insulin-like growth factor binding protein 5 (IGFBP-5) cDNA was sequenced, characterized and over expressed in bacterial expression system. Also, expression profiling of Insulin-like growth factor binding proteins in milk of cows and buffaloes during lactation.
- Buffalo mammary gland protein MGP-40 was cloned, sequenced and over expressed in *E. coli* and recombinant MGP-40 was prepared.
- Polyclonal antibody against MGP-40 was prepared and used for analysis of its expression in milk lactating cows and buffaloes. This protein is probable biomarker for mastitis.
- Mammary epithelial cells from milk were isolated and characterized. Proteome reference map and proteome profile of milk mammary epithelial cells of cow and buffalo by high throughput Mass Spectrometry were generated.
- Regulatory pathway analysis of lactation specific proteins of bovine mammary epithelial cells associated in lactation functions in cows was achieved.
- Differentially expressed proteins in lactating cows having varied lactation potential (High *vs* low producing cows) were identified. Also, a differentially expressed proteins having potential role in lactation persistency in cows. Further, sequence characterization of 4 differentially expressed proteins in bovine mammary epithelial cells during lactation was completed.
- Spontaneously transformed buffalo mammary epithelial cell line was established.
- Biophysical characterization lactoferrins from different animal species was achieved. Protein-protein interaction of lactoferrins from buffalo, cow, goat and camel suggested distinct advantage of buffalo lactoferrin for iron release capacity at normal gastric pH.
- Buffalo xanthine oxidoreductase was purified and characterized.

Animal Breeding and Genetics: A few landmarks...

- A Karan Fries cow has produced 8216 kg of milk in a lactation period of 415 days during her second lactation. This excellent cow has been produced using imported semen of a Holstein Friesian bull on a Sahiwal dam.
- A Sahiwal cow has produced 4339 kg of milk in a lactation period of 490 days during her first lactation. This cow is the daughter of Sahiwal bull no. 1404, which has been progeny tested under VII Set. Two first calver Sahiwal cows have produced >2900 kg, while three first calvers have produced

>3000 kg of milk in a lactation. Presently, 14% Sahiwal cows have their best lactation 305 day milk yields of 3000 kg and above.

- Highest yielding buffalo namely Karankeerti has produced a peak yield of 23.3 kg in a day and produced 4428 kg of milk in a lactation period of 427 days during her first lactation. This record holder buffalo is the daughter of Murrah bull no. 4915, which has been declared proven bull under Set VII.
- The performance recording including information on daily, weekly and monthly test day milk yields and part lactation records of the daughters of Sahiwal, KF and Murrah bulls was done. The test day lactation curve models were developed using daily, weekly and monthly test day milk yields and part lactation records for predicting monthly and total lactation milk yields in organized herds and under field conditions.

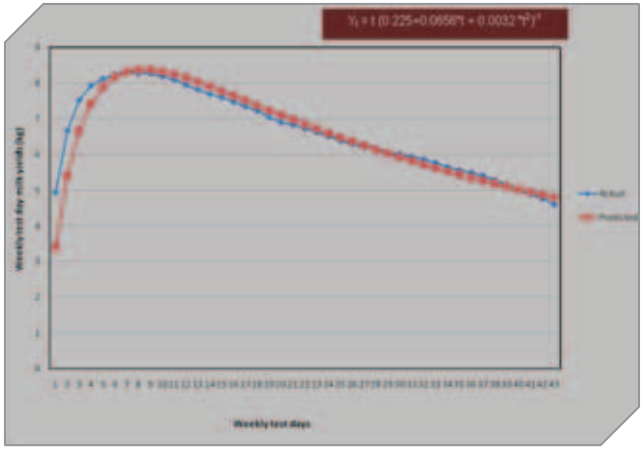


Fig. Observed and predicted WTDMYs (kg) for inverse polynomial function in Sahiwal cattle

- Two sets each of Sahiwal (11 bulls) and KF (17 bulls) and three sets of Murrah bulls (43 bulls) were evaluated during the period. Out of these bulls, 4 Sahiwal, 5 KF and 3 Murrah bulls were selected as proven bulls with their EBVs ranging from 1641-1917 kg, 3228-4144 kg and 1972-2116 kg, respectively; while their superiority over herd average ranged from 9.33-27.73%, 12.00-16.70% and 8.41-17.26%, respectively.
- During 2007-2011, a total of 2152 KF and 2325 Murrah female progeny were born from bulls under field conditions.
- The growth bands were constructed for male and female calves using 26 weeks body weight in Sahiwal calves. Average daily weight gain from birth to twenty six weeks (6 months) of age was 339 g/day in female calves and 333.5 g/day in male calves.
- The different methods of sire evaluation namely contemporary comparison, least squares, simple regressed least squares, BLUP and DFREML were used to evaluate sires. The single trait DFREML was more efficient than multi trait DFREML for estimating the breeding value of Sahiwal sires for FL305DMY, individual third month milk yield and cumulative 90 days milk yield.
- For prediction of first lactation 305-day milk yield in Sahiwal cattle, Multiple Linear Regression (MLR) and Artificial Neural Network (ANN) models were developed using body weights at different ages as independent variables and FL305DMY as dependent variable and the accuracy of fitting both models was compared. It was interpreted that ANN was comparatively more accurate to predict FL305DMY using body weights in Sahiwal cattle.

- Cytogenetical investigation revealed gross anomalies of sex chromosomes in reproductively deficient animals and twin born calves. A case of male sexual behaviour was found in an intersex-crossbred goat.
- Sahiwal Cattle exhibited two genotypes of IL-8 gene (578 bp fragment from 3205-3783 nt containing exon 4 and 3'UTR) by PCR-RFLP using *Dra* 1 restriction enzyme with frequencies of C and D alleles as 0.846 and 0.154 respectively.
- PCR-RFLP analysis using *Dra* 1 restriction enzyme of exon 4 of IL 8 gene in Murrah buffaloes exhibited three (AA, AB and BB) genotypes. However, these genotypes indicated non-significant association with incidence of mastitis in Murrah buffaloes.
- Identification of Factor XI gene deficiency in Sahiwal and Karan Fries cattle revealed that the herds are free from the Factor XI gene deficiency.
- DNA polymorphism of Toll-like receptor 4 (TLR 4) gene using PCR-RFLP analysis in Sahiwal cattle and Murrah buffalo was observed in various exons and the genetic variants were found to be associated with mastitis.
- AA genotype of exon 12 of CARD 15 gene in Murrah buffalo was found to be more resistant to mastitis. Whereas, association of polymorphic patterns of CARD 15 gene in Sahiwal cattle with incidence of mastitis was found to be non- significant.

Record milk production by buffalo at the Institute

Buffalo No.5517 was observed to have a high potential for milk production as it yielded 4425.5 kg of milk in its first lactation in 427 days of lactation and a yield of 3812.5 kg in 305 days. This buffalo was challenged to produce at its highest in its second lactation. The challenge feeding was started one month before the expected date of calving and it continued

Karan Keerti

up to the peak production. Feeding of good quality green and dry fodders along with standard concentrate mixture fortified with by-pass fats (full fat soybean meal), herbal galactogogue (shatavari), jaggery and extra mineral mixture helped in performance. A daily yield of 23.3 kg was recorded in this buffalo on 20.11.09 in the 57th day of lactation. However, a peak yield of 25.1 kg was recorded on 63rd day of lactation. This was the highest daily yield of a buffalo so far recorded in the history of Institute. This buffalo was, therefore, named as Karan Keerti.

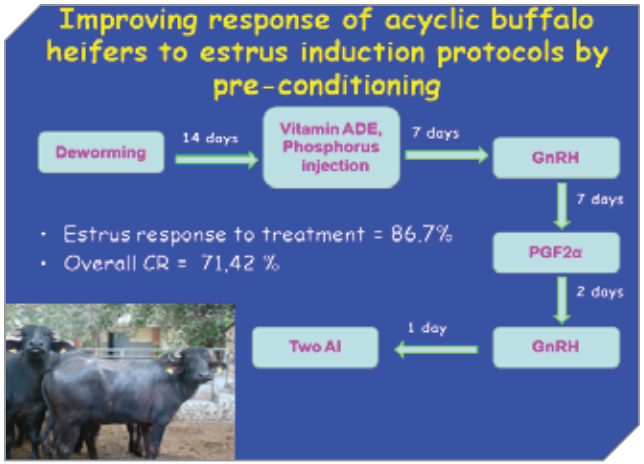
Improved estrus response and fertility in acyclic buffalo heifers

Delayed age at sexual maturity is one of the major problems associated with poor reproductive efficiency in buffaloes. On contrary to Egyptian buffaloes, which attain sexual maturity at an early age, Murrah buffaloes reach sexual maturity at the age of 31 – 36 months. Different protocols were used to advance the age at puberty in buffaloes but the response was poor to the hormonal protocols. Low fertility with estrus induction protocols is yet another but the most significant problems in buffalo heifers. Experience and earlier research findings shows that the estrus response and fertility to Ovsynch protocol was higher in buffaloes with good body

condition. It was assumed that conditioning buffalo heifers by proper deworming, Vitamin and Mineral supplementation would increase the effect of estrus induction protocol. For this purpose, 30 acyclic Murrah buffalo heifers (crossed the normal age of sexual maturity and acyclicity was confirmed using progesterone levels and ultrasound evaluation two times at 11 days interval) were used for experimentation. For one group of heifers the Ovsynch protocol (Buserelin acetate 10µg on day 0 and day 9, Cloprostenol sodium 500 µg on day 7) was applied directly without any deworming or supplementation of Vitamins or Minerals. In this group, only 3 heifers responded to the treatment (heifers showed estrus) but none conceived. Heifers in other group were administered with Vitamin A (30 lakh IU), D3 (10 lakh IU) & E (500 mg), phosphorus (2g) per heifer and Ivermectin (0.2 mg/kg body weight). In this group, only one heifer showed estrus signs within a month after treatment. In the third group, the heifers were first administered with Vitamin A, D3, E, phosphorus, Ivermectin and one month later Ovsynch protocol was applied. In this group, 90 of heifers responded to the treatment and 47 heifers conceived in first insemination and 45 conceived after second insemination leading to an overall conception rate of 71 These results demonstrate that estrus induction can be achieved in non-cyclic buffalo heifers and conditioning the buffalo heifers before application of exogenous hormones improves the estrus response and fertility. This protocol has substantial potential to augment estrus in non-cyclic buffalo heifers, especially under field conditions where the heifers are generally neglected in terms of body conditioning.

Better Housing and Fertility Management Practices

Feeding of young calves with surplus colostrums, whole milk diluted with Dahi (1:1) and probiotics supplement improved the growth rate and reduced morbidity and mortality.



- Total Mixed Ration feeding in growing KF heifers was effective in achieving higher growth rate (upto 700g/d) for attaining early sexual maturity (16-18months).
- One (KF) and 2 weeks (Sahiwal and Murrah) prepartum training in the milking parlour helped to improve the productive performance and milking temperament of first calf heifers.
- In KF calves aged 1-6 months, replacing skimmed milk with soya and maize based milk replacer was effective in reducing the cost of calf rearing without adversely affecting the growth rate

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

- The mist and fan cooling was very effective in ameliorating the impact of heat stress in KF cows by maintaining the milk production and feed consumption of lactating crossbred cows during hot dry and hot-humid seasons.
- Higher concentrate allowances in the ration along with effective evaporative cooling system was the best strategy to maximize production of crossbred cows under hot environmental conditions.
- The feeding of 50-60 gm mineral mixture, 100 gm mustard oil and 750 gm protected mustard oil cake daily in the ration of high yielding animals under rural households helped increase average daily milk yield in cattle and buffaloes.
- Provision of sand bedding and rubber mats to KF cows during winter significantly improved milk production and resting and feeding behaviour.
- Additional feeding of high energy during early postpartum in high yielding KF cows was effective in ensuring higher feed intake, higher peak milk production, better reproductive efficiency and persistency.
- It was established that the marked depression in the immunity of dairy cows and buffaloes during peripartum period as reflected by the decreased phagocytic activity and lymphocyte proliferation index of neutrophils could be largely restored by supplemental feeding of Vitamin E, Cu and Zinc during one month pre and postpartum period.
- Somatic cell counts of indigenous and crossbred cows and buffaloes under farm and field conditions as well as under hand and machine milking practices have been standardized and prediction equations to predict milk loss from SCC values developed.
- The cows under evaporative cooling (fan + water sprinkler) consume significantly higher dry matter, total digestible nutrients and crude protein. The milk yield increase significantly when the cows are provided with fan and water sprinkler.
- **Vocalization pattern in buffaloes:** Acoustic features from different Murrah buffaloes in different conditions differed significantly ($p<0.001$). Resonance frequency (F0) was proved to be the best suited acoustic feature which might be utilized in pattern recognition system for the identification of the stage of dairy animals. The stress conditions isolation, delayed milking and estrus were identified with efficiency 75.71, 77.91 and 77.45 percent, respectively in buffaloes.
- **Early detection of lameness in cattle:** Body weight shifting to the individual limb was used to evaluate the lameness in cows. For this purpose, an indigenously developed electronic static weigh-pad was designed. Five-point scale of lameness could be classified with a correct percentage of 45.90% (R2 =33.70%) whereas lameness of 3-point scale were classified with an overall correct percentage of 73.60% (R2 =54.00%) indicating the suitability of developed system in identifying the lameness at an early stage.
- **Organic buffalo production system:** The productive, reproductive and health performance was better and cost of milk production per kg was lower in organically managed buffaloes in conversion as compared to that in conventionally managed buffaloes. The quality of organically produced milk was better in view of lower levels of contamination by pesticides, antibiotic and heavy metal residues in organically produced milk as compared to conventionally produced milk.
- Combined assessment of milk pH, electrical conductance and SCC gives a better picture of udder health and milk quality in both organized and unorganized dairy farms. Among the three milk parameters (pH, EC and SCC) studied, SCC is the best indicator for subclinical mastitis. In subclinical cases, EC and pH is highly correlated ($r=0.733$). Similarly EC and SCC is also highly correlated in normal ($r=0.723$) and subclinical mastitic animals (0.514). Stage of lactation markedly influences the milk parameters in both subclinical and clinical mastitis cases.

- Supplementation of micronutrients improves the udder health by reducing milk SCC, percent neutrophils of milk. and milk yield. Micronutrient supplementation also increased the total immunoglobulin secreted in colostrums.
- Freezing protocols were standardized for successful freezing of indigenous, crossbred and buffalo semen and managemental interventions evolved for augmenting fertility in sub fertile bulls. Cryopreservation process induces alterations in protein tyrosine phosphorylation (PTP) pattern of boar spermatozoa.
- Dynamics of PTP in "live" boar and bull spermatozoa during the process of cryopreservation was studied and it was found that the "cooling" and not "freezing" initiates the PTP in substantial proportion of spermatozoa. A novel concept that modulating this particular proportion of spermatozoa in an ejaculate would result in improved freezability and the post-thaw fertility was put forth.
- Owing to the differential biochemical composition of portions of boar ejaculate, it was assumed that the spermatozoa in different portions might differ in their ability to undergo capacitation-like changes. First 10 ml of ejaculate differed from the rest of the sperm rich fraction.
- A new triple-stain flow cytometric method for simultaneous assessment of cAMP and protein tyrosine phosphorylation in cryopreserved boar spermatozoa was developed.
- Simultaneously assessment of cAMP and protein tyrosine phosphorylation (PTP) in a given spermatozoa using flow cytometry was achieved. Spermatozoa displaying a particular pattern of PTP bind to the oocyte and are related to the fertility.
- Two freezing methods (conventional-CF and simplified- SF method) for their effect on the ability of boar spermatozoa to undergo protein tyrosine phosphorylation in response to oviductal fluid (ODF) were compared and it was found that the method of freezing significantly affect the PTP in spermatozoa in response to ODF. These results are important in designing a suitable protocol for freezing of boar and bull spermatozoa.
- The poor quality ejaculates are very high in crossbred bulls (48 %).
- Effect of management and processing interventions on preservability of sub-fertile crossbred bull semen was studied.
- Supplementing the bulls with Vitamin E significantly improved the quality of the ejaculate as well as its preservability.
- Behavioural and biochemical bio-markers that could predict post-partum metritis in crossbred cows were identified. Behavioural markers include reduced feeding time and feeding bouts and increased inactive standing time during near term are good indicators of post-partum metritis. Biochemical markers include elevation of NEFA, BHBA and NEFA:Total cholesterol ratio and low concentration of glucose and total cholesterol during last 2-3 weeks of gestation is associated with post-partum metritis development.
- In Sahiwal cows, the mounting behaviour is less intense and expressed for shorter duration making this behaviour less conclusive in detection of estrus cows. Tumefaction of vulva, reddening of vulvar mucus membrane, mucus discharge, chin resting and sniffing/licking could be better predictor of ovulation time in this breed of cattle.

Biochemical/ Bio-technological and Bio-Nano-technological interventions...

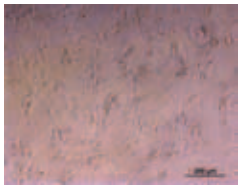
- The fertility of cryopreserved buffalo spermatozoa was improved in presence of additives like Taurine, Trehalose as assessed by post thaw motility, sperm and viability, membrane integrity, total antioxidant status and *in vitro* capacitation. The apoptotic changes in buffalo spermatozoa

contribute significantly towards cell death in addition to necrotic cell death. Cysteine hydrochloride was also found to be potential cryoprotectant to regulate capacitation like changes in cryopreserved buffalo spermatozoa.

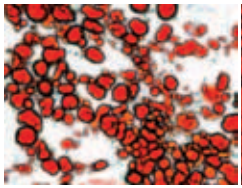
- The new soyamilk extender significantly protected the buffalo spermatozoa against oxidative stress ($P<0.05$) and protein tyrosine phosphorylation on cryopreservation compared to the conventional egg yolk extender.
- The cryopreserved buffalo spermatozoa exhibited large number of tyrosine phosphorylated proteins compared to the number observed during *in vitro* capacitation of spermatozoa by heparin. Spermine NO NOate, a nitric oxide releasing compound maintained better motility and capacitation compared to heparin under *in vitro* capacitation conditions.
- Angiotensin II was found to intiate multiple signaling pathways (viz. PKA, Ca^{+2} calmodulin & phospholipase C) in buffalo sperm capacitation and acrosome reaction. cAMP, Erk and PI cycle dependent and independent signaling pathways are involved during protein tyrosine phosphorylation in the cryopreserved buffalo spermatozoa. The isozymic forms of the enzymes like Glutathione-s-transferase and dihydrolipoyl dehydrogenase were differentiailly tyrosine phosphorylated during capacitation and on cryopreservation of buffalo spermatozoa.
- A rapid colorimetric MTT assay was developed to evaluate buffalo sperm viability and plasma membrane integrity compared to HOST and Trypan Blue Assay. DNA fragmentation in fresh and cryopreserved buffalo spermatozoa is directly correlated with the total antioxidant status of the semen. Immunolocalization patterens of the enzymes viz like Glycerol-3-Phosphate dehydrogenase, Glutathione-s-transferase and Dihydrolipoyl dehydrogenase were translocated on different sperm organelles in fresh buffalo spermatozoa compared to the cryopreserved buffalo spermatozoa.
- IGF-I synergistically enhanced FSH-stimulated aromatase *in vitro* mRNA expression in buffalo granulosa cells. IGF-I induced *in vitro* steroidogenesis and apoptosis through PI3K pathway and in cattle granulosa cells.
- Expression of major Cyp19 gene transcripts was driven by promoter II (granulosa cells), promoter I.1 (corpus luteum placenta) and promoter I.4 (brain) in buffalo. Studies on aromatase gene regulation in buffalo revealed that the promoter II is the major promoter responsible for aromatase expression in the preovulatory stages and promoter I.1 in postovulatory stages in buffalo. The -135 position in promoter II is a putative methylation site, which could be responsible for varying expression level of Cyp19 gene.
- Cyp19 gene was differentially expressed and regulated in promoter specific manner in large follicle, follicular cyst and luteal cyst in buffalo. A novel single nucleotide polymorphism (SNP) in proximal promoter region, at position -135 from translation start site was identified and its association in late maturity studied. The presence of significantly lower levels of Cyp19 gene transcripts ($P<0.05$) in the placental cotyledons of animals affected with Retained Fetal Membrane in comparison to normal animals, indicated the role of Cyp19 gene in low estrogen production and thus placental retention. Buffalo Cyp19 gene (coding and regulatory region), encoding rate limiting enzyme in oestrogen biosynthesis, cloned and sequence characterized.
- Tissue specific proximal promoter PII in ovary was identified, amplified, cloned and sequenced. Involvement of this promoter in the regulation of ovary during folliculogenesis and luteinization was established. PII has been found to be epigenetic (hypermethylation), switched off during luteinization. While distal promoter (PI.1) was found to be the major promoter responsible for *Cyp19* gene expression in buffalo placenta and differences in the methylation status of PI.1 coincides with *Cyp19*

gene expression in buffalo placenta of different stages of gestation.

