



वार्षिक प्रतिवेदन  
**ANNUAL REPORT**  
**2017-18**



**भाकृअनुप - राष्ट्रीय डेरी अनुसंधान संस्थान**

(मान्य विश्वविद्यालय) कर्नाल - 132 001 भारत

**ICAR-NATIONAL DAIRY RESEARCH INSTITUTE**

(Deemed University) Karnal - 132 001 India

# MILESTONES

1923	Established in Bangalore as Imperial Institute of Animal Husbandry and Dairying.		and to serve as an interface between Institute and Industry.		
1936	Renamed "Imperial Dairy Institute".	1998	A Modern Cafeteria with a seating capacity of 150 constructed in front of the Institute Hostels.		NRC on Milk Quality and Safety established at NDRI, Karnal.
1955	National Dairy Research Institute came into existence at Karnal, at the former Central Cattle Breeding Farm. Bangalore facilities became Southern Regional Station of the Institute.	1999	Total no. of 9 NATP Projects with financial outlay of 266.25 lakhs initiated.	2013	Business Planning and Development (BPD) Unit established at NDRI, Karnal.
1957	B.Sc. Dairying commenced at NDRI, Karnal.	2000	A Guest House with two suites named as "Kamdhenu" was constructed at SRS, Bangalore. Web-site of NDRI was created and launched by the Hon'ble Union Minister for Agriculture on 23rd December 2000.	2013	First female calf named 'Mahima' was born to a cloned buffalo on 25th January 2013. A male cloned buffalo calf named 'Swam' was born on 18th March 2013. Donor somatic cell used was isolated from the seminal plasma of an elite bull.
1961	B.Sc. Dairying bifurcated into two branches, namely B.Sc. (Dairy Technology) and B.Sc. (Dairy Husbandry); M.Sc. Dairying courses commenced at Karnal.	2001	Foundation stone of the Agricultural Technology Information Centre laid on 1st August, 2001 under NATP project at NDRI, Karnal.	2013	A Diploma in Dairy Technology started at Southern Regional Station, Bangalore.
1962	Western Regional Station established at Bombay.	2002	International Students' Hostel equipped with modern facilities and amenities constructed at NDRI, Karnal. Feed Quality Control Lab. set up to help keep-strict quality check on feeds being fed to bovine livestock.	2014	NDRI bagged the Sardar Patel Outstanding ICAR Institution Award presented by Hon'ble Prime Minister of India, Sh. Narendra Modi Ji. NDRI produced a clone of endangered wild buffalo of Chhattisgarh named "Deepasha" on 12th December, 2014.
1964	Eastern Regional Station established at Kalyani (W.B.).	2003	State-of-the-art milking parlour system introduced in cattle section.		Garima, a cloned buffalo, earlier born at NDRI produced second female calf named "Karishma" on 27th December, 2014.
1966	Institute brought under the aegis of ICAR.	2004	First IVF goat kid born at NDRI. ATIC centre made functional at NDRI.		A new extension educational approach "Farmers' Farm School" of NDRI was started at village Gorgarh NDRI, Karnal.
1975	Operational Research Project initiated.	2006	New Animal Biotechnology Centre commissioned.		NDRI got ISO 9001:2008 certification.
1976	Department of Human Nutrition and Dietetics established at NDRI, Karnal.	2007	Creation of Video Conferencing Lab and Mini Auditorium.		NDRI implemented MIS/FMS to carryout administrative and financial activity of the Institute.
1979	M.Sc., Ph.D. Programme in Dairy Engineering commenced at Karnal.	2009	World First Cloned Buffalo Calf and second cloned calf "Garima" produced by hand-guided cloning technique at NDRI. DST supported Technology Business Incubator (TBI) facility made functional. New Course Curricula for B.Tech in Dairy Technology and Masters and Doctoral Programmes introduced. Reforms in examination system, grading system and introduction of comprehensive exam. for Ph.D. programme introduced. A new extension programme "Dairy Education at Farmers' Door" started.	2016	Two service centres established at Lalukheri, Mazzafamagar Muzzafamagar (UP) and Piprakothi East Champaran (Bihar).
1983	IDD (DH) started at Bangalore.			2017	Foundation stone of KVK laid at Eastern Campus, Kalyani. ICAR - NDRI ranked first among all Agricultural Universities and four Deemed Universities of ICAR (2016-17). One month Foundation Course for newly admitted students of 2017-18 batch introduced.
1985	"Farm Advisory Bureau" and "Industrial Consultancy Cell" set up. The Institute recognised as Centre of Excellence in Animal Biotechnology.				Automation of the 'Academic Management System' implemented
1987	Embryo Biotechnology Centre established.	2010	8th Convocation of NDRI, Deemed University held in presence of Dr. A. P. J. Abdul Kalam, Former President of India.	2018	A mega world-bank funded Institutional Development Plan (IDP) of National Agricultural Higher Education Project initiated. National Referral Center for Milk Quality and Safety (NRCMQS) granted accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL).
1989	The Institute granted "Deemed to be University" status. M.Sc. in Biotechnology started.	2011	M.Sc. in Forage Production Introduced at NDRI, Karnal. NDRI recognized as Centre of Advanced Faculty Training (CAFT) in the Disciplines of Dairy Production and Dairy Processing.		
1990	Birth of Pratham, first IVF buffalo calf of the world.	2012	Sahiwal Calf "Holi" through Ovum Pick up (OPU-IVF) technique born on 7th March, 2012.		
1991	20 bedded Hospital Complex set up and made functional.				
1994	The Institute got recognition as Centre of Advanced Studies in Dairy Technology and Dairy Cattle Breeding.				
1996	A two-year National Dairy Diploma (NDD) course introduced at Southern Regional Station of NDRI at Bangalore. The ICAR award (1993-94) for outstanding KVK conferred on the KVK located at NDRI.				
1997	A state-of-the-art Auditorium having seating capacity of 950 and 2 conference rooms and 2 meeting rooms made functional. A commercial Model Dairy Plant with a capacity of 60,000 lit./ day commissioned for providing practical training to the students of NDRI University				

## VISION

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

## MISSION

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

## GOAL

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

## MANDATE

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



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*ICAR-NDRI secured FIRST RANK amongst Agricultural Universities in the Ranking of Agricultural Universities in India by the ICAR in 2016-17*



*ICAR-NDRI was placed in the Special Mention Category of Institutions by National Institutional Ranking Framework, Ministry of Human Resource Development, Govt. of India Ranking- 2018*

# PREFACE



It gives me immense pleasure to present before you the Annual Report of NDRI for the period 2017-18. This report chronicles the significant achievements of the Institute in the areas of Dairy Research, Education, Extension and Infrastructure development during the last one year. The information has been so arranged that it provides a comprehensive portrayal of this premier dairy Institute of the country and its functioning.

The research and development activities of NDRI got further impetus through its mandate oriented and well-structured research programmes comprising 77 in-house and 70 externally funded research projects, which also include five International collaborative research projects. NDRI has been successful in getting external funding from almost all leading national funding agencies in the field of agricultural and biological sciences.

The Institute has already made a mark in the area of cloning by producing many cloned calves one after the other. In the preceding year, application of pulsed electromagnetic field to reconstructed embryos during hand-guided cloning has shown to increase the blastocyst production rate and improve the quality of cloned embryos produced. Apart from this the other achievements in the area of dairy production are: LC-MS method for identification of A1 and A2 beta caseins in the milk of dairy animals; a highly efficient method for isolating next-generation sequencing quality RNA from the adipose tissue of recalcitrant animal species; a proof-of-concept for the detection of pregnancy in cattle, as early as 35 days, using an antibody against Pregnancy Associated Glycoprotein-7; identification of key proteins involved in Pashmina fibre growth and development of cost effective housing systems for dairy animals.

In the area of dairy processing, manufacturing protocols have been developed for several products such as milk protein concentrates, milk protein enriched pearl millet malt based complementary food, double-emulsion-based functional mayonnaise enriched with bitter-gourd extract, smoothie enriched with *amla* bioactives etc. Anti-aging, anti-inflammatory, antimicrobial and mineral binding properties of the milk derived bioactive peptides have been established. The remarkable role of probiotics and their products on the hyperglycemic condition due to obesity has been established. Probiotics and their products have also been found to be the best alternative for the drugs to treat sterility associated with metabolic disorders. The various biochemical methods to ensure the quality and safety of milk and milk products were developed which includes: new HPLC and aptamer based protocols for antibiotic residues, FTIR based method for assessment of proteolysis in UHT milk and an intelligent oxygen sensor to assess the shelf-life of dairy products.

In the area of mechanization, microprocessor based automated pneumatic paneer hoop-cum-pressing unit has been developed for mechanized production of paneer and cheeses. A continuous mechanized system for the commercial production of *rabari*, a heat-desiccated traditional dairy product has been developed. Likewise, continuous *kheer* manufacturing equipment suitable for medium scale processors has recently been designed. The developed system will be useful in reducing the production cost and ensuring the quality of *kheer*. A low cost can washer system has been developed for efficient cleaning of cans with minimum amount of water with the aim to reduce effluent generation at milk collection centers.

(ii)

The Institute has also developed optimum farm plans for reducing risk in agricultural enterprise in agriculturally distressed regions of Vidarbha and Marathwada. A database has been developed to provide empirical support to Govt. initiative on doubling farmers' income. A Web-enabled Interactive Information Delivery System has been developed to provide information regarding scientific dairy farming practices to different stakeholders including dairy farmers. Two mobile Apps on "environment friendly dairy farming practices" & "physiological technologies for improving productivity" have been developed in Hindi & English to educate dairy farmers.

NDRI is all set to bring in new reforms to keep its activities aligned to the trends in global institutions of higher learning. NDRI has introduced one month Foundation Program at the start of the semester and before commencement of regular coursework to tap the innate talents of the freshers and nurture them develop into outstanding professionals and accomplished human beings. From 2017-18, the Institute has implemented the automation of Academic Management System encompassing the entire academic activities starting from registration, payment of fees and regulation of progress of academic and research work of the students and uploading of results. The entire admission process including conduct of admission test for Ph. D program has been made online.

A mega world-bank funded Institutional Development Plan (IDP) of National Agricultural Higher Education Project has recently been initiated. Through this project, the Institute proposes to strengthen its academic programmes by introducing industry oriented and outcome centric course modules to make them more relevant to the stakeholders. It also proposes to leverage its strong alumni base located in leading industries and academic institutions across the world to enrich its programme and mentor the students to be globally competitive. Sustained efforts are being made to explore opportunities for engagement with researchers and academia based at leading world universities through student exchange, twinning/sandwich/dual degree programs and on campus mentoring for international exposure of the students. The IDP for the Institute also lays great emphasis on nurturing the soft skills of the students and offering them ecologically sustainable and vibrant campus life for their overall development so critical for employability. The Institute has also built in strong provisions for equity action plan for disadvantaged students.

Training programmes are being conducted for varying periods for the benefit of milk producers, prospective entrepreneurs and farmers by Business Planning & Development Unit, Dairy Extension Division, Krishi Vega Kendras and both the Regional Campuses of the Institute. Seven entrepreneurs were admitted for incubation, 14 Entrepreneur Development Programmes (EDPs) were organized during the period under report. NDRI outreach centre situated at Piprakothi, East Champaran, Bihar organised seven training programmes during the period under report. KVK of NDRI, Karnal organised 165 on-campus and off-campus training programmes participated by 6210 farmers and farm women from 12 states across India on different aspects of agriculture and allied subjects including dairy farming and processing.

During the period three patents were granted and 12 technologies were transferred to different commercial houses. Management Information System (MIS) including Financial Management System (FMS) has been implemented at the Institute. This system includes solutions for Financial Management, Project Management, Material Management, Human Resource Management and Payroll. Recently, we have also implemented the Expenditure, Advance and Transfer (EAT) module of PFMS (Public Financial Management System) as per the instructions of Govt. of India.

I am happy to inform that all our endeavours have resulted in increasing number of Awards/ Recognitions/ Appreciations for the Institute. NDRI has been ranked first among all Agricultural Universities of India including 4 Deemed Universities for the year 2016-17 besides receiving a number of Prestigious Awards such as ICAR Best Teacher Award; NAAS Fellowship, ICAR Jawahar Lal Nehru Awards and ICAR Awards for Best Workers. The Institute has been placed in the Special Mention Category of Institutions by National Institutions Ranking Framework (NIRF), MHRD, Govt. of India. Another milestone this year has been the accreditation of NDRI till 2021 by UGC. Recently, National Referral Center for Milk Quality and Safety of NDRI has also been granted NABL accreditation.

All this could be achieved by the Institute with the dedication, hard work, cooperation and understanding of the NDRI fraternity. The Institute is committed to provide an enabling and vibrant environment to its faculty and the students to be creative, exuberant, professionally & academically accomplished and socially responsive to take up future challenges for fulfilling the nation's dairy dreams.

I sincerely hope that the Annual Report 2017-18 would serve as a valuable source of information to the professionals of the other Institutions of Higher Learning and Dairy Development Organizations in the country.

**(R. R. B. Singh)**

# EXECUTIVE SUMMARY

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

## ORGANISATIONAL STRUCTURE

In consonance with the administrative pattern of the Deemed University System of the ICAR, the Institute is managed through various policy/decision making bodies viz. Board of Management, Research Advisory Committee, Academic Council, Executive Council and Extension Council. The Director is the Chief Executive Officer assisted by the Joint Directors for managing research, academic and extension functions. The Institute has three major areas of R & D activities viz. i) Dairy Production, ii) Dairy Processing and iii) Dairy Extension/Management. All the R & D activities are managed through thirteen Research Divisions/Sections, namely, Animal Genetic & Breeding, Livestock Production and Management, Animal Nutrition, Forage Research and Management, Animal Physiology, Animal Biochemistry, Animal Biotechnology, Dairy Technology, Dairy Engineering, Dairy Chemistry, Dairy Microbiology, Dairy Extension and Dairy Economics, Statistics and Management. The Institute also has an Agricultural Technology Information Centre (ATIC), Krishi Vigyan Kendra and Dairy Training Centre, Artificial Breeding Research Centre, Krishi and Dairy Vikas Kendra at KVK, Piprakothe, East Champaran, Motihari, Bihar and Model Dairy Centre at Lalukheri in Muzzafarnagar, U.P. The Institute has infrastructure consisting of central facilities such as Livestock Research Centre, Forage Research and Management Centre, Animal Health Complex, Model Dairy Plant, Technology Business Incubator, Business Planning and Development Unit, National Referral Laboratory for Milk Quality and Safety, Experimental Dairy Plant, Consultancy Unit, Library and National Bio-informatic Centre, Computer Centre, Estate Section and Maintenance Engineering Section. The administrative functions viz. purchase, stores and security are under the administrative control of the Joint Director (Admn.) and Registrar, whereas finance division is under the administrative control of Comptroller (Finance). The Institute presently has strength of 157 scientists, 186 technicians, 127 administrative and 402 skilled supporting staff.

## BUDGET OUTLAY

The financial outlays of the Institute in terms of actual expenditure during the year 2017-2018 was ₹ 21570.59 lakhs and budget sanctioned for the year 2017-2018 was ₹ 21596.40 lakhs. These figures also include the financial outlays for the strengthening of Regional Campuses.

## RESEARCH

A total number of 77 in-house and 70 externally funded research projects were in operation during the year 2017-18. NDRI has been successful in getting external funding from almost all leading national funding agencies i.e. Department of Biotechnology (DBT); Department of Science and Technology, Science and Engineering Research Board (DST-SERB); National Agriculture Science Fund (NASF); Ministry of Food Processing Industries (MOFPI); Food Safety and Standards Authority of India (FSSAI). Indian Council of Social Science Research (ICSSR); Indian Council of Medical Research (ICMR); Ministry of Environment Forests and Climate Change (MOEF&CC); National Dairy Development Board (NDDB).

The support from funding agencies has encouraged Scientists to work on stem cell, buffalo cloning, transcriptome, embryogenesis, semen sexing, biosensors, nanotechnology, abiotic stress in farm animals, nutraceuticals and functional foods. The grants from funding agencies have helped students to opt for modern tools and techniques in their dissertation. Some of the research highlights during the period under report are given as under:

- Application of pulsed electromagnetic field to reconstructed embryos during Hand-guided cloning was shown to increase the blastocyst production rate and improve the quality of cloned embryos produced.
- Transgenic goat embryos, having GFP integration at Rosa 26 locus, were produced using one of the latest genome editing tools Transcription Activator-like Effector Nucleases (TALEN).
- Tetraploid complementation with putative parthenogenetic embryonic stem cells was successfully used for production of chimeric blastocyst-stage goat embryos.
- MicroRNAs, which were uniquely expressed during early pregnancy (30 days) in buffalo, were identified.
- A proof-of-concept was developed for the detection of pregnancy in cattle, as early as 35 days, using an antibody against Pregnancy Associated Glycoprotein-7 (PAG7).
- Increased expression of sperm coat protein, beta-defensins 126 and 129 was detected in epididymis of buffalo testes.
- LC-MS method was developed for identification of A1 and A2 beta caseins in milk of Karan Fries and Sahiwal cattle. The method has been validated in more than 200 cow milk samples.
- A stably transfected COS-1 cell line was developed, which expresses recombinant bovine Leukemia Inhibitory Factor.
- Key proteins involved in Pashmina fibre growth and development were identified by analysis of Pashmina fibre and skin proteome.
- Mesenchymal stem cells were used successfully cure hoof wounds in cattle and buffaloes.
- A total of eight elite Murrah male calves were reserved for future breeding on the basis of EPD (superiority 3.08 to 10%) and dam's best first lactation 305d (2838-3570 kg).
- Microsatellite markers SPS115 and ETH 225 for Sahiwal cattle and SPS115 for Murrah buffaloes were found to be the most suitable for parentage determination.
- In Murrah buffaloes, TT genotype of SNP C10869T in OLR1 gene; GT genotype of G81T and TT genotype of C82T in ATF4 gene had significant effect on FAT % and LFY respectively.
- SNPs A37913198G, G37913263A, T37913318C and G37913325A of ABCG2 gene had positive effect on milk and fat traits in Sahiwal cattle.
- Feeding of supplementation mixture containing Prilled fat, *Saccharomyces cerevisiae* and sweetener (100g: 25:1g/d/animal) from 45 day prepartum to 60 day postpartum resulted in an increase in DMI, body weight and milk production without affecting health of animal.
- The in-house shelter management with floor bedding of paddy straw during winter season was effective to minimize cold stress and improve milk production through upregulation of milk PG-PL system in buffaloes.
- The genotypes AA, DD and RR could be used in marker assisted selection for resistance to mastitis in buffaloes. TLR2 and IGF1 were identified as potential candidate genes for mastitis resistance.
- Level of Nitric oxide in seminal plasma could be used to determine semen quality in crossbred bulls.
- Sodium nitroprusside at low concentration proved beneficial for the maintenance of post-thaw sperm motility and viability up to 1 hour which reduces lipid peroxidative damage of sperm membranes.
- Activity of neutrophils and their gene expression along with plasma cytokine levels can be used together as early indicators of pregnancy in cows.
- Reproductive performance of cows fed with Betaine was significantly improved during heat stress.
- Periparturient feeding of astaxanthin (0.25 mg/kg body weight) in Murrah buffaloes down regulated mRNA gene expression of NFkB p65 and improved immunity.

- Dietary Cu and Zn supplementation @ 15 ppm and 60 ppm respectively to Murrah bulls resulted in increased semen ejaculate volume, sperm concentration, intact acrosome, HOST reacted spermatozoa.
- Propionic acid (1.0% fresh matter basis) and Sodium benzoate (0.1% fresh matter basis) were effective to improve Sugargraze silage quality while Potassium sorbate (0.1% fresh matter basis) and Sodium benzoate (0.1% fresh matter basis) could be used for maize silage preparation.
- Hanging drop is the best method for 3D culturing of buffalo and sheep primary liver cells as well as buffalo granulosa cells.
- Lower presence of salivary miR-16, miR-191 and miR-223 could be an intuitive indication of the presence of dominant ovarian follicles in buffaloes.
- A highly efficient method was developed for isolating next-generation sequencing quality RNA from the adipose tissue of recalcitrant animal species.
- Hepatic injury marker enzymes increased in the higher concentration of nanoparticles (NPs) exposed mother mice, but histological examination revealed no changes in the placenta of pregnant mice, whereas testis of male offsprings showed gross pathological changes.
- Antioxidative peptide VLPVPQK from milk exhibited anti-osteopenic effects through inhibition of oxidative damage and bone-resorbing cytokines in ovariectomized rats.
- Anti-aging and anti-inflammatory property of milk derived bioactive peptide VLPVPQK was established in rat fibroblasts.
- Consumption of probiotic *Lactobacillus fermentum* and *Lactobacillus rhamnosus* fermented milk attenuates dyslipidemia, oxidative stress and inflammation in male rats fed on cholesterol enriched diet.
- Supplementation of milk fermented with *Lactobacillus gasseri* prevented the progression and occurrence of obesity due to feeding of High Fat Diet.
- Probiotic bacterial secretomes (secreted bacterial proteins) obtained in a modified compromised MRS and its isolated EPS has a profound and increasing effect on TM3 cell viability.
- Adherence ability of *Lactobacillus fermentum* (MTCC: 5898) was significantly (11.1 folds) higher than *L.rhamnosus* (MTCC: 5897) on intestinal epithelial cells.
- Manufacturing protocols were developed for several products such as chocolate steamed *dahi*, milk protein concentrates, milk protein enriched pearl millet malt based complementary food, double-emulsion- based functional mayonnaise enriched with bitter-gourd extract, smoothie enriched with *amla* bioactives.
- An intelligent oxygen sensor was developed and evaluated on modified atmosphere packaged mozzarella cheese.
- Defined strain mesophilic lactic starter was formulated for preparation of flavour rich ripened cream ghee.
- Forty nine lactic cultures (*Lactococcus*: 33; *Lactobacillus*: 5; *Leuconostoc*: 5; and *Pediococcus*: 6) isolated from Cold Dessert Region were characterized for their technological properties.
- Probiotic *Lactobacillus brevis* 42K and MG3, showed GABA production of  $41.02 \pm 0.12$  mM and  $37.65 \pm 0.55$  mM, respectively. The feeding of GABA producer *Lactobacillus* strains increased the body weight of diabetic rats, while the blood glucose concentration of diabetic rat decreased significantly ( $p < 0.05$ ) after 7 weeks of feeding.
- Feeding of diabetic rats with bacterial *L. fermentum* SR4 zinc lysate vis-à-vis inorganic zinc significantly increased body weight and feed intake, serum metallothionein, serum insulin, femur and serum Zn levels accompanied by a significant decrease in fasting blood glucose.
- Functional *dahi* was developed using bacterial lysate prepared from Zn enriched biomass of *L. fermentum* SR4 and fed to Wistar rats to evaluate bioavailability of Zinc. The study demonstrated significant increase in the levels of zinc in terms of apparent Zinc Absorption in serum and different body parts such as liver, hair and femur as compared to inorganic Zinc.

- A commercially feasible encapsulation system was developed for probiotic organisms suitable for ambient storage in tropical (Indian) climatic conditions.
- Genome sequence of Indian isolates *L. reuteri* 6 and *L. fermentum* NCDC 400 was deciphered.
- The comparative analysis of predominating Gut Enterotypes in children of varying nutritional status (malnourished children) showed significant ( $P < 0.05$ ) decrease in the abundance of Bifidobacteria with the decline in the nutritional health of the children using absolute qPCR quantification approach.
- North-Eastern human Gut microbial diversity was studied among vegetarian and non-vegetarian population under different age groups (20-30 and 50-60). No significant gut microbial changes were observed at the phylum and Family level in all the population groups except Enterobacteriaceae and Veillonellaecae, which showed higher abundance in the gut microbiota of North-Eastern population compared to North India.
- Gut microbiota composition is distinctive in Autistic children. Among the four predominant phyla, decreased abundance of *Firmicutes* phylum and increased abundance of *Bacteroidetes*, *Actinobacteria* and *Proteobacteria* was observed in ASD children.
- Among the surface proteins from probiotic *Lactobacilli*, Elongation factor (43.45 kDa, EF-Tu) was identified that is mainly involved in adhesion in probiotic *Lactobacilli*.
- The probiotic strain *L. fermentum* MTCC 5954 emerged as candidate GLP-1 incretinotropic and secretagogue strain for developing dietary based biotherapeutics for the management of type 2 diabetes.
- The two indigenous probiotic *L. plantarum* Lp91 (MTCC 5690) and *L. fermentum* Lf1 (MTCC 5689) with well established probiotic attributes and functional efficacy were found to be pre-clinically safe using animal model studies. The test strains were also found to be devoid of any genotoxic effects in the chromosomal aberration test and micronucleus assay.
- Heat killed biomass of probiotic *Lactobacilli* could be used to mitigate AFM<sub>1</sub> menace in milk and milk products.
- Synbiotic fermented beverage was prepared using characterized *Pediococcus* cultures (PD-34 and 14-PD) with good antimicrobial and phytate degradation potential.
- Sheep milk fermentate of *L. rhamnosus* C25 produced various biopeptides. Out of these, 24 peptides were identified as antioxidant peptides, 21 as antimicrobial and 30 ACE as inhibitory peptides.
- HPLC analytical protocols were developed for tetracycline group (tetracycline and oxytetracycline) and novobiocin antibiotics. Extraction protocol was optimized for the selected antibiotics to obtain average recoveries in the range of 78-89% and 92-104% for tetracycline group and novobiocin, respectively.
- A total of 539 raw and 159 pasteurized milk samples were tested for the presence of pesticide residues using strip based technology developed at ICAR-NDRI. Out of these, 7.05% samples revealed presence of pesticides.
- FTIR based rapid method was developed for assessment of proteolysis in UHT milk during storage.
- A methodology was standardized to harvest the fat globules based on their size from cow and buffalo milk.
- Five potential DPPIV inhibitory peptides were identified from beta casein (K.YPVEP.F, K.YPVEPF.T, N.LHLPLP.L, N.LHLPLPL.L, L.HLPLPL.L) and one from k-casein (I.NNQFLPYP.Y) following digestion of goat casein under *in vitro* simulated gastrointestinal conditions.
- Nano Iron (III) Oxo-Hydroxide Complex fortified biscuits were developed and the organic acid-iron complex was found to be a better iron fortificant with good oxidative stability and bioavailability.
- Microprocessor based automated pneumatic paneer hoop-cum-pressing unit was developed for mechanized production of paneer and cheeses.
- A continuous mechanized system was developed for the commercial production of *rabri*.

- Continuous *kheer* manufacturing equipment suitable for medium scale processor was developed. The developed system would be useful in reducing the production cost and in ensuring the quality of *kheer*.
- A low cost can washer system was developed for efficient cleaning of cans with minimum amount of water which could reduce effluent generation at milk collection centers.
- Optimum farm plans were developed for reducing risk in agricultural enterprise in agriculturally distressed regions of Vidarbha and Marathwada.
- Modeling the sensitivity of milk production to heat stress and projecting the potential economic losses from rising temperatures in Trans and Upper Gangetic Plain region.
- Prepared the strategy document for Doubling Farmers Income in Haryana.
- Technological changes in dairy farming and their effect on rural employment in trans-gangetic plains were assessed and significant technological change was found in adoption of scientific dairy farming technologies.
- An exclusive Composite Livelihood Vulnerability to Drought Index (CLVDI) was developed to appraise livelihood vulnerability of livestock dependents of Bihar and found that livelihood vulnerability was increased significantly with the increase in degree of drought proneness.
- A Web-enabled Interactive Information Delivery System was developed to provide information regarding scientific dairy farming practices to different stakeholders including dairy farmers.
- One bilingual (Hindi and English) Multimedia on the production procedure of six traditional dairy products viz. *Paneer, Ghee, Khoa, Gulab Jamun, Dahi, and Lassi* was developed.
- Two mobile Apps on environment friendly dairy farming practices and physiological technologies for improving productivity were developed in Hindi & English to educate dairy stakeholders.
- During the year 2017-18, a total number of 422 research articles were published in the peer reviewed Journals, out of which 124 articles were published in Journals having more than 7.0 NAAS Rating.
- A total of twelve technologies were commercialized to ten different Commercial Houses.
- During the year 2017-18, twelve new technologies were developed and at present the Institute has 85 technologies ready for commercialization.
- Four patents on new inventions were filed and three patents were granted.

## EDUCATION

- ICAR-NDRI secured FIRST RANK amongst Agricultural Universities in the Ranking of Agricultural Universities in India (2016-17) by the ICAR.
- ICAR-NDRI was placed in the Special Mention Category of Institutions by National Institutional Ranking Framework, Ministry of Human Resource Development, Govt. of India Ranking- 2018.
- ICAR-NDRI was approved for accreditation by National Agricultural Education Accreditation Board, ICAR, New Delhi upto March 2021.
- ICAR-NDRI initiated implementation of the automation of Academic Management System including entire academic activities starting from registration, payment of fees and regulation of progress of academic and research work of the students and uploading of results.
- The entire admission process including conduct of entrance test for Ph. D program was made online from 2017-18.
- NDRI introduced one month Foundation Program for the freshers of 2017- 18 at the start of the semester and before commencement of regular course work to tap the innate talents of the students and nurture them to develop into outstanding professionals and accomplished human beings. The students were exposed to

multifarious extra-curricular group activities such as Theatre & Dramatics, Dance, Music, Art & Craft, Literary, Soft Skills and Yoga.

- Adjunct Faculty Scheme was also initiated under which outstanding professionals selected from across the globe visited the Institute to teach and mentor the students.
- Sixteenth Convocation of ICAR-NDRI Deemed University was held on 10<sup>th</sup> March, 2018. Sh. Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare delivered the Convocation Address. A total of 277 students (including 112 girls) were conferred different degrees i.e. B. Tech. (Dairy Technology) -27, Master's -146 and Doctoral - 104.

### EXTENSION

- A total number of 34 camps were organized in the adopted villages of NDRI namely Shahpur, Hemda and Dadupur. A total number of 432 animals were treated for reproductive disorders and various veterinary ailments.
- Thirty four Kisan Sangosthies were organized for the dairy farmers in the adopted villages of NDRI.
- Twenty enrolled farmwomen successfully completed the prescribed courses of Farmers' Farm School.
- Scientists regularly visited villages as a part of the 'Education at the Farmers' Door' program.
- A total number of 235 farmwomen benefitted through eight different programmes conducted by women empowerment laboratory.
- National Dairy Mela was organised during 23<sup>rd</sup> – 25<sup>th</sup> November, 2017 to showcase the various technologies developed at NDRI and the mela attracted more than 10000 visitors from different states like Uttar Pradesh, Haryana, Punjab, Delhi and Rajasthan.
- Under the Tribal Sub-Plan (TSP) programme, a total number of 473 cattle, 385 calves and 60 buffaloes were vaccinated against FMD, HS and BQ. Apart from that, 690 goats, 160 sheep were vaccinated against PPR and 1020 birds were vaccinated with R<sub>2</sub>B Vaccine.
- Under the NEH activities, several inputs like Chicks (5300 Nos.), Piglet (71 Nos.), Black Bengal Goat (50 Nos), Broiler pre-starter (200 kg), Crumbo starter (400 kg), Cattle feed (5350 kg), Calcium supplement (50 lit), Mineral mixture (1567 kg), poultry feed (1000 kg), Varaahar pellet (1500 kg) were distributed among the 943 farmers of Meghalaya, Mizoram, Tripura and Sikkim.
- KVK of NDRI, Karnal organised 165 on-campus and off-campus training programmes on different aspects of agriculture and allied subjects including dairy farming and processing. A total number of 6210 farmers and farmwomen from 12 states benefitted through these programmes.
- ATIC of NDRI rendered 5045 services to 6606 persons from different corners of the country through toll free number, video shows, personal interactions, etc.
- NDRI outreach centre situated at Piprakothi, East Champaran, Bihar organised eight training programmes and a total number of 268 farmers benefitted through these training programmes.

### CAPACITY BUILDING

- Under Entrepreneurship Development Programme, 14 trainings/courses on "Commercial Dairy Farming" and "Milk and Milk Products" were organized and attended by 465 participants.
- Fifteen incubatees were enrolled under the mentorship of Scientists and seven entrepreneurs initiated their ventures under business incubation through SINED (TBI).
- Three Government sponsored trainings on dairying were organized in which 139 stakeholders from different States participated.

- One International training on modern dairy technology and management for the dairy professionals from developing countries and 9 other training programmes for the dairy professionals were also organized.
- Two CAFT courses in Dairy Processing for the faculty of ICAR Institutes and SAUs were organized.
- During the period, 150 students from 44 Universities and Colleges were offered training in different disciplines of dairying.

## INFRASTRUCTURE

- National Referral Center for Milk Quality and Safety (NRCMQS) granted accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL) for two years till 21.03.2020.
- University Examination Hall with a seating capacity of 600 students at the main campus, Karnal.
- A Dairy Processing Unit under the aegis of Krishi evam Dairy Vikas Kendra established at *Piprakothi, Motihari (Bihar)*. The Kendra works for the benefit of farmers by imparting extensive training on dairy processing with backward and forward integration to the dairy farmers.
- Providing and fixing of chain link fencing around the Sewage Treatment Plant, civil works of existing water trough of animal shed for installing water saving devices and providing water trough for animal shed at ICAR-NDRI, Karnal
- Water metering devices were installed to minimise energy and water utilization in the Experimental Dairy.
- Renovation of Bull pens and water supply at ABRC, ICAR NDRI, Karnal.
- Renovation of PG lab, semen quality control lab, semen processing lab, semen storage lab, bathrooms and toilets at ABRC Main building at ICAR NDRI, Karnal.
- Extension and strengthening of Kitchen space at Alaknanda Hostel at ICAR NDRI, Karnal.
- Repair and renovation of two roads in ABRC at ICAR NDRI Karnal.
- Distempering and painting work of 4 class rooms of B.Tech (DT), 25 old rooms of Kaveri Hostel and 48 rooms along with balcony area of the Alaknanda Hostel at ICAR-NDRI, Karnal.
- Repair & Renovation of Room No. 141 of Agronomy Section at ICAR-NDRI, Karnal
- Fodder Demonstration Unit with 21 fodder varieties was established at Southern Campus, Bengaluru.
- Hydroponic fodder production cum demonstration unit established for production of 50 kg hydroponic fodder (maize) per day at Southern Campus, Bengaluru.
- A vermicompost production unit established at Southern Campus, Bengaluru for better utilization of cattle dung and tree leaves and other organic waste from the station.
- Construction of Krishna Wing of Girls Hostel at Southern Campus, Bengaluru.
- Theriogenology laboratory at Southern Campus, Bengaluru.

## ADMINISTRATIVE REFORMS

- Management Information System (MIS) including Financial Management System (FMS) has been implemented at the Institute. This system includes solutions for Financial Management, Project Management, Material Management, Human Resource Management and Payroll. Recently, Expenditure, Advance and Transfer (EAT) module of PFMS (Public Financial Management Systems) has been implemented as per the instructions of Govt. of India.



# कार्यकारी सारांश

## कार्यकारी सारांश

राष्ट्रीय डेरी अनुसंधान संस्थान राष्ट्र का एक अग्रणी एवं प्रतिष्ठित संगठन है जो देश में डेरी विकास कार्यक्रमों के लिए अनुसंधान एवं विकास तथा मानव संसाधन विकास में सहयोग के लिए पूर्ण रूप से समर्पित रहा है। वर्ष 1923 में बंगलौर में संस्थापित इस संस्थान के मुख्यालय को वर्ष 1955 में इसके मौजूदा स्थान करनाल में स्थानांतरित किया गया था। इस संस्थान के दो क्षेत्रीय केन्द्र हैं जो बंगलौर तथा कल्याणी में स्थित हैं। दक्षिण व पूर्वी क्षेत्रीय केन्द्र स्थानीय क्षेत्र में कृषि वातावरण के अनुरूप डेरी विकास के लिए अनुसंधान एवं सहयोग प्रदान करने में लगे हुए हैं। भाकृअनुप-राडेअनुसं को वर्ष 1989 से शैक्षणिक कार्यक्रमों के संचालन हेतु मानित विश्वविद्यालय का दर्जा प्राप्त है। संस्थान को वर्ष 2016 के लिए भारतवर्ष के सभी कृषि विश्वविद्यालयों जिनमें चार मान्य विश्वविद्यालय भी शामिल हैं, में प्रथम स्थान प्राप्त हुआ है।

## संगठनात्मक स्वरूप

संस्थान की प्रबंध प्रणाली भारतीय कृषि अनुसंधान परिषद के मान्य विश्वविद्यालय की प्रशासनिक पद्धति के अनुरूप ही है। संस्थान के अनुसंधान, शिक्षण, प्रशिक्षण, विस्तार शिक्षा तथा प्रशासनिक कार्यकलाप के क्षेत्र में नीति निर्धारण और निर्णय का दायित्व प्रबंध मंडल, अनुसंधान सलाहकार परिषद, शिक्षा परिषद समितियों को सौंपा गया है। संस्थान के निदेशक इसके मुख्य कार्यकारी अधिकारी हैं तथा प्रबंधन, अनुसंधान, शैक्षणिक एवं विस्तार कार्यकलापों के लिए संयुक्त निदेशक उनकी सहायता करते हैं। संस्थान के अनुसंधान और विकास के तीन मुख्य क्षेत्र (i) डेरी उत्पादन (ii) डेरी प्रसंस्करण तथा (iii) डेरी विस्तार/ प्रबंधन हैं। सभी अनुसंधान एवं विस्तार कार्यक्रम तेरह प्रभागों/अनुभागों-पशु अनुवांशिकी एवं प्रजनन, पशुधन उत्पादन एवं प्रबंधन, पशुपोषण, चारा अनुसंधान एवं प्रबंधन, पशु शरीर क्रिया विज्ञान, पशु जीव रसायन, पशु जैव प्रौद्योगिकी, डेरी प्रौद्योगिकी, डेरी अभियांत्रिकी, डेरी रसायन, डेरी सूक्ष्म जीवाणु विज्ञान, डेरी विस्तार तथा डेरी अर्थशास्त्र, सांख्यिकी एवं प्रबंधन प्रभाग के अन्तर्गत संपन्न होते हैं। संस्थान में एक कृषि प्रौद्योगिकी सूचना केन्द्र (एटिक), कृषि विज्ञान केन्द्र तथा डेरी प्रशिक्षण केन्द्र, कृत्रिम प्रजनन अनुसंधान केन्द्र है। पीपराकोठी, पूर्वी चंपारन, मोतीहारी, बिहार पर कृषि विज्ञान केन्द्र के अन्तर्गत कृषि तथा डेरी विकास केन्द्र तथा मुजफ्फरनगर (उ.प्र.) में लालूखेड़ी में मॉडल डेरी केन्द्र, भी संस्थान के कार्यक्षेत्र में आते हैं। संस्थान में पशुधन अनुसंधान केन्द्र, चारा अनुसंधान एवं प्रबंधन केन्द्र, पशु स्वास्थ्य परिसर, माडल डेरी संयंत्र, टैक्नोलॉजी बिजनेस इनक्यूबेटर, व्यवसाय नियोजन एवं विकास एकक, दुग्ध गुणवत्ता एवं सुरक्षा के लिए नैशनल रैफरल प्रयोगशाला, प्रयोगात्मक डेरी संयंत्र, परामर्श एकक, पुस्तकालय तथा राष्ट्रीय जैव सूचना केन्द्र, कंप्यूटर केंद्र, संपदा अनुभाग, राजभाषा एकक एवं अनुरक्षण अभियांत्रिकी अनुभाग जैसी केन्द्रीय सुविधाएं उपलब्ध हैं। प्रशासनिक कार्यकलाप जैसे क्रय, भंडार, एवं सुरक्षा आदि संयुक्त निदेशक (प्रशासन) एवं कुलसचिव के नियंत्रण में हैं जबकि वित्त विभाग नियंत्रक (वित्तीय) के प्रशासनिक नियंत्रण में है। संस्थान में इस समय 157 वैज्ञानिक, 186 तकनीशियन, 127 प्रशासनिक एवं 402 निपुण सहायक कर्मचारी हैं।

## बजट परिव्यय

संस्थान का वर्ष 2017-18 के लिए वास्तविक व्यय बजट 21570.59 लाख रूपए था तथा वर्ष 2017-18 के लिए स्वीकृत बजट 21596.40 लाख रूपए था। इन आँकड़ों में क्षेत्रीय केन्द्रों के सुदृढीकरण का बजट परिव्यय भी शामिल है।

## अनुसंधान

वर्ष 2017-18 के दौरान कुल 77 अन्तः संस्थानीय (इन हाउस) तथा 70 बाह्य पोषित अनुसंधान परियोजनायें परिचालन में रहीं। राष्ट्रीय डेरी अनुसंधान संस्थान लगभग सभी अग्रणी राष्ट्रीय फंडिंग एजेन्सियों जैसे जैव प्रौद्योगिकी विभाग (डी.बी.टी.); विज्ञान एवं प्रौद्योगिकी विभाग एवं विज्ञान एवं इंजीनियरी अनुसंधान बोर्ड (डी.एस.टी.-एस.ई.आर.बी.); राष्ट्रीय कृषि विज्ञान निधि (एन.ए.एस.एफ.); खाद्य प्रसंस्करण उद्योग मंत्रालय (एम.ओ.एफ.पी.आई.); भारतीय खाद्य सुरक्षा एवं मानक प्राधिकरण (एफ.एस.एस. ए.आई.); भारतीय सामाजिक विज्ञान अनुसंधान परिषद (आई.सी.एस.एस.आर.); भारतीय आयुर्विज्ञान अनुसंधान परिषद (आई.सी. एम.आर.); पर्यावरण वन एवं जलवायु परिवर्तन मंत्रालय (एम.ओ.ई.एफ. एण्ड सी.सी.) तथा राष्ट्रीय डेरी विकास बोर्ड (एन.डी.डी.बी) भा.कृ.अनु.प. से बाह्य वित्तीय सहायता प्राप्त करने में सफल रहा है।

फंडिंग एजेन्सियों से प्राप्त सहायता ने वैज्ञानिकों को स्टैम कोशिका, भैंस की क्लोनिंग, ट्रांसक्रिप्टोन, एम्ब्रायोजेनेसिस, सीमन सेक्सिंग, बायोसेंसर्स, नैनोप्रौद्योगिकी, फार्म पशुओं में अबायोटिक स्ट्रेस, न्यूट्रास्यूटिकल्स तथा प्रकार्यात्मक आहारों पर कार्य करने के लिए प्रोत्साहित किया है। फंडिंग एजेन्सियों से प्राप्त अनुदानों ने छात्रों को अपने शोध-लेखन में आधुनिक उपकरणों एवं तकनीकियों के चयन के लिए भी सहायता प्रदान की है। रिपोर्टाधीन अवधि में हुए अनुसंधानों के कुछ मुख्य बिन्दुओं का उल्लेख नीचे दिया गया है :

- हैंड गाइडिड क्लोनिंग के दौरान पुनः संरचित भ्रूण के लिए स्पंदित इलैक्ट्रोमेगनेटिक फील्ड के अनुप्रयोग ब्लास्टोसिस्ट उत्पादन दर को बढ़ाने के लिए तथा उत्पादित क्लोन्ड भ्रूणों की गुणवत्ता में सुधार हेतु प्रदर्शित किये गए।
- रोज़ा 26 लोकस पर जीएफपी समाकलन वाले ट्रांसजीनिक बकरी के भ्रूण उत्पन्न किए गए, इसके लिए एक नवीनतम जीनोमिक एडिटिंग टूल्स ट्रांसक्रिप्शन एक्टिवेटर—लाइक इफैक्टर न्यूक्लिसिस (टीएएलईएन) का प्रयोग किया गया।
- अनुमानित अनिषेक जनन भ्रूणीय स्टैम कोशिकाओं सहित टेट्राप्लायड सम्पूरण का काइमेरिक ब्लास्टोसिस्ट अवस्था बकरी के भ्रूण के उत्पादन के लिए सफलतापूर्वक प्रयोग किया गया।
- सूक्ष्म आरएनए, जीन का भैंसों में प्रारंभिक गर्भाधान (30 दिन) के दौरान विलक्षण अभिव्यंजन थी, का पता लगाया गया।
- गोपशुओं में गर्भाधान, 35 दिन तक के गर्भ की जांच के लिए एक प्रूफ—आफ—कनसेप्ट का विकास किया गया इसके लिए गर्भाधान सम्बद्ध ग्लाइकोप्रोटीन—7 (पीएजी7) के लिए एक रोगप्रतिकारक का प्रयोग किया गया।
- भैंस के परीक्षणों के एपिडिडाइमिस में शुक्राणु आवरण प्रोटीन, बीटा डाइफेन्सिनस 126 तथा 129 की बढ़ती हुई अभिव्यंजना का पता लगाया गया।
- करन फ्रीज तथा साहीवाल गोपशुओं के दूध में ए1 तथा ए2 बीटा केसीन की जांच के लिए एलसी—एम.एस विधि विकसित की गई। यह विधि 200 से अधिक गायों में मान्य है।
- एक स्थिर ट्रांसफेक्टिड सी.ओ.एस—1 कोशिका रेखा का विकास किया गया जो कि पुनःसंयोजक गोपशु ल्यूकीमिआ निरोधक कारक को अभिव्यंजित करती है।
- पशमीना रेशा की वृद्धि तथा विकास में लगे प्रमुख प्रोटीनों की पशमीना रेशा तथा त्वचा प्रोटीओम के विश्लेषण द्वारा जांच की गई।
- गायों तथा भैंसों में खुरों के घावों के स्थायी रूप से इलाज के लिए मिसेनकाइमल स्टैम कोशिकाओं का सफलतापूर्वक प्रयोग किया गया।
- कुल आठ मुराह कटड़ों को ईपीडी (श्रेष्ठता 3.08 से 10:) तथा डैम के श्रेष्ठ प्रथम दुग्ध स्त्रवण 305 दिन (2838—3570 कि.ग्रा.) के आधार पर भविष्य में प्रजनन के लिए आरक्षित रखा गया।
- माइक्रोसेटेलाइट मार्कर एस.पी.एस 115 ई.टी.एच 225 साहीवाल गोपशुओं के लिए तथा एस.पी.एस 115 मुराह पशुओं के लिए पैतृत्व जांच के लिए सबसे अधिक उपयुक्त पाए गए।
- मुराह भैंसों में ओ.एल.आर.आई. जीन में एस.एन.पी.सी. 10869 टी के टी.टी.जीनोटाइप; जी 81 टी के जी.टी.जीनोटाइप तथा ए.टी.एफ 4 जीन में सी 82 टी. के टी.टी.जीनोटाइप का क्रमशः : वसा तथा एल.एफ.वाई. पर महत्वपूर्ण प्रभाव पाया गया।
- साहीवाल गोपशुओं में दूध तथा वसा विशेषकों पर एस.एन पी ए 37913198जी, जी 37913263ए ; टी.37913318सी. तथा ए.बी.सी. जी.2 जीन का सकारात्मक प्रभाव पाया गया।
- प्रसवपूर्व 45 दिन से 60 दिन प्रसव पश्चात से प्रिल्ड वसा मिश्रित सम्पूरण, सेकरोमाइसिस सेरीवाइसिस तथा स्वीटनर (100 ग्रा: 25:1जी/दिन/पशु) खिलाने से पशु के स्वास्थ्य पर बिना किसी प्रभाव के शुष्क पदार्थ अन्तर्ग्रहण (डी.एम.आई), शरीरभार तथा दुग्ध उत्पादन में वृद्धि हुई।
- भैंसों में दूध पी.जी—पी.एल प्रणाली के अपरेग्यूलेशन द्वारा दुग्ध उत्पादन में सुधार तथा शीत के प्रभाव को कम करने के लिए शीत ऋतु में घर के अन्दर धान की भूसी का बिस्तर लगाकर आवास प्रबंधन करना प्रभावकारी था।
- भैंसों में थनैला को प्रतिरोधक बनाने के लिए जीनोटाइप एए, डीडी तथा आरआर को मार्कर सहयोगी चयन में प्रयोग किया जा सकता है। थनैला प्रतिरोध के लिए टी.एल आर 2 तथा आईजीएफ1 की संभावित जीन के रूप में पहचान की गई।
- संकर सांडों में वीर्य गुणवत्ता की जांच के लिए वीर्य प्लाज्मा में नाइट्रिक आक्साइड के स्तर का प्रयोग किया जा सकता है।
- शुक्राणु मेम्ब्रेन (झिल्ली) के लिपिड परआक्सीडेटिव क्षति की कमी के कारण पोस्ट—थॉ शुक्राणु मर्त्यता के रखरखाव तथा कम सान्द्रण पर 1 घंटे तक जीवनक्षमता के लिए सोडियम नाइट्रोप्रुसाइड लाभप्रद सिद्ध हुई।
- गायों में गर्भाधान के शीघ्र संकेतकों के रूप में न्यूट्रोफिलस की सक्रियता, प्लाज्मा साइटोकाइन स्तरों के साथ उनकी जीन अभिव्यंजना का प्रयोग किया जा सकता है।
- गर्मी के दाव के दौरान बीटाइन आहार दी जाने वाली गायों की प्रजनन क्षमता में महत्वपूर्ण सुधार पाया गया।

- मुराह भैंसों में एस्टाकसेन्थिन के पेरीपारटयूरेन्ट आहार (0.25 एमजी/कि.ग्रा. शरीर भार) एनएफकेबी पी65 के एमआरएनए जीन अभिव्यंजना से कम नियंत्रित हुई तथा असंक्राम्यता में सुधार हुआ।
- मुराह भैंसों को 15 पीपीएम तथा 60 पीपीएम की दर से आहारिय सी यू तथा जिंक सम्पूरण से वीर्य निक्षेपण धनत्व, शुक्राणु सान्द्रण, विशेषक एक्रोसोम, एचओएसटी प्रतिक्रिया में वृद्धि हुई।
- शुगर ग्रेज साइलेज किस्म में सुधार के लिए प्रोपियोनिक अम्ल (1.0:) ताजा पदार्थ आधार पर) तथा सोडियम बेन्जुएट (0.1: ताजा पदार्थ आधार पर) प्रभावी थे जबकि मक्का साइलेज तैयार करने के लिए पोटेशियम सोरबेट (0.1: ताजा पदार्थ आधार पर) तथा सोडियम बेन्जुएट (0.1: ताजा पदार्थ आधार पर) का प्रयोग किया जा सकता है।
- भैंस की ग्रेनुला कोशिकाओं तथा भैंस एवं भेड़ की प्रारंभिक जिगर कोशिकाओं के 3डी संवर्धन के लिए हैंगिंग ड्राप श्रेष्ठ विधि है।
- लार एमआईआर-16, एमआईआर 191 तथा एमआईआर 223 की अल्प विद्यमानता भैंसों में प्रबल डिम्बाणु पुटिकाओं की विद्यमानता अन्तर्ज्ञात संकेत हो सकती है।
- अड़ियल पशु जातियों के एडीपोज़ ऊतकों से अगली पीढ़ी के अनुक्रम गुणवत्ता आरएनए वियोजित करने के लिए एक उच्च सक्षम विधि विकसित की गई।
- हेपेटिक घाव मार्कर किण्वक सूक्ष्म कणों के उच्च सान्द्रण में बढ़े माता चूहों को प्रदर्शित किया, लेकिन गाभिन चूहों की जेर में ऊतकीय परीक्षण से कोई परिवर्तन नहीं हुए, जब कि नर सन्तति के अण्डों ने भारी रोगात्मक परिवर्तन प्रदर्शित किए।
- दूध से एंटीऑक्सीडेटिव पेप्टाइड वीएलपीवीपीक्यू ऑक्सीडेटोमाइज्ड चूहों में ऑक्सीडेटिव क्षति और बोन-रिसोरबिंग साइटोकिन्स के अवरोध के माध्यम से एंटी-ऑस्टियोपेनिक प्रभाव प्रदर्शित करता है।
- दूध से व्युत्पन्न बायोएक्टिव पेप्टाइड वीएलपीवीपीक्यू की एंटी-एजिंग और एंटी-इन्फ्लेमेटरी गुणों की चूहे के फाइब्रोब्लास्ट्स में स्थापना की गई थी।
- प्रोबियोटिक लैक्टोबैसिलस फेरमेंटम और लैक्टोबैसिलस रमनोसस किण्वित दूध की खपत कोलेस्ट्रॉल समृद्ध आहार पर पोषित नर चूहों में डिस्प्लेडमिया, ऑक्सीडेटिव तनाव और सूजन को क्षरण करता है।
- लैक्टोबैसिलस गैसेरी के साथ किण्वित दूध को देने से उच्च वसायुक्त आहार के कारण होने वाले मोटापे की वृद्धि व पुनरावृत्ति को रोकता है।
- रूपांतरित सुलभ एमआरएस एवं इसके पृथक ईपीएस में अर्जित प्रोबायोटिक बैक्टीरियल सेक्रीटोम्स (स्रावित बैक्टीरियल प्रोटीन), टीएम 3 कोशिका व्यवहार्यता पर गहन व अभिवृद्धि का प्रभाव दिखाते हैं।
- आंतों की उपकला कोशिकाओं पर सलैक्टोबैसिलस फेरमेंटम (एमटीसीसी: 5898) की अनुपालन क्षमता, ड्रमनोसस (एमटीसीसी: 58 9 7) से उल्लेखनीय रूप से काफी अधिक (11.1 गुना) थी।
- विभिन्न उत्पादों जैसे चॉकलेट स्टीम्ड दही, मिल्क-प्रोटीन कन्सन्ट्रेट्स, दुग्ध-प्रोटीन समृद्ध पर्ल मिलेट माल्ट आधारित पूरक भोजन, करेले के सत्व से समृद्ध डबल-इमल्शन-आधारित प्रकार्यात्मक मेयोनेज़, आमला बायोएक्टिव्स से समृद्ध स्मूदीज के लिए विनिर्माण प्रोटोकॉल विकसित किये गये।
- मॉडिफाइड वातावरणी पैकेज्ड मोजरेला पनीर पर एक प्रज्ञ ऑक्सीजन सेंसर विकसित और मूल्यांकन किया गया।
- बकरी के दूध के दही की गुणवत्ता को सुधारने के लिए अल्ट्रा फिल्टरेशन को एक टूल माना गया।
- स्वादिष्ट पकी क्रीम के घी को तैयार करने के लिए परिभाषित स्ट्रेन मेसोफिलिक लैक्टिक स्टार्टर को निरूपित किया गया।
- कोल्ड डिजर्ट क्षेत्र से पृथक किए गए उनचास लैक्टिक कल्चर्स (लैक्टोकोकस: 33; लैक्टोबैसिलस: 5; ल्यूकोनोस्टोक: 5; और पेडियोकोकस: 6) को उनके तकनीकी गुणों के लिए चिन्हित किया गया।
- प्रोबायोटिक लैक्टोबैसिलस ब्रेविस 42 के और एमजी 3 ने क्रमशः 41-02 ± 0-12 एमएम और 37-65 ± 0-55 एमएम के जी.ए.बी.ए. उत्पादन को दर्शाया। जी.ए.बी.ए. उत्पादक लैक्टोबैसिलस उपभेदों के आहार ने मधुमेहग्रसित चूहों के शरीर के वजन में वृद्धि की, जबकि मधुमेहग्रस्त चूहे के रक्त ग्लूकोज की सांद्रता 7 सप्ताह की फीडिंग के बाद काफी कम हो गई।
- मधुमेहग्रस्त चूहों को बैक्टीरियल एल.फर्मन्टम एसआर4 जिंक लाइसेट के साथ-साथ अकार्बनिक जिंक का आहार देने से उनके शरीर का वजन काफी बढ़ गया और फीड इनटेक, सीरम मेटलॉथियोनेयन, सीरम इंसुलिन, फीमर और सीरम जिंक स्तर के साथ फास्टिंग रक्त ग्लूकोज में उल्लेखनीय कमी आई।

- जिंक समृद्ध एल.फर्मन्टम एस.आर.4 के बायोमास से तैयार बैक्टीरियल लाइसेट का प्रयोग करके निरूपित दही को विकसित किया गया और इसे जिंक की जैवउपलब्धता के मूल्यांकन के लिए विस्तार चूहों को खिलाया गया। इस अध्ययन में सीरम में जिंक अवशोषण और अकार्बनिक जिंक की तुलना में यकृत, बालों और फीमरस जैसे शरीर के विभिन्न अंगों के मामले में जस्ता के स्तर में उल्लेखनीय वृद्धि हुई है।
- उष्णकटिबंधीय (भारतीय) जलवायु परिस्थितियों में परिवेशनुकूल भंडारण हेतु उपयुक्त प्रोबियोटिक जीवों के लिए व्यावसायिक रूप से व्यवहार्य इन्कैप्सूलेशन प्रणाली विकसित की गई।
- भारतीय आइसोलेट्स एल.रियूटेरी 6 एवं एल.फर्मन्टम एनसीडीसी 400 के जीनोम अनुक्रम को डीसाइफर किया गया।
- भिन्न पौष्टिक स्थिति वाले बच्चों(कुपोषित बच्चों) में सर्वाधिक गट एंटरोटाइप के तुलनात्मक विश्लेषण ने बिफीडोबैक्टेरिया की प्रचुरता के कारण बच्चों के पोषण स्वास्थ्य में गिरावट पायी गई।
- पूर्वोत्तर मानव गट माइक्रोबायल विविधता का विभिन्न आयु समूहों (20–30 और 50–60) वाले शाकाहारी और मांसाहारी आबादी के बीच अध्ययन किया गया। सभी आबादी समूहों, एंटरोबैक्टेरियासिया और वीलोनेलासेई को छोड़कर, फायलम और परिवार स्तर पर कोई महत्वपूर्ण गट माइक्रोबायल परिवर्तन दिखाई नहीं पड़े, जो उत्तर भारत की तुलना में पूर्वोत्तर आबादी के गट माइक्रोबायोटा में अत्यधिक प्रचुरता दिखाता है।
- ऑटिस्टिक बच्चों में गट माइक्रोबायोटा संरचना विशिष्ट है। चार प्रमुख फायला में, फर्मिक्यूट्स फाईलम की बहुतायत में कमी आई है और एएसडी बच्चों में बैक्टीरॉयडेट्स, एक्टिनोबैक्टेरिया और प्रोटेबैक्टेरिया का बहुतायत बढ़ गया है।
- प्रोबायोटिक लैक्टोबैसिलि से सतही प्रोटीन में, लम्बाई कारक (43.45 केडीए, ईएफ-तु) की पहचान की गई जो मुख्य रूप से प्रोबियोटिक लैक्टोबैसिलि में चिपकने में शामिल है।
- टाइप 2 मधुमेह के प्रबंधन हेतु प्रोबायोटिक स्ट्रेन एल फेरमेंटम एम.टी.सी.सी. 5954 आहार आधारित बायोथेरेपीटिक्स विकसित करने के लिए केंडीडेट जीएलपी-1 इंकटिनोट्रोपिक और सेकरिटेगोग स्ट्रेन के रूप में सामने आया।
- अच्छी तरह से स्थापित प्रोबियोटिक विशेषताओं और कार्यात्मक प्रभावकारिता के साथ दो स्वदेशी प्रोबियोटिक एलप्लैंटारमएलपी 91 (एमटीसीसी 5690) और एल .फेरमेंटमएलएफ 1 (एमटीसीसी 5689), पशु मॉडल अध्ययनों का उपयोग करके पूर्व-चिकित्सकीय रूप से सुरक्षित पाए गए थे। परीक्षण उपभेदों को गुणसूत्र विपथन परीक्षण और माइक्रोन्यूक्लियस परख में किसी भी जीनोटॉक्सिक प्रभाव से रहित पाया गया।
- दूध और दूध उत्पादों में एएफएम1 खतरे को कम करने के लिए प्रोबियोटिक लैक्टोबैसिलि के बायोमास का उपयोग किया जा सकता है।
- विशेषीकृत पेडीओकोकस कल्चर्स (पीडी –34 और 14–पीडी) का अच्छी एंटीमाइक्रोबायल और फाइटेट अवक्रमण क्षमता के साथ उपयोग करके सिन्बायोटिक किण्वित पेय को तैयार किया गया।
- एल 1 रमनोसस सी 25 के भेड़ के दूध किण्वन ने विभिन्न बायोपेप्टाइड्स का उत्पादन किया। इनमें से 24 पेप्टाइड्स को एंटीऑक्सीडेंट पेप्टाइड्स के रूप में 21 एंटीमाइक्रोबायल और 30 एसीई अवरोधक पेप्टाइड्स के रूप में पहचाना गया था।
- टेट्रासाइक्लिन समूह (टेट्रासाइक्लिन और ऑक्सीटेट्रासाइक्लिन) और नोवोबायोसिन एंटीबायोटिक दवाओं के लिए एचपीएलसी विश्लेषणात्मक प्रोटोकॉल विकसित किए गए। एक्सट्रैक्शन प्रोटोकॉल को चुनिन्दा एंटीबायोटिक दवाओं के क्रमशः 78–89 : और 92–104 : की श्रेणी में औसत ग्राह्यता प्राप्ति के लिए अनुकूलित किया गया था, क्रमशः टेट्रासाइक्लिन समूह और नोवोबायोसिन के लिए।
- भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान में विकसित स्ट्रिप आधारित प्रौद्योगिकी का प्रयोग करके कीटनाशी अपशिष्टों की विद्यमानता के लिए कुल 539 कच्चे दूध के 159 पारचुरीकृत दूध के नमूनों का परीक्षण किया गया। पेपर स्ट्रिप विश्लेषण ने दूध में कीटनाशी की विद्यमानता (7.05%) नमूनों में प्रकट की।
- संग्रहण के दौरान यूएचटी दूध में प्रोटियोलाइसिस के मूल्यांकन के लिए एफटीआइआर आधारित तीव्र विधि विकसित की गई।
- गाय तथा भैंस के दूध से उनके आकार पर आधारित वसा गोलिकाओं को एकत्रित करने के लिए एक विधि मानकित की गई।
- पांच संभावित डीपीपीट निरोधक पेप्टाइड बीटा केसीन (केवाईपीवीईपी.एफ, केवाईपीवीईपी.एफ.टी, एन.एलएचएलपीएलपी.एल, एन.एलएचएलपीएलपीएल.एल, एल.एच.एल पी.एल.पी.एल.एल.) तथा एक के-केसीन(आई.एन.एन.क्यू.एफ.एल.पी.वाई.पी.वाई) से पहचाने गए इन बिट्टी समकालिक जठरीय आन्त्र परिस्थितियों के अन्तर्गत बकरी के केसिन के पाचन अनुकरणीय थे।

- सूक्ष्म लौह(तीन) ओक्सो-हाइड्रोक्साइड संयोजित पुष्टीकारक बिस्किट विकसित किए गए तथा आर्गेनिक अम्ल लौह संयोजक अच्छी आक्सीकर स्थिरता तथा जैव उपलब्धता के साथ एक श्रेष्ठ लौह पुष्टिकर पाया गया।
- पनीर एवं चीज के यन्त्रीकृत उत्पादन के लिए सूक्ष्म संसाधक आधारित स्वचालित वायवीय पनीर हूप-कम-प्रेसिंग यूनिट विकसित की।
- रबड़ी परम्परागत डेरी उत्पाद के व्यावसायिक उत्पादक के लिए एक निरन्तर यन्त्रीकृत प्रणाली विकसित की गई।
- मध्यम स्तर के संसाधक के लिए उपयुक्त निरन्तर खीर बनाने का उपकरण विकसित किया गया। विकसित प्रणाली उत्पादन लागत को कम करने तथा खीर की गुणवत्ता को सुनिश्चित करने में लाभप्रद सिद्ध होगी।
- पानी की न्यूनतम मात्रा द्वारा कैनों की अच्छी प्रकार से सफाई करने के लिए एक कम लागत की कैन वाशर प्रणाली विकसित की गई जोकि दुग्ध संग्रहण केन्द्रों पर निस्सारी उत्पादन को कम कर सकेगा।
- विद्रभा तथा मारथवाड़ा के कृषि की दृष्टि से विपदाग्रस्त क्षेत्रों में कृषि उद्योग में जोखिम को कम करने के लिए अनुकूलतम क्षेत्र योजनाएं विकसित की गई।
- ऊपरी गंगा मैदानी एवं उस पास के क्षेत्रों में बढ़ते तापमान से संभावित आर्थिक क्षति को प्रक्षेपित करने ऊष्मा दाब से दुग्ध उत्पादन की संवेदनशीलता का प्रतिरूपण।
- हरियाणा में कृषकों की आय दोगुनी करने के लिए रणनीतिक दस्तावेज तैयार किए गए।
- गंगा पार के मैदानों में ग्रामीण रोजगार पर डेरी फार्मिंग में प्रौद्योगिकीय परिवर्तनों तथा उनके प्रभावों का मूल्यांकन किया गया तथा वैज्ञानिक ढंग से डेरी पालन की प्रौद्योगिकियों को अपनाने में महत्वपूर्ण प्रौद्योगिकीय परिवर्तन पाए गए।
- बिहार के पशुधन पर आश्रितों की आजीविका सुवाह्यता के मूल्यांकन के लिए सूखा सूचकांक के इतर एक विशेष संयुक्त आजीविका भेद्यता (सीएलवीडीआई) विकसित की गई और यह पाया गया कि सूखे की प्रवणता की डिग्री में वृद्धि के साथ आजीविका भेद्यता में उल्लेखनीय वृद्धि होती है।
- डेरी कृषकों सहित विभिन्न स्टेक होल्डरों को वैज्ञानिक ढंग से डेरी फार्मिंग प्रक्रियाओं संबंधी सूचना एवं जानकारी प्रदान करने के लिए एक वैब समर्थ परस्पर समन्वय सूचना प्रणाली विकसित की गई।
- छ: परम्परागत डेरी उत्पादों जैसे पनीर, घी, खोआ, गुलाब जामुन, दही तथा लस्सी के उत्पादन की प्रक्रिया की द्विभाषी (हिन्दी तथा अंग्रेजी) मल्टीमिडिया विकसित किया गया।
- डेरी स्टोक होल्डरों को शिक्षित करने के लिए उत्पादकता सुधार के लिए पर्यावरण अनुरूप डेरी फार्मिंग प्रक्रियाओं तथा शरीर क्रियात्मक प्रौद्योगिकियों पर हिन्दी तथा अंग्रेजी में दो मोबाइल ऐप विकसित किए गए।
- वर्ष 2017-18 के दौरान कुल 422 अनुसंधान लेख पीर पुनरीक्षित जर्नलों में प्रकाशित किए गए जिनमें से 124 लेख उन जर्नलों में छपे जिनकी नास रेटिंग 7.0 से भी अधिक थी।
- दस विभिन्न व्यावसायिक हाऊसों को कुल 12 प्रौद्योगिकियों का व्यावसायीकरण किया गया।
- वर्ष 2017-18 के दौरान, बारह नई प्रौद्योगिकियां विकसित की गई तथा इस समय संस्थान में 85 प्रौद्योगिकियां व्यावसायीकरण के लिए तैयार हैं।
- नई अविष्कारों पर चार पेटेंट फाइल किए गए तथा तीन पेटेंट प्रदान किए गए।

### शिक्षण

- भाकृअनुप द्वारा भारत में कृषि विश्वविद्यालयों की रैंकिंग कृषि विश्वविद्यालयों में भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान को (वर्ष 2016-17) के लिए प्रथम स्थान मिला।
- भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान राष्ट्रीय संस्थानीय रैंकिंग फ्रेमवर्क, मानव संसाधन विकास मंत्रालय, भारत सरकार रैंकिंग-2018 द्वारा संस्थानों की विशेष मैशन वर्ग में रखा गया।
- भाकृअनुप पीर रिव्यू टीम की संस्तुतियों पर राष्ट्रीय कृषि शिक्षण मान्यता बोर्ड, भाकृअनुप, नई दिल्ली ने भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान को मान्यता प्रदान की।
- भाकृअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान ने शिक्षण प्रबंधन प्रणाली के स्वचलन के कार्यान्वयन को प्रारंभ किया जिसमें पंजीकरण, शुल्क भुगतान तथा छात्रों के शैक्षणिक एवं अनुसंधान कार्य की प्रगति का नियंत्रण तथा परिणामों को अपलोड करने संबंधी सम्पूर्ण शैक्षणिक गतिविधियां सम्मिलित हैं।

- सम्पूर्ण प्रवेश प्रक्रिया यहा तक कि वर्ष 2017-18 से पीएच.डी कार्यक्रम की प्रवेश परीक्षा भी ऑनलाइन आयोजित की गई।
- राष्ट्रीय डेरी अनुसंधान संस्थान ने वर्ष 2017-18 के नए छात्रों के लिए सेमेस्टर प्रारंभ होने पर तथा नियमित पाठ्यक्रम प्रारंभ होने से पहले छात्रों की स्वाभाविक प्रतिभा को बाहर निकालने तथा उन्हें श्रेष्ठ व्यावसायी के रूप में विकसित करने के लिए प्रशिक्षित करने एवं सुसंस्कृत नागरिक बनाने के उद्देश्य से एक माह का फाउंडेशन कार्यक्रम प्रारंभ किया। छात्रों ने थिएटर एवं ड्रामा, नृत्य, संगीत, आर्ट एवं क्राफ्ट, साहित्यिकी, साफ्ट स्क्रिल्स तथा योगा जैसी विविध पाठ्येतर सामूहिक गतिविधियां प्रदर्शित की।
- सहायक संकाय योजना भी प्रारंभ की गई जिसके अन्तर्गत पूरे विश्व के श्रेष्ठ व्यवसायियों को चुना गया तथा वे छात्रों को पढ़ाने एवं परामर्श देने के लिए संस्थान में आए।
- भाकृअनुप-राडेअनुसं मानित विश्वविद्यालय के सोलहवें दीक्षांत समारोह का 10 मार्च, 2018 को आयोजन किया गया। इसमें श्री राधा मोहन सिंह, माननीय केन्द्रीय कृषि एवं किसान कल्याण मंत्री ने दीक्षांत संबोधन प्रस्तुत किया। समारोह में कुल 277 विद्यार्थियों(112 छात्राओं सहित) को विभिन्न डिग्रियाँ अर्थात् बी.टेक(डेरी टेक्नोलॉजी)-27, मास्टर्स-146 एवं डॉक्टरल-104 प्रदान की गई।

## विस्तार

- दुग्ध गुणवत्ता एवं सुरक्षा (एनआरसीएमक्यूएस) के लिए राष्ट्रीय रेफरल केन्द्र ने परीक्षण एवं व्यासमापन प्रयोगशालाओं के लिए राष्ट्रीय मान्यता बोर्ड द्वारा दो वर्षों के लिए 21.3.2020 तक मान्यता प्रदान की गई।
- राडेअनुसं के द्वारा अपनाए गए गाँवों शाहपुर, हेमदा और दादुपुर गाँवों में कुल 34 कैंप आयोजित किए गए। कुल 432 पशुओं का प्रजनन विकारों व विभिन्न पशु चिकित्सा बीमारियों संबंधी इलाज किया गया।
- राडेअनुसं के द्वारा अपनाए गए गाँवों में डेरी किसानों के लिए 34 किसान संगोष्ठियाँ आयोजित की गई।
- फार्मर्स फार्म स्कूल में 20 फार्म महिलाओं का नामांकन किया गया एवं उन्होंने सफलतापूर्वक निर्धारित कोर्स को पूरा किया।
- "एजुकेशन एट द फार्मर्स डोर" कार्यक्रम के अन्तर्गत वैज्ञानिकों ने गाँवों का दौरा किया।
- महिला सशक्तीकरण लेबोरेटरी के द्वारा आयोजित आठ विभिन्न कार्यक्रमों के द्वारा कुल 235 फार्म महिलाएं लाभान्वित हुईं।
- दिनांक 23-25 नवंबर 2017 के दौरान राडेअनुसं द्वारा विकसित की गई विभिन्न प्रौद्योगिकियों को प्रदर्शित करने के लिए राष्ट्रीय डेरी मेला का आयोजन किया गया एवं इस मेले में उत्तरप्रदेश, हरियाणा, पंजाब, दिल्ली और राजस्थान राज्यों से 10000 से अधिक आगन्तुक आकर्षित हुए।
- जनजातीय उप-योजना(टी.एस.पी.) कार्यक्रम के तहत, कुल 473 मवेशियों, 385 बछड़ों व 60 भैंसों का एफ.एम.डी., एच.एस. व बी.क्यू. के विरुद्ध टीकाकरण किया गया। इसके अलावा, 690 बकरियों व 160 भेड़ों का पी.पी.आर. के विरुद्ध टीकाकरण किया गया व 1020 पक्षियों का आर2बी वैक्सीन से टीकाकरण किया गया।
- एन.ई.एच. गतिविधियों के तहत, कई इनपुट जैसे चिक्स (5300 नंबर), पिगलेट (71 नंबर), ब्लेक बेंगाल बकरी (50 नंबर) ब्रायलर प्री-स्टार्टर (200 किलोग्राम), क्रम्बो स्टार्टर (400 किलोग्राम), कैटल फीड (5350 किलोग्राम), कैल्शियम सफ्लीमेंट (50 लीटर), मिनरल मिक्सचर (1567 किलोग्राम), पौल्ट्री फीड (1000 किलोग्राम), वराहार पैलेट (1500 किलोग्राम) को मेघालय, मिजोरम, त्रिपुरा व सिक्किम के 943 किसानों के मध्य वितरण किया गया।
- राडेअनुसं के के.वी.के. ने कृषि व डेरी फार्मिंग व प्रसंस्करण सहित कई संबद्ध विषयों के पहलुओं पर 165 ऑन-कैम्पस एवं ऑफ कैम्पस प्रशिक्षण कार्यक्रमों का आयोजन किया। इन कार्यक्रमों से भारतवर्ष के 12 राज्यों के कुल 6210 किसान व खेतिहर महिलायें लाभान्वित हुए।
- राडेअनुसं के ए.टी.आई.सी.(एटिक) ने टॉल फ्री नंबर, वीडियो शो, वैयक्तिक इन्टरैक्शन आदि के द्वारा देश के विभिन्न हिस्सों के 6606 व्यक्तियों को 5045 सेवायें प्रदान की।
- पीपराकोठी, पूर्वी चम्पारण, बिहार में स्थित राडेअनुसं के सुदूरवर्ती केन्द्र ने 8 प्रशिक्षण कार्यक्रम आयोजित किए व इन कार्यक्रमों से कुल 268 किसानों को लाभ पहुँचाया गया।

## क्षमता निर्माण

- उद्यमशीलता विकास कार्यक्रम के तहत "वाणिज्यिक डेरी खेती" व "दुग्ध व दुग्ध उत्पाद" विषयों पर 14 प्रशिक्षणों का आयोजन किया गया जिसमें 465 प्रतिभागी शामिल हुए।

- वैज्ञानिकों की मेंटरशिप में 15 इन्क्यूबेटी नामांकित हुए एवं सात उद्यमियों ने साइनेड(टी.बी.आई.) के माध्यम से बिजिनेस इनक्यूबेशन के तहत अपने उपक्रम प्रारंभ किये।
- डेयरिंग पर सरकार द्वारा प्रायोजित तीन प्रशिक्षणों का आयोजन किया गया जिसमें विभिन्न राज्यों के 139 हितधारकों ने भाग लिया।
- विकासशील देशों के डेरी व्यवसायियों के लिए एक अन्तर्राष्ट्रीय प्रशिक्षण कार्यक्रम आधुनिक डेरी प्रोद्योगिकी एवं प्रबंधन विषय पर आयोजित किया गया। इसके अतिरिक्त डेरी व्यवसायियों के लिए 9 अन्य प्रशिक्षण कार्यक्रम आयोजित किये गये।
- इस अवधि में, 44 विश्वविद्यालयों व महाविद्यालयों के 150 विद्यार्थियों ने डेयरिंग के विभिन्न विषयों में प्रशिक्षण प्राप्त किया।
- इस अवधि में भाकृअनुप संस्थानों व राज्य कृषि विश्वविद्यालयों (एस.ए.यू.) की फैकल्टी के लिए डेरी प्रसंस्करण में दो सी.ए.एफ.टी. आयोजित किये गये।

### आधारभूत संरचना

- मुख्य परिसर, करनाल में 600 विद्यार्थियों के बैठने की क्षमता वाला विश्वविद्यालय परीक्षा हॉल बनाया गया।
- कृषि एवं डेरी विकास केन्द्र के तत्वावधान में पीपराकोठी, मोतिहारी (बिहार) में एक डेरी प्रसंस्करण युनिट किसानों को पिछड़े व अग्रणी सुदृढीकरण सहित डेरी प्रसंस्करण में व्यापक प्रशिक्षण देकर उन्हें लाभान्वित करने का कार्य करता है।
- सीवेज ट्रीटमेंट प्लांट के चारों ओर चैन लिंक फेंसिंग की फिक्सिंग प्रदान किया जाना, पशु शेड के अद्यतन पानी की नाली के सिविल वर्क्स को जल संरक्षण प्रणालियों के संस्थापन एवं भाकृअनुप-राडेअनुसं करनाल के पशु शेड के लिए पानी की नाली प्रदान किया जाना।
- प्रयोगात्मक डेरी में ऊर्जा व पानी के उपयोग को न्यूनतम करने के लिए वाटर मीटरिंग डिवाइसों को इंस्टाल किया गया।
- सांडों के बाडों की मरम्मत एवं भाकृअनुप-राडेअनुसं करनाल के ए.बी.आर.सी. में पानी की आपूर्ति।
- भाकृअनुप-राडेअनुसं करनाल के ए.बी.आर.सी. मुख्य भवन में स्नातकोत्तर प्रयोगशाला, वीर्य गुणवत्ता नियंत्रण प्रयोगशाला, वीर्य प्रसंस्करण प्रयोगशाला, वीर्य भण्डारण प्रयोगशाला, बाथरूमों व शौचालयों की मरम्मत।
- अलकनन्दा छात्रावास के किचन स्पेस का सुदृढीकरण व विस्तार।
- भाकृअनुप-राडेअनुसं करनाल के ए.बी.आर.सी. में दो सड़कों का जीर्णोद्धार व मरम्मत।
- भाकृअनुप-राडेअनुसं करनाल के अलकनन्दा छात्रावास के 48 कमरों कावेरी छात्रावास के 25 पुराने कमरों एवं बी.टेक (डी.टी.) के 4 क्लास रूमों में डिस्टेम्परिंग व पेंटिंग का कार्य सम्पन्न किया गया।
- भाकृअनुप-राडेअनुसं करनाल के पशु जैवरसायन प्रभाग में स्थित सस्य अनुभाग के कमरा नंबर 141 का जीर्णोद्धार व मरम्मत।
- दक्षिण कैम्पस, बैंगलुरु में 21 चारा किस्मों हेतु चारा प्रदर्शन यूनिट की स्थापना की गई।
- दक्षिण कैम्पस, बैंगलुरु में 50 किलोग्राम हाइड्रोपोनिक चारा (मक्का) प्रति दिन उत्पादन हेतु हाइड्रोपोनिक चारा उत्पादन एवं प्रदर्शन युनिट की स्थापना की गई।
- केन्द्र से निकले मवेशियों के गोबर व पेड़ की पत्तियों व अन्य कार्बनिक कचरे के बेहतर उपयोग के लिए दक्षिण कैम्पस, बैंगलुरु में एक वर्मीकम्पोस्ट उत्पादन युनिट की स्थापना की गई।
- दक्षिण कैम्पस, बैंगलुरु में गर्ल्स हॉस्टल के कृष्णा विंग का निर्माण।
- दक्षिण कैम्पस, बैंगलुरु में थेरिओजिनोलॉजी प्रयोगशाला।

### प्रशासनिक सुधार

- संस्थान में वित्तीय प्रबंधन प्रणाली (एफ.एम.एस.) सहित सूचना प्रबंधन प्रणाली (एम.आई.एस) को कार्यान्वित किया गया है। इस प्रणाली में वित्तीय प्रबंधन, परियोजना प्रबंधन, सामग्री प्रबंधन, मानव संसाधन प्रबंधन व वेतन रोल का समाधान उपलब्ध है। हाल ही में, व्यय, लोक वित्तीय प्रबंधन प्रणाली(पब्लिक फाइनेंशियल मैनेजमेंट सिस्टम) के अग्रिम व स्थानांतरण(ई.ए.टी.) मॉड्यूल को भारत सरकार के निर्देशानुसार कार्यान्वित किया गया है।

# INTRODUCTION



ICAR-National Dairy Research Institute (NDRI) at Karnal, Haryana is one of the premier Institutes in dairy sector which has contributed a lot in the growth of dairy industry and played a crucial role in milk production of India with its continuous research. Over ninety year old NDRI's lineage goes back to the Imperial Institute for Animal Husbandry & Dairying which was set up in Bangalore in 1923 as a center for dairy education. In 1955, it was shifted to its present site in Karnal and renamed as National Dairy Research Institute. The infrastructure of Imperial institute was retained as southern regional station of NDRI and later in 1964 Eastern regional station was set up at Kalyani in West Bengal. In 1970, NDRI was brought under Indian Council of Agricultural Research. Since, 1989, the Institute has the distinction of being a Deemed University for implementing its academic programmes. The Institute has secured First Rank amongst Agricultural Universities of India assessed by ICAR (2016-17) and accredited by NAEA Board, ICAR (up to 2021). The Institute is placed in the special mention category of Institutions by NIRF, Ministry of Human Resources Development, Ranking (2018). The Institute is also ISO 9001: 2008 certified and the process for obtaining ISO 9001: 2015 is in progress. The primary goal of the Institute is to provide R&D support towards generation and dissemination of knowledge for development of national milch herd, milk production enhancement, greater productivity of dairy industry and upliftment of dairy profession leading to socio-economic and environmental benefits to the nation as well as contribute towards manpower development programme. This is a unique campus, which alongside Deemed University and residential buildings, has various well equipped research laboratories as well as green space with perennial plants and gardens. Well equipped sports facilities and attractive leisure time opportunities are offered to the students and employees of the Institute.

## Southern Campus, Bengaluru

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

## Eastern Campus, Kalyani

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

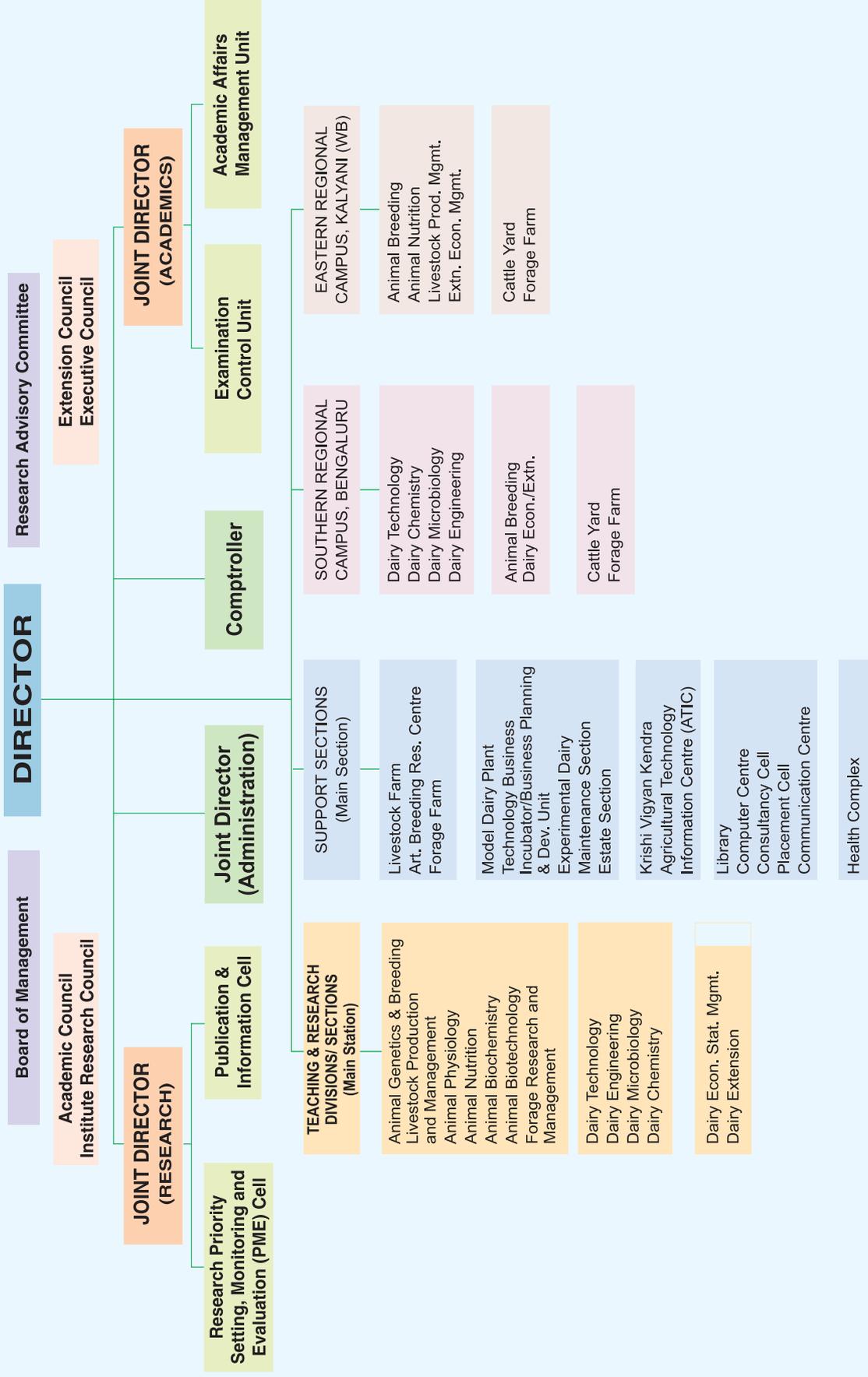
## Krishi and Dairy Vikas Kendra, Piprakothi - Motihari

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

## Model Dairy Centre, Lalukheri - Muzzafarnagar

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

# Organizational Structure of NDRI



# ORGANISATIONAL SETUP

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

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

The highest policy making body is the Board of Management (BOM). The Director NDRI, is the Chairman of this Board. The Research Advisory Committee (RAC) is responsible for all round progress in research at the Institute and its application. The Academic Council is responsible for all issues relating to the education and training. The Academic Council, in turn, is supported by (i) Standing Committees, (ii) the Post Graduate Faculty, and (iii) the Board of Studies in the respective disciplines. The Extension Council is responsible for guiding extension programmes. Institute Research Committee (IRC) is responsible for prioritization, monitoring and evaluation of research conducted in the Institute. The Executive Council is the main task implementing body on Administrative matters and the powers and the function of this Council shall be those as may be delegated by the BOM. The research, education and extension activities of the Institute are managed by the Director and the Joint Directors through scientific, technical, administrative and supporting staff. The Director is the overall Administrative Head of the Institute and its Regional Stations. The Joint Directors in addition to extending support to the Director in the area of research, academics and administration are responsible to co-ordinate research and educational activities of various Divisions and Regional Stations, respectively. Each of the Regional Stations is administered through the Head located at the station. The scientific and teaching work at the main campus and its regional campuses is conducted in 16 subject-matter disciplines.

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**Member Secretary** : Joint Director (Admn. & Registrar)

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**Director (F) DARE**

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# NEW INITIATIVES IN RESEARCH, TEACHING AND EXTENSION

NDRI is a prestigious institute catering to the research and human resource needs of the dairy sector of the country. The demand for milk is increasing and it is expected that by 2050 the milk production will be increased to the tune of 400 million tonnes/year. The population pressure and emerging global opportunities further necessitate that the efforts for enhancing animal productivity and milk processing are accelerated in the following areas:

1

Genetic improvement of dairy animals through genomic semen sexing and strengthening of Institute's bull mother farm.

2

Technologies for economic production of nutrient-balanced ration for dairy animals to address the issue of feed and fodder scarcity.

3

Development of new generation methods to assess quality and safety of milk and milk products.

4

Development and validation of health promoting dairy foods to address nutritional and health security issues.

5

Linking rural youth, women and other target groups to markets through skill and entrepreneurship development programmes.

6

Strengthening outreach programmes for doubling farmers' income.

7

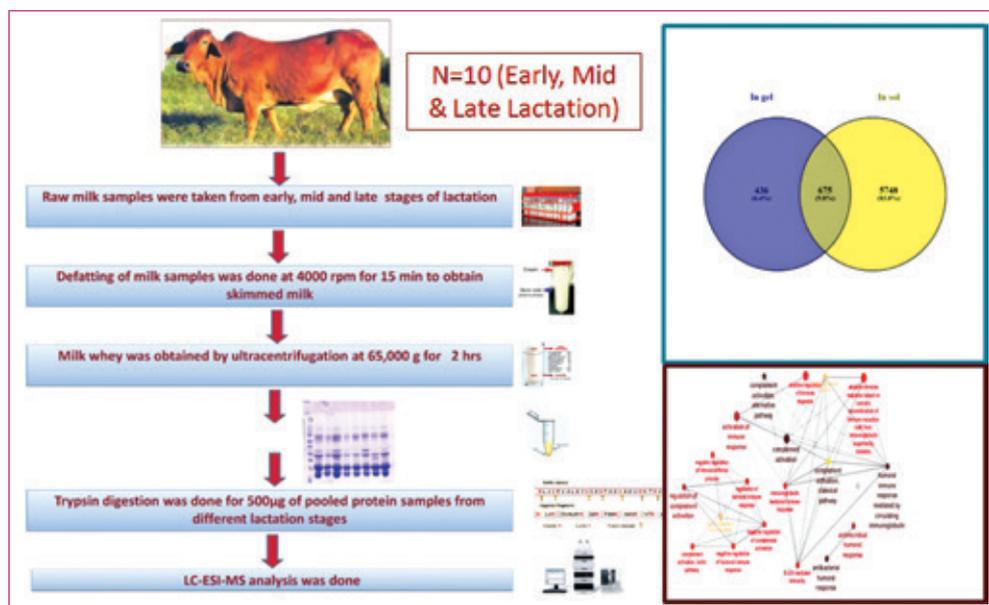
Strengthening HRD programme at the Institute with greater focus on quality and employability together with establishment of stronger international linkages.

## RESEARCH ACHIEVEMENTS

# BIOTECHNOLOGICAL INTERVENTIONS FOR HIGHER PRODUCTIVITY

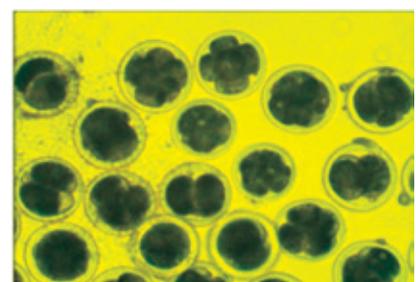
### High Throughput Mass Spectrometry used for Proteome Profiling of Milk Whey Proteins in Sahiwal Cattle

Milk, which is a complete food and a vital source of human nutrition, serves as a medium for transfer of host defense proteins from mother to offspring. Milk proteome comprises of casein proteins in high abundance, and whey proteins and immunoglobulins in low abundance. For exploring the milk whey proteome of Indian zebu (Sahiwal) cattle, milk samples collected from early, mid and late lactation stages were defatted, ultracentrifuged for whey preparation and further subjected to peptide identification by LC-MS/MS which resulted in identification of more than 6800 proteins. Protein-protein interaction network for identified proteins was built by Online pathway analysis software string. Identified pathways were found to be involved in complement activation, defense response, innate immune response, humoral immune response, activation and regulation of immune response, acute phase response, lymphocyte mediated immunity, defense response to bacteria and fungus, regulation of Cdc42 protein signal transduction pathways. Majority of the proteins with high score play important roles in immune regulation and host defense.