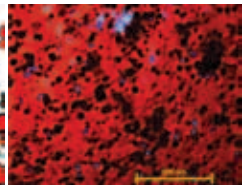
- A new method was developed to prepare stable gold nanoparticles (GMPs). As compared GMPs prepared by citrate reduction method, GMP prepared by new method provides nearly 5 fold more stability towards NaCl.
- Scanning electron microscopy of buffalo spermatozoa loaded with europium oxide nanoparticles revealed their attachment to membrane surface as well as their entry in the head and tail of spermatozoa. Dose dependent increase in DNA damage with nanoparticles was also observed by sperm chromatin dispersion test.
- The effect of TiO2 and Eu2O3 nanoparticles on membrane and DNA integrity of buffalo spermatozoa was elucidated. TiO2 nano particles (NPs) decreases sperm viability at 100 µg/mL but not at 1 and 10 µg/ml Eu2O3 NPs did not affect viability, capacitation and acrosome reaction of spermatozoa. TiO2 concerntration 10 &100 µg/mL decreases membrane integrity. Eu2O3 NPs did not affect membrane integrity of spermatozoa.
- After application of nano-TiO2 formulation on mice, NPs were observed in the skin and testis sections by transmission electron microscopy.
- Mesenchymal stem cells (MSC) from mouse adipose were isolated, proliferated and differentiated into mature adipocyte, osteocytes and chondrocytes. Colony forming capacity of MSCs established. These cell lines are maintained upto 5 passages.



Stem cell in proliferation stage



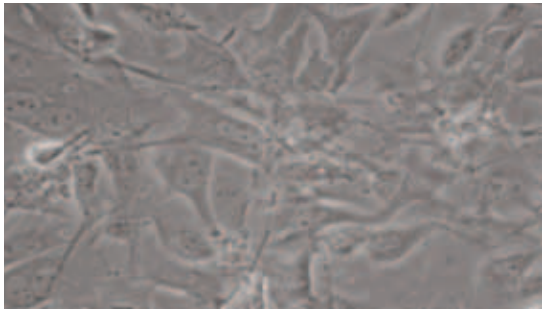
Mature adipocytes



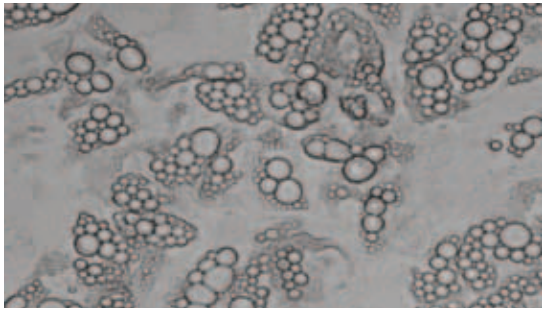
Osteocytes

Colony forming assay

- During proliferation of MSCs from subcutaneous and visceral adipose depots, expression of CD34, CD73, CD 81, CD 90, CD 105 and CD 146 surface markers and stem cell antigen-1 (sca 1) and preadipocyte factor 1 (pref 1) marker has been established. However, CD 5 wass not expressed.
- Proliferation and differentiation of brown adipocytes from mouse established. Differentiation process resulted in



Brown adipocyte at Proliferation stage



Brown adipocyte at Differentiation stage

accumulation of numerous multilocular lipid droplets. During proliferation Hox A1, HoxA5, Hox C4, HoxC8, Gpc4, Sfrp2, Shox2, Thbd, En1, Tbx15, Nr2f1 developmental gene and pref1 marker were expressed. However, HoxB1 and HoxA2 developmental genes were not expressed.

Improved Feeding Strategies and Efficient Nutrient Utilization for Enhanced Productivity

- Bypass fat supplementation at 2.5% of DMI increased milk production and proportion of unsaturated fatty acids in milk fat in high yielding cows. Bypass fat also reduced the time required for involution of uterus and commencement of cyclicity, service/ conception and incidence of metrits.
- Calcium hydroxide and ferric choloride treatments and fungal treatments (*Pleurotus ostreatus*) were developed for reducing the tannins of tanniferrous feeds such as babul pods and mango seed kernel. Amongst different isolates resistant to high tannin contents *Enterococcus faecalies* from the goats faeces GF-2 was found most promising using tannins from babool pods.
- Anaerobic rumen fungi from neelgai were isolated and the trans-inoculation of selective fungi was found beneficial for improving the utilization of poor quality roughages in buffaloes.
- Feeding of lactating cow and buffaloes on sole green fodder diets increased the Conjugated Linoleic Acid (CLA) content in milk. Incorporation of mustard cake in concentrate mixture also favoured higher milk CLA contents as compared to other oil cakes.
- Dual purpose as well as traditional variety of wheat could be harvested at 60 days of sowing for fodder purpose without effecting the grain and straw yield. The nutritive value of wheat fodder was found to be high.
- Lead, Cadmium, Arsenic and Mercury concentration in feeds and fodder was within their permissible limits, however, water samples from industrial towns contained higher Hg content than its permissible limits.
- Adverse effects of dietary arsenic can be partly counteracted by vitamin E administration as evidenced from various blood metabolites.
- *In vitro* cultured methanogens were suspected to be *methanobrevibacter ruminentium* and *methanomicrobuim* mobile in cattle using 16s rDNA method, identified sequences matched with *methanomicrobium* and *methanopyrus kandleri.*
- Among the plant extracts of neem, mehendi, pudina, dalchini, green chill, and aloe veera emerged as the potent methane inhibitors. Fumaric and malic acids were also found to be effective on methane reduction.
- Significant increase in crude protein, calcium iron, and zinc content of oats and berseem was found with application of farm yard manure.
- *Butyrivibrio fibrisolvens* could produce conjugated linoleic acid with supplementation of dietary oil as a source of linoleic acid.
- A method was standardized for dietary supplementation of fibrolytic enzymes (@ 1.5g/kgDM) for improving nutrient utilization.
- Lymphocyte proliferation decreased and SOD expression increased with increased dosage of lead and cadmium under *in vitro* studies indicating increased oxidative stress due to heavy metals exposure.
- Vitamin E @ 1000 IU/d, Zn (80ppm) and Cu (20ppm) supplementation during transition period was found to be beneficial to reduce oxidative stress, improve immune status, reduce the incidence of mastitis and improve milk production as well as reproductive performance of crossbred cows.
- Addition of sulphur @ 0.22% in the diet of buffalo calves fed wheat straw based complete feed blocks containing

fungal zoospores of *Neocallimastix sp.* GR-1 improved the growth rate, digestibility of proximate principles and rumen fermentation.

- Administration of 50 ppm Pb to goat kids did not cause any significant adverse effect on blood parameters. Supplementation of Zn had beneficial effect in lowering the adverse effects of Pb.
- *In vitro* studies showed positive response to high synchronous diets in terms of higher microbial protein synthesis and rumen fermentation pattern.
- Blood Se concentration and erythrocyte GPx activity were found to be good indicators of Se status of animals.
- Pentasulphate mixture @ 9g/100 kg body weight and Arsenic @ 40ppm of diet were effective in alleviating chronic selenosis in buffaloes.
- On farm trials of feeding tannins from babul pods @4.5% in concentrate mixture proved beneficial in reducing the number of gastro intestinal nematodes in grazing sheep.

Impact of Climate Change on Animal Productivity

- The Temperature humidity Index (THI) map based on average temperature and humidity observed at different places of India was developed. The THI scenario indicates that majority of places in India observe THI > 75 and more than 85% places in India experience moderate to high heat stress during April, May and June and THI range between 75-85 at 2.00 PM. At about 25% places in India during May and June the THI exceed 85 i.e. severe stress levels. All India Temperature Humidity Index (THI) maps for baseline and 2030 indicates a temperature rise and change in THI in Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan and other states of India based on the regional climate model PRECIS A1B scenario.
- Climate change scenario constructed for India revealed that temperature rise of about or more than 4°C is likely to increase uncomfortable days (THI>80) from existing 40 days (10.9%) to 104 days (28.5%) for HADCM 3 - A2 scenario and 89 days for B2 scenario for time slices 2080-2100.
- The negative impact of temperature rise on total milk production for India was estimated about 1.6 million tons in 2020 and more than 15 million tons in 2050. The Northern India is likely to experience more negative impact of climate change on milk production of both cattle and buffaloes due to rise in temperature during 2040-2069 and 2070-2099.
- Induction of Heat Shock Protein (HSP) in lymphocytes of Sahiwal has indicated that thermo tolerance in Sahiwal is due to induction of HSP and low induction makes crossbreds thermal intolerant. HSP induction in buffaloes has also been observed to be of low magnitude during thermal stress.
- The total methane emitted due to enteric fermentation and manure management of 485 million heads of livestock has been worked out at 9.37 Tg/annum for the year 2003. The major contributors to methane emission were Indigenous, Crossbred Cattle and Buffalo accounting 40%, 8%, and 40%, respectively. Lactating animals comprising of buffaloes and cattle contributed 3.42 Tg with a major share of 2.04 Tg from lactating buffaloes. Draught animals contribution to global warming is significant and they emit about 1.2 Tg methane /annum.

Improved Fertility Management...

- Ovsynch protocol for fertility improvement was successfully applied in anestrus and repeat breeding buffaloes belonging to farmers of different villages. A new protocol "Heatsynch Protocol" for estrus synchronization and fixed time

insemination was evaluated in terms of endocrine changes, timing of ovulation and conception rates in both summer and winter seasons. Heat Synch protocol for induction of ovulation followed by A.I. resulted in 62% pregnancies in anestrous buffaloes under field conditions.

- The fibroblast cells were successfully transfected with Green Fluorescence Protein (GFP) gene by lipofection and electroporation techniques.
- Phagocyting ability of the milk neutrophils was estimated and found to be lowest during early lactation, followed by late and mid lactation. Maximum in vitro phagocytic activity ($P<0.01$) of milk neutrophils was seen when vitamin E @ 19.6 ug/dl was added to the culture medium.
- Cows of medium and high body condition score (BCS) showed variation of oxidative status during periparturient period as indicated by levels of Superoxide Dismutase (SOD) and catalase enzymes. In comparison to medium body condition score (BCS), high BCS cows showed higher plasma SOD activity as the animals approach calving indicating that high BCS cows were more stressed as compared to medium BCS cows. High BCS cows lose more body condition than medium BCS cows from late pregnancy to 20 days postpartum. Milk yield (100 days) of medium BCS cows was significantly higher than high BCS cows (18.73 vs. 16.97 kg). Body condition of the cows should be maintained between 3.0 and 3.5 during dry period and calving and vitamin E @ 1000 I.U./day should be supplemented during dry period for improved production of cows.
- A sensitive EIA for oxytocin in milk of cows was developed. Cows administered 25 I.U. or 50 I.U. (250 to 500 times the dose required for milk ejection) of oxytocin showed minimal increases in milk oxytocin (0.3-0.6% of the dose administered). Milk oxytocin was stable to the tune of 43% at pasteurization and heat treatment conditions upto 130°C.
- Measurement of Lymphocyte activity such as lymphocyte proliferation and NO production could be used to indicate functional status of cell mediated immunity in the Murrah buffaloes

Nutraceuticals and other Bio-active Compounds for Improved Human Health

- Health-benefits of cow ghee were validated. Studies established that dietary cow ghee confers protection against mammary gland and gastrointestinal tract carcinogenesis.
- The two Probiotic Dahi, Acido-bifidus Dahi and Acido-plantarum Dahi, evaluated for anticancer properties were found to decrease progression of DMH induced gastrointestinal tract carcinogenesis, also increased the efficacy of cancer treatment with piroxicam in experimental animals. Probiotic dahi was also found very effective in decreasing blood cholesterol level, and taste similar to regular Indian dahi. These products have great potential for dairy industry, and would help control the increasing incidence of cardiovascular diseases.

Acido-bifidus Probiotic Dahi

- **Protects from colon cancer**
- **Lowers serum cholesterol & decreases depositions in arteries**

- **Protects from enteric infection**
- **Stimulates immune system and anti oxidant status**

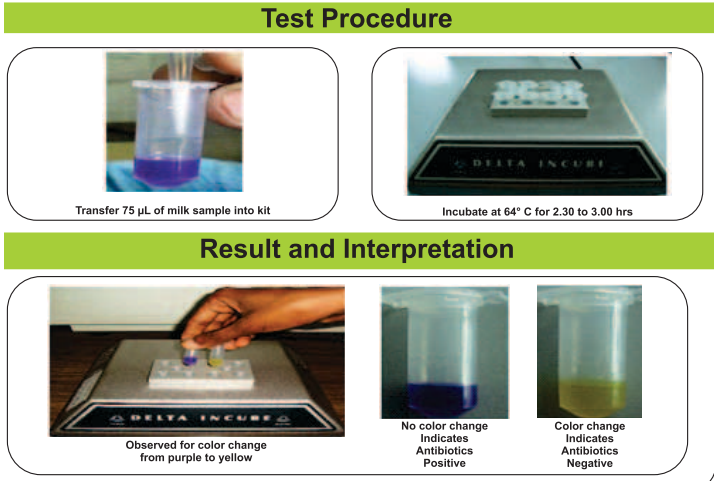
- Dietary conjugated linoleic acid (CLA) reduced body fat mass, and the effect was furthered by including skim milk powder (SMP) in the diet. The body slimming

effect of CLA involves decreased biosynthesis of fatty acid in adipose tissue and skeletal muscles. Dietary calcium decreased serum cholesterol. Excessive dietary intake of CLA caused fatty liver and spleen enlargement.

- A significant difference in body weights and cumulative body weight gains was observed by supplementation of high fat diet (HFD) with prebiotic fibers (inulin and β-glucan) as compared to control animals (HFD mice). β-Glucan feeding exhibited lower neuronal activation in different appetite centers of brain in comparison to inulin suggesting a higher satiating effect of β-glucan consumption.
- Among the eight different strains of potential probiotic lactobacilli studied, *L. casei* NCDC 19 was found to be a good strain on the basis of ACE inhibitory as well as extent of proteolysis during fermentation of milk. Supplementation of skim milk with Aloe vera resulted in enhancement of ACE inhibitory activity in fermented milk, and also effective in increasing the viable counts of probiotic in fermented milk.
- Caseinophosphopeptides isolated from cow and buffalo milk enhanced both systemic as well as mucosal immunity and exhibited protective effect against ovalbumin induced IgE mediated allergy in experimental mouse. The osteogenic potential of casein hydrolysate was also established.
- Comparative evaluation of hyperimmune properties of milk in mouse model revealed, 1.8 and 1.67 folds lesser ($P \leq 0.05$) titer of anti-buffalo β-LG and casein specific IgE as compared to anti- cow β-LG and caseins, respectively.
- Impact of thermal processing on allergenicity revealed that autoclaving of cow and buffalo milk reduced the total and protein specific IgE levels considerably ($P < 0.01$) as compared to raw milk proteins sensitized mice. Similarly, significant decrease ($P<0.05$) in lymphocyte proliferation index in presence of mitogens (Con A and LPS) and respective milk proteins were also observed in animals sensitized with proteins (caseins and whey) obtained from autoclaved milk in comparison to raw milk.
- Allergenic response of bioactive peptides was determined by degranulation of bone marrow derived mast cells in presence of BCM-5, ACE and milk derived CPP. It was observed that β-casmorphin-5 released significantly ($P<0,05$) higher amounts of histamine and higher tryptase activity than ACE and CPP sensitized mast cells.
- Membranes of five-fold alamethicin-resistant *Staphylococcus aureus*, *Enterococcus faecalis* and *Bacillus cereus* showed decreased interaction with alamethicin due to changes in membrane fluidity and surface charge. Development of cross-resistance to pediocin against alamethicin resistant *Enterococcus faecalis* and *B. cereus* was through a common mechanism altering cell membrane. Pediocins produced by *P. acidilactici* NCDC 252 and *P. pentosaceous* NCDC273 were identical to pediocin PA-1. Artificial Neural Network can be used as a reliable modeling method for predicting *in vitro* response given the composition of the colorimetric biosensing nanosomes.

Microbial drug residues test kit for broad spectrum detection of antibiotic residues in milk and dried milk products

A real time and cost effective test for broad spectrum detection of antibiotic residues in milk based on spore germination was developed.



Novel features of process:

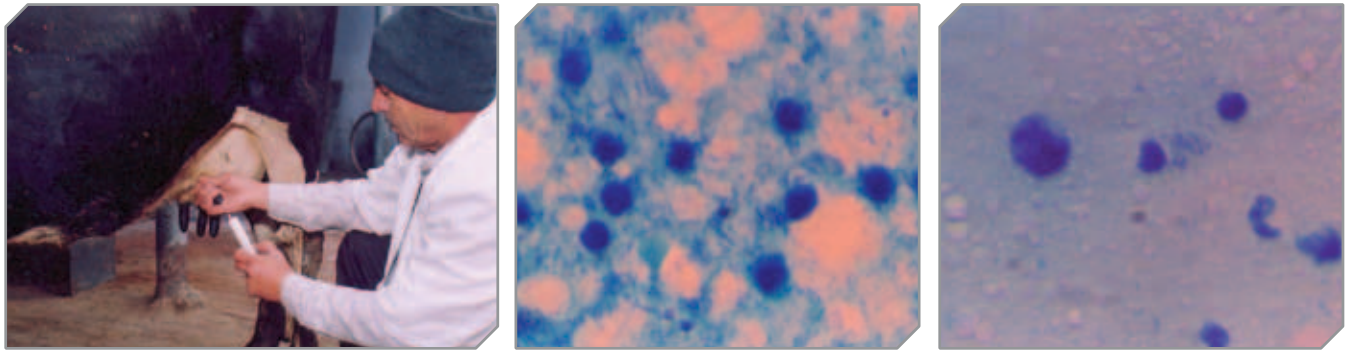
- Cost effective
- Better sensitivity
- Semi quantitative detection
- No false positive/ negative results
- Insensitivity towards detergents & sanitizers
- Consistency in color development in 3 hrs
- Validated with AOAC approved Charm 6602 system
- Wide spectrum of application for different type of types of milk

Antimicrobial Packaging (AMP) System Developed

A bacteriocin based antimicrobial packaging (AMP) system was developed using casein as a binder. Shelf life extension of khoa and paneer was achieved using such an AMP system.

A bacteriocin-based preparation developed for the treatment of bovine mastitis.

A bacteriocin-based preparation was developed for its potential use in the treatment of bovine mastitis.

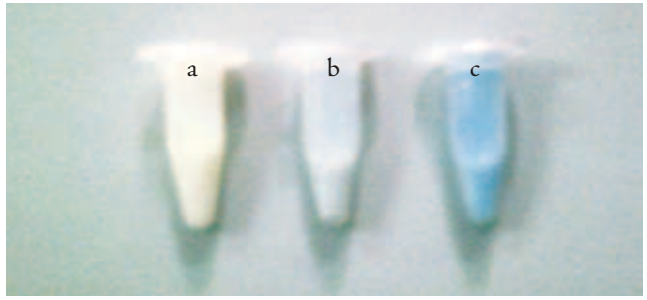


0 Day *5 Day*

Intramammary infusion of the bacteriocin based preparation in mastitic animals resulted in drastic improvement in milk Somatic Cell Count within 3–5 days of treatment

Development of a Real Time Spore Based Bioassay for Monitoring Aflatoxin M1 in Milk

Real Time Spore Based Bioassay for Monitoring Aflatoxin M1 in Milk was developed. The assay showed excellent performance in natural milk or spiked milk sample with wide range of application with different types of milk and milk products like raw milk (cow, buffalo, mixed), heat treated milk (toned / standardized, double toned, full cream milk) and dried powders (skimmed milk powder, milk powder, infant food etc). The spore inhibition based-enzyme substrate assay



Colour grade for Aflatoxin M1

a) ≥ 0.5 ppb of codex limit with no colour change; b) 0.25-0.5ppb with slight colour change; c) Negative sample with sky blue colour change

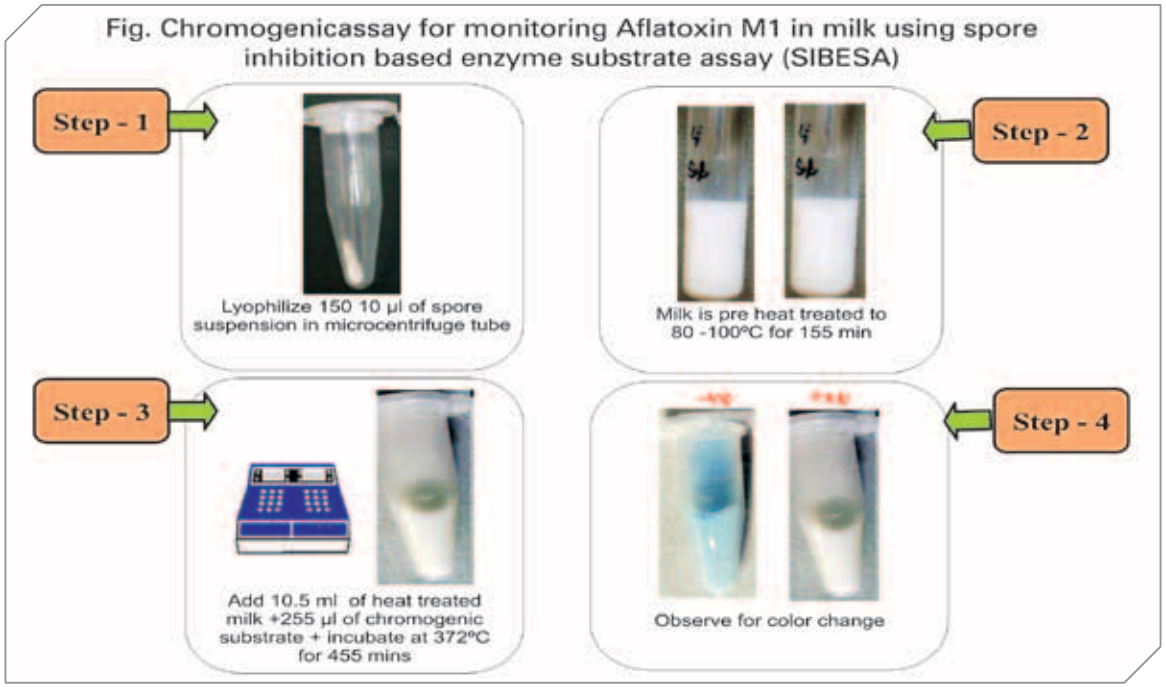


Fig. Chromogenicassay for monitoring Aflatoxin M1 in milk using spore inhibition based enzyme substrate assay (SIBESA)

(SIB-ESA) has the potential for its commercial application for routine monitoring of milk for Aflatoxin M1 under Indian condition of milk production and processing.

Microbiological interventions for improved human health...

- Putative probiotic strains of Indigenous lactobacilli viz.Lp21, Lp43, Lp55, Lp57, Lp9, Lp91 and CH4 demonstrated strong antioxidative properties and significantly up regulated the expression of SOD2, GPx-1 and CAT genes in HT-29 cells in vitro and hence can be explored as novel antioxidants to protect the host against oxidative stress induced diseases.
- The indigenous probiotic lactobacillus strain Lf1 exhibited a protective role in DSS induced colitis in mice based on improvement in DAI, histological scores, decrease in MDA levels and increase in the expression of SOD2and TrxR-I.
- Another potential indigenous probiotic lactobacillus strain Lp91 exhibited strong immuno-modulatory properties under in vivo conditions in mice colitis model
- Lp91 significantly reduced the plasma total cholesterol, LDL-cholesterol and triglycerides by 18, 27 and 27% in SD rats fed on high cholesterol diet through the mediation of Bsh activity
- Two of the putative indigenous Lactobacillus strains Lp9 and Lp91 not only survived at acidic pH and high bile salt concentrations, but also possessed strong hydrophobicity and adherence property to support their effective colonization in the gut.
- Lp9 and Lp91 also boosted the immune response by modulating the expression of pro- and anti-inflammatory cytokines, mucin barrier function along with other signaling molecules in HT-29 cells under different sets of experimental conditions.

- Process for preparation of carbonated lassi, vitamin B12 rich propioni-yoghurt, mannitol production from whey, symbiotic herbal yoghurt, folate rich dahi, bioethanol from whey, symbiotic kulfi and spray dried micro encapsulated probiotic lacto bacilli was developed.
- Investigation on anti-cancerous probiotics showed that probiotic fermented milk has preventive action of AFB1-induced hepatocellular carcinoma in rats.
- Technology for production of multiple strains probiotic direct vat set cultures for preparation of short set Dahi was developed. The DVS has shelf life of one year at 7°C in glass ampoules and EVOH pouches.
- *In vitro* observations reveal that Lb. bulgaricus LB-2 reduce cholesterol to the tune of 43%
- Process and cultural parameters were standardized for production of synbiotic Misti Dahi and Yoghurt using inulin as prebiotic with enhanced shelf life of >35 days.
- Spore inhibition based assay for Aflatoxin M1 on gold chip surface has been developed
- Process was optimized for production of antifungal bacteriocin like substance (BLIS) from the lactobacillus. The BLIS was partially purified and further used for the preservation of the paneer and other milk products.
- Antimicrobial bioactive peptides were produced from milk proteins from whey and sodium caseinate fermentate using proteolytic lactobacilli. The molecular wt. of the peptides was 10 KDa which possess broad spectrum antimicrobial activity towards gram negative and Gram positive bacteria.
- A functional probiotic whey drink was developed having antimicrobial and antioxidative activity.
- Whey based cost effective media for culturing, biomass production and enumeration for Lactobacillus spp. equivalent to MRS medium was formulated.
- Optimum conditions for biomass production of L. casei NCDC 298 under batch, fed batch and continuous culturing systems in whey based media were standardized.
- Spore Germination based bioassay for detection of Enterococci on sensor disc/Gold chip: The spore based bio-assay using esculin as marker-enzyme substrate was developed with assay i.e. sodium azide & esculin based medium (EBSAM) within real time of 8 + 2 hrs. The bioassay was also carried out by immobilizing spores on Gold chip based on IOD which increased form 7.069+1.30 to 14.493+1.41.

A new simple and rapid test for detection of detergent in milk developed

A simple colour based test for detection of detergent in milk was developed. The test is sensitive enough to detect presence of 20 mg laboratory grade detergent in 100 ml milk implying that even 2 liters of synthetic milk added to 100 liters of milk can be easily detected. The test is colour based and results are available just after mixing of reagents and milk samples. The test can detect all brands of commercial detergents available in the market. The test does not require use of any equipment and the cost of ingredient used for preparation of test reagent is very low.

Quantitative method for estimation of levels of detergent in milk

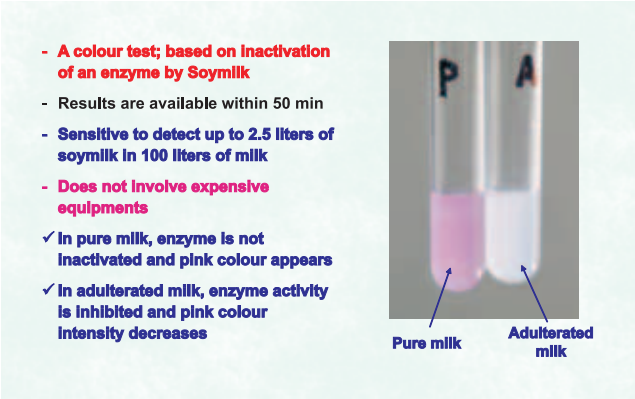
A method for quantitative estimation of anionic detergent in milk was developed. The linear relationship between the absorbance and the detergent concentration in milk was observed up to 80 mg L-1 and 300 mg L-1 in SDBS (sodium dodecylbenzensulfonate) and Labolene, respectively and the calculated value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

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

with different levels (150, 400 and 800 mg L-1 labolene) of detergent. The recovery was quantitative.

A Test for Detection of 'Soyamilk' in Milk

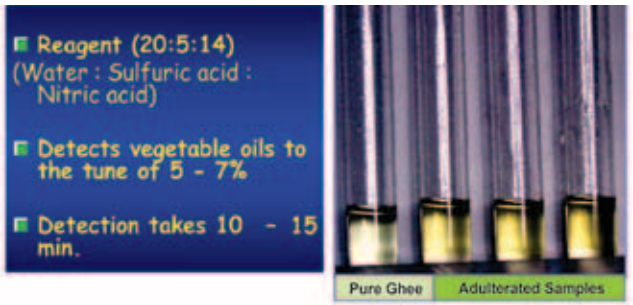
- A colour based test was developed to detect adultration of soya milkup to 2.5% in milk.



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

Rapid method for detection of vegetable oils in ghee

- A rapid colorimetric test for detection of vegetable oil adulteration in ghee has been developed.



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

- Two simple enzymatic colour based methods for ascertaining the heat treatment of milk around 80°C were developed based on the development of colour when substrates of GGTP or LPO added to milk samples. Active enzymes result in formation of pink coloured products in both cases. Absence of pink colour indicates enzyme is inactivated during heat treatment. Results indicate that at 80°C, there is no formation of pink colour thus, indicating the complete destruction of both GGTP and LPO. However, in raw milk as well as in milk heated at other temperatures (65° to 75°C), a distinct pink colour formation was observed, which can be distinguished visually. These methods are simple, rapid (5-10 min) and can be adapted by the dairy industry as indicator of heat treatment of milk around 80°C.
- Methods for estimation of beta-cyclodextrin and cholesterol were standardized.

Technology Developed

- Technologies for preparaton of low cholesterol ghee colostrum powder, strawberry fortified dahi and whey lemon beverage were developed.

- Technology for the preparation of artificially sweetened lassi, flavoured milk, burfi and kalakand was developed
- Technology was developed for high antioxidant based fruit whey beverages.
- A laboratory scale process was developed for calcium fortification of milk. Thermal stability and calcium bioavailability of such milk was studied. The technology was transferred to Bihar state cooperative milk producers federation Ltd., Patna for Rs 1.0 lakhs.

Basic and Evaluation Studies

- Two antioxidant peptides with peptide sequences VKEAMAPK β-casein f (98-105) and HIQKEDVPSER alpha-s1-casein [precursor] f (95-105) were isolated from Cheddar cheese made with adjunct culture L.casei ssp. casei 300.
- Evaluated antioxidant activity of skim milk with added Whey protein hydrolysates
- The cheese prepared with adjunct culture (Lactobacillus casei ssp. casei 300) showed higher sensory score, antioxidant activity and level of caseinophosphopeptides during ripening period of 3 to 4 months as compared to control cheese without adjunct culture.
    - Buffalo and cow milk casein and their fractions differed significantly ($P<0.05$) in terms of radical quenching activity
    - $\alpha s > \beta$-> κ-casein
    - Enzymatic hydrolysis of casein, resulted in increase in antioxidant activity
    - But no significant difference ($P < 0.05$) in the antioxidant activity of hydrolysates
- Comparative evaluation of antioxidant activity of buffalo and cow milk casein and their hydrolysates wasd achieved.
- Developed a simple color test for detection of melamine in milk using gold nanoparticle with the detection limit in milk 100-200 ppm.
- Analytical methods i.e. HPLC/HPTLC were developed for the quantification of artificial sweetners viz. saccharin, acesulfame K, aspartame and sucralose in dairy products viz. flavoured milk, lassi, burfi and kalakand. Except aspartame, all other sweeteners were stable during storage at least up to 7 days. Aspartame degraded to aspartylphenylalanine at day 5 during storage of flavoured milk.

Peptide sequences established

- Twelve peptides have been identified from the whey protein hydrolysates optimized for max. ACE Inhibitory activity, out of which eight peptides are known ACE Inhibitory peptides.
- The incorporation of WPHs in the ice-cream (@1 percent) raised its antioxidant activity by 55% and over-run was 26.6% times higher than that of control.
- Addition of herb extracts of withania somnifera (Ashwagandha), asparagus racemosus (Shatavari), pueraria tuberosa (Vidarikand) to ghee had a significant effect on oxidative stability of ghee. Antioxidative behaviour of herbs is more effective than Green tea extract and comparable with rosemary extract but less effective than BHA and TBHQ.

	PEPTIDE SEQUENCE
αs_1-CN(37-58)	VNELSTDIGSESTEDQAMEDIK
αs_1-CN(35-58)	EKVNELSTDIGSESTEDQAMEDIK
αs_1-CN(43-58)	DIGSESTEDQAMEDIK
αs_2-CN(2-21)	HTMEHVSSSEESIISQETYK
αs_2-CN(138–142)	TVDMESTEVITK
β-CN(2-27)	ELEELNVPGEIVESLSSSEESITHINK
β-CN(32-47)	FQSEEQQQMEDELQDK

- 10 peptides have been identified from the Flavourzyme Whey protein Hydrolysates (WPH) optimised for Max. ACE Inhibitory activity, out which 8 peptides are known ACE Inhibitory peptides. These fragments are β- lg(92-100), β- lg(9 -14), β- lg(84-91), β- lg(125-135), α- la(99-107), pp- 3(66-71), pp- 3(141-153), pp- 3(141-152), β-cn(203-209), β- cn(108-113) and αs1- cn(24-34).
- 8 peptides have been identified from the Flavourzyme Whey protein Hydrolysates (WPH) optimised for Max. antioxidant activity, out which 3 peptides are known antioxidant peptides. These peptides are β- lg(92-100), β- lg(9 -14), β- lg(84-91), β- lg(125-135), α- la(99-107), pp- 3(66-71), , β-cn(203-209), β- cn(108-113) and αs1- cn(24-34)
- Casein was hydrolysed with crude proteinase preparation from L helveticus NCDC288 to produce hydrolysate with antioxidant activity. Fraction 4 from HPLC exhibiting highest antioxidant activity was further separated and sequenced by LCMS. Following the sequence interpretation, the first peptide GVSKVKEAMAPK matched with sequence ß-Casein (94-105) and the second peptide RPKHPIKHQGLPQ matched with sequence -CN (1 – 13).

Caseinophosphopeptides Enriched Ingredient from Buffalo Casein

- The process for production of caseinophosphopeptides by hydrolyzing buffalo casein with digestive enzyme was optimized. A method for the enrichment of CPPs was developed by using membrane filtration. The product contains phosphopeptides of buffalo casein i.e. αs1 -CN(37-58), αs1 -CN (35-58), αs1 -CN (43-58), αs2-CN(2-21), β-CN(2-27).These sequences matched with already known sequences in the literature and identified as mineral binding and anticariogenic peptides.
- In-vivo studies showed that the antioxidative enzymes (AOE) viz, Catalase, Superoxide dismutase and Glutathione peroxidase activities in RBC lysates and liver homogenates were increased significantlyin the Whey protein hydrolysates (WPH) fed group as compare to control after 15 and 30 days.

Thrust on New Product Development

New products were developed such as long life milk cake, brown peda, whey-based lassi like beverage, milk cereal based fermented foods, natural banana flavoured milk, mango lassi with extended shelf life. New functional dairy products such as Probiotic Cheese, Probiotic Dahi, Sports Drinks, Low Cholesterol Ghee, Herbal Ghee, Ice cream and Burfi for diabetics were developed with potential to improve human health.

Advancements in Convenient Dairy Products

A number of new technologies for serving ready made indigenous, convenient & widely acceptable dairy products in dry form were standardized for preparation of "Kheer" and "Ras malai".

Ready-to-Reconstitute Paneer Curry Mix

A process was developed for milk chocolate with encapsulated cells. Similarly, modified atmosphere packaging of mozzarella cheese was developed. Cow skim milk using ultrafiltration and its potentiality as dairy whitner was also established.

Instant Rasmalai Mix

Standardization of Technology for the Manufacture of Kradi using Cultures NCDC 167 and NCDC 144

A technology was standardized after thorough market survey of this product in different regions of J & K and after subjecting the market samples to descriptive sensory analysis, physico-chemical, microbiological, textural, mechanical, functional & instrumental colour analysis. The standardization trials with two Response Surface Methodology designs (four factor CCRD) were carried out to develop manufacturing technology with culture NCDC 167 and NCDC 144, respectively. The product was found better than market samples of any region in comparison to sensory analysis, physico-chemical, microbiological, textural, mechanical, functional & instrumental colour analysis. The developed technology could be commercially utilized for large scale manufacture of this product.

Vacuum packaged Kradi

Quarg Type Fresh Cheese with Enhanced Health Attributes and Shelf Life Developed

Quarg type fresh cheese with enhanced health attributes and shelf life was developed. Trials were conducted to prepare quarg cheese using starter culture, rennet and employing gravity filtration for separation of curd. The effects of two microbial rennets viz Meito and Fromase with different levels of their addition on sensory, physico-chemical and textural characteristics were investigated. The study revealed that small amount of rennet addition resulted in desired quality of cheese. The higher levels of rennet resulted in coarse and very firm body and texture defect and bland taste.

Buffalo Milk Quarg Cheese

Development of Technology for Long Shelf Life Paneer through Modified Atmosphere Packaging

A technology was standardized to increase the shelf life of paneer by employing Modified Atmosphere Packaging (MAP) technique. The paneer samples were evaluated for changes in physico-chemical, textural, microbiological, and sensory characteristics. Modified atmosphere packaging of paneer resulted in significant increase in shelf-life.

Development of Technology for Manufacture of Feta Cheese with Enhanced Functional Attributes from Buffalo Milk

A technology was developed to manufacture good quality Feta cheese with enhanced functional attributes from buffalo milk. In order to obtain an acceptable quality Feta cheese, various processing parameters such as C/F ratios, heat- treatments, type and level of Starter culture, level of rennet, brine condition, level of rennet and brine concentration were studied. Feta and commercial Feta cheese with advantages of higher yield and without adding additives. Augmentation of starter with starter adjunct like *L. helveticus* and *L. casei* had further improved the quality of buffalo milk Feta cheese. Attempts were also made to reduce the sodium content by replacement of NaCl by KCI. The study revealed that replacement up to 30% could be done without adversely affecting the quality of buffalo milk Feta cheese.

Feta Cheese

Bajra Lassi (Milk-Pearl Millet Based Fermented Beverage)

A technology was developed for manufacture of Bajra Lassi (Milk-Pearl Millet Based fermented Beverage) using milk solids and pearl millet which possess health attributes. Development of Bajra lassi is based on the selection of milk solids source; selection of level, form & stage of addition of pearl millet solids; fermentation conditions and stabilization of developed product in terms of preventing sedimentation and wheying-off in the product during storage. Although the traditional product is prepared from sour buttermilk, yet keeping in view the suitability for industrial production and easy availability, skim milk or standardized milk was selected as source of milk solids for development of the beverage. Pearl millet solids are added to milk in three different forms viz. a) raw flour obtained from milling pearl millet grains, b) slurry obtained by grinding of soaked pearl millet grains and c) flour obtained after grinding of 24 h & 48 h germinated and dried pearl millet grains (malt). The shelf life could be enhanced from 7 days to 35 and 28 days at refrigeration storage by adding Potassium sorbate and Nisin or MicroGARD, respectively.

Anti-Anaemic Properties and Storage Stability of Iron Fortified Biscuits from a Composite Dairy-Cereal Mix

A protocol was standardized to manufacture biscuits from composite wheat-pearl millet flour in combination with valuable dairy ingredients such as whey solids and enriched with a suitable iron fortificant selected on the basis of sensory evaluation. The iron fortified biscuit contained 6.53 mg iron

per 100 g. The other nutrients present were 18.81% fat, 12.23% protein, 1.13% ash, 1.42 crude fiber, 3.2% moisture and 63.28% carbohydrates. The product showed storage stability up to 4 months without any significant change in the sensory as well as nutritional attributes. In vivo trials on Wistar rats indicated that the iron fortified biscuits helped to maintain the haematic status of normal animals and repair that of anaemic ones. Biological indices (apparent digestibility coefficient, retention of iron and percentage retention of iron) were greater in anaemic rats than in normal ones indicating that the iron bio-availability is dependent on the iron status of the body. The haemoglobin concentration (mg/dl) increased significantly by about 25% and 70% in normal and anaemic rats respectively. Ferritin concentration in the blood plasma also increased. The cost of manufacture of the product was estimated as Rs. 17 per 100 g of the product.

Iron fortified biscuits from a composite dairy-cereal mix

- Technology for whey based sports beverage was developed. The beverage was formulated to deliver carbohydrate as well as electrolytes. Another variant of sports beverage based on artificial sweeteners was also developed.
- Process for malted milk beverage was optimized.
- Process and formulation of WPC and barley malt extract based Milk Caramel was developed.
- Formulation and manufacturing technology for functional doda barfi was standardized.
- A low cost complementary food formulation and processing technology was developed. The complementary food contained whey-skim milk in the ratio of 70:30, 20% millet flour, malt extract, and maltodextrin. The product met the standards as laid down in PFA. The product was further fortified with calcium gluoconate at 500 ppm level.
- Technologies/ protocols were standardized to produce ready-to-reconstitute sorghum-based fermented milk beverage, medium-fat and full fat liquid dairy whiteners from buffalo milk, co-microencapsule probiotic organisms with a prebiotic to increase their stability and viability.
- Investigations were conducted to evaluate suitable cryoprotective agents like carbohydrate and protein during lyophilisation of probiotic direct vat set ferments for production of short set dahi.
- Methods were standardized to incorporate certain spices such as ginger, pepper, cumin, cardamom, turmeric into butter milk to prepare spiced butter milk drinks. These spices are known to have proven health benefits and are commonly used in Indian kitchen.
- Technology was standardized for preparation of artificially sweetened whey lemon beverage.
- Studies were carried out to replace sugar in basundi with non-conventional sweeteners like sucralose, aspartame and stevia. Investigations were also undertaken to standardise the technology for production of Shrikhand by using selected artificial sweeteners.
- Method was standardized for the production of Chhana jhili. Superior quality product was obtained by mixing chhana with 15% suji (semolina) to form a batter of 60 - 65% moisture.
- A technology was developed for high antioxidant based fruit whey beverages.
- The technology for the preparation of Vitamin B12 rich 'Propioni Yoghurt' containing Propionibacterium was

developed. Freudenreichii sub sp. freudenreichii PrSo, a high Vitamin B12 producer native and novel strain was developed with a potential to address the problem of Vitamin deficiency and related diseases.