### *In Vitro* Development of Cattle Embryos using Triiodothyronine as a Media Supplement

The aim of the present study was to produce cattle embryos through *in vitro* maturation, fertilization and culture by supplementing culture media with triiodothyronine (T3). Immature oocytes were aspirated from surface follicles (3-8 mm dia.) of the Cattle ovaries collected from Kolkata slaughter house and the cumulus-oocyte-complex (COCs) were then washed thoroughly 5-6 times in washing media (TCM-199 + 10% FBS + 27 µg/ml Sod. Pyruvate + 50 µg/ml Gentamycin) and matured *in-vitro* for 24h in maturation media (TCM-199 + 10% FBS + 5 µg/ml FSH-P + 0.33 mM sodium pyruvate + 50 µM β-Mercaptoethanol + 50 µg/ml gentamicin sulfate) supplemented with T3 with three different concentrations (20, 50 and 100 ng/ml) at 38.5°C in CO<sub>2</sub> incubator with maximum humidity. Then, oocytes were allowed for fertilization with capacitated sperms in Fert-BO media at 38.5°C in CO<sub>2</sub> incubator. After 15-18 h of sperm-oocyte co-incubation, the cumulus

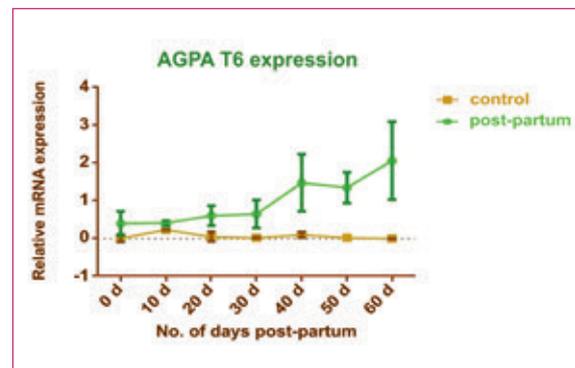
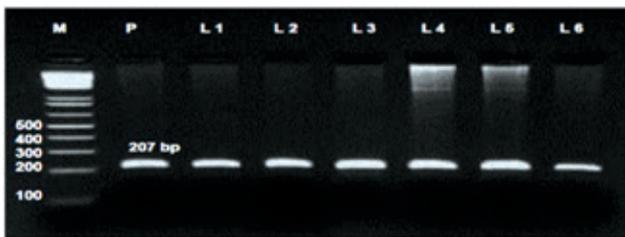


Cattle embryos developed *in vitro*

cells were washed off from the oocytes by gentle pipetting in washing medium. The oocytes were washed 1-2 times with RVCL media and cultured in 100  $\mu$ l RVCL medium supplemented with T3, and cultured for cleavage. After 48h, cleavage was checked and further co-cultured with oviductal cells for development. Results revealed significantly higher early embryo development rates in the treatment than control group. The mean cleavage rate was  $21.02 \pm 1.38\%$  in control group. The highest mean cleavage rate was  $43.72 \pm 6.2\%$  in 100 ng/ml treatment group.

### Expression Profiling of AGPAT6 Gene towards Milk Fat Synthesis in Post-Partum Deoni Cows

PBMC Expression of AGPAT6 gene was studied in post-partum Deoni cows (day 0, 10, 20, 20, 40, 50 and 60 of post-partum) using quantitative PCR. There was significant increase in expression values from day 0 ( $0.401 \pm 0.32$ ) to day 30 ( $0.653 \pm 0.37$ ) followed by day 50 ( $1.351 \pm 1.38$ ) and day 60 ( $2.065 \pm 1.02$ ). Expression of AGPAT6 gene was influenced significantly by stage of lactation (>10-fold at 0 day Vs day 60). The results indicate that there is a strong role of AGPAT 6 gene for regulating the channeling of fatty acids toward copious milk fat synthesis in bovine mammary gland during lactation.



### Application of Pulsed Electromagnetic Field to Cells or Cloned Embryos Leads to Several Beneficial Effects

Application of pulsed electromagnetic field (PEMF) at a low dosage is reported to affect biological processes at molecular and cellular levels leading to several beneficial effects. Exposure of cumulus cells, isolated from in vitro matured oocytes, to different dosages of PEMF were found to increase the relative cell viability and cell proliferation. PEMF treatment also affected the relative expression level of several important genes such as *OCT4*, *SOX2*, *NANOG*, *BCL2*, *BAX*, *DNMT1*, *DNMT3A*, *DNMT3B*, *GLUT1*, *GSK3B*, *CCNB1*, *P53*, *SOD1*, *GPX1* and *HSP70* but not that of *CASPASE3* and *CATALASE*. PEMF treatment of embryos produced by Hand-guided cloning had several beneficial effects such as increased blastocyst rate and lower apoptotic index of blastocysts but it did not affect the total cell number of blastocysts, ratio of ICM:trophectoderm cell numbers and the global level of the epigenetic mark H3K18ac. PEMF treatment increased the global level of H3K27me3 and altered the expression level of several important genes



PEMF Equipment Setup. A: PEMF Controller, B: PEMF Generating Platform, C: CO<sub>2</sub> incubator, D: PEMF measuring device

such as *OCT4*, *SOX2*, *NANOG*, *CDX2*, *BCL2*, *BAX*, *DNMT1*, *DNMT3B*, *HDAC1*, *GLUT1*, *GSK3B*, *CCNB1*, *P53*, and *HSP70*. These results show that PEMF treatment of cloned embryos at selected dosages increases the blastocyst rate, lowers the apoptotic index, changes the epigenetic status and alters the expression level of pluripotency-, cell cycle-, metabolism-, stress- and apoptosis-related genes in cloned blastocysts.

### TALEN used for Production of Goat Transgenic Embryos by Targeted Integration

Transcription Activator-Like Effector Nucleases (TALEN), which has been widely used to perform precise genome editing in a wide range of organisms and cell types, is an efficient technique for production of transgenic cells, which

can then be utilized for production of transgenic animals through somatic cell nuclear transfer. A site-directed transgenesis protocol was developed using TALEN for introduction of GFP at Rosa 26 locus. The study was completed in five phases; viz., i) identification, cloning and sequencing of Rosa 26 locus of goat, ii) construction of TALEN vectors against Rosa 26 locus, iii) construction of Rosa 26- targeted expression vector containing GFP (donor vector) and its *in vitro* functional analysis, iv) co-transfection of TALEN and donor vector into goat fetal fibroblast cells and checking for site-specific integration and v) production of transgenic goat embryos using correctly targeted goat fetal fibroblast cells as nuclear donor by hand-made cloning. This could further be used for site-directed insertion of bio-pharmaceutically important genes for production of transgenic animals expressing these proteins in milk.

### Tetraploid Complementation with Putative Parthenogenetic Embryonic Stem Cells used for Production of Chimeric Goat Embryos

The limited developmental rate of parthenogenetic embryos in mammals has been directly linked to the absence of paternal genetic imprints. First, procedures were standardized for the production of tetraploid embryos by electrofusion of *in vitro* fertilized 2-cell goat embryos. Karyotype analysis of electrofused blastocysts revealed that 40% of them were tetraploid (4n). The second part was aimed at reducing the developmental failure of parthenogenetic embryos through tetraploid complementation with putative embryonic stem cells (pESCs). Complementation with zona-free 4-cell tetraploid embryos aggregated with early passage pESCs enabled the embryos to develop to the blastocyst stage. Then, the expression level of genes related to genomic imprinting (*GRB10*, *IGF2R*, *XIST*, *MEST* *SNRPN* and *IGF2*), placenta (*IFNT*, *CDX2* and *PLAC1*), pluripotency (*OCT4*, *SOX2* and *NANOG*), development (*BMP4*, *VEGF* and *CCNB1*) and methylation (*DNMT1* and *DNMT3A*) was analyzed in IVF, parthenogenetic, tetraploid and chimeric (4n-2n) blastocysts. Tetraploid blastocysts showed significantly ( $P < 0.05$ ) higher expression of paternal imprinting and placenta-related genes. The complemented blastocysts showed a compromised gene expression which was similar to that in the IVF blastocysts. This work could pave the way for production of offspring from parthenogenetically derived embryos in future.

### Modulation of Cumulus Characteristics to Improve the Developmental Competence of Poor Quality Buffalo Oocytes

Staining with brilliant cresyl blue (BCB) dye is used for differentiating cumulus oocytes complexes (COCs) of high developmental competence (BCB+) from those with low developmental competence (BCB-). The cumulus expansion characteristics of BCB- COCs were modulated by treatment with interleukin- $\beta$  (IL- $\beta$ ) during *in vitro* maturation with the aim of improving their fertilizability. The parameters used were morphological appearance of COCS by scanning electron microscopy (SEM), expression analysis of genes related to cumulus expansion, numbers of sperm bound to zona pellucida and development rates. Expression of versican isoforms and *ADAMTS-1* was observed to be significantly different between cumulus cells of BCB+ and BCB- COCs. *ADAMTS-1* expression was increased in BCB- COCs along with corresponding cumulus expansion rates upon IL-1 $\beta$  supplementation. SEM analysis also revealed improved cumulus expansion in IL-1 $\beta$ -supplemented BCB- COCs. Significantly more number of sperm crossed the cumulus barrier, especially in the 100 ng/mL IL-1 $\beta$ -supplemented group. Supplementation with IL-1 $\beta$  also improved the cleavage and blastocyst development rate of BCB- oocytes.

### $\beta$ -defensins to Express a Dynamic Expression Pattern in Different Segments of Buffalo Testes

$\beta$ -defensins coat the mature spermatozoa in epididymis of male reproductive tract in bovine. They are implicated in sperm motility, immunomodulation, cervical mucus penetration, formation of sperm reservoir and evasion of immune response in female reproductive tract, and thus, play an important role in regulating the fertilizing ability of spermatozoa. Out of many  $\beta$ -defensin genes, class-A genes are associated with sperm surface remodelling in epididymis, vas deferens and rete testis in male reproductive tract. The expression pattern of  $\beta$ -defensins (BBD) genes was examined in different segments of male reproductive tract using real-time PCR. Tissue from five segments of male reproductive tract viz. caput, corpus and cauda epididymis, vas deferens and rete testes was collected aseptically from healthy mature buffalo bulls (n=4), 3-4 years of age. Expression pattern of *BBD125*, *BBD127*, *BBD129* and *BBD132* was found to be static in different segments of male reproductive tract. Interestingly,  $\beta$ -defensin-126 and -129 showed 3-4 log fold increase in expression in the distal segment of buffalo epididymis. This study suggests that BBD126 and BBD129 could be possible candidates for coating of mature spermatozoa in male reproductive tract of buffalo bulls.

### Pashmina Fibre and Skin Proteome Unraveled to Understand Fibre Development

Proteome profiling of pashmina fibre and skin were carried out to understand the fibre composition and development. Proteome analysis of pashmina fibre is quite challenging due to its poor solubility and difficulty in protein extraction. Moreover, *Capra hircus* genome has not yet been very well characterized. Unique pashmina fibre and skin proteins could be identified with high reliability by using proteogenomics approach. The identification was

more reliable and specific with respect to pashmina proteins when pashmina goat transcriptomics data generated under the project was used. Several isoforms of keratins (KRTs), keratin-associated proteins (KAPs) and other proteins associated with keratinization and fibre development and structure formation were identified. Around 65 different KRTs and KAPs involved in fibre development, cell and follicle cycle, intermediate filament organization, and other associated functions were identified. Proteins associated with melanogenesis pathway active at anagen stage were also identified. Important signaling pathways regulating fibre growth and hair cycling process which include JAK-STAT, PI3K-AKT, MAPK and WNT, were also delineated. Combining next generation sequencing with mass spectrometry helped identify the proteins specific to pashmina goat. More data are being generated for creating a comprehensive proteome map of pashmina.

### Differentially Expressed Proteins Identified in Buffalo Mammary Epithelial Cells during Lactogenic Differentiation

Development of secretory mammary epithelial cells (MEC) making them capable of synthesizing and secreting milk proteins is called differentiation. The molecular machinery governing the transition from proliferation to differentiation of MECs is fully understood. Proteins differentially expressed during lactogenic differentiation of MECs compared to the non-differentiated MECs were identified using high throughput RNA sequencing (NGS) and mass spectrometry (TMT labeling) approaches. The transcriptome analysis revealed 1371 differentially expressed genes (DEGs) whereas, differential proteome analysis, revealed 757 differentially expressed proteins (DEPs). Pathway analysis revealed that a majority of DEGs and DEPs were involved in a number of pathways such as JAK2-STAT5, insulin, PPAR $\gamma$ , wnt/beta-catenin and MAPK which has major role in differentiation of BuMECs. Other cellular activities such as tight junctions, cell-cell/cell-matrix interactions and cell polarization were found to be upregulated.

### A Stably Transfected COS-1 Cell Line for Expression Recombinant Bovine Leukemia Inhibitory Factor

Leukemia Inhibitory Factor (LIF) is a pleiotropic molecule which plays a very important role in maintenance of pluripotency in stem cells by preventing their differentiation. To date, LIF used for maintaining bovine or buffalo stem cells in culture is of human or murine origin. In order to produce recombinant buffalo LIF (rBuLIF), buffalo LIF gene was cloned in two vectors pCIneo and pAcGFP which were then transfected in COS cell line for expression. A stable cell line COS\_BuLIF\_GFP expressing BuLIF was established and the expression was checked by SDS-PAGE and western blot. Purification strategy by pull down assay was optimized. Using this approach, pure rBuLIF could be obtained from a mammalian expression system. The glycosylated rBuLIF was further used to investigate the signaling pathways under its control to find out whether in addition to canonical pathways Stat3, MAPK and JAK, other pathways like mTOR, Ras, ERK and Hippo-Taz are also responsible for growth inhibition properties of rBuLIF in COS-1 cells.

### Association of TLR2 and IGF-1 Gene Variants with Microbial Mastitis in Murrah Buffaloes

Restriction fragment length polymorphism was detected in exon 2 and 3 UTR 1 regions of TLR2 and in exon 3+ part of Intron 3 region of IGF1 in Murrah buffaloes. The PCR-RFLP (Sau3AI) of exon 2 (partial) of Toll like receptor (TLR2) gene revealed polymorphic pattern with three genotypes: AA (318 bp), AB (318 bp, 66 bp & 252 bp) and BB (66 bp & 252 bp). Animals of AA genotype were least susceptible to mastitis incidence. In TLR2 exon 2-Sau3AI PCR-RFLP, homozygous AA had highest genotype frequency (0.535) among all the screened animals. Frequency of homozygous BB (0.909) genotype was higher in mastitis infected animals. *Staphylococcus* infection was prevalent in genotypes AB, whereas BB genotype was more (50%) prone to *Streptococcus* infection. However, homozygous RR genotype was less susceptible to mastitis incidence in the contig IGF1 exon 3 Rsa I PCR-RFLP while animals with genotype SS were more susceptible to *Streptococcus* mastitis. Association of PCR-RFLP polymorphic patterns of TLR2 exon 2-Sau3AI, TLR2 3'UTR1- PstI and IGF 1 exon 3 with incidence of mastitis was significant. The genotypes AA, DD and RR could be used in marker assisted selection of animals for resistance to mastitis in buffaloes.

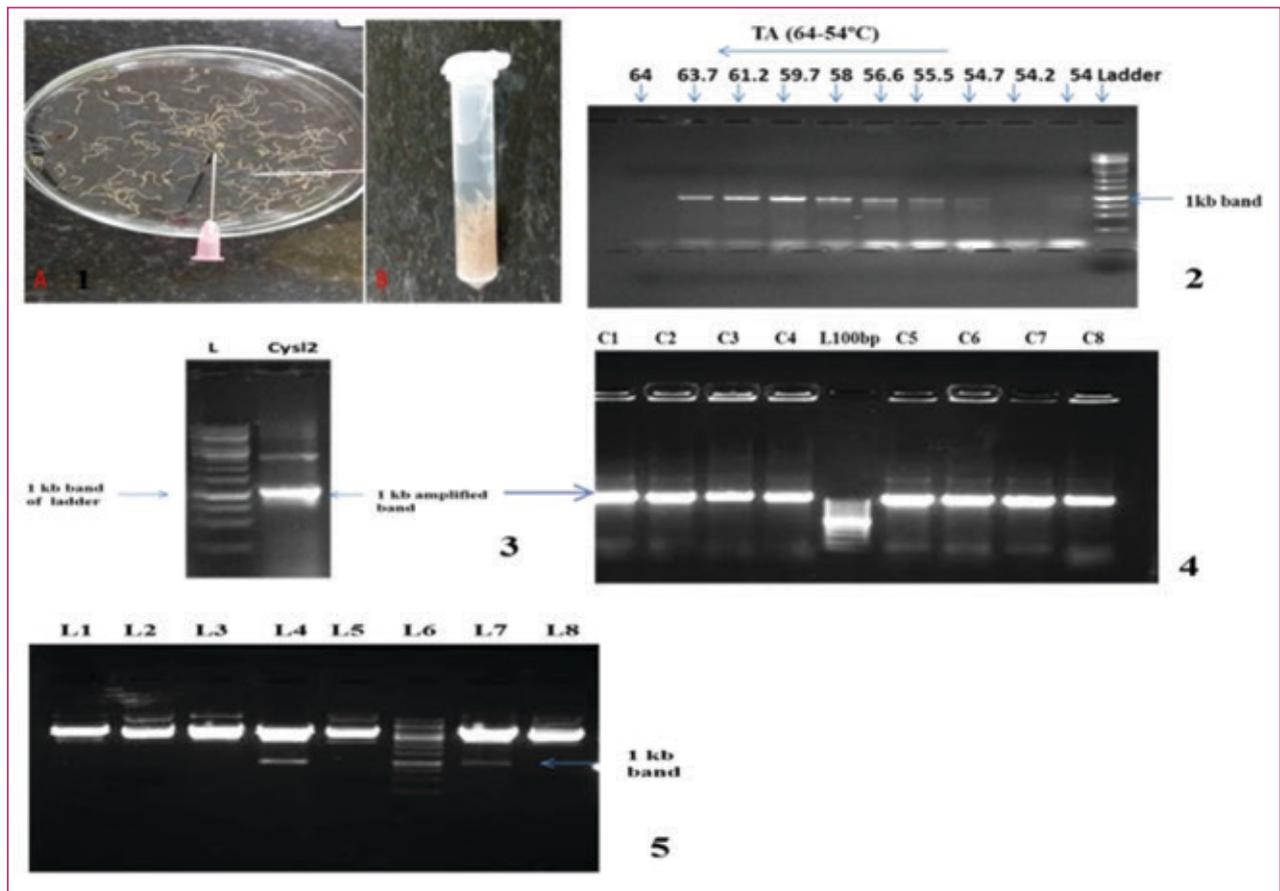
### Expression of Metabolic, Immunological and Inflammatory Related Genes in Transition Cows

The peripheral blood mononuclear cells showed the up regulation of Pro-inflammatory cytokines (IL-6, TNF- $\alpha$ ) during transition period. Pro-inflammatory cytokines (IL-6, TNF- $\alpha$ ) and SAA levels were higher during transition period. The study concluded that there was an up regulation of inflammatory related parameters around or on the day of calving in Karan Fries cattle as compared to Sahiwal indicating less susceptibility of later to periparturient stress.

### Isolation, Identification, and Cloning of Cysteine Synthase Gene of *H. Contortus*

*Haemonchus contortus* is one of the most pathogenic blood sucking parasites of small ruminates (Sheep and Goats). In the present study, collected parasitic worm *Haemonchus contortus* samples from local slaughter house and from Health Division at ICAR-CSWRI, Avikanagar were used for Isolation, identification, and cloning of Cysteine Synthase

gene. Adult *H. contortus*, were manually picked with sterile forceps from the abomasums of slaughtered sheep/ goats, especially from the parasitic infected animals, and samples were washed and stored in RNAlater at -80 °C. Total RNA was extracted directly from fresh *H. contortus* using Trizol reagent and quality and concentration of the RNA was checked at 260/280 ratio by nano-quant, was 1.99 to 2.0, and 2000 to 4000 ng/ul, respectively. After this complementary DNA (cDNA) was synthesised from the total RNA (1000 ng/ul) using oligo dT primer following the standard protocol. The cDNA, thus, synthesized was used for PCR based amplification of Cysteine Synthase protein gene of *H. contortus* using specific primers. Amplification of gene was confirmed by running PCR product in Agarose gel (1%) along with 1kb ladder and examining the gel in gel documentation system (gel doc system). Amplified PCR product size was 1000bp in length, which corresponds to hypothesized Cysteine Synthase protein gene which is actually 1004bps in length. Large amount of PCR product was amplified by using Q5 polymerase (proof reading polymerase) and product was cloned in P-JET1.2 vector and subsequent sequencing of cloned plasmid was done, to confirm Cysteine Synthase protein gene. Sequencing results confirmed that amplified PCR product was indeed Cysteine Synthase gene.



**Collection of worm sample 2: Gradient PCR of *Cys2* 3: Confirmation of *Cys2* gene cloning in pJET1.2 vector by plasmid PCR 4: Cloning confirmation in expression vector (PET302) by Plasmid PCR 5: Cloning confirmation in expression vector (PET302) by single and double RE digestion**



# GENETIC IMPROVEMENT OF DAIRY ANIMALS

## Indigenous Cattle Improvement Programme

The herd strength for Sahiwal was 301 female including 186 breedable females as on 31.12.2017. A total of 31 growing males and breeding bulls were available at the Germplasm Unit. Herd strength of females of Gir cattle was 116 as on 31.3.18. To widen the genetic basis, 9 Gir cows and semen of high genetic merit of 4 bulls of Gir breed from different areas of Gujarat were introduced in the herd. Herd strength of Tharparkar females as on 31.3.2018 was 135.

## Germplasm Production and Utilization

During the period (Jan-Dec, 2017) 8944 doses of frozen semen from 2 Sahiwal bulls were produced. A total of 4830 and 6070 doses of frozen semen were produced from high pedigree bulls of Gir and Tharparkar breeds, respectively. Semen doses were supplied to DRU units at GLF, Hisar, GADVASU, Ludhiana, GBPUA&T, Pantnagar and Bhiwani for AI at those centres. Besides, the centre produced 34864 doses of frozen semen of Murrah buffalo during the period. The centre supplied 2700 doses of frozen semen of two bulls to other centers, NDRI Field Unit and sale to farmers and other dairy development organizations during the period.

## Field Progeny Testing Programme

A total of 3241 AI were performed in Murrah Buffaloes under field conditions during 2017-18 and as a result 50.74% conception rate was obtained. Across the villages, the highest conception rate was observed in Rindal (52.23) and lowest was observed in the village Darar (47.48%). A total of 1397 (757 males and 640 females) Murrah buffalo calves were born in the farmers' herds and performance data on 119 daughters have been recorded for evaluation of bulls under field conditions. The total herd strength of registered females and the breedable females at different centers was 5346 and 3499, respectively.

## Identification of Genetic Variants for Milk Production and Composition Traits

Single Nucleotide Polymorphisms (SNPs) were identified in OLR1, ATF4 and SOCS2 genes in 130 Sahiwal cows to explore homozygous and heterozygous genotypes. A total of 17 SNPs in OLR1, ATF4 and SOCS2 gene were found with 11 transitions and 7 transversions. Polymorphism in 3'UTR of OLR1 gene had positive ( $p < 0.01$ ) effect on ATDFP and LFY. Two SNPs at locus T219C and A280G in 5' UTR of SOCS2 gene had significant effect ( $p < 0.05$ ) on the Lactational fat yield. The CGC haplotype of OLR1 gene with mean  $5.05 \pm 0.12$  had positive effect ( $p < 0.05$ ) on ATDFP in Sahiwal population. Two SNPs in 5' UTR of ABCG2 gene and polymorphisms in exon 2-3 of GHRH gene had positive effect on ADTFP. Nucleotide change in exon 7 of STAT5A gene had positive effect on FL305DMY and LFY while a variation in exon 16 of STAT5A gene had positive effect on ATDFP ( $4.99 \pm 0.03$ ) and LFY ( $102.43 \pm 1.10$ ) in Sahiwal cattle. To summarize, 3 RFLP and 4 SNPs Markers were identified having significant effect on milk yield and milk composition traits in Sahiwal cattle

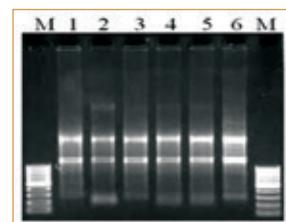
In Murrah buffaloes, a total of 21 nucleotide sequence variations and 6, 8 and 7 SNPs were confirmed in OLR1, ATF4 and SOCS2 genes respectively. There were one amino acid change each in OLR1 (R271T) and SOCS2 (V178I) genes, whereas two amino acid insertion (Y, T) and 9 amino acid change (A56T; G145S; T167A; T198A; G199V; C203R; I204V; A267V and L348P) in ATF4 gene were found. TT genotype of C10869T SNP in OLR1 gene had positive ( $p < 0.033$ ) effect on ATDFP ( $8.248 \pm 0.124$ ). TT genotype of C82T SNP in ATF4 gene had positive ( $p < 0.002$ ) effect on LFY-kg ( $168.37 \pm 3.81$ ). GT genotype of G81T in ATF4 gene also had positive ( $p < 0.024$ ) effect on LFY-kg ( $176.069 \pm 2.795$ ). CA genotype explored by *TaqI* in ATF4 gene had positive ( $p < 0.041$ ) effect on ATDFP ( $7.794 \pm 0.116$ ).

A total of ten variations with 5 transition, 4 transversion and one deletion were observed CRH gene in 100 lactating Murrah buffaloes. Six nucleotide variations were in the coding region of exon 2. Out of which two were non-synonymous resulting in amino acid substitutions: R4L and A37V due to SNPs G11T and C110T, respectively. PCR-RFLP using restriction enzymes *Alu* 1 and *Taq* 1 produced monomorphic fragment pattern showing only with AB and

BB genotypes, respectively. RFLP with *Hae* III revealed three genotypes GG, AG and AA with respective genotypic frequencies 0.40, 0.23 and 0.37 that of G and A and G allele as 0.52 and 0.48. No association was observed between GG, AG and AA genotypes and first lactation 305 days milk yield, average test day milk yield, average test day fat percentage and lactational fat yield.

### Method for Isolating Next-Generation Sequencing Quality RNA from the Adipose Tissue of Recalcitrant Animal Species

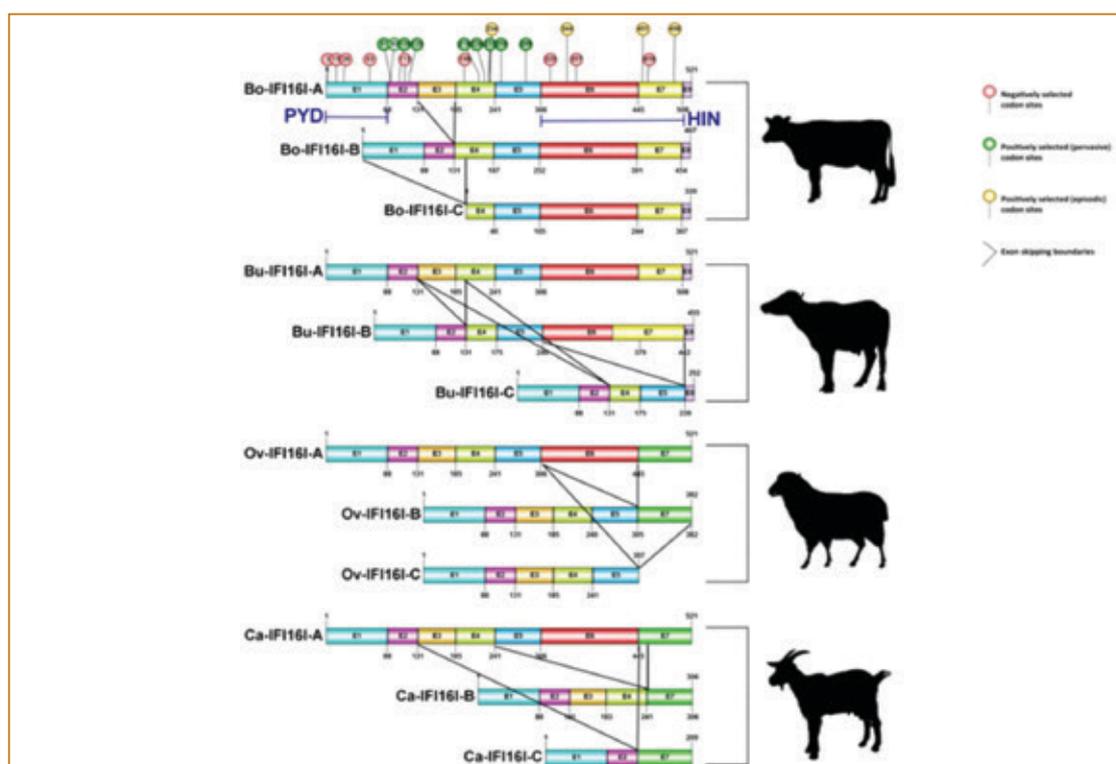
High quality RNA is absolutely essential for next-generation sequencing (NGS) to explore the transcriptome of any tissue. However, isolating high quality RNA from the adipose tissue of buffaloes was a challenging task with the currently available commercial RNA isolation kits. Therefore, a novel two-step RNA isolation method was developed without using the traditional Trizol method. This method worked for the isolation of high quality RNA for NGS from the adipose tissue of multiple species, including buffaloes.



RNA isolation from the adipose tissue of (1) Chicken, (2) Mouse, (3) Sheep, (4) Goat (5) Pig (6) buffalo using the novel isolation method. M: Marker.

### Viral DNA Sensor (IFI16) Transcript Variants Elucidated in Indian Dairy Animals

After viral infection, the host-encoded Pattern-Recognition Receptors (PRR) which recognize viral nucleic acids include TLRs, RIG-I-like receptors and certain DNA sensors such as cGAS and IFI16 (interferon-inducible protein 16). They play an important role in restricting the viral multiplication inside the host cell. The disease resistance capacity of Indian dairy animals was compared to the exotic germplasm especially in the IFI16 host DNA sensor. This led to elucidation of the full length transcript of the IFI16 DNA sensors from Indian dairy animals with a number of different transcript variants. The IFI16 gene sequences were selectively amplified, cloned and sequenced from Indian cattle (*Bos indicus*), water buffalo (*Bubalus bubalis*), goat (*Capra hircus*) and sheep (*Ovis aries*). They were amplified from cDNA preparation of peripheral PBMCs. Three transcript variants of IFI16-like gene were obtained in all cDNA preparations. They have been named as transcript variants A, B and C out of which the largest and the most abundant was variant A. The ORF residue length of 'A' transcript is conserved in all ruminants while the lengths of other two transcripts i.e. B and C have different lengths in all the ruminants. These results provide transcript sequence information about host cellular IFI 16 molecules which counter DNA virus replication in the nucleus. It may be possible in the long run develop approaches for enhancing the ability of host cells to resist DNA virus infections. Bovine Herpes Virus is a typical example of DNA virus infecting ruminants (cattle and buffalo) without any permanent cure.



Three transcript forms of IFI16 gene (viral DNA sensor) in ruminants. The illustration depicts exon skipping event among transcript variants of IFI16 gene. Exon skipping events are marked in black lines.

## Genetic Analysis of Lactation Persistency and its Relationship with Economic Traits of Crossbred Cattle

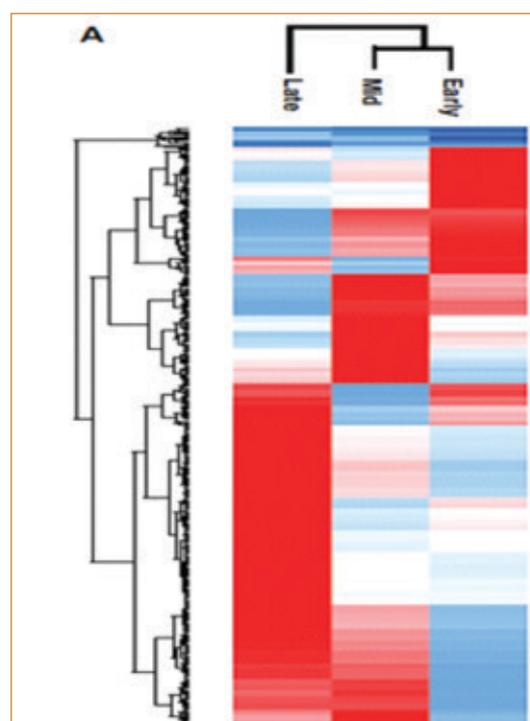
Data on lactation traits of 250 Jersey crossbred cattle, maintained at the Eastern Regional Station of ICAR-(NDRI, Kalyani) were collected for a period of 36 years (1980-2015) to study the effect of important environmental factors on lactation persistency of animals. The lactation traits viz. part lactation (1<sup>st</sup> 100 days, 2<sup>nd</sup> 100 days), 305 days milk yield, total milk yield, lactation length, peak yield and 5<sup>th</sup> month milk yield was considered. Lactation persistency was estimated by ratio methods. Two lactation persistency indices for each animal was calculated by using the formulae: i) P1 (Persistency index 1) = 2nd 100 day milk yield / 1st 100 day milk yield and ii) P2 (Persistency index 2) = lactation milk yield / peak yield. The overall least squares means of P1 and P2 were  $0.72 \pm 0.02$  and  $190.53 \pm 8.67$ , respectively. In this study, the season of calving was significant ( $p < 0.05$ ) for P1. The animals calved in winter were most persistent than summer and rainy calvers. Period of calving had also significant ( $p < 0.05$ ) influence on all the persistency indices. However, there was no definite trend over the periods but animals calved during 1980-1985 had comparatively higher persistent; whereas, the cows calved in 2010-2015 had lower persistent than others. The parity/lactation number of cow showed significant effect on persistency index 2 in the present study. Cows in first parity had the highest persistency than those in other parity. The persistency values tended to decrease with advance of age (parity), until the fifth lactation. Older cows were less persistent than the young ones. Age at calving didn't have any significant effect on all persistency indices in this study.

## Genotype by Environment Interaction on Milk Production Traits of Crossbred Dairy Cows

A genotype (G) x environment (E) interaction may be defined as a change in the relative performance of a trait of two or more genotypes measured in two or more environments. A total of 12364 monthly milk yield (MMY) and 12364 average daily milk yield (ADMY) in a month records of crossbred cows reared at institute herd of ICAR-NDRI, Eastern Regional Station, Kalyani were collected to investigate the existence of genotype (genetic group) by environment (THI) on milk production traits. The data were classified into 8 genetic groups according to the breed composition (CB cattle with  $\geq 50\%$  Holstein inheritance, 50% Jersey and 50% Red Sindhi, 50% Jersey and 50% Tharparkar, 50% Jersey and 25% exotic inheritance from Holstein/Brownswiss and 25% indigenous inheritance, 50% Jersey and 50% indigenous inheritance form more than one breed, 25% Jersey and 25% Holstein with 50% indigenous inheritance,  $>50\%$  to  $<75\%$  Jersey inheritance,  $\geq 75\%$  Jersey) and Least Squares Analysis revealed highly significant effect ( $P < 0.01$ ) of non-genetic factors (parity, period of calving, age group and stage of lactation) on both MMY and ADMY. The data were adjusted for the significant non-genetic factors and were used for GxE interaction study. GxE interaction significantly affects the milk production traits of the herd. HF crossbred cows are more heat sensitive than Jersey Crossbred cows w.r.t. milk production traits. Crossbred cows with 50% Jersey inheritance perform better than higher Jersey inheritance.

## Whey Proteome Variation at Different Stages of Lactation in Malnad Gidda Cattle

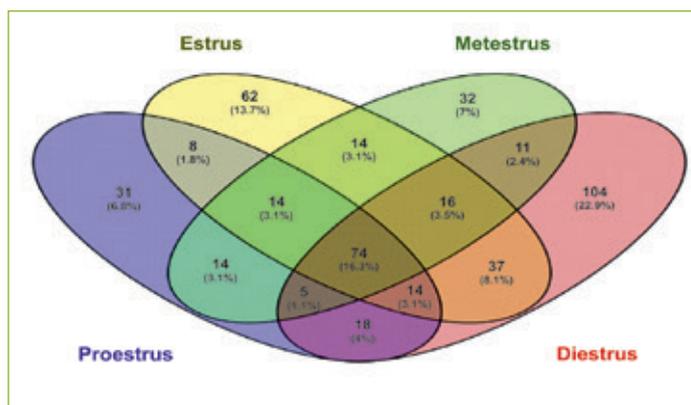
High-resolution mass spectrometry-based quantitative proteomics of milk-whey proteins at early, mid and late lactation in Malnad Gidda cows was studied. Out of the 564 proteins identified, 403 proteins were differentially expressed among the lactation stages. Hierarchical clustering of total proteins identified across lactation stages were carried out. Identified 30 proteins that were found to be involved in complement and coagulation cascade pathway, in which 90% were highly abundant in mid or/and late lactation. Our study represents the first and largest inventory of bovine milk proteins identified to date for an Indigenous breed of cattle.



# ANIMAL FERTILITY, REPRODUCTION AND DIAGNOSTICS

## Identification of Estrus Specific Candidate Proteins in Buffalo Saliva Using High Throughput Mass Spectrometry

Saliva collected from 8 Murrah buffaloes at different stages of estrous cycle were subjected to global proteome analysis using in-solution digestion and nano-LC-MS/MS. A total of 275, 371, 304 and 565 proteins were identified with  $\geq 2$  peptides during proestrus, estrus, metestrus and diestrus stages of estrous cycle. Among the identified proteins 31, 62, 32 and 104 proteins were found specific to proestrus, estrus, metestrus and diestrus. Among the identified proteins 74 proteins were found to be common to all the stages. Gene Ontology based on molecular function revealed majority of the proteins were involved in catalytic activity (44.1%), binding activity (39.8%) and rest of the proteins were involved in structural molecule activity (7.5%), transporter activity (5.4%) and receptor activity (3.2%). Identified estrus specific proteins were involved in several pathways such as PI3K-Akt signaling, Oxytocin signaling, Antigen processing and Presentation, Salivary secretion, oocyte meiosis, estrogen signaling and calcium signaling pathways which are important for various events associated estrus. Few salivary proteins such as Cullin associated NEDD8-dissociated protein 1, Heat shock 70 kDa protein 1A, 17-beta-hydroxysteroid dehydrogenase type 1, Inhibin beta A chain, testin were identified as estrus specific and are important for estrus physiology. Further analysis using iTRAQ based quantitative proteomics revealed 583 differentially expressed proteins (DEPs), out of which 28 proteins identified with at least two peptides were up-regulated (fold change  $\geq 1.5$ ) and 32 proteins identified with at least two peptides were down-regulated (fold change  $\leq 0.6$ ) at estrus stage as compared to other stages of estrous cycle. Out of up-regulated proteins, Vomeronasal type-1 receptor, Nucleobindin-1, Mucin-19, Cadherin-19, Thioredoxin, Tudor domain-containing protein 6 and protocadherin gamma-C3 proteins were found highly abundant at estrus.

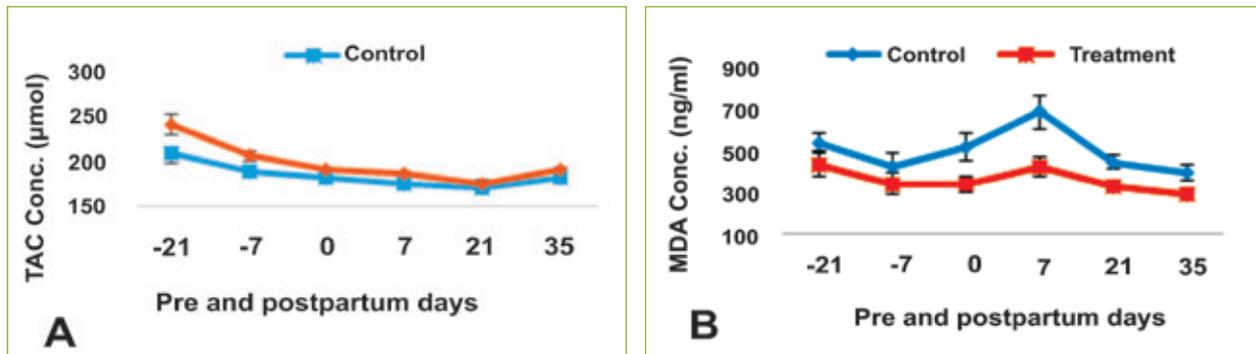


Venny schematic diagram depicted the protein identities of proestrus, estrus, metestrus and diestrus stages in buffalo saliva.

## Effect of Administration of Vitamin E and Se on Oxidative-Antioxidative Status and Postpartum Uterine Health in Crossbred Cows

The effect of administration of vitamin E and Se (Selenium) on ameliorating oxidative stress status during peripartum period and their relationship with postpartum uterine health was assessed in crossbred cows (n=14). Cows in control group received no supplementation while the cows in treatment group received vitamin E (550 IU) and Se (15mg) through subcutaneous administration on day -30, -15, 0, 15 and 30 of calving. Peripheral blood concentrations of vitamin E, selenium (Se), total antioxidant capacity (TAC), malondialdehyde (MDA) and nitric oxide (NO) during peripartum period and uterine health was monitored during postpartum period in cows. Vitamin E concentration was significantly ( $P < 0.05$ ) higher on day 7 and day 21 of calving and plasma Se concentration ( $P < 0.05$ ) was high on

day -21, 0 and 21 post-calving in treated cows compared to control. Further, TAC level was higher on day -21, -7 and 7 of calving in treated cows than control group. MDA and NO concentration was higher ( $P < 0.05$ ) on day 0, 7, 21, 35 and on day -21, -7, 0, 7 and 21 of calving, respectively, in untreated control cows compared to treated cows. Occurrence of uterine infection was higher in untreated control group than treatment group of cows. Further, reproductive performance was higher in cows in treatment group as compared to control group.



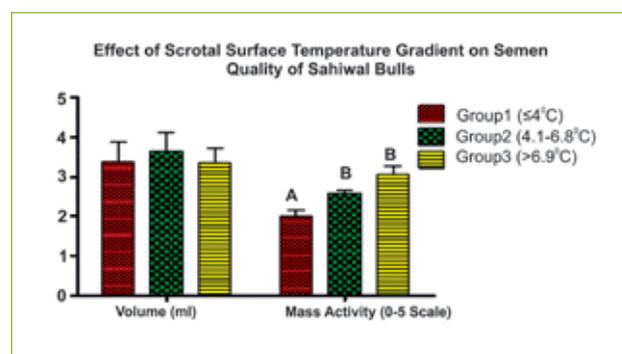
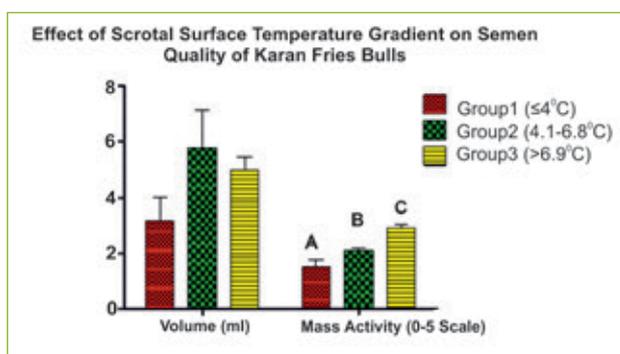
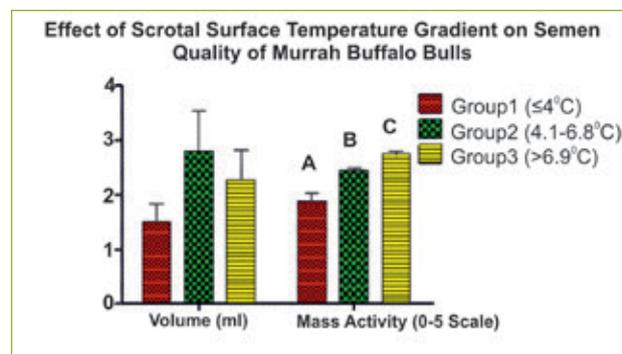
Circulating conc. of TAC (A) and MDA (B) during peripartum period in untreated control and vitamin E and Se treated cross bred cows.

### Effect of Betaine Supplementation on Reproductive Performance of Karan Fries Cows during Hot-Humid Condition

The effect of betaine supplementation on heat stress amelioration and improvement of reproductive performance was studied in crossbred cows. Cows in treatment group ( $n=9$ ) were supplemented with betaine for 112 days while the other 9 cows acted as control. Rectal temperature and skin temperature of cows showed significant decrease ( $p < 0.05$ ) in the treatment group. The fold change in mRNA expression of Heat Shock Proteins (HSP 70.1, HSP 70.2, HSP 70.8 and HSP 90) showed significant decrease ( $p < 0.05$ ) in the treatment group. Plasma levels of cortisol, progesterone, total cholesterol differed significantly ( $p < 0.05$ ) between two groups. The incidence of RFM and metritis, service period, interval from calving to conception, interval from calving to days of first insemination, days of first ovulation and days of first observed heat were found significantly less ( $p < 0.05$ ) in the treatment group. Uterine involution occurred more rapidly in the treatment group and there was significant decrease ( $p < 0.05$ ) in the number of medium sized ovarian follicles and significant increase ( $p < 0.05$ ) in the number of small sized ovarian follicles in the Betaine supplemented group. In conclusion, betaine is found to be effective in mitigation of heat stress and improved reproductive performance of KF cows during hot-humid condition.

### Relationship of Scrotal Infrared Digital Thermography and Sperm Abnormalities of Dairy Bulls during Winter Months

Scrotal infrared digital thermography was studied in Karan Fries ( $n=15$ ), Sahiwal ( $n=15$ ) and Murrah buffalo (18) bulls were studied and related to the sperm abnormalities in the ejaculates. Scrotal circumference (SC) and testicular covering thickness (TCT) were measured. Temperature at different body points and at scrotum was measured three times a day per week during peak winter using an infrared camera and scrotal surface temperature gradient (SSTG) was calculated. In all the three breeds, the mass activity and sperm viability were significantly higher in bulls with high SSTG. Sperm abnormality reduced significantly ( $p < 0.01$ ) with



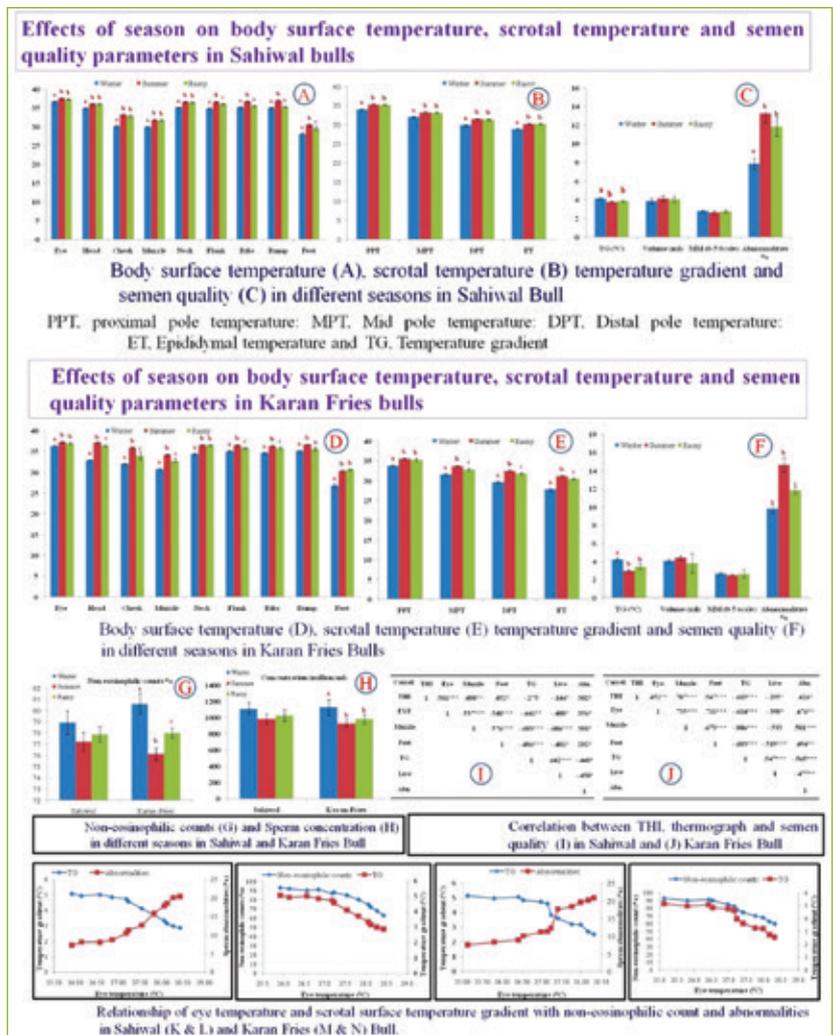
increase in SSTG. The bulls with higher scrotal circumference and lower thickness of testicular coverings and showing higher scrotal surface temperature gradient produced better quality semen. Therefore, SSTG, SC and TCT may be used as an indicator of semen production in Murrah, Karan Fries and Sahiwal bulls during breeding soundness evaluation.

### Role of Estrus Specific Molecules on Semen Production Performance of Sahiwal and Karan Fries Bulls

The influence of estrus specific molecule(s) on reproductive behavior and libido of donor bulls was studied. Based on sexual behaviour score, bulls were classified into weak and strong libido groups. Seven synthetic estrus specific molecules i.e. coumarin, squalene, oleic acid, 2-butanone, acetic acid, propionic acid, 1-iodoundecane were used on ten breeding Sahiwal bulls. Same bulls were used as a control and exposed to each molecule one by one by giving a refractory period of 14 days. An individual nasal spray of acetic acid or 2-butanone to strong libido bulls reduced reaction time (RT) and Total Time Taken to Ejaculate (TTTE), and increased Libido Score (LS), Mating Ability Score (MAS), Sexual behaviour Score (SBS), but no change was observed in overall semen production. With the exposure of acetic acid, oleic acid and 2- butanone in weak libido group, RT and TTTE decreased while LS, SBS, MAS and sperm concentration increased. In another experiment, 12 Sahiwal bulls (irrespective of libido status) were divided into two groups i.e. control and treatment group. In control group, water and glycerol were applied as a nasal spray and in treatment group mixture of acetic acid, 2-butanone and oleic acid were applied as a nasal spray. The results revealed that RT, TTTE, LS, MAS and sexual behaviour score was significantly ( $p < 0.01$ ) improved after application of estrus specific molecules. Volume, mass activity, sperm concentration and total sperm per ejaculate improved significantly after application of estrus specific molecules as compared to control. The above said synthetic estrus specific molecules were also tested for their effectiveness on six Karan Fries bulls selected based on the higher reaction time and obtained similar trend of results. It was concluded that acetic acid, 2-butanone and oleic acid are effective for better sexual preparation of Sahiwal and Karan Fries bulls and to increase the total sperm output.

### Breed Specific Effect of Season on Bull Semen Quality and its Relationship with Body and Scrotal Surface Infrared Thermogram

Weekly thermographic profiling of different body points of 17 Sahiwal and 16 Karan Fries breeding bulls were carried out over a period of one month each during winter (November–February) and summer season (March–June) to assess the effect of breed on body and scrotal surface temperature. Additionally, the relationship of season on semen quality was also studied. The body surface and scrotal temperatures were significantly higher during the summer season as compared to winter season. In both the breeds, season had a significant ( $P < 0.05$ ) effect on the cheek, muzzle, flank, feet, proximal pole temperature (PPT), mid pole temperature (MPT), distal pole temperature (DPT) and ear temperature (ET) and sperm abnormalities. Additionally, the effect of season was significant on sperm viability and concentration in Karan Fries bulls. Deterioration of semen quality was significantly higher in crossbred KF bulls as compared to Sahiwal bulls, possibly due to higher thermal stress susceptibility of the former breed. Season and breed of bull had a marked influence on thermal profile of scrotum. It can



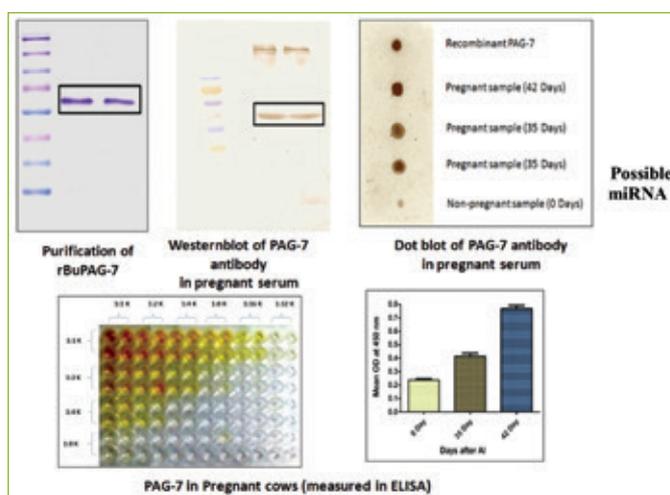
be concluded that winter is the most favourable season for good quality semen production in both the breeds. Moreover, monitoring of body surface temperature by infrared thermography was found to be useful in evaluating the effects of thermal stress.

### Sperm Kinematics and Functional Attributes in High and Low Fertile Sahiwal Bulls

Sperm kinematics and functional attributes were assessed in high and low fertile Sahiwal bulls. Bulls were classified into high and low fertile based on conception rate ranging from 43 to 58 % and 25 to 37%, respectively. Ejaculates with mass motility  $\geq 3+$  and individual progressive motility  $\geq 70\%$  were diluted with Tris-egg yolk-glycerol extender @  $80 \times 10^6$  sperm/ml and cryopreserved as per the standard protocol. Frozen-thawed semen samples were evaluated for CASA parameters viz., VAP, VSL, VCL, ALH, BCF, STR, LIN, Motile pct, Progressive pct, Rapid pct and Slow pct and sperm functions such as membrane integrity, acrosome reaction and hypo-osmotic swelling (HOS) response. VAP, VSL, VCL, Motile pct, Progressive pct, Rapid pct were significantly ( $P < 0.05$ ) higher in high fertile as compared to low fertile bulls. However, Slow pct was significantly ( $P < 0.05$ ) higher in low than high fertile bulls. The percentage of live, live acrosome intact and HOS responsive sperm were significantly ( $P < 0.05$ ) higher in high as compared to low fertile bulls. Per cent moribund, dead acrosome intact and dead acrosome-reacted sperm were significantly ( $P < 0.05$ ) higher in low fertile as compared to high fertile bulls. It was inferred that sperm kinematics and function tests may be used for assessing fertility level of Sahiwal bull semen.

### Development of a Proof-of-Concept Based on Buffalo Pregnancy-Associated Glycoprotein-7 (BuPAG7)

Early diagnosis of pregnancy is essential for efficient reproductive management in animal herds for maximizing economic benefits. Pregnancy-associated glycoproteins (PAGs) are potential pregnancy biomarkers in farm animals since they are secreted from the conceptus into the maternal circulation during pregnancy. Their concentration rises to detectable levels in maternal blood and milk during days 22 to 28 after fertilization. If pregnancy failure occurs, PAG concentrations drop and they disappear from milk and maternal blood. BuPAG7 was cloned and expressed in genetically engineered *E. coli* host. Purification of recombinant buffalo PAG-7 was done by using different types of chromatography. Recombinant purified proteins and their peptides were used for generation of antibodies in rat and rabbit models. PAG antigen-antibody interaction analysis was done by western blot, dot blot and Surface Plasmon Resonance. Reactivity and sensitivity of the antibodies were checked by dot blot, western blot and ELISA. The best interacting antibodies were used for standardization of ELISA. Validation of the test was done by screening of serum samples of pregnant and non pregnant cattle and buffaloes. The ELISA developed offered high specificity and sensitivity.



### Candidates Identified for Early Detection of Pregnancy in Buffaloes

miRNAs belong to a class of small non-coding RNAs which are associated with several biological processes including establishment of pregnancy. miRNAs related to pregnancy, which probably come in circulation at an early stage of pregnancy, were investigated. The profile of miRNAs associated with buffalo placentomes consisting of caruncle and cotyledon, was generated. Uterine horns of pregnant buffaloes were obtained from gravid uteri collected from slaughterhouse. Based on the crown rump length, pregnancy was classified into early, mid and late stages. Next-generation sequencing of the tissue was carried out to generate the profile of miRNAs associated with buffalo placentomes. Nearly 418 conserved and 129 novel miRNAs were identified. Preliminary bioinformatics analysis showed a positive correlation of RNA polymerase with the identified miRNAs. Based on the abundance of the read count and RPM values, 14 miRNAs were short-listed for their presence in circulation in pregnant animals. The study provides a crucial lead for identifying miRNAs associated with the establishment of pregnancy in buffaloes.

### Studies on Seminal Plasma Reactive Nitrogen Species as Biomarkers of Semen Quality

Hot humid and winter season have significant impact on semen functional parameters such as percent viability, acrosome intact spermatozoa, morphologically normal spermatozoa and membrane intact spermatozoa. Parameters like mass activity, percent progressive motility and sperm concentration remain unaffected in both the

seasons. Nitric oxide concentration in semen plasma was significantly ( $P < 0.01$ ) higher in samples collected during hot humid season ( $60.97 \pm 4.50 \mu\text{M/L}$ ) as compared to winter ( $37.11 \pm 3.80 \mu\text{M/L}$ ) among different bulls. Higher levels of malonaldehyde ( $P < 0.01$ ) were observed in seminal plasma collected during hot humid season ( $1.23 \pm 0.13$ ) as compared to winter ( $0.89 \pm 0.09 \mu\text{M/ml}$ ). ALT and AST activity in semen is a good indicator of acrosomal damage. Testosterone levels were not influenced in hot-humid and winter season but higher estradiol levels were negatively correlated to sperm motility and sperm abnormality. NO concentration greater than one micro-molar enhanced TBARS, thus demonstrating its role in lipid peroxidation of the polyunsaturated fatty acids (PUFA) within the sperm plasma membrane. Sperm motility was affected by L-NAME in a dose dependent manner. However, no significant difference in sperm ATP concentration was observed during the course of exposure to different concentration of L-NAME.

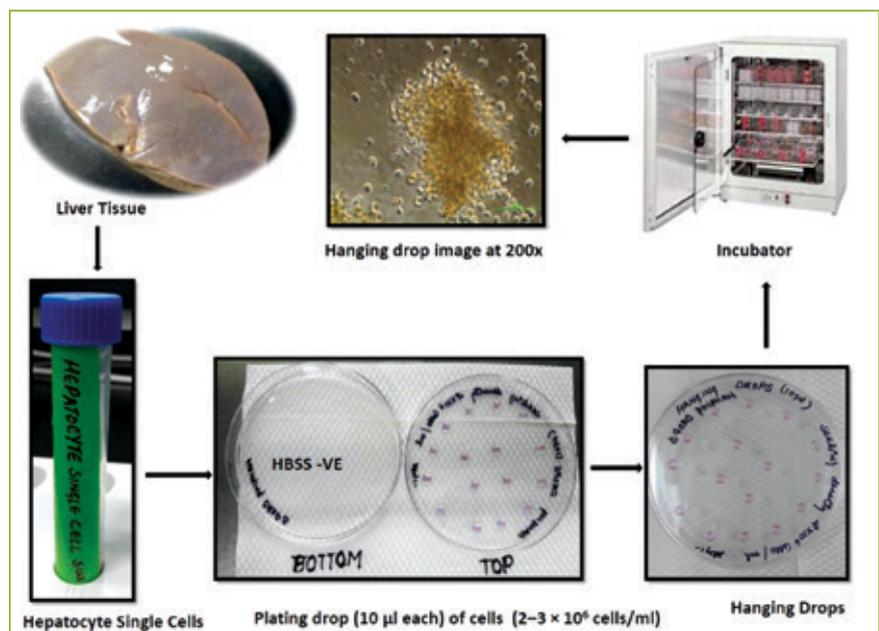
### Role of Trace Minerals Supplementation on Semen Quality of Bulls

The effect of dietary supplementation of Cu and Zn on nutrient digestibility, semen quality parameters, and certain bio-chemicals parameters were evaluated in Murrah bulls. The animals were given supplemented diet with 0%, 25% Cu and Zn, and 50% Cu and Zn above the basal diet for 180 days. Quantitative and qualitative characteristics of semen, blood and seminal plasma antioxidant status, blood and semen minerals (Cu, Zn, Ca, Mn), blood glucose level along with sexual behaviour were measured. The level of Cu and Zn supplementation did not influence dry matter intake, nutrient intake, digestibility of the nutrients (DM, OM, EE, NDF, ADF) and body weight of the animals. Cu and Zn supplementation improved ( $P < 0.05$ ) Zn level in blood and seminal plasma and Cu level in blood plasma only, but not in seminal plasma. Similarly, blood glucose concentration in different groups was similar by different levels of Cu and Zn supplementation. Semen ejaculate volume (mL), sperm concentration (million/mL), intact acrosome (%), HOST reacted spermatozoa (%), were increased at (50%) Cu and Zn supplemented groups compared to the mass motility, pH, live spermatozoa (%). No difference was observed in sexual behaviour except dismounting time. Treatment effect was found in activity of SOD in blood plasma and LPO activity in seminal plasma in both (25% and 50%) Cu and Zn supplemented groups whereas catalase activity did not show any significant difference. Therefore, it can be concluded that supplementation of Zn and Cu @50% above recommended levels of ICAR (2013) improved the qualitative and quantitative attributes of semen in Murrah bulls.

### Hanging Drop Method for 3D Culturing of Buffalo and Sheep Primary Liver Cells as well as Buffalo Granulosa Cells

Three-dimensional (3D) cell culture systems using collagen-coated plates, collagen sandwich, polyHEMA-coated plates

and hanging drop method were developed to culture the primary hepatocytes of the buffalo and sheep. The sheep hepatocytes formed 3D-structures on the fifth-day and maintained until the tenth-day on polyHEMA-coated plates and in hanging drops with William's E media (HDW). Similarly, buffalo hepatocytes formed 3D structures on the third-day and maintained until the sixth-day on polyHEMA and HDW. In addition to morphology, the HDW maintained the liver transcript markers more or less similar to the fresh hepatocytes of the sheep and buffalo for ten and six days, respectively. Overall, hanging drop was considered as an efficient method for 3D culturing of primary sheep and buffalo hepatocytes (Shri et al., 2017. *Sci Rep.* 2017 Apr 26;7(1):1203). A similar system was also developed for buffalo granulosa cells (GC) collected from small ovarian follicles. The expression profile of nine GC-specific transcripts revealed that 3D-spheroids developed in hanging drop method maintained the GC phenotype of preovulatory follicles. Therefore, hanging drop method is a best method for culturing GCs to mimic the intrafollicular environment (Yadav et al., 2018. *J Cell Physiol.* Mar; 233 (3) :1959-1970)



**Methodology for 3D culturing buffalo primary hepatocytes in hanging drops**

A similar system was also developed for buffalo granulosa cells (GC) collected from small ovarian follicles. The expression profile of nine GC-specific transcripts revealed that 3D-spheroids developed in hanging drop method maintained the GC phenotype of preovulatory follicles. Therefore, hanging drop method is a best method for culturing GCs to mimic the intrafollicular environment (Yadav et al., 2018. *J Cell Physiol.* Mar; 233 (3) :1959-1970)

## Lower Presence of Salivary miR-16, miR-191 and miR-223 - An Intuitive Indication of the Presence of Dominant Ovarian Follicles in Buffaloes

The expression analysis of the estrogen responsive microRNAs (miR-24, miR-200c, miR-16, miR-191, miR-223 and miR-203) in the buffalo saliva indicated that these microRNAs could be an intuitive indication of the presence of dominant ovarian follicles in buffaloes. Samples collected at the estrus (0 day), 6<sup>th</sup>, 10<sup>th</sup> and 18-19<sup>th</sup> days of estrous cycle indicated that there was a significant ( $P < 0.05$ ) increase in the salivary presence of the miR-16, miR-191 and miR-223 at 6<sup>th</sup> and 18-19<sup>th</sup> days of the buffalo estrous cycle and no significant difference in their levels among estrus (0 day), 10<sup>th</sup> day and the following consecutive estrus day. These observations may indicate an association between the representative lower presence of these miRNA in saliva and the presence of dominant ovarian follicles.

## Polymorphism in Luteinizing Hormone (LH) beta gene and its effect on semen quality traits and LH concentration in Murrah Buffaloes

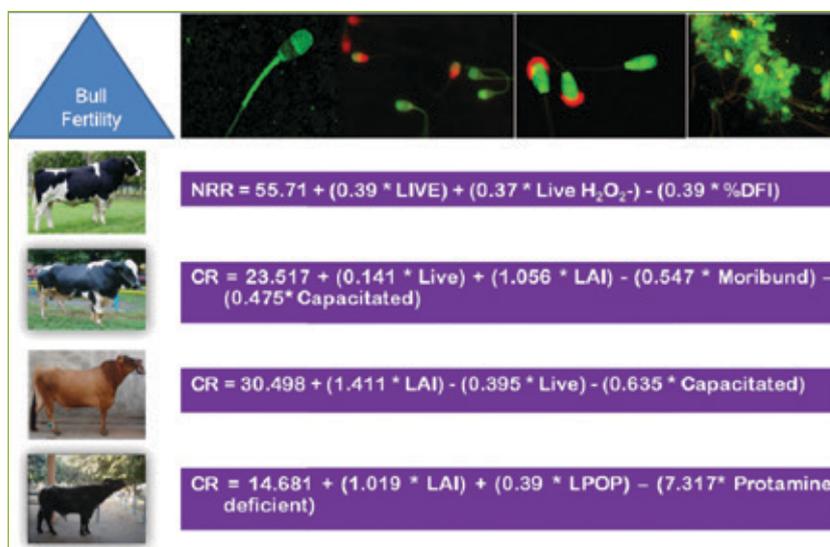
Association of Single Nucleotide Variants of the *LHβ* gene with the semen quality and luteinizing hormone (LH) concentration was studied in Murrah bulls. A total of six SNPs (g C356090A, g C356113T, g A356701G, g G355869A, g G356330C and g G356606T) were identified in *LHβ* gene. Mutation at g A356701G in the exon 3 is predicted to change amino acid from Histidine to Arginine. SSCP variants of fragment (FR) 1 had highly significant ( $P < 0.01$ ) effect on ejaculate volume, sperm concentration, acrosome integrity and membrane integrity of spermatozoa. SSCP variants of FR 2 had highly significant ( $P < 0.01$ ) effect on sperm concentration while SSCP variants of FR 3 had highly significant ( $P < 0.01$ ) effect on sperm concentration, mass motility, live spermatozoa, acrosome integrity and membrane integrity. SSCP variants of FR 2 and FR 3 of *LHβ* gene had highly significant ( $P < 0.01$ ) effect on LH concentration.

## Sperm-Oviduct Binding Index as a Tool for Buffalo Bull Fertility Prediction

The relationship of sperm-oviduct binding index with buffalo bull fertility was studied. Cryopreserved spermatozoa from Murrah buffalo bulls with different fertility rating were utilized for the experiment. To study sperm-oviduct binding, frozen thawed spermatozoa were incubated with oviduct explants for 1h under 5% CO<sub>2</sub>, 38.5°C with 95% relative humidity. The number of spermatozoa bound to unit area of oviduct explants (binding index-BI) was assessed using JC-1 fluorescent staining. It was found out that the relationship between BI and bull fertility was highly significant and positive ( $r=0.845$ ;  $P = 0.004$ ). The predictive value of BI for buffalo bull fertility was about 71%. BI was positively and significantly related to the live-acrosome intactness and negatively and significantly related to moribund status of spermatozoa. These results indicate the possibility of developing a fertility prediction tool using sperm-oviduct explants binding model, once validated in greater number of bulls with defined fertility.

## Development of Sperm Function Based Fertility Prediction Models in Cattle and Buffalo Bulls

Cryopreserved semen from HF crossbred, Jersey crossbred and Murrah buffalo bulls with known field fertility were utilized for development of fertility prediction model. Functional attributes of spermatozoa including sperm kinematics, viability, membrane integrity, capacitation status, acrosome reaction status, lipid peroxidation status, protamine deficiency and tyrosine phosphorylation status were assessed for each bull and related with the field fertility. For each breed, the sperm parameters accounting to high variability were identified. Partial least square analysis was also carried out to confirm if the findings of PCA and ANOVA corroborate with PLS. Based on the results of these tests, the most suitable combination of tests for fertility prediction was identified and fertility prediction model were developed for the three breeds studied. The model showed high accuracy for identification of high and low fertility bulls (Adjusted R<sup>2</sup> range from 0.92 to 0.95). These findings would help in selecting superior quality semen for use in artificial insemination, thus, facilitating high conception rates at field level.



### Transcriptional Abundance of Type-1 Endocannabinoid Receptor (CB1) in Spermatozoa Differs in Bulls with Different Field Fertility Ratings

A highly sophisticated endogenous cannabinoid system (ECS) has been shown to play a crucial role in controlling sperm functions and fertility in men. We assessed the differences in the expression level of certain components of ECS [type-1 endocannabinoid receptor (CB1) and fatty acid amide hydrolase (FAAH)] in spermatozoa between high- and low-fertile bulls. The expression level of CB1 gene was significantly ( $p < 0.05$ ) lower in spermatozoa from low and medium fertile bulls compared to high fertile bulls. The expression of CB1 gene was 21.07 and 4.23 times greater in high- and medium fertile bulls, respectively compared to low fertile bulls. The correlation between CB1 gene expression and field conception rate of bulls was significant ( $r = 0.58$ ;  $p < 0.001$ ). Unlike CB1 receptors, FAAH gene was expressed to similar extents among high, medium and low fertile groups. The correlation of FAAH expression with bull conception rate was positive but not significant. It was concluded that the transcriptional abundance of type-1 endocannabinoid receptor (CB1) was positively and significantly related to bull fertility.

### Anandamide, an Endocannabinoid, Suppresses Sperm Binding with Oviduct Explants in Buffaloes

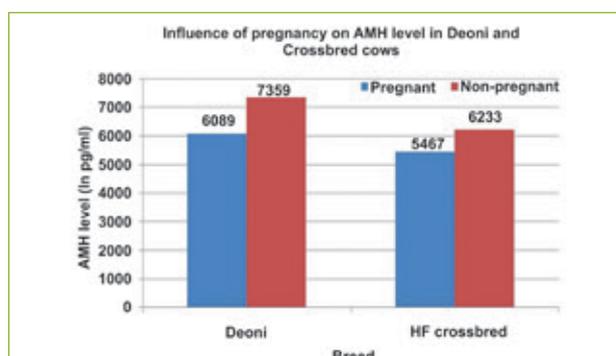
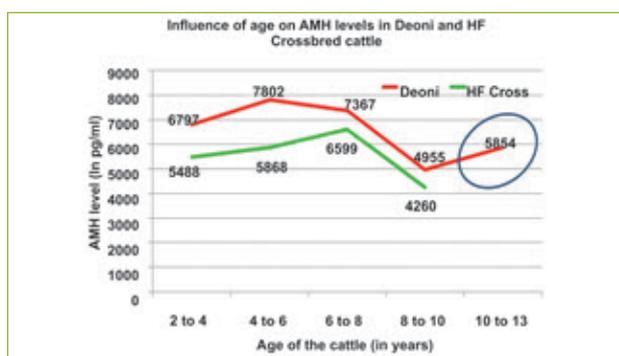
An endocannabinoid system comprising of Anandamide (AEA) and its receptor (CB1) has been shown to play a role in sperm acquisition of fertilizing potential and sperm-oviduct interaction. The effect of sperm pre-treatment with AEA or co-incubation of sperm-oviduct explants with AEA in the presence or absence of CB1 receptor antagonist on sperm-oviduct binding was assessed in the water buffalo. Frozen-thawed spermatozoa were incubated with oviduct explants for 1 h and sperm binding index was assessed. The results indicate that BI decreased significantly ( $P < 0.05$ ) when spermatozoa were either pre-treated with AEA or sperm-oviduct explants were co-incubated with AEA at 1 nM concentration compared to the control group ( $29.12 \pm 2.17$ ), however such effect was not observed when AEA was used at 1  $\mu$ M concentration. Incorporation of CB1 antagonist in the incubation medium inhibited the suppressive effect of AEA on BI. It was inferred that AEA at 1 nM concentration decreased the number of spermatozoa bound to the oviduct explants and the suppressive effect of AEA on sperm-oviduct binding was inhibited by CB1 receptor antagonist suggesting that the effect of AEA was mediated through CB1 receptor in the buffalo.

### Proteomic Profiling of Uterine Fluid from Normal and Subclinical Endometritis Affected Buffaloes

To identify the proteomic differences between the uterine fluids collected from normal and subclinical endometritis (SE) affected buffaloes were subjected to proteomic analysis. LC-MS/MS analysis of buffalo uterine fluid revealed 2136 non-redundant proteins. A total of 196 proteins were down regulated and 139 proteins were up regulated in uterine fluid of SE affected buffaloes. These proteins were associated with metabolic process (25%), cellular process (22.2%), biological regulation (10.1%), developmental process (9.1%), localization process (7.5%), cellular component organization or biogenesis (6.3%), response to stimulus (5.5%), multicellular organismal process (4.3%), immune system process (3.9%) and biological adhesion process (2.6%). Based on the molecular function, it was observed that catalytic activity (33.4%) and binding activity (28.2%) were the major functions wherein large numbers of differentially expressed proteins were related. Among the differentially expressed proteins. It was found that five proteins may act as putative markers for SE in buffaloes.

### An investigation on the use of Anti-müllerian Hormone as a Predictive Biomarker of Fertility in Crossbred and Deoni Cows

The peripheral concentrations of anti Mullerian hormone in relation to breed, age and reproductive status was investigated in HF crossbred and Deoni cattle. Also the association between anti Mullerian hormone, antral follicle population and fertility responses in HF crossbred and Deoni cattle were studied. It was observed that the AMH



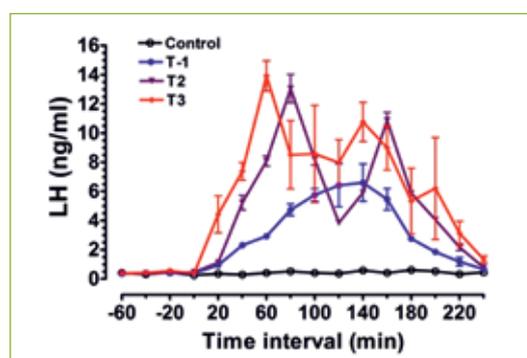
level varied in relation to age, pregnancy and parity. The AMH level was higher in Deoni cattle than HF crossbred cattle. AMH level declined as the age and parity increased. However, it was interesting to observe that the AMH level was higher even beyond 10 to 13 years of life (with more than 7 parities) in Deoni cattle. In addition, pregnant HF crossbred and Deoni cattle showed lower levels of AMH as compared to non-pregnant cattle.

### Field Validation of the Developed Kisspeptin-Based Estrus Synchronization Protocol for TAI

The kisspeptin-based estrus synchronization protocol for TAI that was developed and validated at Farm level was further validated in the field condition and also compared with OvSynch protocol for anestrus heifers/cows. For the purpose, a total of 43 anestrus animals were selected from the adopted villages of ICAR-NDRI, ERS, Kalyani. Out of 43 selected animals, 32 were subjected to the kisspeptin based protocol [day 0: KP10; day 7: PGF2 $\alpha$ ; day 9: KP10; day 10: TAI] and remaining 11 animals were treated with OvSynch method of estrus synchronization [day 0: KP10; day 7: PGF2 $\alpha$ ; day 9: KP10; day 10: TAI]. Reproductive status of these animals was monitored through scanning of the reproductive organs specifically the ovaries using B-mode and CFM ultrasonography. All animals were checked for estrus on the day of AI [day 10]. All inseminated animals were followed for at least 42 days post-AI for conception. Out of the 32 animals treated with KP-based protocol, 28 (87.5%) exhibited estrus and 22 (69%) were found to be pregnant after successful AI. On the other hand, out of 11 animals treated with OvSynch protocol, five exhibited estrus (45%) and three were conceived post-AI. Initial ultrasound scanning of the ovaries of all the selected animals showed either smooth ovaries or few follicles <5mm in diameter on the ovaries. Upon KP administration, follicles started growing and reached the size of  $14 \pm 0.1.9$  mm on the day before ovulation.

### Optimization of the Dosage of Phoenixin (PNX) for Reproduction Augmentation in Bovine Species

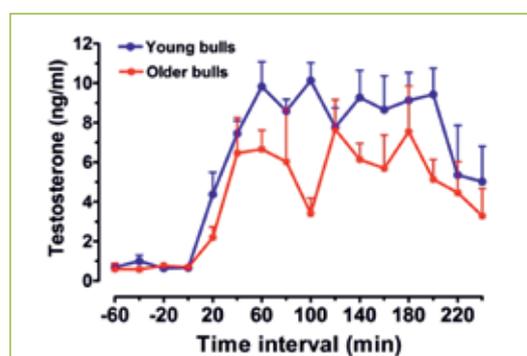
As a prerequisite, the dosage of PNX for reproduction augmentation in bovine species was optimized. For the purpose, a total of 12 prepubertal heifers aged between 18 to 20 months weighing  $220 \pm 10.75$  kg were randomly divided into four groups (n=3 each): Control (0 $\mu$ g PNX), T1 (100  $\mu$ g PNX, i.v.), T2 (200  $\mu$ g PNX, i.v.) and T3 (300  $\mu$ g PNX, i.v.). Blood samples (2ml) were collected at every 20 min intervals beginning with 1h prior to till 4h post administration of PNX. The response of different dosages of PNX in terms of endogenous LH release has been depicted graphically in Figure. Among the all doses tested, 300  $\mu$ g/animal (1.4  $\mu$ g/kg body weight) was found to be optimum in terms of endogenous LH release. Mean plasma LH concentrations at different time point post-PNX administration was higher in animals of T2 and T3 than T1 and Control. In both T2 and T3, two peaks of LH were recorded. The commencement of first LH peak was found to be earlier in T3 than T2. Area under LH response curve (AUC) was the highest for T3 followed by T2 and T1.



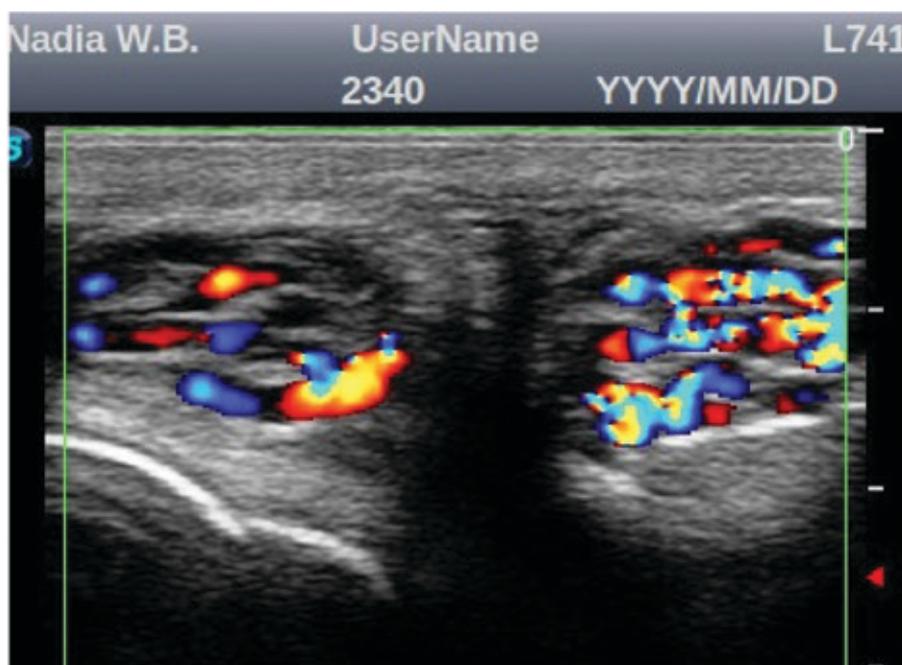
Effects of different dosages of exogenous PNX administration on blood LH release in crossbred heifers.

### Effects of Kisspeptin-10 Administration on Plasma Testosterone in Young Crossbreed Bulls

The aim of the present study was to determine plasma testosterone concentrations after an intravenous administration of kissepetin-10 and also to analyze the correlation between plasma testosterone concentration and testicular morpho-biometric parameters, live body weight and age in pre-pubertal and pubertal crossbreed bulls. For the purpose, 6 pre-pubertal and 6 pubertal male calves aged 12 and 24 months, respectively were used and 3 animals of each group were injected intravenously with 1.5  $\mu$ g KP-10/kg. b.w. Blood samples were collected at every 20 min beginning with 1h prior to till five hour post-KP administration for assaying blood testosterone concentrations. Our results revealed that KP injection stimulated plasma testosterone release that reached its first peaks at 40 min with 6.45 ng/ml and 60 min with 9.82 ng/ml after injection in pubertal and pre-pubertal groups, respectively. The area under testosterone response curves (AUC) during post-treatment period was higher ( $p < 0.05$ ) than that of pre-treatment period in both the groups. No correlation between plasma testosterone and age, live body weight of the bulls, scrotal circumference and width and height of the testes were found ( $P > 0.05$ ).



Comparative mean plasma testosterone concentrations between older and younger bulls treated with KP-10 (1.5  $\mu$ g/Kg BW).



*Structural characteristics of pampiniform plexus in a crossbred bull by USG- Color Doppler mode*

### Predicting Body Weight and Discriminating Reproductive Structure of Different Aged Bulls Using Ultrasonography

The aim of the present study was to develop a simple method of body weight measurement based on the relationships between testis parameters and body weight by using caliper and ultrasound methods and to compare genital tract structure between males of different ages. For the purpose, 12 crossbred bulls aged 11-13 months (group 1) and 18-24 months (group 2) were selected. Caliper and ultrasound gray methods with Doppler mode were used not only to measure width and circumference of the testis but also to analyze testicular tissue. Our results showed positive ( $p < 0.01$ ) correlation between the body weight and all testicular parameters measured, irrespective of the methods used. The regression equations devised between body weight and testicular parameters were found to predict body weight with high accuracy ( $P < 0.01$ ). Furthermore, B mode USG revealed the testicle parenchyma as homogenous tissue with hyper-echoic areas that correspond to the interstitial connective tissue and hypo-echoic to anechoic areas corresponding to the seminiferous tubules. While with Doppler mode, these areas showed little or no blood streams, respectively in the testis of Group 2 or 1. On the other hand, epididymis and pampiniform plexus tissues showed more anechoic areas with enhanced blood flow in the that was more prominent in Group 2.

### Effect of Melatonin Implant on Production of Murrah Buffaloes during Summer

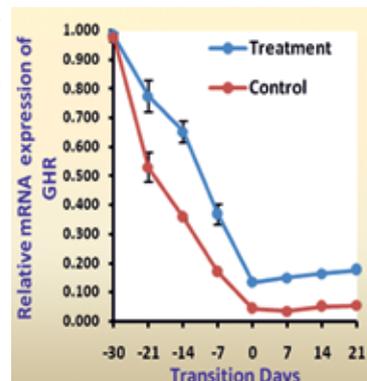
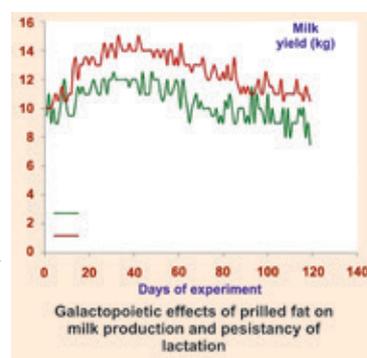
Twelve healthy growing and 12 healthy lactating Murrah buffaloes were divided into two groups i.e. control and treatment. These animals were implanted melatonin @ 18 mg/ 50 kg body weight subcutaneously. The experimental trial for growing animals was conducted for 5 months and on lactating buffaloes were performed from the 14<sup>th</sup> day of calving up to 63<sup>rd</sup> day of lactation. Plasma GPx, GR, SOD, TAC and MLT activity was higher ( $P \leq 0.05$ ) in treatment group whereas, TBARS, Cortisol was higher ( $P \leq 0.05$ ) in control group. Concentration of IgM and melatonin was higher ( $P \leq 0.05$ ) in treatment group buffaloes, whereas SOD, TBARS, TAC & IgA were non-significant and nitric oxide, cortisol, progesterone & prolactin were higher ( $P \leq 0.05$ ) in the control group. The expression of HSP family gene (60, 70, 90), pro-apoptotic genes (BAX and Caspase-3) and immunity related genes (IL-2, IL-6) were found to be higher in control group but anti-apoptotic gene (Bcl-2) and antioxidants (Mn SOD and Cu, Zn SOD) were found to be significantly higher ( $P \leq 0.05$ ) in treatment group in both set of animals during summer season. Mean values of body weight, ADG and DMI was significantly higher ( $P \leq 0.05$ ) in treatment group of growing buffaloes than the control but no significant difference was observed in body weight and DMI of control and treatment group lactating buffaloes. No significant impact of melatonin implant was observed on milk yield, milk fat, SNF (%) and service period. However, interval from calving to first ovulation, number of insemination/conception was higher ( $P \leq 0.05$ ) in control whereas conception rate and size of follicles were higher in treatment group.



# FEED, FODDER AND PRODUCTIVITY

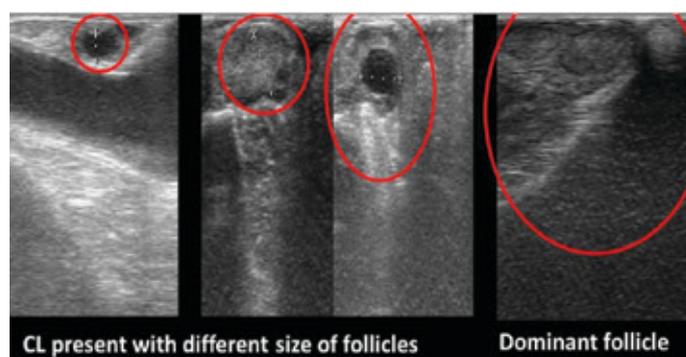
## Augmentation of Milk Production and Persistency by Prilled Fat Feeding

Prilled fat, a non-hydrogenated vegetable oil contains more than 85% palmitic acid with high melting point. Due to this reason it does not melt at low pH, by pass rumen degradation and is digested in small intestine. Experiments were carried out to enhance the energy content of feed by supplementation of prilled fat. Feeding of prilled fat @ 75, 100 and 150g/d during transition and early lactation phases enhanced milk production ( $P < 0.05$ ) by 1.0 to 2.1 kg/d with high fat contents. Treatment did not influence fat, protein, lactose, milk cholesterol; feed intake, haematology and plasma lipid profile (LDL, HDL, cholesterol, triglyceride). Milk fatty acid profile analysis showed low ratio of saturated: unsaturated fatty acids in supplemented group due to increase in polyunsaturated and monounsaturated fatty acids content. The increase in milk yields was due to more expression of GH receptor on lymphocytes, increase in plasma GH ( $P < 0.05$ ) and IGF-I levels indicating thereby better partitioning of nutrients towards mammary gland. The higher digestibility of prilled fat led to improved energy balance, higher feed efficiency and improved persistency of lactation in cows and buffaloes. Metabolic hormone (insulin,  $T_3$ ,  $T_4$ ) and energy regulator hormone (ghrelin, adiponectin, orexin, resistin) were not influenced by feeding. Higher plasma leptin in fed group was reflection of improved BCS and body weight. Validation of results in rural buffaloes also indicated higher milk production (2.1 kg/d; 18%), early onset of postpartum heat, reduced service period and higher conception rate in prilled fat fed group without affecting DMI and milk SCC. Supplementation generated additional income of ₹ 50-125/day/animal and was cost effective. It was recommended that prilled fat could be fed @3% to augment overall productive performance of dairy animals.



## Plasma Leptin, IGF-1 Levels and Association of their SNPs with Milk Plasminogen in Cows

Experiment on low and high producing crossbred cows revealed positive correlation ( $p < 0.05$ ) of SNP-2 (C297T) with milk yield. Milk fat, protein, lactose and SNF didn't vary between the low and high producing cows but milk plasminogen level was higher ( $p < 0.01$ ) in low producing as compared to high producing cows indicating less stress on mammary gland in low producers. Plasma leptin and progesterone level were more ( $p < 0.01$ ) in low producer than high producing cows but IGF-I, cortisol level did not differ. Plasma triglycerides, HDL level were more and glucose level was less in high producing cows than low producing cows. Thus, low and high producing cows differ in terms of lipid profile, glucose, milk plasminogen, hormone levels and postpartum follicular dynamics. The detected SNP-2 could be used as a biomarker of high milk production performance in crossbred cows. The follicular dynamics of growth pattern revealed significant differences in the size of follicles in low and high producing cows in early lactation, while number of follicles and conception rate did not differ between low and producer crossbred cows.



## Influence of Astaxanthin Supplementation on Growth Performance and Antioxidant Status in Heifers during Summer Season

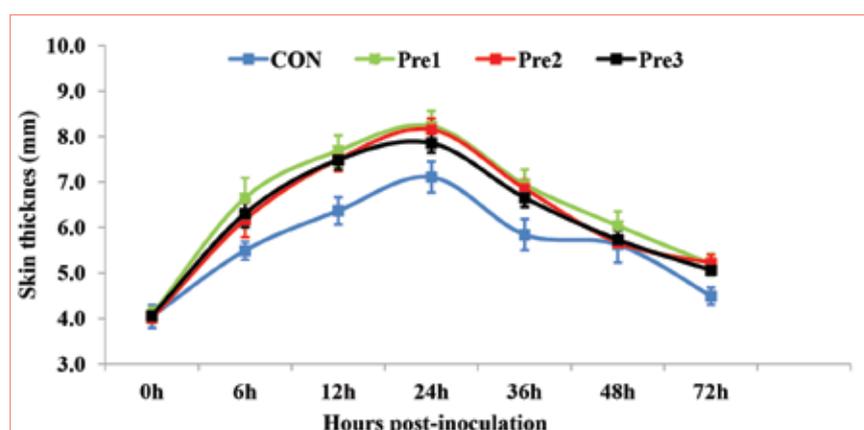
Sahiwal and Karan Fries growing heifers supplemented with astaxanthin @0.25 mg/kg body wt/animal/day exhibited higher GH ( $P \leq 0.05$ ) and cortisol but lower leptin level ( $P \leq 0.05$ ) than the control group in both the breeds. Mean concentration of TBARS, SOD, GPx, and catalase and IL-12 decreased ( $P \leq 0.05$ ) in treatment group of heifers as compared to control group in both the breeds. The DMI and ADG was higher ( $P \leq 0.05$ ), while FCR was lower ( $P \leq 0.05$ ) in treatment group of Sahiwal and Karan Fries heifers. Mean expression patterns NF $\kappa$ B, HSP70, MnSOD, IL-2, and caspase-3 were lower ( $P \leq 0.05$ ) and Nrf2 and Bcl-2 was higher ( $P \leq 0.05$ ) due to treatment. Astaxanthin treated heifers showed intense symptoms of heat and attained puberty earlier. It was found that astaxanthin supplementation ameliorated adverse effects of heat stress and potentiated immunity and growth rate in Sahiwal and Karan Fries heifers.

## Immunity and Antioxidant Status of Murrah Buffaloes Supplemented with Astaxanthin

Astaxanthin supplementation (0.25 mg/kg body weight) in Murrah buffaloes improved the milk production performance (7%) by changing the energy markers and decreasing the SCC due to improvement in immunity, antioxidant status during summer and winter seasons. The supplementation around parturition down-regulated the mRNA gene expression of NF $\kappa$ B p65, which coordinated alteration in cytokines production thereby improving immunity in animals.

## Dietary Supplementation of Prebiotics, Probiotics and Synbiotics to Augment Health of Calves

A study was designed to investigate the effect of different levels of chicory root supplementation on growth performance, faecal characteristics, immune response and antioxidant activity in calves. Twenty eight Murrah buffalo calves (7-10 d old and  $31 \pm 2$  kg) were randomly selected and divided into four groups. All the four groups were fed as per ICAR (2013) feeding schedule except that these were additionally supplemented with 0, 8, 16 and 24 g/d chicory root powder (in the four respective groups i.e. CON, PRE1, PRE2 PRE3) for 90 days. Average daily gain, total DMI, final body length and heart girth was significantly higher in treatment groups as compared to control. The faecal *Lactobacillus* and *Bifidobacterium* count was significantly ( $P < 0.05$ ) higher in all the supplemented groups with concomitant reduction in faecal Coliform count as compared to control. Faecal ammonia, lactate, pH, and fecal score was also altered favourably ( $P < 0.05$ ) on supplementation. Antioxidant enzymes SOD, catalase, and glutathione peroxidase were significantly higher in treatment group as compared to control. Immunological parameters i.e., DTH response and humoral immunity were significantly higher in treatment groups as compared to control, though IgG was not significant between treatments and control. Thus it may be concluded that the supplementation of chicory root powder may be useful for enhancing health status and performance of calves irrespective of the doses.



DTH response to intra-dermal PHA-P

## AFEX- A Technology for Addressing Seasonality in Access to Quality Cattle Feed in India

Two different experiments were conducted on Murrah buffaloes and crossbred cattle. Ten animals per treatment were fed diets for ten weeks, with two levels of AFEX treatments and negative and positive controls. Murrah buffaloes responded to changes in diet quality primarily through changes in body weight loss (1.4 kg/day vs 0.2 kg/day) in negative control and High AFEX respectively, rather than increase in milk yield. Lower quality diets also produced less milk fat than the positive control diet. In contrast, the Karan-Fries cattle responded to changes in diet quality primarily via increase in milk production and milk energy (7.4 vs 6.1 MCal/day) in High AFEX and negative control,

respectively. Level of acetamide in the milk of negative control (2-2.5 ppm), Low AFEX (3-4 ppm), High AFEX (10-12 ppm) and positive control (0.2- 0.5 ppm) in case of crossbred Karan-Fries cattle while this level was a bit higher in Murrah buffaloes with negative control (3.5-4.5 ppm), Low AFEX (4-8 ppm), High AFEX (15-18 ppm) and positive control (0.5- 1.5 ppm) during AFEX pellet feeding was observed setting a new baseline for acetamide in the rumen of AFEX pellet fed animals.

### Rice Dried Distillers Grains with Soluble Feeding in Buffaloes

Rice dried distillers grains with solubles can be used as an alternative protein source replacing 75% of groundnut oil cake and mustard oil cake in the concentrate mixtures on nitrogen basis of growing Murrah heifers and lactating Murrah buffaloes with improved growth performance and higher milk yield with added advantage in terms of reduction in methane emission and cost of feeding per unit milk production.

### Studies on Vanadium and Boron for their Role in Immuno-Endocrine Functions, Bioavailability of Minerals and Production Performance in Dairy Animals

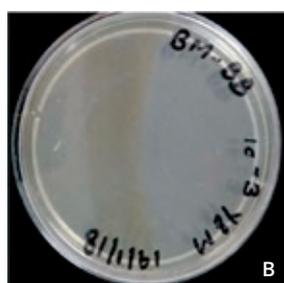
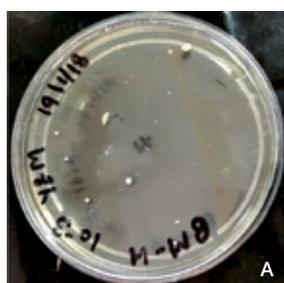
24 lactating goats (Alpine x Beetal and Sannen x Beetal) supplemented with different levels (0, 2, 4 and 6 ppm) of vanadium. Results revealed:

- » Vanadium supplementation upto 6 ppm has no effect on DMI, nutrient utilisation, milk yield and milk composition in goats.
- » Blood glucose (mg/dL) showed increasing ( $P < 0.05$ ) and total cholesterol (mg/dL) decreasing ( $P < 0.05$ ) trend on vanadium supplementation at 2, 4 and 6 ppm
- » Improved ( $P < 0.05$ ) GPx activity and decreased ( $P < 0.05$ ) SOD levels was observed at 2, 4 and 6 ppm V supplementation.
- » Plasma hormones (insulin, cortisol, IGF1) were not affected by vanadium supplementation.
- » Expression of GLUT 4 gene decreased but PTP levels remained unaffected due to vanadium supplementation.

The overall findings are indicative of the fact that vanadium has a potential role in influencing the energy metabolism and antioxidant system.

### Effect of Chemical Additives on Silage Quality

The present study was taken to ascertain the effect of different chemical additives on silage quality of two different crops i.e. maize and sugargraze. For maize silage preparation crop was harvested at 60 d of sowing (30-33% DM) and sugargraze crop was harvested at 28% DM (at 100 d of sowing). Crop was chopped into 2-4 cm of length before ensiling. Crops were conserved in used fertilizers bags (after inserting a polythene lining) of capacity 35kg opened for analysis on 4<sup>th</sup> and 30<sup>th</sup> d of ensiling. The results provide the evidence that silage can be prepared in used fertilizer's bags with the help of chemical additives. Propionic acid (1.0% fresh matter basis) and Sodium benzoate (0.1% fresh matter basis) were effective to improve Sugargraze silage quality whereas Potassium sorbate (0.1% fresh matter basis) and Sodium benzoate (0.1% fresh matter basis) can be used for maize silage preparation.



Yeast and mold colonies in Maize silage: Control silage (A) and with sodium benzoate (0.1%) (B)

Yeast and mold colonies in Sugargraze silage: Control silage (A) and with sodium benzoate (0.1%) (B)

### Effect of Polyherbal Mixture Supplementation on Reproductive Performance in Murrah Buffaloes

A poly-herbal mixture comprising of Ajwain (*Trachyspermum ammi*), Haldi (*Curcuma longa*), Jeera (*Cuminum cyminum* Linn), Methi (*Trigonella foenum-graecum*), Saunf (*Foeniculum vulgare*), Sowa (*Anethum graveolens*) and Sundh (*Zingiber officinale*) was developed to improve the post-partum immunity and reproductive efficiency in buffaloes. Upon feeding this mixture for 10 days from the day of calving, it was observed that the buffaloes supplemented with herbal mixture had faster cervical and uterine involution, early onset of post-partum heat, improved neutrophil functions and shorter service period as compared to buffaloes in control group. While the total supplementation

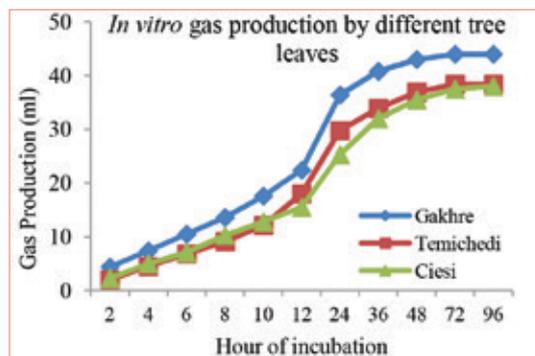
was estimated to cost ₹ 372.5 per animal, the improvement in reproductive efficiency observed was to the tune of 12 days early to first insemination, 15 days less service period, 7% higher conception rate, 10% increase in animal became pregnant within 115 days and 12% reduction in the number of buffaloes suspicious for mastitis. This practice can be recommended to the farmers for increased returns from buffalo rearing.

### Phenotypic Plasticity of Digestive System of Dairy Cattle and Location Specific Fodder Production

Phenotypic plasticity of digestive system of indigenous Deoni cattle was <10% compared to >55% in HF crosses. Plasma glucose, triglycerides and cholesterol levels were higher in Deoni heifers than crossbred calves due to slow export to tissue and body mass growth was also slow. Hybrid napier is more resilient to climate in dry matter yield and chemical quality than Para or guinea grass and thus, Hybrid napier cultivation could be recommended as the most optional perennial grass to meet green fodder demand for the dairy cows. DM or OM% change in cultivated grasses was independent of heat index.

### Evaluation of Eastern Himalayan Forest Tree Leaves as Herbal Feed Additives to Manipulate Rumen Fermentation

In north-eastern states of India, tree leaves generally used as a livestock feed. However, these tree leaves were not nutritionally evaluated as animal feed. Twenty one tree leaves e.g., Temichedi (*Ficus hirta*), Preyano (*Ficus religiosa*), Horu (*Leea asiatica*), Theidie (*Trema orientalis*), Tego (*Bauhinia hookeri*), Mecho (*Schima willichii*), Hutuo (*Erythrina variegata*), Khusia (*Melia azadiracta*), Khapo (*Curculigo recusvata*), Thumero (*Lagerstroemia spp.*), Tenha (*Litsea spp.*), Thotseno (*Ficus carica*), Kartos (*Pranus cerasoides*), Ciesi (*Litsea citrata*), Dzapri (*Oroxylum indicum*), Tegho (*Saurauia roxburghii*), Medzi (*Spondias pinnata*), Mela (*Bisehafia spp.*), Gakhre (*Hibiscus subdariffa*), Khekri (*Phyallantha spp.*), Tosmshu (*Rhus semiulata*) were collected from Nagaland and nutritional evaluation of these collected tree leaves was done by *in vitro* gas production test using cattle rumen liquor. These collected trees leaf contained 18.1 to 48.6% DM on fresh basis. OM and CP content of these collected tree leaves varied from 86.6 to 96.7% and 5.7 to 18.2% where as EE content varied from 1.1 to 6.8% on DM basis. Highest EE content was observed in *Rhus semiulata* followed by *Litsea sp.* (6.1%) tree leaves. Highest CP content was observed in *Hibiscus subdariffa* (18.2%) followed by *Litsea citrata* (16.8%) and *Trema orientalis* (16.1%) tree leaves. NDF and cellulose content were varied from 21.4 to 57.6 and 8.4 to 27.5% on DM basis, respectively. Highest cellulose content was observed in *Pranus cerasoides* followed by *Ficus religiosa* (26.9%), *Ficus hirta* (23.2%) and *Lagerstroemia spp.* (22.2%) tree leaves. Lignin content was highest (16.1%) in *Ficus religiosa* tree leaves while it was lowest (2.1%) in *Ficus hirta* tree leaves. *In vitro* gas production (ml/96h) of these collected tree leaves varied from 3.3 to 44.1 ml. Maximum gas production (40.8 ml/36 h) was observed due to incubation of *Hibiscus subdariffa* tree leaves followed by *Pranus cerasoides* (34.2 ml/36h) tree leaves. Higher gas production due to incubation of Gakhre (*Hibiscus subdariffa*) and Kartos (*Pranus cerasoides*) tree leaves indicated that those three tree leaves were highly degradable in the rumen and found better tree fodder in comparison to other tested tree leaves.



Dzapri (*Oroxylum indicum*)



Kartos (*Pranus cerasoides*)

### Nutritional Evaluation of Five Aquatic Plants Available in New Alluvial Zone of West Bengal

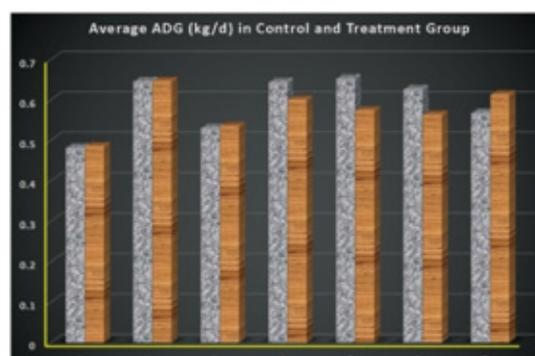
A study was carried out to evaluate the comparative chemical composition of five naturally occurring aquatic plants (*Spirodela polyrrhiza*, *Lemna minor*, *Pistia stratiotes*, *Ipomoea reptans* and *Salvinia auriculata*) collected from various ponds, water logged areas and other water bodies in new alluvial zone of West Bengal. *Pistia* and *Lemna* had nearly similar DM (6.50 & 6.51) which was slightly lower than *Spirodela* (7.02) and *Salvinia* (7.34). *Ipomoea*, being a semi aquatic plant, had significantly ( $P < 0.05$ ) higher DM content (9.92) than all other plants. Organic matter content in the five aquatic plants ranged from  $79.20 \pm 0.57$  (*Lemna*) to  $87.12 \pm 0.37$  (*Salvinia*). Crude protein (CP) content of *Spirodela*, *Salvinia*, *Pistia*, *Ipomoea* and *Lemna* were 16.86, 9.42, 9.65, 16.27 and 18.05%, respectively.

*Salvinia* and *Pistia* had significantly lower CP content than other three plants. *Lemna* was having highest CP content which was statistically similar to *Spirodela* and significantly higher than *Salvinia*, *Pistia* and *Ipomoea*. *Ipomoea*, *Lemna* and *Spirodela* had significantly higher Ether Extract content than *Salvinia* and *Pistia*. ADF content was also significantly higher in *Pistia* and *Salvinia* than *Spirodela*, *Ipomoea* and *Lemna*. The ( $P_A + P_{B1}$ ) protein fraction, which are highly degradable in rumen, was much higher in *Ipomoea* than other four plants. *Lemna* was having highest  $P_{B2}$  fraction followed by *Salvinia*, *Spirodela*, *Pistia* and *Ipomoea* had much lower  $P_{B2}$  fraction. Fraction  $P_C$ , that is neither degraded in rumen nor digested in lower tract, was much higher in *Salvinia* ( $11.69 \pm 0.06\%$ ) than other four plants. *Lemna*, *Pistia* and *Spirodela* were found to be good source of Ca and P. All the plants were found to be rich in Fe and Zn and poor source of Cu and Co with varying levels of Mn (8.9 to 679 mg/kg). *Spirodela*, *Pistia* and *Lemna* were very good source of Mn. Based on the overall chemical composition of the five aquatic plants, it was obvious that *Spirodela*, *Lemna* and *Ipomoea* were comparatively much better source of nutrients than *Salvinia* and *Pistia*. Comparative protein fraction and mineral profile were better in *Lemna* and *Spirodela* than *Ipomoea*.



### Effect of Partial Replacement of Wheat Bran by Duckweed (*Spirodela polyrrhiza*) Meal on Nutrient Utilization and Growth Performance of Jersey Crossbred Calves

Fresh *Spirodela polyrrhiza* was collected from local water bodies, dried under partial sunlight and then crushed/grinded to prepare *spirodela* meal. A Growth trial for 105 days and a digestibility trial of 6 days were conducted on twelve crossbred calves. Concentrate mixture for control groups was prepared using maize grain, wheat bran, mustard oil cake, mineral mixture and salt, while in case of experimental group 20% of wheat bran of control concentrate mixture was replaced by *Spirodela* meal (making 5 % of concentrate mix on DM basis). The two concentrate mixtures were isonitrogenous (22.09 and 22.01 % CP, respectively). Proximate analysis indicated that in *Duckweed* (*Spirodela sp*) mean values for CP, TCHO, EE, total ash, AIA, NDF and ADF (DM basis) were 16.86, 58.08, 4.06, 21.5, 3.1, 39.80, and 25.1%, respectively. It was a good source of some macro and micro minerals such as Ca, P, Fe, Mn, and Zn. Fortnightly DMI, CPI and TDNI did not differ significantly ( $P > 0.05$ ) between the groups. No difference ( $P > 0.05$ ) was observed in digestibility of DM, OM, EE, CP, TCHO, NDF and ADF, average daily gain (ADG) and feed conversion efficiency between the groups. Therefore, it can be concluded that *Spirodela* can be utilized as an alternative feed resource to economize the dairy cattle ration @ 5 % (DM basis) of concentrate by replacing 20% of wheat bran mixture without any adverse effect on Intake, digestibility, growth rate.

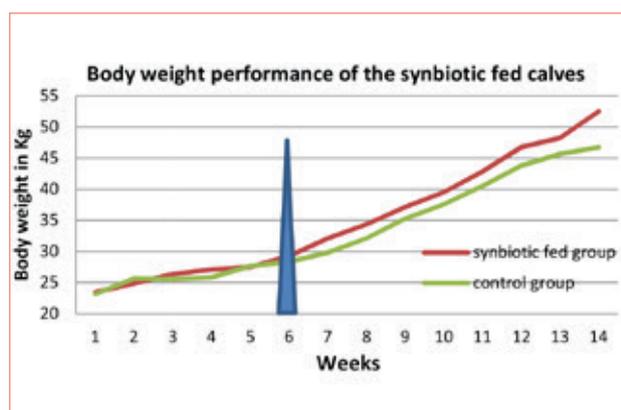


### Effect of Synbiotic Supplement on Health and Growth of Prewaned Jersey Crossbred Calves

A study was conducted to evaluate the efficacy of a 'Synbiotic' formula comprising *Lactobacillus rhamnosus* NCDC 298 and fructo-oligosaccharide on calf health. Twelve new born calves were randomly selected and equally divided into treatment (T) and control (C) group. T group was given "Synbiotic" preparation (100 ml cultured milk/calf containing bacterial dose of  $10^9$ cfu/ml plus fructo-oligosaccharide @ 10% of milk) for 42 days, while the C animals were maintained as per the routine existing farm practices. The performance of the calves was assessed up the



Feeding of Synbiotic supplement to calf



weaning age of 90 days. The calves in the T group had higher ( $P < 0.05$ ) average body weight gain (g/d) than the animals in C group. After the feeding period of 42 days, parasitic eggs/g was significantly ( $P < 0.05$ ) lower in the T than C group ( $240.00 \pm 52.69$  Vs  $492.86 \pm 113.38$ ). Hence, higher body weight gain was recorded in the symbiotic treatment group with few incidences of scour problem when compared to the control animals.

### Study of Fodder Crop Assessment for Dairy Industry and Potential Areas of Intensification at State Level

A rapid technology was developed using remote sensing for the estimation area under different fodder crops. Using this technology, the total area estimated under fodder crops in Gujarat was 2.86 lakh ha during Kharif 2016 and the dominated district were Ahmedabad and Kheda. In Rajasthan, the total area under fodder crops was estimated 4.26 lakh ha during summer season 2016 and dominated district were Sikar, Jaipur and Tonk. In Bihar, the total area under fodder crops during summer season 2017 was estimated 3.25 lakh ha where dominated district were Patna, Purnia and Araria. In Uttar Pradesh, the total area under fodder crop during summer season 2017 was estimated 7.6 lakh ha where dominated districts were Meerut, Rae Bareilly and Saharanpur.

### Standardization of Seed Rate of Berseem With Rye Grass under Mixed Cropping System

Under Mixed Cropping System 10 combination of Berseem and Ryegrass consisting of sole Berseem (seed rate @25 kg/ha) sole Ryegrass (seed rate @8kg/ha), mixed crops with different proportions were studied for the yield of the crop and nutritional value. The Green Fodder yield was obtained highest in 100% Rye Grass +25% Berseem followed by 100% Berseem + 25% Rye Grass. Dry matter yield also noticed in significantly difference and maximum recorded with 100% Rye Grass +25% Berseem. The crude protein content and protein yield was highest recorded in Sole Berseem followed by 100% Ber+25% RG. Highest benefit: cost ratio was calculated from Sole Berseem followed by 100% Rye Grass +25% Berseem. Therefore, it can be concluded that under mixed crop the seed rate of 100% ryegrass with 25% Berseem can be grown for higher green forage yield. The seed rate of 100% Berseem with 25% ryegrass as mixed crop can be grown for higher green fodder yield, dry matter yield and crude protein yield.

### Dual Purpose Baby Corn Production under Varying Crop Establishment Methods and Nitrogen Management

The experiment consisted of 18 treatment combinations comprising of 3 contrasting tillage systems viz., Zero tillage (ZT), Conventional tillage (CT) and Raised Beds (RB) as main plots while 6 nitrogen management practices viz., N0, N75%, N75+Azotobactor, N100%, N100+Azotobactor and N125% were assigned in sub-plots in split plot design with three replications. The two year data revealed that RB showed significantly higher growth parameters (Plant height, No. of leaves, leaf width, leaf stem ratio, LAI and dry matter accumulation) and yields (green, dry fodder and baby corn) over CT and ZT. Amongst the nitrogen (N) management options, increasing levels of N increased growth and yields up to 100%N with application of azotobactor. However, highest fodder yield was recorded with 125%N, while highest green, dry fodder and baby corn yields were observed with 100%N with application of azotobactor. The cost of cultivation was maximum under CT followed by RB and lowest in ZT (Rs. 25,258/ha) while mean net returns was observed highest under RB (Rs. 112,907/ha) followed by ZT (Rs. 104,976/ha) and lowest in CT (Rs. 90,666/ha). The saving in total cost of cultivation due to ZT was ₹ 2,500 and Rs. 2,100/ha, as compared to CT and RB, respectively. Based on two year study it can be concluded that dual purpose maize may be planted under raised bed with application of 100%N with Azotobactor for higher productivity and profitability.

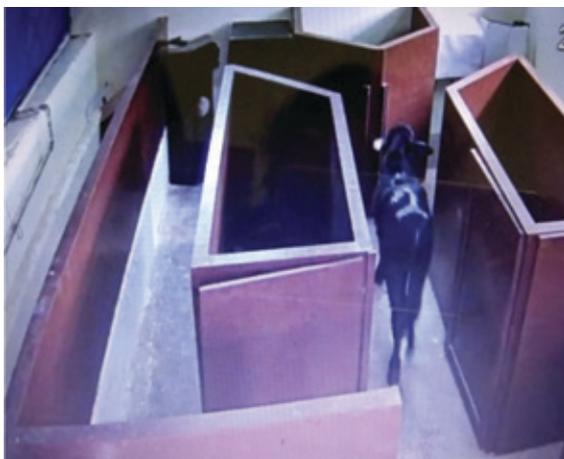


*Extension team observing fodder crop in the field*

# INNOVATIVE APPROACHES IN MANAGEMENT OF DAIRY ANIMALS

## Studies on Cognitive Behavior of Murrah Buffalo Calves

The performance of buffalo calves in a cognitive test was assessed. At 4 weeks of age, the calves were challenged to a visual discrimination task in a Y-maze to assess their initial and reversal learning. Training sessions (14 trials per session) were performed to the calves (n=12) twice daily in the morning and evening and the performance of the calves was recorded continuously during each session by video camera. The initial learning consisted of training the calves to discriminate between two colours (black and white) until the calves reached a learning criterion of 90% correct choices over three consecutive sessions. The calves were rewarded (0.1L milk from bottle placed at one arm of maze) on choosing the correct side and punished for approaching the incorrect side (empty milk bottle in another arm of the maze). After reaching the learning criterion the training stimuli was then reversed (i.e. the previously rewarded colour was now unrewarded, and vice-versa). The calves learned the initial discrimination task after  $4 \pm 0.22$  training sessions (range 3-5), however took  $7.5 \pm 0.37$  sessions (range 6-9) to reach the learning criterion in the reversal task. The performance of the calves improved gradually and reached up to 100% with the increase in number of sessions. Interestingly, the calves remembered the learning task even after 2 months of the stoppage of maze test. This study represents the first of this kind in Murrah buffalo calves.



*Calf locating the reward (correct side-white)*



*Calf located the correct side (reward- milk)*

## Effect of Habituation to Milking and Natural Suckling on the Performance and Behaviour of Primiparous Sahiwal Cows

The effect of pre-partum habituation to milking and natural suckling vs. calf weaning on the performance and behaviour of primiparous Sahiwal cows (n=18) was studied. A group of cattle were subjected to habituation to milking routine and weaning of calf from mother at birth and provided with concentrate feeding at the time of milking as milk ejection stimuli. In another group of six advanced pregnant Sahiwal heifers, habituation to milking routine was practiced along with calf suckling as stimuli for milk letdown. In control group, routine farm practice was adopted. The results revealed that the mean of daily temperament scores, mean frequency of defecation and urination were reduced significantly ( $P < 0.05$ ) in both the treatment groups from first day to fifteenth day of pre-partum habituation to milking routine. Besides this, milking performance, udder health and milk quality parameters were improved and stress levels were reduced in cows that were habituated to milking routine for about 15 days before actual calving and allowed natural calf suckling as a milk ejection stimulus. However, the practice of natural calf suckling as a milk ejection stimulus had some adverse effect of reproductive performance and prolonged the service period of Sahiwal cows by about one month. The cows which were habituated to milking routine and in which the calves were weaned post-calving had better milking temperament, lower milk let-down time and reduced stress levels as compared to non-habituated and weaned cows.

### Effect of Increasing Frequency of Feeding on the Growth, Health and Behavior of Crossbred Calves

An investigation was undertaken to find out the effect of feeding colostrums/ milk at different intervals and frequencies on the health, growth performance, behaviour, and economics of feeding of crossbred dairy calves. Crossbred calves (n=20) were selected at birth and randomly allotted to 3 groups (6 calves in control, 7 in Treatment 1 and Treatment 2 each) for a period of 90 days. The calves in control group were offered colostrums and milk twice-a-day at intervals of 8 and 16 hours daily. The calves in T1 group were also fed colostrums and milk twice-a-day but at equal intervals of 12 hours each throughout experimental period. The calves in T2 group were offered colostrums and milk thrice-a-day at equal intervals of 8 hours each for up to one month of age and thereafter twice-a-day at equal intervals of 12 hours. The mean intake of colostrums, average daily weight gain, mean time taken for ingestion of colostrums and milk was significantly higher while the NEFA concentration was significantly lower in calves belonging to T2 group as compared to the calves in the other two groups. It was concluded that the feeding of colostrums/ milk at equal intervals and increasing the frequency of feeding from twice to thrice daily from birth to one month of age improved the growth performance and health of crossbred calves and was found to be economically beneficial.

### Effect of Precision Feeding and Housing Modifications on Growth and Puberty in Murrah Buffalo Heifers

Murrah buffalo heifers (n=24; 12 months age) were randomly distributed into four treatment groups of 6 animals each. T1-routine shelter management + standard feeding, T2-routine shelter management + enhanced feeding, T3-modified shelter management + standard feeding and T4-modified shelter management + enhanced feeding. Animals under routine management were provided with concrete floor, roof height 12ft, one time body washing in summer and feeding as per ICAR, 2013. Whereas, animals under improved management group were provided with rubber mat, extended roof height up to 15 ft, there was provision of fogger and fans in summer and curtains in winter, and fed 20 % more energy and protein than ICAR, 2013. The experiment was undertaken for a period of 12 months. The average weight gain and average daily gain were found to be higher in group T2 and T4 groups, respectively than T1 and T3 groups. However, there were no significant differences for age and body weight at puberty in all the treatment groups.



### Effect of Sericin Supplementation on Freezability of Crossbred Bull Semen

Effect of supplementation of sericin in semen extender on semen freezability and oxidative stress during semen cryopreservation was studied. Thirty ejaculates, collected at weekly intervals, from five KF bulls were utilized for the study. Each ejaculate was divided into two aliquots; one was diluted with TRIS extender (control) and the other was diluted in TRIS extender containing 0.25 % (w/v) sericin (treatment). It was observed that post-thaw sperm motility, viability, HOST response and acrosomal integrity was significantly ( $p < 0.01$ ) higher in the treatment as compared to control group. Significantly higher LPO ( $p < 0.01$ ) was observed in control as compared to treatment group and significantly higher activities of SOD and GPx ( $p < 0.01$ ) were observed in treatment group compared to control. It was concluded that incorporation of sericin @ 0.25% in semen extender improved freezability of crossbred bull semen.

### Effect of Modified French Mini Straw on Cryosurvival of Low Sperm Doses

The present investigation was designed to study the effect of modified sperm packaging on functions of spermatozoa frozen in low sperm doses. Ejaculates with mass motility  $\geq 3+$  and individual progressive motility  $\geq 70\%$  from 8 Sahiwal bulls were utilized. Four types of straws were prepared based on the position of cotton plug viz type I (normal French mini straw with no displacement of the cotton plug), and type II, type III & type IV with cotton plug pushed 2cm, 4cm and 6cm, respectively from the manufactures end. Each ejaculate was split into four parts viz., Part I, Part II, Part III and Part IV and diluted up to 20, 15, 10 and 5 million sperm/0.25ml, respectively. Twenty million doses were filled in all types of straws and 15, 10 and 5 million doses were filled with type I straws. The semen-filled straws were then kept for equilibration at 5 °C for 4-5 hours and then frozen. Frozen-thawed samples were evaluated for sperm functions such as progressive motility, membrane integrity, acrosome reaction and hypo-osmotic swelling (HOS) response. There was significant ( $P < 0.05$ ) reduction in per cent progressive motility,

live, live acrosome intact and HOS responsive sperm from 15 to 5 million sperm doses. In type II, type III & type IV straws, no significant difference in per cent progressive motility, live sperm, moribund sperm, dead sperm, live acrosome-intact sperm, live acrosome-reacted sperm, dead acrosome intact and dead acrosome-reacted sperm was reported. It may be concluded that the presently modified packaging attenuates the dilution effect and provides enhanced cryosurvival of low sperm doses without compromising their freezability.

### Mesenchymal Stem Cells Used Successfully for Wounds Healing in Cattle and Buffaloes

Hoof wounds render the animals unproductive and are an important source of economic loss in India. Lameness is a widely encountered problem even in well-managed dairy farms throughout the world. This study was aimed at exploring the use of allogenic mesenchymal stem cells (MSCs) for treatment of hoof wounds. The adipose tissue was aseptically collected, processed and cultured *in vitro* for producing MSCs, which were then characterized by examining the expression of alkaline phosphatase, CD44, CD90, CD105 CD34 and CD45 in cattle. The MSCs were then proliferated by culture *in vitro* for around 2 weeks after which they were cryopreserved in liquid nitrogen. Prior to treatment, the cryopreserved MSCs were thawed and cultured for around one week. The animals suffering from wounds were given a single shot of  $10^6$  to  $10^7$  MSCs at the site of wound. A total of 241 cattle, 28 bulls and 41 buffaloes were treated with MSCs at NDRI Livestock Research Centre. All the animals were cured completely within 30 days. Several wounded animals at Gausala Hospital, Shrikishna Gosala and Radhakrishna Gosala at Karnal were also provided this treatment. Treatment with mouse allogenic and cattle xenogeneic MSCs was shown to successfully cure fractured tibial bone in mice.



Mesenchymal stem cells were used to successfully cure massive wounds in cattle and buffaloes

### Mastitis Pathogens and Somatic Cell Counts in Milk of Buffaloes

A total of 118 Murrah Buffaloes milk samples were screened with California Mastitis Test. The colonies in mastitis samples were examined for morphological appearance and haemolytic characteristics. *Staphylococcus* organisms produced large, creamy white, white, grey colored colonies with a complete zone of haemolysis, no zone of haemolysis or partial zone of haemolysis. The *Streptococcus* colonies were small grey colored with partial and complete zone of haemolysis. The isolated pathogens were finally identified by using Hi Staph TM and Hi Strep TM biochemical Identification tests kits. The major agents involved in bacterial intra-mammary infection (IMI) isolated from mastitis milk samples were *S.aureus*, *S.epidermidis*, *S. saprophyticus*, *Streptococcus agalactiae* and



Colonies of *Staphylococcus*

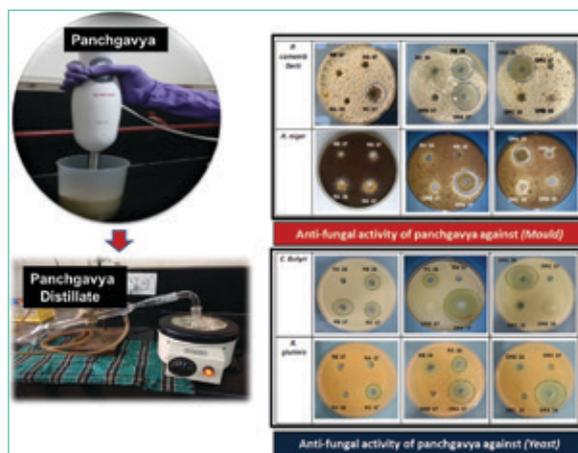


Colonies of *Streptococcus*

*Streptococcus uberis*. The culturally examined and characterized samples revealed *Staphylococcus aureus* (35.29%) as the predominant bacteria followed by *Streptococcus agalactiae* with an isolation rate of 25.49%. The incidence of coliform bacteria was not detected in any of the sample cultured. SCC ranged between  $1.28-1.48 \times 10^5$  cells/ml (in normal milk samples as compared to  $3.85-6.21 \times 10^5$  cells/ml ( $p < 0.01$ ) in mastitis milk samples).

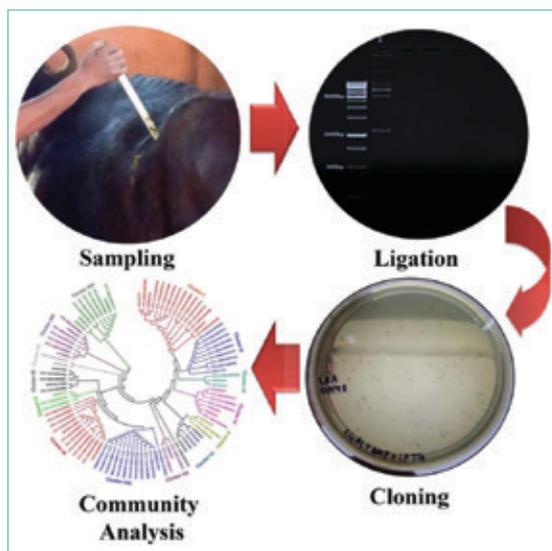
### Standardization of Methodology for Characterization of Panchgavya Formulation from Indigenous Cow "Sahiwal"

Panchgavya formulation prepared by mixing the five basic components obtained from sahiwal cows viz; cow milk, ghee, curd, urine and dung in equal ratio and used to standardize the analysis method for compositional analysis. The methods for analysis of crude lipid, nitrogen, lactose in prepared panchgavya have been standardized. The antimicrobial activity of panchgavya prepared from sahiwal cows was also tested against indicator bacterial and fungal strains. Three different ratios of basic ingredients were used to prepare panchgavya formulation and subjected to fermentation at 37 and 25°C up to 30 days. At 10 days interval, raw samples and their distillates were analyzed for pH and antimicrobial activities against selected indicator cultures. Distillate obtained from panchgavya sample of ratio A, showed highest and consistent antimicrobial activity against all the tested fungal (*Rhodotorula glutinis* NCDC-51, *Candida butyri* NCDC-280, *Aspergillus niger* NCDC-55 and *Penicillium camemberti* NCDC-56) and gram positive bacterial strains (*Bacillus cereus* NCDC-66 and *Bacillus subtilis* NCDC-70).



### Metagenomic Analysis of Reductive Acetogens and their Impact in Controlling Ruminal Methanogenesis In Vitro

PCR-cloning based metagenomic library was constructed targeting formyl-tetrahydrofolatesynthetase (FTHFS) as a functional gene for reductive acetogens. A total of 125 positive clones were derived from the library and after sequencing 69 OTU were obtained at 98% protein sequence similarity criterion. The phylogenetic tree of the revealed 14 different clusters comprising majority of uncultured clones (36%) followed by different species of *Pseudobutyrvibrio ruminis* (18%), *Eubacterium* sp. (14%), *Butyrvibrio* sp. (14%), *Desulfovibrio* sp. (10%), *Treponema primita* (3%), *Lachanospiraceae* sp. (2%), *Ruminococcus productus* (1%), *Thermoanaerobacter kivui* (1%) and *Sporomusa ovata* (1%). By cultivation based methods, 267 isolates were obtained and 51 isolates were confirmed reductive acetogens by PCR. Similar types of isolates were screened using 16S rDNA PCR-RFLP by 3 different restriction enzymes (AluI, HaeIII and MspI). Dendograms constructed from the restriction band patterns showed invariably 11 different groups for these enzymes while genotyping yielded 12 different genotypes. Two isolates showing H<sub>2</sub>S production were excluded and rest were identified by 16S rDNA sequencing. Sequencing data showed maximum similarity (99%) to different strains of *Clostridium* spp. (6), *Vagococcus fluvialis* (1), *Eubacterium limosum* (1), *Ruminococcus* sp (1) and *Acetobacterium woodii* (1). *Vagococcus fluvialis* (ACB19) and *Eubacterium limosum* (ACB66) were found as potent reductive acetogens without affecting the overall digestibility parameters and in the absence of methanogenesis, they can sustain normal functioning of the rumen.



### Metabolic Inflammation during Transition Period in Relation to Postpartum Productive and Reproductive Performance in Deoni Cows

The levels of innate immune molecules (Haptoglobin: Hp, Serum Amyloid A: SAA, IL-6, TNF- $\alpha$ , IL-1 $\beta$ , and IL-8) and energy indicators [NEFA, BHBA; Dry Matter Intake (DMI) and body condition score (BCS)] in transition Zebu (Deoni breed) cows that became pregnant within breeding period and remained non-pregnant even after the breeding period were assessed. The cows that became pregnant within breeding period had higher concentrations of plasma

Hp and SAA during transition period than the cows that remained non-pregnant. During transition period, plasma IL-6 and TNF- $\alpha$  concentrations were higher ( $P < 0.05$ ) in cows that later become pregnant within breeding period. The cows that became pregnant within breeding period had higher ( $P < 0.01$ ) DMI during pre-partum period than the cows remained non-pregnant. Although, plasma NEFA and BHBA concentrations were higher during transition period in cows that became pregnant as compared to those that were open at the end of breeding period, their levels were within physiological range. High yielding cows had significantly ( $P < 0.05$ ) higher concentrations of SAA, TNF- $\alpha$ , and IL-6 during pre-partum and early postpartum period than low yielding cows. It is concluded that an immune stimulation and metabolic adaptation during transition period enabled early conception during breeding period and increased milk yield in Deoni cows.

### Development of Suitable Management Measures to Augment Milk Production, Quality and Udder Health Status in Dairy Cattle at Lower Gangetic Region

Based on initial milk SCC (similar type), eight Jersey crossbred cows (Parity: 2 to 4) were divided into two comparable groups. The first group (G-I) was allowed to be milked with traditional practice of water washing of udder before and after each milking whereas second group (G-II) was milked by washing with Potassium Permanganet (1%) before and after each milking. The full hand milking was carried out in both the cases. Some demonstration and hands on training were provided to farmers. After an adaptation time, the main experimental course was continued for 4 months. The 70 ml of sample was collected from whole milk bucket after complete milking of animals in sterilized glass bottles at fortnightly interval ( $n=112$ ). The initial  $\text{Log}_{10}$  SCC (cells/ml) was similar for G-I and G-II ( $14.70 \pm 0.87$  &  $15.09 \pm 0.76$ ); whereas, the final  $\text{Log}_{10}$  SCC (cells/ml) significantly ( $P < 0.01$ ) decreased in G-II ( $4.85 \pm 0.06$ ) than G-I ( $6.31 \pm 0.15$ ). The MCMT grade was also lower ( $P < 0.01$ ) in G-II ( $1.44 \pm 0.11$ ) than G-I ( $2.73 \pm 0.13$ ). The MBRT (min) was higher ( $P < 0.01$ ) for G-II ( $437.36 \pm 31.27$ ) than G-I ( $115.24 \pm 22.93$ ). Though, there was no difference of the test day milk yield between the groups, higher production was observed in morning than evening session in both groups. The similar trend of fat (%) and SNF (%) was observed for both the groups. From this study, it was concluded that management measure like udder washing with 1% Potassium permanganate solution before and after each milking can reduce intra-mammary infections and improve udder health status without affecting milk composition and quantity in Jersey crossbred cows at lower Gangetic region.

### Alteration of Micro-Environment of Cow-Shed Enhanced Animal Comfort and Milk Yield in Jersey Crossbred Cows

Observations on the effect of soft flooring (sand bed) and roof thermal-insulations (using paddy straw) were investigated by subjecting 10 lactating cows as experimental (T1) and 10 as control (T0) group at ICAR-NDRI, ERS, Kalyani. Modified house diminished the stress conditions of animals by reducing 5-7 °C roof temperature. Floor surface temperature of sand bed was also significantly lower than concrete surface temperature. Thermal and flooring comfort also significantly reduced rectal temperature, pulse rate and respiration rate of experimental cows compare to control group. During summer season, there was significantly higher temperature (°C) in T0 (36.53 and 37.49, respectively) shed compare to T1 (27.41 and 32.33, respectively) shed during peak hours (11 am and 3 pm, respectively) in a day. During evening, difference of temperature was non- significant. During winter also the trend was similar to that of summer. The results indicated that insulation by paddy straw ceiling reduced the thermal radiation and hence created better thermo-comfortable environment in the modified shed as compare to existing shed. Milk yield (kg/d) was significantly higher in T1 ( $11.55 \pm 0.08$ ) as compared to T0 ( $11.17 \pm 0.10$ ). On overall basis, cows kept in thermo-comfortable soft floored shed produced 380 g more milk per cow per day. Higher sub-clinical mastitis test score (MCMT grade) in T0 group compare to the T1 indicated better udder health status in cows kept in stress ameliorated shed. Though, SCC was higher in T0 than T1, it was statistically non-significant. Due to cushioning effect of sand floor, lesions on knee, hock, leg and other parts of body in T1 group animals were significantly less compared to cows kept on concrete floor. Hoof lesions score was higher in T0 compared to T1; however, did not differ significantly. Locomotion score was poorer in T0 as compared to T1.



Roof ceiling thermo-protection by paddy straw and floor comfort by sand bed in cow shed

### Development of Low Cost Thermo-Comfortable Model Housing for Dairy Cattle

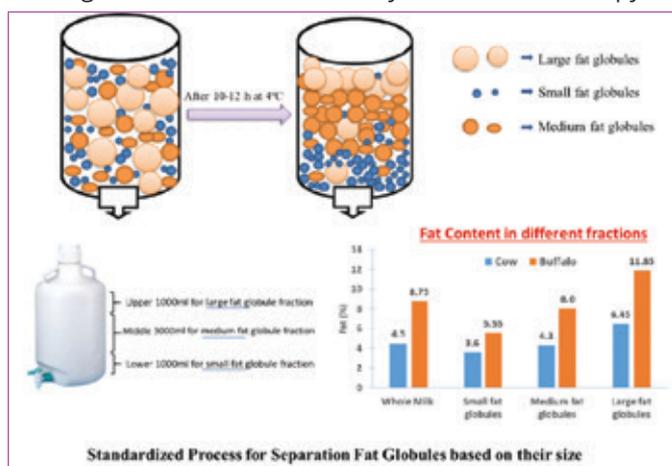
One low cost thermo-comfortable model house for dairy cattle was developed at ERS, NDRI, Kalyani. Paddy straw was used as roofing materials. Truss was constructed using bamboo and MS pipe, wherever required. Roof design was made for ridge ventilation to reduce thermal stress. Total constructed area of the shed was 237.13 sq. m, covered area 116.17 sq. m and open area 120.96 sq. m. The shed is having central passage with two wings for cow standing and feeding manger. The shed was ready by June 2017 and was inaugurated by Dr. R. R. B. Singh, Director & Vice-Chancellor, NDRI, Karnal. Experimental observations on thermo-comfortable cow shed is in progress by subjecting 20 lactating cows as experimental and 20 as control group; keeping best possible uniformity between groups on the basis of their milk yield, stage of lactation, age and parity.



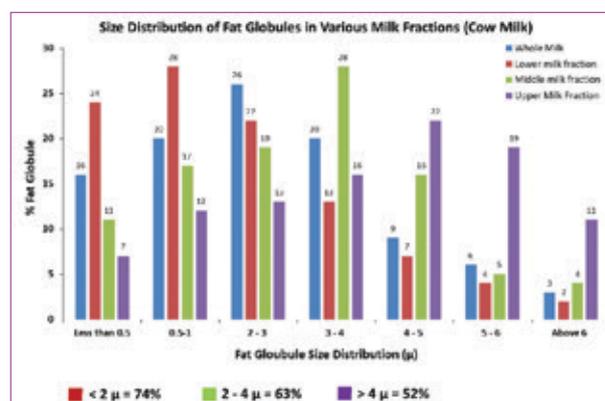
# NOVEL APPROACHES IN VALUE ADDITION AND PROCESS ENGINEERING

## Size Dependent Variations in Lipid Fractions of Fat Globules in Milk from Different Species

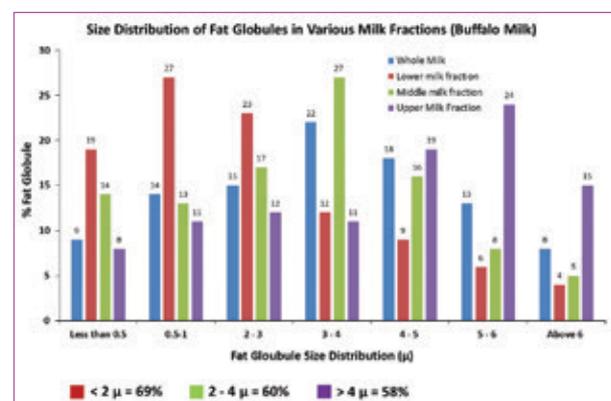
A gravity separation method has been standardized to harvest the fat globules based on their size from cow and buffalo milk. The fat globules in both cow and buffalo milk were separated into three different fraction based on their size viz., small fat globules (SFG), medium fat globules (MFG) and large fat globules (LFG). The fat content in various fractions was checked and in cow milk (fat 4.5%) was found to 3.6%, 4.3% and 6.45% in SFG, MFG and LFG fractions. The corresponding values in buffalo milk (fat 7.75%) were found to 5.55%, 8.0% and 11.85%, respectively. The fat globule size distribution in three fractions and original milk was estimated by confocal microscopy. In general, SFG fraction contains more than 69% fat globules of size  $\leq 2 \mu$ . The MFG fraction contains more than 60% fat globules of size 2 – 4  $\mu$ . The LFG fraction contains more than 52% fat globules of size > 4  $\mu$ . Fatty acid composition of each fraction was analysed and results indicated that in case of cow milk, SFG fraction was rich in short chain fatty acids (C4-C6); MFG fraction was rich in monounsaturated fatty acids, as well as total unsaturated fatty acids; and LFG fraction was rich in total saturated fatty acids. However, there was no appreciable difference in fatty acid composition of different fat globules in case of buffalo milk. Study also revealed that cholesterol content was more in SFG vis-à-vis other fat globule fractions in both cow and buffalo milk.



MFG fraction contains lowest level of cholesterol.  $\beta$ -carotene content was found highest in large fat globules in case of cow milk. While,  $\beta$ -carotene was completely absent in buffalo milk, retinol content was found higher in buffalo milk.



Size distribution of fat globules in various milk fractions of cow milk

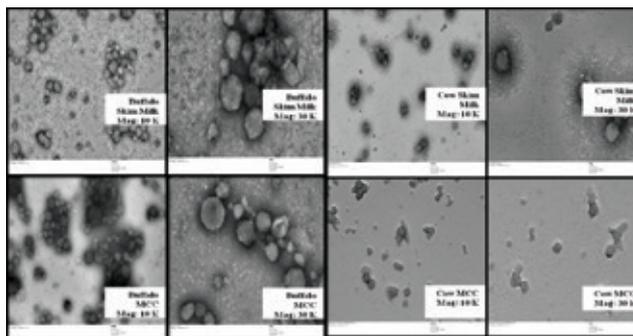


Size distribution of fat globules in various milk fractions of buffalo Milk

## Preparation of Micellar Casein Concentrates (MCC) from Buffalo and Cow Skim Milk Using Microfiltration

MF of skim milk from cow and buffalo was done in manual hollow fiber ultra filtration assembly (QSM-03S model, M/s. GE Healthcare, Gurgaon, Haryana) using a hollow fiber membrane Cartridges of 0.1 micrometer pore size.

The protein concentration increased from  $3.96 \pm 0.2\%$  to  $16.342 \pm 0.4\%$  (about 4.12 folds) and  $3.57 \pm 0.4\%$  to  $14.42 \pm 0.7\%$  (about 4.00 folds) respectively in buffalo and cow skim milk. There was only 18.0% and 14.5% retention of whey protein in buffalo and cow MCC respectively constituting about 0.6-0.7% of total protein in the MCC. The structural analysis was done using transmission electron microscopy. The TEM micrograph showed intact CN micelles and no sign of distortion of structure or aggregation in case of buffalo MCC whereas in case of cow MCC there was some distortion and aggregation of casein micelles.



TEM images of Skim Milk and MCC (of buffalo and cow milk) at different magnifications

### Preparation of Paneer Making Coagulant Powder

Paneer whey was fermented with Probiotic *Pediococcus pentosaceus* NCDC273 followed by cell separation to prepare fermented powder of cell free fermented supernatant. The shelf life of the paneer prepared with fermented powder was increased to 14 days as compare to 8 days. Paneer prepared with dried powder achieved higher sensory score than paneer prepared with citric acid.



Fermented powder



Paneer with powder



Paneer with Citric Acid

### Bio-prospecting of Lactic Cultures from 'Cold Desert Regions' to Develop Functional Fermented Milk Products with Potential Health Benefits

Thirty eight samples comprising dahi (23), lassi (7), pickles (7) and goat milk (1) were collected from cold desert region (Lahaul and Spiti District, and Bharmaur of Chamba District) of Himachal Pradesh. Thirty two (32) *Lactococcus* spp. isolates were characterized based on quality of curd form skim milk. *Lactococcus* spp. were further identified genotypically. Twenty three were identified as *Lactococcus lactis* spp. *lactis* and five as *Lactococcus lactis* spp. *cremoris*. Nineteen *Leuconostoc*, 16 *Lactobacillus*, and 26 *Pediococcus* spp. isolates were also characterized and identified by genus specific PCR. Thirty two *Lactococcus lactis* isolates were evaluated for their suitability as starter cultures for fermented milk. Nine *Lactococcus lactis* isolates with faster acidification and diacetyl production have been characterized for preparation of starter culture for dahi and lassi. *Lactobacillus* and *Pediococcus* isolates displayed considerable antimicrobial potential against *E. coli*, *B. cereus* and *S. aureus*. Thirty two *Lactobacillus* and 11 *Pediococcus* isolates displayed phytase activity on Na-phytate-MRS agar. Gouda cheese culture(s) with *Lactococcus* and *Leuconostoc* isolates has been formulated.

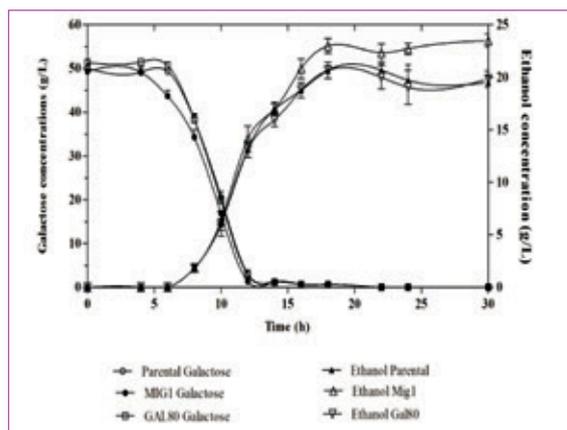
### Defined Strain Starter Culture for Ripened Cream Ghee

The diacetyl production (determined by Creatine test) potential of 13 *Lactococcus lactis* cultures from National Collection of Dairy Cultures, NDRI Karnal was examined and four potent diacetyl producing cultures (*L. lactis* NCDC 97, 127, 128, 193) were selected. Diacetyl negative *L. lactis* NCDC 314 was used as control. *L. lactis* NCDC 128 and 193 started diacetyl production at 6 h of fermentation in skim milk as well as in cream, which was further increased upto 8 h. Viable counts were observed to be increased by 2 log from initial count of 7 log cfu/ml. Butter was prepared from cream fermented at 6, 8, 10 h and ghee was prepared by clarifying butter at 105-110 °C for 15 min. Flavour scores of ghee as well as buttermilk increased upon fermentation of cream. Maximum flavour scores were observed with *L. lactis* NCDC 193 at 8 h. Fermentation of cream with *Lactococcus lactis* ssp. *lactis* NCDC 193 at 30 °C for 8 h was found to be the optimum. Moisture, free fatty acid and total carbonyl content of ghee prepared from ripened cream butter under optimized condition were 0.34%, 0.48% oleic acid and 6.75 µmol/ g fat, respectively.

### Enhancing Galactose Metabolism by Genetically Engineered Thermotolerant *Kluyveromyces Marxianus*

*K. marxianus* strains (Lab isolates) were used in the present study which showed significantly different ethanol, sugar and thermo-tolerance as determined by their viability. *K. marxianus* 6C17 was sugar tolerant towards

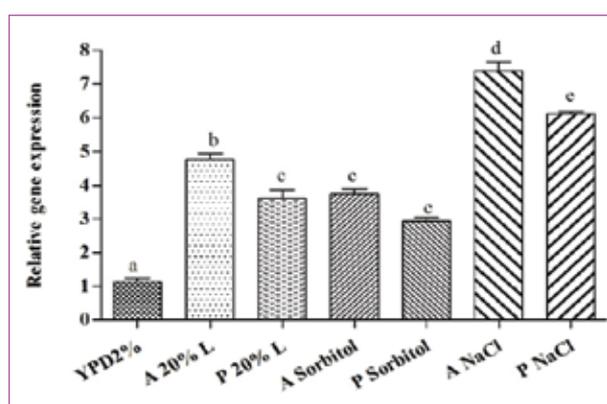
15% galactose. Ethanol production was maximum in 15% galactose and lactose by 6C17 strain. During batch cultivation in complex medium YPG and whey media, maximum specific growth rate on galactose was found to be  $0.35 \text{ h}^{-1}$  and  $0.32 \text{ h}^{-1}$  respectively at  $37^\circ\text{C}$ . Ethanol yield was maximum at  $37^\circ\text{C}$  using galactose alone which was measured as  $0.39 \text{ g/g}$  of galactose. Moreover, GAL genes are tightly regulated, being repressed by glucose and induced by galactose up to 1,000-fold. The efficient conversion of galactose into a desirable product requires an optimum flux flow through the central carbon metabolism and genetic engineering of regulatory network genes provided us a balanced increase in galactose utilization. So, the deletion of the MIG1 and GAL80 gene was employed in *K. marxianus* using the Cre-LoxP system



for the efficient utilization of both glucose and galactose by preventing the catabolite repression. The disruptant (mig1 mutant and gal80 mutant) obtained could grow in the medium containing G418. This led to an increase in the galactose uptake rate of 9 % in the mutant MIG1 strain compared to wild type strain whereas no significant difference was found in galactose utilization in GAL80 mutant strain. The mig1 deleted strain was examined for the production of ethanol under controlled batch cultivation on concentrated whey and 47 g/l of ethanol yield was obtained during fermentation of concentrated whey containing 100 g/l of lactose which is 19% higher than the parental strain. The increase in whey lactose concentration was found to increase the ethanol yield directly. Besides the major carbon flux from whey into ethanol production and the other metabolites biomass, pyruvate and acetate were also measured in terms of yield coefficient. The improved flux was accompanied by the decrease in the biomass yield from  $0.35 \text{ g CDW}^{-1}$  to  $0.33 \text{ g CDW}^{-1}$ . The findings of the present study have the potential to pave way to develop a future industrial strain for bioethanol production from whey.

### Comparative Analysis of wild and Engineered Strain in YPG

Lactose utilization from whey by evolutionary engineering of *Kluyveromyces marxianus* MTCC1389 was used to adapt in concentrated whey containing 20% lactose. *K. marxianus* MTCC1389 and *Saccharomyces cerevisiae* MTCC170 and *S. cerevisiae* CEN.PK2-1D yeast strains were grown under oxidative stress and cells of both strains induce glutathione which acts as an antioxidant molecule. *K. marxianus* MTCC1389 found to be more resistant towards oxidative stress than *S. cerevisiae* strains. Under ethanol stress, an elevated glutathione content of  $8.1 \mu\text{g/mg}$  protein was found at 7% (v/v) ethanol. *K. marxianus* showed highest glutathione level at 100 g/l lactose. Trehalose played a major role in yeast cell survival under osmotic stress. Highest trehalose concentration was found in presence of lactose (150 g/l)  $83.64 \pm 0.8 \text{ mg/gCDW}$  while under NaCl (0.25M) its level reduced to  $76.33 \text{ mg/g CDW}$ . GPD1 expression was found higher in NaCl stress followed by lactose and sorbitol stress. Moreover, the expression of genes was significantly ( $p < 0.05$ ) higher in adapted strain than parental strain. The stimulation and up-regulation of stress related genes showed that the first hour, immediately after the initiation of stress treatment, corresponds to a sensitive response period. Strain MTCC 1389 was subjected to adaptation to lactose up to 200 g/l for 65 days and used for fermentation of lactose rich whey for ethanol production. Fermentation with adapted *K. marxianus* MTCC 1389 strain in 3L fermentor resulted in final ethanol titer of  $79.33 \pm 0.82 \text{ g/L}$  which was nearly 20% more than the parental strain  $65.66 \pm 0.12 \text{ g/L}$ . Further,  $\beta$ -galactosidase enzyme activity was also increased in adapted strain ( $1.353 \pm 0.038 \text{ IU mg}^{-1} \text{ DW}$ ) than parental strain ( $1.20 \pm 0.016 \text{ IU mg}^{-1} \text{ DW}$ ). Adapted strain was found stable even



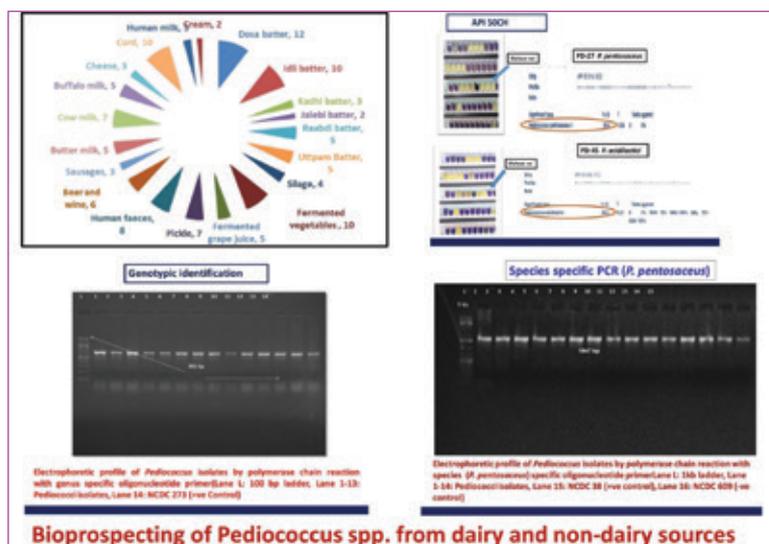
TPS1 and TPS2 gene expression in adapted strain *K. marxianus* 1389

Significant difference ( $p < 0.05$ ) in TPS1 and TPS2 gene expression was found in adapted strain compared to parental strain in all conditions.

after 10 cycles of fermentation in whey (50 g/l). The experimental analyses suggested that the MTCC 1389 adapted strain was able to valorize lactose to ethanol at a faster rate than the parental strain. Thus, the study illustrates that evolutionary engineering is an efficient strategy to obtain a superior bioethanol producing yeast strain, which efficiently ferments four-fold concentrated cheese whey.

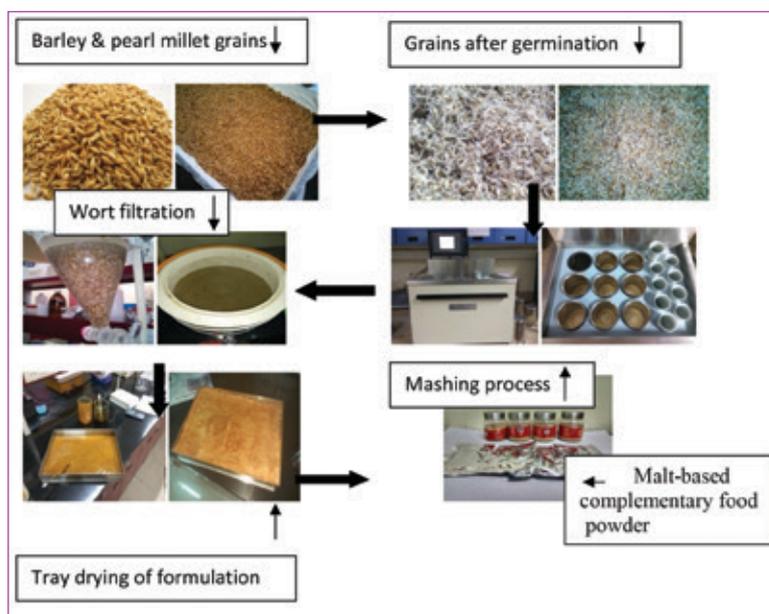
### Network Project on dairy microbes under ICAR-National Centre on Veterinary Type Cultures (NRCE, Hisar)

The isolation and identification of *Pediococcus* spp. from dairy and non-dairy sources was carried out during the period under report. A total of 115 samples (dairy as well as non-dairy) were collected from different locations for the isolation of *Pediococcus* spp. As many 40 presumptive isolates of *Pediococcus* were isolated and bicochemical (API 50 CH) and genotypical characterization confirmed 39 isolates as *P. pentosaceus* and one as *P. acidilactici*. A total of 37 (92.5%) out of 40 identified *Pediococcus* isolates were from non-dairy samples while three isolates (7.5%) belonged to dairy sources.



### Development of Milk Protein Enriched Pearl Millet Malt Based Complementary Food

A process was developed for malt-based complementary food powder from pearl millet-barley malt. It was fortified with calcium, iron and zinc. The product remained stable for over three months in metallized polyester pouches. The cost of production was observed to be ₹ 363.81 per kg, which was found to be cheaper by ₹ 96.18 compared to similar products available in the market.



Manufacture of Malt-based Complementary Food Powder

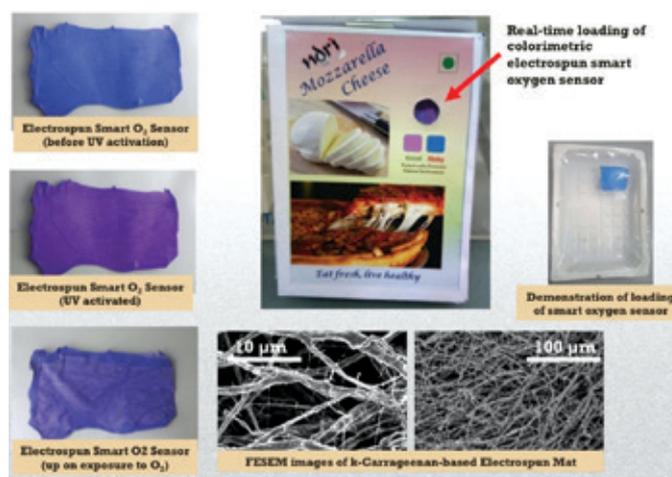
## Process Optimization for Industrial Manufacture of Milk Protein-Iron Fortified Paneer

*Paneer*, a popular dairy product is available in several pack sizes commercially (200, 500 and 1000g) across the country, is a good source of nutrition, but is deficient in iron. An attempt was made to improve the iron content of *paneer* through sodium caseinate-based coating solution containing selected iron salt. Process parameters such as dipping volume (coating solution: *paneer*), dipping time and block size of *paneer* were optimized and the residual iron content in the coating solution after each dipping up to three times was determined. It was found that the iron content of *paneer* block (200 g) increased from 28.30 ppm to 92.86 ppm. Studies indicated that iron fortification of *paneer* on an industrial scale is feasible using milk protein based edible coating that could result in an increased nutritive value.



## Electrospun On-package UV-activated Smart Oxygen Leak Indicator for Modified Atmosphere Packaged Dairy Products

A biopolymer-based ultraviolet light-activated electrospun smart oxygen leak indicator (mat) was fabricated for detecting oxygen leak in modified atmosphere packaged dairy products. Electrospinning process parameters such as voltage, flow rate and distance between collector plate and spinneret were optimized based on the instrumental color difference values of original, photo-activated and recovered spun mats. Electrospinning solutions presented pseudoplastic behavior. The microstructure of the electrospun mat revealed compact non-woven fibers with an average fiber size of 1-2 microns. The fabricated electrospun smart mat was sensitive enough to detect as low as 0.1% oxygen in the packaged food. The electrospun mats were found to be stable for at least 60 days when stored under dark at 25°C. The developed electrospun oxygen sensor can be easily integrated with packaging material and would be useful as an intelligent indicator for all the stakeholders in the supply chain.



Preparation of low cost value added extruded product for making complementary food

## Low Cost High Protein Extrudates for Developing Weaning Food Based

Attempts were made to develop low-cost weaning food for infants using extrusion technology. Baseline survey questionnaire was developed to assess the awareness regarding weaning practices, formulation aspects and dietary practices. Based on the data collected, preliminary screening of milling by-products *viz.* rice brokens and maize grits, non-conventional legumes and milk solids for the preparation of high protein extrudates was completed. The combination of rice brokens flour, maize flour, yellow pea flour and skim milk powder was selected for further studies.

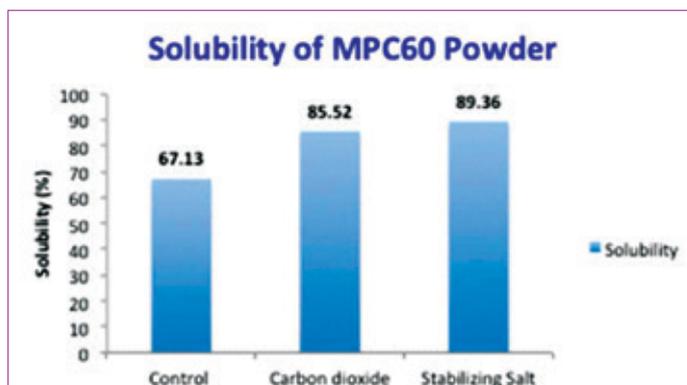


Preparation of low cost value added extruded product for making complementary food

## Enhanced Solubility of Buffalo Milk MPC60 with Carbon Dioxide and Stabilizing Salt Treatment

Milk protein concentrate 60 (MPC60) was manufactured from pasteurized buffalo skim milk and characterized. The Solubility of the freshly manufactured MPC60 powder was  $67.13 \pm 0.50\%$ . Injection of carbon dioxide either in milk or in ultrafiltered retentate, significantly improved the solubility of resultant MPC60 powders. Addition of

various stabilizing salts also led to higher solubility than control. All powders were characterized for their physico-chemical, reconstititional, functional and rheological properties.



### Process Optimization for Ricotta Cheese Manufacture from Buffalo Milk Systems

Ricotta Cheese is a soft, unripened variety of whey cheese mostly prepared from small ruminants' milk. Lower availability of small ruminant's milk limits the production and availability of ricotta cheese in India. Attempts were made to optimize ricotta cheese from buffalo milk system with maximum protein recovery and acceptable sensory properties. Varying ratios of buffalo milk/whey, fat content and coagulation temperatures were studied to evaluate their effect on the sensory, physico-chemical, rheological and textural properties of ricotta cheese. All process parameters significantly affected cheese properties and whey protein recovery. In the optimized ricotta cheese, a maximum of 97% protein recovery was achieved. The optimized product had 25.64% total solids, 6.54% fat, 12.17% protein and 0.14% acidity. The product exhibited 12 days of shelf life in refrigerated storage conditions.



### Mechanized Production Systems for *Rabri* and *Kheer*, Indian Traditional Delicacies

Continuous *Rabri* making equipment comprising of rapid milk concentrator and milk flake formation system, which ensures rapid and uniform layer formation of clotted cream (*malai*) was developed. The equipment, which could manufacture approximately 20 kg *rabri* per hour, is quite suitable for ensuring product uniformity, consistency with considerable saving of fuel and time. The phenomenon of clotted cream layer formation during thermal concentration of milk in *rabri* making was studied using thermal imaging technique. Equipment for mechanized production of *kheer* was developed which is suitable for small and medium level of commercial production. The system comprises of milk concentrator, rice pre-conditioning system, a mixing system of rice-concentrated and flash

heater to ensure desirable heating of mix before hot filling in packages. The developed equipment can produce about 60 kg *kheer* per hour and has provisions for controlling the process variables.



a) Equipment for Kheer making



b) Equipment for Rabri making

### Development of Can-washer for Small/ Medium Chilling Centres

Existing can cleaning systems involve holding the milk can in an inverted position and cleaning with the help of high-pressure water and/or detergent solution jets. A can rinsing test rig was fabricated in collaboration with Chem Process System Pvt. Ltd., Ahmedabad. The objective of the present work was to minimize the water and detergent usage during milk cleaning thus reducing the effluent generation. The spray jet nozzles of varying apertures speed and jet pattern were optimized for efficient cleaning of cans and improving the microbiological quality. The performance of the fabricated milk cleaning test rig was also evaluated.

### Measurement and Modelling of Cooling Characteristics of Curd (*Dahi*) Under Varying Cooling Conditions

Studies were conducted to understand the transient cooling process of curd set in 200 mL high-impact polystyrene (HIPS) cups placed in cold air flow. The exponential curves of cooling for the dimensionless temperature of curd were obtained for 5-different velocities of cooling air and two different directions *viz.* radial and axial directions airflow to cup. Based on this, Biot number and surface heat transfer coefficient were evaluated and found that surface heat transfer coefficient increased and cooling time decreased with rise in air velocities from 0.5 m/s. This pattern was more effective during initial stages of cooling, which reduced with higher velocities of air ranging from 3.5 to 4.5 m/s. Keeping the velocity of air in higher range during forced cooling was found to be effective not only in reducing the overall processing time but also economical.

### Improved Moisture Barrier Properties of Coconut Shell and Areca Sheath for Potential Applications in Dairy Foods Packaging

An attempt has been made to increase the moisture barrier properties of coconut shell through uniform coating of beeswax (INS 901), carnauba wax (INS 903) and food grade epoxy. The average water absorption with beeswax, carnauba wax and food grade epoxy was  $0.62 \pm 0.08\%$ ,  $5.83 \pm 0.22\%$  and  $0.51 \pm 0.05\%$ , respectively while the uncoated shell had  $7.84 \pm 0.12\%$  water absorption. Water vapour transmission rate (WVTR) of the coconut shell when coated with beeswax, carnauba wax and food grade epoxy showed an average value of  $45.12 \pm 2.3$  g/m<sup>2</sup>/day,  $142.74 \pm 2.52$  g/m<sup>2</sup>/day and  $18.14 \pm 1.02$  g/m<sup>2</sup>/day at 30°C, respectively. The average WVTR value for uncoated coconut shell was found to be  $306.62 \pm 3.56$  g/m<sup>2</sup>/day. The average moisture ingress at 30°C and 79% RH with coating of beeswax, carnauba wax and food grade epoxy was expressed as weight gained by calcium chloride, the corresponding values were  $2.39 \pm 0.14$  g,  $3.35 \pm 0.18$  g and  $2.27 \pm 0.16$  g, respectively during seven days. The uncoated coconut shell showed an average moisture ingress value of  $4.19 \pm 0.24$  g during the same period. Hence, these coatings reduced the moisture transfer rate across coconut shell significantly. Water absorption percent, WVTR and moisture ingress were reduced by 93.5%, 94% and 45.8%, respectively.

### Characterization, Process Optimization and Shelf Life Evaluation of *Thirattupal*- A Heat Desiccated Dairy Product of Tamil Nadu

*Thirattupal* is one of the region-specific traditional dairy products, popular in Tamil Nadu. The market samples contained on an average 19.81% moisture, 16.95% fat, 14.24% protein, 14.24% lactose, 38.27% sucrose and 1.99% ash. Optimization of the levels of milk fat (2.78 to 6.82 %), sweetener (6.64 to 13.36 %) and coagulant (0.16 to 1.84 %) was done using central composite rotatable design of response surface methodology. The optimized product

had 6% milk fat, 10.87% (w/v) sweetener and 0.5% (w/v) coagulant. The chemical composition of the optimized product was: 19.16% moisture, 18.87% fat, 11.83% protein, 13.97% lactose, 35.33% sucrose and 1.82% ash. Use of *khoa* making machine for *thirattupal* production could be helpful in producing *thirattupal* having quality similar to that of the standardized product. The shelf life of *thirattupal* in low-density polyethylene pouches and polystyrene tubs was 16 days and in laminates and multilayer pouches, it was 18 days at  $30 \pm 1^\circ\text{C}$ .

### Application of Hurdle Technology in Development of Shelf Stable New Varieties of Paneer

*Paneer* has a short shelf life owing to its high  $a_w$  (0.992), pH (5.4) and microbial load. In this project, hurdle technology concept was used to enhance the shelf life of *paneer* with smoke as one of the hurdles. Water activity of *paneer* was reduced by partial drying at  $55^\circ\text{C}$  to about 51.4% moisture and pH was reduced by soaking in citric acid solution in refrigerator for about 12 h. The *paneer* cubes were smoked by burning wood/leaves (mango, neem, mint leaves) and spices (ajwain, black pepper, clove and their combination) in a smoking chamber. Based on the sensory evaluation, the combination of pH, water activity and smoke was selected as the best combination. The *paneer* samples subjected to this combination of hurdles were packed in different packaging materials *viz.* polystyrene, LDPE and laminates. These treatments did not enhance the shelf life of *paneer* at room temperature. However, the shelf life was found to be enhanced from 8 days to 29, 41 and 53 days in polystyrene, LDPE and laminate, respectively at  $7 \pm 1^\circ\text{C}$ . During storage, changes were observed to take place in terms of increase in hardness and chewiness of both the control and treated *paneer*. Moisture and pH were decreased while acidity increased. Gel electrophoresis showed slightly more degradation of protein in control than in *paneer* treated with the selected combination of hurdles during storage.

### Effect of Different Coagulants on the Yield and Selected Quality Characteristics of Cow Milk Paneer

Attempts were made to enhance the yield of *paneer* by using non-conventional coagulants and also study their influence on colour and appearance of *paneer*. *Paneer* was prepared from cow milk by using combinations of alum, malic acid, calcium lactate, citric acid and glucono-delta lactone (GDL) in different proportions. Among various levels of combinations, calcium lactate, malic acid and GDL in the proportion of 50:25:25 gave superior quality product with respect to sensory attributes. Colour and appearance, body and texture, flavour and overall acceptability score of this combination were 8.23, 7.95, 7.81 and 7.85, respectively which were higher than the control sample made from citric acid. The yield of *paneer* made by this combination was 18.23%, which was higher compared to the control (16.15%). Experimental *paneer* had higher hardness and chewiness values but lower springiness and cohesiveness values than control. Experimental sample also had more instrumental lightness value than the control indicating more whiteness.

### Role of Ionic Silver in the Preservation of Paneer

An attempt was made in this investigation to reduce the microbial load of *paneer* using ionic silver solution. Ionic silver solution (ISS) of 11 and 17 ppm concentration were prepared by electrochemical method (Fig. 1). ISS of 17 ppm concentration was found to be more effective. The initial total bacterial count (TBC) of control sample was 4.51 log cfu/g which increased exponentially to 6.8 log cfu/g at the end of 18 days of storage in control samples. However, for ISS (17 ppm) added *paneer* samples had 5.72 log cfu/g after 25<sup>th</sup> days of storage at refrigerated temperature. Coliform count was increased from 1 log cfu/g to 2.37 log cfu/g at the end of 18 days of storage in control sample. However, ISS (17 ppm) added samples had 2.43 log cfu/g of coliform count at the end of 25 days of storage. The yeast and mold count increased from an initial value of 1.2 log cfu/g to 2.68 log cfu/g on 18th day of storage and from 1.00 to 2.41 log cfu/g on 25<sup>th</sup> day of storage in control and ISS treated samples, respectively.

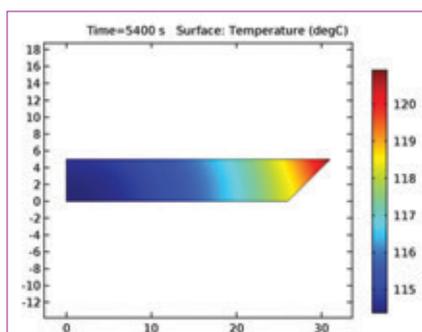


### Post Processing Interventions to Improve Quality and Shelf Life of Curd Rice

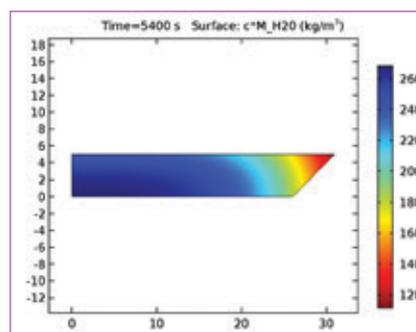
Spiced curd rice prepared using standardized process technology subjected to mild thermal treatments (hydrothermal and microwave), vacuum packaging and pulsed electric field treatment was evaluated for its keeping quality under ambient and refrigerated conditions under elevated temperature ( $37\text{--}38^\circ\text{C}$ ) and refrigerated ( $7\text{--}8^\circ\text{C}$ ) storage. It was observed that the post processing interventions had only a marginal influence on the keeping quality of the product under storage at elevated temperatures, while a significant enhancement in the shelf life of refrigerated samples was achieved. Among all the treatments evaluated, vacuum packaging performed better, the vacuum packed samples were found to be acceptable up to 24 days of storage as against 15 days for control.

## Development of Infrared Assisted Baking Oven and Evaluation of Baking Characteristics of *Chhana Podo*

The temperature and moisture profiles of *chhana podo* during baking were simulated using finite element approach. The 2-D model of *chhana podo* was prepared in COMSOL. Heat and mass transfer module was invoked and the concerned equations were used for coupling the heat and moisture transport in the system. The temperature profile closely matched the experimental data. The same approach was used to simulate the moisture content using a finite element solver (COMSOL) in 2-D space. The final baked product had crumb and crust moisture concentrations of 260 and 120 kg/m<sup>3</sup>, respectively. Baking process could, thus, be considered as a moving boundary problem in which an evaporation front was established on the surface of the product in the beginning of baking.



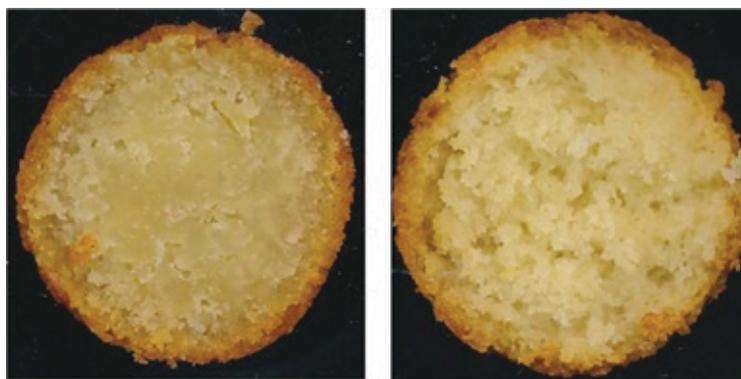
Simulated temperature profile of *chhana podo* at 5400 s of baking



Simulated moisture profile of *chhana podo* at 5400 s of baking

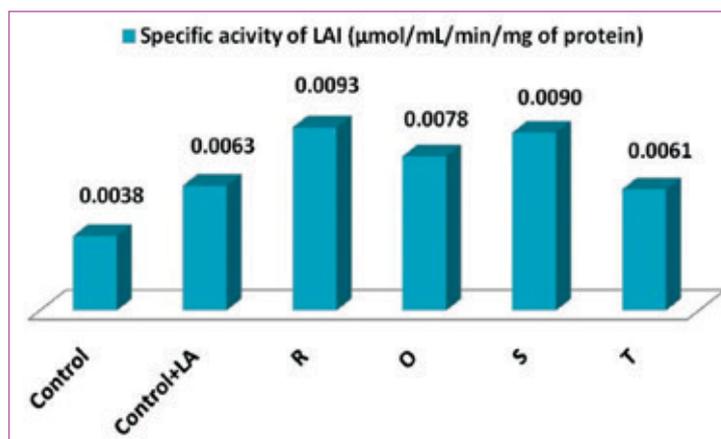
## Modelling of Heat and Mass Transfer during Sub-Baric Frying and Soaking of *Gulabjamun*

Comparative evaluation of the sub-baric and conventionally processed *Gulabjamun* showed that sub-baric processed product had superior quality attributes and sensory attributes; Sub-baric frying of *Gulabjamun* proved to be a promising technique to reduce the oil content (by 36 %) and enhanced porosity when compared to conventionally fried *Gulabjamun*. The study established the relative benefits of the sub-baric process over the conventional methods of *Gulabjamun* preparation, both in terms of product quality and process engineering.



## Manipulation of Rumen Microbes using Medicinal Plants Extract to Enhance the Nutraceutical Value of Milk

Twenty six plant extracts on different concentrations (1, 2.5, 5, 10 mg/mL) were screened for their growth promoting/inhibiting activity of *Butyriovibrio* sp. Out of these twenty six, four plant extracts [*Curcuma longa* (R), *Trigonella foenum*

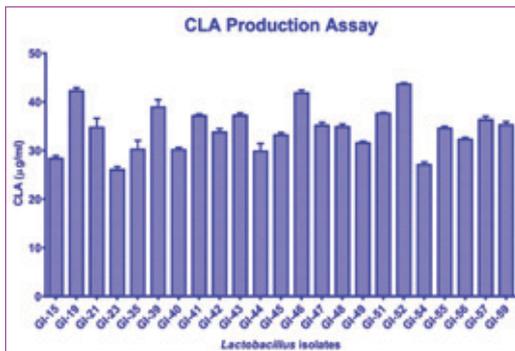


Effect of plants extract on Linoleate isomerase (LAI) specific activity

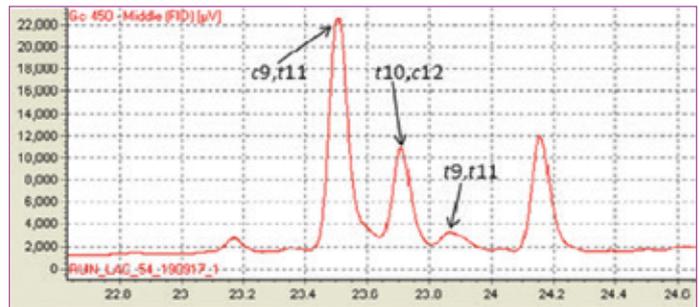
(O), *Bacopa monnieri* (S) and *Alovera* (T)] enhanced the growth of *Butyrivibrio* sp. The growth of *Butyrivibrio* sp. was not affected significantly @ 1 and 2.5 mg/ml of extract dry weight, however, at 10 mg/ml, growth of *Butyrivibrio* sp was inhibited with all the plant extracts. The screened four samples were found to enhance CLA isomerase activity as well as increase in growth at 5 mg/ml. Further, these 4 samples were studied for their effect on rumen fermentation, digestibility and shift in growth of CLA producing microbes. The results showed highest positive effects with *Bacopa monnieri* extract which increase the digestibility and decrease in methane production value. However, no change in shift of rumen CLA producing microflora was recorded from *in vitro* digestibility results. In addition to that increase in linoleate isomerase (LAI) specific activity was observed with all the screened plant extracts and it was found that addition of *Bacopa monnieri* increased the linoleate isomerase activity comparatively higher than other screened plant extracts (Figure).

**Identification and Characterization of CLA Producing *Lactobacillus* spp. Isolated from Rumen**

Micro-organisms are major influential factors in the fatty acid biohydrogenation process of rumen and some pathways ultimately leading to the formation of conjugated linoleic acid (CLA). In the present investigation, attempts have been made to explore the potential of *Lactobacillus* spp. for CLA production, isolated from rumen fluid samples of lactating goats. A total of 64 isolates of lactobacilli were isolated using MRS agar from rumen fluid content of goats and were subjected to morphological and biochemical characterizations. Isolates found as Gram-positive, catalase negative rods were presumptively identified to *Lactobacillus* spp. and further confirmed by genus specific PCR corresponding to a product size of 220 bp. Out of 64 goat isolates (GI), 23 isolates were observed positive for CLA production by linoleate isomerase (LAI) gene based amplification (968 bp) and quantitatively by spectrophotometric assay for conversion of linoleic acid to CLA as well as Gas chromatographic methods. In all *Lactobacillus* spp. c9, t11 isomer was observed as the most predominant CLA isomer.

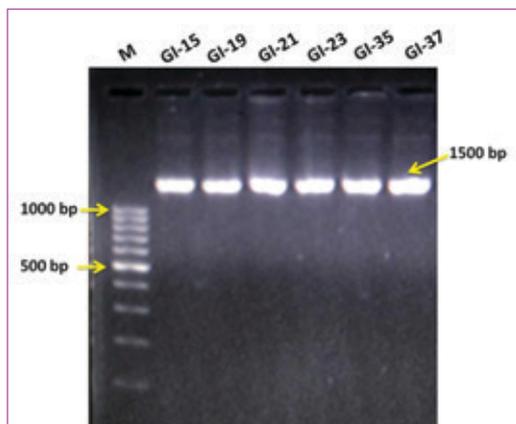


CLA production assay of the positive isolates after 24 h incubation (µg/mL)

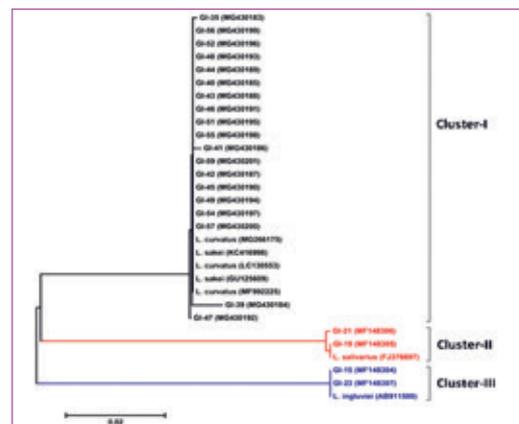


GC peaks of CLA produced from LA (Isolates GI-39)

These CLA positive isolates were identified by 16S rRNA based PCR sequencing and identified to be different species of *Lactobacillus ingluviei* (2), *L. salivarius* (2), *L. curvatus* (15) and *L. sakei* (4). The study showed that lactic acid bacteria isolated from goat rumen fluid have the potential to produce CLA and may be applied as direct fed microbial to enhance the nutraceutical value of animal food products.



(A)



(B)

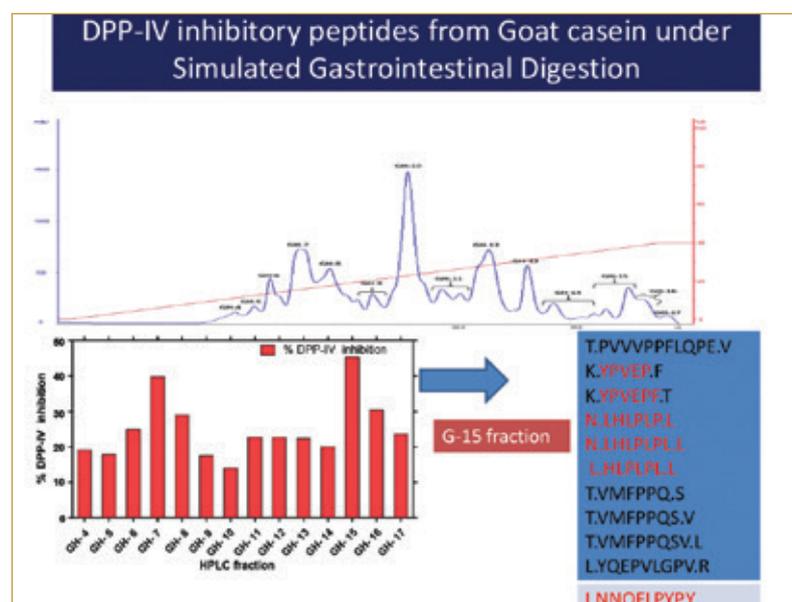
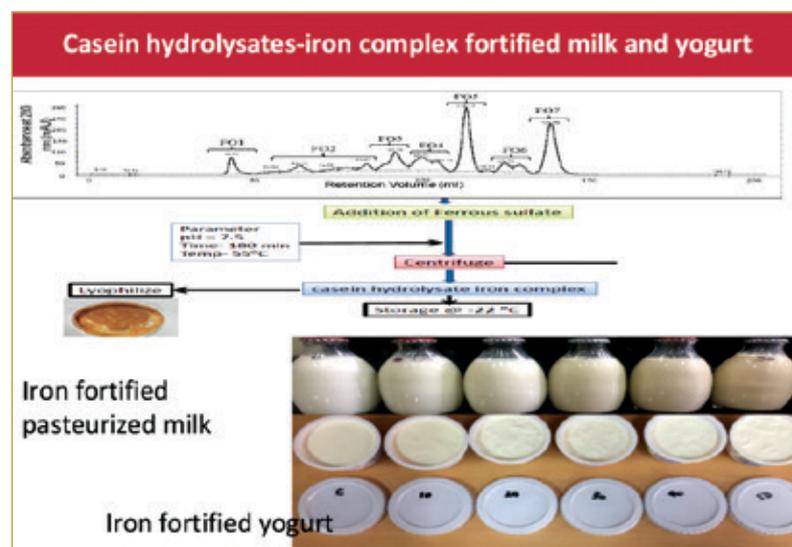
16S PCR amplification showing a product size ~1500 bp (A) Phylogeny of CLA producing *Lactobacillus* spp. (B)



# DEVELOPMENT AND VALIDATION OF HEALTH PROMOTING DAIRY FOODS

## Casein Hydrolysates-Iron Complex Fortified Milk and Yogurt

Iron fortification using casein hydrolysates-Iron complex in milk and yogurt observed to be an effective strategy to increase the iron, its bioavailability and reduction in fat oxidation without sacrificing the sensory attributes and affecting shelf life of the product.



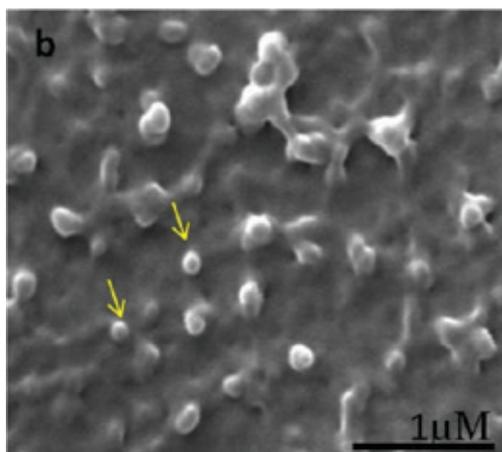
Following digestion of goat casein under in vitro simulated gastrointestinal conditions, the low molecular weight peptides separated over ultrafiltration and subjected to RP-HPLC. The fractions were evaluated for DPP-IV inhibitory activity. The fraction with maximum activity subjected to MS/MS and five potential DPP-IV inhibitory peptides identified from beta casein (K.YPVEF.F, K.YPVEF.T, N.LHLPL.L, N.LHLPL.L, L.HLPL.L) and one from k-casein (I.NNQFLPYP.Y).

### Development and Evaluation of Nano Iron (III) Oxo-Hydroxide Complex Fortified Biscuits

Organic acids (adipic, citric, tartaric and mallic acid) modified Fe (III) oxo-hydroxide complexes were prepared with particle size below 200 nm. The combinations of adipic, citric acid and iron in the ratio of 1:1:2 (A:C:Fe) resulted in lowest particle size (4 nm) among all modified iron complexes and it also matched with the size of ferritin core material. A:C:Fe complex possessed better stability (resistance towards release of bound iron) during different processing conditions such as heat treatments and pH. Phen green assay indicated that the iron from A:C:Fe complex was not affected by the presence of iron absorption inhibitor i.e. phytic acid. Biscuits were fortified with 15 mg of iron/100 g of biscuits in the form of A:C:Fe complex. Shelf life of fat extracted from biscuits fortified with A:C:Fe complex was higher than the fat extracted from biscuits fortified with iron salt. Overall acceptability scores of fortified biscuits were identical with the control biscuits upto 120 days of storage. *In vitro* bioavailability using Caco-2 cell culture method showed that iron uptake from biscuits fortified with A:C:Fe complex was significantly higher than biscuits fortified with iron salt. Therefore, the organic acid-iron complex could be a better iron fortificant with good oxidative stability and bioavailability.

### Milk Exosomes Enhance the Bioavailability of Hydrophobic Molecules like Curcumin as well as Hydrophilic Molecules like siRNA

The study demonstrated that milk exosomes act as stable oral drug delivery vehicles for both hydrophobic and hydrophilic molecules. Efficient delivery potential of milk exosomes was tested for curcumin, a hydrophobic molecule, and siRNA, a hydrophilic molecule. Results indicated that the encapsulation of curcumin and scrambled Alexa Fluor (AF)-488 siRNA into milk exosomes enhanced their stability and bioavailability against harsh *in vitro* digestive processes. The bioavailability was studied by transepithelial transport experiments using Caco-2 cell line.



Scanning Electron Microscopy of Milk Exosomes

### Probiotic Powder

Three preparations of Arginine deiminase i.e. in cell lysate, purified using anion exchanger and further purified by gel filtration were found to have anti-proliferative activity in Caco2 Cell line *in vitro*. Probiotic *Pediococcus pentosaceus* NDC273 cells separated after fermentation were freeze dried alone and with banana puree for packing in capsules.