- A "folate rich functional dahi" containing a high folate producing probiotic strain (S. thermophilus RD104) was developed to be used as a functional dairy food.

Design and development using three stage Scraped Surface Heat Exchanger (SSHE) system

- An integrated three stage thin film scraped surface heat exchanger (TFSSHE) for Khoa Making Machine was designed and fabricated. The capacity evaluation of the system indicated that 50 kg/h khoa was produced with buffalo milk having 6% fat and it could be enhanced to 120 kg/h if milk is pre concentrated to 30% T.S.
- Three stage three thin film SSHE was designed and developed for continuous manufacture of Khoa was used for continuous manufacture of Burfi. The sugar dosing device was designed, fabricated and provided at the inlet of three stage SSHE to blend sugar with khoa. Machine capacity is 60 kg/h Burfi and 150 kg/h using concentrated milk (30% T.S.)

Three Stage Scraped Surface Heat Exchanger

- Continuous manufacture of Basundi was performed in three stage thin film scraped surface heat exchanger. The quality of Basundi so produced was evaluated in terms of proximate composition, physico-chemical and sensory evaluation. The quality of product was comparable to the product made by conventional method. The machine capacity for Basundi manufacture is 165 kg/h.
- The performance evaluation of three stage TFSSHE was made for continuous manufacturing of Rabri. The process and machine parameters were optimized in terms of sensory evaluation and product quality. The machine capacity for Rabri manufacture is 40 kg/h.

Development of In-line production system

- Unit operation based system was developed for improved flavour, colour and texture formation in traditional dairy product. A scraped surface heat exchanger and conical process vat was integrated for in-line production of khoa. The quality of khoa was comparable to the product made by conventional method. For 60 kg batch process time taken for khoa production in inline system (63 min.) was significantly reduced with compared to khoa production in only conical process vat (140 min.) or jacketed steam kettle (200 min.).
- Burfi was manufactured using buffalo milk (6% fat and 9% SNF). Milk was concentrated to 45% T.S. in scraped surface heat exchanger and was further processed in conical process vat for proper texture development. The quality of Burfi manufactured was comparable to market sample in terms of sensory and textural scores.

Development of mechanized system for continuous cooling of khoa

- A mechanized system was designed and developed for continuous cooling of khoa at 60 kg/h from processing

temperature to 34°C. Maximum cooling efficiency of 84.30% can be achieved by using chilled water as cooling medium. Prototype cooling mechanism does not induce changes in the original texture of the product.

Continuous cooling system for khoa

Development of a mechanized system for production of Malai Lachha

A Flat Plate Heat Exchanger (FPHE) was designed and developed for mechanized production of Malai Lachha. The FPHE was provided with feed cylinder, gear system, steam control valve, pressure gauge, safety valve, air vent and steam trap. Malai lachha can be manufactured at 2 kg/h using concentrated milk (30% T.S.).

Mechanized system for production of Malai Lachha

Paneer making gadget

A gadget was designed and developed for handling 1.5-3 litres of milk for production of uniform quality paneer. Gadget has inbuilt heating and pressing mechanism.

Paneer making gadget

Design and Development of Kinematic Half turn nut pressing mechanism for paneer

- A paneer pressing system was designed and developed for medium scale application (5-20 liters of milk per batch). Kinematic half-turn nut (KHTN) pressing mechanism is simple in design and gave excellent performance in relation to moisture content, hardness, density and sensory scores. Paneer made by KHTN pressing mechanism was uniform in quality.
- Continuous rasogolla-cooker with machine-vision quality-inspection was developed.
- Shelf life prediction software for moisture and/or oxygen sensitive dairy products, based on product package-environment interaction was developed.

Value Chain Analysis

The study entitled value chain analysis of milk in high hills temperate wet zone of Himachal Pradesh conducted in milk shed area of revealed that the cost of milk procurement was relatively high very high ranging from Rs. 4.04 to Rs. 6.50 per litre because of the hilly area. The milk plant was found to be working at breakeven level. The variable cost of manufacturing

standard, toned and double toned milk were worked out as Rs. 20.19, 18.95 and Rs. 18.76, respectively.

Repayment performance of SHGs

The study of factors Influencing Group Repayment Performance of loan (micro finance) in Haryana concluded that if the essence of self help group and cooperation is fostered and monitored properly, the poor can also repay the loan. Peer monitoring, group size and female percentage in the self help group was found to have positive influence on the repayment performance of the Self Help Groups.

Visioning Analysis of Indian Dairy Sector

The visioning analysis for the dairy sector in India indicated that overall country will remain net surplus in milk till 2021 under all situations of supply and demand. The lowest surplus could be 1.724 million tonnes under Business As Usual (BAU)-High growth combination of situations of supply and demand, respectively. The surplus may go up to 48.719 million tonnes in case of HOS-Low growth situations. However, the situation does not continue to be the same by 2035. Even the surplus systems of milk production show the sign of deficit especially in the situation of high growth on the side of factors affecting demand. In 2035, country would be surplus under all situation of demand growth only if HOS of milk production prevailed. Under HOS, the surplus varied from 19.190 million tonnes under High Growth to 75.747 million tonnes under Low Growth situations of demand.

For higher growth in milk production, the capital expenditure on dairy development as percentage of total animal husbandry expenditure be increased from 6.58% to 14%. This will result in enhancing the capacity of production by improving the health services, fodder production and processing of milk.

Future policy of export need to be concentrated on cheese, whey-based and fermented dairy products in new and emerging markets in Asian and North African countries.

Prediction of Economic Traits

Emerging connectionist paradigm has been successfully employed to predict economic traits in Murrah buffaloes for the first time. The connectionist models have been found better alternative to the conventional multiple linear regression models.

New Website of the Institute Developed

New Website of the Institute has been developed in accordance with the 'Uniformity Guidelines for ICAR Website'. The website is fully operational and being used extensively for information dissemination among the different stakeholders/end-users. One of the salient features of the website is role-based security mechanism, which allows instant updating of information at the source of information itself, e.g., every faculty members/division and the purchase section can independently update/upload its information as and when required. Website content is regularly updated.

Promoting dairy enterprise through transfer of technologies

- A film on the story of successful dairy entrepreneur was made based on case studies conducted on successful dairy entrepreneurs.
- Farmer participatory field trials for estrus synchronization and fixed time AI (FTAI) programme were conducted in cattle & buffaloes to propagate simple, cost-effective hormone treatment schedules.
- A Learning module on reproductive management was developed and used to educate farmers.

- To generate rural employment, the dairy microenterprise was found to be most viable option.
- The empowerment of dairy farmers through CIGs was significantly related with interpersonal trust, manageable group size, group goals achievement, need satisfaction, group competition, group leadership and group cohesiveness.
- Intervening modules for HRD of rural youth in the area of dairy based enterprises were developed.
- Through strategic nutrient supplementation for enhancing milk and reproductive performance in dairy animals under field conditions, the peak yield of cow and buffalo was increased by approximately 4.00 and 3.00 liters; respectively and service period was also reduced up to 30 days per lactation.
- SHGs played proactive role in dairy farming by enhancing the level of knowledge, adoption, income and productive and reproductive performance of dairy animals.
- Urea-Ammonia treated straw' and 'Mineral Mixture' supplementation maintained the level of milk production even in the summer season. The feeding of the 'Common Salt' to their dairy animals helped in prevention of diarrhoea, to a greater extent, as this happened to be a common phenomenon in that area.
- The current calf rearing practices were assessed and it was found that nobody was feeding milk replacer to their calves and deworming was followed by only 11.45 percent of the dairy farmers. Recommended calf rearing practices were disseminated through extension materials such as folder, leaflets, group discussions, PRA etc. The recommended practices of colostrum feeding to calves were adopted by 100 percent of the dairy farmers.
- Adoption and knowledge level about improved dairy farming practices were found to be enhanced among the selected dairy farmers. Further, a little bit changes in terms of milk production and disposal pattern among the dairy farmers was also observed.
- Efficient plan for fodder production and low cost feeding interventions was introduced and it was found beneficial during fodder scarcity period.
- Extension strategies were developed for promoting value addition in milk among farming community.
- Information flow pattern among Dairy Stakeholders in Milk Production Innovation System was mapped using PRA tools.
- Existing ITKs' followed by dairy farmers on coping up with climate change were identified.
- Disease risk factors affecting animal health management in field condition were identified.

Southern Research Station, Bangalore

Malnad Gidda: A Valuable Disease Resistant Indigenous Cattle of Karnataka, India

The study was taken up on **Malnad Gidda**, to investigate the occurrence of diseases with special reference to Foot and Mouth Disease (FMD) through survey and molecular approaches. These cattle are maintained for manure and ploughing puposes in Malnad regions of Karnataka. This breed is maintained with low input system of management and produce about 0.5 to 3 kg milk per day. Though milk yield of this native breed is low, it is important in view of its disease resistance and adaptability traits. Survey indicated that there was no occurrence of FMD in its native tract even the animals were maintained along with Jersey x Malnad Gidda crosses in which there was report of occurrence of the FMD.

Studies on NRAMP1 gene polymorphism indicated that two alleles are present at this locus in this Malnad Gidda breed and both seem to be equally important in respect of disease

resistance. Further, molecular characterization of MHC II BoLA DRB3 and DQAI polymorphism were also studied. Animals with specific BoLA typing were considered for vaccination. *In vitro* proliferative response measurements were conducted with the lymphocytes isolated from experimentally vaccinated calves of Deoni and Malnad Gidda. The average proliferation index with inactivated virus reached 3.7 in Deoni and 5.7 in Malnad Gidda native cattle indicating Malnad Gidda showed higher cellular response to FMDV antigen and sub viral practices than Deoni breed. BoLA typing studies showed that locus DRB3.* 11, 15, and 9 were more prevalent in Malnad Gidda cattle than Deoni. Studies on immune response in vaccinated animals showed that animals with BoLA DRB3.2*15 in Malnad Gidda cattle more resistant than other genotypes. Malnad Gidda cattle which did not show any antibody titres (log0.9) in prevaccinated sera showed maximum antibody titres of log2.7 indicating that the animals expressed 10 fold high antibody responses with single injection. This indicates that Malnad Gidda animals mount robust immune response to the virus as and when the animal is exposed to the pathogen, which helps in rapid clearance of the virus from the mucosal tissue. Hence, Malnad Gidda breed of cattle has been proven to be disease resistant/tolerant against FMD, which has been reported first time in India.

Malnad Gidda cattle in its Native Tract

- The Simple Regressed Least Squares (SRLS) and Best Linear Unbiased Prediction (BLUP) methods, followed by Least Square (LS) were better than others for estimating the breeding values of dairy bulls under field conditions.
- Characterization of BoLA DRB3.2 alleles under bovine MHC locus was carried out in Hallikar and Deoni native breeds of cattle.
- The dairy farmers in Kerala are facing the constraints of high cost of roughages and feed and feeding related reproductive problems, which is resulting in diminishing milk production.
- The studies on incidence of mastitis in Bangalore and Kolar districts of Karnataka revealed that the overall prevalence of subclinical and clinical mastitis in crossbred cows (N=507) using CMT was 22.09 and 4.34 %, respectively, the incidence of mastitis was found to be higher in graded HF (28.69 %) followed by HF crossbred (19.64 %) and Jersey crossbred (20.51 %).
- Deoni cattle exhibited significantly better degree of oestrus symptoms.
- The overall incidence of hoof disorders in dairy cows in the region (N=456) was 28.3 %, the occurrence of hoof problems was found to be highest in graded HF cows (35.2 %), followed by HF crossbreds (10%) and Jersey crosses (5.6 %).

- PCR-SSCP analysis of Heat Shock Protein 70 (HSP70) gene showed three SSCP patterns in Deoni cattle and two SSCP patterns in HF Crossbred cattle. The PCR-SSCP analysis of Heat Shock Protein 70 (HSP70) gene revealed three genotypic combinations viz, AA, AB and BB in the frequencies of 0.034, 0.254 and 0.712 in Deoni cattle respectively. The genotypic frequency of AB and BB genotypes were 0.429 and 0.571 in Crossbred cattle.
- PCR-SSCP analysis of Heat Shock Protein 90AA1 (HSP90AA1 gene) gene in Deoni cattle showed three unique SSCP patterns with a genotypic frequency of 0.250, 0.638 and 0.111 respectively in exon 8. Two SSCP patterns with a genotypic frequency of 0.153 and 0.847 were observed in exon 9 of HSP90AA1 gene and two unique SSCP patterns in exon 10 with a genotypic frequency of 0.236 and 0.764 respectively were observed.
- Data analyzed on productive and reproductive performances in Deoni cattle depicted that the mean birth weight and weight at AFC were 20.81±0.21 (n, 140) and 223.64±3.59 (n, 101) kg, respectively. The age AFC calculated in this study was 38.73±0.73 months. The overall mean lactation milk yield based on first 5 lactations was 779.27±18.31 kg with an average lactation length of 186.31±3.02 days. The present study also revealed that there was a significant increase in milk yield in second lactation than first lactation. The overall mortality rate in Deoni cattle recorded was 2.17%.
- Method was standardized for production of Curd rice with enhanced shelf life by hurdle technology using culture, pH and natural preservative like ginger as hurdles.
- A recipe for cheese pickle preparation has been finalized. Paneer and Cheese can be used as the base material for the pickle, however paneer was considered better than cheese for pickle
- A mechanized process was developed for the manufacture of Kunda using a batch type khoa making machine which is less laborious & energy consuming.
- The conditions for digestion of banana and mango fruit pulps by using enzymes have been optimized. A maximum of 70% of clarified juice from banana pulp and 65% from mango pulp could be obtained. Addition of 20% of clarified juices individually into 1.5 times concentrated toned milk was found to have optimum sensory qualities in naturally flavored milks.
- Whey protein hydrolysate with 10% protein and 5% degree of hydrolysis was found to be most acceptable for incorporation into milk @ 20% for enriching the milk with functional peptides.
- Technology for manufacturing milk chocolate, basundi, shrikhand and chhana podo using artificial sweetners were developed.
- Extruded breakfast foods were produced successfully by blending ground popped / roasted NP - jowar, SMP/ WMP and sugar. A comparison between the extruded foods prepared from blends of SMP and WMP indicated that that the WMP based extruded food was more acceptable in comparison to SMP based product
- Technology for production of khoa jalebi, whey drink, whey based health food, kasha halwa, carrot halwa and chhana jhili was developed.
- A method was developed for utilization of whey in jaggery, bread, bun and soup sticks
- Shelf life of khoa jalebi, basundi, kunda and chhana podo was enhanced.
- An ergogenic drink from hydrolysed whey has been developed.
- BHC and DDT were the residues detected in most of the milk samples of Southern States. It was found that

the organochlorine pesticide residue levels in milk in the southern states are normally within permitted limits.

- The inclusion of glycine in the semen extender showed good results in the conception of repeat breed cows, thus protecting natural seminal taurine from conjugating with egg-yolk cholic acid.
- The physico-chemical characteristics of branded ghee samples, sold in Southern States are within the normal range. Several market ghee samples analyzed were not able to meet the Agmark standard for RM value. Methods such as HPLC, crystallization, fractionation etc are very useful in detection of adulteration.
- Higher macrophage load, Superoxide Anion (SOA) generation and phagocytic index were found in the genital tract of Repeat Breeding cows. Seminal taurine protected acrosomal integrity of spermatozoa by scavenging the SOA generated by the genital tract MP, besides increasing the sperm motility.
- Investigations were conducted to evaluate suitable cryoprotective agents like carbohydrates and proteins during lyophilisation of probiotic direct vat set ferments for production of short set dahi.
- Studies were carried out on the effect of supplementation of varied levels (6,8,10, 12 & 14%) of added sucrose to milk on metabolic activities of probiotic lactic ferments namely Lactobacillus bulgaricus), Lb.acidophilus), Streptococcus thermophilus and Lactococcus lactis biovar. diacetylactis and their combinations. The observation revealed that the probiotic cultures are suitable for manufacture of probiotic Misti Dahi and yoghurt.
- Methods were standardized to incorporate certain spices such as ginger, pepper, cumin, cardamom, turmeric and herbs like tulsi and pudina into butter milk to prepare spiced butter milk drinks.
- Technology for the preparation of a beverage containing ragi extract and milk was standardized.
- The use of whey protein as well as horse serum resulted in higher cryoprotective effect at 10% concentration. Among the cryoprotective agents examined, whey proteins were selected due to the restriction on use of ingredients from animal sources. Freeze dried cultures were packaged in two packaging materials viz. EVOH and polythene, The results revealed that DVS culture stored at 8°C even up to seven months could be used for preparation of dahi with good organoleptic properties.
- A method for the preparation of ready to reconstitute payasam dry mix, ragi malt dry milk mix and foxtail millet was standardized.
- Extracts of some of the vegetables and fruits were used in the preparation of buttermilk drinks for enhanced health benefits. An attempt was made to improve the textural stability of buttermilk drinks through homogenization of the milk used and addition of stabilizers. Thermization and carbonation of buttermilk drinks helped to extend the shelf-life of the buttermilk drinks.
- Lactic cultures with antagonistic activity against pathogenic strains of E.coli and Staphylococcus aureus were isolated from dahi.
- The kinetics of colour changes in gulabjamun during frying was modeled using fractional conversion first order reaction kinetics and Arrhenius relationship.
- Technology for continuous manufacture of starch-whey protein isolate films using twin screw extrusion was developed. The 0.4-0.6 mm thick films were characterized for their tensile, sorption, thermal, water vapour permeability properties.
- The moisture sorption characteristics of kunda and four commercially available gulabjamun mixes were established

at 10, 25 and 40°C using gravimetric method. Various sorption equations were fitted to the equilibrium moisture content data to model the sorption behaviour of these dairy products.

- Economic analysis of dairy farming in Maharashtra revealed that by and large , feed cost constituted about 60 percent of the gross cost in milk production, while labour cost accounted for about 20 percent. The local cow milk production incurred net losses. The crossbreds and buffaloes generated positive net income and family labour income. Uncertain rain, low availability of fodder, high cost of feeds and fodder and low productivity of local cow and buffalo were the major constraints perceived by dairy farmers

Eastern Research Station

- Shelter Management Systems of dairy cattle in rural areas were evaluated in terms of micro environmental conditions and production performance under hot-humid agro climatic conditions of Eastern India.
- Cattle embryos through *in vitro* technique were prroduced.
- Performance of dairy animals under organic management system was studied.
- Effect of dietary manipulation of rumen fermentation was studied using locally available vegetable oils. Supplementation of sunflower oil thrice in a week improved the growth rate and feed conversion efficiency of growing calves.

Mr. Bazivamo Christophe, Minister for Agriculture and Animal Resources, Rawanda on visit to NDRI

Research & Development Facilities

Livestock and Fodder Farm

The Institute possesses an elite herd of over 1600 Dairy animals, which mainly include cattle and buffaloes. The Institute herd serves as a nucleus stock of superior germplasm for its propagation and dissemination to various agencies. It also caters to the requirement of milk and experimental animals for various research projects. Surplus milk is utilized for running experimental dairy. Karan Fries crossbred cows (Tharparkar X Holstein Friesian) developed at this Institute are currently producing over 4,000 litres of milk per lactation. Further, Sahiwal cows and Murrah buffalo produce over 2,100 litres of milk per lactation. These lactation yields are much higher than the national average i.e. 1,050 litres. The highest peak yields of 44 and 46.5 kg have been recorded in Karan Swiss (Sahiwal X Brown Swiss) and Karan Fries, respectively. Also, through consistent selection, the indigenous cattle breeds i.e. Sahiwal and Tharparkar have been improved and the highest peak yields of 23 and 19.5 kg milk per day have been obtained in these two breeds, respectively. In Murrah, the best buffalo breed of the world, the peak milk yield of 25.1 kg in a day has been achieved. A small flock of indigenous and crossbred goats is also maintained for conducting research and the peak milk yield of 5.4 kg per day has been registered. A modern Milking Parlor System and Shelter Management System set up recently at the Livestock Farm serve as demonstration models for the progressive farmers and provide infrastructure for conducting research on various aspects of milk production system, reproductive performance, growth profile and nutritional requirements for elite milch breeds.

The entire fodder need of the farm is met by cultivating fodder crops in over 300 hectares of land and under a Revolving Fund Scheme on Seed Production of Fodder Crops, good quality seeds of improved varieties of fodder crops are produced in 40 hectares area and supplied to farmers for enhancing the fodder yield. Initiatives have also been taken to modernize the irrigation system by brick-lining of irrigation channels for improving the conveyance efficiency of limited quantity of irrigation water available. Systematic and computerized data and records on all aspects of dairy production and management are being maintained and used by students, researchers and the farm managers.

Institute dairy farm, one of the most modern and well managed farms of the country, has been serving has a model training cum demonstration unit for the benefits of dairy farmers and farmers organizations. Training on scientific dairy farming and consultancy for setting up of commercial dairy farming enterprise is also provided to budding entrepreneurs, banking institutions, NGOs and Govt agencies.