Probiotic *Pediococcus*



Probiotic with banana puree

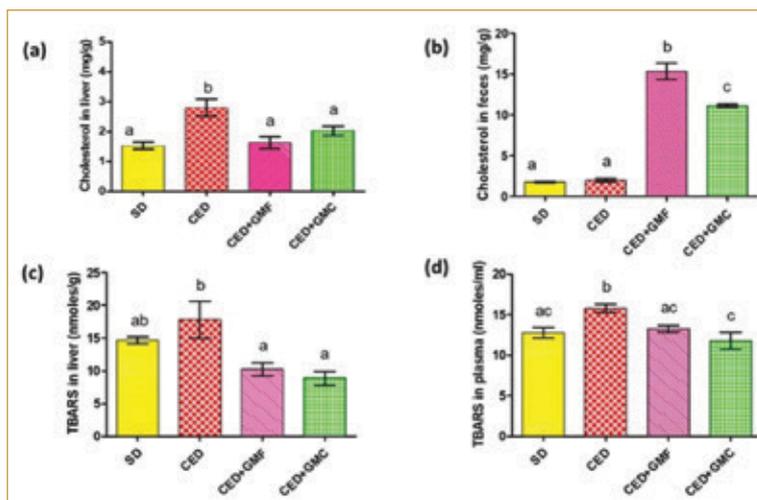


Powder packed in capsules

### Anti-Hypercholesterolemic and Antioxidative Properties of Goat Milk Fat and Goat Milk Casein

A systematic study was conducted to investigate the component of goat milk (fat or casein) for its antioxidative and anti-hypercholesterolemic potential in diet-induced hypercholesterolemia in rats to investigate their effects on lipid homeostasis. Thirty two rats were randomly divided into four groups of eight rats each and were fed

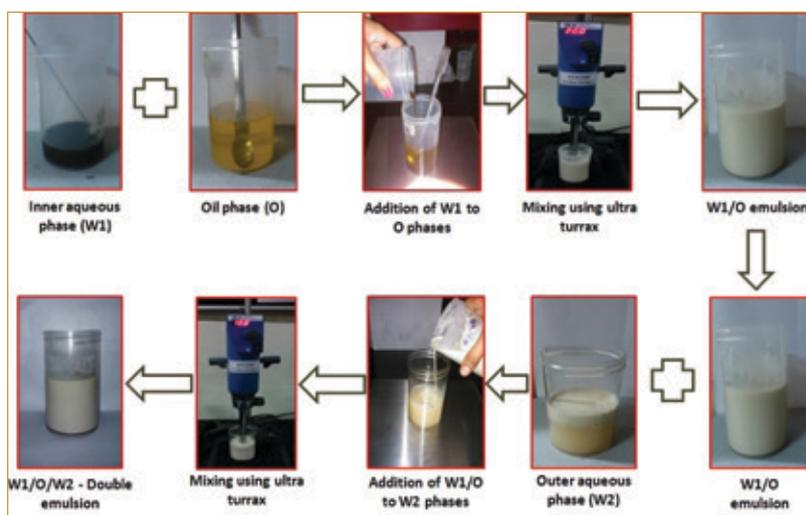
on (i) standard diet (SD), (ii) cholesterol-enriched diet (CED), (iii) CED containing GMF (CED+GMF) and (iv) CED containing GMC (CED+GMC). Feeding of CED containing 1.5% cholesterol for one month resulted 3-fold increase in TC ( $53.8 \pm 3.49$  to  $153.7 \pm 10.01$  mg/dl), 10-fold increase in LDL-C ( $11.69 \pm 4.39$  to  $125.3 \pm 9.96$  mg/dl) and 2-fold decrease in HDL-C ( $26.29 \pm 3.54$  to  $13.00 \pm 1.42$  mg/dl) but there was no noticeable change in TG and VLDL-C levels. It was observed that goat milk-based diets (CED+GMF and CED+GMC) were effective in reducing the plasma TC levels and LDL-C and were only 2-fold higher and 5-fold higher respectively as compared to SD group. Plasma HDL-C levels were increased in rats fed with GMF based CED. Interestingly, CED supplemented with GMC casein also protected rats by increasing plasma HDL-C levels as compared to CED group. A 27-fold increase in the atherogenic index was observed in experimental rats fed on CED ( $11.94 \pm 3.08$ ) as compared to that of SD ( $0.54 \pm 0.20$ ) and it was significantly less in both goat milk-based diet groups (CED+GMF and CED+GMC) to that of CED and the values were comparable to SD group. CED supplemented with goat milk fat or casein both were more effective in preventing cholesterol deposition in rat liver than CED alone (Fig a). The cholesterol-lowering effect of GMF and GMC in plasma and liver is attributed to the excess cholesterol excretion through faeces (Fig b). Due to less cholesterol deposition in liver, there was less cholesterol induced oxidative damage and therefore, the levels of TBARS in liver (Fig c) and plasma (Fig d) were also less in rats of CED+GMF and CED+GMC groups.



Cholesterol level in (a) liver & (b) feces and TBARS in (c) liver & (d) plasma in SD, CED, CED+GMF and CED+GMC. Values are mean  $\pm$  SEM where  $n=8$ . Dissimilar alphabets indicate significant differences ( $P<0.05$ )

## Evaluation of Dairy Protein-Based Double Emulsion for the Encapsulation of Cardio-Protective Herbal Extract

Six herbs namely garlic (*Allium sativum*), ashwagandha (*Withania somnifera*), tulsi (*Ocimum sanctum*), roselle (*Hibiscus sabdriffa*), ginkgo (*Ginkgo biloba*) and gooseberry (*Emblca officinalis*) were screened for their antioxidant and ACE inhibitory activities. Among all these herbs, *Emblca officinalis* was selected on the basis of its highest antioxidative potential. A double emulsion matrix was optimized to contain maximum quantity of the herb without destabilization. Dairy protein-based double emulsion was not suitable for stabilizing the emulsion. The matrix could hold 50% herbal extract and was stable for one month. During *in vitro* simulated release studies, it was observed that 65% of the active component was released in intestinal fluid, revealing the effectiveness of the matrix containing pectin as stabilizer. Herbal extract-containing double emulsion increased phagocytic activity in proportion to the concentration of the herb during *in vitro* phagocytosis assessment. It was concluded that double emulsion technique could be a successful tool to encapsulate *Emblca officinalis* extract for application in food matrices as a therapeutic approach in the management of cardiovascular diseases.



Flow diagram for preparation of water-in-oil-in-water double emulsion

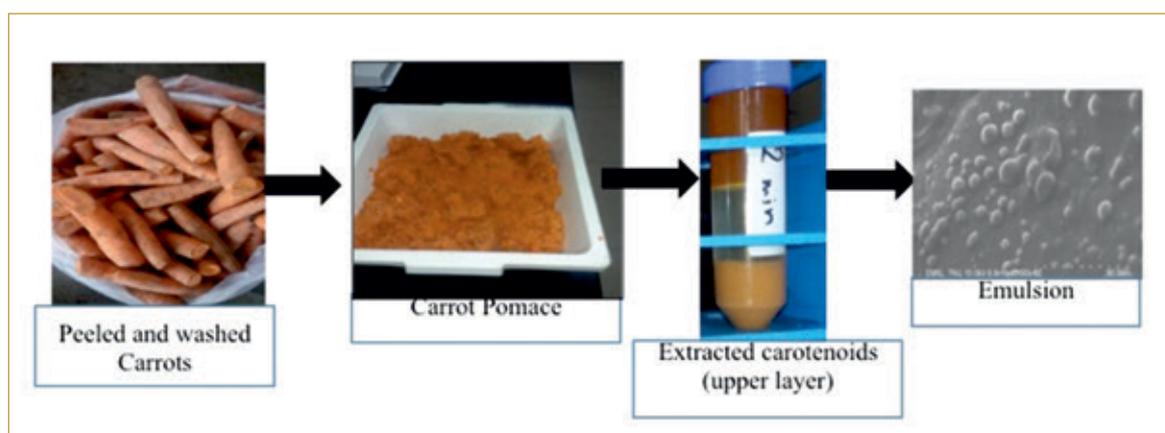
## Application of Dairy Protein-Polysaccharide Complexes in Double Emulsion based Functional Mayonnaise

A functional mayonnaise containing bitter melon extract was optimized by double emulsion technique. The inner aqueous phase contained bitter melon extract and the middle oil phase contained oil and a stabilizer while the

outer aqueous phase contained dairy protein-polysaccharide complex. The double emulsion was found to be stable for almost one month at 37°C and more than one year at 7°C. The double emulsion based functional mayonnaise could encapsulate 55.2% (*w/w*) bitter gourd extract with 87.45% encapsulation efficiency and acceptable sensory scores. The product when fed to streptozotocin-induced diabetic rats resulted in decreased blood glucose, HbA1c, increased body weight, haemoglobin and plasma insulin levels indicating good anti-diabetic potential.

### Preparation and Characterization of Micro/Nano Delivery Systems for 'Green' Carotenoids

Attempts were made to extract carotenoids from mango pulp and carrot pomace using different techniques *viz.* microwave, ultrasonication, high speed homogenization. The extraction technique was selected based on the effect of technique of extraction, duration of extraction, green solvent used for extraction, ratio of the solvent to raw material on the carotenoid content. The recovery of carotenoids from carrot pomace was 94.8%. The total carotenoid content, antioxidant activity in terms of ABTS, DPPH and FRAP were found to be  $82.66 \pm 0.06 \mu\text{g/g}$ ,  $1596.04 \pm 69.45 \mu\text{g Trolox eq/mL}$ ,  $380.21 \pm 39.62 \mu\text{g Trolox eq/mL}$  and  $941.20 \pm 19.91 \mu\text{M Trolox eq/mL}$ , respectively. An emulsion-based delivery system was optimized using a three factorial design. Suitable emulsion combination was selected on the basis of particle size, zeta potential, viscosity, color value, centrifugal stability and gravity separation. The optimized emulsion had a particle size of  $120.03 \pm 8.20 \text{ nm}$  with an encapsulation efficiency of more than 90%. The emulsion was found to be stable to gravity separation up to 15 days. The total carotenoid content, antioxidant value in terms of ABTS, DPPH and FRAP of the optimized emulsion were found to be  $34.6 \pm 0.137 \mu\text{g/g}$ ,  $1133.28 \pm 25.67 \mu\text{g Trolox eq/mL}$ ,  $292.07 \pm 23.22 \mu\text{g Trolox eq/mL}$  and  $622.96 \pm 18.91 \mu\text{M Trolox eq/ml}$ , respectively.

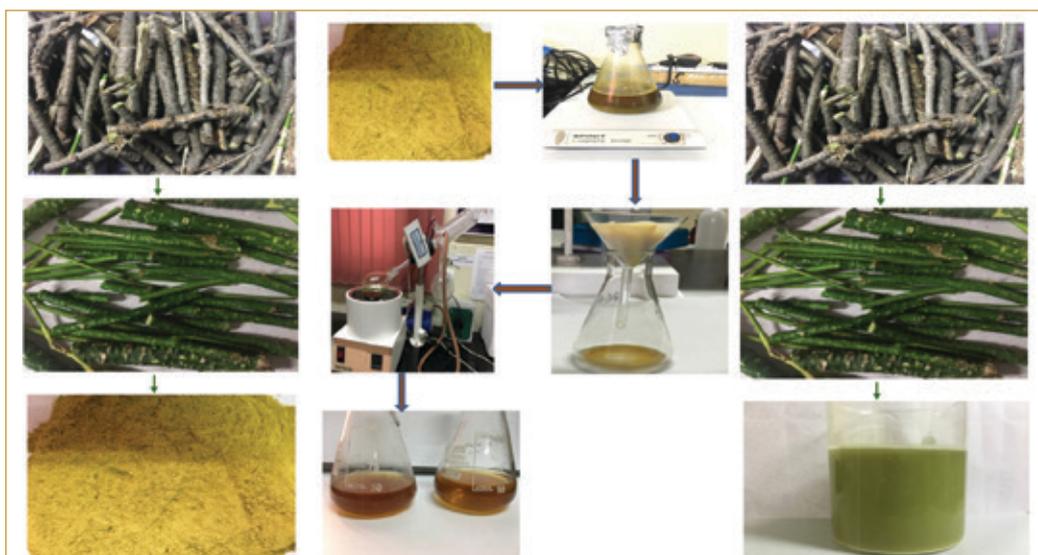


### Efficacy of Buttermilk as Encapsulating Agent for Omega ( $\omega$ )-3 Fatty Acids

Deodorized flaxseed oil was added at the rate of 1 and 2% to buttermilk obtained from butter, which was manufactured from standardized cream (40% fat). Coarse mixture was converted into an emulsion by homogenization and was evaluated for homogenization efficiency and visible oil separation. Homogenization efficiency was observed to be 4.7% and 6.1% for oil incorporated at the rate of 1% and 2%, respectively. No visible oil separation was observed in any of the samples. Microscopic images revealed formation of a fine emulsion with uniform droplet size. Based on these results, oil-loading capacity of buttermilk was evaluated in the range of 0.5% - 3% oil and found that 3% can be loaded. Zeta potential, emulsion stability and thermal stability of emulsion were evaluated and observed that the zeta potential of the 3% oil-loaded emulsion was similar to that of milk and the emulsion was stable at the pasteurization temperatures, both LTLT and HTST.

### Giloy (*Tinospora cordifolia*): A Potential Ingredient for Goat Milk Based Functional Beverage

Attempts were made to standardize the methods for the preparation of three forms of *Tinospora cordifolia* (Giloy) *viz.*, powder, extract and juice. The extract was prepared in both aqueous and ethanolic bases. Qualitative analysis of *giloy* powder revealed presence of alkaloids, glycosides, tannins, phenols, terpenoids and flavonoids while absence of saponins. The total phenolics, DPPH activity and total flavonoid content of *giloy* powder were found to be  $2133 \pm 100.67$ ,  $7.16 \pm 0.28$  and  $6.93 \pm 0.13$ , respectively. Each preparation was analyzed for pH, acidity, total solids, total soluble solids, colour and anti-oxidant activity. The effect of two different temperatures (25°C and 40°C) on the quality attributes of both aqueous and alcoholic extracts was also studied. It was observed that in alcoholic extract, the total phenolic content and DPPH activity decreased with rise in temperature and time. The



*Preparation of Giloy Powder, Giloy Extract and Giloy Juice*

*giloy* powder purchased from reputed firm was also analyzed for different active components and it was found that all the phyto-components were present in the commercial sample.

### Development of Spray Dried Whey Protein based Curcumin Encapsulates

Studies were undertaken to develop spray dried curcumin encapsulate using various dairy (butteroil, WPC-80 and partially concentrated skimmed milk with 13% TS) and non-dairy (maltodextrin and gums) ingredients and evaluate their physico-chemical and functional characteristics during storage. Butter oil prepared from buffalo milk was used as core material for encapsulate preparation and curcumin added at the rate of 0.4% was found optimum. The resultant core material had a curcumin solubility of 58.26% and DPPH free radical scavenging activity of 65.82%. Best stable emulsion was obtained with gum arabica as compared to xanthan gum, gum acacia and guar gum in core material. The core to wall ratio of the optimized emulsion was found to be 1:2 while the ratio of protein to carbohydrates in the wall material was observed to be optimum at 1:2. The optimized emulsion had a viscosity of 0.062 mPas, particle size of 539.55 nm, zeta-potential of -11.27 mV and encapsulation efficiency of 97.59%. The optimized inlet and outlet air temperatures for spray drying were found to be 180°C and 80°C, respectively. The encapsulate powder properties such as loose bulk density (0.328 g/ml), packed bulk density (0.586 g/ml), particle density (1.136 g/ml), angle of repose (37.86°), wettability (197 s), dispersability (69.73%) and solubility (77.09%) were determined. The encapsulate powder had an encapsulation efficiency of 96.96% and moisture content of 1.75%.

### Heart Friendly Herbal-Milk Smoothie with Prophylactic Effects against CVD and Associated Risks

Water-in-oil-in-water (W/O/W) double emulsion (DE) matrix was formulated to encapsulate *Emblica officinalis* aqueous extract at the rate of 25%. The DE matrix was observed to have more than two months stability at refrigeration temperature. However, DE prepared with the pure extract of herb was very dark in colour, leading to poor sensory characters in milk smoothie. Hence, *Emblica officinalis* extract was diluted suitably to obtain acceptable sensory scores in milk smoothie. Amla incorporated double emulsion (ADE) was added to mango flavored milk smoothie at varying levels and the best level selected based on sensory and physico-chemical characteristics. No significant changes ( $p > 0.05$ ) in the physico-chemical, microbiological and sensory attributes were observed. Bioaccessibility of tannins from ADE was 99.85, 99.75 and 98.98% after simulated saliva digestion, gastric digestion and intestinal digestion, respectively, while the respective values in the smoothie supplemented with ADE, the values were 90.97, 90.86, and 89.47%. The overall bioaccessibility (%) after complete simulated digestion of tannin from ADE and optimized smoothie was 98.84% and 89.47, respectively. The addition of encapsulated amla extract into the milk based mango smoothie had improved its antioxidant status. Optimized smoothie can be used as functional beverage to meet the increasing consumer demands for health foods.

### Microencapsulated Flaxseed Oil Powder and its Application for Producing Omega-3 Fatty Acids Fortified Curd

Stable flaxseed oil emulsions, microencapsulated flaxseed oil powder (rich vegetarian source of omega-fatty acids) and omega-3 fatty acid fortified curd were developed. Stable flaxseed oil emulsions (oil-in-water) were prepared using commercial octenyl succinylated starches viz. N Creamer 46 (corn starch) and N Creamer 180 (Tapioca starch)

and soy protein isolate. All the stable emulsions exhibited shear-thinning behaviour. The emulsion of flaxseed oil prepared with N creamer 46 starch at 30% oil load and 30% TS was observed to be most stable with a zeta potential value of -38.50 mV. The emulsions thus prepared were stable up to 28 days at 4°C. Microencapsulation of flaxseed oil was done by spray drying of pre-heated (40 °C) emulsion samples prior to atomization. It was observed that the sample prepared from 30% oil load and 30% TS was found to be best suited for microencapsulation of flaxseed oil. The solubility of the resulting powder was found to be 89.65% with a microencapsulation efficiency of 95.84%. The microencapsulated flaxseed oil powder was used in curd preparation at different levels. Based on the sensory evaluation, 3% level of flaxseed microcapsules was found to be most acceptable. With the selected level of microcapsule fortification, two servings of curd *i.e.* 100 g each can provide more than 50% of the RDA of alpha linoleic acid.

### Incorporation of Non-dairy Ingredients in Processed Cheese to Enhance Functional Attributes

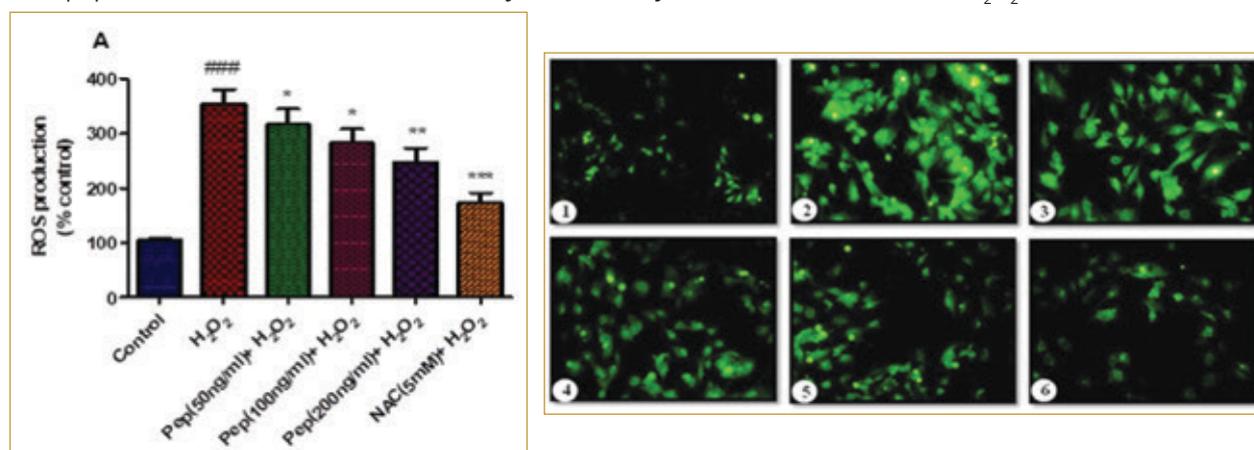
Processed cheese was prepared with non-dairy ingredients *viz.* 40% potato, 10% peanut and 6% inulin and observed to have non-significant ( $P > 0.05$ ) influence on the sensory and textural properties except on meltability with the addition of 40% potato. Fatty acid profile showed an increase in polyunsaturated fatty acids content (8.73%) in 10% peanut added cheese as compared to control processed cheese (2.73%). Free fatty acids content was found to be highest in peanut incorporated processed cheese. Electrophoretic study indicated maximum protein degradation in potato incorporated processed cheese while minimum in inulin added samples. Addition of spice extract into the potato and peanut incorporated cheese increased the shelf life by 20 to 25%. It was observed that incorporation of potato (40%) reduced the cost by 15-20% while inulin (6%) and peanut (10%) incorporation reduced the cost by only 3-5%.

### Development of Milk based Functional Flavoured Drink Containing Canola Oil and Inulin

An attempt was made to replace the milk fat to improve the functional qualities of flavoured drink. The sensory scores of the flavoured drink showed that among the different levels of replacement of milk fat, 50% of milk fat replacement by the canola oil and their mixture, resulted in sensory characteristics comparable to those of control flavoured drink. Incorporation of inulin at 5% was found to be the most acceptable level that increased the viscosity and sweetness of the drink. Among the different flavours tried, the mango flavoured drink was preferred. The physico-chemical analysis of the developed flavoured drink showed that the drink had fat, protein, total carbohydrates and ash content of 2.9, 3.35, 18.63 and 0.72 percent, respectively. The viscosity, acidity and pH of the sample were 2.40 cP, 0.166% lactic acid and 6.55, respectively. The fatty acid analysis of the control samples revealed that it had oleic acid and linoleic acid content of 21.3 and 1.8%, respectively. The developed drink had a shelf life of 6 days at refrigerated temperature.

### Osteoprotective Role of Milk Derived Bioactive Peptides

Osteoprotective effect of buffalo milk casein-derived novel peptide VLPVPQK against  $H_2O_2$ -induced dysfunction in rat osteoblastic cells and OVX-induced bone loss in rats was investigated. Osteoblast cells were pretreated with peptide for either, 2, 7 and 14 or 21 days followed by treatment with 0.3mM of  $H_2O_2$  for 24 h. The markers

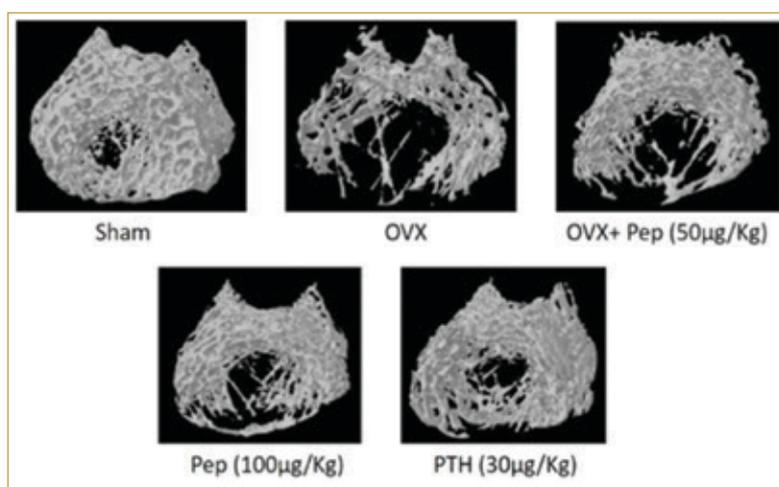


#### Peptide Pre-treatment Inhibited $H_2O_2$ -Induced ROS Generation in Rat Osteoblast Cells

A: Osteoblasts were cultured in differentiation media supplemented with peptide at different concentrations for 7 days followed by treatment with 0.3mM  $H_2O_2$  for 24 h. A: Quantitative analysis of ROS production by fluorescent probe DCFH-DA using multimode detection plate reader. B: Representative images (X20) of ROS production by fluorescent microscope (Olympus). The values are expressed as mean  $\pm$  SEM (n= 3). 1: Control group; 2:  $H_2O_2$ ; 3: Pep (50ng/ml) +  $H_2O_2$ ; 4: Pep (100ng/ml) +  $H_2O_2$ ; 5: Pep (200ng/ml) +  $H_2O_2$ ; 6: NAC (5mM, positive control) +  $H_2O_2$ . ##P < 0.01 compared with the control group; \*P < 0.05 and \*\*P < 0.01 in comparison to the group treated with  $H_2O_2$  alone.

of osteoblasts differentiation and oxidative damage were examined. The results indicated that pretreatment of peptide significantly increased osteoblast cell viability, alkaline phosphatase (ALP) activity, matrix mineralization and expression of osteogenic genes. Moreover, peptide treatment caused increase in osteocalcin(OCN) level, cytokine TGF- $\beta$  levels and inhibited H<sub>2</sub>O<sub>2</sub>-induced increase in proinflammatory cytokines, malondialdehyde (MDA) level and caspase-3/9 activities. In addition, peptide suppressed H<sub>2</sub>O<sub>2</sub>-induced decrease in antioxidative enzymes activities.

The *in vivo* study, demonstrated that, administration, of peptide at 50 and 100  $\mu$ g/kg daily for eight weeks significantly inhibited OVX-induced uterine weight loss and atrophy and increased anthropometric parameters such as femora and tibiae dry weight, ash weight and bone ash calcium level. (The peptide suppressed the OVX-induced increase in bone turnover rate by preventing increase in serum level and ALP activity and by elevated serum calcium and phosphorus levels. Moreover, peptide prevented OVX-induced decrease in bone strength, resulted in increased bone mineral density (BMD) and partially suppressed the deterioration of trabecular micro-architecture in both femur epiphysis and proximal tibia metaphyseal regions when compared to untreated OVX group). Furthermore, peptide reduced serum MDA level and increased antioxidative enzyme activities. The results demonstrated that, peptide protects rat osteoblast cells against H<sub>2</sub>O<sub>2</sub>-induced dysfunction. Moreover, peptide administration in OVX rats improved bone mass and strength. Altogether, these results suggest that peptide could be valuable as osteoprotective agent for preventing and treating postmenopausal osteoporosis. Representative micro-CT images of distal femur epiphyseal regions of various experimental groups.



*Peptide display protective effects on trabecular micro-architectures in OVX rats*

### Resveratrol Loaded Niosome: Process Optimization for Preparation and Characterization and Evaluation of Functional Properties

An attempt was made to optimize the preparation of biocompatible resveratrol loaded niosomes (R-niosomes) using non-ionic surfactants and fatty alcohol as stabilizer employing the novel method. R-niosomes exhibited mean particle size of 108 nm with narrow size distribution (PDI=0.24) and high zeta potential (-56.8 mV). The niosomes had more than 80% of resveratrol encapsulated into the vesicles and exhibited controlled release under simulated GI conditions. FTIR, XRD and DSC analyses confirmed successful encapsulation of resveratrol into the vesicles. Assays in macrophage RAW264.7 cell lines showed that R-niosomes had lower cytotoxicity and higher intracellular ROS scavenging activity when compared to resveratrol in its free form. This study also demonstrated that nanoencapsulation of resveratrol has dramatically improved its solubility and functionality

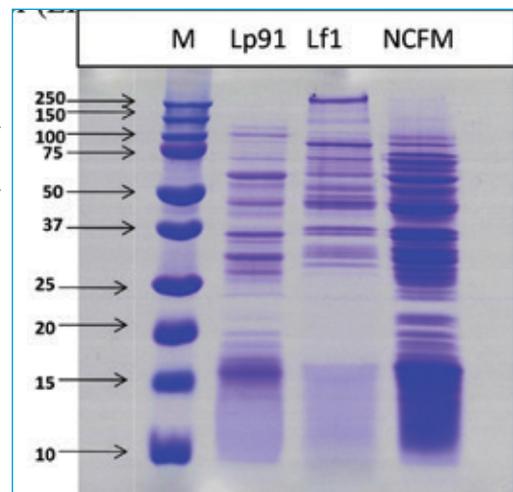


SEM image of resveratrol loaded niosomes and TEM image (Inset) of resveratrol loaded niosomes at 20 nm.

# PROBIOTICS, BIOACTIVE MOLECULES AND FUNCTIONAL FOODS

## Cell Wall Components of Probiotic Lactobacilli as Therapeutics for Amelioration of Inflammatory Gut Diseases

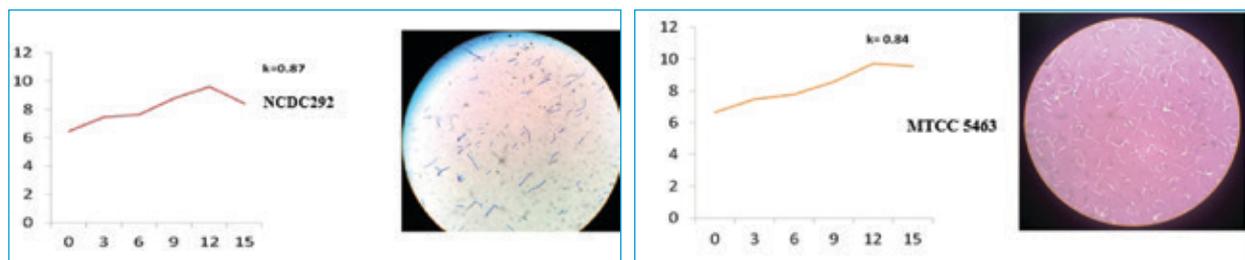
S layer protein / total surface proteins were extracted using Lithium Chloride and Guanidine-HCl protocols from six strains of probiotic *Lactobacilli* namely *L. plantarum* LpA1, Lp91, Lp9, LpA5, *L. fermentum* Lf1, LfS4 along with two reference strains of probiotic lactobacilli viz. *L. acidophilus* NCFM and *L. rhamnosus* GG. A prominent band of 45 kDa size in *L. acidophilus* NCFM representing S layer protein was observed. Since, similar type of band was not observed in any of the test strains of *L. plantarum* and *L. fermentum* strains, the bands of surface proteins near 45 to 50 kDa were excised from SDS-PAGE and subjected for MS/MS spectrum. No protein was identified as surface layer protein with very high score and did not match with respective surface layer proteins in the public protein database (NCBI/Uniprot), suggesting that given lactobacilli do not possess surface layer proteins on their surfaces as many *Lactobacillus* strains have been documented as non surface layer producers. The bands with apparent molecular mass of 45 – 50 kDa from *L. plantarum* and *L. fermentum* strains were identified using MS as Elongation factor (EF-Tu) with molecular weight of 43.447 kDa.



SDS-PAGE showing total surface proteins extracted from *Lactobacillus* cultures

## Bile Responsive Proteo-Transcriptomics Investigation of Native Probiotic Strain *Lactobacillus helveticus* MTCC 5463

Growth phase in *Lactobacillus helveticus* strains (probiotic MTCC 5463 and non-probiotic NCDC 292), was investigated. *L. helveticus* strains preferably entered in early stationary phase and were tested for tolerance to various concentrations of bile salts (0, 0.3, 0.9, 1.2, 1.5 and 1.8%) for 0, 3, and 6 h. Growth phase study indicated that the early stationary phase for *L. helveticus* MTCC 5463 and NCDC 292 was achieved at 12 h. The log count of both *L. helveticus* MTCC 5463 and NCDC 292 gradually decreased with increase in bile concentration and time interval. *L. helveticus* MTCC 5463 count showed significant reduction at 1.5% bile and further diminished at 1.8% bile after 6 h. *L. helveticus* NCDC 292 count diminished at 0.3% bile after 6 h.

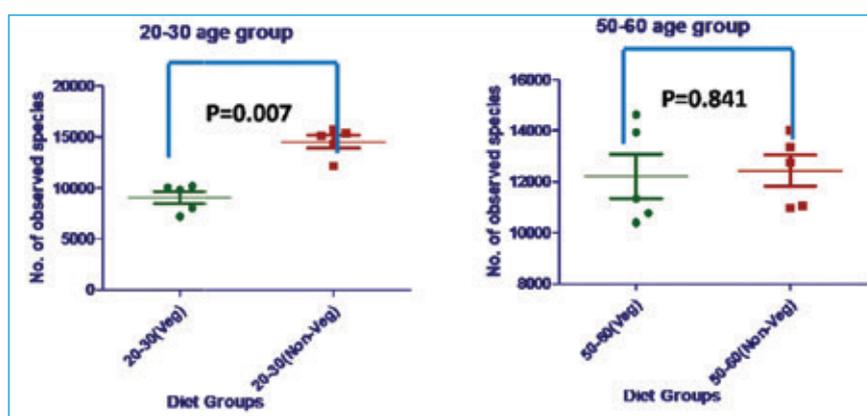


Growth phase of MTCC 5463 and NCDC 292

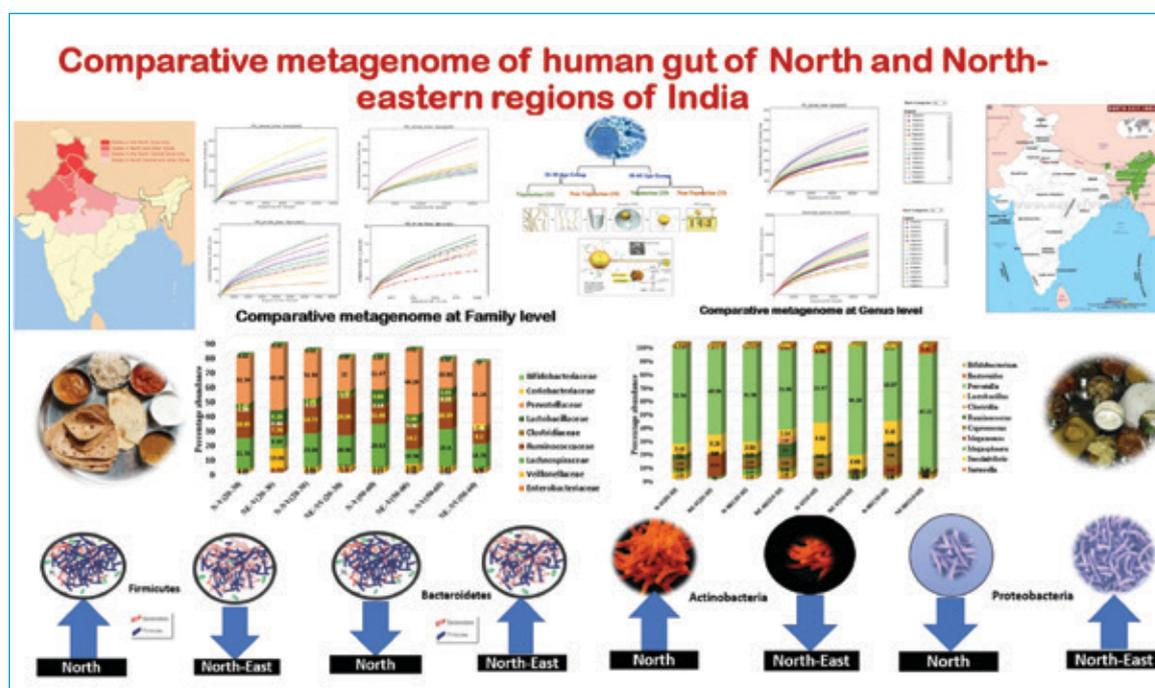
## Comparative Metagenome of Human Gut of North and North-eastern Regions of India

The study population for generation of metagenome data of human gut of 40 subjects each from North and North Eastern regions of India included 10 vegetarian and 10 non-vegetarian under the age group of 20-30 yrs and similarly 10 vegetarian and 10 non-vegetarian under the age group of 50-60 yrs after following the inclusion and

exclusion criteria. Multiplex pyrosequencing of the V5 and V6 hypervariable regions of 16S rRNA gene amplified from metagenomic DNA of all the 80 samples was performed according to standard 454 GS-FLX (Roche) protocols using the GS Titanium Sequencing Kit (Roche Diagnostics) and the GS Junior device. The metagenome data from both the populations was compared at Phylum, Family and Genus level. Decreased Gut microbial richness with age was observed in all the population groups. *Firmicutes* were found to be more in North Indian population and *Bacteroidetes* in North Eastern region besides increase in *Proteobacteria* and *Enterobacteriaceae* with age. Higher abundance of *Enterobacteriaceae* and *Veillonaceae* was observed in the gut microbiota of North-Eastern population compared to North India. Comparatively higher abundance of *Clostridium*, *Sutterella* and *Ruminococcus* was observed in the North-East Non Vegetarian population in the age group of 20-30 yrs whereas lower abundance of *Megasphaera* and *Coprococcus* in 50-60 yrs age group. Dietary interventions as well as geographical locations may lead to shift in different gut phylotypes. As far as SCFA profile is concerned, no significant difference was observed in the faecal metabolite composition of acetate, propionate and butyrate between vegetarian and non-vegetarian diets of same and different age groups. Baseline data for designing dietary based strategies including probiotics for maintaining healthy gut homeostasis



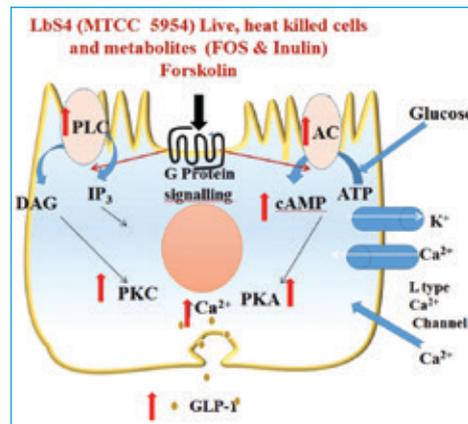
North-eastern Human Gut Microbial Diversity/Richness between Vegetarian and Non-Vegetarian Population



### Elucidation of Signaling Mechanism Underlying the Release of Glucagon like Peptide-1 (GLP-1) from Enteroendocrine Cells by a Probiotic *Lactobacillus* Strain

A total of nine potential probiotic *Lactobacillus* strains (*L. plantarum* A1, *L. fermentum* A2, *L. plantarum* A5, *L. fermentum* A6, *L. fermentum* A8, *L. plantarum* A9, *L. fermentum* Ad06, *L. casei* LbS2, and *L. fermentum* MTCC 5954) along with the standard *L. rhamnosus* GG were selected. These probiotic strains were screened for their GLP-1 incretinotropic (GLP-1 production) and secretagogue potential by measuring relative expression of proglucagon and prohormone convertase1/3 (PC1/3) genes with RT-qPCR and GLP-1 secretion with ELISA respectively in both murine STC-1 pGIP/

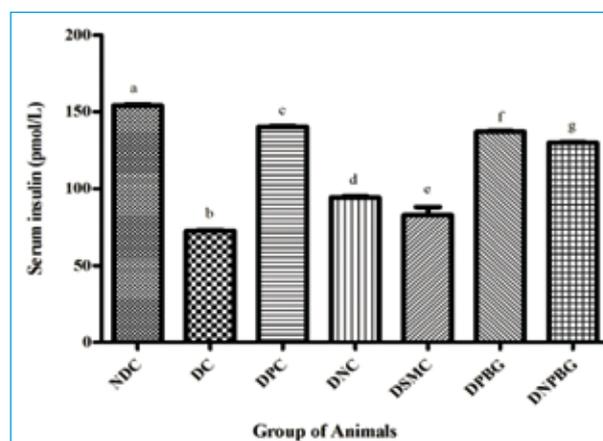
Neo and human NCI-H716 enteroendocrine L cells. *L. fermentum* LbS4 (MTCC 5954) emerged as potential GLP-1 incretinotroph and secretagogue in both STC-1 pGIP/Neo and NCI-H716 cell lines. Both live and heat killed forms of MTCC 5954 significantly increased the expression of proglucagon gene and GLP-1 secretion. The metabolites of MTCC 5954 produced in the presence of FOS and inulin also significantly increased the GLP-1 secretion whereas no significant changes in expression of proglucagon gene were observed. The data regarding elucidation of mechanism underlying production of GLP-1 by MTCC 5954 indicated the role of c-AMP mediated activation of Protein Kinase A (PKA)/AMPK pathway in the transcriptional activation of both proglucagon and PC1/3 genes and the major role of voltage gated calcium channels (VGCC) in the secretion of GLP-1 from enteroendocrine cells.



**Mechanism underlying production of GLP-1 by MTCC 5954 for developing dietary based biotherapeutics for the management of type 2 diabetes**

### Anti-Diabetic Potential of Gamma-Amino Butyric Acid (GABA) Producing Probiotic Strain of *Lactobacillus Spp.*

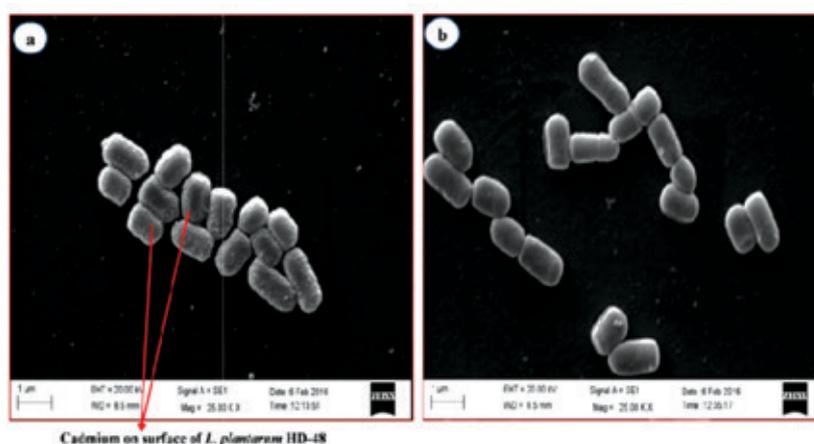
Three isolates namely 42K, MG3 and C9 showed relatively intense spots on TLC when screened for both intracellular and extracellular GABA production. The quantitative production of GABA in MRS broth was also determined spectrophotometrically which revealed GABA production in the range of  $44.00 \pm 1.41$  mM to  $96.83 \pm 1.17$  mM and maximum GABA production was revealed by a Kimchi isolate 42K ( $96.83 \pm 1.17$  mM), followed by dairy isolates MG3 ( $82.33 \pm 1.41$  mM) and C9 ( $79.00 \pm 0.94$  mM). The GABA production by *L. brevis* 42K and a non-probiotic GABA producer strain *L. brevis* MG3 were found to be  $41.02 \pm 0.12$  mM and  $37.65 \pm 0.55$  mM, respectively after optimization. The diabetes was induced in the Wistar strain rat model by streptozotocin. The body weight of diabetic probiotic GABA group (DPBG) increased and blood glucose concentration decreased significantly ( $p < 0.05$ ) after 7 weeks of feeding as compared to other diabetic groups. Serum triglyceride concentration decreased and serum insulin concentration increased in DPBG significantly ( $p < 0.05$ ) as compared to diabetic control (DC). Serum concentration of cytokines IL-12, TNF-alpha and IFN-Gamma and Plasma PAI and malondialdehyde concentration in DPBG fed group decreased significantly as compared to DC. The histopathological studies revealed least degeneration of pancreatic tissue in case of DPBG group as compared to other diabetic groups.



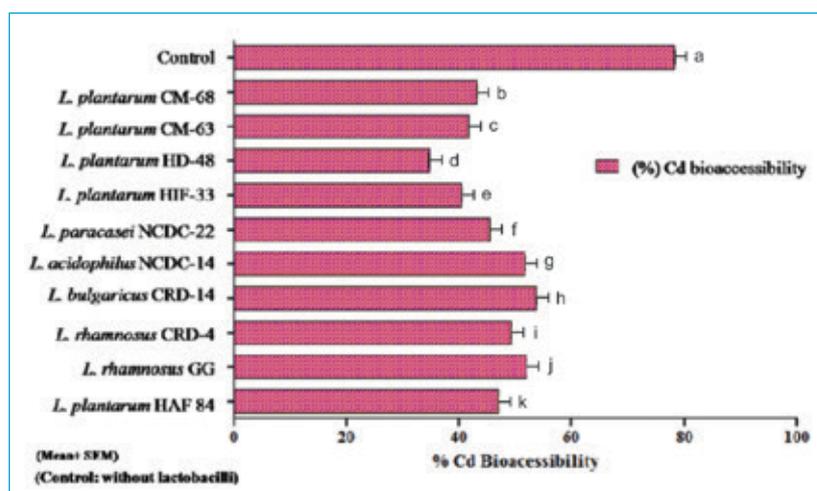
**Serum insulin level in different group of animals**  
 NDC-Nondiabetic-Control; DC- Diabetic Control; DPC-Diabetic positive control; DNC-Diabetic negative control; DSMC-Diabetic skim milk control; DPBG-Diabetic probiotic GABA group; DNPBG-Diabetic non-probiotic GABA group The values are expressed as mean  $\pm$  S.E (values with different superscript letters are significantly ( $p < 0.05$ ) different

## Cadmium Bioadsorption Potential of Probiotic *Lactobacillus* Species

Forty eight probiotic lactobacilli strains were evaluated for Cd bio-adsorption potential using flame atomic absorption spectroscopy. *Lactobacillus plantarum* HD-48 was selected based on its highest Cd binding ability ( $57.38 \pm 0.27\%$ ) which was found to be pH and time dependent. Ten selected probiotic strains demonstrated Cd bio-accessibility reduction (24.71 - 43.85%) in *in-vitro* digestive model. These strains also showed strong lactobacilli-Cd complex stability. *L. plantarum* HD-48 also demonstrated Cd binding functionality in mouse model against Cd intoxication. Results on effect of Cd on displacement of Ca, Cu, Fe, Mg, and Zn in liver showed significant ( $p < 0.05$ ) depletion of Ca, Mg and Zn levels in Cd control group (CCG) in comparison to treatment groups (Lp HD-48 & LGG). Liver functions enzymes i.e. aspartate transaminase and alanine transaminase levels were also lower in treatment groups as compared to CCG group after 2 weeks indicative of reduction in liver stress. Both probiotic fed groups (LpHD-48 & LGG) exhibited significantly ( $p < 0.05$ ) low levels of oxidative stress markers (malonaldehyde) and higher levels of anti-oxidative enzyme (superoxide dismutase, glutathione peroxidase & catalase) in liver and kidney as compared to CCG. These biochemical changes were also confirmed by histopathology of liver and kidney tissues.



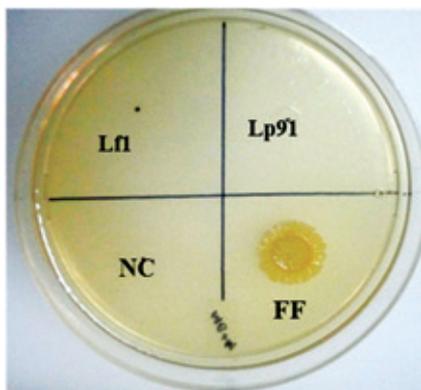
Scanning electron microscopy of *L. plantarum* HD-48 a) in presence of cadmium chloride solution [irregular globules or coarseness on the surface of bacteria] and b) without cadmium where only cells were visualized (culture grown in MRS media)



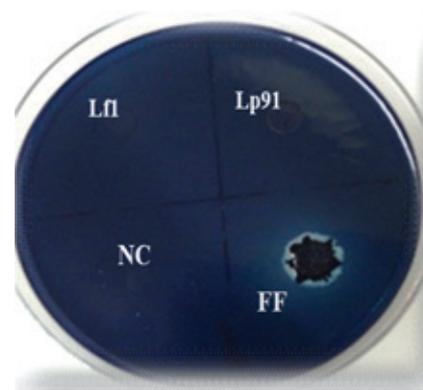
*In-vitro* per cent reduction of Cd bio-accessibility by selected probiotic *Lactobacillus* strains

## Assessing Preclinical Safety of Indigenous Probiotic *Lactobacillus Plantarum* Lp91 and *L. Fermentum* Lf1 Strains

The safety and toxicological status of the two indigenous probiotic *Lactobacillus* strains viz. *L. plantarum* Lp91 (MTCC 5690) and *L. fermentum* Lf1 (MTCC 5689), whose probiotic attributes and functional efficacy had been thoroughly established previously was evaluated. Both the test strains did not show any undesirable metabolic activities as was revealed from various *in vitro* safety evaluation assays such as hemolysis test, mucin degradation activity, platelet aggregation test, biogenic amine formation and absence of virulence and faecal enzyme genes. However, both the test strains were resistant to antibiotics of the group aminoglycosides, fluoroquinolones and glycopeptide when tested for antimicrobial resistance. The test strains were susceptible at MIC levels to all the enlisted antibiotics



Without Staining



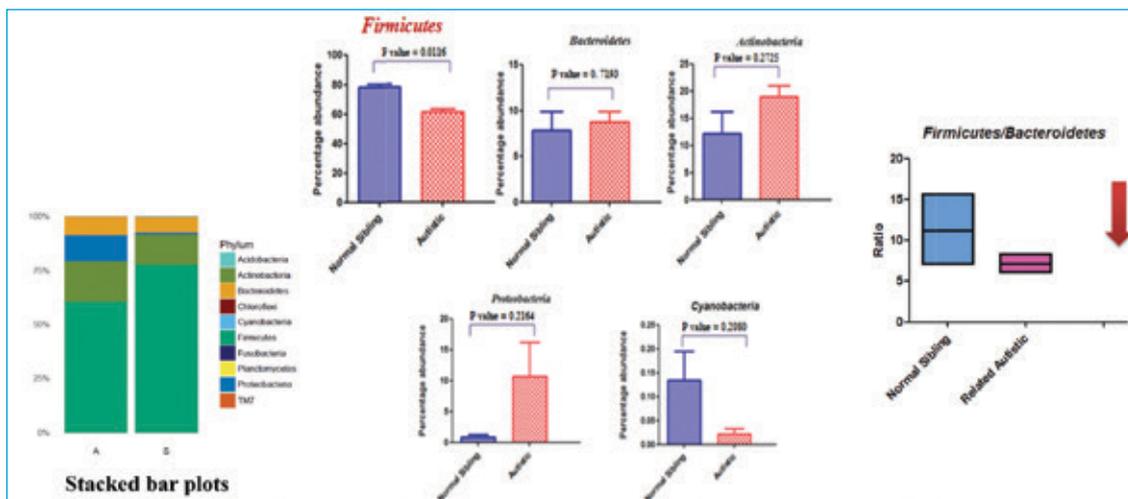
With Amido Black Staining

**Mucin degradation plate assay of probiotic test strains. a. Medium B without amido black staining and b. Medium B with amido black staining. Positive control-faecal flora (FF), Negative control (NC) - Heat killed faecal flora, Lp91 and Lf1- test strains**

in the EFSA guidelines except for Kanamycin. The results from the acute oral toxicity studies revealed that the administration of even high cell concentration was well tolerated by the experimental mice. Similarly, subacute and subchronic toxicity studies further substantiated the safety of the two strains. The test strains were also safe at very high dose during intra-peritoneal and intra-venous administration and also safe in diseased animal model of colitis since no translocation was observed. The test strains were also found to be devoid of any genotoxic effects in the chromosomal aberration test and micronucleus assay.

### Comparative Analysis of Predominant Gut Microflora and their Metabolites in Autistic versus Normal Children for Probiotic Interventions

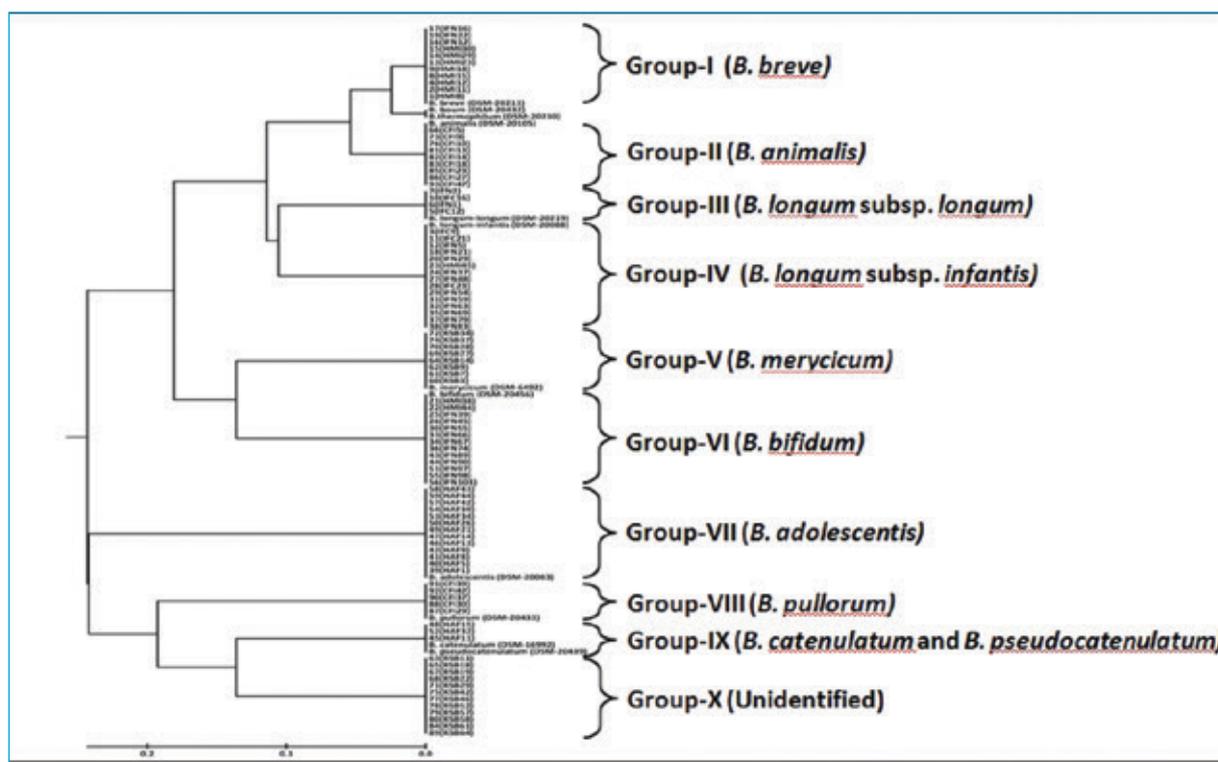
A total of eighteen subjects that included six each of normal siblings, related and unrelated autistic children belonging to age group less than 15 years were selected after getting ethical approval from AIIMS, New Delhi. Relative and Absolute qPCR as well as 16S rRNA diversity using High throughput Sequencing (HTS) of metagenomic DNA were carried out for studying comparative abundance of the targeted microbiota. Decreased gut microbial diversity was observed in autistic children. The phylum *Firmicutes* significantly decreased whereas increased abundance of phylum *Bacteroidetes* in autistic children as compared to normal siblings was observed in both qPCR and HTS approach. Increased abundance of *Bacteroides*, *Clostridium*, *E.coli* and *Suttrella* and decreased abundance of *Desulfovibrio*, *Lactobacillus* was observed in autistic children by qPCR approach. The significant increase in the abundance of *Actinobacteria* was observed in the autistic children compared to the normal children. Considerable decline in the abundance of bacterial species such as *Lactobacillus ruminis*, unclassified species of *Megasphaera*, *Prevotella copri*, *Bacteroides fragilis*, *Bacteroides ovatus*, *Ruminococcus bromii* in the autistic children. Inversely, increased abundance of *Bifidobacterium adolescentis*, *Bifidobacterium longum*, *Blautia producta*, *Bifidobacterium bifidum* and *Clostridium perfringens* in the gut microbiota of autistic children. The mean total SCFA and butyric concentrations was significantly increased (P value < 0.0001) in related autistic children as well as unrelated autistic children as compared to normal. Out of the eight indigenous probiotic *Lactobacillus* strains, *L. plantarum* Lp91 and *L. plantarum* A5 showed maximum antibacterial activity against *Clostridium perfringens* (>10mm zone of inhibition), the predominant species in the gut of autistic children.



Comparative analysis at Phylum level of autistic and normal siblings

## Development of RFLP based Molecular Markers for Differentiation of *Bifidobacterium* Species

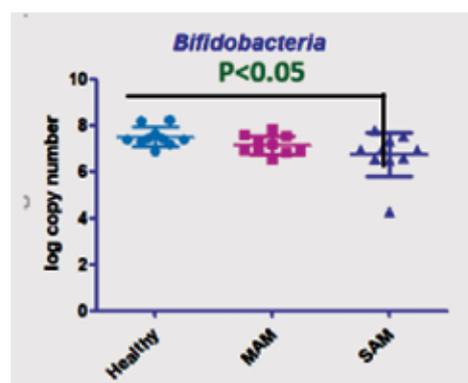
A total of 93 morphologically distinct isolates were presumptively identified as *Bifidobacterium* and further confirmed at genus level by genus specific and transaldolase PCR. The confirmed isolates were PCR amplified for 5 different taxonomic markers and 3 different restriction enzymes for digestion of each gene separately, viz; *hsp 60* gene (HaeIII, Hin1I and Tail), *tuf* gene (AluI, Hin1I and HindII), *clpC* gene (Hin1I, MspI and Tail), *rpoB* gene (HhaI, HinfI and BanI) and 16S rDNA gene (AluI, HinfI and TaqI). Twelve standard *Bifidobacterium* strains from DSMZ were also included to estimate the group specific positions of the isolates, and their similarity with standard reference strains. Dendrograms were constructed from the fingerprints for each gene and enzymes separately and group wise band patterns were estimated. Genotyping based on *hsp60* restriction patterns yielded 9 different genotypes while *tuf*, *clpC*, *rpoB* and 16S rDNA genes yielded 10 different genotypes. Repetitive PCR also generated similar type of groups and validated the group specificity of RFLP genotyping. Composite genotyping grouped all the isolates with different reference strains at species level to *B. breve* (11), *B. animalis* (9), *B. catenulatum* (3), *B. adolescentis* (13), *B. bifidum* (13), *B. merycicum* (8), *B. pullorum* (5) and at sub species level to *B. longum* subsp. *longum* (4) and *B. longum* subsp. *infantis* (15); except one group (12) for which no placement was obtained and further identified to be *B. ruminantium*. None of the isolates grouped with reference strains of *B. boum*, *B. pseudocatenulatum* and *B. thermophilum*. The findings suggested that *hsp60* with HaeIII and *clpC* with MspI can be used as single restriction markers for species level differentiation.



Dendrogram constructed from RFLP fingerprints of amplified *tuf* PCR products with Hin1I (GR/CGYC)

## Comparative Analysis of Predominating Gut Enterotypes in Children of Varying Nutritional Status

Comparative abundance of major gut enterotypes which include the predominant phyla such as *Bacteroidetes* ("B" type enterotypes), *Firmicutes* ("F" type), *Proteobacteria* ("P" type) and *Actinobacteria* ("A" type), major probionts such as Lactobacilli and Bifidobacteria and butyrogenic bacteria such as Roseburia and Faecalibacteria and enteric pathobionts like Escherichia and Klebsiella was investigated in children of varying nutritional status by absolute qPCR quantification approach in a population size of 30 children, ten each under the nutritional health status of Healthy, Moderately Acute Malnourished (MAM) and Severely Acute Malnourished (SAM) category. No significant ( $P > 0.05$ ) difference in the total bacterial diversity was observed among all the nutritional groups of children. At phylum level, *Bacteroidetes* and *Firmicutes* showed increased and decreased trend respectively with the decline in nutritional status, however, the results were non-

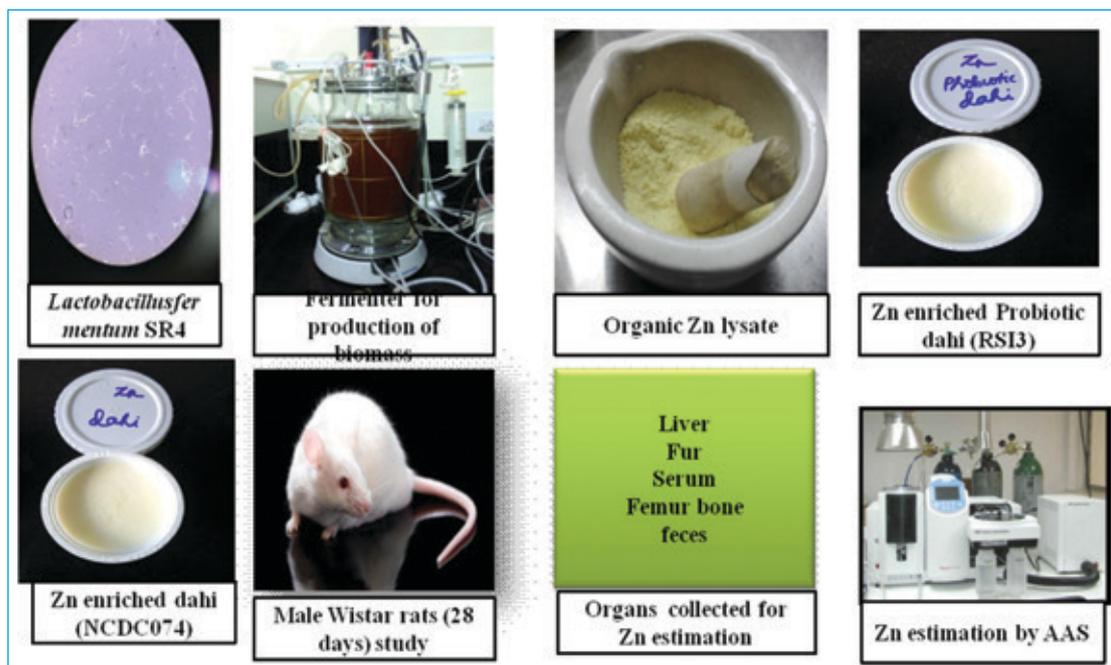


Log copy number of Bifidobacteria in healthy, MAM and SAM children

significant due to small sample size and intra-group differences. Similarly, non-significant ( $P>0.05$ ) decrease in the abundance of *Proteobacteria* and *Actinobacteria* was observed with the poor nutritional health. Among probiotics, a significant ( $P<0.05$ ) decrease in bifidobacterial population was recorded in the malnourished gut compared to the healthy gut. However, contrary to this, significant ( $P<0.05$ ) increase in *Lactobacillus* population was observed in the malnourished children. In butyrogenic bacteria like *Roseburia* and *Faecalibacterium*, again non-significant ( $P>0.05$ ) increase in abundance was observed with poor nutritional health. Among pathogenic genera, significant and non-significant ( $P>0.05$ ) decline in the abundance of *Escherichia* and *Klebsiella* was observed in malnourished children. On comprehensive comparative analysis, only significant ( $P<0.05$ ) decrease in the abundance of Bifidobacteria was observed with the decline in the nutritional health of the children.

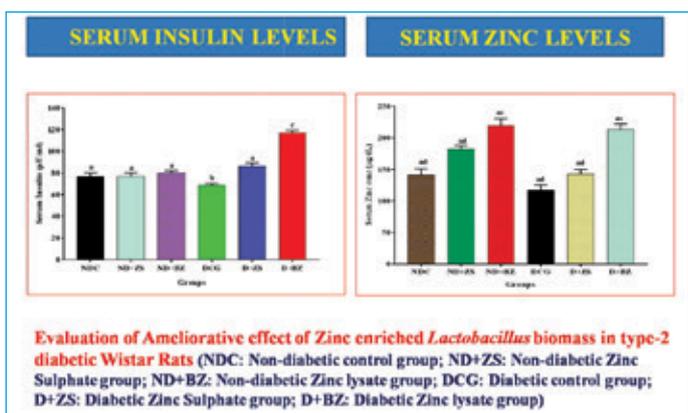
### Evaluation of Bioavailability of Zinc Enriched Probiotic Dahi

The highest inorganic Zinc biotransforming *Lactobacillus fermentum* SR4 culture was used for conversion of inorganic Zinc into organic form. The Zinc content of bacterial lysate was measured by Atomic Absorption Spectroscopy which was found to be 1.69 mg/g of dry weight. In order to prepare Zinc enriched *Dahi*, Zinc lysate (Zinc content 15 ppm on dry weight basis) was added to heated and cooled milk just before the inoculation of the lactic cultures (*S. thermophilus* NCDC074 and *Lactobacillus rhamnosus* NCDC 610). Functional *Dahi* containing biotransformed organic zinc was evaluated for zinc bioavailability in Wistar rats. The rats fed with bacterial lysate enriched *Dahi* significantly ( $p<0.001$ ) improved body weight and food intake. The zinc concentrations analyzed by AAS were significantly higher Zinc in serum, femur bone, liver and hair of rats fed zinc enriched *Dahi*. The fecal excretion of zinc was observed more in the animals fed with basal diet and inorganic zinc sulphate. The results of *in-vivo* studies indicated that the bioavailability of organic zinc through *Dahi* was high compared to its inorganic forms.



### Ameliorative Effects of Zinc Enriched *Lactobacillus* Biomass in Type-2 Diabetic Wistar Rats

A study was undertaken to investigate the ameliorative effect of zinc enriched biomass of *Lactobacillus fermentum* SR4 in a rat model of type 2 diabetes. The zinc enriched biomass of said bacteria was produced under previously optimized conditions at fermenter level by the addition of  $ZnSO_4$  (200 ppm) followed by cell lysis and freeze drying (Zn content of lysate,  $1.121 \pm 0.3$  mg/g dry weight). The *in-vivo* study on ameliorative effects of zinc enriched *Lactobacillus* biomass in type-2 diabetes was carried out in male albino type-2 diabetic Wistar rats. The prepared zinc lysate of SR4 was supplemented in diet of diabetic (D+BZ) and non-diabetic (ND+BZ) rat groups at the rate of 7.5 mg /kg body weight) for 6 weeks after diabetes induction. After 6th week, a significant ( $p<0.05$ ) reduction in fasting blood glucose, was



observed which was accompanied by an increase in the levels of metallothionein, insulin, femur and Zn of blood serum of diabetic rats fed with bacterial zinc lysate as compared to those of diabetic control group. The present study endorses the role of Zn in amelioration of hyperglycemia induced in type-2 diabetes. Further, significantly better performance of bacterial zinc lysate prepared from native strain of *Lactobacillus vis-à-vis* zinc sulfate in this regard was indicated.

### Extended Shelf-life Functional Lassi Using Non-Thermal Interventions

*Streptococcus thermophilus* strain NCDC 436 was selected for preparing *Aloe vera* supplemented probiotic lassi (APL) with improved quality attributes and reduced fermentation time. Based on relative bacterial growth ratio (RBGR), a potent probiotic strain *Lactobacillus paracasei* ssp. *paracasei* (NCDC 627) was chosen for use in APL manufacture. Pectin addition at the rate of 0.3% reduced the syneresis and improved the quality attributes of APL. Addition of copper and natamycin increased the shelf life of APL up to one month at refrigeration temperature. Ethylene vinyl alcohol (EVOH) was selected as high barrier packaging material for packaging of APL to extend its shelf life. The combination of non-thermal treatments viz. addition of pectin (0.3%), use of copper (5 ppm) and packaging in EVOH enhanced the shelf life of APL up to 25 days at  $6 \pm 1^\circ\text{C}$ .

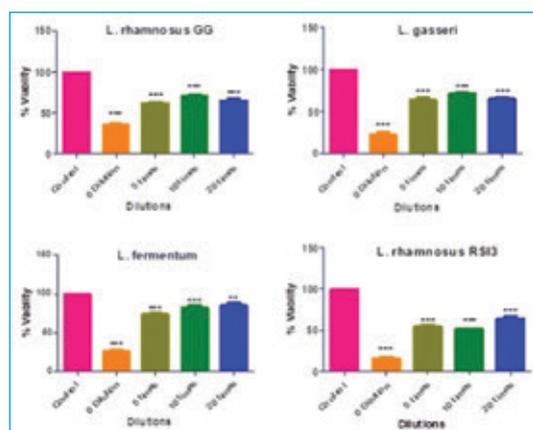


### Preparation of Synbiotic Kefir Using Probiotic *Lactobacillus Rhamnosus* GG and Prebiotic Inulin

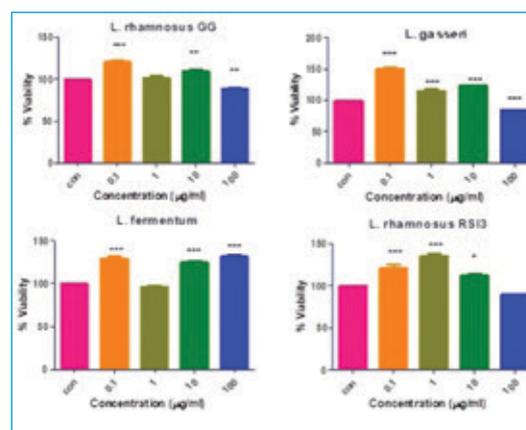
Addition of probiotic *Lactobacillus rhamnosus* GG at the rate of 2% reduced the flavour as well as viscosity of Kefir. The acidity increased slightly in probiotic Kefir but textural properties were better in control Kefir. Synbiotic Kefir containing 2% probiotic showed significantly ( $p < 0.05$ ) higher flavour with 4% inulin than that with 2% inulin and control. Significant difference ( $p < 0.05$ ) was observed in acidity and pH of synbiotic and control Kefir. All the textural properties including viscosity improved on addition of inulin. The alcohol content quantified using gas chromatography was found to be 0.03/100g in control and 0.20/100g in developed synbiotic Kefir. All the samples were packed in 150 mL polypropylene cups and stored at  $7-8^\circ\text{C}$ . The flavour of synbiotic Kefir was better than control throughout storage. Body and texture of synbiotic Kefir was significantly ( $p < 0.05$ ) better than control on 12<sup>th</sup> day of storage. The initial acidity of synbiotic Kefir (1.226 % LA) was significantly ( $p < 0.05$ ) higher than control (0.934 % LA) but no significant change ( $p > 0.05$ ) was observed as storage progressed. The viability of probiotic organism reached maximum (7.09 log CFU/g) on 6<sup>th</sup> day of storage thereafter gradually decreased as storage progressed.

### Role of Probiotics on Steroidogenesis and Male Fertility through a Unique *In Vitro* Approach

In the present study, the effect of supernatant of different lactobacillus strains (*L. rhamnosus* GG, *L. gasseri*, *L. fermentum* & *L. RS13*) on cell viability of mouse leydig cell line i.e., TM3 cell line by using MTT and Neutral Red



Effect of bacterial supernatant (*L. rhamnosus* GG, *L. gasseri*, *L. fermentum* & *L. RS13*) on cell viability using MTT assay



Effect of compromised bacterial supernatant (*L. rhamnosus* GG, *L. gasseri*, *L. fermentum* & *L. RS13*) on cell viability using the MTT assay

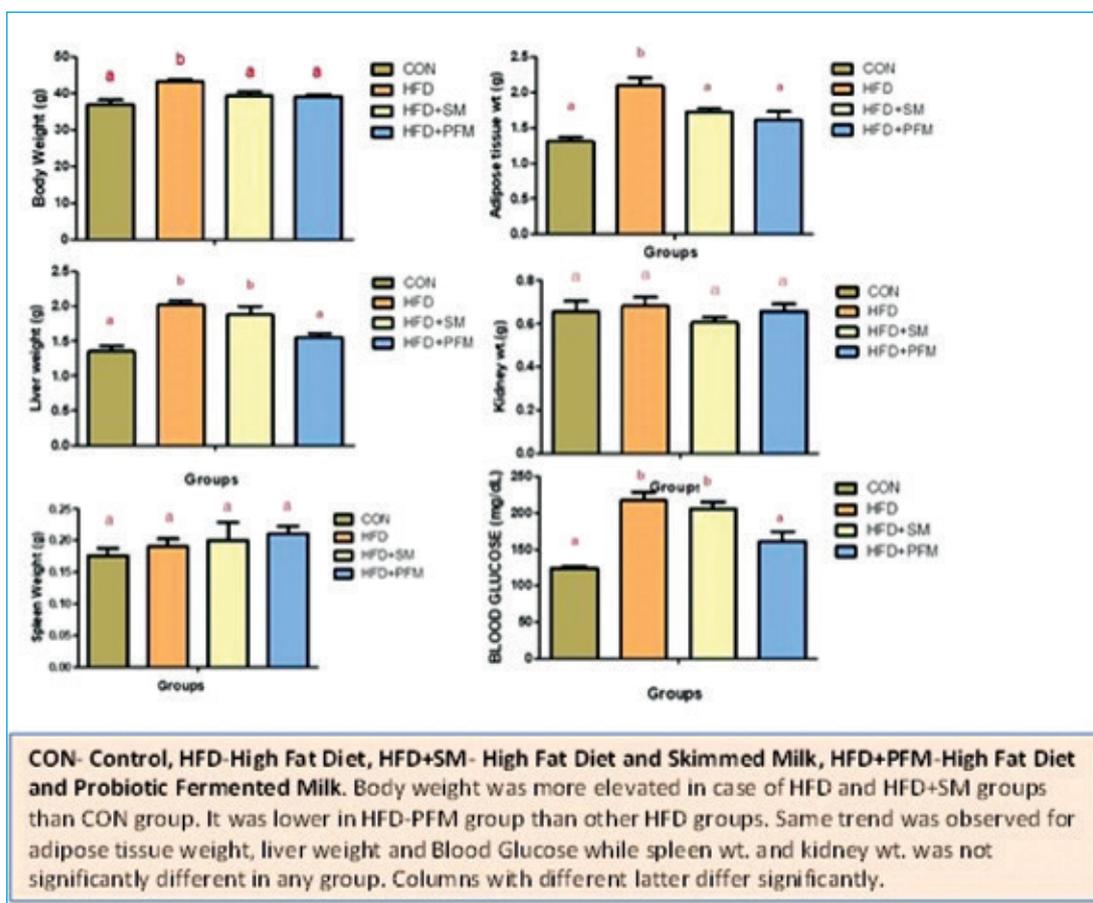
assay was investigated. Results from these assays shows a significant reduction in cell viability, after TM3 cells were exposed to bacterial supernatant of different dilutions prepared in MRS. Then, the effect of probiotic bacterial proteins secreted in a compromised MRS media, on the cell viability of TM3 cells using MTT and Neutral Red assay was studied. Results obtained from compromised bacterial supernatant treatment shows a significant increase in the cell viability of TM3 cells. Extra Polymeric Substance (EPS) from these bacterial strains was isolated and their effect on viability of TM3 cell line using MTT and Neutral Red assay was also investigated. Result from EPS treatment on TM3 cells also shows a significant increase in cell viability.

### Development of Reduced Fat Probiotic Cream Cheese by Using *Lactobacillus helveticus* with Added Inulin and Whey Protein Concentrate

The focus of the present investigation was to develop reduced fat probiotic cream cheese to increase health benefits by incorporating inulin and whey protein concentrate (WPC) as fat replacers and *Lactobacillus helveticus* as a probiotic. Incorporation of 4% inulin resulted in better flavour, body and texture and more spreadability. Incorporation of 4% WPC in reduced fat cream cheese (RFCC) showed better sensory, physico-chemical and textural properties than that made with 6% WPC. With increased levels of inulin and WPC, firmness decreased while spreadability increased in RFCC. The moisture content of cheese decreased significantly ( $p < 0.05$ ) with increased inulin and WPC levels. RFCC prepared by incorporating *L. helveticus* showed that addition of 1% culture resulted in better flavour and spreadability. Finally, RFCC with 4% inulin and 1% probiotic was selected. Maximum ACE inhibitory activity (%) was observed in developed product (53.39%) than control (27.47%). Shelf life study indicated 4 days more shelf life in developed cheese than control when packed in polypropylene cups and stored at refrigeration temperature.

### Dietary Incorporation of Milk Fermented with *Lactobacillus gasseri* Prevents the Increase in Body Weight and Hyperglycemia Occurred due to Feeding of Obesogenic Diet

The current study was conducted to see the effects probiotic fermented milk on diet induced obesity in C57BL/6 mice fed with high fat diet for 16 weeks. There were four treatment groups fed with Control diet (CON), High fat diet (HFD), High fat diet and Skimmed Milk (SM) (HFD+SM), and High fat diet Probiotic Fermented Milk (PFM) (HFD+PFM). The mice were fed for 16 weeks and allowed free access to food and drinking water during experimental period. Body weight was measured weekly. At the end of the experimental period, Blood glucose was measured after overnight fasting and the mice were anaesthetized and sacrificed. Organ weight was measured and liver sample,



adipose tissue, caecum samples were collected for further analysis. Blood samples were also collected and serum was separated for further analysis. The body weight was significantly higher in HFD and HFD+SM groups than control group. While the body weight was controlled in the group fed with Probiotic Fermented milk and HFD. Increase in liver weight and adipose tissue weight due to feeding of High Fat diet was also prevented by Probiotic fermented milk. Blood glucose level was elevated in case of HFD and HFD+SM group as compared to control group while it was significantly lower in case of HFD-PFM group. Kidney weight and Spleen weight was not significantly different in any group of mice. Blood glucose level was also higher in both HFD group and HFD+SM group. However the level of glucose in not elevated due to feeding of HFD-PFM.

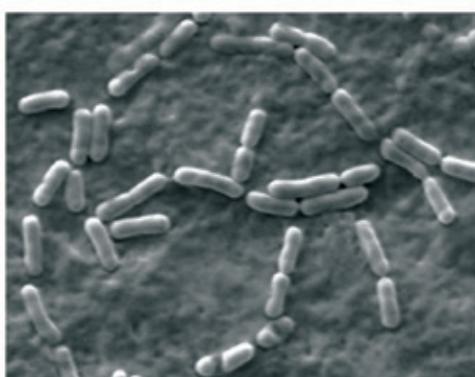
### Adherence Ability of Probiotics Lactobacilli on Intestinal Epithelial Cells

The colonisation potential of *L. rhamnosus* and *L. fermentum* was determined by plate counting method as well as by scanning electron microscopy respectively. Both lactobacilli strains were able to adhere to epithelial Caco-2 cells, but they have diverse degree of adhesion. Under the present study, adhesion indices were calculated after 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> washing with saline. In case of *L. rhamnosus*, the adhesion indices were  $1800 \pm 18$ ,  $300 \pm 18$  and  $166.7 \pm 11$  cfu/100 cells respectively after first, second and third washing. On the other hand *L. fermentum* showed adhesion indices of  $4083 \pm 220$ ,  $2983 \pm 72$  and  $1850 \pm 104.1$  cfu/100 cells respectively. The percentage adhesion capacity was 18, 3 and 1.7% for *L. rhamnosus* and 40.8, 29.8 and 18.5% for *L. fermentum* respectively based upon total bacteria (cfu) inoculated with Caco-2 cells and later recovered after subsequent washings. Comparative analysis between the two bacterial strains clearly depicted 2.3, 9.9 and 11.1 folds more probiotic efficiency of *L. fermentum* than *L. rhamnosus* respectively. The adhesion capabilities of probiotic strains were also visualised by scanning electron microscopy (Plate ). Moreover, relative expression of genes associated with probiotic attributes (*AtpD*, *Bsh*, *Mub* and *MapA*) of both lactobacilli as well as host mice (*MUC2*) were also studied under *in vitro* and *in vivo* milieu to establish interactions between the gut microbiota and the host which may promote the mutual cooperation and functional stability of gut ecosystem. Significantly ( $P < 0.05$ ) enhanced expression of *AtpD*, *Bsh*, *Mub* and *MapA* gene in *L. fermentum* and *L. rhamnosus* were observed respectively under simulated gut conditions of increased acidity, presence of bile salts and mucin than control. Similar results were also confirmed during *in vivo* mice experiments after oral intubation of respective bacterial strains.

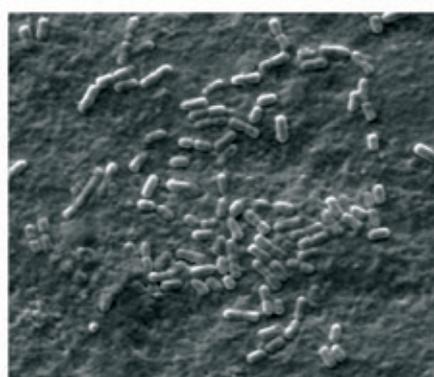
### Effect of Probiotic Lactobacilli on mRNA Expression of Junctional Proteins during Challenge with Inflammatory Agents

Temporal changes in mRNA expression of genes associated with tight junction proteins (*Zonula occluden-1*, *Claudin-1*, *Occludin*, *Cingulin*) during separate exposure of inflammatory agents (*E. coli*. and LPS) and probiotic lactobacilli (*L.rhamnosus* : 5897 and *L.fermentum* MTCC; 5898) were also determined. Statistically ( $p < 0.05$ ) significant suppression in expression of these four junction genes was noticed during 6 hrs of exposure of either of the inflammatory agents. Contrarily, mRNA expression of these junctional genes enhanced significantly ( $p < 0.05$ ) in host epithelial cells when either of the probiotic strains individually or together were incubated with caco-2 cells for 6 hrs. Both probiotic strains either increased the mRNA expression of tight junction genes or maintained equal expression to untreated control cells under competition assays with live *E. coli*/LPS. Further, it was important to note that competition of LF with inflammatory agents exhibited better response by enhancing ( $p < 0.01$ ) the expression of gene associated with this tight junctions (*Zonula occluden-1*, *Claudin-1*, *Occludin*) than *L.rhamnosus* or combination of both probiotic strains. On the other hand, displacement treatment was not found effective consistently in restoring the gene expression of tight junctions.

***Lactobacillus rhamnosus***



***Lactobacillus fermentum***



Scanning Electron Micrographs of *Lactobacillus rhamnosus* and *L.fermentum* on intestinal epithelial cells (Caco-2 cells)

## Production of Antimicrobial Bioactive Peptides from Bovine and Non-Bovine Milk by Proteolytic *Lactobacillus* Fermentation

Fermentation of sheep, Goat, Camel cow and buffalo milk by *L. rhamnosus* C25 at 37°C for 48 hrs with 2% inoculum was carried out to generate bioactive peptides for maximum antimicrobial activity. 10 kDa fractions showed maximum antimicrobial activities followed by 5 kDa fractions. However, antimicrobial activity was also observed in 3 kDa fractions. MIC for 10 kDa was found to be 16-21.7 µg/ml (cow milk), 11.11-15.79 µg/ml (buffalo milk), 3 kDa camel milk was 24.96-36.5 µg/ml, 10 kDa goat milk was 8.2-12.56 µg/ml, and for sheep milk 10 kDa, it was between 50.52- 61.24 µg/ml. Bovine milk peptides showed better antimicrobial activity than non bovine milk fermentate derived peptides. Sheep milk on simulated gastric digestion showed maximum antioxidant activity followed by cow milk. The peptide fractions of all the milk samples were stable for 15 days at refrigeration temperature and heating at 60°C/30 min. Different fractions of cow and buffalo milk showed more antimicrobial activity than goat and sheep milk. Identification of peptides was done by HPLC and LC-MS/MS in sheep, camel and goat milk. In sheep milk, 10 kDa peptide fractions, 33 peptides from  $\beta$  casein fraction were identified. Sheep milk generated antimicrobial, ACE inhibitory, antidiabetic, immunomodulatory, anticancer, opioid and antioxidant peptides. Goat milk released ACE inhibitory, antioxidant, antimicrobial and antidiabetic peptides. Similarly, fermented camel milk released ACE inhibitory, antidiabetic, opioid and cytomodulatory peptides were released. Sheep, goat, cow, buffalo and camel milk bioactive peptides were added in shrikhand and flavour milk. Antimicrobial activity was observed in all the samples upto storage period of 10 days in flavoured milk and 15 days in shrikhand against some of the pathogens. The antimicrobial bioactive peptides in the fermentate of different milk may be used as ingredient for the development of functional foods.

## Adherence of Probiotic Lactobacilli to Intestinal Epithelial Cells and Maintenance of Cellular Junctions during Challenge with Inflammatory Agents

Intestinal junction integrity is foremost requisition for optimum health and its aberration often called as “Leaky gut syndrome” leads to development of various gastrointestinal dysfunctions as well as extra-intestinal pathological conditions, such as type 1 diabetes mellitus, allergic diseases or autism and therefore, it is deemed as a potent therapeutic target. Probiotics are living drug that are at epicentre of modern medicine and are considered as the best remedy to prevent these ailments. Probiotics protect the host against pathogen driven epithelial hyperpermeability via increased expression of important tight junction proteins.

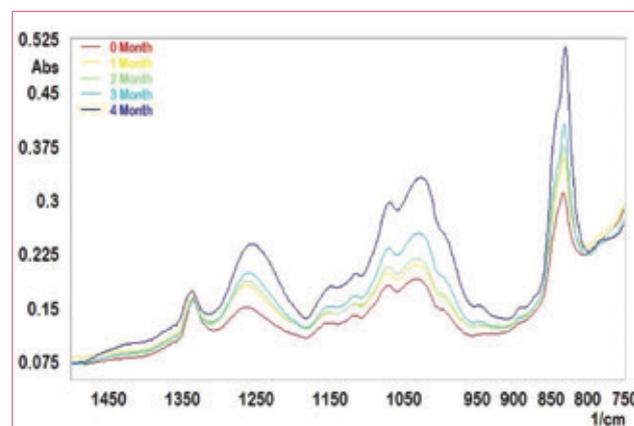


Dr. R. B. Singh, Director, NDRI launching two health drinks in chocolate and raspberry flavour at NDRI milk parlour

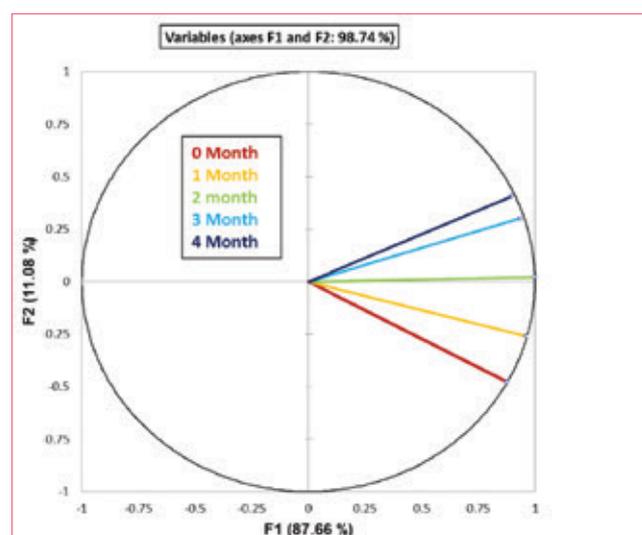
# NEW GENERATION METHODS TO ASSESS THE QUALITY AND SAFETY OF MILK AND MILK PRODUCTS

## FTIR based Method for Assessing Proteolysis in UHT Milk during Storage

Suitability of Fourier Transform Infrared Spectroscopy (FTIR) as a rapid technique to assess the proteolysis in UHT milk was evaluated. The method was compared with other prevailing techniques such as RP-HPLC, Trinitrobenzenesulphonic acid (TNBS) and Fluorescamine method. The commercially obtained UHT milk samples were stored at 5°C and 30°C and analyzed for four months and progress of proteolysis was assessed. The concentrated TCA supplemented of milk sample was applied on FTIR and spectrum was obtained (400-4700  $\text{cm}^{-1}$ ). Principal Component Analysis was carried out in the spectral range 1500-750  $\text{cm}^{-1}$ . As the storage period increased the sample moved from 4<sup>th</sup> quadrant to the 2<sup>nd</sup> quadrant in correlation circle indicating a significant change in the absorbance in the said spectral range. This increased in absorbance can be attributed to formation of peptides in UHT milk during proteolysis. The comparison of FTIR spectral data with RP-HPLC chromatograph and increased absorbance in TNBS & Fluorescamine method showed correlation for assessment of proteolysis in the UHT milk samples. The milk sample stored at 30°C showed more proteolysis as compared to samples stored at 5°C. Present study indicated that FTIR based rapid and convenient method can be used as an alternative to available methods for assessing proteolysis in UHT milk.



FTIR spectra of UHT milk samples during storage (30°C). The samples were prepared using trichloroacetic acid



Principle Component Analysis of UHT milk stored at Room Temperature.

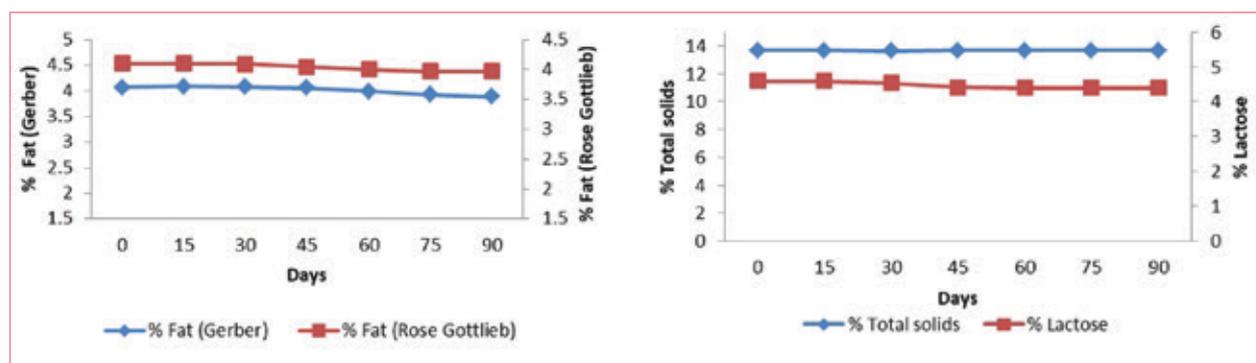
## Validation and Standardization of the GC Analysis Method given in ISO 17678: 2010 for Determination of Milk Fat Purity in Bovine Milk other than Cow's Milk

Ten samples each of cow and buffalo milk were collected from different farms located in Eastern (Patna), Northern (Karnal), Southern (Bengaluru) and western (Mehsana) parts of the country. These milk samples were processed

to prepare Ghee samples. Till date, 234 samples of ghee have been prepared. These samples will be analyzed for their triglyceride profile using GC- based method as described by ISO/ IDF 17678: 2010. During the period under report, GC- method using a capillary column SLBTm- 5ms, of 2.5 m length (cut from 15 m X 0.25 mm X 0.25  $\mu$ m) has been standardized on the GC- machine available in the Division. Analysis of standard triglyceride mixture [( Supelco 17811- 1AMP) Tricaprin, Tricarylin, Trilaurin, Trimyresitn, Tripalmitin] using ISO/ IDF 17678: 2010 method showed clear cut resolution of all the five triglycerides. Response factor for individual triglycerides has also been determined and was close to 1.0. In addition to these triglycerides two more triglycerides i.e. Triolein and Triheptadecanoate were also run on GLC. The linearity of the method was also tested and R2 was found to be in the range of 0.97-0.98 for different triglycerides.

### Standardization of Preservative Formulation (Bronopol™ and Kathon™) for Milk Analytical Analysis

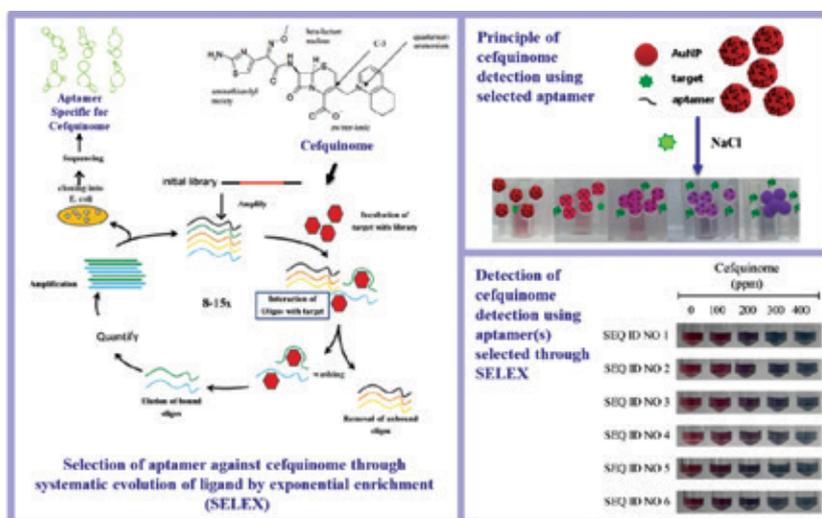
Bronopol™ (0.05-0.10%) and kathon™ (0.20-0.40%) showed good antimicrobial activity against all groups of microorganisms. Therefore, an attempt was made to develop suitable alternative to formalin by using combination of preservative bronopol™ and kathon™ as a novel approach for efficient preservative action. Three different combinations (A, B and C) were prepared using different ratios of kathon™ and bronopol™. From combination A to C, there was a decrease in concentration of kathon™ and an increase in concentration of bronopol™. All three combinations were added to milk at different concentrations (0.2-0.6%) and antimicrobial activity was elucidated by assessing the milk samples for total plate count, lactic acid bacterial count, coliform count, yeast and mould count. Combination C @ 0.6% was selected as it had the lowest concentration of kathon™, all microbiological counts were nil in first dilution in milk and also no significant effect was observed on compositional parameters (fat-Gerber and Rose Gottlieb, total solids and lactose content) of milk for 45 days at 37°C (as shown in graph) . This formulation was stable for 90 days when stored in amber colored bottles both at refrigeration and 37°C.



### Selection of Aptamer(s) against Cefquinome for its use as Ligand in gold Nanoparticle based Aptasensor

In present work, aptamers against cefquinome are generated and tested for establishing proof-of-principle of recognition of cefquinome by generated aptamer. Aptamers for cefquinome were selected from a random pool

( $10^{14}$ ) of ssDNA sequences which has 18nt long constant regions at both 5' and 3' ends and 36 nt long random sequences between constant regions. The aptamers were selected through the Systematic Evolution of Ligands by Exponential Enrichment (SELEX). The aptamer pools obtained after SELEX were sequenced. Examination of sequences of aptamers revealed 6 different aptamer sequences. The generated aptamers against cefquinome exhibited dissociation constant values in the range of 83-266 nM. Each of the aptamers was further tested for its ability to be used in aptasensor. All aptamers recognized cefquinome as indicated by colour change (red to purple or

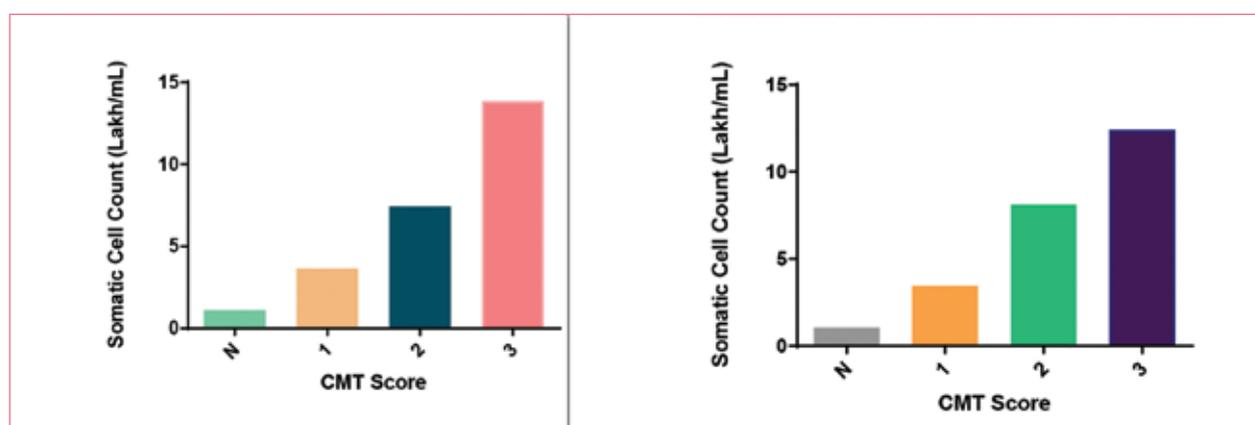


Selection of aptamer(s) against cefquinome for its use as ligand in gold nanoparticle based aptasensor

blue) of aptamer coated gold nanoparticle in presence of 200 ppm cefquinome. The study resulted in generation of a number of aptamers against cefquinome and proof-of-principal for detection of cefquinome by aptamers.

### Evaluation and Validation of Enzyme Substrate Based Strip Test for Detection of Subclinical Mastitis

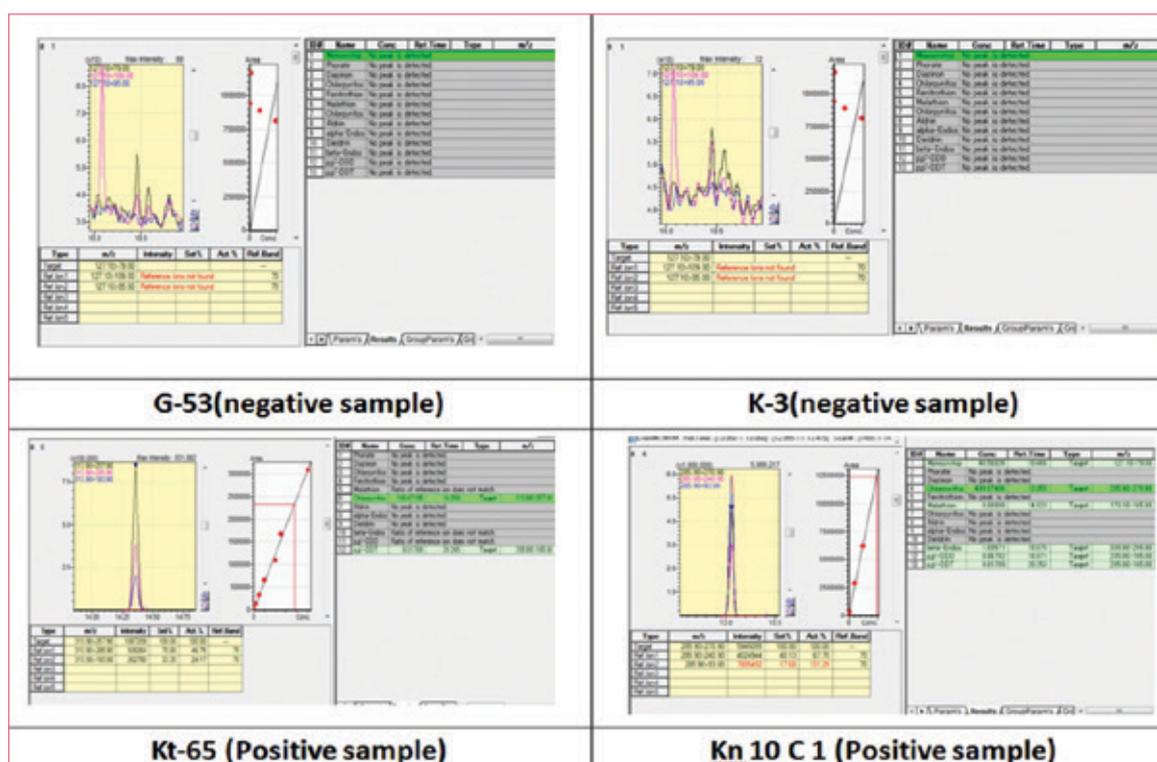
For detection of subclinical mastitis, conditions for support based strip test were optimized. Six different supports (I, II, III, IV, V and VI) and two substrates (I and II) were evaluated for their suitability for development of the test. The supports were functionalized by loading different substrates and further dried. Milk samples were screened for its mastitis status by somatic cell count, pH and California mastitis test. Functionalized strips were dispensed in vials, impregnated with milk samples and incubated to observe for colour development. Selection of substrate and support was based on minimum time required for color development. Among the studied substrates and supports, substrate-I and support III were selected as they showed better activity in terms of color development in minimum time. The optimized substrate levels and volume demonstrated differentiable color development in minimum time for marker enzyme. The developed test will be helpful in detection of subclinical mastitis in dairy animals under field conditions in minimum time.



Correlation between Somatic cell count & California mastitis test

### Pesticide Residues Analysis in Milk and Milk Products using GC-MS/MS

GC-MS/MS- MRM protocol was optimized for the analysis of pesticide residues in milk. Mainly eleven pesticides from two different groups of OP (fenitrothion, chlorpyrifos- methyl, monocrotophos, diazinon, malathion, phorate and

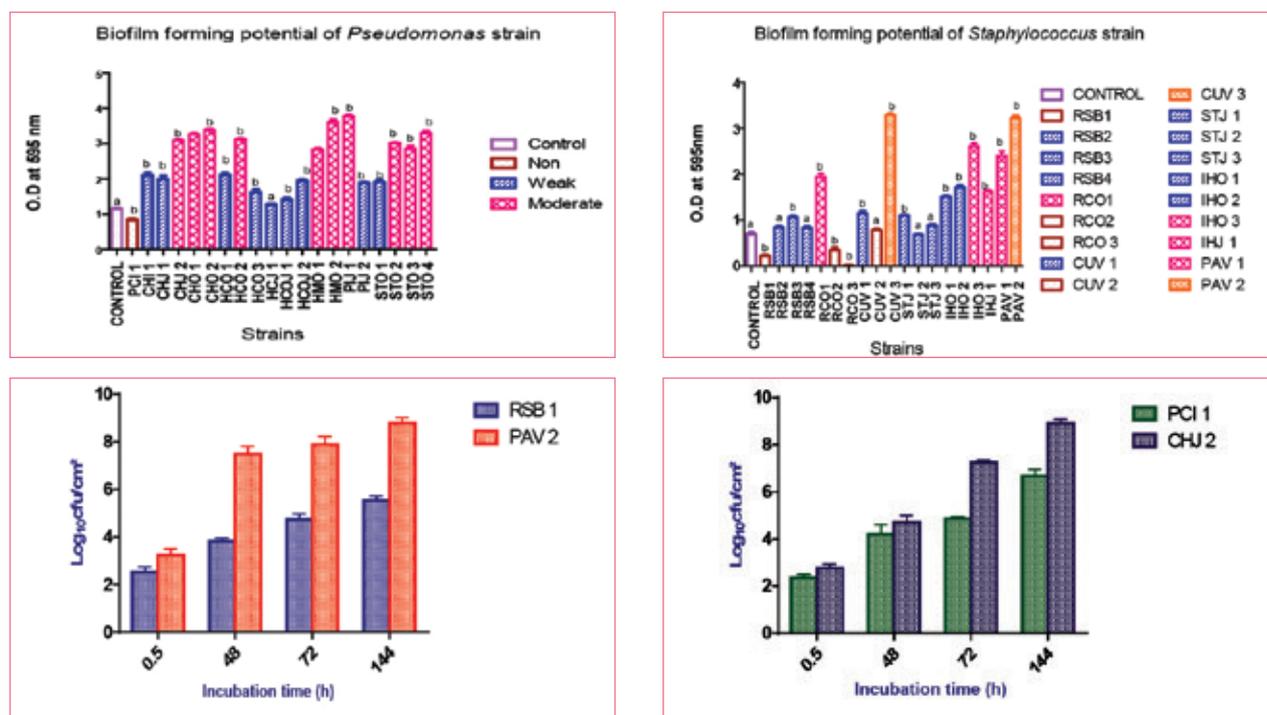


Analysis of Pesticide Residues in milk using GC-MS/MSMRM protocol

chloropyrifos) and OC (aldrin, dieldrin, endosulphan and DDT) were targeted for optimization on TQ- 8030 model (Shimadzu) to have distinct separation of all compounds. The method was optimized that enabled the resolution of eleven pesticides (additional two isomers) in single run of 32 min in solvent and milk matrix. Optimized protocol showed good linearity ( $\approx 99\%$ ) and RSD ( $< 20\%$ ) in solvent and milk matrix for all compounds except monocrotophos which was unstable under GC-Conditions. Two QuEChERS methods (original and acetate) were also compared for achieving maximum efficiency and it was found that acetate method gives better efficiency with mean recovery in the range of 90-110%. The developed method was evaluated for detection and quantification of pesticides in milk (40) and milk powder (10) samples. No peak of targeted compound was obtained in 23 milk samples. On the other hand, 17 samples showed presence of different groups of pesticides. Out of the 10 milk powder samples analyzed, 6 samples were found to be negative while 4 samples contaminated with traces of pesticides from different groups (chloropyrifos, malathion and  $\beta$ -endosulphan) below MRL limits.

### Efficacy Evaluation of Antibiofilm Agents against *Pseudomonas* and *Staphylococcus* Species

A total of 20 *Pseudomonas* and 18 *Staphylococcus* strains were examined for their biofilm forming potential. The potency of anti-biofilm agents i.e. iodophore, benzalkonium chloride and sodium hypochlorite, essential oils such as trans-cinnamaldehyde, eugenol and p-cymene was evaluated for their biofilm extermination at irreversible stage on food grade stainless steel (SS) surfaces. Ten strains of *Pseudomonas* and eight strains of *Staphylococcus* species exhibited biofilm forming potential which were further evaluated for biocide resistance against anti-biofilm agents by minimum inhibitory concentrations (MIC) and minimum biofilm eradication concentrations (MBEC). Benzalkonium chloride (BKC) was found most efficacious both in planktonic and sessile state as its MIC ranged from 120-210 ppm and 5-55 ppm, whereas MBEC for *Pseudomonas* and *Staphylococcus* species ranged from 300-5080 and 550-1095 ppm, respectively. The bio-transfer potential of selected strain on SS surfaces showed significant increase in viable counts by 6 log from initial counts of 2 log cfu/cm<sup>2</sup> for *Pseudomonas* and by 5 log from initial counts of 3 log cfu/cm<sup>2</sup> for *Staphylococcus* species. Benzalkonium chloride demonstrated inhibition of biofilm formation at irreversible stage at MBEC dosage. Chemical analysis of extracellular polymeric substances exhibited more polysaccharide in a biofilm forming *Staphylococcus* strains as compared to non-biofilm producing strains. However, no such trend was noticed in *Pseudomonas* strains.



Efficacy evaluation of BKC in control of biofilm formation at irreversible stage

### Outreach Program on Monitoring of Drug Residues and Environmental Pollutants

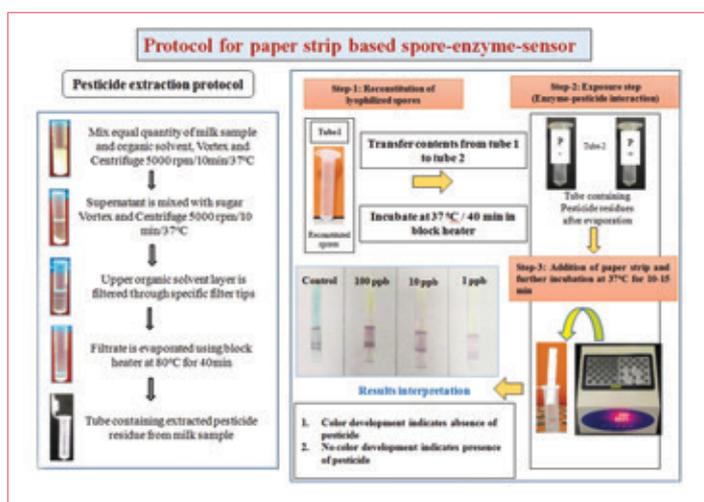
Screening of 539 samples of raw milk procured from Rajasthan, Punjab, Haryana and UP using developed strip based test revealed that 10.95% samples were contaminated with antibiotic residues. The contaminated samples were further analyzed with Charm / ROSA test and presence of  $\beta$ -lactam (2.41%), chloramphenicol (2.22%), tetracycline (3.15%), sulfa drugs (1.85%), streptomycin (0.55%) and quinolone (0.92%) was detected. Further, 159 samples of pasteurized milk representing different brands procured from similar sources were also screened and 5.03% samples were found contaminated with 1.88% each of  $\beta$ -lactam and tetracycline and 0.62% sulfa drugs. The raw and pasteurized milk samples were also tested for the presence of pesticide residues using strip-based technology

earlier developed at ICAR-NDRI and it was observed that 7.05% samples contained pesticides. The pesticide contaminated samples were further tested using gas chromatography for confirmation and quantification. Raw milk samples showed the presence of dichlorvos (2.59%), monocrotophos (0.92%), malathion (0.18%), chlorpyrifos (0.92%) and profenofos (0.18%). The presence of  $\beta$ -endosulfan and DDD were observed in only few samples analyzed so far. In pasteurized milk, pesticide residues were detected in 4.40% samples when tested with paper strip test and these samples showed the presence of dichlorvos (1.88%), monocrotophos (1.25%), malathion (1.25%) and chlorpyrifos (1.88%) in GC analysis.

### Inter-laboratory Assessment and Validation of the Technology for Pesticide Detection in various Food

The strip based assay was linked with extraction protocol and the developed spore-enzyme sensor on paper-strip that was evaluated to determine the limits of detection (LOD's) for different groups of pesticides in milk and were found invariably within regulatory limits. The LODs achieved were in the range of 1-10 ppb (OP), 1-50 ppb (CM), and 250- 500 ppb (OC); 0.1 to 50ppb for fungicides and 1 ppb for herbicides. The results obtained with different variants of fluid milk and milk products indicated no interference of fat in terms of extraction of pesticide /assay running.

This technology was also evaluated through inter-laboratory assessment by various analytical labs like FICCI Research and Analysis Centre (FRAC Labs), New Delhi, VIMTA,Labs, Hyderabad; M/s Snow Organic Green Farms, Paonta Sahib and Duke Thomson's India Pvt. Ltd, Indore MP as depicted in below Fig.



*Protocol for the Development of Strip Based Spore-Enzyme Sensor for Detection of Pesticides in Milk*



*FICCI Research and Analysis Centre, Dwarka, New Delhi*



*Representative from VIMTA, Labs Hyderabad*



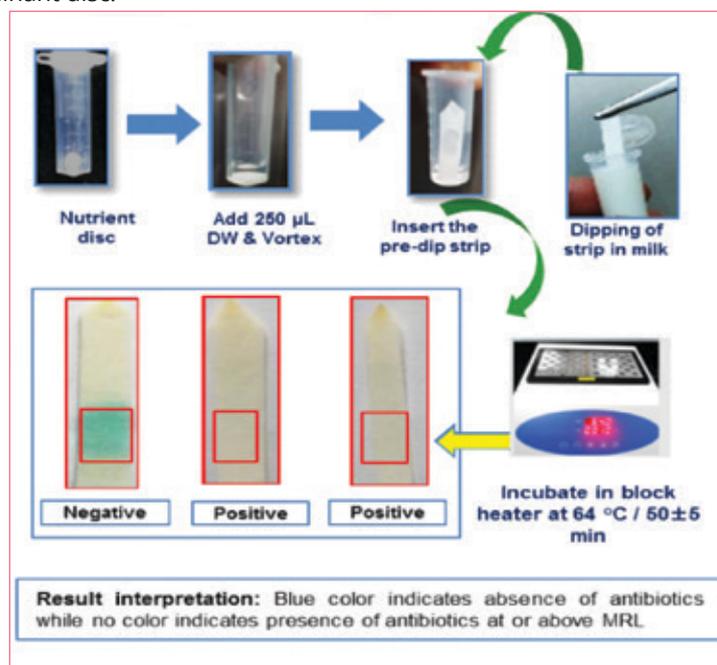
*M/s. Snow Organic Green Farms, Paonta Sahib*



*Duke Thomson's India Pvt. Ltd, Indore MP*

## Evaluation and Validation of Strip Based Sensor for Detection of Antibiotics in Milk

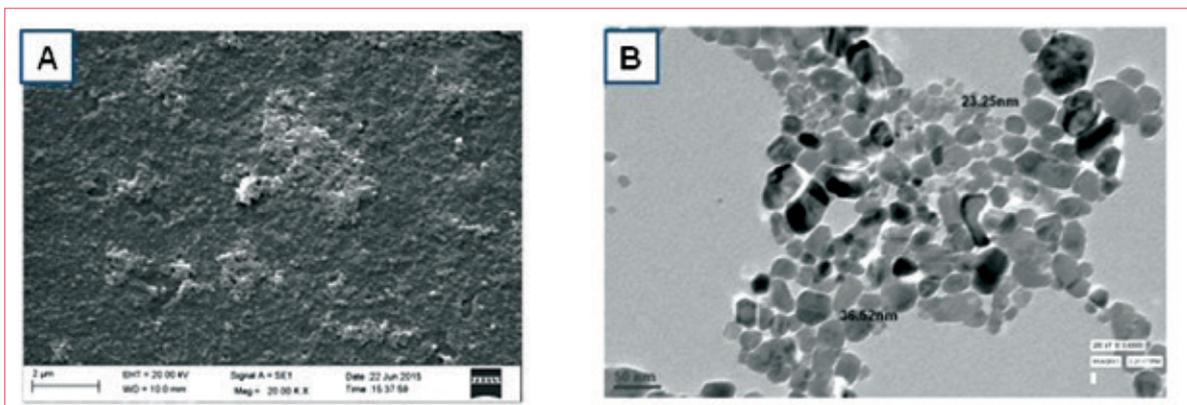
A total of 48 different germinants were screened using strip based sensor and finally 5 germinants were selected based on their active concentration, colour development and solubility in water. Components of the kit media were individually re-evaluated and yeast extract was found to have significant impact on spore germination. Subsequently, the strip making process was optimized by evaluating papers from different sources, substrate concentration / immobilization, spore production, their activation, dispensing and functionalization on strip leading to color development within 30 min. The developed sensor on paper strip was evaluated for LODs against 42 antibiotics commonly used as veterinary medicines. The sensor was found sensitive at regulatory limits (Codex and EU) to all 14 groups of antibiotics viz. aminoglycosides,  $\beta$ -lactams, bacitracin, amphenicols, quinolones, glycopeptides, ionophore antibiotics, lincosaminides, macrolides, nitrofurans, polymyxins, rifamycins, sulphonamides, tetracycline and diaminopyrimidines. The sensor was validated under field condition by analyzing raw milk (529), pasteurized milk (50) and dried milk (25) samples. About 15.63% of raw milk and 4% of dried milk samples were found positive for antibiotics and were further screened by AOAC approved Charm II and ROSA methods. The shelf stability of assay components was established to be 3 months at 4°C after vacuum packaging of functionalized paper strip and 6 months for germinant disc.



*Paper strip based assay for detection of antibiotic residues in milk*

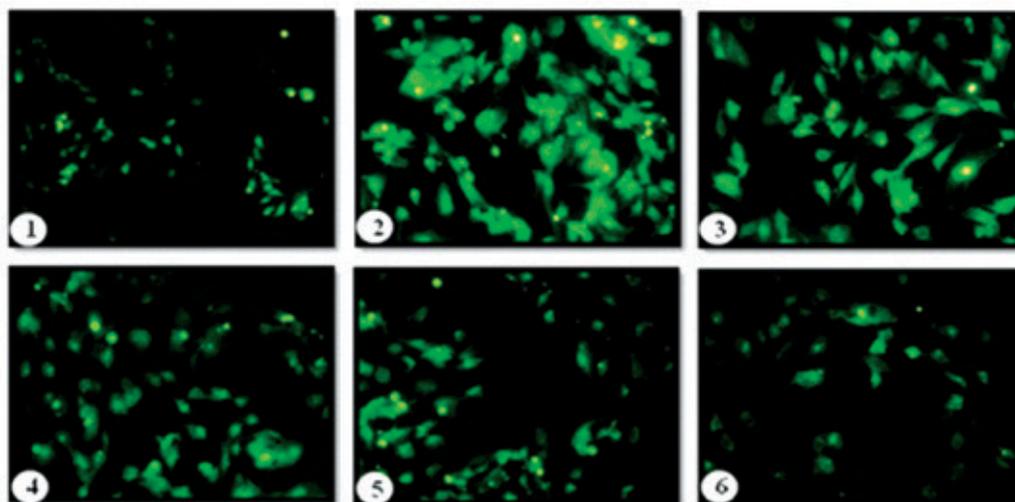
## Safety of Mesoporous Silica Nanoparticles via a Controlled Release Nanodispensers for the Delivery of Semiochemicals

The study on safety profile of Mesoporous Silica nanoparticles (MSN) indicated noxiousness of Zn NPs by being cytotoxic, causing steroidogenic effect in Leydig cells and increasing autophagic vacuole formation possibly via alteration of antioxidant enzyme activity in TM3 Leydig cells. Transmission electron microscopy (TEM) micrographs

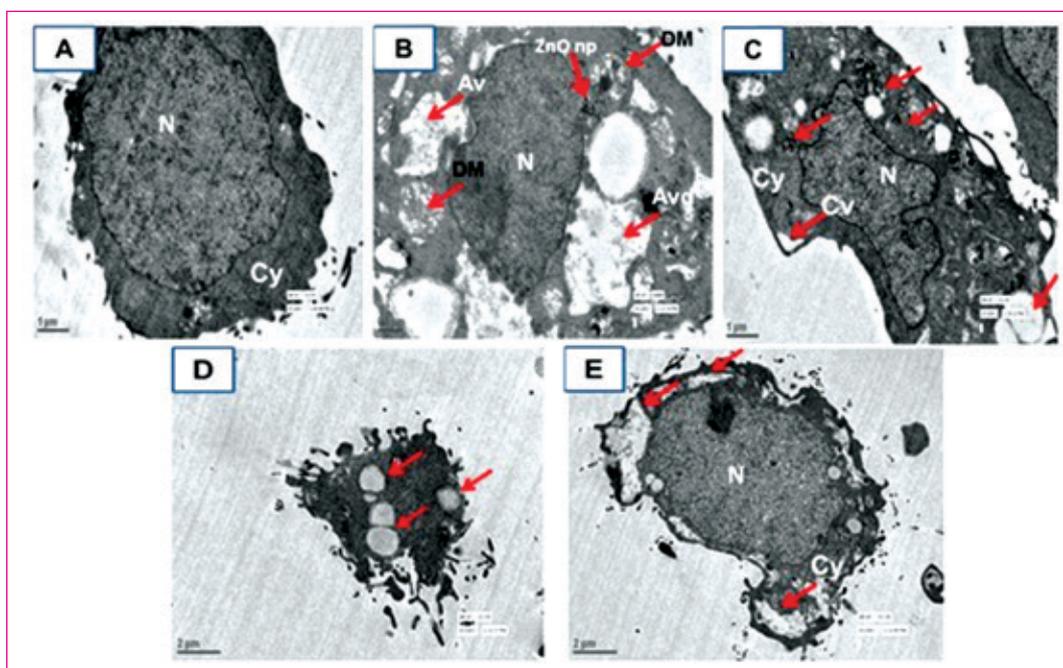


*Characterization of ZnO NPs by SEM and TEM. (A) SEM micrograph showing ZnO NPs are spherical in shape. (B) TEM micrograph of ZnO NPs illustrate that size of the NPS is ranging between 20-40nm*

illustrated that Zn NPs were taken up by Leydig cells and resulted in formation of autophagosomes, autolysosomes and autophagic vacuoles. Concomitant real time PCR data indicated that Zn NPs significantly increased the expression of steroidogenesis related genes (StAR and P450scc) and decreased the antioxidant enzyme gene (SOD) expression. Our findings confirm the Zn NPs were actively interacting with TM3 Leydig cells and ZnO NPs exposure induced the accumulation of autophagosomes, autolysosomes and damaged the mitochondria in cells and having steroidogenic effect at lower concentrations and incubation periods.



*Characterization of NPs induced death in TM3 cells. (A) TM3 cells stained with FITC (B) TM3 cells stained with DAPI & (C) Merge; (1) control, (2) 5 µg ZnO & (3) 20 µg ZnO.*



*Thin section transmission electron micrograph of TM3 cell incubated with 50 µg/ml ZnO NPs for 4h. Figure (A) control TM3 cells, (B), (C), (D) and (E) ZnO NPs treated cells showing autophagic vacuoles (AV), damage mitochondria (DM) indicated with red arrows. Cellular uptake of ZnO NPs induces accumulation of autophagosomes and autolysosomes. Abbreviations: AV-autophagic vacuoles, N-nucleus, Cy-cytoplasm, DM-damaged mitochondria*



# DAIRY DEVELOPMENT: POLICY ANALYSIS, STRENGTHENING DATABASE AND IMPACT ASSESSMENT

## Impact of Dairy based Livelihood Programme in Rajasthan funded under *Mahila Kisan Shashaktikaran Pariyojana (MKSP)*

ICAR-NDRI, Karnal signed a MoU with Centre for micro Finance (CmF), Jaipur to evaluate the impact of the project with a sample size of 452 comprising 39 *pashu sakhi*, 363 beneficiaries and 50 non-beneficiaries in five districts of Rajasthan. After joining MKSP, *pashu sakhi* enhanced their access to technology, information, credit, market and government schemes apart from recognition as farmers and performing additional community role. Majority of *pashu Sakhis* readily adopted deworming, vaccination and milk products preparation as compared to moderate adoption with respect to improved animal shed, artificial insemination, use of mineral mixture, balanced ration and maintenance of production records. The number of animals possessed by 362 beneficiaries of *pashu sakhies* in the study area increased from 294 to 349 after MKSP and visualised the milk production increase by one to two litres per day; reduce the calving interval by three to four months and age at first calving by three months which have ensured significant economic gain for them. The *pashu sakhi* and their clients should be linked with ATMA groups for utilizing the schemes and promoting synergy to enhance the access to formal extension sources of information.

## Perception and Familiarity of Researchers on Animal Cloning

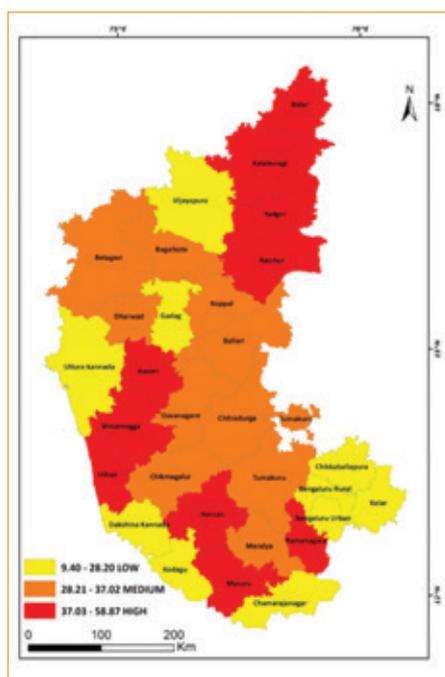
The study was undertaken to understand the familiarity of researchers towards animal biotechnological tools and techniques (Scientists and Students) from production, processing and management disciplines of animal husbandry and dairying. In case of familiarity of scholars about animal biotechnological tools: It was reported that 54.44 per cent of scientific faculty and (43%) of students had moderate familiarity about cloning followed by use of stem cells (53%) scientific faculty and (37%), gene therapy (50%) scientific faculty and (45%), Nano technology (43%) of scientific faculty and (38%) students and (50%) respondents had moderate familiarity about Genetic engineering as a biotechnological tool. It was also found that majority of respondents perceived that they will trust animal cloning if it is approved by GOI, meanwhile researchers also perceived that even cloning is beneficial but it is fundamentally unnatural. Likelihood for cloned animal and its products were also assessed and the ordered logistic regression model is estimated using maximum likelihood method. The  $\chi^2$  result shows that the parameters were significantly different from zero at  $P < 0.01$  for the likelihood of purchasing of cloned animal products. The McFadden's R-square or Pseudo  $R^2$  was 0.987, indicating that 98.7 per cent of the variations in probabilities of getting in high level of likelihood of purchasing of cloned animal products was explained by the selected explanatory variables. Explanatory variables that are selected for econometric model and statistically significant are self-explanatory in nature. As and when if government formulate policy regarding purchasing of cloned animal products, the significant variables should be given importance meat from cloned animals, lesser price, such as products should indicate the ingredients, environmentally friendly, higher nutrient value, free from chemicals and safe to eat.

## Livelihood Vulnerability of Livestock Dependents in Drought Prone Districts of Bihar

Livelihood vulnerability of livestock dependents in drought prone districts of Bihar was assessed keeping in view of the large areas in Bihar suffered from moderate to severe droughts during four out of five years from 2009 to 2013. Perceived Impact to Drought Index (PIDI), Composite Livelihood Vulnerability to Drought Index (CLVDI) and Drought Adaptation Index (DAI) was developed exclusively for this study. The study revealed that perceived economic, social and environmental impact of drought has increased significantly with the increase in degree in drought proneness. Study also established that livelihood vulnerability was increased significantly with the increase of degree of drought proneness. Exposure i.e. reconnaissance drought index (RDI) was increased significantly with the increase in degree of drought proneness. It was also found that livestock dependents adopted seven coping mechanisms and adoption of coping mechanisms was increased significantly with the increase in degree of drought proneness.

## A Geo-Spatial Database for Strategic Planning and Development of Dairy Sector in Karnataka State

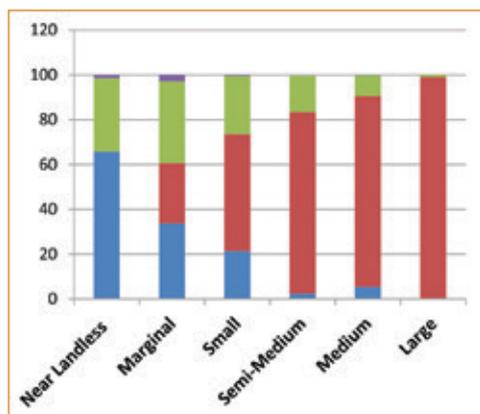
The database include data on milk production and productivity, cattle and buffalo population, veterinary infrastructure and breeding, cost of milk production, consumption of milk and milk products, price statistics, dairy processing and quality, dairy entrepreneurship, dairy policies and programmes, land use pattern., GIS maps etc. Some of the major applications of the database included a) forecasting milk production trends in Karnataka State b) forecasting procurement and retail prices c) hedonic price model of *ghee*. Using the database it was found out that despite diminishing resources the increasing milk production trends in the state was due to improvement in herd efficiency ratio (defined as in-milk population to total population of a given breed) and productivity. State level aggregation of forecasted milk production was done and model forecasts were validated.



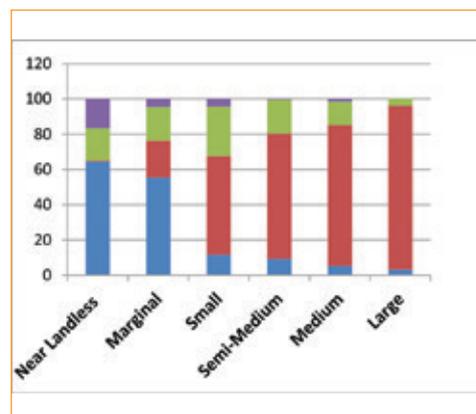
## Level and Trends in Sources of Income of Rural Farm Households in Haryana

Data on current status of rural farm household incomes across regions, landholding classes, and social groups in Haryana was extracted from the NSSO survey on the Situation Assessment of Farm Households. There are high regional disparities in annual income of agricultural households. The State average stood at ₹ 1.73 lakh per annum, while it was ₹ 2.52 lakh in Western Haryana (WH) and ₹ 1.18 lakh in Eastern Haryana (EH). Income from cultivation is a more dominant source of income in WH (84%) than in EH (60%). There were stark differences in the levels of income from cultivation in EH (₹ 43000) and WH (₹ 168000). The marginal and near landless farmers constitute 56% of total HH, but their income levels are 48-89% lower than the state average. Deviations from regional averages across landholding categories are higher in WH than EH. This is suggestive of high income inequalities across landholding categories. The income distribution in WH across landholding classes is very highly skewed.

Eastern Haryana



Western Haryana



Income composition of households across landholding categories

It is only the large farmers who are garnering the bulk of the share of income that comes from cultivation. Stark difference was found in the per hectare incomes of marginal (₹ 43,000) and large (₹ 1,00,000) farmers suggesting that either the technologies are not scale-neutral or large farmers have better access to infrastructure, services, and technology. The real growth in incomes has been much higher in WH (10.27%) as compared to EH (1.36%). At the prevailing rate of growth of real income, it will take 13 years in EH and 10 years in WH to double the income of marginal farmers. Considering no change in the inflation rate, to double farmers' income in a period of 7 years (2015-2022), the warranted real growth rate in income is 10.41%.

### Commercialization of Green Fodder Production in Haryana

With the commercialization of dairy farming, demand for green fodder is increasing and farmers are taking up fodder production as a commercial business, which have created a need for effective and efficient marketing system. The study estimated overall total cost of cultivation (cost C) for major green fodder crops- sorghum, maize, bajra, and berseem as ₹ 49,603/ha; ₹ 54,983/ha, ₹ 55,672/ha and ₹ 56,832/ha, respectively. The overall gross returns for sorghum, maize, bajra, and berseem was found to be ₹ 1,06,285/ha; ₹ 1,24,207/ha, ₹ 1,38,320/ha, and ₹ 1,82,139/ha, respectively. The most common problem faced by the farmers and traders was lack of proper market place followed by loss of green fodder by stray animals. Some farmers were also facing problems related to price of output and transportation because of distant location of fodder markets. A few traders were worried about high market fees charged by the government.

### Optimum Farm Plans for Rural Households in Maharashtra

Optimization results of the study indicate that, multiple goals of farm households can be achieved primarily in two ways- a) shifting of cropping pattern from high risk cotton and less remunerative soybean crops to the pulses tur and gram and b) by changing composition of herd to include high productive cows. It was confirmed that through the implementation of suggested optimal farm plans landless farmers in Marathwada and Vidarbha could increase their net income by 41% and 74%, respectively, which was at par of their aspiration level. Marginal and small farmers in Marathwada could double their net returns by acquiring suggested farm plan as it shows 102% additional returns to that of actual. For Vidarbha, this percentage was 52%. medium category farmers could enhance their income by 78% and 57% in both the respective regions which were above their target levels.

### Role of Cooperatives in Enhancing Farmers' Income

Gujarat has been a pioneer state in dairy cooperatives where dairy industry is more organized and efficient in comparison to others. A comparative analysis of technical efficiency of cooperative member and non-member dairy farms in Gujarat indicated that member farmers (83.27%) were more efficient than the non-member (75.31%) farmers which mean scope lies for further production with the existing resources. The small farmers (81.59%) were found to be most efficient across all herd size. The results also showed that on an average the member farmers can increase their output by around 4 liters per day in addition to their actual output, while non-members can increase the same by around 5 liters. In the case of cooperative non-member farmers, the estimated efficiency score had a negative relation with the herd size. As the size of herd increases, the technical efficiency was found to be decreasing. The overused resources were found to be green fodder and dry fodder among all the inputs taken into consideration. The technical efficiency of farmers can be significantly improved by providing more access to information, increased non-farm income and promotion of dairy cooperatives. The non-members in the study region preferred to sell their milk output to the private sector or directly to the end-users because of remunerative price.

### Economics of Dairy-based Farming Systems in Mizoram

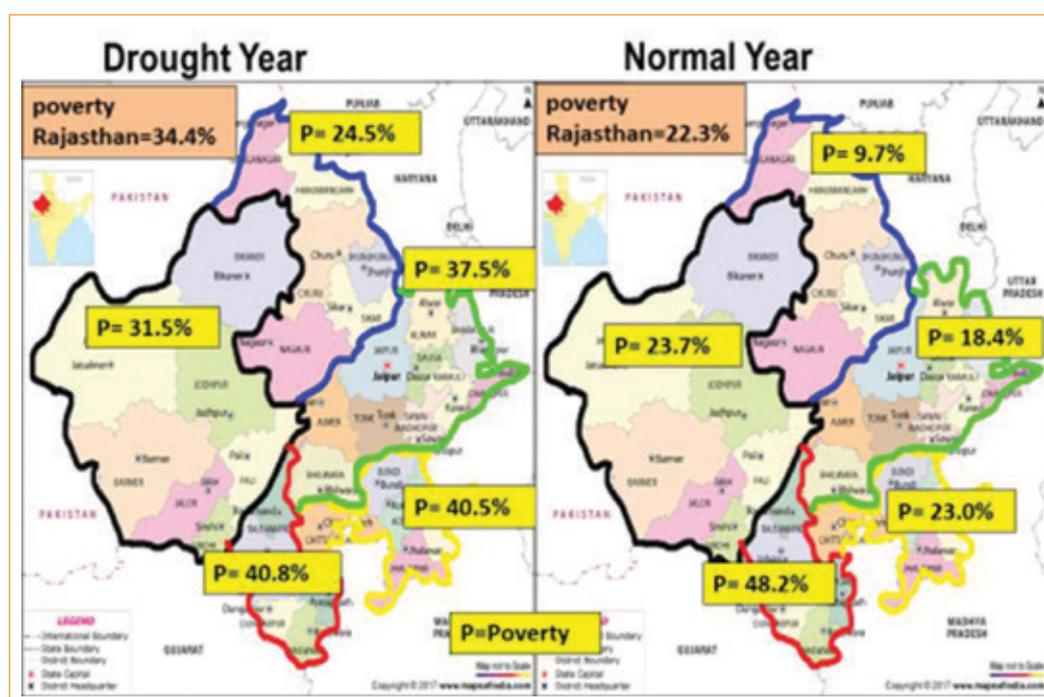
Livestock production is an integral and inseparable part in agricultural production systems of Mizoram. A study was conducted in the state to examine linkages of various components in each of the dairy based farming systems. The study identified ten dairy based farming systems based on the major contribution to income of farm enterprise. The inter-component linkages from livestock to crop were stronger as compared to crop to livestock for all the farming systems. Farm capital, manures, fertilizers and labour were the dominant factors in determining the profit. The mean level of profit efficiency for farm, which has both cattle and crop enterprises, was estimated to be 62 percent, which was higher than the mean profit efficiency of farm without crop enterprise, i.e., 55 percent. The analysis on optimal plan suggested keeping more number of cattle, decreasing the number of pigs except in two farming systems and increase in crop area for almost all the farming systems. The optimum plan also suggested decrease in number of poultry birds and decrease in fish pond size for almost all the farming systems where these two systems are present which may be due to their lower productivity. Cattle remained to be the most important enterprise in the optimum farm plans.

## Comparative Analysis of Vulnerability to Poverty of Dairy and Non-dairy Households

The study of dairy and non-dairy rural households of Maharashtra found that vulnerability percentage was higher for non-dairy households as compared to dairy households. In 1993-94, about 56% non-dairy farming households were found vulnerable to poverty as against 44% dairy households. In 2003-04, this percentage was 41% for non-dairy households and 34% for dairy households in Maharashtra. Similarly, households in dairy developed districts were less vulnerable than in dairy under-developed districts. Thus, promotion of dairy as an enterprise can become a crucial way out to enhance resilience of rural households. Major risk reduction strategies adopted by rural households in agriculturally distressed regions of Marthawada and Vidharbha were production of less risky crops, adoption of new technology, permanent migration and personal insurance. The access and utilization of risk management instruments were found somewhat discriminatory especially for the households belonging to lower socio-economic status.

## Impact of Drought on Vulnerability of Rural Households

In drought prone state of Rajasthan, Dungarpur, Banswara, Udaipur and Dholpur were identified as the most vulnerable districts while Ganganagar and Hanumangarh were identified as least vulnerable districts. In the most vulnerable districts it was seen that irrespective of the trend, the variability in mean Kharif rainfall was high especially after 1990s. The regional dimension of poverty in Rajasthan shows in all the regions except for the southern flood prone region, the incidence of poverty was much higher in the drought year than in the normal year. Interestingly, the difference in incidence is much sharper in regions that are agriculturally better endowed and have irrigation facilities. The estimates of vulnerability to poverty show that there are 4.7-6.9% households that are currently non-poor but are vulnerable to poverty. Out of the 22.3-34.4% households that are below poverty line, a sizeable proportion are infrequently poor (that is their vulnerability is less) and hence skill development can be an important measure to pull them out of poverty.



*Regional dimensions of poverty in Rajasthan*

## Vulnerability Assessment of Agricultural Production System to Climate Change in Trans- and Upper Gangetic Plains

Results of the study showed that vulnerability of the agriculture production system increase as one moved from western to eastern parts of the Trans and Upper Gangetic Plains. Around 28 per cent of the districts were extremely or high vulnerable, 27 per cent were moderately vulnerable. Most of districts in eastern region (Etawah, Auriya, Mainpuri, Fatehpur, Kannauj etc.) of the study area were extremely vulnerable owing to high to extreme exposure and sensitivity and very low adaptive capacity. The north-western part of the study area (Gurudaspur, Hoshiarpur, Ludhiana etc.) was very less vulnerable mainly due to very low sensitivity and very high adaptive capacity.

### Economic Losses from Climate Change

Study carried out in the Gangetic plains found that there was an upward trend in average temperature in the both season Kharif and Rabi across the study region. The temperature rose faster across the study area in the Rabi indicating that winters are becoming warmer. However, the average rainfall shows a mixed trend across seasons and the plains. The effect of increase in both, Kharif and Rabi temperature on gross margin per hectare was negative, but more pronounced in Kharif season (-10.48 % and -6.55%, respectively). Unlike temperature, effect of precipitation in either of the season was positive ( $> +0.02\%$ ) but much smaller than the effect of temperature. Loss in annual gross margin per hectare in Trans and Upper Gangetic plains will be -15.11 % for the time slice 2010-39, the losses would escalate in 2030s (-18.17%) over 2020s (-16.7%). The magnitude of losses will be higher in northern part of the region (like districts of Hoshiarpur, Ambala, Saharanpur etc.) in Kharif yet few districts in this region are likely to gain marginally due to change in climatic variables in Rabi season. Further, annual loss in milk production in the region is projected to be around 361 and 377 thousand tons for the time slice 2010-39 under BAU and alternate scenario respectively. At current prices, the annual losses in monetary terms amount to ₹ 11.93 billion and ₹ 12.44 billion in BAU and alternate scenario respectively during the same time slice.



*UGC Expert Committee at Climate Resilient Livestock Research Centre, NDRI, Karnal*

# EXTENSION APPROACHES FOR SOCIO-ECONOMIC UPLIFTMENT THROUGH DAIRYING

## Assessment of Educational Gaps in Dairy Husbandry in Northern India

The educational gaps as perceived by vital stakeholders of dairy husbandry were identified to suggest the plausible change in current educational system. Data was collected from a total 305 stakeholders including farmers, faculty, students and veterinary officers in Karnal, Palampur and Patna districts through direct interview method. As per opinion of students, more number of practical classes and regular visit to dairy plants is the top priority with respect to syllabus coverage in the undergraduate courses. Other priorities included nutrition and feed management, with perception that more time is wastage in the examination process. Students were satisfied with the time devoted by teachers to them. As per perception of teachers is concerned, more practical exposure and field visit was given top priority. Other priorities were need for periodic rectification of the syllabus, more focus on entrepreneurship development, with need of periodic rectification of syllabus of undergraduate and post graduate courses. As per opinion of veterinary officers, the major gap in current dairy education system is less practical exposure to students. They suggested that more field visits should be conducted during graduation so as to make students more competent in service life. As per opinion of farmers, most unsatisfactory area of veterinary service is incomplete treatment of animals followed by poor service of AI. It has been suggested that major areas of focus in dairy education should be entrepreneurship development, reproductive health management and dairy production and marketing.

## Ration Balancing Programme under National Dairy Programme-1

Ration balancing programme is implemented in 100 villages of Muzaffarnagar district of Uttar Pradesh under NDP-1. Under this project, 100 LRPs were trained about the ration balancing software. During this period 3730 new farmers were covered including 260 women farmers, and 388 SC/ST farmers. A total 4489 numbers of the animals were covered including 1316 descript local cows, 923 crossbreed cows and 2206 buffaloes. Fifty-five farmers meetings were conducted during this period. Quantity of mineral mixture supplied in RBP villages was about 60 quintal. Monthly stipend given to LRPs was ₹ 2020 and average monthly income per LRP was ₹ 3200/. Change in milk production and milk fat per animal was 600 gm and 0.7, respectively. Reduction in cost of feeding per kg of milk was 9.5%. Change in cost of feeding per day per animal was 9.98%. Increase in net income of a farmer per animal per day was ₹ 22.

## Development of Climate Resilient Model for Gender Mainstreaming in Crop and Dairy Enterprises

The study analysed gender roles, gender-differentiated climate risks and micro-evaluation of interventions under TDC-NICRA, Haryana for developing climate resilient model for gender mainstreaming. Roles were changing as 'addition' for seeking more information on adaptation options (66.67%), 'substitution' of male's role by female role performance (26.67%) and 'claiming more time'. Composite 'Climate induced vulnerability index' revealed 41.11% households as medium and 21.11%, highly vulnerable. Identified vulnerability issues were gender prioritized. Farmers gave highest scores to Zero Till Drill, Mineral mixture supplementation, berseem varieties HB1 & HB2 and salt tolerant wheat variety. Generic TOT model for gender mainstreaming and its application was developed.

## Technological Change in Dairy Farming and its Effect on Rural Employment in Trans-Gangetic plains

The study was conducted in Trans-Gangetic plains. Majority of area of the Trans-Gangetic plains has fallen in two states i.e. Punjab and Haryana. Afterwards, two districts from Punjab and two districts from Haryana were selected, purposively. There was significant technological change in adoption of scientific dairy farming technologies and it was increased over the period of 10 years from 62.71% (in 2005-06) to 70.73% (in 2015-16) in the Trans-Gangetic plains. Further all the productive and reproductive parameters of dairy animals were improved by adoption of

scientific dairy farming practices. Moreover, there was substantial increase in rural employment through dairying. In nutshell, in 2005-06 the total number of peoples was 1109 who were engaged to different activities for their livelihood and in 2015-16 it reached to 1658. This change reflects proper management of the dairy animals due to the effective mechanism of extension service and technological development by agricultural research system in the Trans-Gangetic plains.

### Smallholder Dairy Production Systems in Karnataka

The present study was conducted in four districts of Karnataka and data were collected from 240 respondents. The existing farming systems in the study area were Crop+Dairy, Crop+Dairy+Horticulture, Crop+Dairy+Poultry, Crop+Dairy+Goat, Crop+Dairy+Sheep and Crop+Dairy+Horticulture+Poultry. The Crop+Dairy (43.33%) and Crop+Dairy+Horticulture (24.16%) were most dominated farming systems in the study area. The major adopted milk marketing channel was Milk Producer → Dairy Co-operatives → Milk Union → Consumers in Tumkur, Kolar, Shivamogga and Kalaburagi Districts respectively. The prospects of smallholder dairy production systems were analyzed by integrating strength, weakness, opportunity and threat by analytical hierarchy methodologies.

### Farm Diversification and Its Effects on Livelihood Security of Farmers in Punjab

A study was conducted on farm diversification and its effects on livelihood security of farmers in Punjab. It was observed that, Higher education (93.00%) and assured income (92.00%) from different farm enterprises were the major pull factors. Whilst, seasonality of agricultural activity (93.00%) and non-availability of labour (89.00%) were important push factors of farm diversification in the study area of Punjab. Farm diversification index values reveals that marginal (0.65) and small (0.64) farmers were more diversified as compared to medium (0.38) and large (0.28) farmers. It was noticed that about 38 percent farmers were following Rice- Wheat + Dairy system in Punjab. Whereas, Rice- Wheat + Dairy + Poultry (Backyard) enterprise combination generating more employment. The average livelihood security through farm diversification among landless, marginal and small farmers was observed to be 0.70, 0.71 and 0.72, respectively. Rice-Wheat+ Dairy + backyard poultry generated more employment hence focus should be given to promote it. The Livelihood security of farmers indicates the medium level (0.75) in Punjab. Policy makers should plan farm diversification promotion activities to meet the substantial livelihood of the farming community in Punjab in particular and India in general.

### Antibiotic Usage in Dairy Animals in Eastern Haryana Region

The study was carried out to assess the awareness level of stakeholders regarding the antibiotic resistance and trace the antibiotic usage pattern among the dairy animals in eastern region of Haryana. Awareness regarding the antibiotic resistance was found higher among large farmers, but required more efforts to create awareness to ensure the sustainable usage and antibiotic conservation practices. The consultancy to veterinarians was preferred most by large farmers as compared to other field level veterinary professionals. The post-treatment follow-up was mostly practiced by large farmers thus paving the way for valid veterinary-client relationship responsible for behavioural change regarding antibiotics usage. The major constraints aggravating the antibiotic resistance were identified as insufficient awareness among the farmers, lack of stewardship and antibiotic conservation practices by veterinarians and absence of surveillance and legislations regarding antibiotics prescription.

### Usage of Antimicrobials in Milk Production in Punjab: A Multidimensional Study

Study was carried in Punjab purposively and it was found for sick animals 52% dairy farmers consulted veterinarians, 19% consulted the paravet. Whereas veterinary doctor was considered the most credible source by dairy farmer as far as treatment was concerned. Providing quick relief to sick animals (97.50%) and prior experience (96.66%) was the major factor in prescribing antimicrobial by veterinary doctor. Prior Experience (98.33%) was the most influential factor followed by price (95.83%) influencing the prescribing behaviour of Paravets. It was observed that subjective norms were significant and positively correlated with intention towards usage of antimicrobials for dairy farmer and paravet. Attitude was significantly and positively correlated with intention for veterinary doctor towards usage of antimicrobials.

### Livelihood Security through Dairying among *Bhil* Tribe of Madhya Pradesh: An Exploratory Study

Livestock-rearing is an integral part of livelihood of tribal households. Further, dairying plays a significant role in nourishing the rural livelihoods. Apart from the dairy animals like cattle and buffaloes, others, including sheep, goat, pig and poultry also play a significant role towards livelihood security of the tribes. The present study was undertaken to assess the extent of livelihood security through dairying among the *Bhil* Tribe of M.P. The study found that around half of the respondents had low level of livelihood security. Major constraints perceived by the

respondents were: distant location of veterinary hospitals; lack of credit facilities for purchase of feeds, fodders and mineral mixture; and non-availability of veterinary doctors and staff.

### Urban & Peri-Urban Dairies among Marginalized Dairy Holders & Its Effect on Society

Environmental and situational aspects of the urban dairy holders and their role in the production and disposal pattern of milk to the urban residents were studied and it was found that majority (67.50%) of the respondents followed water disposal mechanism by discharging to municipality sewage line, while 16.67% discharged by making pits, 13.33% were discharged in and around the sheds, and remaining( 2.50%) used for cultivation of crops. Mobile App on “environment friendly dairy farming practices” and “physiological technologies for improving productivity” were developed in Hindi and English to educate dairy holders to maintain the biodiversity etc. Various scientific modules are being implemented through capacity development programme. Major issues in urban and peri urban dairy farming perceived by respondents were ‘limited space for waste disposal’, ‘no grazing land, inadequate space for shelter of animals’ and ‘increasing incident of disease in animals’.

### Clean Milk Production Practices in National Capital Region

A study was conducted in NCR region of national and study revealed that majority of dairy holders have no social participation (69.17%), low income (54.17%) and were landless (44.00%). Majority of dairy holders (86.00%) didn't receive any training in dairy farming. Only 54.17% were providing green fodder to their animals. About 30.00% of respondents were discharging animal waste to drain line. Among existing clean milk production practices; Provision of clean water to animals, Cleaning of udder with water before milking, avoiding use of oxytocin before milking were found to be highly adopted by dairy holders which were having weighted mean score (percentage) of 74.58, 91.67, 86.67; respectively. Average milk consumption was found 2.58 liter per day per household. Higher favorable perception was found among consumers towards hygiene of milker and milk quality (natural flavor, high fat and SNF) whereas, lower favourable perception was found regarding isolation of diseased animal and use of oil/lubricants over teats. It was found that modules were effective at 1% level of significance having mean score of 6.39 and 6.97 in pre and post-test; respectively.

### Technological Needs and Manpower Requirement of Dairy Production and Processing Units in Karnataka

The technology needs of dairy production units identified included but not limited to good quality cost-effective feed, small scale dairy machinery/equipments for small production and processing units, farm level all-in-one testing kits for testing fat & SNF, antibiotics, mastitis and adulterants and cost effective mini-chilling units at production level for extended shelf-life of milk. The technology needs of dairy processing units included skilled manpower for operation level management, customized dairy processing equipments for small-scale dairy units, technical know-how of dairy products and database for establishment of dairy units and cold-chain management facilities for quality milk production. The constraints in dairy production units as expressed by the respondents included, high cost of critical inputs cattle feed (86.00%), severe water scarcity (82.00%), low milk procurement price (80.00%), limited veterinary services (68.00%), recurring FMD and mastitis problem 65.00% and repeat breeding (54.00%).

### Socio-Economic Assessment of Indigenous Dairy Cattle Holders in Southern India

Socio-economic assessment of Indigenous dairy cattle holders were carried out in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu covering 13 recognized indigenous breeds of cattle. It was found that, majority of the farmers reared indigenous cattle under low external input system with grazing primarily for their family use and crossbreds and buffaloes for economical returns. These indigenous cattle were maintained not only for milk, but also for dung, urine, sport-game and herding (for instance Umblachery and Pulikulam) purpose which supports the livelihood of farmers to the greater extent and forms an important integral component of organic farming in the study area. The farmers opined that a monthly cash surplus of at least ₹ 1500-4500 is secured from rearing indigenous cattle without incurring much expenditure for its management. Regular supply of breed specific semen, improving productivity, facilitation of farmers participatory breed conservation programme, scientific evidence on benefits of indigenous cattle milk, urine, dung; exclusive market - procurement price; promotion of community grazing lands and access to forest land grazing and promotion of indigenous cattle through Govt. Schemes are th ended of the hour in promoting indigenous dairy cattle farming.

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

Under the Farmer FIRST Programme of ICAR, dairy cattle health & infertility camp, exposure training for women self-help groups on clean milk production and demonstration of machine milking, awareness campaign on

balanced feeding in dairy animals and green fodder demonstration and distribution of fodder seeds were taken up besides providing critical inputs for the benefit of the target beneficiaries. Improved varieties of green fodder seeds of fodder Maize, Jowar and Cowpea were distributed among the selected 110 farm beneficiaries of the project villages. The farm families were oriented on importance of balanced feeding and cattle health and the dairy animals were provided with mineral mixture supplementation (100 no.), Urea Mineral-lick blocks (100 no.) and treated for infertility, nutritional problems, mastitis, de-worming and first-aid.



*Indigenous cattle breeds of Southern India*

### Documentation of Traditional Knowledge of Livestock Keepers of Karnataka

The traditional knowledge of livestock keepers in relation to livestock production, health and processing of livestock products were documented in 10 agro-climatic zones of Karnataka. Indigestion, urinary problems, wounds, reproductive problems, fractures, mastitis are commonly treated by livestock keepers using traditional methods and herbal remedies. A total of 372 medicinal plants belonging to 189 families were reported to have use in treating various ailments in cattle and other livestock. These plants were identified and their usages in traditional treatment of ailing animals were documented from different regions of Karnataka. Upon validation, these plants may have potential value in developing novel therapeutic agents.

### Livelihood Security vis-a-vis Resilience to Adverse Weather Events among Tribal and Non Tribal Livestock Farmers

An exclusively 'Resilience scale' was developed with 14 statements and five dimensions of the developed scale were identified by using Principal Component Analysis. These identified dimensions were renamed as: Adverse weather preparedness dimension, Peer Support and recognition dimension, Pessimistic attitudinal dimension, Optimistic attitudinal dimension and Priority setting dimension. Finally, this scale was applied amongst the tribal and non-tribal farmers and it was found the significant differentiations amongst them in term of their resilience capacity. A livelihood index was also developed in the present study and applied amongst the tribal and non-tribal farmers and significant differentiation in the livelihood status was found between the tribal and non-tribal farmers.

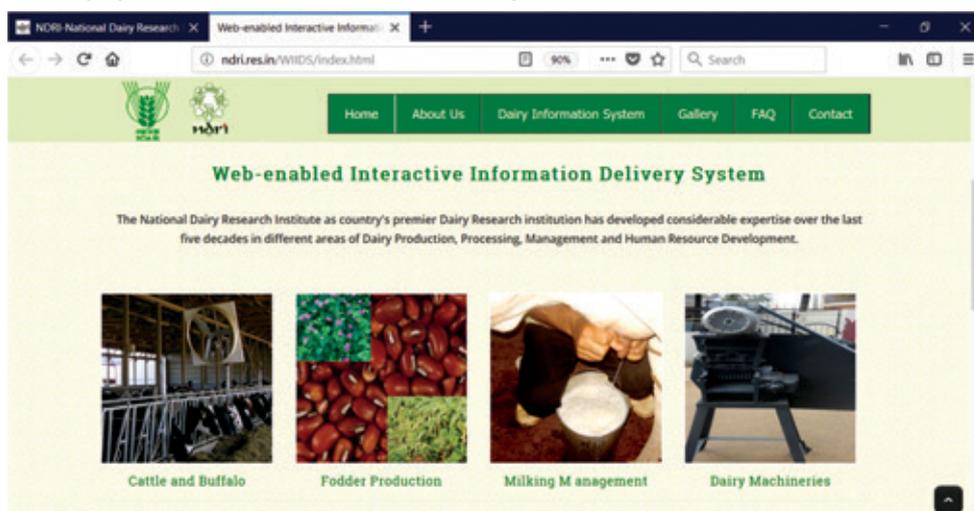
### Technology Dissemination of Supplementation of Prilled Fat

The experiment on supplementation of prilled fat @ 100 g per day in rural buffaloes revealed significant rise in milk production, improved persistency of lactation and early onset of estrous cycle. The responses of higher milk production were more pronounced in rural as compared to urban buffaloes. The dry matter intake, lipid profile and milk composition remained unchanged while the udder health and milk fat improved. The prilled fat supplementation proved to be economical for the dairy farmers as it generated an additional income.

# ICT TOOLS AND SOFT COMPUTING APPLICATIONS IN DAIRYING

## Participatory Development of Need-Based 'Web-enabled Interactive Information Delivery System' for Dairy Stakeholders

Web-enabled Interactive Information Delivery System was developed in a participatory mode, while having discussions vis-à-vis Identification/ Assessment of 'Needs' of varying nature across different categories of 'stakeholders' involved in dairying, including Dairy Farmers, were held during the occasions like Dairy Mela, Farmers- Scientists Meet/ Interaction, Dairy Education at Farmers' Doors, Interface(s), etc. Information as collected from the Dairy-based stakeholders, based on their needs & feedback, were compiled and collated/edited; and, accordingly, the necessary 'Content' was developed, which has been uploaded as Dairy Information System/Web-enabled Interactive Information Delivery System on the website of ICAR- NDRI, Karnal. Now it is expected that this Information Delivery System will serve the interest of dairy stakeholders.



## Application of the Multimedia in Improving Knowledge in Preparation of Traditional Milk Products at the Household Level

Bilingual (Hindi and English) Multimedia on the production procedure of six traditional dairy products were developed: *Paneer*, *Ghee*, *Khoa*, *Gulab Jamun*, *Dahi*, and *Lassi*. Afterwards, validity of the developed multimedia was tested on 12 parameters and found highly valid. The developed multimedia played an important role in increasing knowledge level by 38.73% at the household level. It was also found that farmers adopted improved practices in preparation of traditional dairy products due to exposure of the multimedia.

## Development of ICT based app on Environment Friendly Dairy Farming Practices

The study was conducted on 150 dairy holders in NCR region of National Capital and it was found that among all the elicited environment friendly breeding practices the most followed were 'Consulting Vet /Para Vet before performing A.I. (91.33%)' and 'inclusion of indigenous buffalo breeds in the farm (84.67%)'. The study further revealed that among all the elicited environment friendly feeding practices the most followed were 'providing fresh and cool water to animal during heat stress (84.67%)', reducing dietary fibre intake during summer or heat stressed condition (71.33%). The study showed that among all the elicited environment friendly management practices the most followed were proper drainage facilities in the farm, avoid pooling of milk from sick/ quarantined animals with those of healthy animals. Effectiveness of the application was calculated in terms of knowledge gain and it was found that overall knowledge gain was 6.95% only.



# RESEARCH PRIORITIZATION, MONITORING AND EVALUATION (PME)

Intensification of R&D activities at NDRI Karnal in recent years has necessitated introduction of professional management approach for managing research functions. PME Cell has been created at NDRI to coordinate and manage research activities and facilitate the decision support system with the following terms of reference:

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

## Research Advisory Committee (RAC)

The main functions of the RAC are:

- » To suggest research programmes based on national and global context in the thrust areas.
- » To review the research achievements of the Institute and to see that these are consistent with the mandate of the Institute.

The meeting of the RAC of NDRI, Karnal was held on 22<sup>nd</sup>- 24<sup>th</sup> January, 2018 under the chairmanship of Dr. M. L. Madan, Former DDG (AS), ICAR.

## Institute Research Committee (IRC)

The key functions of Institute Research Committee (IRC) are to critically review the on-going and completed research projects, to consider the new research proposals and to advise on fostering of linkages between the groups/divisions of the Institute in respect of multi-disciplinary/multi-locational projects. The IRC meeting to evaluate the outcome of the completed research projects and to consider new research projects proposals was held during 25<sup>th</sup> to 28<sup>th</sup> April, 2017 at NDRI, Karnal, 22<sup>nd</sup> April, 2017 at Southern Campus, Begaluru and 27<sup>th</sup> June, 2017 at Eastern Campus, Kalyani, respectively. The completed and new research projects were critically discussed in order to address current emerging issues of the dairy sector. The mid-term review of IRC projects of NDRI was taken up during 9<sup>th</sup>, 11<sup>th</sup> - 13<sup>th</sup> October and 23<sup>rd</sup> October, 2017 at NDRI, Karnal, 10<sup>th</sup> November, 2017 at Eastern Campus, Kalyani and 3<sup>rd</sup> January, 2018 at Southern Campus, Bengaluru, respectively.

Institute Research Committee (IRC) meetings were conducted under the Chairmanship of Dr. R. R. B. Singh, Director and convened by Dr. Bimlesh Mann, Joint Director (Res.), NDRI, Karnal.

## Project Information Management System (PIMS)

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

## Evaluation of Proposals for Contract/Consultancy Projects/Training Programmes

PME Cell also screened and evaluated contract research proposals received from time to time. PME cell meetings to consider the following contract projects proposals were held on 5<sup>th</sup> April 2017, 2<sup>nd</sup> June, 2017, 5<sup>th</sup> September 2017, 16<sup>th</sup> September 2017, 24<sup>th</sup> February 2018 and 12<sup>th</sup> March, 2018 and MoUs with the concerned organizations were signed.

- » Evaluation of Chymax-M based Paneer Analogue Preparation and its Shelf-life Study.
- » Evaluation of Orafti GR and Orafti Fix for Partial Fat Replacement in Dahi (Curd) and Lassi for Texture, Mouthfeel and Shelf Stability.
- » Influence of different Sources of Zinc Supplementation on its Bioavailability in Lactating Cattle.
- » Development of Oat Fortified Juices Sponsored by Futuresion Pvt. Ltd.
- » Effect of Supplementation of Graded Levels of Sodium Sesqui-Carbonate on Productive of Lactating Animals.

Besides, PME cell also considered the proposals for organization of International Training Programme on "Dairy Plant Management" for the Kenyan Nationals and another proposal for organization of Training Programme on "Milk and Milk Product Processing for Value Addition".

## Research Projects Database Management

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

## Technical Screening Committee Meetings

Technical Screening Committee constituted under the Chairmanship of Joint Director (Res.) evaluated the "Manuscripts for Publication as Books, Technical Bulletins/Manuals etc." Based on the recommendations of the committee, the manuscripts were also sent to outside experts for evaluation. The same were again evaluated in light of the comments received from experts and the contents of the publications got modified. During the period, four meetings of Technical Screening Committee were held on 13<sup>th</sup> December, 2017, 27<sup>th</sup> January, 2018, 1<sup>st</sup> March, 2018, and 20<sup>th</sup> March, 2018 to screen and evaluate the manuscripts submitted by the scientists.

## Research Documentation and Publication

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

- » Annual Report 2016-2017.
- » NDRI News Letter - a quarterly newsletter in English.
- » 16<sup>th</sup> Convocation Director's Report.
- » Compilation of Research Projects (2017).
- » Institute Research Committee (IRC) Proceedings (2 No) under the identified research programmes of the Institute.
- » Information on research achievements of NDRI for inclusion in ICAR/DARE Annual Report 2017-2018.

## Research Information Management

This Unit also prepared/consolidated/collated the following information for submission to the Council and other research and development organizations:

- » RAC agenda items covering ATRs of last RAC meeting, proceedings of IRC meetings, etc.
- » Proceedings of the RAC Meeting held on 22<sup>nd</sup> -24<sup>th</sup> January, 2018.
- » Additional information with respect to NDRI, Karnal for inclusion in the ICAR/DARE Annual Report (2017-2018).
- » Information on major technologies developed/ transferred/ commercialized by NDRI through (ITMU) Unit of the Institute.

- » Information regarding the research achievements of the Institute for the period of last three years (2014-2017).
- » Information regarding significant events for the period April to June, 2017.
- » Information on skill development trainings imparted to rural youth and farmers during- 2017.
- » Consolidation of information on agricultural research products including varieties/hybrids/breeds/species etc. and technologies developed and commercialized by the Institute.
- » Report on NDRI by highlighting the significant achievements and technologies developed by the Institute.
- » Information on development of research technologies for the farming community and dairy industry.
- » Information on transfer of technology in the area of animal sciences.
- » Monthly Progress Reports consisting significant events.
- » Six Monthly Progress Reports of the research achievements with targets of next six months.

### Follow up for XII Plan EFC Memo Document

PME Cell prepared the information as follow up action related to various activities duly reflected in XII Plan EFC Memo Document of the Institute (2012-2017) as per the directives of the Council:

- » Prepared information on outcomes and evaluation of XII Plan schemes of ICAR approved for the period (2012-17) for onward submission to Animal Science Division of ICAR, Krishi Bhavan, New Delhi.
- » Consolidation of information regarding monitoring the financial implications/research activities of TSP Scheme being carried out during XII Plan at Eastern Regional Station, Kalyani.
- » Consolidation of information with respect to NDRI Karnal and its regional stations on important salient research achievements, current research projects (in- house/ externally foreign aided), recent areas of development in Animal Science Division.
- » Information on skill development programme conducted during XII plan and future proposed programmes.
- » Consolidation of information with respect to research activities carried out at Eastern Regional Station, Kalyani under Tribal Sub Plan (TSP) and North-Eastern Hill (NEH) Region.
- » Consolidation of Quarterly, Six monthly and Annual Progress Report with respect to implementation of Tribal Sub Plan (TSP) and North-Eastern Hill (NEH) in the Animal Science Division of the Council.

### Formulation of XIII Plan EFC Memo Document (2017-20)

- » Formulation of XIII Plan EFC Memo under the theme No. 24: " Dairy Production & Technology" with total outlay of (₹ 16737.23 lakhs as ICAR Share and ₹ 770.18 lakhs as state share) comprising sub schemes- 24(i) : ICAR-NDRI, Karnal, (₹ 9031.76 Lakhs, 24(ii) ICAR-CIRB, Hisar (₹ 2371.69 lakhs) including Network project on Buffalo Improvement (₹ 2371.69 lakhs) and 24 (iii) ICAR-CIRC, Meerut (₹ 941.05 lakhs) including All India Co-ordinated Research Project (AICRP) on Cattle (₹ 2465.48 lakhs for the period (2017-20).
- » Prepared Action Taken Report (ATR) on the recommendations emerged out during the meeting held on 8<sup>th</sup> -9<sup>th</sup> May, 2017 at NASC Complex New Delhi for finalising SFC/EFC document of the Institute for the year (2017-20).
- » Prepared comments of the Institute in terms of Action Taken Report (ATR) on the observations made on the EFC document of the Institute during the EFC/SFC meeting held on 13<sup>th</sup> September, 2017 under the Chairmanship Secretary, DARE and Director General of ICAR at Krishi Bhavan, New Delhi.
- » Prepared counter comments of the Institute on the points/observations made by Animal Science Division & Finance Advisor, Secretary, ICAR, Chairman, ADG (PIM), Director (Works) as well as representatives of appraisal agencies I. Ministry of Finance, NITI Aayog etc.
- » Prepared proceedings of the EFC/SFC meeting in respect of thematic area " Dairy Production and Technology" for the period (2017-2020) of DARE/ ICAR held on 13<sup>th</sup> September, 2017 under the Chairmanship Secretary, DARE and Director General of ICAR at Krishi Bhavan, New Delhi.
- » Prepared information regarding savings in contingencies of the Institute covering cumulative RF of XII Plan, Proposed in EFC/SFC (2017- 20), Approved in EFC for the period (2017-20) and reduction of budget.

- » Prepared information pertaining to NDRI, Karnal on Salient Decisions made in EFC/SFC for three years (2017-20) in respect of on-going schemes held under the Chairmanship of Secretary, DARE & Director General of ICAR on 13<sup>th</sup> September, 2017 at ICAR, New Delhi.
- » Revised information on year wise programmes/ targets for the period (2017-20) approved in the EFC document of the Institute.

## Research Co-ordination

**Action Taken Reports:** This Unit also prepared the following Action Taken Reports on recommendations emerged during various meetings for onward transmission to Animal Science Division of ICAR, New Delhi:

- » Indigenous technology for sex sorted semen production with respect to NDRI made by the Group of Secretaries of Agriculture and Allied Sector.
- » On the recommendations emerged during XXIII meeting of ICAR Regional Committee No. II held at NAARM, Hyderabad during 24<sup>th</sup> – 25<sup>th</sup> June, 2016.
- » On the recommendations emerged pertaining to NDRI during the meeting held on 24<sup>th</sup> March, 2017 at NASC Complex, Pusa, New Delhi while deliberating the issues of urgent national importance.
- » On the recommendations contained in the Thirty Ninth Report of the Standing Committee on Agriculture on the subject "Comprehensive Agriculture Research based on Geographical conditions and impact of climate changes to ensure food security in the country.
- » On the recommendations of the Working Group on Consumer Affairs (Modi) Report on Food Inflation with respect to NDRI, Karnal.
- » On the recommendations pertaining to emerged during ICAR Directors' Conference held on 16<sup>th</sup> July, 2017 at NASC Complex, New Delhi submitted to the office of Joint Director (Admin. & Registrar ) of the Institute.
- » On the recommendations made during XXIV meeting of ICAR Regional Committee- No.V held from 3<sup>rd</sup> -4<sup>th</sup> October, 2016 at ICAR- IARI, New Delhi.
- » On the recommendations made during the regional review meeting and national level meetings pertaining to livestock and fishery sector.
- » On the recommendations emerged during the meeting of ICAR Directors Conference held on 16<sup>th</sup> July, 2017 at NASC Complex, New Delhi.
- » On the recommendations related to NDRI, Karnal emerged during the weekly review meeting of ICAR held under the Chairmanship of Hon'ble AM for inclusion in the list of agenda items to be tabled before Hon'ble AM to review the matters on 7<sup>th</sup> Feb., 2018 at ICAR.
- » Information for midterm review of action taken report on the recommendations made during XXIII meeting of ICAR Regional Committee- No.II held at ICAR- Hyderabad.

## Collation

This Unit also consolidated the following information sought by the Council:

- » Major research achievements with respect to NDRI, Karnal for inclusion in the ICAR/DARE Annual Report (2017-2018).
- » Significant research achievements of last five years pertaining to NDRI for DARE/ICAR, New Delhi.
- » TSP activities carried out at Eastern Campus, Kalyani.
- » Scientific studies conducted on different breeds of cows and state-wise study conducted on effect of global warming on milk production.

- » Information pertaining to NDRI, Karnal for inclusion in the IAUA News Letter Vol. 17 No. 02 for the quarter ending June 2017.
- » Impact assessment on the points emerged during the meeting held with Hon'ble MoS for Agriculture & Farmers Welfare Government of India.
- » Programmes related to action supports the implementation of new version and strategic plan for ASEAN- Co-Operation in food, Agriculture and forestry (2016-2025) .
- » Information for committee on welfare of OBC (2016-17) constituted for Examination of the subject measures under taken to secure representation of OBCs, in employment and for their welfare in PSUs, other organizations and Institutes under Ministry of Agriculture and Farmers Welfare in response to the memorandum No. 13/1/1/OBC/2016-19 dated 23.10.2017 issued by the Director, Lok Sabha Secretariat Parliament House New Delhi.
- » Information pertaining to NDRI, Karnal for Inputs- Minutes of the meeting held under the Chairmanship of Agriculture and Farmers Welfare Minister with Senior Officers of the Agriculture Ministry on 25<sup>th</sup> October, 2017 at ICAR, New Delhi.
- » Achievements of the Institute regarding number of patents applied/ granted/number of agri-entrepreneurs incubated new and graduated / skills imparted to farmers/number of young farmers trained through training programmes, dissemination of superior male germplasm/technologies transferred to the dairy stake holders and farming community.
- » Additional information on the slides sent earlier to DDG (AS) regarding the major achievements of NDRI during 2017.
- » Technologies transferred during last three years by NDRI.
- » One page write-up on mobile App developed by NDRI.
- » Information on list of points in connection with the examination of demands for grants (2018-19) of the Ministry of Agriculture and Farmers Welfare (DARE).
- » Quarter-wise targets for 2017-18 against the output/ deliverables mentioned for Animal Science Division of ICAR.
- » Report on the visit of Sh. Suresh Chandel, Member, GB, ICAR at NDRI, Karnal.
- » Report on the visit of Sh. Ratneshwari Prasad Singh Member, GB, ICAR at NDRI, Karnal.

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

**Parliament Questions:** A total number of 46 parliament questions (Lok Sabha & Rajya Sabha) were attended during 2017-18.

### Parliamentary Standing Committee (PSC) on Agriculture

Prepared a document on the (ICAR- NDRI- A Performance Review) in English and Hindi for onward submission to Parliamentary Standing Committee on Agriculture. The counter comments of the Director of the Institute were also prepared on the Actionable points raised on the performance review of NDRI during the meeting of Parliamentary Standing Committee (PSC) on Agriculture held at Parliament House, New Delhi on 27<sup>th</sup> November, 2017 and the same was submitted to DARE for further onward submission to office of Parliamentary Standing Committee on Agriculture.

### Promotion of National and International Linkages

The unit also acted as a catalyst to promote and strengthen linkages with other Institutions of National and International repute. Visits of International delegations and distinguished visitors at the national level were coordinated and through scientific interactions/deliberations, agenda for mutual collaboration was chalked out with a view to arrive at MoUs for promotion of research and educational endeavours. During the period, 22 visits were coordinated by section.

## Research Projects-2017-18 (In-house)

SL. No.	Project Title	PI
1.	Generation of induced pluripotent stem (iPS)-like cells from buffalo fibroblasts (Lead Division: Animal Biotechnology Centre).	M. K. Singh
2.	Genomic selection for improvement of reproduction and roduction performance in dairy animals (Lead Division: Animal Genetics & Breeding).	A. K. Chakravarty
3.	Mass spectrometry based targeted quantitation and validation of urine-based early pregnancy biomarkers in cattle (Lead Division: Animal Biotechnology Centre).	A. K. Mohanty
4.	Identification and targeted validation of unique proteins expressed during subclinical mastitis in Sahiwal and Karan Fries cattle (Lead Division: Animal Biotechnology Centre).	Sudarshan Kumar
5.	Exploring the use of mesenchymal stem cells for treatment of hoof wound of bovine (Lead Division: Animal Biotechnology Centre).	D. Malakar
6.	Genetic evaluation of reproductive and productive efficiency of crossbred cattle in relation to heat stress under tropical climate (Lead Station: ERS-Kalyani).	Rajalaxmi Behera
7.	Genetic diversity and evaluation of Gir and Tharparkar cattle (Lead Division: Animal Genetics & Breeding).	A. K. Chakravarty
8.	Mastitis related bacterial antibiotic resistance pattern mapping in Karnal district (Lead Division: Animal Biotechnology).	S. De
9.	Characterization of beta-defensin genes and their relation with bull fertility (Lead Division: Animal Biotechnology).	Rakesh Kumar
10.	Selection of Deoni cattle using QTN data mining for faster genetic improvement (Lead Station: SRS, Bengaluru).	D. N. Das
11.	Influence of different growth promoting factors and macromolecules on <i>in vitro</i> development of cattle embryos (Lead Station: ERS, Kalyani).	S. K. Das
12.	Screening the role of seminal proteins and antioxidants on cryopreservation of buck semen (Lead Station: ERS, Kalyani).	M. Karunakaran
13.	Orchestrating reproduction in bovine: Crosstalk between phoenixin (PNX) and Kisspeptin (KiSSI) (Lead Station: ERS, Kalyani).	Mohan Mondal
14.	Genetic analysis of lactation persistency and its relationship with economic traits of crossbred cattle (Lead Station: ERS, Kalyani).	Ajoy Mandal
15.	Effect of Azolla supplementation on growth, reproductive and productive performance of Alpine x Beetal goats (Lead Division: LPM).	Ramesh Chandra
16.	Development of suitable housing for dairy cows in lower Gangetic regions of West Bengal (Lead Station: ERS-Kalyani).	D. K. Mandal
17.	Evaluation of bovine major acute phase proteins as a predictive biomarker of postpartum performance in Deoni Cows (Lead Station: (Lead Station: SRS-Bengaluru).	A. Manimaran
18.	Studies on seminal plasma reactive nitrogen species as biomarkers of semen quality in crossbred cattle and buffaloes and its association with seminal hormones and sperm functions- (Lead Division: Animal Physiology).	Sujata Pandita
19.	Strategies to improve semen production performance in indigenous dairy bulls - (Lead Division: LPM).	Mukesh Bhakat
20.	An investigation on anti-mullerian hormone as a predictive biomarker of fertility in HF crossbred & indigenous Deoni cows - (Lead Station: SRS, Bengaluru).	S. Jeyakumar
21.	Diversity in bio-chemical quality of fodder influenced by weather and soil fertility forcing variables - (Lead Station: SRS, Bengaluru).	B. Srinivas
22.	Studies on the causes of truncated lactation in Sahiwal cows (Lead Division: Animal Physiology).	A. K. Roy
23.	Development of suitable management measures to aaugment milk production, quality and udder health status in dairy cattle at lower Gangetic region (Lead Station: ERS, Kalyani).	Champak Bhakat
24.	Effect of supplementation of area-specific mineral mixture (KALMIN) on productive and reproductive performance in dairy animals (Lead Station: ERS-Kalyani).	M. K. Gosh
25.	Studies on vanadium and boron for their role in immuno-endocrine functions, bioavailability of minerals and production performance in dairy animals (Lead Division: Animal Nutrition).	Veena Mani

SL. No.	Project Title	PI
26.	Dietary supplementation of prebiotics, probiotics and synbiotics to augment health of calves (Lead Division: Animal Nutrition).	Sachin Kumar
27.	Role of certain trace minerals on semen quality of cattle and buffalo (Lead Division: Animal Nutrition).	Gautam Mondal
28.	Development of feeding module to reduce the age at first conception in Murrah buffalo (Lead Division: Animal Nutrition)	Raman Malik
29.	Dual purpose baby corn production under varying crop establishment methods and nitrogen management (Lead Division: Animal Nutrition).	Hardev Ram
30.	Optimizing the performance of crossbred calves by synbiotic feeding in existing farm conditions (Lead Station: ERS-Kalyani).	Saroj Rai
31.	Development of diversified fodder cum seed production systems for sustainable production and profit maximization of dairy farmers in Indo-Gangetic plains of India (Lead Division: Animal Nutrition).	Rajesh Kumar Meena
32.	Performance of fodder Maize and Cowpea intercropping followed by Oats for seed production under different nutrient management practices (Lead Division: Animal Nutrition).	Magan Singh
33.	Development and evaluation of additives for small scale silage production (Lead Division: Animal Nutrition).	Nitin Tyagi
34.	Nutritional evaluation of some aquatic macrophytes available in lower Gangetic Plain Region for utilization as ruminant feed resources- (Lead Station: ERS, Kalyani).	A. Chatterjee
35.	Evaluation of eastern Himalayan forest tree leaves as herbal feed additives to manipulate rumen fermentation for improving animal productivity (Lead Station: ERS, Kalyani).	A. Santra
36.	Post processing interventions to improve quality and shelf- life of curd rice (Lead Station: SRS, Bengaluru).	Menon Rekha Ravindra
37.	Evaluation of antioxidative potential of goat milk in controlling hypercholesterolemia (Lead Division: Animal Biochemistry).	Sunita Meena
38.	Size dependent variations in lipid fractions of fat globules in milk from different species (Lead Division: Dairy Chemistry).	Rajan Sharma
39.	Production of antimicrobial bioactive peptides from bovine and non-bovine milk by microbial fermentation and simulated gastrointestinal digestion for development of functional ingredients (Lead Division: Dairy Microbiology).	Shilpa Vij
40.	Incorporation of whey and hydrolysed whey proteins in processed cheese to enhance functional attributes (Lead Station:SRS-Bangalore).	Bikash Chandra Ghosh
41.	Design and development of universal turbo disperser for dairy products (Lead Station: SRS, Bengaluru).	M. Manjunatha
42.	Process development for production of banana based <i>pediococcus</i> and <i>pediococcus</i> fermented whey powders (Lead Division: Animal Biochemistry).	S. K. Sood
43.	Evaluation of osteogenic potential of milk derived peptides in osteoporosis model (Lead Division: Animal Biochemistry).	Suman Kapila
44.	Effect of probiotic administration on male reproductive parameters and semen characteristics in male mice model (Lead Division: Animal Biochemistry).	Gautam Kaul
45.	Technology of goat milk based functional beverage (Lead Division: Dairy Technology).	Heena Sharma
46.	Efficacy of buttermilk as an encapsulating agent for omega 3 fatty acids (Lead Division: Dairy Technology).	Gunvantsinh Rathod
47.	Technology of ricotta cheese from cow and buffalo milk system (Lead Division: Dairy Technology).	Sangita Ganguly
48.	Evaluation of coconut shell and areca sheath as packaging material for select dairy products (Lead Division: SRS, Bengaluru).	Sathish Kumar M. H.
49.	Elucidation of physico-chemical quality and nutraceutical properties of select indigenous cattle milk and ghee (Lead Division: SRS, Bengaluru).	Laxman Naik N.
50.	Development of infrared assisted baking oven and evaluation of baking characteristics of <i>Chhana Podo</i> (Lead Station: SRS- Bengaluru)	F. Magdaline Eljeeva Emerald

SL. No.	Project Title	PI
51.	Preparation and characterization of micro/nano delivery system for 'green' carotenoids (Lead Division: Dairy Technology).	Neelam Upadhyay
52.	Technology development for the production of milk protein concentrate (MPC60) from buffalo milk (Lead Division: Dairy Technology).	Ganga Sahay Meena
53.	Omega-3 fatty acids fortified functional butter and curd (Lead Station: SRS, Bengaluru).	Monika Sharma
54.	Preparation of spray dried whey protein based curcumin encapsulates. (Lead Division: Dairy Technology).	Writdhama G. Prasad
55.	Studies on structure, rheology and functional properties of paneer (Lead Division: Dairy Technology).	Prateek Sharma
56.	Development of automatic endo-exo thermal unit for dahi (Lead Division: Dairy Engineering).	Chitranayak
57.	Development of dewatering mechanism for intermediate Indian dairy product-chhana and chakka (Lead Division: Dairy Engineering).	Vairat Amita Dinkar
58.	Development of low cost mechanized stretching and portioning unit for mozzarella cheese production at small scale (Lead Division: Dairy Engineering).	P. Barnwal
59.	Development of electrochemical sensing system for automation of CIP in dairy plants (Lead Division: Dairy Engineering).	Ankit Deep
60.	Modelling of rheological behavior of selected dairy products using machine learning approach (Lead Division: DES&M).	A. P. Ruhil
61.	Monitoring milk urea level as potential tool for milk quality (Lead Division: Dairy Chemistry).	Raman Seth
62.	Formulation of new preservative as an alternative to formalin for chemical analysis of milk and milk products (Lead Division: Dairy Chemistry).	Richa Singh
63.	Preparation and characterization of panchgavya from indigenous cow (Lead Division: Dairy Chemistry).	Priyanka Singh Rao
64.	Conducting polymer based rapid detection of microbial quality of milk (Lead Division: Dairy Microbiology).	Raghu H. V.
65.	Evaluation and validation of enzyme substrate based strip test for detection of sub clinical mastitis (Lead Division: Dairy Microbiology).	Chand Ram
66.	Determination of engineering properties of ghee in relation to frying oil quality management (Lead Division: Dairy Engineering).	P. S. Minz
67.	Geo-spatial databank and data mining for strategic planning and development of dairying in Karnataka state (Lead Station: SRS, Bangalore).	M. Sivaram
68.	Technological needs and manpower requirement of dairy production and processing units in Karnataka (Lead Station: SRS, Bangalore).	M. C. A. Devi
69.	Socio-economic assessment of indigenous dairy cattle holders in Southern India (Lead Station: SRS, Bangalore).	S. Subhash
70.	Improving knowledge in preparation of traditional milk products through multimedia (Lead Division: Dairy Extension).	S. K. Jha
71.	Development & application of multi-market model for policy analysis in Indian Dairy Sector (Lead Division: DES&M).	B. S. Chandel
72.	A Study on sustainability of Gaushalas in Haryana (Lead Division: DES&M).	Ajmer Singh
73.	Career dynamics of dairy graduates in India: A stakeholder's analysis (Lead Division: D. Extn.).	Sanjit Maiti
74.	Livelihood security vis-à-vis resilience to adverse weather events among tribal and non-tribal livestock farmers (Lead Station: ERS-Kalyani).	Asif Mohammad
75.	Level and trends in sources of income of rural farm households in Haryana (Lead Division: DES&M).	Udita Chaudhary
76.	Modeling production and reproductive performance in dairy cattle using time series analysis (Lead Division: DES&M).	R. Malhotra
77.	Dairy farmers' willingness to pay for need-based dairy extension services in Haryana (Lead Division: D. Extension).	Sanchita Garai

# EXTRA-MURAL FUNDING AND COLLABORATIONS

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

Sl. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration
<b>International Collaborations</b>					
1	Development and application of lactic acid bacteria as designer probiotics	S. K. Tomer	-	Indo-UK Collaboration	2012-2018
2	Assessment of antimicrobial residues and resistance in dairy animals in India	Naresh Kumar	-	ICAR/ILRI	2017-2019
3	AFEX (Ammonia fibre expansion): A technology for addressing seasonality in access to quality cattle feed in India	A. K. Tyagi	Nitin Tyagi and Sachin Kumar	USA: Melinda Gates Foundation	2016-2018
4	Regulation of the Gonadotrophin-ovarian Axis by Kisspeptin-KISSI/R System in Cattle and buffaloes	Mohan Mondal	-	Indo-Egyptian Collaboration	2017-2018
5	Understanding enzymatic activities in concentrated milk system	Yogesh Khetra	-	(Indo-Denmark)	2017-2018
<b>National Collaborations</b>					
6	Network project on buffalo Improvement-Field Unit (CIRB Hisar-125001)	A. K. Gupta	A. K. Chakravarty and Ombir Singh	ICAR	2017-2020
7	Network project on buffalo Improvement-Institute herd (CIRB Hisar-125001)	A. K. Chakravarty	Pawan Singh, T. K. Mohanty and Mukesh Bhakat	Network	2017-2020
8	Monitoring of drug residues and other environmental pollutants-outreach project of ICAR	N. K. Goel	Raghu H. V	ICAR	2017-2020
9	Indigenous breed program (Sahiwal Cattle)	Anupma Mukherjee	K. Chakravarty, A. K. Gupta, T. K. Mohanty, S. S. Lathwal and Mukesh Bhakat	ICAR	2017-2020
10	Deciphering the circulating miRNAs from terminal stage pre-implantation embryos and placentomes for early detection of pregnancy in buffalo	T. K. Datta	Rakesh Kumar and A. Kumaresan	DBT	2016-2019
11	National innovations in climate resilient Agriculture	Anjali Aggarwal	Mahendra Singh, Parveen Kumar, S. S. Lathwal, A. K. Mohanty, Nishant Kumar, Rajan Sharma, K. Ponnusamy, Ritu Chakravarty and Nitin Tyagi	CRIDA (ICAR)	2017-2020
12	Scheme on Dairy Microbes under Network Mode	S. K. Tomar	Surajit Mandal and P. V. Behare	ICAR	2010-2022

Sl. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration
13	Upliftment of socio-economic condition of tribal people through integrated livestock farming in north eastern hill region/eastern part of India –ICAR	T. K. Dutta	M. K. Ghosh, S. K. Das, A. Santra, C. Bhakat, A. Chatterjee, D. K. Mandal, Mohan Mondal, M. Karunakaran, A. Mohammad, S. Rai and R. Behera	ICAR	2017-2020
14	Onset of Puberty and Induction of Estrus: Role of Kisspeptin (Kiss1) in bovine species (Mithun and Cattle)	Mohan Mondal	Anupam Chatterjee	DBT	2014-2017
15	Niche Area of Excellence (NAE) Scheme entitled “Development and evaluation of spore based biosensors for monitoring of pesticides residues in milk”	N. K. Goel	Raghu H. V., A. K. Mohanty and Rajan Sharma	ICAR	2014 -2018
16	Manipulation of partitioning of nutrients and energy balance to augment milk production and reproductive performance in dairy animals	Mahendra Singh	S. S. Thakur, A. K. Roy and Parveen Kumar	BRNS	2014-2018
17	Comparative metagenome of human gut of North and North-eastern region of India”	Sunita Grover	Rashmi H. M.	DBT	2014-2018
18	Development of Aptamer Based Detection System for Aflatoxin M1 in Milk	Rajan Sharma	-	DBT	2014-2017
19	Controlled release dispensers for delivery of semiochemicals	Gautam Kaul	K. Subaharan (IISC, Bengaluru) M. Eshwar Morthy (NBAIL, Bengaluru)	DBT	2014-2018
20	Incentivizing Research in Agriculture Project-V Semen sexing in cattle (Component A)	T. K. Mohanty	A. K.Chakravarty, Mukesh Bhagat, A. Kumaresan, A. K. Gupta and Pawan Singh	ICAR	2017-2020
21	Development of mammalian cell based biosensor prototypes for toxins in commercial milk	Suneel Kumar Onteru	Dheer Singh and A. K.Singh	DBT	2014-2018
22	Elucidating the mechanism of pashmina fibre development: An OMICS approach	J. K. Kaushik	-	NASF	2015- 2018
23	Leukemia inhibitory factor: pluripotency in buffalo stem cells	Sudarshan Kumar	A. K. Mohanty, J. K. Kaushik and D. Malakar	NASF	2015-2018
24	Optimization of procedures for improving cloning efficiency in buffalo	P. Palta	R. S. Manik	DBT	2014- 2017
25	Delineating Beta Casein Variants in Indian Cows and Potential Health Implications of A1A2 Milk	A. K. Mohanty	Sudarshan Kumar	NASF	2015-2018
26	Bio-prospecting of lactic acid cultures from cold dessert region to develop functional fermented milk products with potential health benefits	S. K. Tomar	Pradip V. Behare	DST	2015-2018
27	Assessment of early pregnancy by analysis of neutrophil dynamics and gene expression in dairy cattle	A. K. Dang	A. K. Mohanty, Rajeev Kapila	DBT	2014-2017
28	Livestock methane reduction through immunization based approaches	Dheer Singh	Suneel Kumar Onteru and G. Mandal	DBT	2014-2017
29	Lactation stress associated postpartum anestrus SNP array in buffaloes	Suneel Kumar Onteru	Dheer Singh	NASF	2015-2018

Sl. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration
30	Electrospun Smart O2 sensor for modified atmosphere packaged dairy products	P. N. Raju	A. K. Singh and P. S. Minz	ICAR	2016-2017
31	Technology of heart friendly herbal-milk smoothie with prophylactic effects against cvd and associated risks	S. A. Hussain	Latha Sabikhi, A.K. Singh, Sathish Kumar M. H., Rajan Sharma and Suman Kapila	MFPI	2016-2017
32	Social perspective of deagrarianization and its effect on livelihood security of farming community in Punjab	B. S. Meena	H. R. Meena, Gopal Sankhala, and Rakesh Kumar	ICSSR	2016-2018
33	Conservation of indigenous pig of Assam through Handmade Cloning technique	Manoj K. Singh	-	DBT	2017-2020
34	Genetic variability of milk protein and its characterization by proteomic approach in Indian goats	S. De	Sunita Meena	NASF	2017-2020
35	Identification and characterization of peptidic antagonist to the recombinant cysteine synthase protein of <i>Haemonchus Contortus</i>	Vedamuthy G. V.	-	DST	2017-2019
36	Synthesis, characterization and effect of graded levels of nano-selenium supplementation on the performance of broiler chicken	A. K. Mohanty	Sudarshan Kumar	NASF	2017-2020
37	Proteo-genomic approach to elucidate productive and reproductive performance of Malnad Gidda, Deoni and Hallikar Breeds of Cattle	K. P. Ramesha	M. A. Kataktalware, S. Jeyakumar, A. Manimaran, D. N. Das, A. Kumaresan, Keshavaprasad and H. Gowda.	DAHVS, Karnataka	2017-2021
38	Incentivizing Research in Agriculture-Project-V-Semen Sexing in Cattle (Component 'B')	A. K. Mohanty	Sudarshan Kumar	ICAR	2017-2020
39	Development of fertility prediction tools using specific sperm function tests in cattle and buffalo bulls.	A. Kumaresan	-	ICAR	2016-2018
40	Synthetic Endometrium: A novel model to study early embryonic development and uterine health in ruminants	Rubina K. Baithalu	M. K. Singh	NASF	2017-2019
41	Study of fodder crop assessment for dairy industry and potential areas of intensification of state level	Magan Singh	Rajesh Kumar Meena, Rakesh Kumar and V. K. Meena	Space Application Centre, Ahmedabad	2016-2018
42	Ration balancing programme under National Dairy Plan Phase I at Muzaffarnagar District	Amrish K. Tyagi	Nitin Tyagi and Sachin Kumar	NDDDB	2016-2019
43	Veterinary type culture collection-Rumen component.	Amrish K. Tyagi	Nitin Tyagi and Sachin Kumar	ICAR	2016-2017
44	Standardization of seed rate of berseem with rye grass under mixed cropping system	Magan Singh	S. S. Thakur, Rakesh Kumar, Hardev Ram, Rajesh Kumar Meena, Uttam Kumar and V. K. Meena	AICRP-IGFRI, Jhansi	2016-2018
45	Up gradation of methane emission factors for Indian livestock and preparation of inventory of GHGs emission from Indian livestock	Madhu Mohini	Gautam Mondal and S. S. Thakur	MoE&F	2016-2019

Sl. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration
46	To study the effect of Kappaphygalvarezli based feed additive on production and health of dairy animals	Chander Datt	A. K. Tyagi, Veena Mani and N. Kewalramani	CSIR	2016-2018
47	Manipulation of rumen microbes using medicinal plants extract to enhance the nutraceutical value of milk as a functional food	A. K. Tyagi	Sachin Kumar, Nitin Tyagi and Sumit Arora	DBT	2017-2020
48	Utilization of crude glycerol obtained in biodiesel production as an alternate to glycogenic feed supplement for dairy cows	B. Srinivas	S. N. Sondur (KSCST, IISc, Bengaluru)	KSCST	2017-2019
49	Role of probiotic lactobacilli in modulation of intestinal epithelium barrier functions and immune signals	Rajeev Kapila	Suman Kapila and Ajay Dang	DBT	2016-2019
50	Validation and standardization of the GC analysis method given in ISO 17678:2010 for determination of milk fat purity in bovine milk other than cow's milk	Vivek Sharma	Sumit Arora and Priyanka S. Rao	FSSAI	2016-2019
51	Cell wall components of probiotic lactobacilli as therapeutics for amelioration of inflammatory gut diseases	Sunita Grover	Rashmi H. M., J. K. Kaushik and Diwas Pradhan	ICMR	2017-2020
52	Whey protein-iron complexes: Preparation, characterization and application in biscuits, milk and dahi	Kamal Gandhi	-	DST-SERB	2017-2019
53	Bile responsive proteo-transcriptomics investigation of native probiotic strain lactobacillus helveticus MTCC 5463"	P. V. Behare	A. K. Mohanty, Sudarshan Kumar and J. B. Prajapati (AAU)	DST-SERB	2017-2020
54	Preparation, characterization and application of Vitamin A & D loaded milk protein nano-complexes	Sumit Arora	Vivek Sharma, A. K. Singh and Suman Kapila	DBT	2016-2019
55	National Facility on Bioactive peptides from Milk	B. Surendra Nath	P. Heartwin Amaladhas, N. Laxmana Naik, F. M. E. Emerald, K. R. Ruckmani and Subramanian (Anna University)	DST-SERB	2017-2019
56	Development of equipment for mechanized production of traditional Indian dairy products (rabri and kheer)	P. S. Minz	Chitranayak and P. N. Raju	ICAR	2014-2017
57	Resveratrol and catechins-loaded niosomes and nanoparticles as delivery vehicles for fortification of milk products	B. Surendra Nath	-	NASF	2017-2020
58	Agrowaste Utilization: Separation of nutraceutic B-cryptoxanthin from kinnow peels and its conversion to aqueous dispersible nanoemulsions for value addition of foods	Minni Singh, Deptt. of Biotechnology, Punjabi Univesity, Patiala	Rajan Sharma, NDRI Component.	DST-SERB	2014-2017
59	Development of phytopharmaceutical product for bovine mastitis	A. K. Dang	T. K. Mohanty	DBT	2017-2019
60	Water budgeting and improving water productivity livestock based farming	Ashutosh	Manju Ashutosh	ICAR	2015-2018
61	Urban and Peri urban Dairies among marginalized dairy holders and its effect on society	Gopal Sankhala	H. R. Meena, B. S. Meena, K. S. Kadian and S. S. Lathwal	ICSSR	2016-2018

Sl. No.	Title of the Project	Name of PI	Name of Associates	Funding Agency	Duration
62	Documentation of traditional knowledge of livestock keepers of Karnataka state	K. P.Ramesha (SRS)	S. Subash, S. Jeyakumar, Mukund A.Katakataware	Karnataka Biodeversity Board, Karnataka	2016-2018
63	Improving the livelihood through dairy farming in North Eastern region of India	T. K. Dutta	M. K. Ghosh, S. K. Das, A. Santra, C. Bhakat, A. Mandal, A. Chatterjee, D. K. Mandal, Mohan Mondal, M. Karunakaran, A. Mohammad, S. Rai, R. Behera, Chander Dutt, S. Bandopadhyay (IVRI-ERS-Kolkata) Samiran Bandopadhyay (IVRI-ERS-Kolkata), S. Naskar (IVRI-ERS-Kolkata) and P. Dandapat (IVRI-ERS-Kolkata)	ICAR	2017-2020
64	Capacity building of resource for farmers in paddy-wheat cum dairy production system through Farmer First Programme	Gopal Sankhala	A. K. Singh, Sanket borad, Heena Sharma, Sangita Ganguly, B. S. Meena, Ajmer Singh, S. S. Lathwal, Rakesh Kumar, H. R. Meena, Nitin Tyagi and V. K. Pandita (IARI)	ICAR	2016-2018
65	Improving Livelihood of Rural Women through dairy based secondary Agriculture	K. Ponnusamy	G. S. Meena and Parvinder Sharma	DST	2017-2019
66	Technological change in dairy farming and its effect on rural employment in Trans-Gangetic Plains Region-ICAR	B. S. Meena	Pawan Singh, H. R. Meena, Rakesh Kumar and Sanchita Garai	ICAR	2017-2019
67	Enriching knowledge-integrating technology and institutions for holistic village development in horticulture based farming system	-	M. C. A. Devi and S. Subhash	ICAR	2016-2018
68	Development of edible antimicrobial packaging films for traditional dairy sweetmeats using metabolites of lactic and bacteria	Diwas Pradhan	-	DST	2017-2020
69	Tissue-specific mitochondrial biogenesis, transcriptomics and proteomics studies in buffalo	Sadeesh E M	-	DST	2017-2020
70	Risk and vulnerability analysis of rural farm households in drought prone and coastal regions of India	Simita Sirohi	B. S. Chandel and Sanjit Maiti	ICSSR	2016-2018



*Prof. Richard Ipsen and Prof. Lilia Aehne from University of Copenhagen, Denmark visited NDRI from 11<sup>th</sup>-13<sup>th</sup> Oct., 2017*

# INTELLECTUAL PROPERTY MANAGEMENT

## Institute Technology Management Unit (ITMU)

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

## ITMC meetings Conducted

- 34<sup>th</sup> ITMC meeting was held on 17<sup>th</sup> April, 2017
- 35<sup>th</sup> ITMC meeting was held on 14<sup>th</sup> August, 2017
- 36<sup>th</sup> ITMC meeting was held on 31<sup>st</sup> January, 2018
- 37<sup>th</sup> ITMC meeting was held on 16<sup>th</sup> February, 2018
- 38<sup>th</sup> ITMC meeting was held on 8<sup>th</sup> March, 2018

ITMU meetings were held to discuss pricing of new technologies and examination of patent applications for their novelty and commercial applicability before filing to exchange MoUs for technology transfer between ICAR-NDRI and dairy/food industries.