Artificial Breeding Research Center

The Artificial Breeding Research Center (ABRC), erstwhile known as the Artificial Breeding complex (ABC), was renamed in 2010. ABRC has the infrastructure and capacity for managing 146 bulls (Sahiwal, Tharparkar, Karan-Fries breeds of cattle and Murrah breed of buffalo) and is the Largest Institute Breeding Bull Center in the country.

This Center 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 maintains the co-ordination with various departments and sections of the institute, ICAR institutes and state agencies for vertical growth of the center.

The centre has a state-of-the-art seminar-cum-class room; Semen Quality Control Laboratory; Germplasm Information Laboratory; Long range Open Bull Exercising Zone; Mist cooling system for reducing heat stress to breeding bulls.

The center has also strengthened the facilities for scientific management of male animals/ dairy bulls, cryopreservation facility for storage of germplasm, semen processing laboratory, advance training facility on animal breeding / reproduction management and frozen semen technology and dissemination of superior germplasm of cattle and buffaloes.

Model Dairy Plant and Experimental Dairy Plant

The Institute has a Model Dairy Plant with the state-of-the-art equipment and a processing capacity of 60,000 liters of

Model Dairy Plant

milk per day. This ISO 22000:2005 certified plant has been established with collaboration of NDDB to provide hands-on training facilities to B. Tech. students and for scientists to carry out the scaling up of operations for products and processes developed in research laboratories. Further, the Institute also has an ISO certified Experimental Dairy Plant with the milk processing capacity of 10,000 litres per day. The plant is extensively used by the students, research workers and scientists for developing new and innovative dairy products. This Experimental Dairy Plant prides itself for instituting the first successful Revolving Fund Scheme of ICAR for strengthening self-financing operations since 1989-90. Revenue generated through this scheme is being utilized for development of infrastructure of Experimental Dairy. During the year 2011, the Experimental Dairy generated revenue worth Rs. 3,60, 31, 198/-.

Peer Review Team of ICAR Visiting Model Dairy Plant

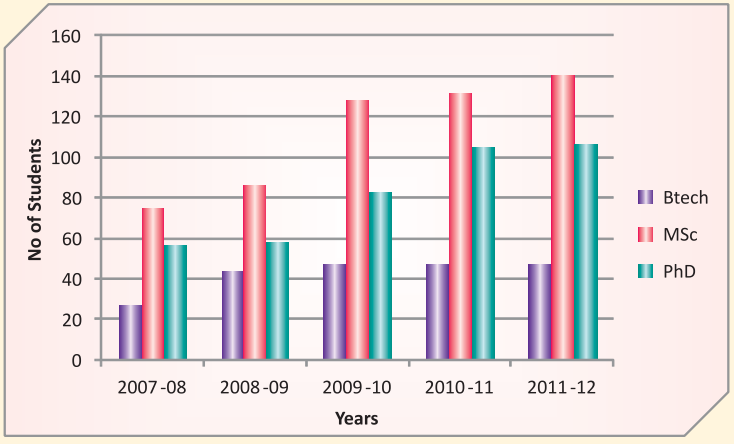
Dairy Education

NDRI Deemed University provides high quality education in the field of dairying, which has no parallel in Asia. Presently, NDRI offers Masters and Doctoral courses in twelve different disciplines viz. Dairy Microbiology, Dairy Chemistry, Dairy Technology, Dairy Engineering, Animal Biochemistry, Animal Biotechnology, Animal Genetics and Breeding, Livestock Production and Management, Animal Nutrition, Animal Physiology, Dairy Economics and Dairy Extension Education and Masters in Agronomy (Forage Production). In addition, the Institute also offers the prestigious degree course leading to award of B. Tech. (Dairy Technology).

NDRI being a front ranking human resource development Institute in the field of Dairying, very high quality standards of education and teaching are maintained. Revamping of the curricula of Degree programmes of B.Tech /M. Sc./ M.Tech. /M.V.Sc. and doctoral academic programmes have been done to bring the same at par with any International Institute. The additional academic programs being introduced are not only need based, but also essential to give the extra edge to the dairyman to obtain state-of-art knowledge in dairy production, processing and management.

The programmes of NDRI Deemed University are constantly reviewed and updated to ensure the requisite knowledge levels to pass-out students and to make them academically proficient in meeting the emerging global challenges. Along with classroom teaching, one year "In-Plant Training" simulating the industrial environment is the outstanding feature of the B. Tech (Dairy Technology) programme. The in-plant training provides an opportunity to the NDRI students to manage dairy processing jobs in commercial milieu. NDRI, being a Research Institute, is able to impart latest scientific knowledge to students, through the process of knowledge generation. For Experiential Learning of Students and provide them better training, the facilities at Experimental Dairy Plant of NDRI have been expanded. NDRI has also got the recognition as Niche Area in Animal Biotechnology for its educational programmes.

Enrolment of students in different sessions



The teaching programmes of National Dairy Research Institute have helped in generating highly trained and motivated manpower, which has been serving the country in various organizations for the improvement of animal productivity. The B. Tech programme in particular has made significant impact on the Indian dairy industry with majority of top and middle management positions in the organized sector being occupied by the dairy professionals coming out of the Institute. The postgraduate training has proved equally beneficial for the R&D, quality assurance as well as management programmes of the industry.

Educational and Training opportunities are provided to visiting scholars from various countries. Students and trainees from Nepal, Bangladesh,

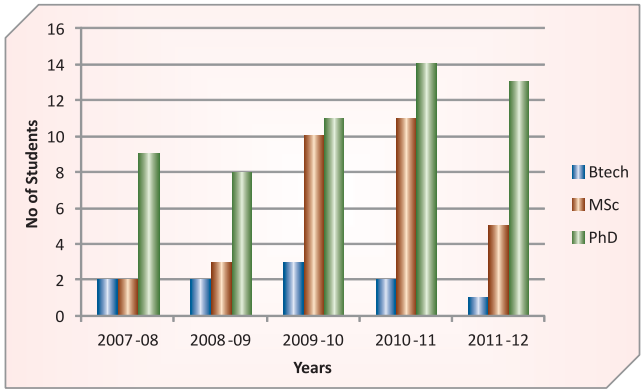
Afghanistan, Iran, Iraq, Myanmar (erstwhile Burma), Mauritius, Sri Lanka, Vietnam, Ethiopia, Rawanda, Ghana, Holland, Egypt etc. have been benefited. In-plant training facilities are also imparted to the students from sister Institutions and SAUs. Advanced training imparted to the faculty members from SAUs and other Institutes has immensely helped in improving the quality of research and teaching in the National Agricultural Research System (NARS).

Under Education Technology Cell, multi-media facilities have been provided in all the lecture halls and seminar rooms of the Institute. Students Hostels have been furnished with modern facilities such as computer connectivity and access to Internet to facilitate the information/knowledge sharing amongst the scholars. NDRI students' community presents a cosmopolitan ambience at the campus and despite heavy load of curriculum, our students allocate some of their time to give expression to their creative talents through cultural and sports events. Their valued participation in inter-institutional competitions has brought laurels to the Institute.

Library and Learning Resources

The Institute Library has an impressive collection of literature on Dairy Science and related subjects. More than 200 periodicals are subscribed to keep track of the current scientific/technical developments. In addition, there are 94,730 volumes, which include 50,395 books, 31,210 bound journals, 8,200 bulletins, 3,357 theses, 268 microfiches and 1300 CDs. The National Library has a computer section having 50 workstations for students and staff of the Institute. The Library is adequately equipped with facilities such as Internet, Documentation, Reference, Current Awareness Services, CD-ROM, Photocopying, Literature & Documentation Scanning services, etc. Library is a major partner of NAIP sub-project 'Strengthening of Digital Library and Information Mangement under NARS (E-Granth).

International students in different sessions



There is a full-fledged Computer Centre functioning at this Institute which is a central facility for scientists and students. The major activities of the Computer Centre include Management Information Systems for Livestock Farm and Personnel Management; Scientific Data Analysis and Payroll Processing; Video Conferencing; and Internet/ E-mail connectivity. There are three specialized cells viz., Agricultural Research Information System (ARIS), Bio-Technology Information System (BTIS) and National Knowledge Network (NKN) node established under the auspices of ICAR, Department of Biotechnology and National Informatics Centre, respectively. All the faculty members in the Institute have on-bench computer and the internet connectivity. An Online Examination Centre with 120 nodes has been established under the NAIP sub project, "Developing, Commissioning, Operating and Managing an Online System for Net/ARS - Preliminary Examination by ASRB, ICAR" for conducting NET/ARS Preliminary Examination for ASRB, ICAR. The work of extending the institute LAN facilities is in progress to connect students hostels (including Boys Hostels, International Hostel and Kaveri Hostel) through Wi-Fi networking enabling 54 Mbps connectivity. After that students will be able to use the Internet and Library Services of the institute round the clock.

Competence Rewarded

They won laurels …

Life-time Achievement Award	
2011	Dr A. K. Srivastava
Dr. D. Sundaresan Award	
2011	Dr. (Mrs.) Harjit Kaur
	Dr. Avtar Singh
2008	Dr. R. S. Gandhi
Dr. N. N. Dastur Award	
2011	Dr R. K. Malik
Dr. K. K. Iya Award	
2008	Dr. A. K. Puniya
2011	Dr. Sumit Arora
	Dr. Y. S. Rajput
Dr. P. G. Nair Award	
2011	Dr. A. K. Singh
Chillapa Memorial Oration Award	
2011	Dr. A. K. Srivastava
M. S. Swaminathan Award for 2006-07	
2007	Dr. B. S. Prakash
Jawaharlal Nehru Award	
2007	Dr. S. C. Roy
2010	Dr. Menon Rekha Ravindra
2011	Dr. Ramya Iyer
ICAR award for Interdisciplinary Team Research	
2008	Dr. K. K. Datta
	Dr. V. Unnikrishnan
2011	Dr. Satish Kulkarni
	Dr. B. Surendra Nath
	Dr. B. V. Balasubramanaym
	Dr. B. C. Ghosh
	Dr. Menon Rekha Ravindra
	Dr. G. R. Patil

Erasmus Mundus Award	
2010	Dr. A. K. Singh
	Dr. Sumit Arora
2011	Dr. Rajesh Bajaj
	Dr. Sudhir Tomar
ICAR Outstanding Research Award	
2008	Dr. Dheer Singh
NDRI Best Doctoral Thesis Award	
2010	Ms. Jaspreet Kaur
	Ms. Ramya Iyer
	Ms. Sanvedna Kumari
NDRI Best Master Thesis Award	
2010	Ms. Archana Chandran
	Ms. Arpana Verma Kumari
	Mr. Bitan Mondal
Prestigious Recognition Award (2005-2006)	
2007	Dr. B. S. Prakash
International Professional Women Opportunity Award	
2007	Dr. Latha Sabikhi
Bharat Ratna Dr. C. Subramanyam Outstanding Teacher's Award	
2008	Dr. S. Kulkarni
Bill A. and Rita L. Stout Outstanding International Graduate Student Award	
2008	Dr. P. Heartwin Amalad
NDRI Best Research Presentation Award	
2009	Mr. A. Kumaresan
Prof. N. J. Chinoy Award	
2010	Mr. G. Jagan Mohanrao, and
	Mr. G. Raj Kumar
	Dr. S. K. Atreja

Compound Livestock Feed Manufacturers Association (CLFMA) of India Felicitation Award	
2010	Dr. S. S. Thakur
Norman Borlaug Fellowship	
2006	Dr. Alok Jha
XV Sukumar Basu Memorial Award for the binnium 2005-2006	
2008	Dr. (Mrs.) P. R. Sinha
Young Scientist Award	
2007	Dr. K. S. Kadian
2011	Ms. Seema
	Ms. Prerna Saini
2012	Dr. P. Narender Raju
Dr. J. R. Patel Memorial Trust Award	
2007	Dr. G. R. Patil
	Dr. R. R. B. Singh
	Dr. A. A. Patel
Honorary DAAD Advisor	
2006-09	Dr. R. K. Malik
Dr. C. R. Sane Oration Award	
2009	Dr. B. S. Parkash
Fellow, Punjab Academy of Sciences	
2011	Dr. A. K. Srivastava
NAAS Fellow	
2011	Dr. G. R. Patil
IDA Fellowship	
2008	Dr. S. P. Agrawala
Life Fellow Academy of Environmental Biology	
2008	Dr. Rajeev Kapila
Shiksha Rattan Puraskar	
2007	Dr. Surjeet K. Jha

Human Resource Development Through Extension

Dairy Farmers who have played crucial role in ushering white revolution in the country remain central to all the R&D activities of the Institute. New scientific know-how on animal husbandry, milk and crop production have been transferred by means of Grameen Dairy Melas, Calf Rallies, Veterinary Camps, Women Agriculture Days, Field Days and various on farm demonstrations.

Dairy Education at Farmers' Door

The Extension Education Programme "Dairy Education at Farmers' Door" initiated since 2008-09, has been continuing to strengthen the effective dissemination of dairy production and processing technologies among farming community. Under this programme, a team of NDRI scientists including subject matter specialists from production, processing and management group organize Dairy Education at Farmers' Door in various villages on 2nd Saturday of every Month.

Dairy Melas

Dairy Mela 2009 participated by more than 3000 farmers was organized at NDRI during 26-28 March, 2009.

Dairy Mela 2010 participated by more than 10,000 farmers was organized from 24th to 26th February 2010.

Exhibitions were organized during the Dairy Mela in which stalls

Dr. Mangala Rai, Former Secretary, DARE &DG, ICAR with Prize Winning Animal during Dairy Mela

A Ring View of Dairy Mela

Rural Women being Imparted Trainng in Milk Products

were put up by various ICAR Institutes, feed companies, veterinary pharmaceuticals, dairy technology and engineering firms. These exhibitions served as a media to disseminate information on newly developed technologies and products to the visiting farmers. During these Melas, Kissan Sangosthies, Milk yield competitions, Competitions in paneer making and milking efficiency, and breed beauty were organized.

Empowerment of Farm Women in Dairy Farming through Self Help Groups

NDRI also worked towards Empowerment of Farm Women in Dairy Farming through Self Help Groups (Satyam Self Help Group in village Subri, District Karnal, Sadbhawana Self Help Group in village Shahpur; Vishwas Self Help Group in village Kulwehri, Distt Karnal) for carrying out the dairy related activities in groups. 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. During this period, 46 awareness campaigns and trainings for women were organized.

Training programmes

Besides, All India Dairy Husbandry Officers' Workshop (2010), Model Training Programme (2008), Research Extension Industry Framer Interface (2007), Farmer Scientist Interface (2009), as many as 102 Off-campus Farm Women Training programmes and 10 On-campus Farmer Training programmes were organized by the Extension Division during 2007-12.

Kisan Sangoshties

During the period under report, 322 Kisan Sangoshties with the dairy farmers and farm women were organized in the adopted villages for transfer of technologies developed by the Institute during the last one year. Farmers were made aware about the reproductive management practices, mastitis control, disease preventive measures, clean milk production practices, preparation of value added milk products, management of fodder scarcity period and round the year green fodder production.

Veterinary Health Camps cum Farmers & Scientists Meets

During the period 2007-12, NDRI organized 305 Infertility and Veterinary aid Campaigns, Exposure Visits at nearby

Veterinary Services to Farmers

villages viz., Nasirpur, Nasirpul tila, vazidpur, Kulwaheri, Budhakhera and Ganjogarhi. A large number of animals were treated against the contagious diseases, infertility, and for pregnancy diagnosis and general veterinary cases. A series of lectures on different areas of dairy farming was delivered to the farmers. Scientists of the Institute were motivated to undertake tours in villages to have direct interaction/interface with the farmers to understand their problems and initiate their research programmes accordingly. Kissan Sangoshtis were organized in villages to bring awareness among dairy farmers on reproductive management through estrus synchronization and fixed time AI in bovines.

ICT Based Information Packages Developed

The Dairy Extension Division of the Institute has developed ICT based information packages in the form of video films and multimedia packages on clean milk production, hygienic milk processing & packaging and scientific calf rearing.

Awareness creation and training cum demonstration on diagnosis and control of subclinical mastitis among dairy farmers of Karnataka, Andhra Pradesh

Efforts towards achieving quality milk production by educating the dairy farmers through training and demonstration have benefitted more than 500 farmers belonging to Karnataka and Andhra Pradesh under NABARD sponsored project. The training cum demonstration programmes on detection of subclinical mastitis in the milking cows by using electrical conductivity meter, CMT kit and digital somatic cell counter were arranged both on campus and off campus i.e. at faermers' door step. Our efforts resulted about awareness creation about subclinical mastitis. Hence, they have started to implement the detection and control of subclinical mastitis. After our demonstration, Karnataka Milk Federation (KMF) both in

Visitors at Krishi Mela, GKVK, Hebbal, Bangalore being explained about detection of Subclinical Mastitis under field conditions

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.

Technology transfer of dairy products for commercial production

Technology for the manufacture of fermented dairy products namely Dahi, yoghurt and butter milk has been transferred to the ABT Dairy, Coimbatore during 2011 – 12. The products in the brand name Sakthi are being marketed in the states of Tamil Nadu and Kerala. The products are also being planned for launch in the city of Bangalore in the current year.

Krishi Vigyan Kendra (KVK)

KVK organized 969 on and off campus training programmes during 2007-12 for 28197 beneficiaries in the area of scientific dairy farming, dairy processing, crop production, vermicompost, fisheries, bee-keeping, Home Science and

related topics. The trainees included dairy farmers, farm women rural and urban youth, entrepreneurs and extension functionaries from across the country.

Landmark History: A Cross-bred Cow under on Farm Trial in a Village Produced 59.5 kg Milk

Training Programmes

Particulars of training	2007-12	
	No. of trainings	No. of trainees
On-Campus	798	23275
Off-Campus	171	4922
Total	969	28197

Animal Health Camps organised

- KVK organized 72 animal health camps.

Activity	Number of cases during 2007-2012
No. of Camps organised	63
No. of general ailment cases treated	269
No. of Infertility cases treated	740
No. of pregnancy diagnosis cases	283
No. of Deworming cases	1876
No. of tick control cases	5140

- Animal Health facilities provided through Dairy Vikas Kendras

Activity	Number of cases during 2007-2012
Artificial Insemination in cows	11468
Artificial Insemination in Buffaloes	6872
Pregnancy cases in cows	609
Pregnancy cases in cows	643
Calves born under A.I.	8747
No. of Infertility cases treated	261
No. of general ailment cases treated	1014
No. of Dehorning cases	1150

Women in Agriculture Day: KVK organizes Women in Agriculture Day every year on 4th December. Five such programmes were organized in which more than 1200 women participated from different villages.

Front Line Demonstrations: KVK is regularly organizing FLDs on oil seed in pulse crops. During this period 80 FLDs on oil seed crops 120 demonstrations on pulses were organized more than 45 villages.

Technology Week: KVK organized two times Technology Week during which all relevant technologies pertaining to dairy farming, dairy processing, crop production, vermicompost, fisheries, bee-keeping were shared with the farmers, farm women, school students and rural youth.

Field Days: The subject matter specialist organized more than 70 field days in the area of dairy farming, dairy processing, crop production, vermicompost, fisheries, bee-keeping, Home Science in different villages.

Agriculture Technology Information Center

Agricultural Technology Information Center (ATIC) at NDRI has been serving as 'a single window' for all ICAR Institutes located at Karnal. It provides help to farmers and

other stakeholders such as entrepreneurs, extension workers, development agencies, stakeholders such as entrepreneurs, extension workers, development agencies, non-government organizations (NGOs) and private sector organizations to provide solutions to their problems in Agriculture and Dairying. The center makes available all the technological information along with technology inputs and products for testing and use by them.

During 2007-12, 75046 visitors/farmers from 18 states visited ATIC which included 365 delegates from 14 different countries. To improve health & productivity of dairy animals, different technological interventions in the area of Nutrition, Breeding, Physiology and Health Care were suggested to 14981 stake holders whereas 10457 stakeholders were suggested different technological interventions in the area of livestock production management and milk processing and 9758 cases were referred for specialized guidance to different divisions of the Institute and 7642 cases to sister institutes located at Karnal. During above said period centre generated revenue of Rs.6712845/- which includes Rs. 687594/-from sale of publications & Rs. 6025251/- from sale of seeds and cultures. Agricultural Technology Information Centre (ATIC) also provided on-line guidance to 8541 stakeholders through e-mail and telephone (Toll Free-1800-180-1199) where as 9547 video shows were organized for the visitors.

Farm Women at NDRI on World Milk Day organised on June 1, 2009

Consultancy, Patents & Commercialisation of Technologies

In pursuance of the technology policy of Govt. of India which lays stress on the development of indigenous technologies and its effective transfer to industry, a Consultancy Service Board has been established at NDRI, Karnal. The Board facilitates transfer of the technologies developed on the basis of R&D work done in various laboratories for infusion of Science and Technology in areas of Dairy Production, Dairy Processing and Dairy Management on professional basis.