During the year (2017-18), a total of 12 technologies developed at the Institute were transferred to 10 commercial houses through 15 different MoUs thereby earning a total of ₹ **28,30,000** (excluding Service Tax) for the Institute through technology transfer fee and fee for additional freeze dried cultures for previously sold technologies. One technology was transferred on more than one occasion. The lists of technologies transferred are as follows:

S. No.	Name of the Technology	Inventors	Date of Signing of MoU	Name of the Firm to which Technology is transferred	Revenue Received *(₹)
1.	Sugar Tolerating Lactic Culture for Preparation of Misti Doi (Misti Doi Culture-15 Freeze Dried Ampoules)	Surajit Mandal, S. K. Tomar and Pradip V. Behare	12.04.2017	NIF Private Limited.	75,000
2.	Whey Jaljeera Drink	Ashish Kumar Singh, Sudhir Singh and G. R. Patil	04.05.2017	J. R. Agritech Pvt. Ltd., Aligarh, UP.	2,00,000
3.	Whey Mango Drink	Ashish Kumar Singh, Sudhir Singh and G. R. Patil	04.05.2017	J. R. Agritech Pvt. Ltd., Aligarh, UP	1,00,000
4.	DNA based Method for Differentiation of Cow, Buffalo, Sheep, Goat and Camel Milk	Sachinandan De, Sushil Kumar and Devika Goutam	05.06.2017	IDMC Ltd. Lucknow	6,00,000
5.	Sugar Tolerating Lactic Culture for Preparation of Misti Doi (Misti Doi Culture-15 Freeze Dried Ampoules)	Surajit Mandal, S. K. Tomar and Pradip V. Behare	04.07.2017	NIF Pvt. Ltd., Kanpur	75,000
6.	Arjuna Herbal Ghee	Rajani Kant, G. R. Patil, R. R. B. Singh and A. A. Patel	23.08.2017	Punjab & Sindh Dairy Products Pvt. Ltd., Mumbai.	1,50,000
7.	Bajra Lassi	Ashish Kumar Singh, Sudhir Tomar, S. K. Kanawjia and Yogesh Khetra	26.09.2017	Aadhar Udyog, Delhi	1,50,000
8.	Milk Protein Enriched Iron Fortified Bajra Biscuit	Latha Sabikhi, Ashish Kumar Singh, Devang Jani, Gayatri and Sumit Arora	26.09.2017	Aadhar Udyog, Delhi	1,50,000

S. No.	Name of the Technology	Inventors	Date of Signing of MoU	Name of the Firm to which Technology is transferred	Revenue Received *(₹)
9.	Detection of Buffalo Milk in Cow Milk using Hansa Test Serum	Archana Varma	29.12.2017	Mother Dairy Fruit & Vegetable Pvt. Ltd., Delhi	4,00,000
10.	Strip Based test for Detection of Maltodextrin in Milk	Rajan Sharma, Y. S. Rajput, Bimlesh Mann and Panchal Bhaveshkumar R.	14.11.2017	The Punjab State Cooperative Milk Producers' Federation Ltd. Chandigarh	1,50,000
11.	Sugar Tolerating Lactic Culture for Preparation of Misti Doi (Misti Doi Culture-15 Freeze Dried Ampoules)	Surajit Mandal, S. K. Tomar and Pradip V. Behare	08.12.2017	NIF Pvt. Ltd., Kanpur	75,000
12.	Preparation of Whey Mango Drink	Ashish Kumar Singh, Sudhir Singh and G. R. Patil	15.02.2018	Tamil Nadu Co-operative Milk Producers Federation Ltd. Channei	1,00,000
13.	Misti Doi with Fast Acidifying High Sugar Tolerating Lactic Cultures	Surajit Mandal, S. K. Tomar and Pradip V. Behare	28.02.2018	Schreiber Dynamix Dairies Pvt. Ltd., Pune	1,60,000
14.	Strip based Test for Detection of Neutralizers in Milk	Rajan Sharma, Priyae Brath Gautam, Y. S. Rajput and Bimlesh Mann	14.03.2018	Delmos Research Pvt. Ltd., Haryana	2,50,000
15.	Strip based Test for Detection of Hydrogen Peroxide in Milk	Rajan Sharma, Y. S. Rajput, Bimlesh Mann and Panchal Bhaveshkumar R	14.03.2018	Delmos Research Pvt. Ltd., Haryana	1,50,000
				<b>Total</b>	<b>28,30,000</b>

### New Technologies Ready for Commercialization

In the year 2017-18 pricing of the following new technologies were fixed.

1. Process for Manufacture of Fruit Pulp Probiotic Dahi for Prevention of Colon Carcinoma.
2. Technology for Preparation of Chocolate Bhapa Doi.
3. Technology for Preparation of Curcumin Enriched Ghee.
4. Technology of Reduced Calorie Peda.
5. Arjuna Herbal Ghee.
6. Enzyme Modified Cheese Technology.
7. A New Rapid Test for Detection of Detergent in Milk.
8. Strip Based Test for Detection of Maltodextrin in Milk.
9. A New Strip Based Tests for Detection of Neutralizers in Milk.
10. Probiotic Bacterial Culture for Preparation of Fermented Milk Products for Healthy Gut.
11. Novel RNA Isolation Method from Liver Tissue of Recalcitrant Animal Species to obtain NGS (Next Generation Sequencing) Quality.
12. Novel RNA Isolation Method from Adipose Tissue of Recalcitrant Animal Species to obtain NGS (Next Generation Sequencing) Quality.

#### 1. Patents Filed (2017-18)

1. Stabilization of non-ionic surfactant based Nanovesicles loaded with resveratrol using stearic acid and method of preparation thereof. **Application No.** 201811004766 (Date of filing: 08.02.2018) **Inventors:** Surendra Nath Battula, Jaya Sravani Vankayala, Ruchmani Kandasamy, Grover Antoniraj, Mariya Antoniraj, Pushpadass Heartwin Amaladhas, Naik Laxman Naik, Franklin Magdaline Eljeeva Emerald.
2. A cross linked membrane with flow-line capable of arresting free-flowing gold nanoparticles and the process for the same. **Application No.** 201711036404 (Date of filing: 03.10.2017) **Inventors:** Y.S. Rajput, D.K. Nanda and Rajan Sharma.

3. The preparation of buffalo milk casein hydrolysates with enriched antioxidative peptides and the process thereof. **Application No.** 201711023424, (Date of filing: 04/07/2017), **Inventors:** Rajesh Kumar, Rajeev Kapila, Nichal Mayur Ashok Rao, Sowmya, Gulshan Dass, Bimlesh Mann, Suman Kapila.
4. Construction of mutant strain of *kluyveromyces marxianus* for enhanced galactose utilization. **Application No.** 201711030808, Date of filing: – 31/08/2017, **Inventors:** Shilpa Vij, Arun Beniwal, Priyanka Saini, S. De.

## 2. Request for Examination Filed (2017-18)

1. Novel peptide sequence and polyclonal antibodies for the detection of cow and buffalo luteinizing hormone. 05/04/2017, 1854/DEL/2015.
2. A process for Iron fortification of paneer using edible coating. 27/10/2017, 3926/DEL/2015.
3. High fiber reduced calorie biscuits from dairy-multigrain composite. 10/11/2017, 758/DEL/2015.
4. A milk-protein based nutritive antacid and a process for its preparation. 15/01/2018, 574/DEL/2014.

## PATENTS GRANTED (2017-18)

1

A process for the preparation of ready to reconstitute kheer mix (**Patent Grant No: 284267, Grant Date: 15.06.2017**). **Inventors:** A. A. Patel, G. R. Patil, R. R. B. Singh, Neerja Tyagi, Vishal Tripathi and Alok Jha.

2

A process of preparing a spore inhibition based enzyme substrate assay for monitoring aflatoxin M1 in milk. (**Patent Grant No: 292836, Grant Date: 13.02.2018**). **Inventors:** Naresh Kumar, Namita Ashish Singh, Vanai Kumar Singh, Sunil Bhand and R. K. Maik.

3

Value addition of paneer and dahi through herbal feed additives from cow milk. (**Patent Grant No: 294928 Grant Date: 26.03.2018**) **Inventors:** Sachchida Nand Rai, and Deepak Kumar Dubay.

## Zonal Agro-Technology Management Centre (ZTMC) Meeting

ZTMC Meeting was held at ICAR-NDRI, on February 26, 2018 to discuss the progress of Zone. The meeting was chaired by Director, NDRI and Chairman of Zonal Institute Technology management Committee (ZITMC). Dr. Inderjeet Singh, Director ICAR-CIRB and Co-Chairman of ZITMC attended the meeting including Mr. Ravinderjit Singh, CEO (Agrinnovate India), Dr. Bimlesh Mann, Joint Director (Research), Mr. D. D. Verma, Comptroller, Dr. A. K. Singh, In-charge (BPD), ICAR-NDRI, Ms. Purwa Rathi, Patent & Trademark Agent, New Delhi along with other member Secretaries (ICAR-CIRC, ICAR-NRCE, ICAR-CIRB, ICAR-NRCY and ICAR-CIRG of Institute Technology management Committee (ITMCs).



Participants of ZTMC meeting held at NDRI

## SUCCESS STORY

- The technology for paper strip based test for rapid detection of maltodextrin in milk developed at NDRI has been licensed to 8 different dairy firms and entrepreneurs across the country since 2014. Among all the technologies commercialized till date, this technology has been licensed maximum number of times.

**Paper strip for detection of maltodextrin milk - successfully commercialized**

We put laboratory in your pocket

Our product **dELstrips** detects Maltodextrin (Adulterant) in milk and milk products.

No special skills/expertise or lab set-ups are required to do this test. You just need to dip the strip in milk, take it out and wait for any colour change (If adulterant is present in milk), its a semi-quantitative analysis of adulteration in milk and milk products.

**dELstrips** can be used anywhere i.e. at Farm level, Village milk collection centres, Milk chilling centres, Factory and even at households.

**dELstrips** are completely safe and easy to use

Product is available in the market

Technology has been licenced to - 08 Dairy Industries/Entrepreneurs

### About the Test

Maltodextrin is a hydrolysed product of starch and is available in market with different DE (Dextrose Equivalent) values. Because of better solubility of maltodextrin and ambiguity in interpretation of iodine test for maltodextrin detection, milk has been reported to be adulterated with maltodextrin to increase SNF content of milk fraudulently. The paper strip based test has been developed by immobilizing enzymes and chromogen on a particular paper. The test requires dipping the paper in milk for 5 seconds followed by observing the change in colour of the strip after 10 min. The colour changes to yellow in case of positive sample. The intensity of yellow colour produced in the strip is proportional to the amount of maltodextrin in milk sample. In case of pure milk sample, the strip retains its original white colour. The developed paper strip can also detect the presence of maltodextrin in various milk products such as khoa, dahi etc. The limit of detection of strip is 150 mg maltodextrin in 100 ml milk (0.15%). The IPR of the developed test has been protected through filing of patent (2097/DEL/2014).



MoU being exchanged for the transfer of technology of detection of buffalo milk in cow milk using Hansa test serum



# ENTREPRENEURSHIP DEVELOPMENT BUSINESS INCUBATION ACTIVITIES AND CONSULTANCY SERVICES

## Organization of Entrepreneurship Development Programmes

- Organization of Entrepreneurship Development Programme (EDP) on Commercial Dairy Farming: To promote scientific dairy farming practice, enhance milk productivity and provide excellent quality milk, 9 training programmes were organized under the Agribusiness Incubation (ABI) activities. The programme was attended by 310 progressive farmers, unemployed rural youth, IT professionals, engineers, and retired officials and women entrepreneurs. Well designed training modules cover all technical and management aspects by internal and external experts, pertaining to establishing a commercial dairy farm for milk and animal production. Participants were also provided opportunities to have interactive sessions with successful dairy farmers and field visits for appraisal of real-life challenges and strategies to mitigate them. Considering the economic importance of farm waste, participants were also imparted information on vermi-composting, biogas, bio-fertilizer and manufacturing of value added products from dung.
- Organization of Entrepreneurship Development Programme (EDP) on Milk and Milk Product Processing: Training programmes were organized with the objectives of promoting value addition at the farm/producer's level and improve the profitability of milk producers. Three training programmes were organized under the aegis of Agribusiness Incubation (ABI) programme, which was attended by 98 participants from various part of the country. The training module consisted of raw milk quality assessment, unit operations in liquid milk processing, technological aspects of processed dairy products, quality & safety issues, regulatory guidelines; packaging requirements, adoption of mechanization and management of dairy plants. Hands-on-training opportunities were also created for the participants during the 10 day training programme.
- Two specialized programme: for entrepreneurs and new startups in the area of Starter culture & fermented milks and Technology of Cheeses were organized for 57 participants from various parts of the country. The programme involved detailed information on every aspects of fermented milk and cheese business.

## Government Sponsored Training Programmes

Three training programmes on Scientific Dairy Farming, Milk and Milk Product Processing, Quality Assurance and Sensory Evaluation Techniques were organized for the progressive farmers, veterinary officials, quality assurance staff and production supervisors of various government organizations. A total number of 139 participants from four states participated in these training programmes.

## Training Programmes for Students

Besides offering regular educational courses for Human Resource Development, the institute also provided opportunity to students of other educational organizations, ICAR institutes and State Agriculture Universities for their short-term projects, dissertation, industrial training and specialized training programmes in the area of biotechnology, microbiological aspects of dairy products, starter culture, biochemical techniques, dairy & food processing, process engineering and animal nutrition. During the period, 150 students from 44 universities and colleges underwent training.

## Business Incubation Activities under Agribusiness Incubation (ABI) Programme

In order to provide technical assistance, mentoring, information related to detailed project report and support in getting the financial support from various funding agencies; 15 incubatee were enrolled under the mentorship of scientists of NDRI, Karnal and graduated to start their business ventures. Seven entrepreneurs initiated their ventures under business incubation through SINED (TBI) during the year 2017-18 and most of the ventures initiated with the technologies sourced from ICAR-NDRI, Karnal. Three of our incubatee have been recognized as Startups by the Department of Industrial Policy & Promotion under the Ministry of Commerce. Two students of ICAR-NDRI under the mentorship of SINED (TBI) and scientists of Dairy Chemistry Division has launched their startups Delmos Research Ltd. to provide strip based adulteration kits for industry and other stakeholders. Besides these startups about 85 entrepreneurs were mentored, trained and assisted in initiating their business ventures in the field of dairy farming, milk processing, food processing units and feed/fodder production units. These startups were linked with successful entrepreneurs for sharpening of their technical skills and marketing lessons.

## SUCCESS STORIES OF STARTUPS & ENTREPRENEURS

1. **Shuddh Dairy Products, Sydney (Australia)** a dairy startup by a group of Non-resident Indians under the leadership of Mr. Harman Singh has launched a range of traditional dairy products based on cow milk in Sydney market a year ago. Mr. Harman has attended a vigorous training session at ICAR-NDRI for manufacturing traditional dairy products like *paneer*, masala *paneer*, *dahi* and sweets from cow milk, which is otherwise not considered ideal for manufacturing these products. Within one year of its launching, the company has generated about 60% share of traditional dairy products in Sydney market.



2. **R. K. Food and Beverages, Karnal:** A young woman entrepreneur and his family members innovated with the assistance of scientists from Dairy Technology Division to develop the technologies of innovative sweets based on vegetables, fruit based kulfi and frozen desserts and launched them in Karnal, Kurukshetra and neighbouring district of Haryana. They tied up with another graduated incubatee company of BPD Unit i.e. Mishti Farmer's Producer Company Ltd., for marketing of their products through their marketing channels. Company has received appreciations from consumers for their quality and innovative products.
3. **JV Foodworks, Gurugram** has started a novel business venture for addressing the child malnutrition problems in the country by launching low cost nutritious snacks under the brand name Hungryfoal. The company has developed nutritious products namely Vanilla Energy Bar, Chocolate Energy Bar, Panjiri, Biscuit, and Muffins. The company is using an innovative channel of marketing involving local community from low income and malnourished population. With a team of more than 30 employees, the company has expanded its business in more than 10 cities of North India. Within a span of two years, the company has registered a growth of 120% in gross sales. Mr. Vivek Kaushik, brain-child of the company and Mrs. Japna Kaushik, the techie have attempted to revolutionized the fight against malnutrition through their innovative products. Hungryfoal has secured funding grant from Gas Authority of India (GAIL) Ltd., under GAIL (India) startup initiative "Pankh" and signed an MOU. Another feather added to their list of achievements through signing of MOU with Government of UP at UP investors Summit-2018 at Lucknow to set up their second manufacturing unit. The unit would be established under the Hungry Foal's flagship project "Uttar Pradesh Foods Programme (UPFP)", which is a unique Public Private Partnership initiative to curb malnutrition in the state.
4. **Shri Shivani Agro Pvt Ltd, Indore** was established by Mr. Anshul Gupta, as Incubatee Company at SINED (TBI). He started his work in biscuits and extruded snacks and thereby expanded his knowledge horizon. On knowing about commercialization of institute technology, he learnt about Iron fortified biscuit technology and how minor cereals could be utilized. He purchased the technology and worked various successful pilot scale studies on Iron-Fortified Bajra-based biscuits, at Karnal and Indore. During the last financial year, the company had turnover of ₹ 37 lakhs against total investment of ₹ 60 Lakhs.

## Professional Service Functions through Consultancy Processing Cell

- Under Professional service functions, 6 new contract/collaborative research projects were initiated during the period. It has strengthened our linkages with private organizations and also provided additional revenue for executing research activities in frontier areas.
- Through contract services including testing of samples, supply of inputs (adulteration kits, microbial kits), outsourcing of facilities, custom hiring of equipments, 35 companies, government organizations, entrepreneurs were benefitted.
- Through consultancy services including advisory and general consultancy more than 100 organizations and individuals were benefitted. Being a government organization, consultancy services were offered free of charge to farmers and rural youth visiting institute for seeking guidance.

## Entrepreneurship Awareness Camp-cum-Got an Idea Challenge

Entrepreneurship Awareness Camp-cum-Got an Idea Challenge Season-2 was organized at NDRI, Karnal during 29-30 May 2017 by SINED-TBI, Karnal in association with Aarambh Startup Advisor Pvt Ltd. Gurugram to promote and inculcate the entrepreneurial skills among students and youths. Fifty seven students participated in the programme and submitted their innovative business ideas. Besides students of ICAR-NDRI, NDRI received 177 online applications in the form of business ideas in the field of agriculture, animal & veterinary sciences, food & dairy technology and other aspects of dairy value chain. The projects were evaluated by a panel of experts mostly from other organizations, business schools, business incubators and out of which 10 were screened for presentation to compete on pitch day. A day long special session on "Entrepreneurship opportunities in dairy sector" was also arranged for the newly joined students to our institute as a part of their orientation programme. A specially designed test was conducted for the students to "Judge their Entrepreneurial Skills". Successful entrepreneurs from our incubation centre shared their journey with the students, which motivated them. Students were also appraised about the activities of Business Planning and Development (BPD) Unit and the way by which they can transform their innovative research ideas into a profitable business model.

### Capacity Building Programmes Organized for Entrepreneurship Development

Sr. No.	Name of EDP Programme	Period	Trainees
1.	Commercial Dairy Farming	17 <sup>th</sup> – 22 <sup>nd</sup> April, 2017	25
2.	Commercial Dairy Farming	22 <sup>nd</sup> – 27 <sup>th</sup> May, 2017	28
3.	Milk Processing & Related Products	29 <sup>th</sup> May – 7 <sup>th</sup> June, 2017	26
4.	Starter Culture & Fermented Milk Products	10 <sup>th</sup> – 15 <sup>th</sup> July, 2017	20
5.	Commercial Dairy Farming	17 <sup>th</sup> – 22 <sup>nd</sup> July, 2017	28
6.	Commercial Dairy Farming	21 <sup>st</sup> – 26 <sup>th</sup> August, 2017	28
7.	Commercial Dairy Farming	18 <sup>th</sup> – 23 <sup>rd</sup> September, 2017	27
8.	Milk Processing & Related Products	25 <sup>th</sup> October – 3 <sup>rd</sup> November, 2017	23
9.	Commercial Dairy Farming	13 <sup>th</sup> – 18 <sup>th</sup> November, 2017	25
10.	Commercial Dairy Farming	18 <sup>th</sup> – 23 <sup>rd</sup> December, 2017	26
11.	Technology of Cheese Making	29 <sup>th</sup> January – 3 <sup>rd</sup> February, 2018	11
12.	Commercial Dairy Farming	5 <sup>th</sup> – 10 <sup>th</sup> February, 2018	24
13.	Milk Processing & Value Addition	5 <sup>th</sup> – 14 <sup>th</sup> March, 2018	29
14.	Commercial Dairy Farming	19 <sup>th</sup> – 24 <sup>th</sup> March, 2018	28
<b>Total EDP Trainings: 14</b>			<b>465</b>

### Training Programmes Organized for Farmers, State Government Departments/ Corporate Sector

Sr.No.	Name of Capacity Building Programme	Period	Trainees	Sponsoring Agency
1	Exposure Visit T.P Dairy Farming, Odisha	27 <sup>th</sup> – 29 <sup>th</sup> July, 2017	20	Veterinary Department, Government of Odisha
2	Training programme for Quality Assurance Officers on Sensory Evaluation of Milk & Milk Products	14 <sup>th</sup> – 17 <sup>th</sup> November, 2017	17	Punjab Milk Marketing Federation (Verka)
3	TP Unnant Pashupalan Chara Avam Taknikiyon	14 <sup>th</sup> – 20 <sup>th</sup> January, 2018	30	ATMA Directorate of Rajasthan Government
<b>Total</b>			<b>67</b>	



# DAIRY EDUCATION

## EDUCATION AND TRAINING

ICAR-National Dairy Research Institute is the premier Institution of International repute in Human Resource Development for the growing dairy industry in India. ICAR-NDRI which has been conferred deemed to be university status vide Govt. of India, Ministry of Human Resource Development, Department of Education, and Notification No. F. 9-15/85-U.3 dated 28.3.1989, is well equipped and staffed to meet emerging needs of the 21<sup>st</sup> Century of the Dairy Industry. The university offers academic programmes at Diploma, under-graduate and post-graduate levels in the field of Dairy Science and Technology. The following courses were offered by NDRI Deemed University during the academic session 2017-18. The courses have been so designed as to provide broad base as well as specialized training on different aspects of dairying.

### Diploma in Dairy Technology and Animal Husbandry

The Diploma in Dairy Technology being offered at Southern Campus of ICAR-NDRI, Bengaluru offers intensive training in dairy processing and quality control of milk and dairy products, engineering aspects of dairy processing equipments and dairy business management and 26 numbers of students passed out during academic year 2017-18. The Diploma in Animal Husbandry and Dairying being offered at Eastern Regional Station of ICAR-NDRI, Kalyani, provides intensive training in Animal Husbandry & Dairying and 17 number of students passed out during academic year 2017-18.

### B.Tech. (Dairy Technology)

This 4 Year degree programme offers intensive training in processing and quality control of milk and milk products; and engineering aspects of milk processing plants.

### Master's and Doctoral Degree Programmes

The Institute offers Master's degree programme in the following disciplines: i) Dairy Microbiology; ii) Food Safety and Quality Assurance; iii) Dairy Chemistry; iv) Dairy Technology; v) Food Science & Nutrition; vi) Dairy Engineering; vii) Animal Biochemistry; viii) Animal Biotechnology; ix) Animal Genetics and Breeding; x) Livestock Production and Management; xi) Animal Nutrition; xii) Animal Physiology; xiii) Agricultural Economics; xiv) Agricultural Extension Education; xv) Agronomy; xvi) Veterinary Gynaecology and Obstetrics. The Institute offers Doctoral degree programme in the all the above disciplines except Food Science & Nutrition:

### Scholarships and Fellowships

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

### Institute Scholarships

Master's degree	₹ 7,560/- P.M. for two years plus ₹ 6,000/- per annum as contingency (227)*.
Ph.D.	₹ 13,125/- P.M. for three years and ₹ 10,000/- per annum as contingency (319)*.
Ph.D. (In-service)	₹ 3,000/- P.M. for three years and ₹ 10,000/- per annum as contingency (19)*.

\* Figures in bracket indicate number of students.

## ICAR Junior Research Fellowship

Master's degree ₹ 8,640/- P.M. (For Non Veterinarians) and ₹ 12,000/- P.M. (For veterinarians) for two years and ₹ 6000/- per annum as contingency (62)\*.

\* Figures in bracket indicate number of students.

## ICAR Senior Research Fellowship

Ph.D. 1<sup>st</sup> & 2<sup>nd</sup> Year ₹ 15,000/- P.M. (For Non Veterinarians) and ₹ 10000/- per annum as contingency.

₹ 17,500/- P.M. (For Veterinarians) and ₹ 10000/- per annum as contingency

Ph.D. 3<sup>rd</sup> Year ₹ 17,500/- (For Non Veterinarians) and ₹ 10000/- per annum as contingency.

₹ 18,700/- P.M. (For Veterinarians) and ₹ 10000/- per annum as contingency.

## National Talent Scholarship

The National Talent Scholarship (NTS) @ ₹ 2000/- per month is awarded by ICAR on merit provided that the University/Institute is located outside the state of his/her domicile.

## Career Guidance, Training and Placement Cell

The placement Cell provides career guidance, training and placement services for the passing out students in various disciplines of the Deemed University. B.Tech. (Dairy Technology) and Masters in Dairying students were provided employment in reputed organizations through campus interviews. Passed out students of NDRI are getting employment in Dairy/ Food Industry (Govt./Cooperative/Multinationals). Salary ranges from ₹ 24,000 to 60,000/- per month. In addition to employment, a number of students also opt for higher studies in India and abroad. The major functions of the Cell are as follows:

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

## Counselling for Admissions

Online Counselling for admission to UG/PG programme was held by the Education Division of ICAR New Delhi. Counselling for admission to Ph.D. programme was held by NDRI at Karnal campus.

## Entrance Examination

An all India Competitive entrance examination for admission to Diploma in Dairy Technology/Diploma in Animal Husbandry & Dairying and Ph.D. Programme for the session 2017-18 was conducted by NDRI on 28.5.2017 at five centers i.e. Karnal, Delhi, Mumbai, Bengaluru & Kolkata.

## Admissions

Admissions for the academic session 2017-18 for Diploma in Dairy Technology; Diploma in Animal Husbandry & Dairying, B. Tech. (Dairy Technology); M.Sc./M.V.Sc./M.Tech. and Ph.D. programmes were made.

S. No.	Courses	No. of Students Admitted
1.	Diploma in Dairy Technology	11
2.	Diploma in Animal Husbandry & Dairying	05
3.	B.Tech.(Dairy Technology)	42
4.	Masters' programme	132 (including one foreigner from Afghanistan)
5.	Ph.D. Programme	105

### Degrees Awarded during the 16<sup>th</sup> Convocation.

1. B.Tech. (Dairy Technology)	:	27
2. Masters in Dairying	:	146
3. Ph.D in Dairying	:	104

### Meetings

- » 85<sup>th</sup>, 86<sup>th</sup>, and 87<sup>th</sup> and 88<sup>th</sup> meetings of the Standing Committee on Course Curricula and Academic Affairs were held on 1.7.2017, 27.9.2017 and 28.11.2017, respectively.
- » 63<sup>rd</sup>, 64<sup>th</sup>, 65<sup>th</sup>, 66<sup>th</sup>, 67<sup>th</sup> and 68<sup>th</sup> meetings of the Standing Committee on Faculty, Students Problems and Discipline were held on 6.4.2017, 31.5.2017, 23.6.2017, 28.9.2017, 21.2.2018 and 1.3.2018, respectively.
- » 43<sup>rd</sup> & 44<sup>th</sup> meetings of Academic Council were held on 30.11.2017 and 9.3.2018, respectively.

### Sixteenth Convocation of NDRI Deemed University

Sixteenth Convocation of ICAR-NDRI Deemed University was held on 10<sup>th</sup> March, 2018. Sh. Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers' Welfare presided over the Function and delivered the Convocation Address. Dr. R. R. B. Singh, Director & Vice Chancellor, NDRI Deemed University presented the Convocation Report. A total of 277 students (including 112 girls) were conferred different degrees i.e. B. Tech. (Dairy Technology), Master's and Doctoral. Dr. Trilochan Mohapatra, Secretary, DARE and Director General, Indian Council of Agricultural Research, New Delhi and Dr. Joykrushna Jena, Deputy Director General (Animal Sciences) also graced the occasion.



*A student receiving degree from Sh. Radha Mohan Singh ji, Hon'ble Union Minister for Agriculture and Farmers Welfare*

On this occasion, Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR was also conferred Doctor of Science (Honoris Causa).



*Award of Doctor of Science (Honoris Causa) to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, New Delhi*

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

### B.Tech (Dairy Technology)

S. No	Name of the Student	Position	Medal
1.	Parul	First	Gold
2.	Pallavi	Second	Silver
3.	Sonam Jain	Third	Bronze

### Master's programme

S. No	Name of the Student	Discipline	Position	Medal
1.	Mitasha Mehta	M.Tech. (Dairy Chemistry)	First	Gold
2.	Meera K	M.V.Sc. (Animal Genetics & Breeding)	Second	Silver
3.	Nancy Talwar	M.Sc. (Food Safety & Quality Assurance)	Third	Bronze

### Doctoral programme

S. No	Name of the Student	Discipline	Position	Medal
1.	Sunil Kumar	Ph.D. (Veterinary Gynaecology & Obstetrics)	First	Gold
2.	Ritu Chakravarty	Ph.D. (Agricultural Extension Education)	Second	Silver
3.	Showkat Ahmad Bhat	Ph.D. ( Livestock Production Management)	Third	Bronze

**Merit Certificates** to 20% of the total pass out students in B. Tech. (DT) Programme based on performance in course work were awarded.

**Merit certificates** to toppers of each discipline in Master's and Ph.D. degree programme for performance in course work as per the eligibility criteria were also awarded.

### Best Thesis Awards

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

### Best Master's Thesis Awards

Group	Name of the student	Discipline
Production	Shruti Shandilya	Animal Biochemistry
Processing	Swathi P. Anand	Dairy Microbiology
Social Science & Management	Vikash Kumar	Agricultural Extension Education

### Best Ph.D. Thesis Awards

Group	Name of the student	Discipline
Production	Rani Alex	Animal Genetics & Breeding
Processing	Priyanka Saini	Dairy Microbiology
Social Science & Management	Bishwa Bhaskar Choudhary	Agricultural Economics

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

## Oration Awards- 2017

- » Dr. D. Sundaresan Memorial Oration Award-2017 was bestowed on Prof. (Dr.) A. K. Srivastava, Chairman, Agricultural Scientists Recruitment Board, New Delhi. Dr. Srivastava delivered the lecture on 6<sup>th</sup> March, 2018 in D. Sundaresan Auditorium on the topic **“Position, Potential, Perspectives and Priorities: Feeding 1.34 Billion with Nutritional Security: Bigger Challenge”**.



*Dr. D. Sundaresan Memorial Oration Award 2018 conferred on Dr. A. K. Srivastava, Chairman, ASRB New Delhi*

- » Dr. K. K. Iya Oration award-2018 was bestowed on Dr. Joykrishuna Jena, Deputy Director General (Animal Sciences), Indian Council of Agricultural Research, New Delhi. Dr. Jena delivered the lecture on 3<sup>rd</sup> March, 2018 in Dr. N. N. Dastur Auditorium on the topic **“Livestock and Poultry Research and Development in India”**.



*Dr. K. K. Iya Memorial Oration Award 2018 conferred on Dr. J. K. Jena, Deputy Director General, Animal Science, ICAR, New Delhi*

## Best Teacher Award for Excellence in Teaching

Best Teacher Award to recognize and promote teaching excellence and motivate the faculty to adopt high standards for content preparation, delivery of lectures, motivation of students and overall development of students was conferred upon Dr. Rajan Sharma, Principal Scientist, Dairy Chemistry Division.



*Dr. Rajan Sharma, Principal Scientist, Dairy Chemistry Division receiving the Best Teacher Award from the Hon'ble Minister for Agriculture and Farmers' Welfare*

## Best Division Award for Academic Achievements and Innovations in Teaching

Heads of Divisions presented the innovations and significant achievements during 2016-17 in education/ research and consultancy during Academic fortnight Celebrations. On the recommendation of the committee, “Best Division Award” was presented to Animal Biochemistry Division.

## Accreditation

On the recommendations of the ICAR Peer Review Team, the National Agricultural Education Accreditation Board, ICAR, New Delhi granted accreditation to the ICAR-National Dairy Research Institute, Karnal (Haryana) and its following programmes upto 31<sup>st</sup> March, 2021.

- » Programmes running at ICAR-NDRI Campus, Karnal.
- » Programmes running at Southern Campus of ICAR-NDRI, Bengaluru.

## Ranking among Agricultural Universities

National Dairy Research Institute, Karnal has secured FIRST RANK amongst Agricultural Universities in the Ranking of Agricultural Universities by the ICAR. The certificate was presented on ICAR Foundation Day Award Ceremony celebrated on 16<sup>th</sup> July, 2017 in A.P. Shinde Symposium Hall, NASC Complex, Pusa, New Delhi.

## Review of Deemed to be University Status of NDRI, Karnal

On the recommendations of UGC Expert Committee, University Grants Commission vide its letter F.No.6-3/85 (CPP-1/DU) dated 12<sup>th</sup> September, 2017 further extended the grant of the Deemed to be University status to National Dairy Research Institute (Deemed to be University), Karnal (Haryana).

## Placement under Special Mention Institutions Category

National Dairy Research Institute has been placed in the special mention category of Institutions by National Institutional Ranking Framework, Ministry of Human Resource Development, Govt. of India Ranking- 2018.

## Laurels to NDRI Students

- » Mr. Ravi Prakash, Ph.D. Scholar in Dairy Engineering at Southern Campus of ICAR-NDRI received the BIRAC-GYTI 2018 award from the Honourable President of India for his doctoral thesis on "Design and Development of Phase Change Material (PCM) Based Milking Cum Cooling Pail". The Scholar is among the 15 awardees selected for the award this year and will receive a grant of ₹ 15 Lakhs to develop his project idea.
- » Dupont organised Nutrischolar awards 2017 in the month of September with 3 categories namely Best Innovation in Local Food, Most Nutritious Food Idea and Ultimate Health and Wellness Product. The competition was meant for students of various food technology, agriculture and dairy technology universities all over India. Competition was held in three phases, in the first phase participants proposed their ideas to develop a new product in the aforesaid categories and send the product formulation details. Four teams were shortlisted from NDRI and a sum of 10,000/- INR was given to each team to develop and execute their product. Out of the shortlisted ideas, NDRI team ( Navan Sampath Kumar and group,) won third prize for the project, '**Ragi Malt Based Long Shelf Life Ready to Drink Nutritive Dairy Beverage**' and received 75,000/- INR as a prize money..

## Students' Foundation Programme - 2017

NDRI introduced one month long Foundation Program for the Freshers of 2017- 18 batch. The Foundation Program aims at tapping the innate talents of the students by providing them enabling and vibrant academic environment and nurturing them into outstanding professionals and accomplished human beings. During this programme, the students were exposed to multifarious extra-curricular group activities such as Theatre & Dramatics, Dance, Music, Art & Craft, Literary, Soft Skills and Yoga. It was made mandatory for all new comers to choose and participate in any event/s as per their interest, aptitude and liking, thus, throwing open to them a world of avenues for expressing their hidden talents and creativity. Besides academics, the month long Foundation Program included workshops on Mastering Public Speaking; Team Building; Climbing the Leadership Curve; Effective Ways to Communicate in English; Improving Professional Communication and Spoken English; Gender Equality & Environmental Awareness; Stress Management and social and ethical issues. These sessions were planned to mentor the students on public speaking; team spirit; developing the power of belief and unlocking human potential; overcoming distractions and bad habits; and leadership development. All the freshers were also made to compulsorily participate in physical exercise & yoga sessions as a part of the Foundation Programme for their balanced intellectual, physical and emotional development. The outcome of the program was a grand success. Within a short time, the students from diverse social and cultural backgrounds could mingle and interact on a single platform in a unique way. They could overcome their stage inhibitions and could express their inner strengths freely. The usefulness of the programme was evident from the feedbacks expressed by the students. For most of them this month long exercise was rejuvenating, eye opening and discovering a new way to enjoy academics.

The Foundation program gave the students a stage to discover themselves in fresh light, to unwind, to share and to realize their slumbering powers that they never dreamt of possessing. The month long journey culminated into formation of clubs for different group activities.



*Glimpses of Activities of Foundation Program*

### Organisations of Workshop cum Interactive Sessions

Student Empowerment Unit of ICAR-NDRI organised a Workshop cum Interactive Session on 'The Art of Understanding Reasoning and Argumentation' on May 6, 2017. Mr Deepak Maun and Ms Purwa Rathi, illustrious alumni of NDRI were the resource persons for this workshop. The resource persons also shared their journeys and experiences, and the role that NDRI played in their success.

Another workshop-cum-interactive session '*Beyond a Life in Classrooms–8 Must Know Truths for success*' was organised on 17<sup>th</sup> July, 2017. Debashish Sarkar, Managing Partner, Proliferator Advisory and Consulting was resource person invited for the workshop. The participants were the undergraduate, postgraduate and doctoral students of NDRI.

### Celebration of Agricultural Education Day

In pursuance of ICAR's well sagacious initiative to inculcate interest in agriculture and allied sciences among the school and college students and to choose 'agriculture' as their professional & research career or engage themselves in farming as agri-entrepreneurs, ICAR-NDRI celebrated the birthday of the first Indian Union Agriculture Minister



*Director NDRI with paintings and award winning school students during Agricultural Education Day*

and the first President of Independent India, Bharat Ratna, Dr. Rajendra Prasad as Agricultural Education Day on 3<sup>rd</sup> December 2017. More than 100 students from schools in and around Karnal and more than 200 students and staff of NDRI participated. Quizzes and painting competitions on Dairy and Agriculture Sciences were organised.

### Intra-university Festival 'Vasantotsava' and Inter-university Festival 'Reverie-2018'

Literary and cultural activities prove a valuable lens to view the inner world of students and thereby enable their holistic development. The Institute provided several opportunities to the students to showcase their talent.



*Dance performance by newly admitted students on Freshers' Day/Reverie*

The Institute organised several cultural, literary, fine-arts activities through Freshers' Day, Intra-university Festival 'Vasantotsava' organised during February 2018 and Inter-university Festival 'Reverie-2018' from 23<sup>rd</sup> - 25<sup>th</sup> March, 2018 for all round development of students.



*Dr. N. S. Rathore Deputy Director General (Education) lighting the lamp during valedictory ceremony of Inter University Festival Reverie-2018*

# TECHNOLOGY DISSEMINATION AND EXTENSION PROGRAMMES

## DAIRY EXTENSION

### Field/ Farm Technician (FFT) Laboratory

The Field/ Farm Technician (FFT) Laboratory of Dairy Extension Division provides a base for extension work in the adopted villages around Karnal and keeps the records of all extension activities of the Division. Newly adopted villages are Shahpur, Hemda and Dadupur.

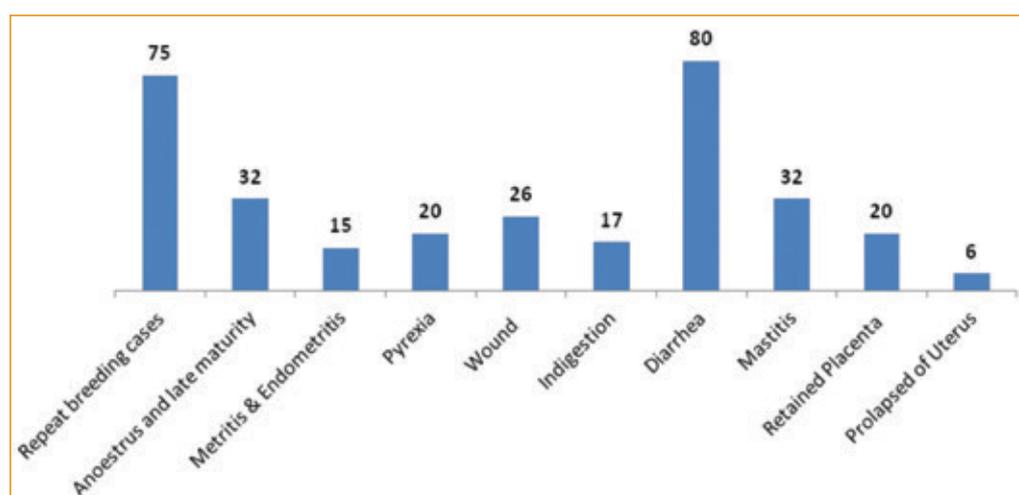
In order to upgrade the existing breeds of dairy animals, cross-breeding was continued in cows and selective breeding in local buffaloes through A.I. using high pedigree bulls. To reduce age at maturity and to minimize inter-calving interval, infertility and veterinary aid campaigns were conducted in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

#### Activities Conducted in Adopted Villages

Sl. No.	Activities	No. of Cases
1	A.I. in Cows (Conception rate)	378 (48.57%)
2	A.I. in Buffaloes (Conception rate)	245 (42.00%)
3	No. of C.B. calves born	215
4	No. of buffalo calves born	126
5	General Treatment cases	432

### Infertility and Veterinary Aid Campaigns

A total number of 34 camps were organized in Shahpur, Hemda and Dadupur villages. During the Campaigns, animals were treated for reproductive disorders and other ailments such as ectoparasitic control. Deworming programmes for control of endo-parasites were also conducted. Special attention was given to improve the productive & reproductive parameters of animals by diagnosis and proper treatment. Besides these, tick control mechanism was applied on the 295 animals and deworming was done on 336 dairy animals.



## Kisan Sangoshthies

Thirty four Kisan Sangoshthies were organized and a large number of farmers attended these sangoshthies in adopted villages. The following topics were discussed in detail:

- » Management of animals during unseasonal rainfall
- » Adaptation practices during extreme climate variability
- » Clean milk production practices in rural areas
- » Role of reducing inter-calving period in lactating animals
- » Preparation of value added milk products
- » Deworming animals and tick control
- » Preventive measure of H.S. Disease
- » Awareness on ecto-parasite infestation
- » Cutting management in multi cut sorghum
- » Role of mineral mixture in animal diet
- » Awareness on ecto-parasite infestation
- » Importance of animal deworming
- » Role of mineral mixture in animal diet
- » Correct Time of Breeding of females

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

## Dairy Education at Farmers' Door (DEFD)

Extension Education Programme "Dairy Education at Farmers' Door" was continued 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 visited various villages on 2<sup>nd</sup> Saturday of every Month. Scientists also obtained all the feedback from the participating farmers. During visits, the discussion on the dairy farming, veterinary practices and clean milk production remained the main activity in the programme.



*Extension scientist educating farmers in a village*

## Farmers' Farm School

National Dairy Research Institute (NDRI) has started an ambitious programme wherein farmers of Haryana State are being provided formal Education in the field of Dairying, Horticulture and Agriculture through Farmers' Farm School. In this School, farmers interact with the scientists of the Research Institutes and there is class room teaching as well as practical classes. There is a provision of enrolling 25 farmers in one batch on first come first basis and the course duration is for one year. The candidates enrolled in the 3<sup>rd</sup> batch of the Farmers' Farm School passed out in the month of July 2017. The 4<sup>th</sup> batch consisting of 20 marginalised and landless farmers of village Deepo started from 5<sup>th</sup> August, 2017.

## Dairy Samachar

Quarterly "Dairy Samachar" was published by Dairy Extension Division, NDRI, Karnal to make them well aware of newly developed dairy technologies of the Institute.

## Educational Visits at NDRI

A total number of 8820 visitors (Students & Faculty) of 183 colleges/Institutions/Universities visited the Institute, which were coordinated by the Division. The groups were sensitized about the different research, teaching and extension achievements and facilities available in the Institute. The details of educational tour as follow:



## National Dairy Mela

A three day National Dairy Mela was organised at NDRI from 23<sup>rd</sup> to 25<sup>th</sup> November, 2017 to showcase various technologies developed at NDRI and other sister institutes located at Karnal. The mela attracted more than 10000 visitors from different states like Uttar Pradesh, Haryana, Punjab, Delhi and Rajasthan. The Mela was inaugurated by Shri Chhabilendra Roul, Additional Secretary (DARE) and Secretary (ICAR) in presence of Dr. R. R. B. Singh, Director NDRI, Dr. Bimlesh Mann, Joint Director (Res.) & Chairperson of National Dairy Mela, Dr. K. S. Kadian, Head, Dairy Extension Division & Mela Co-ordinator and other dignitaries. During the inaugural function, "Dairy Mela Smarika" was also released for the dairy farming community highlighting the important component of dairy farming.

The 100 stalls were a visual treat for the diverse visitors comprising students, farmers, academicians, researchers as well as entrepreneurs. All the stalls were well equipped to cater to the information needs of the visitors. A total number of 180 animals from different parts of Haryana (Sonapat, Panipat, Karnal, Kaithal, Yamunanagar, Ambala etc.) participated in various competitions under different categories such as beauty contest for heifers of





declared as the highest milk yielder in all categories and buffalo breed of Narendra Singh from Panipat was honored with the title "Best Animal of the Show". Prizes were also given to the best stalls among different categories.

indigenous cattle, dry and milch animals (Adults) and milking competitions for various breeds of cattle and buffaloes. Highlighting the need for giving women their due place in value addition and dairy development, competitions were held for women in paneer making and milking on the last day of the Mela. The competition was open to all women and 31 women participated in paneer making and 28 in milking competition, respectively. Cash prizes and mementos were given to the winners under different categories. The HF cross with a milk yield of 49.156 litre belonging to Dhalbir Singh from Ambala was

### TSP Activities: Livestock Development in the Tribal Area of West Bengal

TSP programme undertaken by Eastern Campus is being implemented in different agro-climatic zones of West Bengal. The special emphasis was given on red and lateritic soil zone of West Bengal due to high percentage of tribal population and harsh climatic conditions characterized by low rainfall and less fertile soil. Several interventions like veterinary health care facilities, deworming and vaccination (cattle and buffalo FMD, HS, BQ; goat and sheep PPR and birds R<sub>2</sub>B vaccine) improved fodder seed distribution and distribution of several inputs like mineral mixture, cattle feed and livestock etc. were regularly done in the adopted areas under TSP programme of the Institute. For upliftment of farmers' knowledge, on and off campus training programmes were organized and regular dissemination of scientific information was done by using SMS portal developed under the project. For showcasing technologies developed by ICAR-NDRI and other research organizations, ERS participated in exhibitions and also organized a 'Krishi- cum- Dairy Mela' in tribal village. By these interventions tribal farmers in adopted areas are adopting scientific dairy farming and also getting more benefits from their livestock farming ventures.



Three vaccination-cum-deworming camps were organized for 397 farmers. A total number of 473 cattle, 385 calves and 60 buffaloes were vaccinated against FMD, HS and BQ. Apart from that, 690 goats, 160 sheep were vaccinated against PPR and 1020 birds were vaccinated with R<sub>2</sub>B Vaccine. In these camps, 100 kg of maize seeds, 60 kg oats seeds, 16 kg rice bean seeds, 400 pieces rooted slips of guinea grass and 400 pieces of rooted slips of Hybrid Napier distributed among tribal farmers. Five kg propagation material of azolla was also distributed in these camps. From ERS of ICAR-NDRI, 440 chicks were distributed among 44 tribal farmers in Birbhum and Jhargam district of West Bengal. Apart from that 246 kg of mineral mixture was distributed among 397 tribal farmers.

Four scientists'-farmers' interaction sessions were also organized. A team of scientists and experts of NDRI-ERS, Kalyani interacted with the farmers (with dairy/goat and other animals) on the following areas: Scientific animal rearing practices, mastitis management and control measures, vaccination and deworming protocol, fodder production and feed resource development, breeding strategies, infertility/anestrous/repeat breeding management and calf rearing and heifer management. Experts delivered lectures on various aspects of animal husbandry practices through Santiniketan Doordarsan and All India Radio (AIR) for mass communication during the camp period.

One training programme was also organised under TSP from 5<sup>th</sup> - 7<sup>th</sup> September, 2017 for 14 tribal farmers from Jhargram district of West Bengal. Regular dissemination of information pertaining to scientific dairy farming to the tribal farmers was done by using SMS portal developed by Eastern Campus of NDRI, Kalyani.

## NEH Activities: Improving the Livelihood through Dairy Farming in North Eastern Region of India undertaken by Eastern Campus

During the year, four North Eastern states of India namely, Meghalaya, Tripura, Sikkim and Mizoram were covered. Several visits were arranged and inputs such as veterinary medicines, mineral mixture, concentrate mixture, fodder seeds, livestock, extension literatures etc. were distributed among the farmers. In the scientists-farmers interaction sessions, several aspects of animal husbandry were explained to the farmers of the North Eastern States. The topics which were covered in these sessions were as follows:

- » Importance of feeding mineral mixture to livestock
- » Vaccination schedule
- » Deworming of dairy animals/poultry
- » Important green fodder varieties and their cultivation practices
- » Artificial insemination and heat detection
- » Azolla production
- » Clean milk production

### Activities Undertaken in Meghalaya

In the state of Meghalaya, one session of interaction with farmers was organized in the village of Ri-Bhoi district. In this session, several inputs like Chicks (500 Nos.), Piglet (20 Nos.), Broiler pre-starter (200 kg), Crumbo starter (400 kg), Crumbo poultry feed (400 kg), Varaahar pellet (1500 kg) were distributed among the farmers. Farmers were exposed to the knowledge of different facets of scientific dairy farming. A total number of 111 farmers from Meghalaya were benefitted by these interventions.

### Activities Undertaken in Tripura

Two visits were organized in the state of Tripura (Bagma Samatalpara grampanchayat, South Tripura) during the year 2017-18. Scientists farmers interaction session-cum-veterinary health camp was organized. Several inputs like Chicks (1500 Nos.), Black Bengal Goat (50 Nos), Mineral mixture (800 kg), Poultry feed (600 kg) etc. were distributed among 356 farmers. Apart from these programmes, regular SMS in Bengali language pertaining to various aspects of scientific dairy farming were sent to the registered farmers from Tripura.



### Activities Undertaken in Sikkim

One visit in the state of Sikkim (Ralap and Nandok village of East Sikkim district) was organized in which veterinary health camp cum scientists-farmers interaction session was organized. Inputs like Mineral mixture (525 kg), Cattle feed (4750 kg), Calcium supplement (50 lit) was distributed among farmers. A total of 91 farmers were benefitted by the intervention provided by Eastern Campus of ICAR-NDRI, Kalyani.



### Activities Undertaken in the State of Mizoram

Two camps were organized in Mizoram (Durtlang and Selesih of Aizwal) state by collaborating with College of Veterinary Sciences, CAU, Aizwal. Several inputs like Chicks (3300 Nos.), Piglet (51 Nos.), Mineral mixture (242 kg), Vitamin supplement (4 ltr.), Poultry Feed (200 kg), Pig feed (650 kg), Cattle Feed (600 kg) etc were distributed among 385 farmers. Scientists-farmers interaction session was organized to make them aware regarding the scientific dairy and other animal rearing practices.



### KRISHI VIGYAN KENDRA (KVK)

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

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



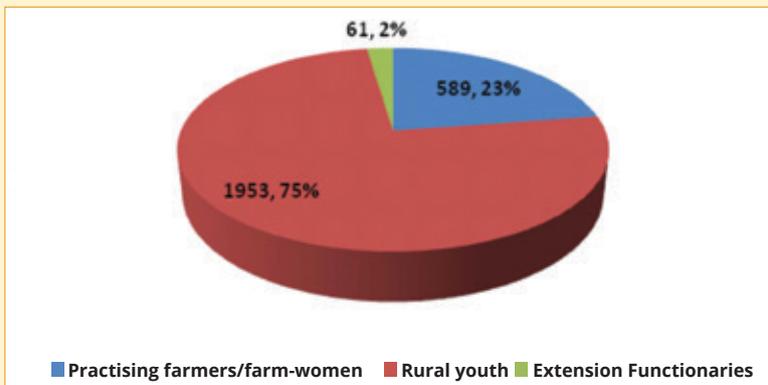
*Training in fish farming at KVK*

#### On Campus Training Programmes Conducted by KVK

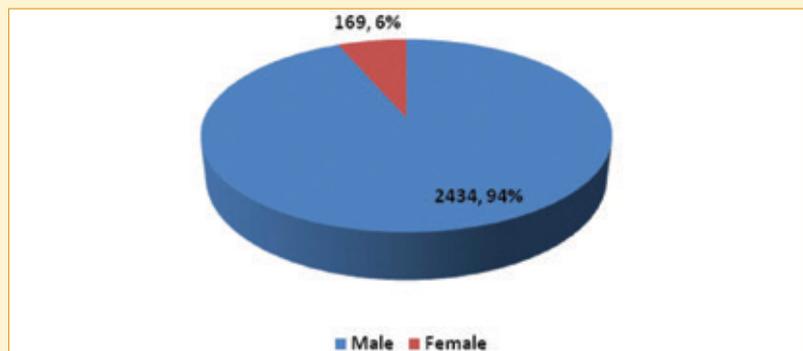
Title of the course	Duration (days)	No. of Courses	No. of Beneficiaries
Dairy Production	5	28	1806
Dairy Processing	5	7	136
Crop Production	1-4	7	158
Vermiculture	3	2	36
Bee-keeping	4	2	128
Fish Farming	4	3	226
Home Science	1-12	5	73
Skill Development in Artificial Insemination	26	1	20
Skill Development in Vermicompost Making	26	1	20
<b>Sub-Total (a)</b>		<b>56</b>	<b>2603</b>
Short Visit cum Integrated Training Programmes (b)	<b>1-3</b>	<b>109</b>	<b>3607</b>
<b>Total (a+b)</b>		<b>165</b>	<b>6210</b>

## State wise Beneficiaries of KVK Training Programmes

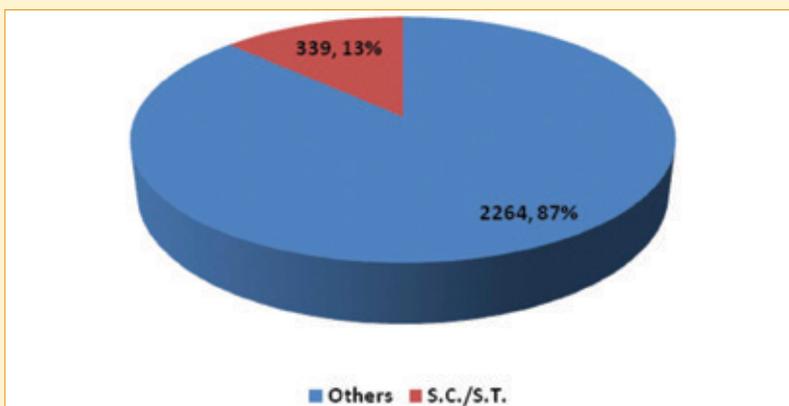
Sr. No.	State	No. of Beneficiaries
1.	Haryana	2128
2.	Bihar	329
3.	Uttar Pradesh	66
4.	Madhya Pradesh	48
5.	Punjab	8
6.	Delhi	7
7.	Himachal Pradesh	7
8.	Rajasthan	4
9.	Maharashtra	2
10.	Uttrakhand	2
11.	Andhra Pradesh	1
12.	Jharkhand	1
	<b>Total</b>	<b>2603</b>



Category-wise Beneficiaries of KVK Training Programmes



Gender-wise Beneficiaries of KVK Training Programmes



Category-wise Beneficiaries of KVK Training Programmes

### Skill Development Training Programmes

KVK organized two training programmes of 200 hrs duration in skill development in the subject of Artificial Insemination and Vermicompost for the rural youth of Karnal district. Each programme was attended by 20 participants. The participants were evaluated for skill gain and successful participants were given certificates by Govt. of India.

### Special Training Programmes on Crop Diversification and Integrated Farming

KVK organized two training programmes for 36 rural youth of Karnal district on crop diversification. The youth were sensitized on crop diversification and its benefits on the soil health and resource conservation. KVK also organized a programme on Integrated farming for 35 rural youth to encourage them to adopt integrated farming to enhance the income.

### Exposure Study Visits Organized

A total number of 109 visits were organized in which 3607 number of farmers and farmwomen participated from Haryana, Himachal Pradesh, Uttar Pradesh, Chattisgarh, Odisha, Punjab, Manipur, Gujarat, Jammu and Kashmir, Uttarakhand, Rajasthan and Madhya Pradesh.

### Front Line Demonstrations

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

#### Results of FLD Conducted by KVK

S. No	Crop	Variety	Total No. of Demo.	Area (ha.)	Av. Yield (q/ha)	BC Ratio
1.	Pulses	Gram	53	20.00	18.0	1:3.99
		Summer Moong	52	20.00	3.80	1:1.32
2.	Oilseed	Mustard	15	6.00	18.52	1:3.83
3.	Fodder	Sorghum	10	2.00	655.00	1:3.85



Front Line demonstration on Summer Moong

#### FLD Organized during Rabi Season (2017)

S. No	Crop	Variety	Total No. of Demo.	Area (Acre)
1.	Mustard	CS-58	8	8
		RH-749	11	11
		Pusa Vijay	5	5
2.	Gram	HC-5	57	50
3.	Berseem	BL-42	8	3.75
		BL-10	5	2.50
		Mescavi	2	1.00



*Front Line demonstration on Chickpea (Gram)*

### Results of On-Farm Trials Conducted by KVK

Technology Assessed	*Production per unit	Net Return (Profit) in ₹ / unit	BC Ratio
<b>Berseem Fodder (Variety)</b>			
B.L-42	1315 Qtls/ha.	163200	1:5.79
BL-10	1105 Qtls/ha.	131700	1:4.86
HB-2	939 Qtls/ha.	106800	1:4.13
<b>Gram (Variety)</b>			
HC-1	18.52 Qtls/ha	70100	1:4.11
HC-5	19.15 Qtls/ha.	73250	1:4.25
PG-186	25.7 qtl/ha	106000	1:5.71

### Seed Produced at Crops Production Unit (2017)

Name of the crop	Date of sowing	Date of harvest	Area (acre)	Details of production		Qty. (Qtl.)
				Variety	Type of produce	
<b>Seed</b>						
Cereal						
Wheat	Nov., 2016	April, 2017	18.30	DBW-88	Seed	320.40
<b>Fodder</b>						
Berseem Mustard	Nov., 2016 Oct., 2016	May, 2017 March, 2017	10.00 2.40	BL 42 Chinese Cabbage	Seed Seed	4.60 1.95
<b>Green Fodder</b>						
Jowar	March, 2017	May, 2017	4.70	Sudan Grass	Green Fodder	248.50
Berseem	Nov., 2016	Jan., 2016	11.00	BL 42	Green Fodder	2820.50
Green						

### Field Extension Activities

- » KVK staff frequently visited various villages in Karnal and nearby districts and advised farmers regarding growing different crops during Kharif and Rabi season 2017.
- » Subject matter specialists of KVK visited various villages of Karnal District to educate and bring awareness amongst the farmers on soil health, Swachh Bharat, recourse conservation apart from crop production and animal husbandry.
- » A Parthenium awareness campaign was also taken up in the villages of Karnal district during the field visits to apprise the farmers, farmwomen and school children of ill effects of weed.
- » KVK arranged an exposure visit of 20 progressive farmers from Karnal district to Krishi Unnati Mela at ICAR-IARI New Delhi on 15<sup>th</sup> March, 2017. Similarly an exposure visit of 20 farmers was arranged to Rabi Kisan Mela organized at ICAR-CSSRI Karnal.
- » Two training programmes were organized in the villages of Karnal district to propagate the utilization of dairy waste which were attended by more than 36 dairy farmers. The farmers were sensitized to utilize cow and buffalo dung for conversion into compost using vermiculture.



*Training programme on vermicompost making*

- » International women Day was celebrated in the village Bastara where more than 50 women participated. The subject matter specialists from KVK delivered lectures to the participants and a Swachchhata Abhiyan was organized in the village.
- » Three programmes were organized in various villages of Karnal district where milk producers were educated on clean milk production. They were informed as to how shelf life of milk can be increased with the clean milk production. Demonstrations were arranged on cleaning and sanitization in milk production. KVK also organized an off campus programme on value addition of milk for 21 rural youth.
- » In a collaborative programme with Dy. Director of Agriculture, subject matter specialists from KVK delivered lectures on wheat production technology and weed control. About 125 farmers participated in the programme.
- » KVK in collaboration with district fisheries department organized a programme in village of Karnal district where more than 200 rural youth participated. The rural youth were informed about the fish farming opportunities in the district to enhance their income. KVK also organized three programmes on various aspects of fish farming in the villages of Karnal district for 57 farmers.
- » An off campus training programme on bee keeping was organized for 20 rural youth to enhance their income by production of honey and improving the productivity.
- » KVK participated in village adoption programme organized by NIFTEM in village Khera Chhapra of Karnal district. The subject matter specialists from KVK delivered lectures to the farmers and farm women in the villages where more than 50 farmers and farmwomen participated.
- » Five short programmes on fruit and vegetable preservation, storage of cereals, women and child care and kitchen gardening were organized for 120 rural women.
- » KVK organized 22 field visits in 56 villages of Karnal district to educate farmers on Rabi and Kharif crops, plant protection, weed management, soil fertility management, water conservation, paddy, wheat, fodder, oilseed and pulse crop management where 335 farmers participated.
- » Twelve campaigns to popularize “Swacch Bharat Abhiyan” were organized in the villages of Karnal district. The farmers and farmwomen were sensitized to keep the surrounding environment neat and clean so that human and animals remain healthy.
- » KVK organized a “Sankalp-se-Siddhi” programme on 6<sup>th</sup> September, 2017 to create awareness amongst the farmers about Prime Minister’s vision to double the income of farmers. More than 300 farmers and farm women participated in the event.
- » Soil Health Day was celebrated on 5<sup>th</sup> December, 2017 by KVK in which more than 110 farmers and farm women from different villages of Karnal district and other states participated. In the programme the farmers were educated about importance of assessing the soil health and linking it with the crop production.

### **New Krishi Vigyan Kendra-II, Nadia District at Eastern Campus of ICAR-NDRI, Kalyani**

As per KVK guidelines and action plan for 2017-18, different activities were organized and conducted to cater the need of practicing farmers, rural youth and extension functionaries. Different training programmes were organized for man and farmwomen. A total number of 17 courses were conducted as on-campus training; whereas, 19 off-campus training were conducted during the year. A total number of 1128 trainee days were covered. Front Line Demonstrations was carried out on “Effect of feeding of KALMIN (Area Specific Mineral Mixtures) on Milk Production of Crossbred/Local Cows”, “Artificial Insemination by using Crossbred Semen followed by Extension Intervention

to Augment the Milk Production”, “Vaccination against FMD, HS and BQ Diseases”, “Azolla Cultivation for Feeding Dairy Cattle”, “Forage Maize Production as Forage Crop for Dairy Cows”, “Sorghum Cultivation as Forage Crop for Dairy Cows” and One OFT was carried out on “Effect of Vit-E Supplementation on Udder Health Status in Jersey Crossbred Cows”. The various extension activities and outreach programmes were organized regularly in different blocks of Nadia district. Out of nine assigned blocks of KVK, eight blocks were covered Viz: Chakdah, Ranaghat-I, Shantipur, Nabadwip, Krishnagar – I, Krishnagar-II, Nakashipara and Tehatta – II. An initiative was taken up for



planting materials/seed production viz: Rooted slips/stem cuttings of Hybrid Napier Grass (Var-CO-4); Fodder Rice Bean Seed (var-Bidhan-1); Fodder Rice bean seed (var-Bidhan-2); Coax (*Coax aquatic*)Var-Bidhan-1: 10 kg; Azolla production; and Rooted slips /stem cuttings of Para Grass. A total number of 35 different types of SMS were sent to farmers covering 249 extension advisory services.

### AGRICULTURAL TECHNOLOGY INFORMATION CENTRE (ATIC)

Agricultural Technology Information Centre at NDRI Karnal became operational in November 2004. This centre is engaged in disseminating information on dairying and allied agricultural fields. Besides NDRI, relevant information available from other research stations of ICAR and state institutions located at Karnal are utilized by this centre for the farmers and other stakeholders visiting this centre. A large number of entrepreneurs, practicing farmers, extension workers and students avail the facilities of ATIC to gather latest information related to dairying and allied fields.



Farmers at ATIC, NDRI, Karnal

#### Mandate of ATIC

- » To provide a single window delivery system for agricultural information as well as products and technologies developed by the research institute with a view to deliver quality services to the clientele.
- » To strengthen the farm advisory services by adopting a multi disciplinary approach to problem solving.
- » To provide mechanism for feedback from the end users to the research system.
- » To function as a repository of agricultural information pertaining to farming skills and practices, farm inputs and agricultural education.

- » To offer consultancy services to the different stakeholders in the state.
- » To arrange training to unemployed youth to equip them to become job providers, rather than job seekers.

### Dissemination of Technological Information

Presently, ATIC NDRI is using following methods for dissemination of information to its users:

- » Personal interaction with visiting farmers.
- » Display of Models etc; organizing /participating in Melas and Exhibitions.
- » Audio/Video shows
- » Visits to Dairy farm
- » Information through toll free telephone number (1800-180-1199)
- » Providing Publications.
- » Providing material inputs like improved seed varieties, Vermi compost etc.
- » Through E-mail

#### Services Rendered in Agricultural Technology and Technology Products (01.04.2017 to 31.03.2018)

Sr. No.	Detail of services	No. of Services	No. of Persons
1.	Dairy/Agriculture Related Information through Video Show and Lecture	45	1363
2.	Personal Discussion with Subject-Matter-Specialist on Dairy Farming	76	150
3.	Information through Dairy/Agriculture Literature	82	88
4.	Information on Agriculture (Seed/Fertilizer/ Compost etc)	1794	1794
5.	Information through Relephone (Toll-free) on Agriculture & Dairying etc.	2901	2901
6.	Information through e-mail on Agriculture & Dairying etc.	144	144
	<b>Total</b>	<b>5045</b>	<b>6606</b>

### Trainings Conducted

Three training courses on Integrated Farmer System were conducted for Holistic Rural Development Program. A total number of 166 farmers including 55 farm women participated in the programme.



*Group Photo of farmers Exposure Visit*

### KRISHI AND DAIRY VIKASH KENDRA, PIPRAKOTHI

ICAR-NDRI established KDVK in KVK, Piprakothi, East Champaran, Bihar in the premises of Dr. Rajendra Prasad Central Agriculture University, Pusa. The centre was established on 10<sup>th</sup> July, 2016. Frozen Semen of Indigenous cattle, buffaloes and crossbred bull was distributed to the AI technicians of the region for breed improvement programme.

### Training Programmes Organized at KVK, Piprakothi

Sl. No.	Date	Topic	Participants
1.	11 <sup>th</sup> - 13 <sup>th</sup> January, 2017	Commercial dairy farming and feed formulation.	88
2.	23 <sup>rd</sup> - 25 <sup>th</sup> February, 2017	Commercial dairy farming and reproduction management.	5
3.	6 <sup>th</sup> - 8 <sup>th</sup> March, 2017	Feed formulation and balance Fraction for dairy animals.	39
4.	15 <sup>th</sup> - 16 <sup>th</sup> March, 2017	Dairy animal housing and feeding management for better milk production.	54
5.	30 <sup>th</sup> May - 1 <sup>st</sup> June, 2017	Commercial dairy farming and reproduction management.	56
6.	27 <sup>th</sup> - 29 <sup>th</sup> June, 2017	Milk and milk product processing.	24
7.	16 <sup>th</sup> - 18 <sup>th</sup> Sept., 2017	Commercial dairy farming and reproduction management.	70
<b>Total</b>			<b>243</b>

### Other Extension Activities

- » A Certificate Course on "Artificial Insemination and Veterinary First Aid was organized for 14 technicians working in Motihari districts from 18<sup>th</sup> July to 18<sup>th</sup> August, 2017.
- » Six scientists and technical officers of Eastern Campus, Kalyani with Director, NDRI, Karnal participated in Pashudhan Arogya Mela at Semuapur, Kesaria Block, Motihari during 28<sup>th</sup> - 29<sup>th</sup> October, 2017. An exhibition stall was also arranged to display the technologies and models developed by the Institute for the farmers. Scientists participated in the health camp organized in the mela. Extension literature and fodder seed was also distributed to the farmers.
- » KVK, Piprakothi participated in Pashudhan Arogya Mela, Gobindganj Block Araria and arranged health camp for the participated animals. Different varieties of hybrid Napier nursery were established in the KVK for demonstration and supply of saplings to farmers.
- » KVK, Piprakothi participated in 10 days flood relief camp in East Champaran District under the guidance of Hon'ble Agriculture Minister in the month of September, 2017.
- » A total number of 800 farmers visited the centre and took advice on treatment and animal management practices.
- » Piprakothi Centre supplied 2500 doses frozen semen of Sahiwal, Karan Fries and Murrah breed to AI workers.

### MODEL DAIRY CENTRE, LALUKHERI

Extension of dairy animal production practices is being performed through the service center of the institute at village Lalukheri in district Muzaffarnagar (UP). Frozen semen of elite bulls of dairy cows namely KF, Sahiwal, Tharparkar and Murrah buffaloes was provided to the dairy farmers for genetic improvement of their dairy animals for higher milk production. The farmers of this region were provided with quality fodder and cereal crops seeds for production of quality fodder for their dairy animals. A total number of 12000 doses of frozen semen and about 90 quintals seed of various fodder, oil and cereal crops were provided for the farmers. An animal fertility camp was organized at village Mindkali on 27<sup>th</sup> May, 2017.



*A buffalo brought for treatment in camp*

# WOMEN EMPOWERMENT AND MAINSTREAMING OF GENDER ISSUES

## Farmers' Farm School for Farm women

National Dairy Research Institute (NDRI) has started an ambitious programme wherein farmers of Haryana are being provided formal education in the field of Dairying, Horticulture and Agriculture through Farmers' Farm School. The 3<sup>rd</sup> Batch (August 2016 – July 2017) of this school was specially organized for farmwomen. Twenty farmwomen were enrolled and successfully completed the prescribed courses.



*NDRI Team with Farmwomen at Farmers' Farm School*

## Empowerment of Women through Socio-technological Interventions in Dairying: An Experimental Study in Karnal district of Haryana

The study was conducted in Pingli and Jundla villages of Karnal district to measure the performance of socio-technological interventions in dairying and the level of empowerment of women on account of interventions such as compound cattle feed preparation at the farm, preparation of milk and milk products, use of serrated sickle for fodder harvesting, California mastitis kit, hybrid napier cultivation and drudgery alleviating farm tools like milking stool, dung scraper etc carried out by NDRI could increase 20 to 30% income of the members of farmwomen in both the villages. Empowerment of women could be observed in terms of economic, social, technological and psychological indicators.

## Women Empowerment Laboratory, Dairy Extension Division

Women empowerment lab was established in Dairy Extension division in 2013 for capacity building of different Self Help Groups of NDRI, DRDA and NGOs. This lab was established with the objective to create awareness and impart skills in the field of dairy processing and fruit and vegetable preservation and also mobilize these groups to take up vocation in these areas. Regular women empowerment trainings and campaigns through this Women Empowerment laboratory were organized to create awareness among rural farmwomen.

Twelve on campus women empowerment-training programmes and demonstrations were organized and 235 number of farmwomen were benefitted.



*Hands on training on preparation of value added milk products being given to farmwomen*

#### Training Programmes organized for Farmwomen

Sr. No.	Title	Number of courses	No. of Participants
1.	Training programme on value added milk product for the members of the women SHG.	5	100
2	Training programme on value added milk products for village Dadupur.	1	20
3	Exposure cum skill up gradation training programme on preparation of value added milk products for farmwomen SHGs of forest circle, Pinjore.	1	20
4	Demonstration cum training programme on preparation of value added milk products for farmwomen of SHGs of Sahadpura village of Karnal district forest circle.	1	23
5	Capacity building of farmwomen on preparation of value added milk products for farmwomen from Nagla Jattan of Ambala district of Haryana.	1	20
6	Exposure cum skill upgradation training programme on preparation of value added milk produces for SHG of Behbalpur and Babahedi village of Ambala District.	1	20
7	Training programme on value added milk products for forest office circle Pinjore.	1	20
8	Training programme on value added milk products for farm women of Panipat & Karnal Districts.	1	12
	<b>Total</b>	<b>12</b>	<b>235</b>

#### On-Farm Trial Conducted in Home Science

An on-farm trials in preparation of Khoa by taking large quantity of milk in bulk and in small batch trials were conducted in the houses of 19 rural women. The Khoa was made by using different methods and the sensory evaluation of the samples was done by participants. It was inferred that Khoa prepared by batch method by taking small quantity of milk in each batch was found best in terms of flavour, body, texture and taste.

## Krishi Vigyan Kendra

### International Women Day Celebrated

International Women Day was celebrated in the village Rindal where more than 50 farmwomen participated. The subject matter specialists of KVK delivered lectures to the participants. Competition to assess the knowledge of farmwomen on agricultural and allied activities was also organized and winners were awarded.

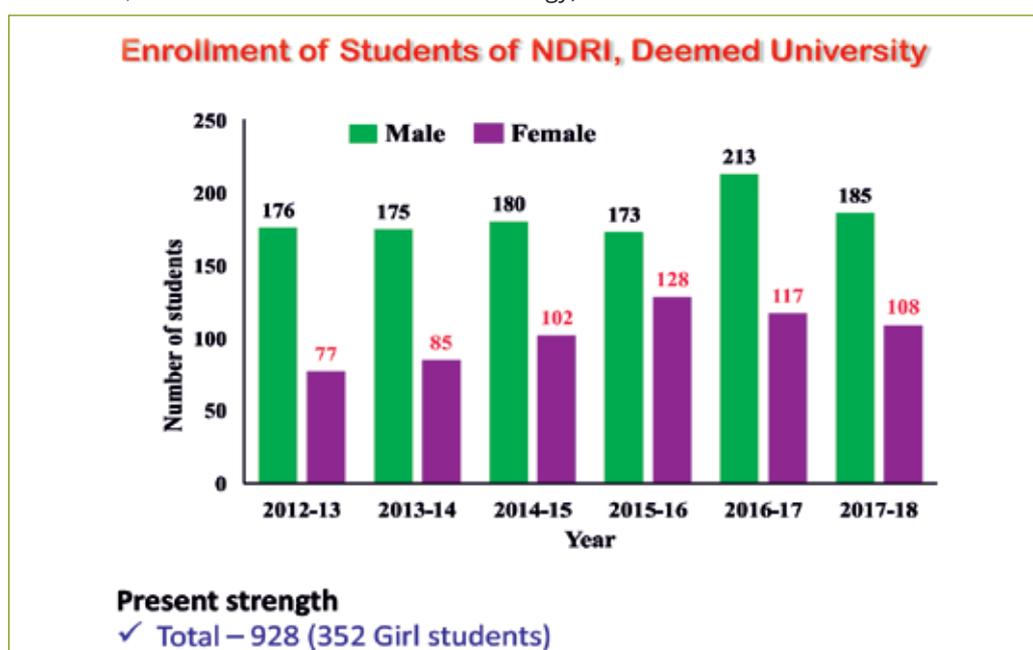


*A team of NDRI delivering lectures to farmwomen*

In addition to this, KVK also organized five short programmes on fruit and vegetable preservation, storage of cereals, women and child care and kitchen gardening for 120 rural women to empower them and encourage them to become self-reliant.

### Emphasis on Academic Empowerment

NDRI Deemed University makes all efforts to take care of its girl students. All the Girls' Hostels are well equipped with necessary facilities and have separate hostel wardens and girls sport advisor. The girl students are encouraged to participate in the students' council. This year, students' council of NDRI Deemed University is being led by girl student (Ms. Shivani, Ph.D. Student in Animal Biotechnology).



## HONOURS AND AWARDS

### National Awards

- » ICAR-National Dairy Research Institute, Karnal has been ranked first among all Agricultural Universities of India including 4 Deemed Universities. The award was received on 16<sup>th</sup> July, 2017 by **Dr. R. R. B. Singh**, Director and Vice Chancellor, ICAR-NDRI, Karnal at Delhi from **Sh. Radha Mohan Singh Ji**, Honorable Union Minister for Agriculture and Farmers' Welfare.



*Dr. R. R. B. Singh, Director and Vice Chancellor, ICAR-NDRI, Karnal receiving Best Institute Award from Sh. Radha Mohan Singh Ji, Hon'ble Union Minister for Agriculture and Farmers Welfare*

- » **Dr. A. Kumaresan**, Principal Scientist, Southern Campus of ICAR-NDRI, Bengaluru received “**Bharat Ratna Dr. C. Subramaniam Award**” for outstanding teachers 2016.



*Dr. A. Kumaresan, Principal Scientist, Southern Campus, Bengaluru receiving Bharat Ratna Dr. C. Subramaniam Award*

- » **Dr. Laxmana Naik N.**, Dairy Chemistry Division, ICAR-NDRI, Karnal received **“Jawaharlal Nehru Award For P.G. Outstanding Doctoral Thesis Research”** in Agricultural and Allied Sciences 2016.



*Dr. Laxmana Naik N. receiving Jawaharlal Nehru Award For P.G. Outstanding Doctoral Thesis Research*

- » **Dr. Shrabani Saugandhika, D.**, Animal Biotechnology Centre, ICAR-NDRI, Karnal received **“Jawaharlal Nehru Award For P.G. Outstanding Doctoral Thesis Research”** in Agricultural and Allied Sciences 2016.
- » **Dr. Ravi Prakash**, Ph.D. Scholar (Dairy Engineering), Southern Campus of ICAR-NDRI, Bengaluru received **“BIRAC-GYTI Award 2018”** for outstanding Doctoral Thesis Research from Hon'ble President of India. (Major Guide: Dr. Menon Rekha Ravindra)



*Dr. Ravi Prakash, receiving award from Hon'ble President of India*

- » **Ms. Prem Kumari Mehta**, Private Secretary, Dairy Technology Division, NDRI, Karnal received **“ICAR Cash Award Scheme 2016 for Administrative Category”** employees of ICAR on 16<sup>th</sup> July, 2017.



*Ms. Prem Kumari Mehta, Private Secretary receiving award*

- » **Sh. Kulvinder Singh**, Skilled Supporting Staff, Dairy Chemistry Division, NDRI Karnal received “**ICAR Cash Award Scheme 2016 for Supporting Category**” employees of ICAR on 16<sup>th</sup> July, 2017.



*Sh. Kulvinder Singh, Skilled Supporting Staff receiving award*

### Fellowships and Associateship of National Academy of Agricultural Societies

- » **Dr. Sunita Grover**, Head, Dairy Microbiology was conferred NAAS Fellowship on 5<sup>th</sup> June, 2017 on the Foundation day ceremony of Academy.



*Dr. Sunita Grover being felicitated with NAAS fellowship*

- » **Dr. R. R. B. Singh**, Director, NDRI, Karnal received “**Fellow of National Academy of Agricultural Sciences (India)**” from National Academy of Agricultural Sciences (India), NASC, DPS Marg, Pusa, New Delhi.
- » **Dr Rajan Sharma**, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal received “**Fellow of National Academy of Agricultural Sciences (India)**” from National Academy of Agricultural Sciences (India), NASC, DPS Marg, Pusa, New Delhi.
- » **Dr. Pradip V. Behare**, Principal Scientist, Dairy Microbiology Division, NDRI, Karnal was selected for “**National Academy of Agricultural Sciences Associateship**” on January, 2017.

### Institute Awards

- » **Dr Rajan Sharma**, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal received “**Best Teacher Award 2016-17**” on recommendation Academic Council, NDRI in recognition of contribution in teaching during 16<sup>th</sup> Convocation organized at NDRI, Karnal on 10<sup>th</sup> March 2018.
- » **Dr. Suneel Kumar Onteru**, Sr. Scientist, Animal Biochemistry Division, NDRI, Karnal received “**Dr. S. K. Sirohi Memorial Outstanding Young Researcher Award**” by National Dairy Research Institute for the year 2018.
- » **Ms. Priyanka Saini**, Ph.D. Scholar (Dairy Microbiology) received “**Best Ph.D. Thesis Award**” of ICAR-NDRI (Deemed University) in Dairy Processing group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.
- » **Ms. Rani Alex**, Student, Southern Campus of ICAR-NDRI, Bengaluru was awarded “**Best Thesis Award**” in production group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.

- » **Mr. Bishwa Bhaskar Choudhary**, Ph.D. Scholar, DESM Division was awarded "**Best Ph.D. Thesis Award**" in Social Science and Management group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.
- » **Ms. Shruti Shandilya**, Student (Animal Biochemistry) received "**Best Master Thesis Award**" of ICAR-NDRI (Deemed University) in Dairy Processing group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.
- » **Mr. Vikash Kumar**, Student (Dairy Extension) received "**Best Master Thesis Award**" of ICAR-NDRI (Deemed University) in Social Science and Management group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.
- » **Ms. Swathi P. Anand**, M. Tech. Student (Dairy Microbiology) received "**Best M. Tech. Thesis Award**" of ICAR-NDRI (Deemed University) in Dairy Processing group during 16<sup>th</sup> Convocation of ICAR-NDRI, Karnal.