INDUSTRIAL CONSULTANCY SERVICES

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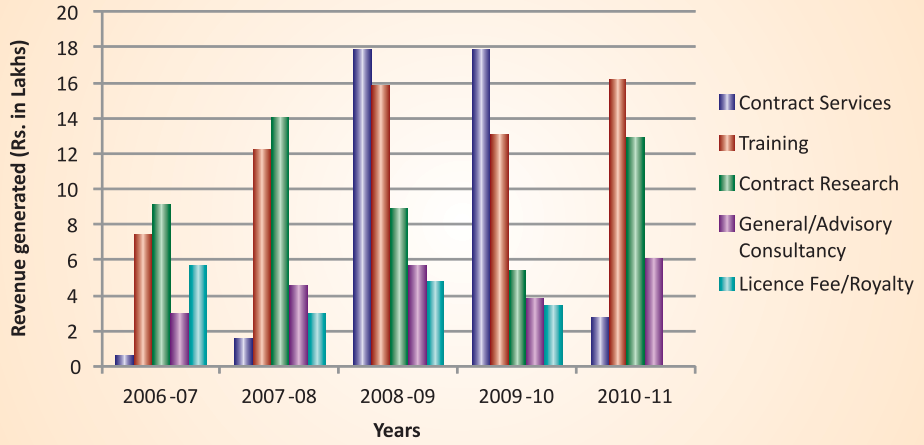
Revenue generated from consultancy services is utilized for strengthening the Institute's infrastructure and R&D work and also part of the money is shared among the scientists rendering such service as an incentive. Consultancy services also provide a via media for two-way communication between scientists and industry. Feedback from industry through such interactions helps the scientists to focus and fine tune their research efforts to fulfill the real needs of dairy industry. During the period 2006-07 to 2010-11, NDRI generated Rs 19,595,029/- revenue through Consultancy Services.

Revenue Generated through Consultancy services



Technologies Transferred during 2007-2012

1. Technology of 'Acido whey soft drink' was transferred to M/S Milan Dairy Foods (P) Ltd., New Delhi in June 2007 at a value of Rs. 25000/-
2. Technology of 'Antibiotic Kit was transferred to M/S Neugen Diagnostics , Hyderabad in Dec. 2008 at a value of Rs.2.5 lakh
3. Technology of 'A kit for detection of detergent in milk was transferred to Mother Dairy,Delhi-110092, in Dec. 2008 at a value of Rs.4.0 Lakh
4. Technology of 'Low Cholesterol Ghee was transferred to Kwality Dairy India Ltd., New Delhi, in June-July 2010)at a value of Rs.20.0 Lakh plus 1.5% royalty

Institute Technology Management Unit

Due emphasis is being given to safeguard IPR issues of innovative and useful research outcomes in the form of Patents. For implementing the new IPR guidelines at the Institute the IPR-unit has named as **'Institute Technology Management Unit'** and an **'Institute Technology Management Committee (ITMC)'** has been constituted as the highest decision-making body at the institute level, relating to all issues of IP management and technology transfer / commercialization. A total number of 28 patent applications were filed for the award of patents in the area of dairy production and processing during the past five years and are at different stages of processing. All the applications were sent to NRDC for patenting and subsequent commercialization of technologies.

Patents Filed

- A PCR based method for differentiating cow and buffalo milk (S. De, K. P. Singh, Rameshwar Singh, T. K. Datta and S. L. Goswami)
- A non-evasive DNA Isolation methodology in Dairy Animals (S. De, Ashutosh Sharma, P. Yadav, T. K. Datta).
- A whey based Lassi-like beverage (Lata Sabikhi and D. K. Thompkinson)
- Process for manufacture of spray dried cheddar flavour based concentrate (D. K. Sharma and B. D. Tiwari).
- Value addition of Dahi through tannin monomers of feeding Acacia nilotica pods containing diet from cow milk (D. K. Dubey and S. N. Rai)
- A process for commercial manufacture of Kradi. (H. A. Punoo, G. R. Patil and R. R. B. Singh). **Application No. 2134/DEL/2008 dated 10.09.2008.**
- Value addition of paneer and dahi through herbal feed additives from cow milk. (D. K. Dubey and S. N. Rai). **Application No.152/DEL/2009 dated 27.01.2009.**
- A kit for detection of adulteration of 'soymilk' in milk. (Y. S. Rajput, Rajan Sharma and Poonam). **Application No.396/DEL/2009 dated 02.03.2009.**
- A kit detection of β-lactum antibiotic group in milk using bacterial spore as biosensor. (Naresh Kumar, Manju G and Saugada Das). **Application No. 115 /DEL/2009 dated 21.01.2009.**
- Enhancement of value addition of Khoa production through herbal feed additives from cow milk. (Mayank Tandon and S. N. Rai). **Patent Application No. 1256/DEL/2009 dated 18.06.2009**
- Enhancement of value addition of condensed milk through herbal feed additives from cow milk (Mayank Tandon and S. N. Rai). **Patent Application No 1843/DEL/2009 dated 17.9.2009**

- Enhancement of value addition of milk powder production through herbal feed additives from cow milk. (Mayank Tandon and S. N. Rai). **Patent Application No 1844/ DEL/2009 dated 17.9.2009**
- Process for the preparation of folate rich functional 'Dahi', (Ramya Iyer and S. K. Tomar). **Patent Application No 2345/DEL/2009 dated 13-11-2009**
- An improved & optimized process for manufacture of Doda Burfi (G. R. Patil; Rekha Chawla and A. K. Singh). **Patent Application No 2357/DEL/2009. dated 16-11-2009**
- Synbiotic Ice Cream and process for the preparation therof. (Omkar Kumar, T. Rai and R. K. Malik). **Patent Application No 2729/DEL/2009 dated 30-12-2009**
- Three stage thin film scraped surface heat exchanger for continuous manufacture of khoa, (A. K. Dodeja, Dharam Pal and S. P. Agrawala) **Patent Application No 583/ DEL/2010 (Provisional), dated 12-03-2010**
- Development of spore inhibition based enzyme substrate assay(SIB ESA) for monitoring aflatoxin M1 in milk, (Naresh Kumar, Namita Ashish singh, Vinay Kumar Singh, Sunil Bhand, R. K. Malik)
- Development of Technology for Manufacture of Feta Cheese from Buffalo Milk using Microbial Rennet, (Sanjeev kumar, S. K. Kanawjia)
- "Method and system for automatic identification and estrous detection in buffaloes on their vocalization patterns" (Yajuvendra Singh, S. P. Lathwal, T. K. Mohanty, A. P. Ruhil and Shiv Prasad). **Patent Application No 3090/ DEL/2011**
- "A qualitative and quantitative test for anionic detergent in milk". (Amit Kumar Barui, Rajan Sharma and Y. S. Rajput). **Patent Application No 3677/DEL/2011**
- A process of bioethanol production by immobilized thermotolerant yeast from whey" (Minakshi Dahiya and Shipa Vij). **Patent Application No 3710/DEL/2011**
- An innovative approach for detection of Enterococci in milk using spore germination based bioassay" (Dr. Naresh Kumar, Ms. Gurpreet Kaur, Ms. Geetika Hakur, Mr. Raghu HV, Ms. Namita Ashish Singh, Mr. Vinai Kumar Singh). **Patent Application No 119/DEL/2012**

First examination report of patent applications submitted:

- HPLC method of analysis of tannin monomers present in animal feeds" (Keshab Barman and Sachchida Nand Rai).
- Estimation of tannins metabolites in blood serum and cow milk using HPLC" (Keshab Barman and Sachchida Nand Rai).
- A kit for detection of detergent in milk" (Y. S. Rajput, Rajan Sharma, Sumandeep Kaur)

Infrastructure Developed

New Biotechnology Building commissioned

- A state-of-the-art biotechnology research facility was created in 2007 to consolidate the biotechnology research at NDRI. The new lab facility offers a working space of more than 20,000 sq. ft. and have specialized laboratories on Embryo Biotechnology, Regenerative Biotechnology, Animal Genomics, Proteomics Research etc.

- Mini Auditorium developed.
- Video Conference Lab Developed
- Conference hall of ATIC Building developed.
- Animal Genomics Laboratory developed.
- Construction of boundary wall of Model Dairy Plant.
- Sixteen flat unit renovated as Married Scholars Hostel.
- Various laboratories of the Institute were equipped with latest sensitive analytical instruments for carrying out research in most advanced areas of Molecular Biology, Cell Culture, Fermentation Technology, Protein Chemistry, Nutritional Studies, Food Technology, Microbiology, Micro Element Analysis etc.
- Technology Business Incubation (TBI) Facility established.
- Establishment of Nutrition Biotechnology Laboratory at ERS, Kalyani.
- Furnishing and upgradation of Labs in Animal Biotechnology Centre, Dairy Technology Division, Dairy Microbiology Division, Dairy Cattle Nutrition Division.
- Renovation of all Lecture Rooms.
- Renovation of Scientist Home.
- Renovation of Boys' and Girls Hostel.
- Renovation of Residential 'A' & 'B', 'D' & 'F' type quarters.

Funding through external sources has enriched research facilities at NDRI

State of the art housing system for elite buffaloes, crossbred cows and indigenous cows (3 sheds)

- State of the art dairy cattle and buffalo housing systems – 3 modern shelters for high yielders

- Installation of state of art milking parlors in CY to strengthen infrastructural and operational aspects of clean milk production

- Civil Work relating to Air Conditioning of Auditorium.
- Construction of Boundary wall for Girl students' Hostel.
- Model shelters for northern plain regions developed and demonstrated
- Weather controlled house with automatic feeding and drinking system
- Computerized automatic animal behavior recording system
- Wireless activity meter for heat detection
- Electronic static weigh pad
- Renovation of **Sports Stadium** including boundary wall and **installation of Sky Lights.**
- Construction of the extension wing of experimental dairy for housing pilot scale dairy and food processing equipments under NAIP and TBI programs
- Renovation of Food Technology Laboratory , UG/PG lab and Sensory Evaluation laboratory
- Establishment of Dairy Biotechnology Laboratory at ERS, Kalyani.
- **Renovation of Laboratories for Technology Business Incubator Programme**
- Protective fencing of newly (2009-10) **developed Children Park.**
- CCTV based Security surveillance system has been installed in Dr. D. Sundaresan Auditorium of NDRI.
- **Construction of Boundary** of Farm Section.
- **Sick Animal Shed**/Car Parking AB Complex.
- Renovation of Small Animal House.
- Renovation and upgradation of Library.
- Renovation of Auditorium
- Renovation of electrical wiring, fittings and switches in all the hostels of NDRI
- Renovation of Seminar Room of Dairy Microbiology Division
- Renovation of Guest House and Staff Quarters at ERS, Kalyani.
- Renovation of Administrative Block.
- Construction of Power House Building at NDRI, Karnal.
- Renovation of Director's Conference Room
- Renovation of Satluj & Krishna Hostel
- Renovation of Seminar Room of Dairy Microbiology Division and Animal Biotechnology Center.
- Fencing of the premises of International Hostel
- Renovation of Mini Auditorium
- Renovation of Milk Parlour
- Carpeting of Approach Roads to Campus and Farm Section
- **Equipment Procured & Installed:** UF Unit plus membranes (Pilot scale), Mini MF-UF system, Binary Gradients HPLC System, UV – Spectrophotometer, Microfuidiser, Solid Phase Vacuum along with vacuum

pump, Refrigerated Centrifuge, GLC Column Accessories, Refrigerated Water bath, Fiber Tech, FES3; B.O.D Incubator, Biosafety cabinet, PCR Machine–III, Baking Oven (Rotary rack), Sealing machine, Flour mill (lab scale), Pulverizer, Planetary Mixer, Refrigerators, Microwave oven, Deep Freezers, Dough Kneader, Single Screw Extruder (Lab Model), Butter churn, Cheese vats and Cheese press.

- Renovation of existing experimental sheds of the animals.
- Metabolic cages for conducting trials on large ruminants fabricated.
- Ion chromatograph for the analysis of anions and cations in the feeds procured
- Development of IVRI land at Kalyani for fodder production
- Renovation and development of six span Molecular Genetics Lab of DCB Division
- Renovation of Administrative wing of NDRI
- Renovation of Divisional Class rooms in Dairy Technology Division and Dairy Cattle Breeding Division
- Renovation of Seminar Room in Dairy Chemistry & Dairy Economic, Statistics and Management Division
- Renovation of Deemed University Committee Room
- **Equipment Procured & Installed:** GLC Column Accessories, Baking Oven (Rotary rack), Sealing machine, Dough Kneader, Single Screw and Twin Screw Extruders (Lab Model), Lab Scale Pasteurizer, Flaking machine, Fluidized bed dryer, Vacuum tray drier

Development of IVRI land at Kalyani for fodder production: ERS NDRI was assigned to develop 30 acres land owned by IVRI at Kalyani. The land was kept barren and unutilized for long. Efforts were made to develop the land and brought under cultivable condition. Presently fodder crops are being grown for animal feeding

- A seminar room and board room facility was created for the benefit of faculty and students at SRS, Bangalore.
- Inducted crossbred cattle into the herd to augment milk supply at SRS, Bangalore.
- Renovation of a part of students' hostel initiated at SRS, Bangalore.
- Renovation and upgradation of guest house/guest rooms at SRS, Bangalore.
- A mini auditorium facility with seating capacity of 90 was created for the benefit of staff and students at SRS, Bangalore..
- A student auditorium facility with seating capacity of 200 was initiated in the engineering block at SRS, Bangalore..
- State of the art instruments like HPLC/PCR/Visconeta/ Thermal Analyser to improve research facility at SRS, Bangalore.
- Procurement of farm equipments like tractors, power tillers, pumps, bullock carts etc for use in the southern campus.

Bio-safety Laboratory developed

Established clean room with Biosafety level-2 facility at NDRI Centre: A Clean room with Biosafety level-2 facility for safe handling of dairy pathogens and dust sensitive equipments has been created with an amount of ~ Rs. 12.188 at NDRI centre under NAIP funded project entitled "Development of Biosensor and micro-techniques for analysis of detection of pesticides residues, Aflatoxins, heavy metals and bacterial contaminations in milk (C4/C10125).

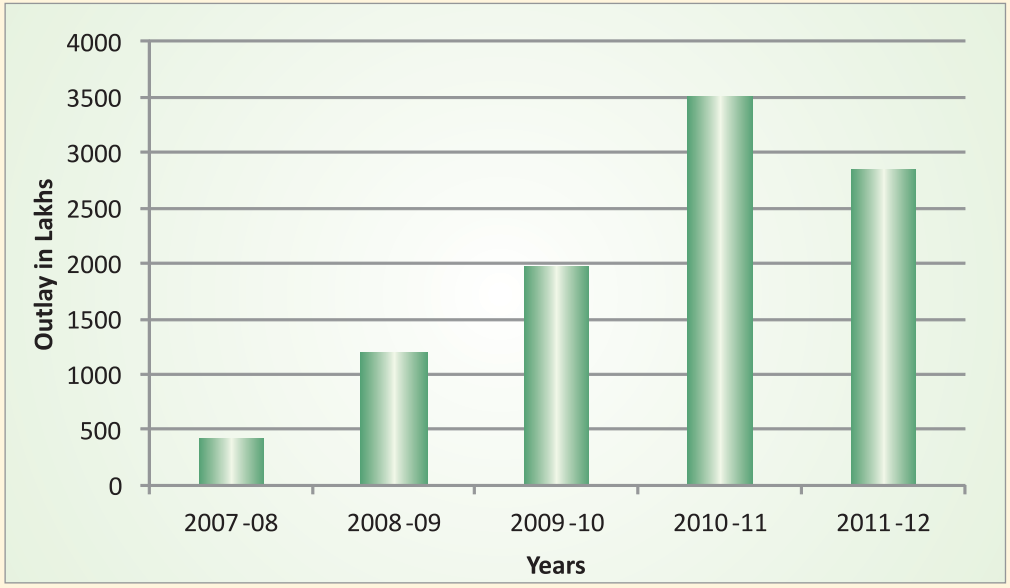
Research Collaborations

World Bank through NAIP has funded twenty research projects (with an outlay of Rs. 34 crores) in Consortium Mode wherein NDRI is either a Lead Institute or a Consortium Partner. The support from NAIP and other funding agencies has encouraged scientists to work on stem cell, buffalo cloning, transcriptone, embryogenesis, biosensor, nanotechnology, abiotic stress in farm animals, nutraceuticals and functional foods.

The scientific competence and excellence of past performance in conducting various research programmes has attracted funds from various National and International organizations/ agencies. The Institute had linkages with several International organizations such as World Bank, IAEA, UNDP, IDF, DAAD, Volkswagen Foundation, AvH Foundation and several leading institutions in UK, USA, Canada, Germany, Netherlands and Australia. Currently, many of the research programmes have Inter-institutional linkages with Dept. of Biotechnology (DBT), Dept. of Science and Technology (DST), National Bureau of Agriculturally Important Microorganisms (NBAIM), National Communication to United Nations Framework Convention on Climate Change (NATCOM-UNFCC), Ministry of Food Processing Industries, State Agricultural Universities (SAUs) and State Development Departments.

At present, research support through external funding from 47 extramural research projects is the highest ever in the history of NDRI. Network Project with an outlay of rupees 9 crores is being implemented at NDRI to address the burning issue of impact adaption and vulnerability of Indian Agriculture to climate change. To strengthen research further on climate change, NDRI has received grant of Rs.20.86 crores from Prime Minister's special fund. There projects worth Rs. 1.7 crores under National Fund for Basic, Strategic and Frontier Application Research have also been sanctioned for NDRI.

Research Funding from External sources



Research Collaborations /Linkages with International/National Agencies (2011)

Area	Project/PI	Sponsoring Agency
Reproduction Genomics	Fertility Performance and Analysis of CYP19 Gene Regulation in Buffalo (Dheer Singh)	DBT
Bioactive/Nutraceutical/ Therapeutic Milk Proteins	Energetics and Dynamics of Protein Stability and Iron Binding Properties and their Modulation by Domain-Domain Interactions in Lactoferrins from Various Animal Species (J. K. Kaushik)	DBT
Genomics	Cloning, Expression and Functional Characterization of a Mammary Gland Protein MGP-40 Expressed during Mammary Gland Involution and Exploring its Potential as a prognostic Mammary Biomarker in Farm Animals (A. K. Mohanty)	DBT
Embryo Production Techniques	Conservation and Multiplication of Germplasm of Yak (Poephagus Grunniens L.) and its Hybrid using in vitro Embryo Production Techniques (M. S. Chauhan)	DBT
Reproduction Genomics	Comparative Analysis of Epigenic Regulation of the Cyp19 Gene in Buffalo and Cattle (Dheer Singh)	DST-DFG (Indo-German Project)
Environmental Physiology	Research Needs and the Financial, Technological and Capacity Needs and Constraints to Address Climate Change Concerns vis-à-vis Livestock and Dairy Products (R. C. Upadhyay)	NATCOM-SNC, Ministry of Environment & Forest, GOI; UNDP-GEF
Climate Change	Enabling Activities for Preparation of India's Second National Communication to UNFCC-UNDP ((R. C. Upadhyay)	Ministry of Environment & Forest
Medical and Nutritional Sciences	Mechanisms of Cholesterol Transfer into Milk – A Comprehensive Gene Expression and Metabolism Study in Buffalo and Cattle (B.S. Prakash).	DST-DAAD
Nutrition and Immunity	Effect of Micronutrients Supplementation on Hormones, Milk Yield, Udder Health and Immunity in Crossbred and Indigenous Cows (A. Aggarwal)	DBT
Embryo Production	Embryo Production by Ovum Pick-up from Live Cattle (M. S. Chauhan).	DBT
Stem Cell	Reprogramming of Goat Fibroblast Cells by Introducing Transcription Factor Genes to Produce Induced Pluripotent Stem (ips) Cells (D. Malakar)	DBT
Animal Nutrition	Rumen Microbial Manipulations for Mitigation of Methane Emission and Productivity Enhancement in Dairy (S. K. Sirohi).	NFBSFARA
Micro-encapsulation	Micro-encapsulation of Bacteriocins for their Controled Release (R. K. Malik)	CIPHET, Ludhiana; (NFBSFARA)
Cellular Immunity	Molecular Basis for Modulation of Immuno Competence of Neutrophilic Function in vivo and in vitro of High Producing Cows and Buffaloes Peripartum (A. K. Dang)	DBT

Quality Assurance	Developing & Evaluation of Multiple Micro-nutrient (Mineral & vitamins) Fortified Milk for Consumer Market (Sumit Arora).	DBT
Probiotics	Development of Traditional Fermented Dairy Products Enriched with an indigenous Probiotic Strain for Promoting the Health and well being of Consumers (Sunita Grover)	MFPI
Quality Assurance	Investigations on High Pressure Induced Effect on Quality Characteristics of Buffalo Milk (A. K. Singh)	NFBSFARA
Animal Production	Bovine Sub-clinical Mastitis in Crossbred Dairy Cattle, Early Diagnosis and Control for Enhancement of Milk Production under Field Conditions : An Integrated Approach (D. N. Dass)	NABARD
Sire Evaluation	Indigenous Breed Improvement Programme (Sahiwal cattle) (R. S. Gandhi)	PDC, Meerut; Govt. Livestock Farm, Lucknow; Govt. Livestock Farm, Hisar; GADVASU, Ludhiana; Sh. Gaushala Trust, Bhiwani
Extension Service	Dairy Extension Education and Services at Farmers' Door through Mobile Extension Unit: Action Research (Jancy Gupta)	NABARD
Reproduction	Deciphering the Mechanism of Aberrant Maternal Recognition of Pregnancy Events in Sheep and Buffalo under Heat and Nutritional Stress (T. K. Datta)	NFBSFARA
Climate Change	National Initiative on Climate Resilient Agriculture (R. C. Upadhyay)	CRIDA
Probiotics	Application of Probiotics in Alleviating Allergic Responses and Immuno-senescence (Rajiv Kapila)	DBT
Crossbred Male Infertility	Molecular Characterization of A Semi-domestic Cattle Breed of Jammu and Kashmir (S. De.)	DBT

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

Area	Project/PI	Collaborating Agencies
Indigenous Milk Product Technologies	Network Project on R&D Support for "Process Upgradation of Indigenous Milk Products for Industrial Application" (G. R. Patil).	SMC College of Dairy Science, GAU, Anand; WBUAFS, Mohanpur (W.B.); SRS, Bangalore; BHU, Varanasi; IIT, Khargpur
Organic Farming	Studies on Organic Milk Production System in the Plains of West Bengal (P. K. Roy).	Department of Veterinary Pharmacology & Toxicology, WBUAFS, Kolkata
Progeny Testing of Murrah Buffaloes	Network Project on Buffalo Improvement (A. K. Chakravarty).	CIRB, Hisar; PAU, Ludhiana and CCS HAU, Hisar; IVRI, Bairelly; NDAUT, Faizabad

Sahiwal Sire Evaluation	Performance Evaluation and Multiplication of Sahiwal Cattle under Open Nucleus Breeding System (R. S. Gandhi).	Govt. Livestock Farm, Lucknow; Govt. Cattle Breeding Farm, Durg, Chhattisgarh; College of Veterinary Science and Animal Husbandry, Durg; Shri Gaushala Trust, Bhiwani
Environmental Physiology	Impact Adaptation and Vulnerability of Indian Agriculture to Climate Change (R. C. Upadhyay).	ICAR (Network Project)
Environmental Physiology	Adaptation of Livestock to Impending Climatic Changes through Shelter Management (R. C. Upadhyay).	ICAR (Network Project)
Reproduction Genomics	Buffalo Production and Reproduction Genomics (T. K. Datta).	Niche Area (ICAR)
Rumen Manipulation	Rumen Microbial Manipulation for Mitigation of Methane Emission and Productivity Enhancement in Dairy Animals (S. K. Sirohi).	NIANP, Bangalore; IVRI, Izatnagar (NFBSRA)
Reproductive Physiology	Endocrine Profiles and Characterization of Candidate Genes Influencing Prolificacy of Black Bengal Goat (B. S. Prakash).	ICAR Research Complex for NEH Region, Tripura
Genomics	Molecular Characterization of Semi Domestic Cattle Breed of Jammu and Kashmir (S. De.).	Doda, SKUAST, Jammu
Endocrinology	Development of Plasma Catecholamines Assays for Evaluation of Sympathetic Neuronal Function and Milk Production Performance in Heat Stressed Cows (Mahendra Singh).	RTAC, BRNS, Mumbai
Quality Assurance	Monitoring of Drug Residues and other Environmental Pollutants (N. K. Goel).	College of Veterinary Science, Mumbai; Chennai; Kolkatta; Gujrat; Pantnagar; A. P.; M. P.; Ranchi; Guwahati; Patna; NRC on Yak, Dirang; NIANP; Bangalore; Outreach Project (ICAR)
Microbiology	Scheme on Dairy Microbes under Network Mode (Remeshwar Singh).	ICAR Network
Lactation Physiology	Candidate Gene Analysis and Identification of Allelic Variants Associated with the Incidence of Mastitis in Dairy Cattle and Buffalo (A. K. Dang).	NBAGR
Feed Resources	Nutritional Evaluation of Azolla for Utilization in Ruminant Ration (A. Chatterjee).	Regional Station for Forage Production and Development, Kalyani, Govt. of India.
Feed Resources	Evaluation and Utiliztion of Brewers Spent Grain as Cattle Feed Supplement (A. Santra).	Dept. of Animal Nutrition, WBUAFS, Kolkata

NAIP Projects

Area	Project/PI	Collaborating Agencies
NDRI as Lead Institute		
Reproduction Augmentation/ Genomics	Elucidating the Physiological and Genomic Regulation Process of Follicular Development, Oocyte Maturation and Embryogenesis in Buffalo (T. K. Datta)	CIRB, Hisar; NIANP, Bangalore and IISC, Bangalore
Genomics/ Proteomics	Analysis of Mammary Gland Transcriptome and Proteome during Lactation and Involution in Indigenous Cattle and Buffalo for Identification of Probable mammary Markers (A. K. Mohanty)	NBAGR, Karnal and NCHGS&R, Punjab University, Chandigarh
Stem Cells	Characterization and Differentiation of Embryonic and Spermatogonial Stem Cells in Cattle and Buffaloes (M. S. Chauhan)	PDC, Meerut
Semen Cryo- preservation	Molecular basis of Capacitation Like Changes in the Assessment and Prevention of Cryodamage during Cryopreservation of Bovine Spermatozoa (Buffalo and Crossbred Bulls) (S. K. Atreja)	SKUAST, Jammu
Reproduction Augmentation	Value Chain on Zona Free Cloned Embryos for Quality Animal Production from Elite Buffaloes and Pashmina Goats' (S. K. Singla)	SKUAST, Srinagar
Functional Dairy Products	Novel Approaches for Production of Nutraceuticles from Milk and Indian Herbs for Potential use in Functional Dairy Foods (R. R. B. Singh)	NBRI, Lucknow
Value Added Dairy Products	A Value Chain on Composite Dairy Foods with Enhanced Health Attributes (A. K. Singh)	CIPHET, Ludhiana; Arpana, Karnal and M/s New Millennium Health Foods Pvt. Ltd. NOIDA
E-education	Development of e-course for B.Tech (Dairy Technology) Degree Programme (A.A. Patel)	SVVU, Triupati; AAU, Anand
NDRI as Consortium Partner		
Biosensors	Development of Biosensors and Micro-techniques for Analysis of Pesticide Residues, Aflatoxin, Heavy Metals and Bacterial Contamination in Milk (Naresh Goel)	BITS, Pilani, Goa, IIT, Delhi and Punjab University, Patiala
Bioinformatics	Development of wireless Sensor Network for Animal Management (T. K. Mohanty)	IIT, Delhi
Policy Planning	PME Cell under Visioning, Policy Analysis and Gender (V-PAGE) (Director, NDRI/B. S. Chandel)	NCAP Delhi; IASRI, Delhi; NAARM, Hyderabad; Yes Bank, Agriwatch; NRCWA, PME Cells
Networking	Agro-Web-Digital Dissemination System for Indian Agricultural Research (ADDSIAR) (D. K. Jain)	SAUs and ICAR Institutes
Animal Nutrition	Rumen Microbial Diversity in Domesticated and Wild Ruminants and Impact of Additives on Methanogenesis and Utilization of Poor Quality Fibrous Feeds (S. K. Sirohi)	IVRI, Izatnagar; GADVASU, Panjab; CIRB, Hisar
Nano Particles	Detection and Mitigation of Dairy Pathogens and Detection of Adulterants using Chemical Biology (Y. S. Rajput)	IIT, Roorkee; BITS, Pilani (Goa)

Reproduction Augmentation	Genetic basis of Inferior Sperm Quality and Fertility of Crossbred Bulls (S. De)	PDC, Meerut; IVRI, Izatnagar
Reproduction Augmentation	Development of Potency of Parthanogenetic Goat Embryos (D. Malakar)	IVRI, Izatnagar; CARI, Izatnagar; CIRG, Makhdoom; JNKVV, Jabalpur
Environmental Physiology	Bio-prospecting of Genes and Allele Mining for Abiotic Stress Tolerance (R.C. Upadhyay)	IVRI, Izatnagar; CIRG, Makhdoom; NRC on Camel, Bikaner; VPKAS, Almora; NEHR, Lucknow; IIT, Kanpur; NBAGR, Karnal; CIBA, Chennai; IARI, New Delhi; NBFGR, Lucknow; CIFA, Bhubneshwar; CARI, Cuttak; DRR, Tamil Nadu
Animal Reproduction	Application of Reverse Genetics: A Novel Approach to Study the Molecular Basis of Differential Immune Response in Indian Cattle Breed (D. N. Das)	II Sc, Bangalore IVRI, Bangalore
Economics	Strengthening Statistical Computing for NARS (R. Malhotra)	IASRI, New Delhi; IVRI, Izatnarar; MPUAT, Udaipur; Water Technology Centre for Eastern Region, Bhubaneshawar; ICAR Res. Complex for NEH Region, Barapani; UAS, Bangalore; NAARM, Hyderabad; CIFE, Mumbai

Rechristening of Auditorium as Dr. D. Sundaresan Auditorium by Dr. S. Ayyappan, Secretary, DARE & DG, ICAR

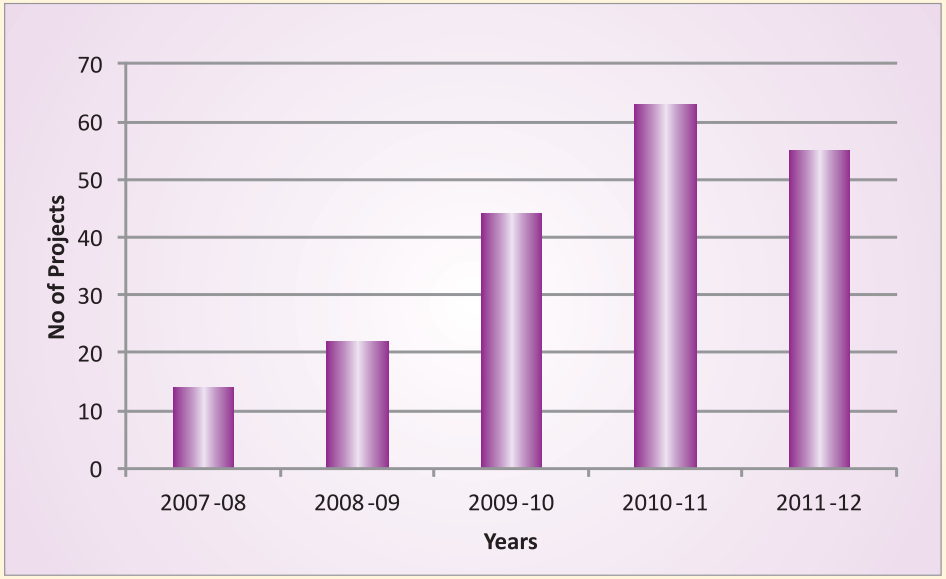
New Initiatives

Research initiatives are being undertaken at NDRI for genetic improvement of milch animals; development of dairy production packages for small, medium and large producers; clean milk production and quality assurance; value addition to milk & milk products and promoting dairy enterprise through transfer of technologies

Research

- World Bank through NAIP has funded twenty research projects (with an outlay of 34 Crores) in Consortium Mode wherein NDRI is either a lead Institute or a consortium partner. This has allowed biotechnology, biochemistry, dairy technology and other disciplines to work in frontier areas.
- NDRI Scientists through proactive approach and under competitive grant have obtained huge funding for basic and strategic research from NFBSR (ICAR) and other Govt. Departments.
- To address the burning issue of adaptation of livestock to climate changes through shelter management, a project on National Initiative on Climate Resilient Agriculture (NICRA) with financial outlay of Rs. 20.86 crores is being executed at NDRI.
- A project has been initiated under collaborative approach with International Livestock Research Institute (ILRI) since Aug 2011.
- Activities on collection and conservation of dairy and probiotic microbes have been strengthened.
- New research initiatives are currently being taken to study the microbial diversity and predominance of microbial communities in the Indian gut under normal healthy and aberrant diseased conditions and subsequent probiotic interventions by applying various metagenomic approaches. Attempts will also be made to link any alterations in microbial communities with the gut functionality. The mechanistic studies are also underway to

Number of Research Projects from External Agencies



Degrees being presented during Eighth Convocation on 13th March, 2010

Convocation of NDRI Deemed University has been made an annual regular feature for the past four years. From the year 2010, NDRI has been organizing Academic Week prior to Convocation by organizing the series of academic events such as (i) Memorial lectures, (ii) presentation of academic achievements and innovations in teaching by different Heads of Divisions, (iii) selection of students for Best Thesis Awards **"Best Thesis Awards"** have been instituted for Master's and Doctoral students to encourage spirit of competition and motivation for quality research work. Best thesis award carries a citation, a certificate and Rs. 5,000 for Master's Thesis and Rs. 10,000 for Doctoral Thesis. Best Thesis award is given in each of Animal Production, Dairy Processing & Management Groups.

Sixth Convocation on 21st April, 2007

Seventh Convocation on 17th January, 2009

Ninth Convocation on 19th February, 2011

understand the novel probiotic functions through global gene expression studies for exploring these as possible bio-therapeutics to mange life style diseases for the healthcare and well being of the target Indian population.

- Visioning Analysis of Indian Dairy Sector has been initiated.
- In XII Plan, ICAR has proposed focussed research under different Research Platform Mode. NDRI will play leading role in research to be conducted under following platforms:
  - Application of Bio-nanotechnology in Agriculture.
  - Genomics for improved Animal (Buffaloes & Cattle) Productivity
  - Secondary Agriculture, value addition to milk and milk products.
  - Dairy and Farm Waste Management Platform: National consultation on water:
  - Climate change platform
- **Two Flagship Programs** on (i) Integrated Fertility Management in Cattle and Buffaloes and (ii) Enhancement of Nutritive Value & Shelf-life of Milk & Milk Products; and a **Network Project** on Modeling Nutrient Requirements of Cattle & Buffaloes under Changing Conditions, are being proposed for XII plan period.
- Probiotic Association of India (PAI) has been established Dr. A. K. Srivastava, Director NDRI is the founder President and Dr. V. K. Batish is Secretary of the association.

Education

- In addition to ongoing **Masters and Doctoral courses in twelve different disciplines and B. Tech. (Dairy Technology)**, the Institute also started **M.Sc. in Agronomy** (Forage Production) from the year 2010-2011.
- NDRI is the first institution to implement new course–curricula for B. Tech in Dairy Technology as per the guidelines laid out in Fourth Dean's Committee Report. Likewise, new PG syllabus has also been introduced from the academic session 2009-10.
- In order to strengthen the activities of the Regional Stations and fully use the research and teaching facilities/ expertise available at the stations, students are being deputed to carry out their Dissertations in Masters programme in Dairy Chemistry and Dairy Technology, and Doctoral dissertation work in Animal Breeding, Dairy Chemistry, Dairy Technology and Dairy Economics at the Southern Regional Station, Bangalore. Likewise, Masters Students in the discipline of Animal Biotechnology, Livestock Production and Management, Animal Nutrition and Dairy Economics are deputed to Eastern Regional Station, Kalyani.
- Academic Regulations have also been revised, which include most importantly the introduction of comprehensive for Masters & Ph.D. students. **Reform in the Admission Process** for Ph.D. in all disciplines of Dairying has been introduced. From the year 2011-2012, admission for the in-service candidates in Ph.D. Courses would be done through written Entrance examination as well as counseling. Comprehensive examination for enrolled PhD students has been introduced. Submission of research paper manuscript before thesis submission has been made mandatory.
- NDRI has been recognized as **Centre of Advanced Faculty Training (CAFT)** in the disciplines of Dairy Production and Dairy Processing.
- Initiatives have been taken for development of e-courses for B. Tech. (Dairy Technology) degree program under NAIP component-1: Some of the courses have been reviewed and finalized through peer reviewers and student's reviewers for online and offline delivery to the State Agricultural Universities (SAU's) and other institutions offering the undergraduate program. Other Educational Reforms include (i) E-learning, (ii) Knowledge Management and Dissemination through ICT, (iii) Web based interactive module and (iv) Teaching manuals.
- **National Academy of Dairy Sciences (NADS)** has been launched since 1st June 2010 at NDRI to work as a think tank and develop policy papers on different issues related to dairy education & research. The mission of the Academy

Launch of National Academy of Dairy Sciences

is to provide views of the scientific community on dairying related issues, and to encourage and promote scientific and technological talent, making it a powerful instrument in fostering knowledge based vibrant dairy industry for the growth of national economy. Dr. A. K. Srivastava, Director NDRI is the founder President of NADS, while the founder fellows are:

1 Dr. G. R. Patil, Vice-President
2 Dr. S. L. Goswami, Vice-President
3 Dr. R. K. Malik, Secretary
4 Dr. R. R. B.Singh, Secretary

5 Dr. A. K. Singh
6 Dr. B. S. Prakash
8 Dr. S. S. Kundu
9 Dr. A. K. Chakravarty
10 Dr. K. K. Singhal
11 Dr. G. S. Sharma
12 Dr. R. S. Gandhi
13 Dr. Rameshwar Singh
14 Dr. Ashok A. Patel
15 Dr. Shivashraya Singh
16 Dr. B. K. Wadawa
17 Dr. V. K. Kansal
18 Dr. Shiv Prasad
19 Dr. Jancy Gupta
20 Dr. K. K. Datta
21 Dr. A. K. Dodeja

- Alumni Awards such as **Dr D. Sundaresan Award, Dr. N. N Dastur Award, Dr. K. K. Iya Award, Dr. P. G. Nair Award** are given to the faculty for their outstanding contributions in the field of research, education and Institute building activities.
- NDRI has been recognized as a **node** for **National Knowledge Network**, Govt. of India. Internet connectivity of 1 GB speed has been provided under this scheme.
- For the first time, new **NCC** Battalion has been established at NDRI. NCC has been made compulsory for the B.

Dr. Mangala Rai, Former Secretary DARE & DG, ICAR delivering Second Dr. D. Sundaresan Memorial Lecture

Dr D. Sundaresan Memorial Lecture Award to commemorate the valuable contributions of Late Dr D. Sundaresan for all round development of NDRI has been instituted since 2010. In the year 2012, Dr. K. K. Iya Oration Award and Dr. N. N. Dastur Oration Award have also been instituted in memory of former legendry directors of NDRI.

First Dr. D. Sundaresan Memorial Lecture Award to Dr. S. L. Mehta

Third Dr. D. Sundaresan Memorial Lecture Award to Dr. R. S. Paroda

First Dr. K. K. Iya Oration Award to Dr. V. K. Taneja

Tech. first year students. Under this scheme, students appear for B Certificate exam, attend NCC drills regularly and also participate in NCC camp held at Haryana Police Commando Complex, Navel, Karnal. Physical Education has also been made coumpulsory for Post-Graduate students of NDRI Deemed University.

- Research scholars at NDRI are encouraged to apply for **INSPIRE** fellowship instituted for Topper students by Dept. of Science and Technology. Many of the students have availed this fellowship during 2010-2011.
- To inculcate the spirit of innovation and creative thinking amongst the students, **"My Idea"** competition is being organized for the students of NDRI Deemed University on **National Science Day** on 28th February every year.
- Students' participation in the **National level competitions** is encouraged. Since last two years NDRI has introduced the convention of celebrating **National Education Day** and **International Non-violence Day** to inculcate moral and ethical values in the student community and make them sensitive towards important social issues.
- **The Placement Cell** of the Institute has been strengthened and given working independence to contact prospective dairy entrepreneurs for placement of the Institute graduates and ensure that reputed firms including multi-national companies absorb our graduates and pay them good salaries.
- Girls' Hostel **"Alakhnanda Sadan"** has been created by converting vacant 'A' Type Residences to a hostel to accommodate additional strength of girl students at Deemed University.
- Under the aegis of Agricultural Scientists Recruitment Board, infrastructure has also been created at NDRI Deemed University for **on-line examination system** for the admission of students.
- New website of NDRI has been developed under the NAIP project of AGROWEB. The new website is to serve as a model for all the animal science Institutes of ICAR and has been designed as per uniform guidelines of ICAR to give the desired look and feel apart from the contents and databases on dairy starter cultures, semen bank, performance of herd animals at NDRI livestock farms.
- Provision has been made for internet connectivity in NDRI hostels through installation of Wi-Fi system.