### Professional Societies Awards

- » **Dr. Rajan Sharma**, Principal Scientist (SS), **Dr. Y. S. Rajput**, Principal Scientist, and **Dr. Bimlesh Mann**, Head, Dairy Chemistry Division, NDRI, Karnal received "**Low Cost Technology Development Award-2016**" from Association of Food Scientist & Technologies (India), Mysore (ICFoST 2017) held from 7<sup>th</sup> - 9<sup>th</sup> December 2017 at Hyderabad.
- » **Dr. R. K. Malik**, Emeritus Scientist and **Dr. Latha Sabikhi**, Head, Dairy Technology Division, NDRI, Karnal received "**Fellowship of the Indian Dairy Association**", 2017-18.
- » **Dr. K. Ponnusamy**, Principal Scientist, Dairy Extension Division, NDRI, Karnal was conferred "**ISEE Fellow Award**" during National Seminar on "Doubling Farmers' Income and Farm Production through Skill Development and Technology Application" at Bihar Agricultural University, Sabour, Bhagalpur, Bihar organised by Indian Society of Extension Education (ISEE) from 28<sup>th</sup> - 30<sup>th</sup> November, 2017.
- » **Dr. M. K. Singh**, Scientist, Animal Biotechnology Centre, NDRI, Karnal received "**Prof. G. P. Talwar Young Scientist Award-2018**" by the Indian Society for the Study of Reproduction and Fertility (ISSRF) on 23<sup>rd</sup>-25<sup>th</sup> February, 2018 at Hyderabad.
- » **Dr. F. Magdaline Eljeeva Emerald**, Sr. Scientist, Southern Campus of ICAR-NDRI, Bengaluru was selected as Distinguished Woman in Engineering (Specialization - Agricultural Engineering) of the Venus International Women Awards-VIWA 2018 on 3<sup>rd</sup> March, 2018 at Radha Regent, Chennai.
- » **Dr. M. L. Kamboj**, Principal Scientist, Livestock Production and Management Section, NDRI, Karnal received "**Developing Countries Congress Attendance Fund**" by the International Society for Applied Ethology (ISAE) for attending its 51<sup>th</sup> Congress at Aarhus, Denmark from 7<sup>th</sup> -10<sup>th</sup> August, 2017.
- » **Dr. Nishant Kumar**, Scientist, Livestock Production and Management Section, NDRI, Karnal received "**Excellence in Teaching Award**" by Samagra Vikas Welfare Society (SVWS), Lucknow on occasion of National Seminar on Farmer centric Cinema organized by SVWS and ICAR—IISR, Lucknow from 14<sup>th</sup>-16<sup>th</sup> October 2017.
- » **Dr. M. Bhakat**, Scientist, Artificial Breeding Research Centre, NDRI, Karnal received "**Faculty Research Award**" one among the top 10 "**Most Outstanding Researchers**" in the field of Veterinary in India on 20<sup>th</sup> of **March 2018 at New Delhi** by Careers360 The Education Hub.
- » **Dr. T. K. Mohanty**, Principal Scientist, Artificial Breeding Research Centre, NDRI, Karnal received "**Faculty Research Award**" one among the top 10 "Most outstanding Researchers" in the field of Veterinary in India on 20<sup>th</sup> **March 2018 at New Delhi** by Careers360 The Education Hub.
- » **Ms. M. Umamageswari**, Student, **Dr. P. K. Dixit**, Principal Scientist and **Dr. M. Sivaram** Principal Scientist Southern Campus of ICAR-NDRI, Bengaluru were awarded "**Bir Singh Aasi Memorial All India Best Publication Awards 2016**" awarded by SADHNA (Society for Advancement of Human and Nature), Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan 173 230 Himachal Pradesh, India, during April 2017.

### Other Awards won by Students

- » **Mr. M. A. Mir**, Student, Animal Genetics & Breeding Division, NDRI, Karnal received "**Young Scientist Scholarship**" for attending 11<sup>th</sup> World Congress on Genetics Applied to Livestock production (WCGALP) to be held at Auckland in February, 2018.
- » **Mr. Shubham Chaturvedi**, M.Tech. (Dairy Technology) II year Student bagged "**First Prize in 'Brain-omania: The Quiz**" on World Food Day organized by Shaheed Rajguru College of Applied Sciences for Women, University of Delhi.
- » **Mr. Shubham Chaturvedi**, M.Tech. (Dairy Technology) II year Student received "**First Prize in 10<sup>th</sup> National Dairy and Food Quiz Contest-2017**" organized by SMC College of Dairy Science, Anand Agricultural University, Gujarat.

- » **Mr. Navan Sampath Kumar, Mr. Suvartan Ranvir, Ms. Sulaxana, Ms. Ankita Hooda and Mr. Shridhar Sameta** students (Master and Ph.D.) of Dairy Chemistry Division, NDRI, Karnal received "**3<sup>rd</sup> Prize**" in Nutrischolar Awards 2017 organized by DuPont at New Delhi (**Mentor: Dr. Bimlesh Mann**).



*Dr. R. R. B. Singh, Director, NDRI with students of Dairy Chemistry Division received 3rd Prize in Nutrischolar Awards 2017*

- » **Mr. Shivam Pawar**, M.Tech. (Dairy Technology) II year Student received "**First Best Project Award**" under the *Engineering & Technology* category at Students Research Convention (North Zone) (ANVESHAN-2018) held at Manav Rachna International Institute for Research and Studies, Faridabad during 26<sup>th</sup> -27<sup>th</sup> February 2018 and represented National Research Convention held at Chitkara University, Rajpura during 15<sup>th</sup> -16<sup>th</sup> March, 2018.
- » **Mr. Saniket Deepak Zagade**, M.Tech. (Dairy Technology) II year Student received "**Second Best Project Award**" under the Basic Sciences category at Students Research Convention (North Zone) (ANVESHAN-2018) held at Manav Rachna International Institute for Research and Studies, Faridabad during 26<sup>th</sup> -27<sup>th</sup> February 2018 and represented National Research Convention held at Chitkara University, Rajpura during 15<sup>th</sup> -16<sup>th</sup> March, 2018.

### Rajbhasha Puraskar

- » **Dr. A. K. Roy**, Sr. Scientist, Animal Physiology Division, NDRI, Karnal got "**Rajbhasha Puraskar (Third Prize)**" for doing official work in Hindi.
- » **Dr. Nishant Kumar**, Scientist, Livestock Production and Management Section, NDRI, Karnal received "**2<sup>nd</sup> Prize**" in poster competition in Raashtriya Sangosthi Sah Kaarya shaalaa organized by Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh on 23<sup>rd</sup> October, 2017.
- » **Dr. Nishant Kumar**, Scientist, Livestock Production and Management Section, NDRI, Karnal received "**Protsaahan Puraskaar**" for the hindi book Dairy Pashu Prajanan: Samasyaaein ewam Prabandhan by Rajbhashaa Vibhaag, NDRI, Karnal.

National Referral Centre for Milk Quality and Safety (NRCMQS), ICAR-National Dairy Research Institute, Karnal had been granted accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL) in the discipline of Chemical Testing. The lab has been accredited for two years and accreditation is valid till 21<sup>st</sup> March, 2020.

- » **Dr. Chitranayak**, Sr. Scientist, Dairy Engineering Division, NDRI, Karnal got **Six-TOLIC-NDRI (ICAR) Awards** for Hindi- 1. First prize for Hindi-Essay at NDRI, Karnal, 2. ICAR-CSSRI, Tippi Mausda lekhan- Second prize, 3. MSME-TOLIC, Hindi Nibandh- Second Prize, 4. NDRI-TOLIC, First Prize in Hindi Shruti Lekhan, 5. NDRI-TOLIC, Hindi prashashnik shabdawali and vakyansh- Third prize, 6. NDRI-TOLIC, Rajbhasha Gyan-Third Prize.
- » **Dr. Chitranayak**, Sr. Scientist, Dairy Engineering Division, NDRI, Karnal got "**Three-Hindi Awards**" at Institute-level in ICAR-NDRI competitions 1. Mool Hindi Tippan evam Aalekhan-Third Prize, 2. Hindi Tankan-Consolation Prize, 3. Hindi Prashnottari- Second Prize.
- » **Dr. Latha Sabikhi**, Head, Dairy Technology Division, NDRI, Karnal bagged "**First Prize**" in the Hindi Paragraph and Shrutlekhan Pratiyogita and **Mrs. Prem Mehta**, Pvt. Secy., Dairy Technology Division bagged "**First Prize**" in the Hindi Muhavara/Lokokti Lekhan Pratiyogita organized by the Karnal Town Official Language Implementation Council on 1<sup>st</sup> December, 2017.

- » **Mr. Bhavesh Baria**, Ph.D. Scholar, **Dr. Neelam Upadhyay**, Scientist, **Dr. A. K. Singh**, Principal Scientist, Dairy Technology Division and **Dr. R. K. Malhotra**, Principal Scientist, Dairy Economics Statistics & Management Division received "**First Prize**" during Research Poster Competition held at Hindi Chetana Mass on 20<sup>th</sup> September, 2017 at NDRI Karnal.
- » **Dr. Ankit Deep**, Scientist, **Dr. P. Barnwal**, Principal Scientist, **Dr. A. K. Dodeja**, Principal Scientist, Dairy Engineering Division, NDRI, Karnal received "**Second Prize**" for Technical Article in Hindi instituted by Official Language Unit, ICAR-NDRI, Karnal in year 2017-18.

### Best Paper/Poster Awards

- » **Dr. Sanjit Maiti**, Scientist, Dairy Extension Division, NDRI, Karnal received "**IAMP-Gang-Mana Sharma Award-2016**" for the short communication on the pack animals during the Asian Veterinary Pathology Conference held at Veterinary College Bengaluru during 9<sup>th</sup> - 11<sup>th</sup> November, 2017.
- » **Dr. Narender Raju Panjagari**, Scientist, Dairy Technology Division, NDRI, Karnal received "**Best e-Poster Award**" at the 46<sup>th</sup> Dairy Industry Conference held at Kochi, Kerala during 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Dr. Mohan, Mondal**, Senior Scientist, Eastern Campus of ICAR-NDRI, Kalyani received "**Best Paper Presentation Award**" presented in the National seminar on "Opportunities and challenges of translational research in the frontier areas of animal Biotechnology" and V Annual convention of "Society of veterinary science and biotechnology" held at College of veterinary science and animal husbandry of OUAT, Bhubaneswar during 22<sup>nd</sup> - 23<sup>rd</sup> September, 2017.
- » **Dr. S. Rai**, Scientist, Eastern Campus of ICAR-NDRI, Kalyani received "**Best Oral Presentation Award**" in International Conference on 'Integrating Climate – The Emerging Areas of Agriculture, Horticulture, Biodiversity, Forestry: Engineering Technology, Fundamental/ Applied Science and Business Management for Sustainable Development' held on 11<sup>th</sup> - 12<sup>th</sup> May 2017 at Kalimpong Science Centre, Kalimpong, West Bengal.
- » **Dr. S. Rai**, Scientist, Eastern Campus of ICAR-NDRI, Kalyani received "**Best Oral Presentation Award**" on 'Innovative Farming for Food and Livelihood Security in Changing Climate' in 1<sup>st</sup> Farm Innovative Congress and National Conference on 12<sup>th</sup> -13<sup>th</sup> January, 2018, jointly organized by Innovative Farming Society for Advancement of Agricultural Innovation (SAAI) and AICRP on Soil Test Crop Response Correlation, Directorate of Research, BCKV, West Bengal.
- » **Dr. M. Bhakat**, Scientist, Artificial Breeding Research Centre, NDRI, Karnal received "**Best Oral Paper Presentation Award**" at 9<sup>th</sup> Asian Buffalo Congress, organized by ICAR-CIRB, Hisar, Haryana from 1<sup>st</sup> – 4<sup>th</sup> February, 2018.
- » **Dr. M. Bhakat**, Scientist, Artificial Breeding Research Centre, NDRI, Karnal received "**Best Oral Paper Award**" at International Conference on "Recent trends in bioinformatics and biotechnology for sustainable development" in collaboration with society for bioinformatics and biological sciences (SBBS) from 12<sup>th</sup> - 13<sup>th</sup> October, 2017.
- » **Dr. Mohan Mondal**, Senior Scientist, Eastern Campus of ICAR-NDRI, Kalyani received "**First Prize**" for the Best Poster Presentation presented in the National Seminar on A Dairy Snapshot-2017 held on 5<sup>th</sup> August, 2017, at Faculty of Dairy Technology, WBUAFS, Mohanpur Campus.
- » **Dr. P. S. Minz**, Sr. Scientist, **Dr. I. K. Sawhney**, Emeritus Scientist **Dr. C. S. Saini**, **Dr. A. K. Singh**, Principal Scientist and **Dr. Chitranayak**, Sr. Scientist, Dairy Engineering Division, NDRI, Karnal received "**Best Poster Second Award**" during National Conference on Emerging and Sustainable Technologies in Food Processing organized by Department of Food Engineering and Technology at SLIET (Sant Longowal Institute of Engineering and Technology), Longowal, Sangrur (Punjab) during 15<sup>th</sup>-16<sup>th</sup> March, 2018.
- » **Dr. Ankit Deep**, Scientist and **Dr. P. Barnwal**, Principal Scientist, Dairy Engineering Division, NDRI, Karnal received "**First Prize for Oral Presentation**" in International Conference on "Bio and Nano Technologies for Sustainable Agriculture, Food, Health, Energy and Industry (ICBN-2018)" held at Guru Jambheshwar University of Science and Technology, Hisar, Haryana during 21<sup>st</sup> – 23<sup>rd</sup> February, 2018.
- » **Mr. Shivam Panwar**, M.Tech., 2<sup>nd</sup> year student and **Dr. Narender Raju Panjagari**, Scientist (Sr. Scale) of Dairy Technology Division, NDRI, Karnal bagged "**2<sup>nd</sup> Best Poster Award**" at International Symposium for Packaging Industry (ISPI) Research Conclave organized by Indian Institute of Packaging, New Delhi during 27<sup>th</sup> – 28<sup>th</sup> October 2017.
- » **Ms. Aneet Kour**, **Dr. A. K. Chakravarty**, **Mr. Varinder Raina**, **Ms. Poonam Ratwan** and **Mr. Arun Pratap Singh**, Animal Genetics & Breeding Division, NDRI, Karnal got "**Best Poster Award**" at International Conference

on “Recent Trends in Bioinformatics and Biotechnology for Sustainable Development” held at SKUAST Jammu from 12<sup>th</sup> -13<sup>th</sup> October, 2017.

- » **Ms. Ankita Hooda**, Student, **Dr. Bimlesh Mann**, Head and **Dr. Rajan Sharma**, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal received “**Best Poster Award**” for the poster presented in the 26<sup>th</sup> Indian Convention of Food Scientists and Technologists (ICFoST 2017) held from 7<sup>th</sup> - 9<sup>th</sup> December, 2017 at Hyderabad organised by Association of Food Scientist & Technologies (India), Mysore.
- » **Mr. Ankit Magotra**, Student, **Dr. I. D. Gupta**, Principal Scientist, **Dr. A. Verma**, Principal Scientist, **Ms. Alex Rani**, Student, **Dr. M. R. Vineeth**, Student and **Dr. Ahmed Tavsief**, Student, Animal Genetics & Breeding Division, NDRI, Karnal received “**Oral Presentation Award**” at International conference on “Recent trends in bioinformatics and biotechnology for sustainable development” organised by SBBS. Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu from 12<sup>th</sup>-13<sup>th</sup> October, 2017.
- » **Ms. Ekta Rana**, Student, **Dr. Ashok Kumar Gupta**, Principal Scientist, **Dr. Anand Prakash Ruhil**, Principal Scientist, **Dr. Ravinder Malhotra**, Principal Scientist, **Dr. Saleem Yousuf**, Student and **Dr. T. Karuthadurai**, Student, NDRI, Karnal received “**Best Poster Award**” during at National Symposium on Sustainable Management of Livestock and Poultry Diversity for enhancing the Farmers’ Income & XV Annual Convention of SOCDAB organized by Rajasthan University of Veterinary and Animal Sciences, Bikaner and SOCDAB, NBAGR, Karnal from 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Ms. D. Dua**, Student, Animal Biotechnology Centre, NDRI, Karnal received “**Certificate of Merit**” at the National Seminar on Small Ruminants: National Scope on Up-Scaling Production to Products Value Addition and their Safety held at ICAR-Central Institute for Research on Goats, Makhdoom, Mathura from 9<sup>th</sup> -10<sup>th</sup> November, 2017.
- » **Mr. Azmal Ali**, Student received “**Young Scientist Award**” during 4<sup>th</sup> International Conference on Emerging Trends in Protein Science and Proteomics from 15<sup>th</sup>-16<sup>th</sup> September, 2017 held at Invertis University, Bareilly.
- » **Ms. S. V. Aparna**, Student, Dairy Microbiology Division, NDRI, Karnal awarded “**Young Investigator Award (YIA)**”, 2<sup>nd</sup> prize for her presentation at 4<sup>th</sup> Biennial Conference of Probiotic Association of India (PAI) and International Symposium on Probiotic Therapy: Translating to Health and Clinical Practice, held at All India Institute of Medical Sciences(AIIMS), New Delhi (16<sup>th</sup>-17<sup>th</sup> February, 2018).



*Dr. A. K. Srivastava, Chairman, ASRB, New Delhi giving award to Ms. S. V. Aparna*

- » **Ms. Ankita Hooda**, Student, **Dr. Bimlesh Mann**, Head, **Dr. Rajan Sharma**, Principal Scientist, **Mr. Suvartan Ranvir**, Student and **Ms. Sulaxana Singh**, Student, Dairy Chemistry Division, NDRI, Karnal received “**First Prize**” for the poster at National Conference on Emerging and Sustainable Technologies in Food Processing (ESTFP-2018) at Sant Longowal Institute of Engineering & Technology, Longowal, Sangrur during 15<sup>th</sup> -16<sup>th</sup> March, 2018.
- » **Ms Sonia Mor**, Student, **Dr. Vivek Sharma**, Principal Scientist and **Dr. Sumit Arora** Principal Scientist Dairy Chemistry Division, NDRI, Karnal received “**First Prize in the E-poster Presentation**” in the 46<sup>th</sup> Dairy Industry Conference 2018, held at Angamaly, Kochi Kerela from 8<sup>th</sup> - 10<sup>th</sup> February, 2018.
- » **Ms. Alka Parmar**, Student, **Dr. Vivek Sharma**, Principal Scientist and **Dr. Sumit Arora**, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal received “**Second Prize**” in the technical session (Poster) at National Conference

on “Emerging and Sustainable Technologies in Food Processing (ESTFP- 2018) held at Sant Longowal Institute of Engineering and Technology (Deemed University) Longowal from 15<sup>th</sup> – 16<sup>th</sup> March, 2018.

- » **Ms. Seema Rani**, Student, **Mr. H. Bodemala**, Student, **Dr. Sumit Arora**, Principal Scientist and **Dr. Vivek Sharma**, Principal Scientist, Dairy Chemistry Division, NDRI, Karnal received “**First Prize**” in the technical session (Poster) at National Conference on “Emerging and Sustainable Technologies in Food Processing (ESTFP- 2018) held at Sant Longowal Institute of Engineering and Technology ( Deemed University) Longowal from 15<sup>th</sup> – 16<sup>th</sup> March, 2018.
- » **Ms. Sonia Mor**, Student, **Dr. Vivek Sharma**, Principal Scientist, **Dr. Sumit Arora** Principal Scientist, Dairy Chemistry Division, NDRI, Karnal and **Dr. P. S. Minz**, Scientist, Dairy Engineering Division, NDRI, Karnal received “**Third Best Poster Award**” for the poster presented in National Conference on “Contemporary food processing and preservation technologies” from 12<sup>th</sup>-13<sup>th</sup> April, 2018 at School of Bioengineering & Food Technology, Shoolini University, Solan (HP).
- » **Dr. B. Chandrasekhar**, Student, Dairy Microbiology Division, NDRI, Karnal received “**Young Investigator Award (YIA)**”, for his oral presentation at 4<sup>th</sup> Biennial Conference of Probiotic Association of India (PAi) and International Symposium on Probiotic Therapy: Translating to Health and Clinical Practice, held at All India Institute of Medical Sciences (AIIMS), New Delhi (16<sup>th</sup>-17<sup>th</sup> February, 2018).
- » **Mr. P. S. Patil**, Student received “**2<sup>nd</sup> Prize in Oral Presentation**” at National Conference on “Advances in food science and technology current trends and future perspectives (AFST-2017)” held at Eternal University, Baru Sahib, Himachal Pradesh (India), 24<sup>th</sup> – 25<sup>th</sup> March, 2017.
- » **Mr. C. Goyal**, Student, **Dr. S. K. Tomar**, Principal Scientist **Dr. R. K. Malik**, Emeritus Scientist and **Dr. S. De** Principal Scientist received “**Second Prize for Poster**” presented in the 46<sup>th</sup> Dairy Industry Conference held at Angamaly, Kochi, Kerala from 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Ms. Rajashree Jena**, Student, **Dr. P. K. Choudhury**, **Dr. R. K. Malik**, Emeritus Scientist, **Dr. A. K. Puniya**, Principal Scientist and **Dr. S. K. Tomar** Principal Scientist, Dairy Microbiology Division, NDRI, Karnal received “**Second Prize for Poster**” presented in the 46<sup>th</sup> Dairy Industry Conference held at Kochi, Kerala from 8<sup>th</sup>-10<sup>th</sup> February, 2018.
- » **Mr. Ravi Prakash**, Ph.D. Scholar, Southern Campus of ICAR-NDRI, Bengaluru received “**Best Oral Presentation Paper Award**” presented at International Conference on Food Processing and Agribusiness “Emerging Trends” held on 18<sup>th</sup> -19<sup>th</sup> January, 2018 at Indian Institute of Plantation Management Bengaluru.
- » **Ms. Vankayala Jaya Sravani**, Student, Southern Campus of ICAR-NDRI, Bengaluru received “**Best Oral Presentation Paper Award**” presented at “International Conference on Food Processing and Agribusiness (ICFPA)-18” during 18<sup>th</sup>-19<sup>th</sup> January, 2018.
- » **Mr. M. Krishnadas**, Student, **Dr. P. K. Dixit**, Principal Scientist, **Dr. M. Sivaram**, Principal Scientist and **Dr. M. C. A. Devi**, Principal Scientist, Southern Campus of ICAR-NDRI, Bengaluru were awarded “**Second Best Paper Award**” awarded by Indian dairy Association , New Delhi, 10<sup>th</sup> February, 2018 at 46<sup>th</sup> DIC, held at Kochi.
- » **Mr. Bhopal Singh**, Student, **Dr. Kaushik Khamrui**, Principal Scientist, **Dr. Writdhama Prasad**, Scientist and **Dr. Anindita Debnath** received “**Best Poster Award**” presented at 46<sup>th</sup> Dairy Industry Conference, organized by IDA-South zone, Kochi during 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Mr. Shamim Hussain**, M.Tech. (Dairy Technology) II year Student bagged “**Second Best Poster Award**” presented at the 46<sup>th</sup> Dairy Industry Conference held at Kochi during 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Mr. Ganesh Saswade**, M. Tech.(Dairy Technology) II year Student bagged “**Third Best Poster Award**” presented at the 46<sup>th</sup> Dairy Industry Conference held at Kochi during 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Ms. Swati Tiwari**, Student received “**Best Oral Presentation Award**” at XXXII Biennial Conference of Home Science Association of India organized by Home Science Association of India, Udaipur Chapter at College of Home Science, Maharana Pratap University of Agriculture and Technology, Udaipur (Raj.).
- » **Ms. Swati Tiwari**, Student received “**First Prize in the E-poster Presentation**” during 46<sup>th</sup> Dairy Industry Conference held at Kochi during 8<sup>th</sup> -10<sup>th</sup> February, 2018.
- » **Ms. P. Vats**, Student, Animal Biotechnology Centre, NDRI, Karnal received “**Young Scientist Award**” at the National Seminar on Small Ruminants: National Scope on Up-Scaling Production to Products Value Addition and their Safety held at ICAR-Central Institute for Research on Goats, Makhdoom, Mathura from 9<sup>th</sup>-10<sup>th</sup> November, 2017.



## PUBLICATIONS

### Research Papers and Review Articles

Sr. No.	Research Papers	NAAS Rating
1	Mahesh, M. S. and Thakur, S. S. (2017) Rice gluten meal, an agro-industrial byproduct, supports performance attributes in lactating Murrah buffaloes ( <i>Bubalus bubalis</i> ). <i>J. Cleaner Prod.</i> , <a href="https://doi.org/10.1016/j.jclepro.2017.12.206">https://doi.org/10.1016/j.jclepro.2017.12.206</a> .	10.96
2	Magdaline Eljeeva Emerald, F., Heartwin A. Pushpadass, Kumar, Braj, Kulkarni, Satish, Ruckmani, K., Ponnusami, V. and Palanimuthu (2017) Physico-chemical, thermal and microstructural properties of commercial <i>Curcuma angustifolia</i> starch. <i>Food Hydrocolloids</i> , 67: 27-36.	10.75
3	Gupta, Chitra, Arora, Sumit, Syama, M. A. and Sharma, Apurva (2017) Preparation of milk protein- Vitamin A complexes and their evaluation for vitamin A binding ability. <i>Food Chemistry</i> , 237: 141-49.	10.53
4	Naik, L., Sharma, R., Mann, B., Lata, K., Rajput, Y. S. and Nath, B. S. (2017) Rapid screening test for detection of oxytetracycline residues in milk using lateral flow assay. <i>Food Chemistry</i> , 219: 85-92.	10.53
5	Shri, M., Agrawal, H., Rani, P., Singh, D., and Onteru, S. K. (2017) Hanging drop, a best three-dimensional (3D) culture method for primary buffalo and sheep hepatocytes. <i>Scientific Reports</i> , 7 (1): 1203.	10.259
6	Sheikh, Aasif Ahmad, Hooda, Om Kanwar and Dang, A. K. (2017) JAK3 and PI3K mediate bovine Interferon-tau stimulated gene expression in the blood neutrophils. <i>J. Cellular Physiology</i> , 11/2017; <a href="https://doi.org/10.1002/jcp.26296">https://doi.org/10.1002/jcp.26296</a> .	10.15
7	Sharma, D., Golla, N., Singh, D. and Onteru, S. K. (2018) A highly efficient method for extracting next-generation sequencing quality RNA from adipose tissue of recalcitrant animal species. <i>J. Cellular Physiology</i> . <a href="https://doi.org/10.1002/jcp.25951">https://doi.org/10.1002/jcp.25951</a> .	10.08
8	Singh, T. P., Kaur, G., Kapila, S., Malik, R. K. (2017) Antagonistic activity of <i>Lactobacillus reuteri</i> strains on the adhesion characteristics of selected pathogens. <i>Front Microbiol.</i> , <a href="https://doi.org/10.3389/fmicb.2017.00486">https://doi.org/10.3389/fmicb.2017.00486</a> .	10.08
9	Thakur, K., Tomar, S. K. and Wei, Z. (2017) Comparative mRNA expression profiles of riboflavin biosynthesis genes in <i>Lactobacilli</i> isolated from human faeces and fermented bamboo shoots. <i>Front Microbiol.</i> , <a href="https://doi.org/10.3389/fmicb.2017.00427">https://doi.org/10.3389/fmicb.2017.00427</a> .	10.08
10	Yadav, M., Agrawal, H., Pandey, M., Singh, D. and Onteru, S. K. (2017) Three-dimensional culture of buffalo granulosa cells in hanging drop mimics the preovulatory follicle stage. <i>J. Cellular Physiology</i> . <i>J. Cell Physiol.</i> , 233 (3) : 1959-70.	10.08
11	Kaur, G., Ali, S. A., Kumar, S., Mohanty, A. K. and Behare, P. V. (2017) Label-free quantitative proteomic analysis of <i>Lactobacillus fermentum</i> NCDC 400 during bile salt exposure. <i>J. Proteomics</i> , 7: 36-45. <a href="https://doi.org/10.1016/j.jprot.2017.08.008">https://doi.org/10.1016/j.jprot.2017.08.008</a>	9.91
12	Parijat, P., Gurjeet, K., Ali, A. A., Bhatla, S., Rawat, P., Lule, V., Kumar, S., Mohanty, A. K. and Behare, P. V. (2017) High-resolution mass spectrometry-based global proteomic analysis of probiotic strains <i>Lactobacillus fermentum</i> NCDC 400 and RS2. <i>J. Proteomics</i> , 152: 121-30.	9.91
13	Maiti, S., Jha, S. K., Garai, S., Nag, A., Bera, A. K., Paul, V., Upadhaya, R. C. and Deb, S. M. (2017) An assessment of social vulnerability to climate change among the districts of Arunachal Pradesh, India. <i>Ecological Indicators</i> , 77 : 105-13.	9.90
14	Sayed, A. A., Kaur, G., Malakar, D., Kaushik, J. K., Mohanty, A. K. and Kumar, S. (2017) Examination of pathways involved in leukemia inhibitory factor (LIF)-induced cell growth arrest using label-free proteomics approach. <i>J. Proteomics</i> , 168: 37-52.	9.87

Sr. No.	Research Papers	NAAS Rating
15	Baddela, V. S., Onteru, S. K. and Singh, D. (2017) A syntenic locus on buffalo chromosome 20: Novel genomic hotspot for miRNAs involved in follicular-luteal transition. <i>Functional &amp; Integrative Genomics</i> , 17 (2-3): 321-34.	9.49
16	Kumar, S., Kumar, M., Dholpuria, S., Sarwalia, P., Batra, V., De, S., Kumar, R. and Datta, T. K. (2017) Transient arrest of germinal vesicle breakdown improved <i>in vitro</i> development potential of buffalo ( <i>Bubalus bubalis</i> ) oocytes. <i>J. Cellular Biochemistry</i> , 119 (1): 278-89.	9.45
17	Pandey, M., Singh, D., Onteru, S. K. (2017) Reverse Transcription-Loop mediated isothermal amplification (RT-LAMP), a light for mammalian transcript analysis in low-input laboratories. <i>J. Cell Biochem.</i> 20. <a href="https://doi.org/10.1002/jcb.26624">https://doi.org/10.1002/jcb.26624</a> .	9.44
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Sr. No.	Research Papers	NAAS Rating
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148	Kumar, Jitender, Swain, Dilip Kumar, Singh, Shanker K., Sirohi, Rajneesh, Dang, Ajay Kumar (2017) Molecular insights into the neutrophils activation in zebu cattle during seasonal variation. <i>Biological Rhythm Res.</i> , 48 (4): DOI:10.1080/09291016.2017.1287818.	6.70
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Sr. No.	Research Papers	NAAS Rating
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160	Abdulah, M., Mohanty, T. K., Bhakat, M., Kumaresan, A., Patbandha, T. K., Madkar, A. R. and Mohanty, A. K. (2017) Metabolic indicators for early pregnancy in zebu and crossbred dairy cows reared in a subtropical climate. <i>Turkish J. Vety. and Anim. Sci.</i> , 41(3): 407-13.	6.45
161	Kumar, Muneendra, Kaur, H., Mani, V., Deka, R. S., Tyagi, A. K., Chandra, G., Dang, A. K., Kushwaha, R. (2017) Supplemental chromium in cold-stressed buffalo calves ( <i>Bubalus bubalis</i> ): Effects on growth performance, nutrient utilization and cell mediated and humoral immune response. <i>Veterinarski Arhiv.</i> , 87 (4): 441-56.	6.32
162	Kumar, S., Dholpuria, S., Chaubey G. K., Kumar, R. and Datta, T. K. (2018). Assessment of nuclear membrane dynamics using anti-lamin staining offers a clear cut evidence of germinal vesicle breakdown in buffalo oocytes. <i>Cytology and Genetics</i> , 52: 80-85.	6.32
163	Ramesha, K. P., Alex, R., Rao, A., Basavaraju, M., Haritha, P., Geetha, G. R. (2017) Status of genetic disorders among indigenous and crossbred breeding bulls in India. <i>Indian J. Biotech.</i> , 16: 138-140.	6.29
164	Vairat, A. D., Mani, I., and Samuel, D. V. K. (2017) Influence of extrusion conditions on system responses during twin screw extrusion of barnyard millet based extrudate. <i>Indian J. Agril. Sci.</i> , 87 (12): 1714-19.	6.22
165	Alex, Rani, Ramesha, K. P., Singh, Umesh, Kumar, Sushil, Alyethodi, R. Rafeeqe, Deb, Rajib, Sharma, Sheetal, Sengar, S. Gyanendra, Ashish and Prakash, B. (2017) Genomic variations in the 2'-5' oligoadenylate synthetase 1 (OAS1) gene in zebu cattle and its crossbreds of Indian origin. <i>Indian J. Anim. Sci.</i> , 87 (11): 1367-74.	6.19
166	Fahim, A., Kamboj, M. L., Prasad, S., Sirohi, A. S., Bhakat, M., Mohanty, T. K. and Malhotra, R. (2017) Effect of parity, stage of lactation and udder type on milk ability of crossbred dairy cows milked in automated Herringbone milking parlour. <i>Indian J. Anim. Sci.</i> , 87 (6): 97-103.	6.19
167	Fahim, A., Kamboj, M. L., Sirohi, A. S., Bhakat, M. and Mohanty, T. K. (2017) Factors affecting milk quality of crossbred dairy cows in automated Herringbone milking system. <i>Indian J. Anim. Sci.</i> , 87 (11): 1396-1401.	6.19
168	Kant, Kamala, Sankhala, Gopal, Prasad, Kamta and Kadian, K. S. (2017) Adaptation practices followed by dairy farmers under adverse climatic Conditions in western dry region of India. <i>Indian J. Anim. Sci.</i> , 87 (2): 215-22.	6.19
169	Karmakar, P., Behera, R. and Mandal, A. (2018) Growth performance and effect of non-genetic factors affecting growth traits in Garole sheep. <i>Indian J. Anim. Sci.</i> , 88 (3): 377-78.	6.19
170	Mandal, A., Behera, R., Ratwan, P., Bhakat, C. and Santra, A. (2018) Genetic parameters for direct and maternal effects on birth weight of crossbred calves. <i>Indian J. Anim. Sci.</i> , 88 (3): 373-76.	6.19
171	Meena, B. S., Sankhala, Gopal, Meena, H. R. and Maji, Saikat (2017) Impact of dairy production technologies on productive and reproductive performance of dairy animals in Haryana. <i>Indian J. Anim. Sci.</i> , 87 (2): 234-37.	6.19
172	Mooventhan, P., Kadian, K. S., Senthilkumar, R., Kumaresan, A., Manimaran, A. and Karpagam, C. (2017) Dissemination of good dairy farming practices through interactive educational multimedia module- An innovative approach in farm technology transfer. <i>Indian J. Anim. Sci.</i> , 87 (3): 396-400.	6.19
173	Mooventhan, P., Kadian, K. S., Senthilkumar, R., Kumaresan, A., Manimaran, A. and Selvan, A. S. (2017) Effectiveness of mastitis management instructional video on knowledge of tribal farmers in northern hills zone of Chhattisgarh. <i>Indian J. Anim. Sci.</i> , 87 (3): 391-95.	6.19
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Sr. No.	Research Papers	NAAS Rating
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176	Nitharwal, K., Singh, P. Bhakat, M., Chaurasia, A., Abdullah, M. and Prabha, C. (2017) Effect of season on semen quality parameters in Murrah buffalo. <i>Indian J. Anim. Sci.</i> , 87 (1): 64-69.	6.19
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178	Patel, Diksha, Devi, M. C. A., Lal, S. P., Singh, A. K., Verma, A. P. and Smitha. S. (2017) Variables predicting the role performance of field extension functionaries in animal husbandry sector of Karnataka: A multivariate approach. <i>Indian J. Anim. Sci.</i> , 87 (4): 506-11.	6.19
179	Ponnusamy, K., Chauhan, A. K. and Meena, Sunita (2017) Testing the effectiveness of Pasu Sakhi: An innovation for resource poor farm women in Rajasthan. <i>Indian J. Anim. Sci.</i> , 87 (2): 229-33.	6.19
180	Prakash, V., Gupta, A. K., Singh, M., Ambhore, G. S., Singh, A. and Gandhi, R. S. (2017) Random regression test-day milk yield models as a suitable alternative to the traditional 305-day lactation model for genetic evaluation of Sahiwal cattle. <i>Indian J. Anim. Sci.</i> , 87 (3): 340-44.	6.19
181	Rai, Saroj, Tyagi, S. Mandal, D. K., Kumar, M., Karunakaran, M., Mandal, A. and Behera, R. (2018) Correlation of HOST to some conventional sperm quality parameters evaluated in frozen thawed semen of Frieswal bulls. <i>Indian J. Anim. Sci.</i> , 88 (3): 311-13.	6.19
182	Rao, T. K. S., Mohanty, T. K. and Bhakat, M. (2017) Effect of vitamin E supplementation on semen and blood profile of vaccinated crossbred bulls. <i>Indian J. Anim. Sci.</i> , 87 (4): 456-60.	6.19
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185	Ratwan, P., Mandal, A., Kumar, M. and Chakravarty, A. K. (2017) Prediction of lifetime performance traits by principal component analysis in Jersey crossbred cattle at an organized farm of eastern India. <i>Indian J. Anim. Sci.</i> , 87 (9): 1163-67.	6.19
186	Saroj, Malla, B. A., Tran, L.V., Sharma, A. N., Kumar, S. and Tyagi, A. K. (2017) Seasonal variation in fatty acid profile in the milk of different species under popularly followed feeding system in India. <i>Indian J. Anim. Sci.</i> , 87: 484-89.	6.19
187	Sinha, Ranjana, Kamboj, M. L., Ranjan, Ashish and Lathwal, S. S. (2017) Effect of modified housing on behavioural and physiological responses of crossbred cows in hot humid climate. <i>Indian J. Anim. Sci.</i> , 87 (10) : 1255-58.	6.19
188	Upadhyay, A., Chakravarty, A. K., Gupta, A. K., Selvan, A. S. and Singh, A. P. (2017) Impact of environmental factors on milk constituents and yield traits in Murrah buffaloes. <i>Indian J. Anim. Sci.</i> , 87 (7): 912-18.	6.19
189	Upadhyay, V. K., Mehla, R. K., Gupta, A. K. and Bhakat, M. (2017) Demographic parameters and disposal pattern in Sahiwal cattle herd. <i>Indian J. Anim. Sci.</i> , 87 (4): 437-42.	6.19
190	Upadhyay, V. K., Mehla, R. K., Gupta, A. K., Bhakat, M., Lathwal, S. S. and Yadav, S. K. (2017) Replacement rate and its components in Sahiwal females from birth to age at first calving. <i>Indian J. Anim. Sci.</i> , 87 (8): 996-99.	6.19
191	Bhakat, Champak, Chatterjee, A, Mandal, D. K., Karunakaran, M, Mandal, A., Garai, S. and Dutta, T. K. (2017) Milking management practices and IMI in Jersey crossbred cows in changing scenario. <i>Indian J. Anim. Sci.</i> , 87 (4): 95-100.	6.19
192	Chaudhari, M. V., Gupta, I. D., Verma, Archana, Singh, Avtar, Das, Ramendra, Sailo, L. and Singh, S. V. (2017) Gene substitution effect of bovine heat shock protein beta-1 gene polymorphism on age at calving in Indian dairy cattle. <i>Indian J. Anim. Sci.</i> , 87 (12): 1513-18.	6.19
193	Gupta, L., Roy, A. K. and Tiwari, G. S. (2017) Supplemental effect of different levels of energy and protein along with groundnut straw ( <i>Arachishypogaea</i> L.) based ration on nutrient utilization in dromedary camels. <i>Indian J. Anim. Sci.</i> , 87 (7): 896-99.	6.19

Sr. No.	Research Papers	NAAS Rating
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195	Chand, P., Sirohi, Smita, Mishra, A. and Chahal, V. P. (2017) Estimation of costs and returns from dairying in Malwa region of Madhya Pradesh. <i>Indian J. Anim. Sci.</i> , 87 (3): 381-86.	6.17
196	Abdullah, M., Mohanty, T. K., Patbandha, T. K., Bhakat, M., Madkar, A. R., Kumaresan, A. and Mohanty, A. K. (2017) Pregnancy diagnosis-positive rate and conception rate as indicator of farm reproductive performance. <i>Indian J. Anim. Res.</i> , 51 (1): 170-74.	6.15
197	Barani, A., Ramesha, K. P., Basavaraju, M., Rao, A., Rao, T. V. L. (2017) Genetic characterization and identification of single nucleotide polymorphisms of ATP1A1 gene in Indian humped cattle. <i>Indian J. Anim. Res.</i> , 51 (1) : 58-63.	6.15
198	Baruah, K. K., Dhali, A., Bora, B., Mech, A. and Mondal, M. (2017) Detection of osteopontin transcript in seminal plasma and its association with post-freeze-thaw quality of cryopreserved spermatozoa in mithun ( <i>Bos frontalis</i> ). <i>Indian J. Anim. Res.</i> , 51 (4): 648-53.	6.15
199	Behera, Rajalaxmi, Chakravarty, A. K., Sahu, A. Kashyap, N., Rai, S. and Mandal, A. (2018) Identification of best temperature humidity index model for assessing impact of heat stress on milk constituent traits in Murrah buffaloes under subtropical climatic conditions of Northern India. <i>Indian J. Anim. Res.</i> , 52 (1) : 13-19.	6.15
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202	Chitra, Anil, Jain, Anand, Kumar, Manoj, Ratwan, Poonam and Gupta, A. K. (2018) Effect of genetic and non-genetic factors on milk yield and milk composition traits in Murrah buffaloes. <i>Indian J. Anim. Res.</i> , 52 (2): 304-08.	6.15
203	Dash, Shakti Kant, Gupta, A. K., Manoj, M., Kumar, Virender, Shivhre, Pushp Raj and Valsalan, Jamuna (2017) Analysis of lifetime performance in Karan Fries Cattle. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.B-3283">https://doi.org/10.18805/ijar.B-3283</a> .	6.15
204	Dash, Shakti Kant, Gupta, A. K. Singh, Avtar, Chakravarty, A. K., Kumar, Manvendra and Singh, Virendra (2018) Performance appraisal and genetic parameter estimation of all lactation traits in Karan fries cattle. <i>Indian J. Anim. Res.</i> , 52 (1): 7-12.	6.15
205	Karunakaran, M., Konyak, P., Mandal, A., Mondal, M., Bhakat, C., Rai, S., Ghosh, M. K. and Behera, R. (2017) Effect of trehalose- an impermeant cryoprotectant on cryopreservation of Black Bengal buck semen. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.B-3470">https://doi.org/10.18805/ijar.B-3470</a> .	6.15
206	Konyak, P., Mandal, A., Mondal, M., Bhakat, C., Das, S. K., Rai, S., Ghosh, M. K. and Karunakaran, M. (2017) Preservation of Black Bengal buck semen in soybean lecithin based chemically defined extender. <i>Indian J. Anim. Res.</i> , DOI: 10.18805/ijar.B-3335.	6.15
207	Kumar, Anshuman, Mandal, Ajoy, Gupta, A. K., Ratwan, Poonam and Kumar, Narendra (2017) Genetic evaluation of reproductive traits in Jersey crossbred heifers at an organized farm of eastern India. <i>Indian J. Anim. Res.</i> , 51 (4): 619-24.	6.15
208	Kumar, S., Ganguly, I., Singh, S., Sodhi, M. and Bhakat. M. (2017) Y-chromosome variation in Indian native cattle breeds and crossbred population. <i>Indian J. Anim. Res.</i> , 51 (1) : 1-7.	6.15
209	Kumar, M., Vohra, V., Ratwan, P., Chopra, A. and Chakaravarty, A. K. (2017) Influence of FASN gene polymorphism on milk production and its composition traits in Murrah buffaloes. <i>Indian J. Anim. Res.</i> , 51 (4): 640-43.	6.15
210	Mumtaz, Shabahat, Mukherjee, Anupama, Rahim, Abdul, Kaiser, Parveen, Joshi, Pooja, Yadav, Alok Kumar and Gupta, A. K. (2017) Association of single nucleotide polymorphisms of PPP1R11 gene with conception rate in Karan Fries bull. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.B-3400">https://doi.org/10.18805/ijar.B-3400</a>	6.15
211	Mundhe, U.T., Das, D. N., Gandhi, R. S. and Divya, P. (2017) Studies on TLR2 gene variants and their association with milk yield and milk quality traits in <i>Bos indicus</i> (Deoni) cattle. <i>Indian J. Anim. Res.</i> , 52 (2): 198-203.	6.15

Sr. No.	Research Papers	NAAS Rating
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213	Patel, B., Kumar, N., Jain, V., Raheja, N., Yadav, S. K., Kumar, N., Lathwal, S. S. and Singh, S. V. (2017) Effect of zinc supplementation on hormonal and lipid peroxidation status of peri-parturient Karan Fries cows during heat stress condition. <i>Indian J. Anim. Res.</i> , Online ISSN:0976-0555. <a href="https://doi.org/10.18805/ijar/v0iOF.9139">https://doi.org/10.18805/ijar/v0iOF.9139</a> .	6.15
214	Rai, S., Tyagi, S., Kumar, M., Karunakaran, M., Mondal, M., Mandal, A. and Behera, R., (2017) Understanding motility dynamics of crossbred bull spermatozoa when analyzed by Computer Assisted Semen Analyzer (CASA). <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar/v0iOF.9130">https://doi.org/10.18805/ijar/v0iOF.9130</a> .	6.15
215	Rao, T. K. S., Mohanty, T. K. and Bhakat, M. (2017) Assessment of antioxidants for preservation of crossbred bull semen in Tris based extender. <i>Indian J. Anim. Res.</i> , 51 (6): 993-97.	6.15
216	Singh, Raushan K., Kumaresan, A., Mir, M. A., Kumar, P., Chhillar, S., Tripathi, U. K., Rajak, S. K., Nayak, S., Mohanty, T. K. (2017) Computer assisted sperm analysis: Relationship between the movement characteristics of buffalo spermatozoa and sire fertility. <i>Indian J. Anim. Res.</i> , 51 (4): 660-64.	6.15
217	Sinha, Ranjana and Kamboj, M. L. (2017) Effect of housing management on production performance of crossbred cows during hot-humid season. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.v0iOF.7817">https://doi.org/10.18805/ijar.v0iOF.7817</a> .	6.15
218	Sinha, Ranjana, Kamboj, M. L., Ranjan, Ashish and Devi, Indu (2017) Effect of microclimatic variables on physiological and hematological parameters of crossbred cows in summer season. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.B-3480">https://doi.org/10.18805/ijar.B-3480</a> .	6.15
219	Verma, Nishant, Gupta, I. D., Verma, Archana, Kumar, Rakesh and Das, Ramendra (2017) Novel SNPs in ATP1B2 Gene and their association with heat tolerance indicator traits in Sahiwal Cattle. <i>Indian J. Anim. Res.</i> , 51 (2): 223-26.	6.15
220	Chaudhari, Alkesh, Tyagi, Nitin, Gautam, Mayank and Sedeqi, Jawid (2017) Influence of varied metabolizable energy levels on antioxidant status and performance of transition Murrah buffaloes. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.B-3379">https://doi.org/10.18805/ijar.B-3379</a> .	6.15
221	Das, Ramendra, Gupta, I. D., Verma, Archana, Singh, Sohanvir, Chaudhari, Mahesh Vishwas, Sailo, Lalrengpuii, Verma, Nishant and Kumar, Rakesh (2017) Single nucleotide polymorphisms in ATP1A1 gene and their association with thermo tolerance traits in Sahiwal and Karan Fries cattle. <i>Indian J. Anim. Res.</i> , 51: 70-74.	6.15
222	Kaur, Jasmine and Thakur, S. S. (2017) <i>In vitro</i> nutrient digestibility and methane production potential of concentrate mixtures containing graded levels of <i>Phalaris minor</i> seeds. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.5958/2277-940X.2017.00132.2">https://doi.org/10.5958/2277-940X.2017.00132.2</a> .	6.15
223	Kaur, Jasmine, Thakur, S.S. and Singh Mahindra (2017) Nutritional value of <i>Phalaris minor</i> seeds and its comparison with conventional grains for livestock feeding, <i>Indian J. Anim. Res.</i> , 51 : 887-91.	6.15
224	Kumar, A., Mandal, Ajoy, Gupta, A. K., Ratwan, Poonam, Kumar, Narendra (2017) Genetic evaluation of reproductive traits in Jersey crossbred heifers at an organized farm of Eastern India. <i>Indian J. Anim. Res.</i> , 51 (4): 619-24.	6.15
225	Kumar, Anshuman, Mandal, Ajoy, Gupta, A, Karunakaran, Muthupalani, Das, S. and Dutta, T. (2017) Genetic analysis of fertility traits in Jersey crossbred cows. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.v0iOF.8493">https://doi.org/10.18805/ijar.v0iOF.8493</a> .	6.15
226	Magotra, Ankit, Gupta, I. D., Verma, Archana, Chaudhari, M. V., Arya, Ashwani, Vineeth, M. R., Kumar, Rakesh and Selvan, A. Sakthivel (2017) Characterization and validation of point mutation in exon 19 of CACNA2D1 gene in Karan Fries ( <i>Bos taurus</i> x <i>Bos indicus</i> ) cattle. <i>Indian J. Anim. Res.</i> , 51 (2): 227-30.	6.15
227	Patel, Brijesh, Kumar, Nishant, Jain, Varsha Raheja, Nitin, Kumar, Satendra Yadav, Kumar, Narender, Lathwal, S. S. and Singh, S. V. (2017) Effect of zinc supplementation on hormonal and lipid peroxidation status of peri-parturient Karan Fries cows during heat stress condition. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.v0iOF.9139">https://doi.org/10.18805/ijar.v0iOF.9139</a> .	6.15
228	Sarkar, S., Mohini, Madhu, Mondal, G., Pandita, S., Nampoothiri, V. M. and M, Gautam (2017) Effect of supplementing Aegle marmelos leaves on <i>in vitro</i> rumen fermentation and methanogenesis of diets varying in roughage to concentrate ratio. <i>Indian J. Anim. Res.</i> <a href="https://doi.org/10.18805/ijar.B-3331">https://doi.org/10.18805/ijar.B-3331</a> .	6.15

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229	Sharma S., Singh M., Roy A. K. and Kumar, H. M. Ajitha (2017) Plasma lipid and haematological profile during transition period in Murrah buffaloes supplemented with prilled fat. <i>Indian J. Anim. Res.</i> , 51 (1): 85-88.	6.15
230	Sharma, R., Manju, Ashutosh, Pandita, S., Ashutosh, Yadav, P. S. and Thulasiraman, P. (2017) Quarter wise prevalence of subclinical mastitis in crossbred cows. <i>Indian J. Anim. Res.</i> : <a href="https://doi.org/10.18805/ijar.v0iOF.7604">https://doi.org/10.18805/ijar.v0iOF.7604</a>	6.15
231	Singh, A, M. Bhakat, Mandal, Mohanty, T. K, Behare, P., Mondal, G., Rahin, A., Yadav, S. K., Gupta, A. K., Gupta, M. D. and Abdulla, M. (2017) Microbial load of frozen thawed Sahiwal semen extended in egg yolk, soya lecithin and liposome extender. <i>Indian J. Anim. Res.</i> , 52 (4): 527-29.	6.15
232	Soren, Simson, Singh, S. V., Upadhyay, R. C., Singh, Pawan and Kumar, Sunil (2017) Seasonal effect on viability and morphology of spermatozoa in Karan Fries (Holstein Friesian×Tharparkar) bulls under tropical climatic condition. <i>Indian J. Anim. Res.</i> , 51 (3): 420-22.	6.15
233	Thakur, Sunita, Singh, Mahendra, Aseri, Gajendra Kumar, Verma, Archana and Khan, Sikander S. (2017) Isolation and characterization of mastitis pathogens and milk composition changes in Murrah buffaloes ( <i>bubalus bubalis</i> ) during winter season. <i>Indian J. Anim. Res.</i> , <a href="https://doi.org/10.18805/ijar.11320">https://doi.org/10.18805/ijar.11320</a> .	6.15
234	Vaidya, M. M., Singh, S. V., Upadhyay, R. C. and Aggarwal, A. (2017) Plasma profile of hormones and energy metabolites in low and high producing periparturient Sahiwal cows during summer and winter season. <i>Indian J. Anim. Res.</i> , 51 (3): 431-37.	6.15
235	Kale V., Kumar, S., Tran, L. V., Malla, B. A. and Tyagi, A. K. (2017) Effects of dietary supplementation of different vegetable oils varying in polyunsaturated fatty acid content on reproductive performance and ovarian follicular characteristics of Murrah buffalo heifers. <i>Buffalo Bull</i> , 36: 505-19.	6.10
236	Kumar, A., Singh, P., Bhakat, M., Singh, S., Nitharwal, K. and Gupta, A. K. (2017) Effect of feed energy levels on semen quality and freezability of young Murrah buffalo bulls. <i>Buffalo Bulletin</i> , 36 (2): 415-26.	6.10
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238	Ramesha, K. P., Rao, Akhila, Alex, Rani, Geetha, G. R., Basavaraju, M., Kataktalware, M. A., Das, D. N. and Jeyakumar, S. (2017) Screening for genetic disorders in Indian Murrah and Surti buffalo ( <i>Bubalus Bubalis</i> ) bulls. <i>Buffalo Bulletin</i> , 36 (1): 115-22.	6.10
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Sr. No.	Research Papers	NAAS Rating
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272	Sailo, L. Gupta, I. D., Das, R. and Chaudhari, M. V. (2017) Physiological response to thermal stress in Sahiwal and Karan Fries cows. <i>Int. J. Livestock Res.</i> , 7 (5): 275-83.	5.36
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303	Meena, D. K., Sankhala, Gopal, Kant, Kamala and Prasad, Kamta (2017) Constraints perceived by the dairy farmers about fodder production in Rajasthan state of India. <i>Indian J. Dairy Sci.</i> , 70 (2) : 244-46.	5.26
304	Meena, G. S., Singh, A. K., Gupta, V. K., Jayswal, D., Parmar, P. T. and Gupta, H. R. (2017) Estimating cost for production of soluble milk protein concentrate70 (MPC 70) <i>Indian J. Dairy Sci.</i> , 70 (3) : 342-350.	5.26
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322	Verma, Rakesh Kumar, Gupta, A. K., Kumar, Manoj and Ratwan, Poonam (2017) Estimates of genetic parameters for milk and milk constituent's yield traits in Sahiwal cattle. <i>Indian J. Dairy Sci.</i> 70 (6): 751-54.	5.26
323	Yadav, S. K., Singh, P., Kumar, P., Bhakat, M., Singh, A., Mondal, S. and Patel, B. (2017) Relationship among testicular, physical and semen quality parameters of Murrah buffalo breeding bulls. <i>Indian J. Dairy Sci.</i> , 70 (4): 462-65.	5.26
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Sr. No.	Research Papers	NAAS Rating
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340	Yogi, R. K., Thakur, S. S., Mohini, Madhu, Singh, S. K. and Malik, Tariq (2017) <i>In vitro</i> evaluation of concentrate mixtures containing incremental level of dried distillers grains with solubles replacing oil cakes in concentrate mixture, <i>Indian J. Anim. Nutr.</i> , 32 : 163-68.	5.02
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342	Kumar, Mukesh, Meena, H. R., Paul, Pampi, Meena, B. S. and Ashutosh (2017) An analytical study on the tolerance level of livestock owners' towards wildlife conflict in the vicinity of Kalesar National Park, Haryana. <i>Indian J. Ecology</i> , 44(1): 72-76.	4.96
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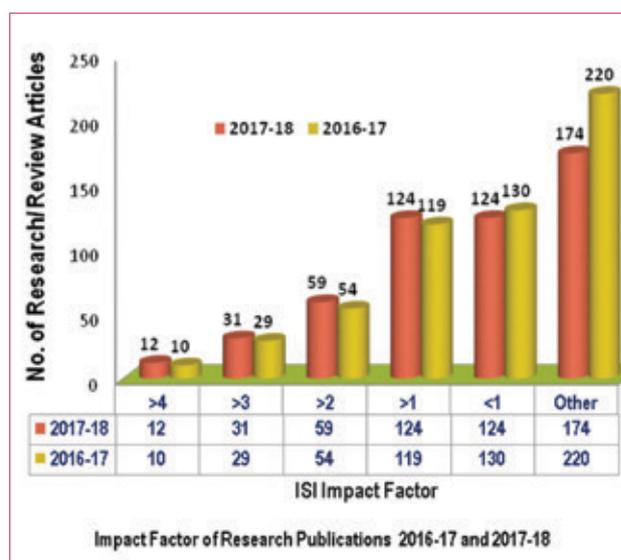
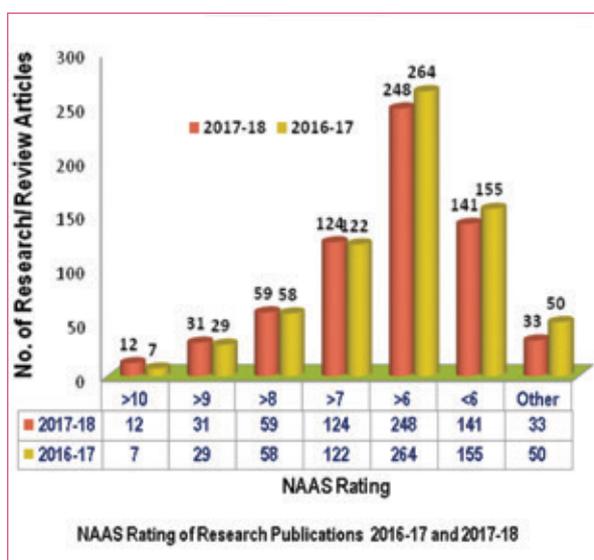
Sr. No.	Research Papers	NAAS Rating
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358	Dash, S., Maity, A., Bisoi, P.C., Palai, T. K., Polley, S., Mukherjee, A. and De, S. (2017) Coexistence of polymorphism in fecundity genes BMPR 1B and GDF 9 of Indian Kendrapada sheep. <i>Exploratory Anim. and Medical Res.</i> , 7 (1): 33-38.	4.27
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373	Ali, S., Kumar, S., Mohanty, A. K. and Behare, P. V. (2018) Draft genome sequence of <i>Lactobacillus fermentum</i> NCDC400 isolated from a traditional Indian dairy product. <i>Genome Announcements</i> , 6 (2) pii:e01492-17. Doi:10.1128/genomeA.01492-17.	
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376	Bharti, P., Bhakat, Champak, Puhle, J. K. and Tamboli, P. (2017) Interdependence and distribution of subclinical mastitis and intra-mammary infection among udder quarters in Jersey crossbred cows. <i>Int. J. Agri. Sci.</i> , 9 (21): 4235-37.	
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385	Kumar, M. C. T., Raju, P. N. and Singh, A. K. (2017) Effect of packaging materials and storage temperatures on shelf life of micronutrient fortified milk-cereal based complementary food. <i>J. Packaging Tech. and Res.</i> , 1(3): 135-48.	
386	Kumar, M., Panjagari, N. R., Kanade, P. P., Singh, A. K., Badola, R., Ganguly, S., Behare, P.V., Sharma, R. and Alam, T. (2018) Sodium caseinate-starch-modified montmorillonite based biodegradable film: Laboratory food extruder assisted exfoliation and characterization. <i>Food Packaging and Shelf Life</i> , 15 : 17-27.	
387	Kumar, Rohit, Chandra, P., Konyak, P, Karunakaran, M., Santra, A. and Subrata Das, K. (2018) <i>In vitro</i> development of caprine embryo in different culture media using cryopreserved black Bengal buck semen. <i>Int. J. Biotech. and Allied Fields</i> , 6 (1) : 1-9.	
388	Kumari, A and Chandra R. (2017) Effect of polyherbal -potash alum mixture supplementation on production performance of crossbred cows. <i>Int. J. Farm Sci.</i> , 7 (3) : 24-27.	
389	Malik, Meena (2017) "Bare Soul: A Euphoric Medley of Love. Passion and Mysticism". <i>Journal of Teaching and Research in English Literature</i> , 8 (3): 1-6.	
390	Negesse, T., Datt, Chander and Kundu, S. S. (2017) Residual feed intake, digestibility of nutrients and efficiency of water utilizations in Murrah buffalo heifers. <i>J. Dairy Vet. Anim. Res.</i> , 5 (2): <a href="https://doi.org/10.15406/jdvar.2017.05.00138">https://doi.org/10.15406/jdvar.2017.05.00138</a> .	
391	Pandey, A. K., Rajput, Y. S., Sharma, R., Singh, D. (2017) Immobilized aptamer on gold electrode senses trace amount of aflatoxin M1. <i>Appl Nanosci.</i> , 7 (8): 893-903. <a href="https://doi.org/101007/s13204-017-0629-0">https://doi.org/101007/s13204-017-0629-0</a> .	
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393	Prasad, W., Khamrui, K. and Sandhya, S. (2017) Effect of packaging materials and essential oils on the storage stability of <i>burfi</i> , a dairy dessert. <i>J. Packaging Tech. and Res.</i> , 1(3): 181-92.	

Sr. No.	Research Papers	NAAS Rating
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396	Rana, S., Bajaj, R. and Mann, B. (2017) Characterization of antimicrobial and antioxidative peptides synthesized by <i>L. rhamnosus</i> C6 fermentation of milk. <i>Int. J. Peptide Res. and Therapeutics</i> , <a href="https://doi.org/10.1007/s10989-017-9616-2">https://doi.org/10.1007/s10989-017-9616-2</a> .	
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Sr. No.	Review Articles	NAAS Rating
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402	Rani, P., Yenuganti, V. R., Shandilya, S., Onteru, S. K. and Singh, D. (2017) miRNAs: The hidden bioactive component of milk. <i>Trends in Food Sci. &amp; Tech.</i> , 65: 94-102.	11.19
403	Kumar, N., Kumari, V., Ram, C., Thakur, K. and Tomar, S. K. (2018) Bio-prospectus of cadmium bio-adsorption by lactic acid bacteria to mitigate health and environmental impacts. <i>Applied Microbiology and Biotechnology</i> . 102 (4):1599-1615.	9.42
404	Meena, G. S., Singh, A. K., Panjagari, N. R. and Arora, S. (2017) Milk protein concentrates: Opportunities and challenges- A review, <i>J Food Sci Technol</i> , 54 (10) : 3010-3024.	7.26
405	Sharma, A.N., Kumar, S. and Tyagi, A. K. (2018) Effects of mannan-oligosaccharides and <i>Lactobacillus acidophilus</i> supplementation on growth performance, nutrient utilization and faecal characteristics in Murrah buffalo calves. <i>Journal of Animal Physiology and Animal Nutrition</i> . <a href="http://dx.doi.org/10.1111/jpn.12878">http://dx.doi.org/10.1111/jpn.12878</a> .	7.24
406	Tyagi, A.K., Tran, L.V., Malla, B. A. and Kumar, S. (2017).Polyunsaturated fatty acids in male ruminant reproduction: A review. <i>Asian-Australasian J. Anim. Sci.</i> , 30 (5): 622-37.	6.86
407	Poonia, A., Jha, A., Sharma, R. Singh, H.B., Rai, A. K. and Sharma, N. (2017) Detection of adulteration in milk: a review. <i>Int. J. Dairy Technology</i> , 70 (1) : 23-42	6.81
408	Kale, V., Kumar, S., Tran, L.V., Malla, B. A. and Tyagi, A. K. (2017) Effects of dietary supplementation of different vegetable oils varying in polyunsaturated fatty acid content on reproductive performance and ovarian follicular characteristics of Murrah buffalo heifers. <i>Buffalo Bulletin</i> , 36: 505-519.	6.1
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410	Mohini, Madhhu, Jha, Pankaj and Babu, Sudeer (2017) Effects of nitrate supplementation on Nutrition, performance and methane mitigation in ruminants- a review. <i>Int. J. Livestock Res.</i> , 7 (9): 19-29	5.36

411	Gandhi, Kamal, Arora, Sumit, and Kumar, Anil (2017) Industrial applications of supercritical fluid extraction: A review. <i>Int. J. Chemical Studies</i> , 5(3): 336-40.	5.31
412	Ganguly, S., Raju, P. N., and Rao, K. H. (2017) Packaging innovations for effective dairy supply chain management-A review, <i>Indian J Dairy Sci.</i> , 70 (6) : 621-632.	5.26
413	Sabikhi, L. and Kumar, M.C.T. (2018) Application of inorganic metal oxide nanoparticles in dairy products: Opportunities and challenges- A review. <i>Indian Journal of Dairy Science</i> , 71 (1): 1-6.	5.26
414	Singla, V., Mandal, S., Anand, S. and Tomar, S. K. (2017) <u>Techno-functional attributes of <i>Pediococcus</i> spp.: A Review.</u> <i>Indian Journal of Dairy Science</i> 70 (4), 381-390	5.26
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S. No.	Details of the Research Papers	Year of publication	Number of citations
<b>2016</b>			
1	Vij, R., Reddi, S., Kapila, S., and Kapila, R. (2016) Transepithelial transport of milk derived bioactive peptide VLPVPQK. <i>Food Chemistry</i> 190: 681-88.	2016	37
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12	Banerjee, Dipak, Upadhyay, R. C., Umesh, B. Chaudhary, Ravindra Kumar, Singh, Sohanvir , Ashutosh, Jagan Mohanarao G., Polley, Shamik , Mukherjee, Ayan, Das, Tapan K. and De, S. (2014) Seasonal variation in expression pattern of genes under HSP70. <i>Cell Stress and Chaperones</i> , 19 (3): 401–08.	2014	41
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S. No.	Details of the Research Papers	Year of publication	Number of citations
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S. No.	Details of the Research Papers	Year of publication	Number of citations
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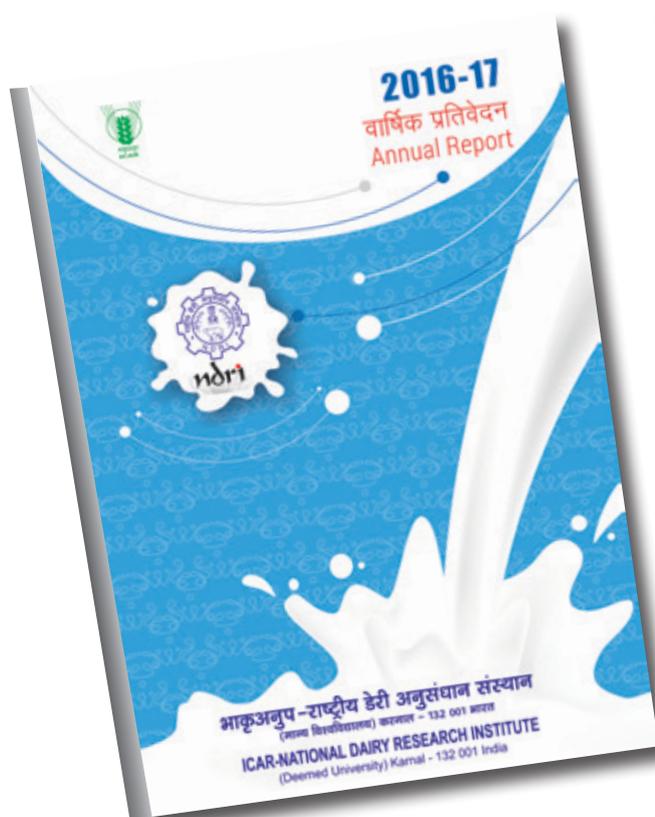
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- Barnwal, P., Chitrnanayak, Minz, P. S. and Deep, Ankit (2018) Compendium on "Dairy and Food Process Engineering: Equipment, Processing and Value Addition". National Dairy Programme organized under the aegis of CAFT (Dairy Processing) at NDRI Karnal.
- Behare, P. V. Mandal, S., Ram, C. and Tomar, S. K. (2017) Starter Cultures And Fermented Milk Products. NDRI Publication No. 149/2017.
- Bhakat, M., Mohanty, T. K., Mondal, G., Singh, A., Patbandha, T. K. and Shah, N. (2018) Kritrim Garvadhan Ke Liye Taral Beerya Ka Istemal. (Leaflet), NDRI Publication, Karnal.
- Bhakat, M., Mohanty, T. K., Singh, A., Mondal, G., Rajkumar and Shah, N. (2018) Linga Nirdhari Beerya (Semen Sexing): Abalokan. (Leaflet), NDRI Publication, Karnal.
- Borad, S., Khetra, Y., Sabikhi, L. and Ganguly, S. (2018) Instruction Manual on Technology of Cheese Making. NDRI Publication No. 162/2018. 69 pages.
- Budhani, L., Parihar, D., Niranjana, S. K., Sarkar, S., Rajvaidya, S. K. and Mondal, G. (2018) Pashudhan Ke Liye Chara Evam Uske Poshashk Maan. (Leaflet), NDRI Publication, Karnal.
- Chitrnanayak, Manjunatha, M., Sawhney, I. K., Kumar, Mahesh G., Minz, P. S., Vairat, Amita, Kumar, Pavan (2018) Practical Manual on "Introduction and Basic Concepts of Instrumentation, Measurement and Process Control". NDRI Publication No. 160/2018, NDRI Karnal.
- Dutta, T. K., Malik, M. and Upadhyay, N. (2017) Foundation Programme for Freshers at ICAR-NDRI 2017.
- Gandhi, K., Seth, R., Arora, S., Sharma, R., Sharma, V., Bajaja, R., Rao, P. S., Singh, R. and Mann, B. (2018) A Laboratory Manual on "Analysis of Milk Products". NDRI Publication No. 164/2018. NDRI, Karnal pp : 1- 121.
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- Karunakaran, M., Ghosh, M. K., Mondal, M., Mandal, A., Rai, S., Behera, R., Das, S.K., Bhakat, C. and Dutta, T. K. (2018) Artificial insemination in goat: Facts and procedures. Technical Folder 1/2018, ICAR-NDRI- Eastern Regional Station, Kalyani, West Bengal.
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- Kumaresan, A. Ramesha, K. P. Srinivas, B. Jeyakumar, S. and Kataktalware, M. A. (2017) Strategies for Enhancing Productivity of Indigenous Cattle. Souvenir of National Seminar, 1<sup>st</sup> July 2017. Bengaluru. pp 1-72.
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- Kumar, Raskesh (2018) Dugdh Ganga (7<sup>th</sup> Edition). NDRI Publication No. 166/2018.
- Manimaran, A., Kumaresan, A., Jeyakumar, S. and Ramesha, K. P. (2017) Management Of Transition Cows for Optimum Production and Reproduction. Published by The Head, ICAR-NDRI, SRS, Adugoddi, Bengaluru.
- Manimaran, A., Kumaresan, A., Rajendran, D., Jeyakumar, S. and Ramesha, K. P. (2017) Transition Cow Management. Technical bulletin, pp: 1-51.
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- Ruhil, A. P. (2017) Reference Manual for Students on Academic Management System. NDRI Publication Number: 158/2018.
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- Sankhala, G., Meena, H. R., Meena, B. S., Malik, Meena., Kumar, Rakesh., Chitranayak and Kadian, K. S. (2017) Feed the Future India Triangular Training Programme on Modern Dairy Technology and Management. ICAR-National Dairy Research Institute, Karnal, Haryana, India, pp : 350.
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- Singh, Richa and Rao, Priyanka Singh (2018) Instruction Manual on "General Safety Guidelines for Chemical Laboratory". NDRI Publication No. 163/2017. NDRI, Karnal pp: 1- 26.
- Singh, Richa, Rao, Priyanka Singh and Gandhi, Kamal (2017). Training Manual on "Basic Training on Routine Chemical Analysis (Broad Area: Instrumentation Techniques)" held from 21 August 2017 to 26 August 2017.
- Thompson, D. K., Sabikhi, L. and Sathish, M. H. K. (2017) Laboratory Manual "Market Milk. (3rd Edition). March. NDRI Publication No. 24/2006. 59 pages.



# TRAINING AND CAPACITY BUILDING

According to the Government of India National Training Policy in 2012 based on the tenet of 'competency-based training for all, Human Resource Management (HRM) unit has been established at NDRI for coordination and effectively implementation of training programmes. The training plan of NDRI addresses the gap between the existing and the required competencies and provides opportunities to the employees to develop their competencies.

## Deputations Abroad

- » **Dr. (Mrs.) Smita Sirohi**, Head, DES&M Division was deputed to attend 18<sup>th</sup> IFCN Dairy Conference on "Dairy Development - Past, Present and Future" from 10<sup>th</sup> - 14<sup>th</sup> June, 2017 at Kiel, Germany.
- » **Dr. M. L. Kamboj** and **Dr. Pawan Singh**, Principal Scientist, Livestock Production & Management Section were deputed to attend "51<sup>st</sup> Congress of International Society for Applied Ethology (ISAE)" from 7<sup>th</sup> - 10<sup>th</sup> August, 2017 at Aarhus, Denmark.
- » **Dr. T. K. Dutta**, Principal Scientist, Animal Biotechnology Centre was deputed to attend International Buffalo Symposium on "**Enhancing Buffalo Production for Food and Economy**" and to deliver the key note lecture "Understanding the fertilizing ability of buffalo oocytes and spermatozoa in functional genomics perspective" from 15<sup>th</sup>- 18<sup>th</sup> November, 2017 at Agricultural Forestry University, Chitwan, Nepal
- » **Dr. Yogesh Khetra**, Scientist, Dairy Technology Division visited the University of Copenhagen, Denmark as a Guest Researcher during 13<sup>th</sup> September to 11<sup>th</sup> October, 2017 under an approved collaborative research project between University of Copenhagen Denmark and NDRI, Karnal entitled "**Understanding Enzymatic Activity in Concentrated Milk System**".
- » **Dr. T. K. Mohanty**, Principal Scientist & Incharge Artificial Breeding Research Centre was permitted to attend a meeting with Counter parts of UK to Process Agriculture organized by Science & Innovation on Network British High Commission, UK from 29<sup>th</sup> January to 2<sup>nd</sup> February, 2018.

## Trainings (Category-wise)

### Scientists

Name of Employee	Name of the Training Programme attended	Duration (days)	Organizing Institute
Dr. Raghu H.V., Sci. Dr. G. S. Meena, Sci. Dr. Heena Sharma, Sci. Dr. Richa Singh, Sci. Dr. Priyanka Singh Rao, Sci. Dr. Kamal Gandhi, Sci. Dr. Rubina Baithalu, Sci. Dr. Prateek Sharma, Sci. Mr. Gunvantsinh Rathod, Sci. Dr. P. Barnwal, Sr. Sci. Mr. Ankit Deep, Sci. Mr. Amit Vairat, Sci. Dr. Rakesh Kumar, Sr. Sci. Dr. M. K. Singh, Sci. Dr. Gautam Mondal, Sr. Sci. Dr. Sachin Kumar, Sci. Dr. Sanchita Garai, Sci. Dr. H. R. Meena, Sr. Sci. Dr. Anupama Mukherjee Sr. Sci. Dr. S. K. Onteru, Sr. Sci. Dr. Sunita Meena, Sci. Ms. Uditia Chaudhary, Sci. Dr. Mukesh Bhagat, Sr. Sci.	Training Programme on "Competence Enhancement for Efficiency and Effectiveness at Work-place".	25 <sup>th</sup> - 30 <sup>th</sup> May, 2017	NAARM, Hyderabad

Name of Employee	Name of the Training Programme attended	Duration (days)	Organizing Institute
Dr. Saroj Rai, Sci.	National Workshop cum Training Programme on "Statistical Tools for Research Data Analysis (Series-II)".	29 <sup>th</sup> May to 11 <sup>th</sup> June, 2017	BCKV, Mohanpur
Sh. P. S. Minz, Sci.	Training Programme on "Big Data Analytics in Agriculture".	1 <sup>st</sup> - 7 <sup>th</sup> June, 2017	NAARM, Hyderabad
Dr. Gautam Kaul, PS	MDP on "Leadership Development"	13 <sup>th</sup> - 24 <sup>th</sup> June, 2017	NAARM, Hyderabad
Dr. M. K. Singh, Sci.	A Summer School on "Improving Reproduction Rate through Assisted Reproductive & Stem Cell Technologies".	6 <sup>th</sup> - 26 <sup>th</sup> July, 2017	Mathura
Dr. Rajan Sharma, PS	Training cum Workshop on "Evaluation of Measurement Uncertainty" and ISO-17025.	25 <sup>th</sup> - 28 <sup>th</sup> July, 2017	CSIR-HRDC, Ghaziabad
Dr. Sangita Ganguly, Sci. Mr. Sanket G. Borad, Sci.	Training Programme on "Analysis of Experimental DATA".	3 <sup>rd</sup> - 9 <sup>th</sup> August, 2017	NAARM, Hyderabad
Dr. Manoj Kumar CT, Sci. Mr. Sanket G. Borad, Sci.	A Training Programme on "Developing Business Proposal for Producer Companies and Start-up in Agril. Business".	19 <sup>th</sup> - 23 <sup>rd</sup> September, 2017	NAARM, Hyderabad
Dr. M. K. Ghosh, PS Dr. M. Mondal, Sr. Sci.	Short Term Training Course on "Advances in Livestock Production Management Technologies".	27 <sup>th</sup> November, 2017	IVRI, Kolkata.
Dr. A. K. Tyagi, Head Dr. Sumit Arora, PS Dr. Vivek Sharma, PS	MDP on Leadership Development (a pre RMP programme).	12 <sup>th</sup> - 23 <sup>rd</sup> December, 2017	NAARM, Hyderabad
Dr. Gautam Mondal, PS Dr. A. K. Roy, PS Dr. Mukesh Bhakat, Sr. Sci. Dr. Nitin Tyagi, Sr. Sci. Dr. M. K. Singh, Sci. Dr. Manoj Kumar, C.T, Sci. Dr. Sangita Ganguly, Sci. Dr. Shaik Abdul Husain, Sci. Dr. Richa Singh, Sci. Dr. Priyanka Singh Rao, Sci. Dr. Nishant Kumar, Sci. Dr. Sathish Kumar, M.H., Sci. Dr. Laxmana Naik, Sci. Dr. A. Mohammad, Sci. Dr. R. Behera, Sci. Ms. Uditia Chaudhary, Sci. Dr. R. K. Meena, Sci. Dr. Sanjiv Kumar, Sci. Dr. Yogesh Khetra, Sci. Dr. Pradeep Behare, Sci. Dr. Sudarshan Kumar, Sci. Dr. Sanjit Maiti, Sci. Mr. Ankit Deep, Sci. Dr. Raghu, H. V., Sci. Mr. P. S. Minz, Sci. Dr. Sachin Kumar, Sci.	An off Campus Training Programme on "Developing Winning Research Proposals (DWRP) in Agriculture".	13 <sup>th</sup> - 16 <sup>th</sup> December, 2017	NAARM, Hyderabad organized at NDRI, Karnal
Dr. Bimlesh Mann, Joint Director (Res.)	Training Programme on "Policy for Science".	1 <sup>st</sup> - 7 <sup>th</sup> January, 2018	NIAS, Bengaluru
Dr. Manoj Kumar C. T., Sci.	A National Training Programme at EDIT.	22 <sup>nd</sup> January to 2 <sup>nd</sup> February, 2018	Ahmedabad, Gujarat
Dr. Sathish Kumar, M. H., Sci.	Training Programme on "Texture Analyser".	15 <sup>th</sup> February, 2018	Fern Citadel Hotel, Bengaluru
Mr. Gunvantsinh Rathod, Sci.	Training Programme on "Analysis of Experimental Data".	19 <sup>th</sup> - 24 <sup>th</sup> February, 2018	NAARM, Hyderabad
Dr. Raghu H. V., Sci.	ISO 17025: 2005 "Laboratory Quality Management System".	20 <sup>th</sup> - 23 <sup>rd</sup> February, 2018	NITS (BIS), Noida
Dr. Rajesh Kumar Meena, Sci.	CAFT - Training Programme on "Statistical Adv. for Agri. Data Analysis".	3 <sup>rd</sup> - 23 <sup>rd</sup> March, 2018	ICAR-IASRI, New Delhi

## Administrative Staff

Name of Employee	Name of the Training Programme attended	Duration (days)	Organizing Institute
Ms. Prem Kumari, PS	Training Programme on "Enhancement of Professional Competence of ICAR Technical and Administrative Personnel".	27 <sup>th</sup> - 29 <sup>th</sup> June, 2017	NBAGR, Karnal
Mr. Gurjeet Singh, Assistant	Training Programme on "Pay Fixation".	12 <sup>th</sup> - 14 <sup>th</sup> July, 2017	ISTM, New Delhi,
Sh. Kunal Kalra, F&AO	Organization Specific Programme (OSP) on "General Financial Rules 2017".	19 <sup>th</sup> - 21 <sup>st</sup> July, 2017	ISTM, New Delhi
Sh. Kunal Kalra, F&AO	Workshop on "Financial Management".	7 <sup>th</sup> - 11 <sup>th</sup> August, 2017	ISTM, New Delhi
Sh. Agnivesh, AO	Training Programme on "Administrative and Finance Management".	17 <sup>th</sup> - 23 <sup>rd</sup> August, 2017	NAARM, Hyderabad
Ms. S. Shashi Kala, AO	Training Programme on "Administration and Finance Management".	17 <sup>th</sup> - 22 <sup>nd</sup> August, 2017	NAARM, Hyderabad
Sh. S. S. Meena	Workshop on "e-Procurement".	21 <sup>st</sup> - 22 <sup>nd</sup> August, 2017	ISTM, New Delhi
Mr. Ravinder Kumar, LDC	Training Programme on "GEM & GFRS 2017".	21 <sup>st</sup> - 22 <sup>nd</sup> August, 2017	NIFM, Faridabad
Ms. Ritu Dalal, AO	Training Programme on "Procurement & PFMS".	11 <sup>th</sup> - 15 <sup>th</sup> September, 2017	ICAR-CPRI, Shimla
Ms. Parvesh Lata, Private Secretary Ms. Ranjna Khurana, Private Secretary	Training Programme on "Enhancing Efficiency and Behavioural Skills".	25 <sup>th</sup> - 31 <sup>st</sup> October, 2017	NAARM, Hyderabad
Ms. Ritu Dalal, AO Sh. Kunal Kalra, F&AO	Training Programme on "Establishment and Financial Matters".	1 <sup>st</sup> - 7 <sup>th</sup> February, 2018	NAARM, Hyderabad

## Technical Staff

Name of Employee	Name of the Training Programme attended	Duration (days)	Organizing Institute
Sh. B. P. Singh, ACTO Sh. Narender Singh, TO	Training Programme on "Library Beyond Borders: Navigating Towards Global Dissemination".	4 <sup>th</sup> - 6 <sup>th</sup> May, 2017	CCSHAU, Hisar
Dr. Subhash, STO Mr. G.S. Meena, TA	Training Programme on "Enhancement of Professional Competence of ICAR Technical and Administrative Professionals".	27 <sup>th</sup> - 29 <sup>th</sup> June, 2017	NBAGR, Karnal
Dr. Manoj Kumar, CTO	Training Programme on "Stress Management".	12 <sup>th</sup> - 15 <sup>th</sup> July, 2017	NAARM, Hyderabad
Sh. Sandeep Deswal, STO Mr. G. S. Meena, TA	Training Camp for "NCC Cadets".	13 <sup>th</sup> - 22 <sup>nd</sup> July, 2017	GIMT, Vill-Kanipla
Sh. Suraj Bhan, STA Sh. Surinder Pandey, STA	Training Programme on "Automobile Maintenance, Road Safety and Behavioral Skills".	18 <sup>th</sup> - 22 <sup>nd</sup> July, 2017	CIAE, Bhopal
Sh. Dheeraj Kumar, STA	Training Programme on "Computer Application".	22 <sup>nd</sup> - 27 <sup>th</sup> September, 2017	IASRI, New Delhi
Sh. J. K. Dabbas, ACTO Sh. Suresh Kumar, CTO Sh. Pawan Kumar, TO	IDEA Executive Committee Meeting .	4 <sup>th</sup> - 5 <sup>th</sup> October, 2017	Verka Milk Plant, Amritsar
Sh. Sudesh Kumar, TO	Training Programme on "Automobile Maintenance Road Safety and Behavioral Skill".	27 <sup>th</sup> November to 1 <sup>st</sup> December, 2017	CIAE, Bhopal
Dr. Om Vir Singh, ACTO	9 <sup>th</sup> Asian Buffalo Congress.	1 <sup>st</sup> - 4 <sup>th</sup> February, 2018	CIRB, Hissar
Sh. B.P. Singh, ACTO Sh. Lakshman, STA	Training Programme on "KOHA for Library Staff".	5 <sup>th</sup> - 9 <sup>th</sup> February, 2018	NARAM, Hyderabad
Dr. Hari Ram Gupta, CTO	46 <sup>th</sup> Dairy Industry Conference.	8 <sup>th</sup> - 10 <sup>th</sup> February, 2018	IDA Zone South, Kochi, Kerala

## Skilled Supporting Staff

Name of Employee	Name of the Training Programme attended	Duration (days)	Organizing Institute
Sh. Neeraj Kumar, SSS Sh. Jalam Singh, SSS Sh. Alam Singh, SSS Sh. Mohan Singh, SSS Sh. Surinder Singh, SSS Sh. Prithvi Singh, SSS	Training Programme on "Capacity Building Personal Development".	29 <sup>th</sup> - 31 <sup>st</sup> August, 2017	NBAGR, Karnal

## C. Participation in Conferences/ Seminars/Workshops within India

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Dr. T. K. Datta, PS Dr. A. K. Mohanty, PS	17 <sup>th</sup> Indian Veterinary Congress and National Symposium on "Newer Generation Vaccines, Diagnostics for Improvement of Animal Health & Productivity vis-à-vis Genomics Interventions for the Societal Benefit" at IVRI, Izatnagar.	8 <sup>th</sup> - 9 <sup>th</sup> April, 2017
Dr. K. Ponnusamy PS	National Conference on "Technological Interventions for Sustainable Livestock Production" at Jammu.	10 <sup>th</sup> - 12 April, 2017
Dr. M. Sivaram, PS	National Workshop on "Developing Protocols for Managing Forests for Stability and Sustainability of Ecosystems" at Kerala Forest Research Institute, Peechi, Kerala.	17 <sup>th</sup> - 19 <sup>th</sup> April, 2017
Dr. Dhruva Malalkar, PS	Symposium on "Ethical and Scientist Issues of Gene Editing Using CRISPR Technology" at New Delhi.	27 <sup>th</sup> -28 <sup>th</sup> April, 2017
Dr. A. K. Tyagi, Head	BAIF Development Research Foundation, Golden Jubilee Year at Pune.	1 <sup>st</sup> - 3 <sup>th</sup> May, 2017
Dr. Sanjit Maiti, Sci.	Workshop on "Research on Extension and Delivery Systems for Impact Acceleration" at NAAS Complex, New Delhi.	4 <sup>th</sup> - 5 <sup>th</sup> May, 2017
Dr. Champak Bhakat, PS Dr. A. Mondal, PS Dr. A. Mohammad, Sci. Dr. Saroj Rai, Sci.	International Conference on "Contemporary Issues in Integrating Climate - The Emerging Areas of Agriculture, Horticulture, Biodiversity, Forestry: Engineering Technology, Fundamental/ Applied Science and Business Management for Sustainable Development" at Kalimpong Science Centre, Kalimpong, West Bengal.	11 <sup>th</sup> - 12 <sup>th</sup> May, 2017
Dr. K. Ponnusamy PS	National Conference on "Sustainable Development Goals India's Preparedness and the Role of Agriculture" at IFPRI, ICAR.	11 <sup>th</sup> - 12 <sup>th</sup> May, 2017
Dr. Pawan Singh, PS Dr. M. Bhakat, Sr. Sci.	National Symposium on "Livestock Resource Management" under Changing Climate Scenario & XXIV Annual Convention of Indian Society of Animal Production & Management at SKUAST, Kashmir.	17 <sup>th</sup> - 19 <sup>th</sup> May, 2017
Dr. K. P. Ramesha, Head Dr. R. Behera, Sci.	International Conference on "Organic Farming for Sustainable Agriculture" at Orissa University of Agriculture and Technology and Centre for Environment and Economic Development, Bhubaneswar.	2 <sup>nd</sup> - 3 <sup>rd</sup> June, 2017
Dr. A. Manimaran, PS	International Workshop on "Advances in Clinical Practices of Large and Small Animals" at Veterinary College and Research Institute (TANUVAS), Namakkal, Tamil Nadu.	22 <sup>nd</sup> - 23 <sup>rd</sup> June, 2017
Dr. Bimlesh Mann, Joint Director (Res.) Dr. K. P. Ramesha, Head Dr. B. Surendra Nath, PS Dr. Bikash Chandra Ghosh, PS Dr. B. V. Balasubramanyam, PS Dr. P. K. Dixit, PS Dr. Bandla Srinivas, PS Dr. K. Jayaraj Rao, PS Dr. D. N. Das, PS Dr. M. C. Arunmozhi Devi, PS Dr. A. Kumaresan, PS Dr. P. Heartwin Amaladhas, PS Dr. Menon Rekha Ravindra, PS Mrs. F. Magdaline Eljeeva Emerald, PS Dr. M. Sivaram, PS Dr. S. Jeyakumar, PS Dr. Mukund .A. Kataktalware, PS Dr. M. Manjunath, PS Dr. S. Subash, PS Dr. A. Manimaran, PS Dr. Monika Sharma, PS Shri. Sathish Kumar.M.H., Sci. Dr. Lakshman Naik, Sci.	95 <sup>th</sup> Foundation Day of ICAR-National Dairy Research Institute and National Seminar on "Strategies for Enhancing Productivity of Indigenous Cattle" at SRS, Bengaluru.	1 <sup>st</sup> July, 2017

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Dr. A. K. Tyagi, Head Dr. K. P. Ramesha, Head Dr. Nitin Tyagi, Sr. Sci.	Workshop on "Augmenting Animal Productivity through Emerging Technologies to Ensure Food Security in the ERA of Climate Change" at Veterinary College and Research Institute, Namakkal, Tamilnadu.	6 <sup>th</sup> - 7 <sup>th</sup> July, 2017
Dr. Latha Sabikhi, Head	International Conference on "Technologies for Value Addition to Food Products" at Hyatt Regency, Chandigarh.	20 <sup>th</sup> - 21 <sup>st</sup> July, 2017
Dr. A. K. Gupta, PS	15 <sup>th</sup> Annual Review Meeting of Network Project on "Buffalo Improvement" at ICAR-Research Complex of Eastern Region at Patna.	21 <sup>st</sup> - 22 <sup>nd</sup> July, 2017
Dr. P. K. Dixit, PS Dr. M. Sivaram, PS	National Consultation on "Farmer Organizations: Status and Prospects" at ICAR-NIANP, Bengaluru.	25 <sup>th</sup> - 26 <sup>th</sup> July, 2017
Dr. T. K. Dutta, Head Dr. D. K. Mandal, PS Dr. A. Mandal, PS	National Seminar on "A Dairy Snapshot 2017" at West Bengal University of Animal and Fishery Sciences, Mohanpur Campus, Nadia, West Bengal.	5 <sup>th</sup> August 2017
Dr. Rajeev Kapila, PS Dr. Gautam Kaul, PS	International Conference on "Environment Genes Health and Disease" at School of Life Sciences, Bharathiar University, Coimbatore.	22 <sup>nd</sup> - 28 <sup>th</sup> August 2017
Dr. Dheer Singh, Head	First International Conference on "Nutraceuticals and Chronic Diseases" at Goa.	1 <sup>st</sup> - 3 <sup>rd</sup> September, 2017
Dr. Magan Singh, PS Dr. Sathish Kumar, M.H., Sci.	National Group Meet Rabi-2017 at GKVK, Bengaluru. Winter school on "Recent Advances in Sub-baric Evaporation and Spray Drying Technologies for Processing and Value Addition to Milk, Food and Fruit Products" at Dairy Science College, Hebbal, Bengaluru.	4 <sup>th</sup> - 5 <sup>th</sup> September, 2017 6 <sup>th</sup> - 26 <sup>th</sup> September, 2017
Dr. Hardev Ram, Sci.	26 <sup>th</sup> National Conference on "Resource Management for Climate Smart Sustainable Agriculture" at College of Post Graduate Studies Barpani, Meghalaya.	11 <sup>th</sup> - 13 <sup>th</sup> September, 2017
Dr. A. K. Mohanty, PS Dr. M. Mondal, Sr. Sci. Dr. M. Karunakaran, Sr. Sci,	National Seminar on "Opportunities and Challenges of Translational Research in the Frontier Areas of Animal Biotechnology" and V Annual convention of "Society of Veterinary Science and Biotechnology" held at College of Veterinary Science and Animal Husbandry of OUAT, Bhubaneswar.	22 <sup>nd</sup> - 23 <sup>rd</sup> September, 2017
Dr. K. Ponnusamy PS	Conference on "Green Revolution in Eastern India: Constraints, Opportunities and Way Forward" at IFPRI, New Delhi.	9 <sup>th</sup> - 10 <sup>th</sup> October, 2017
Dr. Madhu Mohini, PS Dr. G. Mondal, Sr. Sci.	"Preparation of India's Third National Communication and Other New Information to the UNFCCC" organized by MoEF, Govt of India, New Delhi.	12 <sup>th</sup> October, 2017
Dr. Mukesh Bhakat, Sr. Sci. Dr. M. K. Singh, Sci.	International Conference of "Society for Bioinformatics and Biological Sciences on Recent Trends in Bioinformatics" at Jammu.	12 <sup>th</sup> -13 <sup>th</sup> October, 2017
Dr. Sohanvir Singh, PS	National Seminar on "Agrometeorology for Sustainable Development with Special Emphasis on Agrometeorological Practices for Climate Resilient Farming and Food Security" at CCS HAU, Hisar.	12 <sup>th</sup> -14 <sup>th</sup> October, 2017
Dr. Anupama Mukherjee, PS	Training Programme on "In-situ Conservation of Indigenous Livestock & Poultry Breeds" at NBAGR, Karnal.	25 <sup>th</sup> October, to 3 <sup>rd</sup> November, 2017
Dr. Madhu Mohini, PS Dr. G. Mondal, Sr. Sci.	Workshop to Share Experiences between India and Norway on GHG Emission Inventory, TERI, New Delhi.	26 <sup>th</sup> - 27 <sup>th</sup> October, 2017
Dr. Jancy Gupta, PS	Brain Storming Session in the National Round Table of CFOS on Challenges of the Dairy Industry at New Delhi.	27 <sup>th</sup> October, 2017
Dr. A. K. Tyagi, Head	International Conference of Indian Society of Veteromaru Pharmacology and Toxicology and Nutritional Symposium on "Containing Antimicrobial Resistance" at LUVAS, Hisar.	26 <sup>th</sup> -28 <sup>th</sup> October, 2017
Dr. Narender Raju Panjagari, Sci.	International Summit for "Packaging Industry (ISPI) Research Conclave" at Hotel Eros, New Delhi.	27 <sup>th</sup> -28 <sup>th</sup> October, 2017
Dr. Meena Malik. (Professor)	4 <sup>th</sup> International Conference on "English in Multicultural Classrooms" at Kanoria Mahila Mahavidalya, Jaipur.	30 <sup>th</sup> - 31 <sup>st</sup> October, 2017
Dr. B. C. Ghosh, PS	International Conferences on "Compliance in India Across Food Value Chain - Challenges & Future Road Map" Manekshaw Centre, Delhi.	30 <sup>th</sup> - 31 <sup>st</sup> October, 2017
Dr. Smita Sirohi, Head Dr. K. Ponnusamy, PS	25 <sup>th</sup> AERA Annual Conference 2017 at NAARM, Hyderabad.	7 <sup>th</sup> - 9 <sup>th</sup> November, 2017
Dr. Archana Verma, PS Dr. Ashok Santra, PS	3 <sup>rd</sup> International Conference on "Bio-resources and Stress Management" at Jaipur.	8 <sup>th</sup> - 11 <sup>th</sup> November, 2017