Extension

- **Establishment of Milk Processing Unit at Village Level under NAIP Project:** Entrepreneurship development campaign has been launched for transferring composite dairy foods technologies. A group of 14 women all resource poor villagers with an average monthly income of Rs. 4500/- only is formed and they are being trained in for the manufacture of dairy products including the value added dairy products. A processing unit has been established at Amritpur Kalan located near Karnal and commercial production of various composite dairy foods is started since October, 2010. These women have earned a monthly turnover of Rs. 65000/- through sale of these products and generated a profit of Rs. 2000 per person monthly. Another unit is established at Village Shongi near Shimla for procuring and processing of milk into various value-added products. Based on the achievements of the project ICAR has prepared a documentary named **"Kamyabi ki Dastak"**.
- **Empowerment of farm women in dairy farming through SHGs:** Three Self Help Groups: (i) Vishwas Self Help Group in village Kulwehri, Dist Karnal since August, 2011, (ii) Satyam Self Help Group in village Subri District Karnal since July 2007, (iii) Sadbhawana, Self Help Group in village Shahpur since August 2010, are also in operation for empowering farm women engaged in dairy production and dairy processing.
- **Dairy Education at Farmers' Door:** The Extension Education Programme "Dairy Education at Farmers'

Door" has been initiated since 2008-09 to strengthen the effective dissemination of dairy production and processing technologies among farming community.

- **Krishi Vigyan Kendra** made a major thrust in introducing the new farming system in place of paddy-wheat. Majority of the farmers in the district now have paddy-moong-wheat production system. Since 2009 KVK is working on conservation agriculture in association with the IRRI Philippines and CIMMYT, Mexico under cereal system initiative for south Asia (CISA).
- A large number of dairy farmers have been demonstrated the technology of silage making and its feeding to the dairy animals In the district. Nearly 32 progressive dairy farmers have adopted the technology.
- KVK has developed strong linkages with different dairy development organizations in different states of the country during this period. In all 243 sponsored training programmes on scientific dairy farming were organized for the farmers and farm women of different states other than Haryana.
- **Agriculture Technology Information Center:** Agriculture Technology Information Center (ATIC) has been further strengthened by providing required facilities. This centre is serving as 'a single window' for all ICAR Institutes located at Karnal.
- Mobile Extension Unit at NDRI has been initiated to provide veterinary and dairy extension and services at farmer's door.

Other Landmarks...

- Technology Business Incubator (TBI) Facility was established with the support of DST and made fully functional to promote entrepreneurship with technologies developed at NDRI. The DST has sanctioned grant of Rs. 278 lakhs for a period of five years. This project is first of its kind in National Agricultural Research System in India. The TBI has the broad objective of promoting knowledge-based and innovation-driven dairy enterprises in the country.
- Institute Song was conceptualized and introduced to foster stronger bondage in NDRI fraternity and strengthen the sense of motivation, commitment, dedication and sense of belongingness towards the common cause of dairy development in the country.
- NDRI was given specific identity by adopting a uniform style of encrypting and writing the Institutional name, the specific pattern of signature of NDRI was conceptualized, finalized and adopted by BOM on 12.3.2010.

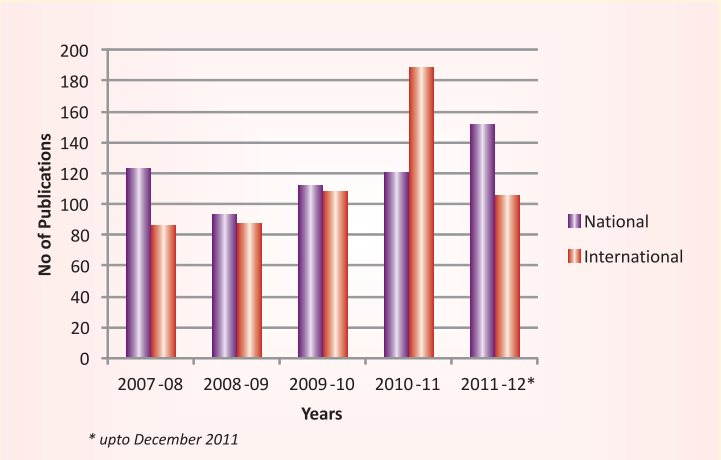
Release of NDRI Signature

- In memory of the valuable contributions of Late Dr. D. Sundaresan during 1970-1981 in all round developments of NDRI, and to rekindle the legacy of the Former legendary Director, the main Auditorium of the NDRI was rechristened as Dr. D. Sundaresan Auditorium on 13.3.2010.
- A new Video Film of the Institute "NDRI at a Glance" was conceptualized and produced.
- Purchase procedures were streamlined and NDRI emerged as one of the only few Institutes to have properly implemented the World Bank's prescribed procedures for procurement/works under NAIP.

Quality Research Output and Seminars & Conferences towards Knowledge Sharing...

Research Output of the Institute is reflected in a good number of research papers being published in various National & International journals with high impact factor. Likevise, thrust is being given on knowledge and expertise sharing amongst the faculty of the institute with that of other institutions through organisation of several National & International Conferences Seminars & Symposia.

Research Publications



** upto December 2011*

SEMINARS/SYMPOSIA/WORKSHOPS/FIELD DAYS ORGANISED

During the last five years (2007- 2012), the Institute hosted quite a good number of Seminars, Workshops and Short Courses with the participation of delegates from India and abroad. Some of the important ones are listed as under:

World Earth Day	22nd April, 2007
World Veterinary Day	28th April, 2007
Training programme on "Buffalo Nutrition"	4th – 6th June, 2007
Summer School on "Instrument Analysis of Dairy Foods for Quality Standards"	6th – 26th July, 2007
Stake Holders' Workshop under NAIP	8th – 9th Sept., 2007
Hindi Diwas Samaroh at ERS, Kalyani	14th Sept.,2007
International Tropical Animal Nutrition Conference Tropnutrition-2007	4th – 7th Oct., 2007
Workshop on "Opportunities for Entrepreneurs in Milk Processing Industries"	6th Oct., 2007
National Training programme on "Genetic Analysis of Animal Breeding Data using Advanced Software Package"	10th – 30th Oct., 2007
International Conference on "Traditional Dairy Foods"	14th – 17th Nov., 2007
26th Annual Conference of Haryana Economic Association	19th – 20th Nov., 2007
39th Annual Regional Science Congress	19th – 20th Nov., 2007
Model Training Course on "Feeding Strategies for Up- keep of High Yielding Dairy Animals"	26th Nov. – 3rd Dec, 2007

Women in Agriculture Day	4th December, 2007
Stake Holders' Workshop under NAIP	14th – 15th Jan., 2008
Celebration of Grameen Dairy Mela	13th Feb., 2008
A Short Course on "Technological Advances in Utilization of Dairy By-products"	27th Feb. to 18th March, 2008
Celebration of National Science Day	28th Feb., 2008
Rajbhasha Workshop for Technical Officers	11th March, 2008
Golden Jubilee Celebration of Dairy Science College and National Seminar on Dairy Education	12th – 13th March, 2008
ARS Field Experience Training	18th March to 5th April, 2008
World Water Day	22nd March, 2008
National Training Programme on "Assisted Reproductive and Management Technologies for Genetic Improvement of Livestock"	25th March to 14th April, 2008
World Milk Day	1st June, 2008
Short Course on Sensory and Related Techniques for Evaluation of Dairy Foods	17th June to 7th July, 2008
Short Course on Basic Aspects of Milk Processing and Milk Products Manufacturing	22nd – 25th July, 2008
Interactive Workshop on Climate Change and Indian Livestock	20th - 21st Sept., 2008
National Seminar on Food Safety and Quality Issues Relevant to Dairy Industry	27th Sept., 2008
National Workshop on AGROWEB Project	3rd-4th October, 2008
Short Course on Analysis of Milk and Milk Products for Quality Assurance and Safety	13th to 19th October, 2008
World Rural Women's Day	15th October, 2008
Workshop on Patent and IPR Awareness	16th October, 2008
World Food Day	16th -18th October, 2008
National Workshop on Genome Analysis and Structural Biology	21st-23rd October, 2008
Winter School on Functional Foods and Nurtraceuticals	1st - 21st, November, 2008
National Seminar on Emerging Opportunities for Commercialization in Dairying	6th -7th Nov., 2008
Model Training Course	18th – 25th November, 2008
Winter School on Advances in Bioactive Components and Dietary Supplements for Functional Dairy Foods	25th November to 15th December, 2008
Genetic Improvement of Farm Animals Using Advanced Breeding and Biotechnological Strategies	3rd to 23rd December, 2008
Women in Agriculture Day	4th December, 2008
Ex-Trainees Convention	15th December, 2008
National Seminar on Food Safety Challenges in Dairy Sector - Current Scenario	7th and 8th January, 2009
A Short Course on Chemical and Microbiological Analysis of Milk and Indigenous Milk Products	13th - 21st January, 2009
Seventh Convocation	17th January, 2009

National Environment Awareness Campaign	20th January, 2009
A training programme on Procurement Related Matter and Financial Management System	3rd to 4th Feb., 2009
National Seminar on Recent Technologies in Horticultural Crop Production Management and Marketing	19th – 20th Feb., 2009
National Science Day	25th Feb., 2009
Need Based Training Programme	27th Feb., 2009 to 5th March, 2009
Launch Workshop of NAIP Projects	20th March 2009
National Training Program on Advances in Breeding and Management Technologies for Improvement in Livestock Productivity	25th March to 14th April, 2009
Dairy Mela	26th - 28th March, 2009

National Training Program on Advances in breeding and management technologies for improvement in livestock productivity	25th March to 14th April, 2009
Dairy Mela (organized after a gap of 12 years)	26-28 March, 09
International Seminar on French Genetics & Technologies	20th April 2009.
World Veterinary Day	24–25 April, 09
International Training Course on Sensory Evaluation of Milk and Milk Products	19th May, 2009
Vacation Programme on Natural Resources	19th May 2009
World Milk Day	1st June 2009
Launch Workshop on Development of e-courses for B. Tech. (DT) Degree Programme	27th June , 2009
Institute Technology Transfer and Management Committee (ITMC) Meeting	15th July, 2009
Consortium Implementation Committee Meeting	8th July, 2009
Launch Workshop for Three Projects under NAIP	10th Aug., 2009
Summer School on Recent Advances in Analytical Techniques and Innovative Approaches for Quality Assurance and Safety of Dairy Foods	7th - 27th July, 2009
Training Programme on Chemical Testing of Milk & Milk Products & Compounded Cattle Feed	28th July 2009 to 3rd August 2009
Zonal Workshop on Front Line Demonstration on Oil Seed and Pulse Crop	12-13th Aug, 09
Brainstorming Session on Vaccine & Diagnostics	10–11th July, 09
Meeting of Bureau of Indian Standards	24th August, 09
National Seminar on Need of the Dairy Industry – Initiative, Innovation and Improvisation	11–12th Sep., 09
Training Programme on Fundamental Aspects of Dairy Microbes and their Safety Concerns in Dairy Industry	29th Sept., 2009
Training Programme on Procurement Related Matters and Financial Management System	17th – 18th August, 2009
International Non-Violence Day	2nd Oct. 2009
Brain Storming Session on Environment & Animal Housing	5th-6th Oct., 2009
Confederation of Indian Industry	22nd Oct., 2009

Seminar on "Higher Education in India" during National Education Day	11th Nov., 09
ADRP Meeting for 2008-09; North Zone ICAR Research Institutes	12-13th Nov, 09
National Workshop on Security Management in Research and Educational Institutions	19th Nov., 09
Women in Agriculture Day	4th Dec. 09
34th Annual Convention of Vice-Chancellors of State Agricultural and Veterinary Universities and a National Symposium on "Application of Bio-Nano Technology in Agriculture and Animal Sciences for Food Security"	7th Dec., 09
National Workshop on "Emerging Machine Learning Techniques in Bioinformatics"	17th-19th Dec., 2009
Seminar on Financial Literacy and Agricultural Diversification	26th December, 2009
Review meeting of PMAC under NAIP Component-I	29th Dec., 09
Training Programme on Conventional and Rapid Techniques for Monitoring Quality and Safety in Dairy Industry.	7th-14th January 2010
Wi Winter School on Recent Advances in Dairy Nutraceuticals and Bio-informatics Applications	1st-21st February 2010
Plenary Session of 20th National Congress of Veterinary Parasitology	20th Feb., 2010
Dairy Mela	24-26th Feb. 10
Seminar on "Indian Agriculture Today: Challenges Opportunities and Perspective" during National Science Day	28th Feb. 10
Brainstorming on Probiotics	5th March 2010
Academic Week	9-13th March, 10
Dr. D. Sundaresan Memorial Lecture	11th March, 10
8th Convocation	13th March, 10
FAO sponsored International Training Programme on Milk Collection, Processing and Marketing for personnel involved in dairy development activities in Afghanistan.	18th -31st March 2010

Hon'ble N. N. Vohra, Governor of J&K addressing on the occasion of 34th IAUA Convention of Vice-Chancellors

Dr. Panjab Singh, Former Secretary DARE & DG, ICAR addressing on the occasion of National Seminar on Indian Dairy & Food Industry

One Day Sensitization Workshop on "Content Management for E-Learning System using Moodle" under Project Management System	26th April, 2010
World Veterinary Day, 2010 Celebrations	27th April, 2010
Second Entrepreneurship Development Programme	17th - 26th May 2010
Vacation Programme on "Bio-Resources" (VPBR-2010)	31st May, 2010
World Milk Day	1st June, 2010.
Conference on "Science and Spirituality for Balanced Growth of India"	17th June 2010
Training Programme for "Online Access of Journal (CeRA)" at NDRI	9th June, 2010
Short Course on "Technological and Engineering Aspects of Dairy Processing" for 19 professional of M/s Nestle India Ltd.	21st - 26th June, 2010
Focus Group Discussion on "Manpower Planning in Indian Dairy Sector"	5th July, 2010
Training cum Workshop on "E-linkage of KVKs"	8th - 9th July, 2010
Consultancy Training Programme on "Starter Cultures and Fermented Milk Products"	12th-16th July, 2010.
Training Programme on "Manufacturing of Ice-Cream" by TBI	24th - 29thJuly, 2010
Agropedia Workshop	31st July, 2010
Training Programme on "SAS: A Comprehensive Overview"	2nd August to 8th Sept., 2010
Training Programmes for Farmers	16th - 20th August, 2010
Meeting on "Updation of the Nutrient Requirement for Different Classes of Livestock and Nutritive Value of Indian Feeds"	11th August, 2010
Invited Lecture Series under the Aegis of Nutrition Scientist Forum	11th August, 2010
TBI Training Programme on "Commercial Dairy Farming"	25th August to 3rd September, 2010
Seminar on "Regulatory Status: Issues and Challenges for Food Beverages" at SRS, NDRI	6th September, 2010
Brainstorming Session on "Haryana Livestock and Dairy Sector: Present Status and Future Road Map"	9th September, 2010
National Seminar on "Indian Dairy and Food Industry – Future Roadmap for Sustainable Growth"	25th September 2010
National Symposium on "Climate Change & Livestock Productivity in India"	7th and 8th October, 2010
Training Programme on "Laboratory Testing and Product Manufacturing"	11th - 14th October, 2010.
National Training by Foreign Experts under NAIP on "Hands on Stem Cell Culture for Quality Animal Production"	11th - 20th October 2010
Six days training programme on "Data Analysis using SAS"	25th - 31st October, 2010
National Convention on "Zoonotic Diseases : Present Status and Future Roadmap"	30th October 2010
Winter School on "Impact, Vulnerability and Adaptation of Indian Livestock to Impending Climatic Changes"	9th - 29th Nov., 2010
Winter School on "Dairy Entrepreneurship Development"	10th - 30th Nov., 2010
Second Meeting and Brian Storming of National Core Group on "Probiotics"	15th Nov., 2010
NDRI - Britannia Industries Meet	18th Nov., 2010

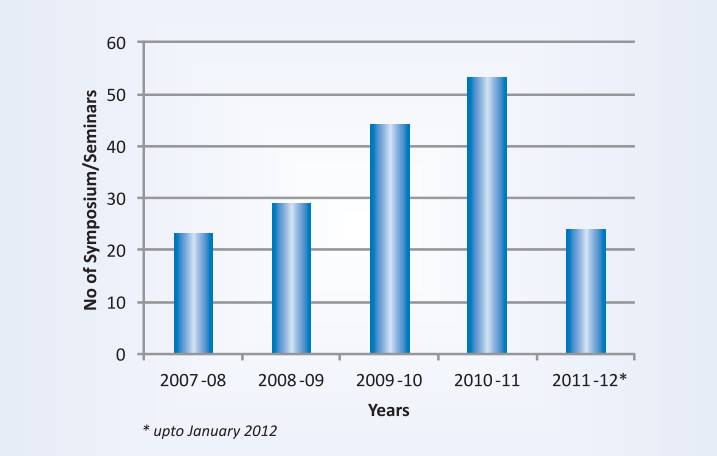
Winter School on "Advances in Dairy Production Management for Precise Output in Relation to Environment and Trade"	22nd November to 14th Dec., 2010
NDRI-Industry Meet	1st Dec., 2010
All India Dairy Husbandry Officers' Workshop-2010	3rd – 4th Dec., 2010
Winter School on "Data Mining Techniques for Farm Animal Management"	8th-28th Dec., 2010
Invited Lecture on IPR	21st Dec., 2010
Training programme on "Data Analysis using SAS"	10th - 15th Jan., 2011
Winter School on "Chemical Analysis of Value Added Dairy Products and their Quality Assurance"	11th - 31st January, 2011
Brainstorming session "Promotion of Indigenous Dairy Products in International Market"	22nd January, 2011
Training Programme on "Data Analysis using SAS"	24th - 31st January, 2011
Annual Workshop for NAIP Component for review of 22 NAIP projects in Frontier Areas of Animal Sciences	4th February, 2011
International Conference on "Frontiers in Reproductive Biotechnology"	9th - 11th February 2011
Dr. D. Sundaresan Memorial Lecture	17th February., 2011
Ninth Convocation of NDRI Deemed University	19th February., 2011
National Science Day	28th February, 2011
Refresher's Training on "Procurement and Financial Management" under NAIP	26th - 28th February, 2011

Training Programmes/Workshops/ Seminars/ Symposia Organized (March 2011 to February 2012)

Winter School on "Technological Advances in Novel Dairy Foods"	1st - 21st March, 2011
National Training Programme on "Intellectual Property Rights" at SRS, Bangalore	9th - 18th March, 2011
National Training Program on "Databases and Softwares for Analysis of Animal Genetic and Breeding Data"	10th-30th March, 2011
National Training Program on "Recent Techniques in Proteome Analysis"	10th - 30th March, 2011
National Training Programme on "Hands on Training on Stem Cell Research for Quality Animal Production"	17th - 30th March, 2011
Advanced Course in Faculty Training on "Advances in Processing and Quality Assurance of Dairy Foods"	22nd March - 11th April 2011
Training Programme on "Data Analysis using SAS"	22nd - 28th March, 2011
Farmers' Awareness and Sensitization Programme on "Climate Change" at Village Jundla under NICRA Project	26th March, 2011
Model Dairy Plant certified under ISO: 22000: 2005	23rd April, 2011
World Veterinary Day	30th April, 2011
National Training on Mitigation Strategies for Methane Production from Dairy Animals	2nd to 16th May, 2011
National Seminar on Multi-Sectoral Innovations for Rural Prosperity	19th to 21st May, 2011
SAARC Countries Meet on Dairy Sector	25th – 26th May, 2011
1st Convocation of National Academy of Dairy Science (India) and National Symposium on Probiotic Dairy Foods for Human Health	1st June, 2011

Training Programme on Technological and Safety Aspects of Dairy Processing	13th – 17th June, 2011
Short Course on Technological and Safety Aspects of Dairy Processing for Professionals of Nestle India	13th – 17th June, 2011
Silver Jubilee (25th Course) National Training Program on Technological Developments in Cheese and Fermented Dairy Foods	5th – 25th July, 2011
National Training Programme on Basic & Applied Approaches in Designing of Dairy Based Nutraceuticals and Functional Foods	18th – 27th July, 2011.
National Workshop on Visioning and Strategic Planning for Dairy Sector in India	2nd - 3rd Sept., 2011
Short Course on Basic and Technological Aspects of Milk and Milk Products	5th - 9th Sept., 2011
Training Programme on Data Analysis using SAS	12th -17th Sept., 2011
Training Programme on Technology Business Incubator	12th -17th Sept., 2011
National Seminar on Integration of Indian Dairy and Food Industry for Future Sustenance	23rd-24th Sept., 2011
Farmers-Industry-Scientist Meet at NDRI, Karnal	28th Sept., 2011
International Conference on Functional Dairy Foods-2011	16th -19th Nov., , 2011
Dairy Conclave: Connecting with the Dairy Farmer	26th Nov., 2011
NDRI-Industry Meet	1st Dec., 2011
Conference on Statistics and Informatics in Agricultural Research	3rd - 5th Dec., 2011
Awareness Workshop on Foot and Mouth Disease in Dairy Animals	15th Dec., 2011
Winter School on Recent Advances in Functional Fermented Dairy Foods and their Quality Assurance	9th - 29th of Dec., 2011
National Training Programme on Strategic Use of Cryopreserved Semen for Assisted Reproductive Technologies	2nd – 15th Jan., 2012
National Symposium on Recent Advances in Reproductive Biotechnology : Retrospective and Prospective Vision	30th– 31st Jan., 2012

Seminars & Conferences Organised



Broadening Horizons Beyond Research & Academics...

GARIMA – World's first cloned buffalo calf born at NDRI

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