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Dr. A. K. Tyagi, Head Dr. G. Mondal, Sr. Sci. Dr. Nitin Tyagi, Sr. Sci. Dr. Sachin Kumar, Sci. Dr. Yogesh Khetra, Sci. Dr. Heena Sharma, Sci. Dr. M. K. Singh, Sci.	Small Ruminants: National Scope in Upscaling Production and Products Value Chain and their Safety organized by ISSGPU, CIRG, Makhdoom.	9 <sup>th</sup> -10 <sup>th</sup> November, 2017
Dr. S. K. Jha, PS	8 <sup>th</sup> National Seminar on "Potential, Prospects and Strategies for Doubling Farmers' Income : Multi-Stakeholder Convergence" at Guwahati, Assam.	9 <sup>th</sup> -11 <sup>th</sup> November, 2017
Dr. Sohanvir Singh, PS	11 <sup>th</sup> Annual Review Meeting of Gramin Krishi Mausam Sewa (GKMS) project jointly organized by IMD and Indira Gandhi Vishwavidyalaya (IGKV), Raipur.	15 <sup>th</sup> -17 <sup>th</sup> November, 2017
Dr. K. Ponnusamy, PS	National Seminar on "Doubling Farmers' Income and Farm Production through Skill Development and Technology Application" at Bihar Agricultural University, Sabour, Bihar.	28 <sup>th</sup> - 30 <sup>th</sup> November, 2017
Dr. A. K. Mohanty, PS Dr. Rubina Baithalu, Sci.	International Conference on "Proteomics in Health and Disease" at Institute of Life Sciences, Bhubaneswar.	30 <sup>th</sup> November to 2 <sup>nd</sup> December, 2017
Dr. I. K. Sawhney, PS	26 <sup>th</sup> ICFOST Indian Convention of Food Science & Technologist at Hyderabad.	7 <sup>th</sup> - 9 <sup>th</sup> December, 2017
Dr. T. K. Dutta, Head	International Conference on "Climate Change Adaptation and Biodiversity Ecological Sustainability and Resource Management for Livelihood Security at ICAR-Central Island Agriculture Research Institute, Andaman, Portblair.	8 <sup>th</sup> - 10 <sup>th</sup> December, 2017
Dr. Chitranayak, Sr. Sci.	6 <sup>th</sup> International Conference on "New Frontiers at Science Management" at IETE, Chandigarh.	9 <sup>th</sup> December, 2017
Dr. Gautam Kaul, PS	Conference on "Bioprocessing India-2017 Beyond Conventions" at Guwahati.	9 <sup>th</sup> - 11 <sup>th</sup> December, 2017
Dr. Sohanvir Singh, PS	International Seminar on "Global Climate Change: Implications for Agriculture and Water Sector (CCAW 2017)" at Aurangabad, Maharashtra.	14 <sup>th</sup> - 16 <sup>th</sup> December, 2017
Dr. Dheer Singh, Head Dr. A. K. Singh, PS Dr. A. Manimaran, Sci.	17 <sup>th</sup> Annual Conference of "Indian Society of Veterinary Pharmacology and Toxicology" and National Symposium on "Combating Antimicrobial Resistance" at College of Veterinary Science and Animal Husbandry, LUVAS, Hisar.	20 <sup>th</sup> - 22 <sup>nd</sup> December, 2017
Dr. Mahendra Singh, PS Dr. Parveen Kumar, PS Dr. A. K. Roy, PS	26 <sup>th</sup> Annual Conference and National Symposium on "Physiological Innovations to Forecast the Impact of Climate Change and to Evolve Strategies for Sustainable Livestock Production" at Department of Veterinary Physiology and Biochemistry, Veterinary College (KVAFSU) Nandi Nagar, Bidar, Karnataka.	21 <sup>st</sup> - 22 <sup>nd</sup> December, 2017
Dr. A. K. Dixit, PS	52 <sup>nd</sup> Annual Convention of ISAE & National Symposium at AAU, Anand	8 <sup>th</sup> - 10 <sup>th</sup> January, 2018
Dr. M. K. Ghosh, PS Dr. M. Mondal, Sr. Sci. Dr. Saroj Rai, Sci. Dr. R. Behera, Sci.	First Farm Innovation Congress 2018 and National Conference on "Innovative Farming for Food and Livelihood Security in Changing Climate" at FACC, BCKV, Kalyani.	12 <sup>th</sup> -13 <sup>th</sup> January, 2018
Dr. P. K. Dixit, PS Dr. M. Sivaram, PS Dr. Menon Rekha Ravindra, PS	International Conference on "Food Processing and Agribusiness: Emerging Trends ICFPA'18" at Indian Institute of Plantation Management Bengaluru.	18 <sup>th</sup> -19 <sup>th</sup> January, 2018
Dr. K. Ponnusamy PS	Policy cum Concluding Workshop on "Technology Enhanced Learning in Agricultural Education (under Niche Area of Excellence of ICAR)" at NAARM, Hyderabad	24 <sup>th</sup> - 25 <sup>th</sup> January, 2018
Dr. Neelam Upadhyay, Sci. Dr. Heena Sharma, Sci.	Workshop on "Opportunities and Challenges for Women in STEM", sponsored by SERB-DST and held at Kurukshetra University, Kurukshetra.	24 <sup>th</sup> -25 <sup>th</sup> January, 2018
Dr. A. K. Tyagi, Head Dr. Raman Mallick, PS Dr. Chander Dutt, PS Dr. Veena Mani, PS Dr. Neelam Kewalramani, PS Dr. Rakesh Kumar, PS Dr. Nitin Tyagi, Sr. Sci., Dr. Sachin Kumar, Sci.	17 <sup>th</sup> Biennial Conference of "Animal Nutrition Society of India" at Junagarh Agricultural University, Junagarh, Gujrat.	1 <sup>st</sup> - 3 <sup>rd</sup> February, 2018

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Dr. Pawan Singh, PS Dr. Sohanvir Singh, PS Dr. M. L. Kamboj, PS Dr. Mukesh Bhakat, Sr. Sci. Dr. M. K. Singh, Sci. Dr. Rubina Baithalu, Sci. Dr. M. Sivaram, PS	9 <sup>th</sup> Asian Buffalo Congress at CIRB, Hisar.	1 <sup>st</sup> - 4 <sup>th</sup> February, 2018
Dr. Bimlesh Mann, Joint Director (Res.) Dr. Latha Sabikhi, Head Dr. K. S. Kadian, Head Dr. K. P. Ramesha, Head Dr. Rajesh Kumar Bajaj, PS Dr. Rajan Sharma, PS Dr. Sumit Arora, PS Dr. Vivek Sharma, PS Dr. Madhu Mohini, PS Dr. Sujata Pandita, PS Dr. Kaushik Khamrui, PS Dr. Jancy Gupta, PS Dr. B. Surendra Nath, PS Dr. Bikash Chandra Ghosh, PS Dr. B.V. Balasubramanyam, PS Dr. P. K. Dixit, PS Dr. Bandla Srinivas, PS, Dr. K. Jayaraj Rao, PS Dr. D. N. Das, PS Dr. M. C. Arunmozhi Devi, PS Dr. A. Kumaresan, PS Dr. P. Heartwin Amaladhas, PS Dr. Menon Rekha Ravindra, PS Mrs. F. Magdaline Eljeeva Emerald, PS Dr. G. Mondal, Sr. Sci. Dr. Narender Raju Panjagari, Sci. Dr. Sangita Ganguly, Sci. Mrs. Khushbu Kumari, Sci. Dr. Kamal Gandhi, Sci. Dr. Meena Malik, Professor	Policy Workshop on "Big Data Analytics in Agriculture" at ICAR-NAARM, Hyderabad.  46 <sup>th</sup> Dairy Industry Conference on "Dairying - Sufficiency to Efficiency" organized by Indian Dairy Association South Zone, Adlux International Convention and Exhibition Centre, Angamaly, Kochi, Kerala.	8 <sup>th</sup> - 9 <sup>th</sup> February, 2018  8 <sup>th</sup> - 10 <sup>th</sup> February, 2018
Dr. T. K. Dutta, Head Dr. M. K. Ghosh, PS Dr. C. Bhakat, PS Dr. D. K. Mandal, PS Dr. A. Mandal, PS Dr. M. Karunakaran, PS Dr. S. K. Das, PS Dr. A. Chattreejee, PS Dr. Champak Bhakat, PS Dr. M. Mondal, Sr. Sci.	33 <sup>rd</sup> Annual Convention and National Seminar of "Indian Society for Studies on Animal Reproduction (ISSAR)" at West Bengal University of Animal and Fishery Sciences, Kolkata.	9 <sup>th</sup> - 11 <sup>th</sup> February, 2018
Dr. Sunita Grover, Head Dr. Chand Ram, PS Dr. Rajiv Kapila, PS Dr. J. K. Kaushik, PS Dr. Rashmi, H.M., Sci. Dr. Diwas Pradhan, Sci. Dr. Sangita Ganguly, Sci.	4 <sup>th</sup> Biennial Conference of PAI and International Symposium "Probiotic Therapy: Translating to Health and Clinical Practice" organized by Probiotic Association of India at AIIMS, New Delhi.	16 <sup>th</sup> - 17 <sup>th</sup> February, 2018
Dr. T. K. Dutta, Head Dr. C. Bhakat, PS Dr. A. Mandal, PS Dr. M. Karunakaran, PS	Workshop on "Developing Multi-disciplinary Approach in Project Formulations and Innovations in Agriculture and Allied Sectors" at CIFRI, Barrackpur, Kolkata.	17 <sup>th</sup> February 2018.
Dr. Hardev Ram, Sr. Sci.	Participation in the "National Agronomy Congress-2018" at Pantnagar.	20 <sup>th</sup> - 22 <sup>nd</sup> February, 2018
Dr. Parveen Kumar, PS Dr. Anjali Aggarwal, PS	National Seminar on "Impact of Global Warming on Water Resources" organized & hosted by Lala Kishan Chand Govt. PG College, Gangoh, Saharanpur (UP).	21 <sup>st</sup> February, 2018

Name & Designation	Title of Workshop/Seminar/ Conferences Training	Period
Er. Ankit Deep, Sci.	International Conference at Guru Jambheshwar University of Science & Technology, Hisar.	21 <sup>st</sup> - 23 <sup>rd</sup> February, 2018
Dr. K. P. Ramesha, Head	18 <sup>th</sup> Indian Veterinary Congress at Tirupati.	23 <sup>rd</sup> - 24 <sup>th</sup> February, 2018
Dr. T. K. Mohanty, PS Dr. Satish Kumar, Sr. Sci. Dr. Mukesh Kumar Bhakat, Sr. Sci.	World Congress in Reproductive Health with Emphasis on "Family Planning & Assisted Reproductive Technology (ISSRF-2018)" at CSIR-Indian Institute of Chemical Technology, Hyderabad	23 <sup>rd</sup> - 25 <sup>th</sup> February, 2018
Dr. Chitranayak, Sr. Sci.	31 <sup>st</sup> National Convention of Agricultural Engineers at New Delhi	2 <sup>nd</sup> - 3 <sup>rd</sup> March, 2018
Dr. T. K. Dutta. Head Dr. A. Mandal, PS Dr. D. K. Mandal, PS	National Seminar on "Trends and Application of ICT in Agriculture (TRACT)" organized by C-DAC, Kolkata, at Palacia-3, Hotel Monotel, Salt lake, Kolkata.	13 <sup>th</sup> March, 2018
Dr. Rajan Sharma, PS Dr. Sumit Arora, PS Dr. Vivek Sharma, PS Dr. G. S. Meena, Sci. Sh. Sanket G. Borad, Sci. Sh. P. S. Minz, Sci.	National Conference on "Emerging and Sustainable Technologies in Food Processing (ESTFP-2018)" at Sant Longowal Institute of Engineering and Technology, Longowal, Punjab.	15 <sup>th</sup> -16 <sup>th</sup> March, 2018
Dr. Neelam Upadhyay, Sci.	National Workshop on "Revisiting FOCARS Course" for ARS at ICAR-NAARM, Hyderabad.	15 <sup>th</sup> - 16 <sup>th</sup> March, 2018
Dr. A. K. Dixit, PS	National Conference at CIPHET, Ludhiana.	16 <sup>th</sup> - 17 <sup>th</sup> March, 2018
Dr. Archana Verma, PS Dr. A. Santra, PS	105 <sup>th</sup> Indian Science Congress at Manipur University, Imphal, Manipur.	16 <sup>th</sup> - 20 <sup>th</sup> March, 2018
Dr. Rajan Sharma, PS	National Conference on "Nutricon 2018" at J.D. Birla Institute, Kolkatta.	23 <sup>rd</sup> March, 2018
Dr. A. Kumaresan, PS Dr. M. Mondal, Sr. Sci.	National Symposium on "Thrust Areas of Relevance to Livestock Research" held at National Institute of Animal Biotechnology (NIAB), DBT, Hyderabad.	27 <sup>th</sup> - 28 <sup>th</sup> March, 2018



*Dr. R. R. B. Singh Director, NDRI with trainees at NDRI, Karnal*



## MAJOR EVENTS

### CONFERENCES/SEMINARS/SYMPOSIA/WORKSHOPS/TRAINING PROGRAMMES/FIELD DAYS ORGANISED

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:

1	An International Training on "Modern Dairy Technology and Management".	15 <sup>th</sup> - 29 <sup>th</sup> April, 2017
2	A Training on "Scientific Dairy Farming".	26 <sup>th</sup> April - 6 <sup>th</sup> May, 2017
3	Workshop - cum - Interactive Session on the "Art of Understanding Reasoning and Argumentation".	6 <sup>th</sup> May, 2017
4	Tree Plantation Programme at Southern Campus of NDRI, Bengaluru.	7 <sup>th</sup> May 2017
5	Programme on "Entrepreneurship and Got - an - Idea Challenge Season - 2".	29 <sup>th</sup> - 30 <sup>th</sup> May, 2017
6	EDP Programme on "Milk Processing and Value Addition".	29 <sup>th</sup> May - 7 <sup>th</sup> June, 2017
7	Training on "Basic Aspects of Milk and Milk Processing".	27 <sup>th</sup> - 29 <sup>th</sup> June, 2017
8	National Seminar on "Strategies for Enhancing Productivity of Indigenous Cattle".	1 <sup>st</sup> July, 2017
9	Workshop on "Beyond a Life in Classrooms-8 Must Know Truths for Success".	17 <sup>th</sup> July, 2017
10	Workshop on "Towards Leadership through Dairy Education"	17 <sup>th</sup> July, 2017
11	Orientation Programme for Freshers at Southern Campus of NDRI, Bengaluru.	2 <sup>nd</sup> - 31 <sup>st</sup> August, 2017
12	The Foundation Programme	2 <sup>nd</sup> August - 14 <sup>th</sup> September, 2017
13	New India Manthan - Sankalp - se - Siddhi Programme at Eastern Campus of NDRI, Kalyani.	24 <sup>th</sup> August, 2017
14	Programme on "Stubble Burning: Option to Address it".	
15	Training on "Scientific Dairy Farming Practices" at Eastern Campus of NDRI, Kalyani.	5 <sup>th</sup> - 7 <sup>th</sup> September, 2017
16	Programme on "Sankalp Se Siddhi New India".	6 <sup>th</sup> September, 2017
17	A Training on "Scientific Dairy Farming".	11 <sup>th</sup> - 14 <sup>th</sup> September, 2017
18	Swachchhta Pakhwada under the "Swachchhta Hi Sewa" Campaign of the "Swachchh Bharat Abhiyaan" programme.	22 <sup>nd</sup> September - 2 <sup>nd</sup> October, 2017
19	A Rally for Rivers Campaign	23 <sup>rd</sup> September, 2017
20	Training under Rashtriya Gokul Mission scheme on Embryo Transfer (ET) in Deoni, a dual purpose indigenous cattle breed at Southern Campus of NDRI, Bengaluru.	2 <sup>nd</sup> - 3 <sup>rd</sup> October, 2017
21	Training on "Microbiological and Chemical Analysis of Milk and Milk Products".	9 <sup>th</sup> - 13 <sup>th</sup> October, 2017
22	Training on "Milk Processing and Value Addition".	25 <sup>th</sup> October - 3 <sup>rd</sup> November, 2017
23	Blood Donation Camp under a banner Model Dairy Plant and Smiling Waves.	31 <sup>st</sup> October, 2017
24	Training on "Sensory Evaluation of Milk and Milk Products".	15 <sup>th</sup> - 17 <sup>th</sup> November, 2017
25	An Antimicrobial Resistance (AMR) Awareness programme.	18 <sup>th</sup> November, 2017
26	National Dairy Mela	23 <sup>rd</sup> - 25 <sup>th</sup> November, 2017
27	CAFT on "Advances in Validation of Functional Foods".	1 <sup>st</sup> - 21 <sup>st</sup> December, 2017
28	A Training Programme on "Skill and Personality Development in an Organization"	11 <sup>th</sup> - 13 <sup>th</sup> December, 2017
29	Training on "Developing Winning Research Proposals"	13 <sup>th</sup> - 16 <sup>th</sup> December, 2017
30	CAFT Training on "Dairy and Food Processing Engineering : Equipment Processing and Value Addition".	10 <sup>th</sup> - 30 <sup>th</sup> January, 2017

31	Training on "Technology of Cheese Making".	29 <sup>th</sup> January - 3 <sup>rd</sup> February, 2018
32	Training on "Milk Processing and Value Addition".	5 <sup>th</sup> - 14 <sup>th</sup> March, 2018
33	Workshop on "Predictive Analytics in Bioinformatics: A Machine Learning Perspective".	27 <sup>th</sup> - 28 <sup>th</sup> March, 2018



*Group photo of International Trainees at NDRI, Karnal*

Specific Day(s) Celebrated		
34	An International Yoga Day	21 <sup>st</sup> June, 2017
35	Agricultural Education day	3 <sup>rd</sup> December, 2017
36	World Milk Day	1 <sup>st</sup> June, 2017
37	National Milk Day	26 <sup>th</sup> November, 2017



*A farmer receiving soil health card at NDRI*

## DISTINGUISHED VISITORS

- 17.4.2017 Mr. Mark Wallace, Attache for Agricultural Affairs and Dr. Vijay Intodia, Agricultural Specialist from US Embassy, New Delhi.
- 5.6.2017 Hon'ble Haribhau Kisanrao Bagade, Speaker of Maharashtra Legislative Assembly alongwith Director, Aurangabad District Co-operative Milk Producers' Union Ltd., Aurangabad.
- 19.6.2017 HCS Extra Assistant Commissioner (HCS Probationers, UT) (30 Nos.) from Saina Nehwal Institute of Agricultural Technology, Training & Education, CCS, Haryana Agricultural University, Hisar.
- 10.7.2017 Dr. Santosh Kumar Singh, Agriculture Specialist in Embassy of the USA, New Delhi.
- 15.7.2017 Sh. Tsering Gyurme, Ex-Minister, Animal Husbandry Veterinary and Dairy Development Government of Arunachal Pradesh.
- 21.7.2017 House Committee of Kerala Legislative Assembly.
- 27.7.2017 Hon'ble Hifikepunye Pohamba, Former President of the Republic of Namibia, Mr. Pius Dunaiki, High Commissioner, High Commission of Namibia and Prof. Lazarus Hangula, Vice-Chancellor, Namibia alongwith other dignitaries.



*Delegation from Namibia led by former President of the Republic of Namibia at NDRI*

- 15.9.2017 42 NRIs (participating in 41<sup>st</sup> Know India Programme in Haryana scheduled from 14<sup>th</sup> to 17<sup>th</sup> Sept., 2017 organized by DSO, Karnal).
- 04.10.2017 Sh. Surendra Nath Tripathi, IAS Additional Secretary, DARE & Financial Advisor, ICAR.

- 11-13.10.2017 Prof. Richard Ipsen and Prof. Lilia Aehne from university of Copenhagen, Denmark.
- 11.12.2017 Dr. Joykrushna Jena, Deputy Director General (AS), ICAR, Krishi Bhawan, New Delhi.
- 11.1.2018 30 Member Delegation (Students and Faculty Members) from Kansas State University, USA.
- 11.1.2018 YB Dato' Sri Haji Tajuddin Bin Abdul Rahman, Deputy Minister of Agriculture and Agro-Based Industry alongwith 13 Members Malasian Delegation and Dr. R. S. Gandhi, ADG (AP&B), ICAR.



- 31.1.2018 Sh. Suresh Chandel, GB Member of ICAR.
- 14.2.2018 Sh. Ratneshwari Prasad Singh (Vill. Ratanpur, Post-Barharwa, Distt. Sitamrahi, Bihar) Non-Official Member of the Governing Body of ICAR.
- 16.2.2018 Dr. Mark Oakes, Head of Economy at Dept. for International Trade, Govt. of United Kingdom and Mr. Andrew Ayre's, British Deputy High Commissioner, Chandigarh and Mr. Dipankar Chakraborty, Senior Sector Manager – Food & Drinks, Agri. Tech. Chemicals and Head of Trade for Northwest India, Chandigarh.



- 28-29.2.2018 Hon'ble Minister of State for Human Resource Development, Govt. of India Sh. Upendra Kushwaha.
- 03.3.2018 Dr. Joykrushna Jena, Deputy Director General (AS), ICAR, Krishi Bhawan, New Delhi.
- 06.3.2018 Dr. A. K. Srivastava, Chairman, ASRB, New Delhi.
- 10.3.2018 Sh. Radha Mohan Singh, Hon'able Union Minister for Agriculture and Farmers Welfare.
- 10.3.2018 Dr. Trilochan Mohapatra, Secretary, DARE & DG (ICAR), New Delhi and Dr. J. K. Jena, DDG (AS), ICAR, New Delhi.
- 23.3.2018 Dr. N. S. Rathore, Deputy Director General (Education ), ICAR, New Delhi.





# PERSONNEL

## INSTITUTE STAFF

(As on 31<sup>st</sup> March, 2018)

### Director's Cell

R. R. B. Singh, PhD  
Nirmala Kumari, BA

Director  
Private Secretary

### Joint Director (Research) Cell

Bimlesh Mann, PhD  
Meena Malik, M Phil, PhD  
Braj Kishor, MA, B Lib Sci  
Sunil Sharma, MSc  
Ranjana, BA

Joint Director (Research)  
Professor (English)  
Assistant Chief Technical Officer  
Technical Officer  
Private Secretary

### Academic Affairs Cell

R. R. B. Singh, PhD  
S. K. Tomar, PhD  
A. P. Ruhil, PhD  
Bhagwan Das, BA  
Parvesh Lata, BA

Joint Director (Academics)  
Academic Coordinator  
Controller of Examinations  
Asstt. Admn. Officer  
Private Secretary

### Administrative Wing

Susanta Saha, MSc, MBA  
H. R. Arya, BA  
Ram Niwas, BA  
Ritu Dalal, B Tech  
A. K. Mishra  
Rajbir, BA  
S. S. Meena, BA  
Braham Prakash, BA  
Dharam Singh Meena, BA  
Subhash Chand, BA  
Ajit Singh, BA  
Mukesh Dua, BA  
Ram Pal  
Anita Rani, BA

Joint Director (Admn.) & Registrar  
Sr. Admn. Officer  
Admn. Officer  
Admn. Officer  
Admn. Officer  
Asstt. Admn. Officer (DDO)  
Asstt. Admn. Officer (Purchase)  
Asstt. Admn. Officer  
Asstt. Admn. Officer (Stores)  
Asstt. Admn. Officer  
Asstt. Admn. Officer (E- IV)  
Asstt. Admn. Officer (II & V)  
Asstt. Admn. Officer (III)  
Private Secretary

### Finance Wing

D. D. Verma, M Com, PGDFM  
S. C. Sharma, BA

Comptroller  
Sr. Fin. & Account Officer

Kunal Kalra, B Com, PGDM  
Vishal Acharya, MA

Finance & Accounts Officer  
Asstt. Fin. & Account Officer

### Animal Genetics & Breeding Division

A. K. Gupta, PhD  
S. M. Deb, PhD  
Archana Verma, PhD  
I. D. Gupta, PhD  
Anupama Mukherjee, PhD  
Om Vir Singh, PhD  
Vinod Kumar, BSc  
Y. K. Panwar, MA

Head  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Chief Technical Officer  
Sr. Technical Officer  
Sr. Technical Officer

### Livestock Production & Management Section

Pawan Singh, PhD  
T. K. Mohanty, PhD  
M. L. Kamboj, PhD  
S. S. Lathwal, PhD  
Arun Kumar Misra, PhD  
Ramesh Chandra, PhD  
Mukesh Bhakat, PhD  
Nishant Kumar, MSc  
Rubina Baithalu, MVSc  
Shiv Kumar, MSc  
R. K. Tonk, PhD

Head  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Sr. Scientist  
Sr. Scientist  
Scientist  
Scientist  
Assistant Chief Technical Officer  
Sr. Technical Officer

### Animal Nutrition Division

A. K. Tyagi, PhD  
Neelam Kewalramani, PhD  
Madhu Mohini, PhD  
Veena Mani, PhD  
Raman Malik, PhD  
Chander Datt, PhD  
Nitin Tyagi, PhD  
Goutam Mondal, PhD  
Sachin Kumar, PhD  
Gian Singh, MSc  
Sumit Narayan, MSc

Head  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Sr. Scientist  
Sr. Scientist  
Scientist  
Sr. Technical Officer  
Technical Officer

### Animal Physiology Division

Mahendra Singh, PhD  
Sujata Pandita, PhD  
Parveen Kumar, PhD  
Sohanvir Singh, PhD  
A. K. Dang, PhD  
Anjuli Aggarwal, PhD  
A. K. Roy, PhD  
Manju Ashutosh, PhD  
Ashutosh, PhD  
Y. P. Singh, BSc

Head  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Principal Scientist  
Sr. Scientist  
Sr. Scientist  
Sr. Scientist  
Technical Officer

### Animal Biotechnology Centre

Dr. P. Palta, PhD	Principal Scientist and In-Charge
Dr. T. K. Datta, PhD	Principal Scientist
Dr. S. De, PhD	Principal Scientist
Dr. J. K. Kaushik, PhD	Principal Scientist
Dr. A. K. Mohanty, PhD	Principal Scientist
Dr. D. Malakar, PhD	Principal Scientist
Dr. Satish Kumar, Ph.D.	Principal Scientist
Dr. Rakesh Kumar, PhD	Principal Scientist
Dr. M. K. Singh, PhD	Scientist
Dr. S. Kumar, PhD	Scientist

### Animal Biochemistry Division

Dheer Singh, PhD	Head
Dr. Y. S. Rajput, PhD	Emeritus Scientist
Gautam Kaul, PhD	Principal Scientist
Rajeev Kapila, PhD	Principal Scientist
Suman Kapila PhD	Principal Scientist
S. K. Sood, PhD	Sr. Scientist
Sunil Kumar Onteru, PhD	Sr. Scientist
Sateesh E. M., PhD	Sr. Scientist
Ms. Suneeta Meena, MSc	Scientist
Vedamurthy G. V., PhD	Scientist
Ravi Kant, PhD	Asstt. Chief Technical Officer

### Dairy Technology Division

Latha Sabikhi, PhD	Head
S. K. Kanawjia, PhD	Emeritus Scientist
A. K. Singh, PhD	Principal Scientist
Kaushik Khamrui, PhD	Principal Scientist
Narender Raju Panjagari, PhD	Scientist
Ganga Sahay Meena, PhD	Scientist
Yogesh Khetra, PhD	Scientist
Prateek Sharma, PhD	Scientist
Shaik Abdul Hussain, PhD	Scientist
Gunvantsinh Rathod, M Tech	Scientist
Neelam Upadhayay, PhD	Scientist
Wridhama Prasad, M Tech	Scientist
Sanket G. Borad, M Tech	Scientist
Sangita Ganguly, PhD	Scientist
Heena Sharma, PhD	Scientist
Manoj Kumar, CT, MTech	Scientist
Prem Kumari, B.A.	Private Secretary

### Experimental Dairy

Hari Ram Gupta, PhD	Chief Technical Officer ( In-Charge)
Lehri Singh, MSc (Chemistry)	Chief Technical Officer
A. K. Kohli, Dip. (Mech. Engg.)	Asstt. Chief Technical Officer
Sanjeev Kumar, MA (Economics)	Asstt. Chief Technical Officer
Probir Mondal, IDD	Sr. Technical Officer
Prathvi Raj, Higher Secondary	Technical Officer
Gurpartap Singh, M Tech (Mech. Engg.)	Technical Officer

### Dairy Chemistry Division

Bimlesh Mann, PhD  
 Raman Seth, PhD  
 Sumit Arora, PhD  
 Vivek Sharma, PhD  
 Rajan Sharma, PhD  
 Rajesh Kumar, PhD  
 Richa Singh, PhD  
 Priyanka Singh Rao, MSc  
 K. P. Indumati, MSc  
 Kamal Gandhi, PhD  
 P. C. Singh, MSc  
 Shakuntla Rani, BA

Head  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Scientist  
 Scientist  
 Scientist  
 Scientist  
 Asstt. Chief Technical Officer  
 Private Secretary

### Dairy Microbiology Division

Sunita Grover, PhD  
 R.K. Malik, PhD  
 S. K. Tomar, PhD  
 Naresh Kumar, PhD  
 Shilpa Vij, PhD  
 Chand Ram, PhD  
 P. V. Behare, PhD  
 Raghu H.V., MSc  
 Rashmi H. M., M Tech  
 Diwas Pradhan, M Tech

Head  
 Emeritus Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Scientist (SS)  
 Scientist (SS)  
 Scientist  
 Scientist

### Dairy Engineering Division

A. K. Singh, PhD  
 I. K. Sawhney, PhD  
 P. Barnwal, PhD  
 Chitranayak, PhD  
 P. S. Minz, M Tech  
 Amita Vairat, M Tech  
 Ankit Deep, M Tech  
 Kushbu Kumari, M Tech  
 Om Prakash, Dip. (Agri. Engg.)  
 S. K. Chaudhary, AMIE  
 J. K. Dabas, PhD  
 Sunil Kumar, M Tech  
 Pawan Kumar, Dip. (Machinist)  
 Sh. Parveen Kumar, Dip. (Machinist)  
 Ms. Manju Bala, Dip Arch

Head  
 Emeritus Scientist  
 Principal Scientist  
 Sr. Scientist  
 Scientist (Senior Scale)  
 Scientist  
 Scientist  
 Scientist  
 Chief Technical Officer  
 Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer

### Dairy Economics, Statistics & Management Division

Smita Sirohi, PhD  
 B. S. Chandel, PhD  
 A. K. Chauhan, PhD  
 Ravinder Malhotra, PhD  
 Ajmer Singh, PhD  
 A. P. Ruhil, PhD  
 A. K. Sharma, PhD  
 Anil Kumar Dixit, PhD

Head  
 Principal Scientist  
 Principal Scientist

Udita Chaudhary, MSc  
 Gunjan Bhandari, MSc  
 Tara Chand, BSc  
 Sunita Chaudhary

Scientist  
 Scientist  
 Asstt. Chief Technical Officer  
 Private Secretary

### Dairy Extension Division

K. S. Kadian, PhD  
 Jancy Gupta, PhD  
 K. Ponnusamy, PhD  
 S. K. Jha, PhD  
 Gopal Sankhala, PhD  
 B. S. Meena, PhD  
 H. R. Meena, PhD  
 Ritu Chakravarty, PhD  
 Sanjit Maiti, PhD  
 Sanchita Garai, PhD  
 Meenu Rani

Head  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Principal Scientist  
 Sr. Scientist  
 Scientist  
 Scientist  
 Private Secretary

### Forage Research & Management Centre

Magan Singh, PhD  
 Rakesh Kumar, PhD  
 Hardev Ram, PhD  
 Rajesh Kumar Meena, PhD  
 Sanjeev Kumar, PhD  
 Uttam Kumar, PhD  
 V. K. Meena, PhD

Principal Scientist & I/c FR&MC  
 Principal Scientist  
 Scientist  
 Scientist  
 Scientist  
 Chief Technical Officer  
 Sr. Technical Officer

### Agricultural Technology Information Centre (ATIC)

Arun Kumar Misra, PhD  
 J. K. Pundir, BVSc  
 Jitendra Rana, PhD

Principal Scientist & Incharge  
 Assistant Chief Technical Officer  
 Assistant Chief Technical Officer

### Krishi Vigyan Kendra/Trainers' Training Centre

Surender Gupta, PhD  
 Rajeshwar Dayal, BSc  
 Mohar Singh, MSc  
 Kulvir Singh, MSc  
 Deepa Kumari, BSc, MA  
 Balraj

Chief Technical Officer & Incharge  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Technical Officer  
 Technical Officer

### Forage Production Section

Ashutosh, PhD  
 Satish Kumar, MSc (Horti.)  
 Anil Kumar Dagar, MSc  
 Ravi Rawat, MSc (Entomology)  
 Sukhdev Singh  
 Mahender Pal

Sr. Scientist & Incharge  
 Chief Technical Officer  
 Assistant Chief Technical Officer  
 Sr. Technical Officer  
 Technical Officer  
 Technical Officer

### Livestock Research Centre

S. S. Lathwal PhD  
 Ramesh Chandra, PhD  
 Nishant Kumar, MVSc

Principal Scientist & Incharge  
 Sr. Scientist  
 Scientist

Rubina Kumari Bithalu, MVSc  
 Pramod Kumar, MSc  
 Amarpal Singh, PhD  
 Ashwani Kumar, MSc  
 Rajbir  
 Samar Singh

### Animal Health Complex

Parveen Kumar, MVSc  
 S. Raju, MVSc  
 Sahdev Singh, MSc

### Artificial Breeding Research Centre

T. K. Mohanty, PhD  
 A. K. Gupta, PhD  
 Mukesh Bhakat, PhD  
 Subhash Chand, BVSc

### Library Services

S.M. Deb, PhD  
 B. P. Singh, MA, PGDCA, M Lib, I Sc  
 Narendra Singh, MCA, M Lib I Sc

### Computer Centre

A. K. Sharma, PhD  
 A. P. Ruhil, PhD  
 Naresh Kumar Dahiya, M Tech  
 Des Raj Dip. CSP

### Communication Centre

Gopal Sankhala, PhD  
 Dharambir, BA

### Vehicle Maintenance Section

Sanjeev Kumar, B Tech, M Sc (CS)

### Official Language Unit

Susanta Saha, MSc, MBA  
 Rakesh Kumar, MA  
 Kanchan Choudhary, MA

### Security Section

Ashutosh, PhD  
 Deepak Chopra, BA  
 Rajvir Singh, MA, PGDCA

### Maintenance Section

R. M. Chayal, Dip.Civil Engg.  
 R. K. Bansal, BE (Civil)  
 S. K. Saini, B Tech (Mechanical)  
 Tek Chand, ITI (Electrical)  
 Sohan Lal, MA (Eco.) ITI (Electrical)  
 Khem Chand, ITI (Electrical)  
 Balbir Singh, ITI (Electrical)

Scientist  
 Asstt. Chief Technical Officer  
 Sr. Technical Officer  
 Sr. Technical Officer  
 Technical Officer  
 Technical Officer

Chief Technical Officer  
 Chief Technical Officer  
 Asstt. Chief Technical Officer

Principal Scientist & Incharge  
 Principal Scientist  
 Sr. Scientist  
 Sr. Technical Officer

Head  
 Asstt. Chief Technical Officer  
 Technical Officer

Principal Scientist & Incharge  
 Principal Scientist  
 Asstt. Chief Technical Officer  
 Technical Officer

Incharge  
 Technical Officer

Technical Officer

Incharge  
 Assistant Director (OL)  
 Asstt. Chief Technical Officer

Incharge  
 Security Officer  
 Security Supervisor

Chief Technical Officer, Incharge  
 Asstt. Chief Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer



V.R.V. Surendranath Naik, MD  
 B. K. Rajashekaraiah, BSc (Agri.)  
 Veeraju, BE (Civil)  
 K. L. Sampath, BSc  
 P. G. Satish, BVSc  
 Siddaramanna, PhD  
 R. Keshavamurthy, BSc (Agri.)  
 Gurunath Gouda Patil, BSc (Agri.)  
 K. Ningaraju, MVSc  
 Meganathan, Dip. (Elec. Engg.)  
 K.P. Lakshminarayanappa, DME(Mech.)  
 Janakshi, MCA  
 M.S. Nagarajaiah, Dip. (Civil Engg.)  
 Sreekanta, Dip.  
 Vimala, BSc  
 K. Ramakrishna Prasad, MSc  
 S. Shashi Kala

Chief Medical Officer  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Asstt. Chief Technical Officer  
 Sr. Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer  
 Technical Officer  
 Admn. Officer

### Eastern Regional Station, Kalyani

T. K. Dutta, PhD  
 M. K. Ghosh, PhD  
 S. K. Das, PhD  
 A. Santra, PhD  
 C. Bhakat, PhD  
 A. Mandal, PhD  
 D. Mandal, PhD  
 A. Chatterjee, PhD  
 M. Karunakaran, PhD  
 M. Mondal, PhD  
 Asif Mohammad, PhD  
 Saroj Rai, PhD  
 Rajalakshmi Behra, MVSc  
 Alokesh Goswami, MSc  
 Amitava Ghosh, MVSc  
 Somnath Dutta, MVSc  
 Prabir Saha, MSc  
 Sukhdev Singh, BA

Head  
 Principal Scientist  
 Sr. Scientist  
 Scientist  
 Scientist  
 Scientist  
 Chief Technical Officer  
 Chief Technical Officer  
 Chief Technical Officer  
 Chief Technical Officer  
 Asstt. Admn. Officer



*NCC Parade being performed by the students*

## PERSONALIA

### Joining/Appointments

- » Dr. Bimlesh Mann, Head, Dairy Chemistry Division, ICAR-NDRI, Karnal entrusted the additional responsibilities of Acting Joint Director (Research), NDRI, Karnal w.e.f. 01.04.2017.
- » Sh. Raj Kumar, Sr. A. O. joined at ICAR-NDRI, Karnal after relieving from ICAR-CIPHET, Ludhiana w.e.f. 03.04.2017.
- » Dr. Vedamurthy G.V. Scientist joined at Animal Biochemistry Division, ICAR-NDRI, Karnal after relieving from ICAR-CSWRI, Avikanagar w.e.f. 06.04.2017.
- » Dr. Sadeesh E. M. Scientist joined at Animal Biochemistry Division, ICAR-NDRI, Karnal after relieving from ICAR-CIRB, Hisar w.e.f. 20.04.2017.
- » Dr. Anil Kumar Dixit, Principal Scientist joined at Dairy Economics Statistics & Management Division ICAR-NDRI, Karnal after relieving from ICAR-CIPHET, Ludhiana w.e.f. 20.06.2017.
- » Dr. Satish Kumar, Sr. Scientist (Animal Biotechnology) joined at ICAR-NDRI after relieving from ICAR-CSWRI, Avikanagar w.e.f. 1.7.2017.
- » Dr. Sanjeev Kumar, Scientist (Agronomy) joined at ICAR-NDRI after relieving from ICAR-IIFSR, Modipuram w.e.f. 1.7.2017.
- » Sh. Brahm Parkash, AAO joined at ICAR-NDRI after premature repatriation from National Test House (ER), Kolkata w.e.f. 17.7.2017.
- » Dr. Arun Kumar Misra, Principal Scientist (LPM) joined at ICAR-NDRI after relieving from ICAR-CAZRI, Jodhpur w.e.f. 20.7.2017.
- » Dr. T. K. Dutta, Principal Scientist entrusted the additional responsibilities of Acting Head, Eastern Campus of ICAR-NDRI, Kalyani for further period of six months w.e.f. 1.8.2017.
- » Sh. A. K. Mishra Administrative Officer joined at ICAR-NDRI after relieving from ICAR-CSSRI, Karnal w.e.f. 7.8.2017.
- » Ms. Gunjan Bhandari, Scientist (Agril. Economics) joined at ICAR-NDRI Karnal after relieving from ICAR-NAARM, Hyderabad w.e.f. 16.10.2017.
- » Dr. S. M. Deb, Principal Scientist (AG&B) joined at ICAR-NDRI Karnal after relieving from ICAR-NRC on Yak, Dirang (AP) w.e.f. 11.12.2017.
- » Sh. H. R. Arya joined as Sr. Admn. Officer at ICAR-NDRI Karnal after relieving from ICAR-NBAGR, Karnal w.e.f. 27.12.2017.
- » Sh. S. C. Sharma joined as Sr. Finance & Accounts Officer at ICAR-NDRI Karnal after relieving from ICAR-CSWRI, Avikanagar w.e.f. 28.12.2017.
- » Dr. S. M. Deb, Principal. Scientist entrusted the additional responsibility to act as Head, Library Services, NDRI, Karnal w.e.f. 6.1.2018.
- » Dr. A. P. Ruhil, Pr. Scientist entrusted the additional responsibility to act as Controller of Examinations, NDRI, Karnal w.e.f. 3.1.2018.
- » Dr. A. K. Gupta, Pr. Scientist entrusted the additional responsibility to act as Head, AG&B Division, NDRI, Karnal w.e.f. 9.3.2018.

### Promotions

- » Dr. Anupama Mukherjee, Sr. Scientist, Animal Genetics & Breeding Division, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 23.08.2014.
- » Dr. A. Kumaresan, Sr. Scientist (Animal Reproduction & Gyna) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 09.07.2015.
- » Dr. S. Jeyakumar, Sr. Scientist (Animal Reproduction) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 16.08.2015.
- » Dr. P. Heartwin Amaladhas, Sr. Scientist (ASPE) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 02.09.2015.
- » Dr. Kaushik Khamrui, Sr. Scientist, Dairy Technology Division, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 03.03.2016.

- » Dr. M. Sivaram, Sr. Scientist (Agril. Statistics), Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 1.8.2016.
- » Dr. Rakesh Kumar, Sr. Scientist (Agronomy), Forage Research Management Centre, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 25.6.2016.
- » Dr. Hans Ram Meena, Sr. Scientist (Vety. Extn. Edu.) Dairy Extension Division, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 22.7.2016.
- » Dr. Pradyuman Barnwal, Sr. Scientist (ASPE), Dairy Engineering Division, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 11.9.2016.
- » Dr. Menon Rekha Ravindra, Sr. Scientist (ASPE) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 22.2.2017.
- » Dr. M. C. Arunmozhi Devi, Sr. Scientist (Agril. Extn.) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 1.1.2011.
- » Dr. Satish Kumar, Sr. Scientist (Bio-Technology), Biotechnology Centre Centre, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 24.7.2016.
- » Dr. Rakesh Kumar, Sr. Scientist (Bio-Technology), Biotechnology Centre Centre, ICAR-NDRI, Karnal promoted as Principal Scientist w.e.f. 22.11.2016.
- » Dr. M. Karunakaran, Sr. Scientist (Animal Reproduction & Gyne.) Southern Campus of ICAR-NDRI, Bengaluru promoted as Principal Scientist w.e.f. 8.8.2016.
- » Dr. Sadeesh E. M. Scientist (Biochemistry) Southern Campus of ICAR-NDRI, Bengaluru promoted as Scientist (SS) w.e.f. 1.5.2015.

### Retirements/Relieving/Transfers

- » Sh. R. C. Meena, Sr. A.O. ICAR-NDRI, Karnal transferred to join his duties at ICAR-DRMR, Bharatpur (Rajasthan) w.e.f. 01.04.2017.
- » Sh. Ashok Mallick, Sr. A.O. ICAR-NDRI, Karnal transferred to join his duties at ICAR-CIRG, Makhdum w.e.f. 08.05.2017.
- » Sh. Raj Kumar, Sr. A.O. ICAR-NDRI, Karnal transferred to join his duties at ICAR-CIPHET, Ludhiana w.e.f. 16.06.2017.
- » Sh. N. K. Jain, Assistant Administrative Officer, E.V (Coord.) Section, ICAR-NDRI, Karnal retired from Council's service w.e.f. 30.04.2017.
- » Dr. O. K. Hooda, Principal Scientist, Animal Physiology Division, ICAR-NDRI, Karnal retired from Council's services w.e.f. 30.06.2017.
- » Dr. Suresh Kumar Singla, Principal Scientist, Animal Biotechnology Centre, ICAR-NDRI, Karnal retired from Council's services w.e.f. 30.06.2017.
- » Dr. S. S. Kundu, Principal Scientist, Animal Nutrition Division, ICAR-NDRI, Karnal retired from Council's services w.e.f. 30.9.2017.
- » Dr. P. S. Oberoi, Principal Scientist, Animal Nutrition Division, ICAR-NDRI, Karnal retired from Council's services w.e.f. 30.9.2017.
- » Smt. K. Geetha Kumari, Senior Technical Officer, Southern Campus of ICAR-NDRI, Bengaluru retired voluntarily from Council's services w.e.f. 01.08.2017.
- » Smt. T. R. Thivija Kumari, Assistant Chief Technical Officer, Southern Campus of ICAR-NDRI, Bengaluru retired voluntarily from Council's services w.e.f. 01.09.2017.
- » Sh. Agnivesh, AO, ICAR-NDRI, Karnal transferred to join his duties at ICAR-CIRG, Makhdoom w.e.f. 19.8.2017.
- » Dr. S. S. Thakur, Principal Scientist, Animal Nutrition Division, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 30.11.2017.
- » Dr. Surajit Mandal, Sr. Scientist, Dairy Microbiology Division, ICAR-NDRI, Karnal relieved from ICAR-NDRI Karnal after tendering technical resignation to enable him to join as Professor in WBUAFS, Kolkata w.e.f. 14.12.2017.
- » Smt. S. Shashikala, Assistant Administrative Officer, on promotion, was transferred from Southern Campus of ICAR-NDRI, Bengaluru to NIANP, Bengaluru as Administrative Officer w.e.f. 30-12-2017

- » Dr. R. S. Manik, Principal Scientist, Animal Biotechnology Centre, ICAR-NDRI, Karnal retired from Council's service w.e.f. 31.1.2018.
- » Dr. D. K. Gosain, Principal Scientist, KVK, ICAR-NDRI, Karnal retired from Council's service w.e.f. 31.1.2018.
- » Dr. A. K. Chakravarty, Head, AG&B Division, ICAR-NDRI, Karnal retired from Council's service w.e.f. 28.2.2018.
- » Mr. Sreekanta. Technical Officer, Southern Campus, ICAR-NDRI, Bengaluru retired from the Council's service w.e.f. 30.04.2017.
- » Mr.. Kumar Bharat, Assistant Chief Technical Officer, ATIC, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.05.2017.
- » Mrs. Prabha Sharma, Technical Officer, Experimental Dairy, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 30.06.2017.
- » Mr. Ashok Kumar, Technical Officer, Farm Section, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.07.2017.
- » Mr. M. P. Sharma, Sr. Technical Officer, Maintenance Section, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.08.2017.
- » Mr. Sarwan Kumar Munjal, Technical Officer, Maintenance Section, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.08.2017.
- » Dr. (Mrs.) Parvinder Sharma, Chief Technical Officer, Dairy Extension Division, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.08.2017.
- » Mr. Prem Chand Singh, Assistant Chief Technical Officer, Estate Section, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 30.09.2017.
- » Dr. Satya Pal, Chief Technical Officer, KVK, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.10.2017.
- » Mr. Naresh Kumar Kanyana, Sr. Technical Officer, Maintenance Section, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.10.2017.
- » Mr. Sukhdev Raj, Technical Officer, Livestock Research Centre, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 28.02.2018.
- » Mr. Probir Mondal, Sr. Technical Officer, Experimental Dairy, ICAR-NDRI, Karnal retired from the Council's service w.e.f. 31.03.2018.



*A view of BOM meeting*

# MAIN CAMPUS, NDRI, KARNAL

## RESEARCH DIVISIONS

### Animal Genetics & Breeding Division

Animal Genetics & Breeding Division has been actively involved in conducting research in the areas of animal genetics and breeding including cytogenetics and molecular genetics. The research thrust areas of the division are development of genomic selection strategies for dairy cattle and buffaloes for improving performance traits, genetic improvement of indigenous and crossbred cattle and Murrah buffaloes by progeny testing of breeding males, faster multiplication of indigenous cattle, development of sustainable breeding plans, part and complete characterization of genes and its association with production/ reproduction traits, disease resistance, screening of young breeding males for genetic disorders and assessment of reproductive efficiency of cattle and buffaloes.

Another important mandate of the Division is the academic activity for development of human resources in the field of animal genetics and breeding.

The Center of Advanced Faculty Training (CAFT) in Animal Genetics and Breeding established at the Division during eighth plan continued its activities on conducting the national training for scientists/ teachers from Research Institutes, State Agricultural/ Veterinary Universities and Livestock Development Organizations in advanced areas of Animal Genetics and Breeding. A total of 33 National Training Programs have so far been organized under the aegis of CAFT (AG&B).

The Division also fulfills the mandate of extension in the area of Animal Genetics & Breeding through training programs in KVK, TBI and Dairy Extension Division, consultancy services to farmers and various dairy stake holders, supplies superior germplasm in the form of frozen semen and surplus breeding males to farmers, livestock developmental agencies, state governments and other stake holders involved in dairy development in the country.

The organizational structure for research consists of Animal Breeding Lab., Biometrical Genetics Lab., Buffalo Breeding Lab., Molecular Genetics Lab., DNA Bank for cattle and buffaloes and Livestock Record Cell. Besides this, breeding herds of cattle (Karan Fries, Karan Swiss, Sahiwal, Tharparkar and Gir) and Murrah buffaloes is also the integral part of the research component of Animal Genetics and Breeding Division.

### Animal Nutrition Division

Animal Nutrition Division undertakes basic and applied research in field of post-graduate programmes of education and participates in the process of extension education through various training programmes and field level technology development and refinement in the discipline of animal nutrition and forage production. The research laboratories are equipped with modern analytical instruments for chemical and physical analysis. The Division has developed excellent laboratory facilities, which are central facilities for research and education not only for the Institute but also for various sister organizations seeking such support from time to time. The central facilities include central fine instrumentation laboratory; laboratory for anaerobic rumen microbial work; laboratory for environment related studies including methanogenesis; quality control laboratory; feed processing unit; nutritional biotechnology laboratory. Some of the sophisticated instruments available include atomic absorption spectrophotometer, gas-liquid chromatography, HPLC system, <sup>15</sup>N- Analyzer, methane analysis equipment using SF<sub>6</sub> technique, spectrophotometer, PCR machine etc. For the past few years research on precision nutrition is being undertaken. Besides research, Animal Nutrition Division also offers the M.Sc./M.V.Sc. and Ph.D. in Animal Nutrition.

### Animal Physiology Division

The objectives of Animal Physiology Division are: to conduct basic and applied research in lactation, environment, growth and reproduction physiology; impart advance training in various aspects of Animal Physiology; undertake post graduate programmes of education in Animal Physiology at Master's and Doctoral levels; and develop and demonstrate technologies at field level.

The salient achievements of the division are: Hastening of early puberty by extending photoperiod during winter in buffalo heifers, milk production and persistency of lactation improved by prilled feeding in cows and buffaloes, immune-modulation achieved by antioxidants supplementation (chromium, zinc, astaxanthin and chromium propionate) during heat stress, light coat colour crossbred cows are more vulnerable to heat stress than darker coat colour Tharparkar cows due to the less skin melanin pigment, lower milk plasminogen-plasmin ratio down-regulates milk secretion in the mammary gland in summer, technique for sewage water treatment and water saving devices developed to optimize water quality productivity for dairy animals, *TLR2* and *IGF1* identified as potential candidate genes for mastitis resistance, low levels of ROS and RNS in semen improved the mass activity of semen, elevated estradiol level and longer exposure to high peroxy nitrite donor concentration lead to poor quality semen. The Division has modern facilities of hormone measurement by radioimmunoassay and enzyme immunoassay methods, tissue culture and molecular biology research. Division has developed strong expertise in climate research by establishing modern state-of-the-art facilities at National Innovations on Climate Resilient Agricultural Research Centre and a modern custom designed shelter system with heat stress amelioration facilities. Some of the unique facilities like psychrometric chamber, CO<sub>2</sub> environment chamber, animal calorimeter chamber and blood gas analyzer are used to determine the extreme climate effects on physiological, biochemical and molecular parameters.

### Animal Biochemistry Division

Research endeavors of the Division are presently directed towards development of probiotic and prebiotic foods; dairy nutraceuticals and their mechanism of action; validation of health benefit claims of Indian dairy products; nutrigenomics; characterization of buffalo fertility genes; sperm functions and cryopreservation of semen; spermatogonial stem cells research and bioinformatics in dairy processing and production.

The Division has instrument rooms with modern equipments viz. Alpha - and Beta-counters, Ultra-centrifuge, High speed centrifuges, Micro-centrifuges, UV-visible spectrophotometers, Spectrofluorometer, PCR, Real Time PCR, ELISA Plate readers, High Pressure Liquid Chromatography, Gas Liquid Chromatography, Inverted and fluorescent microscopes, Ice flaking machines, Freeze dryer, Gel documentation (Imaging) systems, ultra filtration unit, Ultra-low temperature freezers and Carbon dioxide incubators. The Division has a cold room for carrying out research at low temperature. Cell culture facilities are also available in the Division.

The salient research achievements of the Division are: development of different types of Probiotic dahi and validation of their health-benefits in reducing serum cholesterol levels, protection against gastrointestinal cancer and management of diabetes in animal models; validation of nutraceutical attributes of dairy ghee in coronary heart diseases, gastro-intestinal and mammary cancer and improvement of immune system, and elucidation of its molecular mechanism; bioavailability of vitamins and minerals from dairy products; levels of conjugated linoleic acid in milk products; characterization of 8 amino acid transport systems in mammary gland and their induction at the onset of lactation; antiatherogenic properties of milk and its mechanism; hormonal profile of reproductive phases of buffalo; biochemical changes in sperm maturation, capacitation, acrosome reaction and semen freezing; signal transduction mechanism of sperm function; expression and hormonal regulation of fertility related ovarian genes in buffalo; SSCP analysis of CYP19 aromatase gene in anestrus buffaloes; transduction pathways (PI3K and MAPK) in cattle granulosa cells during steroidogenesis and apoptosis.

### Dairy Chemistry Division

The mandate of Division is to conduct fundamental and applied research for understanding chemistry of milk and milk products, to impart educational programmes for undergraduate and postgraduate courses and to provide R&D support towards chemical-quality control related problems of the dairy industry. The Division offers M.Sc./M. Tech and Ph.D. programmes in Dairy Chemistry and Food Technology.

The Division has contributed significant knowledge on the chemistry of milk and milk products. The salient achievements are: evaluation of physico-chemical properties of buffalo milk and alteration in its calcium and casein levels and micellar stability enabling manufacture of satisfactory products like cheese, condensed milk and rasogolla; humanization of buffalo milk and glyceride structure of buffalo milk fat; revealing chemistry of ghee and ghee residue flavour; antioxidant properties of ghee residue; chemical makeup and structural integrity of milk fat globule membrane; influence of various processing parameters on the major minerals and trace elements and their partitioning; rapid and simple methods for the determination of SNF in milk; formulation of quality standards of milk and milk products now prescribed by the Centre Committee of Food Standards under Ministry of Health as well as Bureau of Indian Standards; modification of Gerber test for simultaneous estimation of milk fat and availability of fat for detection of adulteration; simple tests for the detection of adulteration of milk and milk products; structure and bacteriostatic role of lactoferrin; characterization and crystallization of buffalo lactoperoxidase; functional properties of WPC; effect of processing treatments on vitamins; calcium fortified milk, low cholesterol ghee; a platform test for detection of detergent in milk; a colour based test to

detect adulteration of milk with 2.5 to 10% soya milk; a multi-purpose device for dialysis; buffer exchange and concentration.

Different analytical methods developed for testing of milk & milk products: Strip based tests developed for the detection of added Urea, Neutralizers, Hydrogen peroxide, Glucose, Maltodextrin in milk; New color based method developed for rapid detection of detergents in milk; Method developed for Vegetable oil detection in ghee using RP-HPTLC; Nano encapsulation of bioactive components for their application in functional foods.

The Division has state-of-the-art air conditioned Seminar room, Lecture room equipped with interactive board, LCD projectors, Visualiser, Podium etc., Quality control Lab, Undergraduate and Postgraduate labs, Instrument room, Research labs (lipids, proteins and bioactive peptides, minerals, functional foods/ nutraceuticals and quality assurance).

### Dairy Microbiology Division

Dairy Microbiology Division is currently engaged in research, teaching, consultancy, training and technology transfer in specialized field of Dairy Microbiology. Broadly, the research work of the Division covers the areas related to starter cultures and fermented milk products; direct vat starters (DVS); indigenous probiotics and their functional efficacy; gut and milk metagenomic and metabolomics, prebiotics and synbiotics; functional fermented foods, bioactive peptides, microbial metabolites and biopreservatives; biosensors, quality assurance and food safety. The Division has played a leading role in establishing National Collection of Dairy Cultures (NCDC) with current repository of 955 microbial cultures and National Referral Centre for milk quality and safety. The Division has recently transferred technologies on two indigenous strains of probiotics, Misti Dahi/doi, EPS producing culture for preparation of low-fat dahi, rapid kits for antibiotic residues, *Listeria monocytogenes* and *Enterococci* to potential stake holders in our country for their industrial application. Few more such products like carbonated lassi, vitamin B12 rich propioni-yoghurt, blueberry fortified probiotic dahi, real time test for detection of *E. coli* and antibiotic residues in milk have been developed. The faculty is also involved in imparting teaching and guidance for both under-graduate and post-graduate programmes. The Division offers M. Tech and Ph.D. programmes in Dairy Microbiology and in Food Safety and Quality Assurance. Besides, Division is also contributing in teaching Microbiology courses for B. Tech (Dairy Technology) students. The Division offers contractual and consultancy / training services such as supply of starter cultures, freeze-drying of cultures, microbiological analysis and setting standards for regulatory compliance of dairy products in our country. The Division regularly organizes need based specialized short term symposia/ conferences/ Seminars covering basic and applied areas of dairy microbiology including quality assurance, food safety, starter cultures and fermented health foods for HRD development in our country. The Division also co-ordinates the activities of National Referral Centre on milk quality and safety.

### Dairy Technology Division

The Dairy Technology Division, one of the earliest Divisions of NDRI, Karnal, is involved in teaching, research, training and consultancy activities. The educational programmes include the flagship programme of B.Tech. (Dairy Technology), Masters and Ph.D. (Dairy Technology) and Masters (Food Science & Nutrition). The research efforts of the Division faculty are channelled through in-house projects including dissertations of post graduate students, and sponsored projects and focus on basic and applied studies to refine processing and packaging technologies for traditional, composite, western and dried dairy products. The Division has developed strong expertise in the area of membrane processing, biotechnological applications, composite dairy and food products and their packaging. It has successfully organised 35 National Training Programs under the ICAR-sponsored Centre for Advanced Faculty Training in Dairy Processing (earlier, Centre for Advanced Studies in Dairy Technology) since 1994, for teaching faculty of State Agricultural Universities and other Institutions.

### Dairy Engineering Division

Dairy Engineering (DE) Division was established as one of the major research divisions since the inception of the Institute. It is contributing in teaching research, training and industrial consultancy. The Division has research laboratory facilities to cater to the needs of specific areas and programmes such as process engineering, process equipment design, thermal, electronics and Instrumentation. In addition to this, there are post-graduate teaching laboratories, Research & Development Workshop and Equipment testing hall to support both research and teaching activities. During the past three decades, the division has achieved breakthrough in developing a number of process equipment for manufacturing indigenous milk products. Many of these equipments have been patented and efforts are being made to transfer them to the equipment manufacturers. The Division has tie-ups with equipment manufacturers and users for their collaboration in development or in adoption of the developed equipments. The Division has developed equipments for the manufacture of khoa, burfi, basundi, ghee etc on the industrial scale. Recent research achievements include development of weight based filling

system for kheer, machine vision system for colour measurement of dairy products, turbo assisted scraped surface heat exchanger (SSHE) etc. Current research areas are development of weight based filling system for rabri and development of equipment for mechanized production of kheer and rabri. The Division also conducts specialized training to the graduate engineers during summer.

### Dairy Extension Division

Dairy Extension Division was established at NDRI, Karnal in May, 1961 to undertake extension activities, besides teaching and research in Extension Education. Research endeavors of the division are in the areas of Information and Communication Technologies, organizational behaviour, information management, participatory technology development and impact studies of dairy innovations. The faculty has also been engaged in human resource development through post graduate and doctoral programmes of NDRI. The main extension programme of the institute such as Dairy Mela and demonstrations, field days, etc. are organized by the Division. Research-Extension-Industry-Farmer Interface is also organized by the Division to provide an opportunity for the convergence of all stake holders working together for dairy development. Interface not only helps the dairy organizations to find solutions for today's problems, but also to realize the vision for the future. The division also organizes technology transfer campaigns, infertility and veterinary aid campaigns, Kisan Sanghosthi and field workshops at the adopted villages regularly. These activities strengthen the linkages with end users, helps in understanding the problems of farmers and better dissemination of technologies as well as easy availability of feedback from the farmers. A new Extension Education Programme "Dairy Education at Farmers' Door" was initiated in 9<sup>th</sup> February, 2009 to strengthen the effective dissemination of dairy production and processing technologies among farming community. A new Extension Approach "Farmers Farm School" in village was initiated on 30<sup>th</sup> August, 2014 for updating farmers knowledge in the field of dairy farming in particular and agriculture in general.

### Dairy Economics Statistics & Management

The Division of Dairy Economics, Statistics and Management (DES&M) was created during the IV Five Year Plan. In the early stage, the focus of research in the Division was on conducting research in economics of milk production and processing, with thrust on cost-returns studies. During subsequent periods, the research programmes of the Division enveloped more intricate and broader aspects of dairy enterprise encompassing backward and forward linkage factors for facilitating technology evaluation and transfer. The Division, over the years, has developed good infrastructure in terms of scientific manpower, teaching and training aids, divisional library and computer unit. In response to the research demands of the clientele systems, the Division has been orienting its research priorities and conducting the research accordingly. From simple economic analysis of milk production, the Division works on advanced aspects of value chain management, implication of economic reforms on dairy sector, climate change and economic impact assessment through the staff research projects and post-graduate research programmes of the scholars.

### Livestock Production & Management Section

The Livestock Production and Management (LPM) Section came into being in June, 2009 after it was disassociated from the Dairy Cattle Breeding Division. Earlier, a separate faculty of LPM was working alongwith the Dairy Cattle Breeding Division and post graduate and doctorate degrees were being awarded since the year 1976. The Section is working in the frontline areas of all applied aspects of dairy animal production and has been successful in evolving many transferable technologies and development of package of practice on the routine care and management of dairy animals. Beside research, the faculty of LPM has been engaged in teaching both at UG and PG levels.

The Livestock Production Management (LPM) Section is shouldering the responsibility of various important activities of the Institute. LPM faculty is working as four pillars of Livestock Production Management i.e. breeding, feeding, housing and healthcare. This is contributing very meticulously in Livestock Research Centre and Artificial Breeding Research Centre to cater to the research needs of most of the disciplines of ICAR-NDRI. The faculty is also entrusted with the responsibility of HRD development in the area of scientific dairy farming, commercial dairy farming, infertility management of dairy animals and frozen semen production and quality control.

### Animal Biotechnology Centre

Biotechnology was initiated at NDRI, Karnal during mid eighties under a UNDP 'Centre of Excellence on Biotechnology' programme. The urgent need for application of recent biotechnological advances in reproduction and production of superior females of dairy breeds of ruminants for improving animal productivity in our country formed the basis for the establishment of a state-of-the-art Embryo Biotechnology Centre (EBC) with financial support from the Department of Biotechnology. Biotechnology was further strengthened by establishment of Livestock Genome Lab and Molecular Biology Unit. Animal Biotechnology Centre was reorganized in June 1999 by consolidating all

the infrastructure facilities created under various programmes on biotechnology. Besides research on areas relevant to biotechnology in dairy production and processing, the Centre also offers M.Sc./M.V.Sc./M.Tech and Ph.D. (Animal Biotechnology) programmes.

The objectives of the proposed Division are 1) To undertake biotechnology oriented basic and applied research programmes for improving animal productivity and for developing innovative dairy processes for producing superior quality, safe and wholesome dairy products, 2) To train manpower in application of Biotechnology in Dairy Production and Dairy Processing and 3) To organize Masters and Ph.D. programmes in Biotechnology for the NDRI Deemed University.

The centre has a state-of-the-art biotechnology research facility, which offers a working space of more than 20,000 sq. ft., was created in 2007 to consolidate the biotechnology research at NDRI. It has specialized laboratories on Embryo Biotechnology, Regenerative Biotechnology, Animal Genomics, Proteomics Research, Structural Biology etc.

### Forage Research & Management Centre

Farm Management Section was created as a part of Animal Nutrition Division and thereafter, it was renamed as Forage Section in the year 2000. Forage Research Management Centre came into existence in 2010 with following objectives: i) To generate the human resource in Forage agronomy ii) To develop the agro-techniques for enhancing the fodder productivity and quality through efficient management of resources iii) To disseminate the knowledge about new agro-techniques for forage crop production and management to the dairy farmers and extension functionaries.

The Centre has started post graduate programme in M. Sc. / and Ph. D. in Agronomy (Forage Production) during 2010 and 2014, respectively. It has also been approved by Academic Council as Agronomy Section in 2017. The students are acquainted with the recent developments in agronomy and resource management covering major fields viz. crop husbandry, conservation and utilization of different fodder crops, agro forestry and agrostology, soil fertility management, water management, weed management, plant nutrition and sustainability, integrated nutrients management, cropping systems, dairy farming, farming systems, integrated farming systems and fodder seed production agronomy etc. Moreover, about 20 species of grasses/forage legumes germplasms are being maintained in the fields that are used for teaching, demonstrations and multiplication. The centre has initiated Azolla rearing and Moringa (Drumstick) cultivation for conducting research on animal feeding and multiplication.



*Dr. R.R.B Singh, Director NDRI with faculty and newly admitted students of the Institute during Orientation Programme*

# SUPPORT SECTIONS

## Livestock Research Centre

The total milk production of the herd during the current year was 1023046.1 kg. The production performance of the two crossbred strains developed by the NDRI viz. Karan Swiss and Karan Fries was 11.0 and 10.9 kg per head per day, respectively. The milking average of Sahiwal cows and Murrah buffaloes was 6.2 and 7.6 kg per animal per day, respectively. One Sahiwal Cow (SW-2122) produced best milk yield of 20.0 kg in peak lactation. Best yield in Murrah buffalo (MU-7398) was 17.0 kg per day during the current year. The peak milk yield by the KF and KS crossbred cows, respectively were 34.5 kg (KF-7522) and 21.0 kg (KS-4447).

### Bovine Strength of Cattle and Buffaloes as on 31.03.2018

Age group	Cattle					Total	Buffaloes		Total Bovines
	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries		Murrah		
Male (Calves upto 6 months)	11	06	12	02	20	51	40	91	
Female (Calves upto 6 months)	17	06	08	01	28	60	33	93	
Heifers	124	68	39	06	116	353	156	509	
Cows	166	61	69	13	136	445	206	651	
Male (young stock)	-	-	06	05	60	71	32	103	
Bullocks/ Teaser	-	-	-	-	07	07	02	09	
Local Bullock	-	-	-	-	-	-	-	-	
<b>Total</b>	<b>318</b>	<b>141</b>	<b>134</b>	<b>27</b>	<b>367</b>	<b>987</b>	<b>469</b>	<b>1456</b>	

### Flock Strength of Goats as on 31-03-2018

Age Group	Alpine x Beetal		Sannen x Beetal		Total
<b>Female</b>					
Kids upto 6 months	32		10		42
6-12 months	-		-		-
Yearling	51		17		68
Goats	30		09		39
<b>Male</b>					
Kids upto 6 months	33		08		41
6-12 months	-		-		-
Bucks	25		14		39
<b>Total</b>	<b>171</b>		<b>58</b>		<b>229</b>

### Milk production at NDRI, Karnal during 2017-18

Total Milk production (kg)	:	1023046.1 kg
Average Number of Animals in Milk per day:	Cattle	: 229
	Buffaloes	: 99
	Goats	: 39

### Sale of Livestock (2017-18)

Mode of Disposal	Cattle	Buffaloes	Goats	Total (₹)
Public Auction	1142700.00 (180)	1853800.00 (58)	398100.00 (52)	3394600.00 (290)
On Book Value	238034.00 (04)	25208.00 (01)	6630.00 (01)	269872.00 (06)
<b>Grand Total</b>	<b>1380734.00 (184)</b>	<b>1879008.00 (59)</b>	<b>404730.00 (53)</b>	<b>3664472.00 (296)</b>

\* Auction of animals was conducted on 21<sup>st</sup>, 22<sup>nd</sup> & 23<sup>rd</sup> September, 2017 and 22<sup>nd</sup>, 23<sup>rd</sup> & 24<sup>th</sup> March, 2018.

\* Figure in parentheses indicates the total number of animals sold.

## Performance of Dairy Animals (01.04.2017 to 31.03.2018)

Particulars	Genetic Groups									
	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries	Total	Murrah Buffalo	Alpine X Beetal	Saneen X Beetal	Total
Average number of animals in milk per day	72	20	26	07	104	229	99	30	09	39
Average number of dry animals per day	87	45	31	06	52	221	112	13	03	16
Milking average (kg) per day	6.2	5.3	3.8	11.0	10.9	8.1	7.6	1.6	1.7	1.6
Overall average (kg) per day	2.8	2.5	1.7	5.9	7.3	4.1	3.6	1.1	1.3	1.1
Best yield (kg) in a day (Animal Id/No)*	20.0 (2122)	16.0 (1346)	17.5 (16)	21.0 (4447)	34.5 (7522)	- (-)	17.0 (7398)	3.7 (290)	3.4 (247)	- (-)

\*Animal Identity Number

## Month-wise Milking Average (kg) of Cows, Buffaloes and Goats Maintained at NDRI, Karnal (2017-18)

Months	Cows										Buffaloes		Goats			
	Sahiwal		Tharparkar		GIR		Karan swiss		Karan Fries		Murrah		Alpine x Beetal		Sannen x Beetal	
	No of animals in milk/day	Milk yield (kg)/animal/day	No of Animals in milk/day	Milk yield (kg)/animal/day	No of Animals in milk/day	Milk yield (kg)/animal/day	No of animals in milk/day	Milk yield (kg)/animal/day	No of Animals in milk/day	Milk yield (kg)/animal/day	No of Animals in milk/day	Milk yield (kg)/animal/day	No of animals in milk/day	Milk yield (kg)/animal/day	No of animals in milk/day	Milk yield (kg)/animal/day
Apr, 17	77	6.8	22	4.4	31	4.5	09	11.5	120	12.8	115	7.1	40	2.0	12	1.8
May, 17	70	7.4	18	5.2	31	4.5	08	11.3	117	11.0	105	7.2	39	2.1	11	2.1
June, 17	76	6.6	19	5.0	32	4.2	08	10.7	119	10.7	103	6.6	39	1.8	11	1.8
July, 17	82	6.3	20	6.1	30	3.5	07	10.9	117	10.3	97	5.8	38	1.2	08	1.7
Aug, 17	82	6.2	22	6.2	27	2.8	07	9.0	119	8.7	89	5.6	24	0.8	08	1.0
Sep, 17	79	6.4	24	5.6	26	3.1	06	9.6	113	8.8	87	6.7	07	0.6	02	1.0
Oct, 17	73	6.4	24	5.1	25	2.3	05	11.6	93	9.6	78	7.6	03	1.5	-	-
Nov, 17	69	5.8	22	5.2	22	2.7	06	11.5	82	10.1	78	8.3	32	2.1	09	1.5
Dec, 17	64	4.9	19	4.7	24	3.8	07	11.2	77	11.5	97	9.0	38	1.7	12	1.6
Jan, 18	59	5.2	17	4.2	23	3.8	07	11.4	84	12.2	106	9.4	35	1.3	12	1.5
Feb, 18	63	5.5	16	5.3	21	4.3	08	10.4	99	13.4	113	9.0	35	1.2	12	1.7
Mar, 18	71	6.1	20	5.6	25	4.6	07	11.7	104	12.9	119	8.4	31	1.5	11	2.0
<b>Average</b>	<b>72</b>	<b>6.2</b>	<b>20</b>	<b>5.3</b>	<b>26</b>	<b>3.8</b>	<b>07</b>	<b>11.0</b>	<b>104</b>	<b>10.9</b>	<b>99</b>	<b>7.6</b>	<b>30</b>	<b>1.6</b>	<b>09</b>	<b>1.7</b>

## Production and Reproduction Performance of Cattle and Buffalo (2017-18)

Traits	Sahiwal	Tharparkar	Karan Fries	Murrah
<b>First Lactation</b>				
Age at 1st calving (Months)	43.23(37)	40.66 (16)	37.85(47)	42.29(35)
Total milk yield (kg)	1481(30)	1379 (9)	4099(29)	2584(22)
305 or less days milk yield (kg)	1463(30)	1370 (9)	3426(29)	2408(22)
Lactation length (days)	269(30)	285 (9)	373(29)	354(22)
Service period (days)	131(16)	210 (10)	164(15)	167(9)
Dry period (days)	136(16)	246 (8)	138(15)	138(5)
Calving interval (days)	407(16)	502 (8)	462(15)	453(5)
<b>All Lactations</b>				
Total milk yield (kg)	1852(94)	1482 (23)	3740(69)	2523(96)
305 or less days milk yield (kg)	1790(94)	1460 (23)	3288(69)	2387(96)
Lactation length (days)	274(94)	262 (23)	340(69)	335(96)
Service period (days)	126(41)	170 (19)	159(37)	138(49)
Dry period (days)	125(41)	211 (13)	139(38)	127(33)
Calving interval (days)	406(41)	465 (13)	445(38)	432(33)
<b>Best Lactation 305 days</b>				
Milk yield (kg)	3257	2210	5153	3508

## Fodder and Concentrate (2017-18)

Months	Type of Fodder (Qntls.)				Concentrate (kgs)
	Green	Dry/Hay	Silage	G. Total	
April, 17	10388.50	332.00	3564.00	14284.50	110018.00
May, 17	8522.50	747.00	3260.50	12530.00	128378.00
June, 17	10983.50	514.00	1666.50	13164.00	124947.15
July, 17	14136.00	228.50	2840.00	17204.50	118968.00
August, 17	15829.00	5.50	1217.50	17052.00	128593.00
September, 17	15239.50	188.50	321.00	15749.00	110041.00
October, 17	14153.50	32.00	-	14185.50	98350.00
November, 17	15422.50	223.00	-	15645.50	115000.00
December, 17	19243.00	732.50	-	19975.50	101500.00
January, 18	22262.00	376.00	-	22638.00	104832.00
February, 18	19588.50	342.50	-	19931.00	93998.00
March, 18	20278.25	152.00	-	20430.25	101122.00
<b>Total</b>	<b>186046.75</b>	<b>3873.50</b>	<b>12869.50</b>	<b>202789.75</b>	<b>1335747.15</b>

## Total Milk Production and Milk Supplied to Experimental Dairy (2017-2018)

Month	Total Milk Production	Total Disposal Milk	Total Milk Send To Experimental Dairy
April, 17	101006.4	11561.6	89291.0
May, 17	93538.7	10851.3	82420.4
June, 17	86692.7	8725.8	77644.2
July, 17	83001.4	7982.0	74606.6
August, 17	73447.2	8936.3	64141.3
September, 17	73817.6	9615.5	63739.8
October, 17	74088.4	9897.0	63570.6
November, 17	72616.7	11473.0	60381.9
December, 17	82106.6	12377.7	68852.8
January, 18	88159.9	12518.4	74654.7
February, 18	90704.1	11747.0	77808.7
March, 18	103866.4	11671.0	91461.7
<b>Total</b>	<b>1023046.1</b>	<b>127356.6</b>	<b>888573.7</b>

## Fat and SNF Percentage of Cattle and Buffaloes (2017-2018)

(First Lactation)	Cows					Buffaloes Murrah
	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries	
No of observations	268	80	42	14	501	407
Average Fat %	4.33	4.38	4.38	4.16	4.21	7.85
No.of observations	268	80	42	14	501	407
Average SNF%	8.69	8.75	8.69	8.65	8.67	9.73
(All Lactations)	Cows					Buffaloes Murrah
	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries	
No. of observation	781	214	280	76	1244	1146
Average Fat %	4.30	4.35	4.37	4.18	4.19	7.89
No of observation	781	214	280	76	1244	1146
Average SNF%	8.69	8.73	8.69	8.64	8.67	9.73

### Protein and Lactose Percentage of Cattle and Buffaloes during 2017-2018

Particulars (First Lactation)	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries	Buffaloes Murrah
No of observations	268	80	42	14	501	407
Average protein %	3.27	3.36	3.20	3.27	3.29	3.68
No.of observations	268	80	42	14	501	407
Average lactose%	4.34	4.44	4.32	4.29	4.38	4.81
Particulars (All Lactations)	Sahiwal	Tharparkar	GIR	Karan Swiss	Karan Fries	Buffaloes Murrah
No. of observation	781	214	280	76	1244	1146
Average protein %	3.28	3.34	3.23	3.26	3.28	3.67
No of observation	781	214	280	76	1244	1146
Average lactose%	4.37	4.44	4.33	4.33	4.38	4.81

### Artificial Breeding Research Center

The Artificial Breeding Research Centre (ABRC) has 138 breeding bulls (Sahiwal-43, Tharparkar-15, Karan-Fries- 31, Karan Swiss -02, Murrah – 38, Gir-9). It is engaged in progeny testing programme for Sahiwal and Murrah bulls. This centre is engaged in advanced research on bull management, breeding soundness evaluation standards for the indigenous bull, semen cryobiology, sperm sexing; early bull fertility assessment and dissemination of quality germplasm to the farmers and developmental agencies. The Artificial Insemination Laboratory under ABRC is also developing strategies for fertility improvement in dairy cows and buffaloes through reproduction management, oestrous synchronization.

### Research, Extension & Education Achievements

The scientists working in the centre are actively involved in various Institute research projects, inter-institute research projects and externally funded projects to achieve the research objectives.

Two Murrah breeding bulls were selected under Network Project on Buffalo Improvement for the 18<sup>th</sup> set of progeny testing programme.

### Reproductive Status of NDRI Herd during 2017 (January to December)

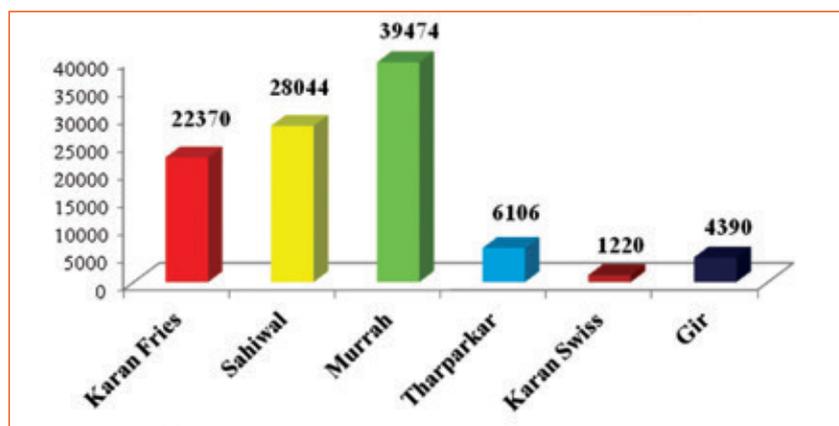
Particulars	Breeds					MU
	SW	TP	KS	GIR	KF	
<b>Cow / Buffalo</b>						
No. of observations	57	26	3	26	66	107
Service period (days)	152.08	127.53	156.33	156.11	148.89	150.12
No. of service/conception	1.40	1.27	2	1.38	1.56	1.48
<b>Heifer</b>						
No. of observations	35	9	-	10	40	47
Av. age at maturity (Month)	28.8	28.66	-	33.8	25.95	31.85
Av. age at conception (Month)	31.68	38.77	-	35.7	26.85	33.51
No. of service/conception	1.34	1.44	-	1.7	1.5	1.44
<b>Conception Rate (%)</b>						
Conception rate 1 <sup>st</sup> service	50.27	53.22	50.00	42.59	41.61	48.29
Conception rate 3 <sup>rd</sup> service	74.86	77.41	62.5	74.07	68.78	74.78
Over all conception rate	45.37	42.97	22.22	39.81	35.92	41.64

SW-Sahiwal, TP-Tharparkar, KS- Karan Swiss, KF-Karan Fries, MU-Murrah

### Production of Superior Germplasm

The centre is involved in production and conservation of superior male germplasm of cattle and buffaloes. During 2017-18, a total of 1,01, 604 doses of frozen semen were produced.

Breed wise production of superior germplasm (April, 17 - March, 18)



*Breed wise production of superior germplasm (April, 17 - March, 18)*

### Dissemination of Superior Germplasm

The centre is disseminating superior male germplasm for genetic improvement programme of cattle and buffaloes. During the year, ABRC disseminated 76,840 ml doses liquid semen of Sahiwal, KF and Murrah bulls to local farmers and also disseminated / supplied 71,705 doses frozen semen of Sahiwal, Tharparkar, KF and Murrah bulls to farmers and various Dairy development organizations / Institutes / Gaushalas of 12 states viz., Haryana, Punjab, Uttarakhand, Delhi, U.P, Rajasthan, Bihar, Himachal Pradesh, Bihar, J&K and Maharashtra.

#### Month-wise Dissemination of Semen Doses (2017 - 2018)

Month	Liquid semen doses (ml) to Farmers	Frozen semen doses to Farmers / Institutes / Dairy Development Agencies
April, 17	5925	3483
May, 17	5705	4228
June, 17	6405	4918
July, 17	7015	5115
August, 17	7065	6199
September, 17	7650	4822
October, 17	6630	10293
November, 17	5340	4243
December, 17	6960	7803
January, 18	6685	11885
February, 18	5385	5452
March, 18	6075	3267
<b>Total</b>	<b>76840</b>	<b>71705</b>

### Training Programmes Organized

- » ABRC provided exposure visit to all the participants of Entrepreneurship Development Program on Commercial Dairy Farming under SINED-TBI during this period.
- » ABRC provided exposure to farmers and trainees of KVK and students of In Farm Training.

### Extension Activities

- » Distribution of breeding bulls: The centre distributed 37 surplus breeding bulls (Karan Fries - seven, Sahiwal - five, Tharparkar - one, Murrah - eighteen and Gir- six) to government agencies/farmers.
- » ABRC did straw testing of empty frozen straws for different animal husbandry departments.
- » Advisory service was provided to the farmers in use of A.I., different breeding activities and other aspects of dairy bull management remained the regular activities of the centre.
- » ABRC supported the students of Animal Biochemistry, Animal Biotechnology, Livestock Production Management, Animal Physiology and Animal Genetic & Breeding Division to carry out research work on various aspects on sperm biology.

## Forage Production Section

### Allocation of the Farm Land to Different Units

Sr. No.	Unit	Area (Acres)
1.	Forage Production Section &RFS ( Seed)	805.69
2.	Farm Building, Road Drains, Channel & Silo Pit.	106.21
3.	Area under Eucalyptus trees (Farm)	5.01
	Land under Forage Production Section	916.91
	Land under Campus, Buildings and other Institute Activities	
1.	Narmda Hostel, Kalki Bhawan, Plantation area and Dairy Mela Ground	42.75
2.	Institute campus and Building	324.53
3.	Dairy Demonstration & other schemes , KVK	33.39
4.	Artificial Breeding Research Complex, Block-5	10.00
5.	Model Dairy Plant	20.50
	Total	431.17
	Grand Total (Land with NDRI, Karnal as on May, 2017)	1348.08
	Land handed over to other Agencies	
	Indian Railway	0.49
	33 KVA H.S.E.B., Karnal (Station)	0.49
	N.B.A.G.R (ICAR)	74.99
	DWR	47.97
	Total	123.94
	<b>Overall Land</b>	<b>1472.02</b>

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

### Fodder/Seed/Feed Production and Supply

A total number of 1,73,435.25 quintal good quality green fodder was produced from high yielding varieties of fodder crops of Maize, Sorghum, Napier Grass, Sugargraze and Cowpea during Kharif season and Berseem, Oats Chinese Cabbage and winter Maize in Rabi season. Similarly, seed/grain crops of Oats, was also grown. During the period under report, a total of 2,01,562.25 q of fodder including 1,85,219.25 q. green fodder 12,869.50 q. Silage and 3473.50 q. dry fodder was supplied to cattle yard. Total production of seed/grains of Oats was 1699.70 q.

### Production and Productivity of Forage Crops (Green Fodder) (2017-18)

S. No.	Crop	Area(ha)	Production (q)	Average Yield (q/ha)
1.	Berseem + Mustard	24.14	25848.25	1070.76
2.	Oats	6.05	2880.00	476.03
3.	Mustard	10.12	3601.50	355.87
4.	Berseem + Oats + Mustard	36.93	35147.00	951.72
5.	Maize	126.15	26088.00	206.80
6.	Napier Grass	1.01	1723.00	1705.94
7.	Sugargraze + Cowpea	21.72	4871.50	224.29
8.	Maize + Sugargraze	14.03	2567.00	182.96
9.	Maize + Cowpea	9.39	2128.50	226.68
10.	Sugargraze	80.20	15832.75	197.41
11.	Jowar (SC)	68.40	10944.00	160.00
	<b>Total</b>	<b>398.14</b>	<b>131631.50</b>	-

### Production and Productivity of Grain Crops (2017-18)

Crop	Area(ha)	Production (q)	Average Yield (q/ha)
Oats	98.38	1699.70	17.28
<b>Total</b>	<b>98.38</b>	<b>1699.70</b>	-

### Production and Productivity of Straw (2017-18)

Crop	Area(ha)	Production (q)	Average Yield (q/ha)
Oats Straw	98.38	3683.47	37.44
<b>Total</b>	<b>98.38</b>	<b>3683.47</b>	<b>37.44</b>

### Fodder Supply to Livestock Research Centre/Animal Nutrition (2017-18)

Month	Green (q)	Silage (q)	Dry (q)	Total (q)
April, 2017	10388.50	3564.00	309.00	14261.50
May, 2017	8485.50	3260.50	679.00	12425.00
June, 2017	10791.00	1666.50	404.00	12861.50
July, 2017	14136.00	2840.00	29.50	17005.50
August, 2017	15829.00	1217.50	5.50	17052.00
September, 2017	15239.50	321.00	188.50	15749.00
October, 2017	14228.50	-	32.00	14260.50
November, 2017	15422.50	-	223.00	15645.50
December, 2017	19360.00	-	732.50	20092.50
January, 2018	22342.00	-	376.00	22718.00
February, 2018	19201.50	-	342.50	19544.00
March, 2018	19795.25	-	152.00	19947.25
<b>Total</b>	<b>185219.25</b>	<b>12869.50</b>	<b>3473.50</b>	<b>2,01,562.25</b>

### Forage Conservation

A total of 3683.47 q. of dry fodder such as oats straw in the form of by-product of these crops was produced. To fulfill the nutritional requirements of the herd during lean period and to provide required dry matter during winter months, when DM content in the lush green forages is very low, silage and oats straw were supplied.

### Calculated Cost of Fodder Supplied to Livestock Research Centre/Animal Nutrition from Forage Production Section (2017-18)

Sl. No.	Crop Name	Quantity (q.)	Rate (₹/q.)	Amount (₹)
1.	Green	185219.25	150/-	27782887.50
2.	Silage	12869.50	225/-	2895637.50
3.	Straw	3473.50	450/-	156307.50
	<b>Total</b>	<b>201562.25</b>	-	<b>3,08,34,832.50</b>

### Revolving Fund Scheme on Seed Production

Unavailability of good quality seeds/ grains of improved varieties of fodder crops is the biggest constraint in increasing the production of fodder grains crops. A Revolving Fund Scheme on Seed Production of Fodder Crops was initiated at NDRI, Karnal in 80 hectare area to produce the seeds grains of improved varieties of fodder crops for cultivation at Institute Farm, Institute Regional Campuses sale to Farmers and other Agencies. During the year under the report, a total of 226.70 q. seeds of improved varieties of fodder crops, 859.55 q. grains, 41803.75 q. green fodder and 1707.28 q. Bhusa were produced and total calculated cost of Seed, Grain, Green Fodder and Bhusa is ₹ 96,01,198.50 under Revolving fund scheme on Seed Production during the report as per given below:

### Production of Seed under RFS Seed Production (2017-18)

Kind of seed	Quantity of Seed (q.)	Rate (Rs./q.)	Calculated Cost (₹)
Oats Kent	225.00	3500/-	787500.00
Mustard Chinese Cabbage	1.70	7000/-	11900.00
<b>Total</b>	<b>226.70</b>		<b>7,99,400.00</b>

### Production of Grains under RFS Seed Production (2017-18)

Kind of grain	Quantity of Grain (q.)	Rate (₹/q.)	Calculated Cost (₹)
Mustard Chinese Cabbage	242.30	3200/-	775360.00
Oats	617.25	1600/-	987600.00
<b>Total</b>	<b>859.55</b>	<b>-</b>	<b>17,62,960.00</b>

Production of Green Fodder, Dry Fodder (Bhusa) under RFS, Seed Production and Supplied to LRC through Forage Production Section (2017-18)

Kind of Fodder	Quantity (q.)	Rate (₹/q.)	Calculated Cost (₹)	Remarks
Green Fodder	41803.75	150/-	62,70,562.50	Supplied to LRC
Straw, Oats	1707.28	450/-	7,68,276.00	Balance in Stock
<b>Grand Total</b>	<b>-</b>	<b>-</b>	<b>70,38,838.50</b>	

### Revenue Generation by Sale/Supply of Seed/Grains under RFS (Seed Production)

Kind	Supplied in q.	Sold Qty. in q.	Total Qty. Supply/ Sold in q.	Rate per q.	Amount (₹)
Mustard Seed Cabbage	1.7905	0.11	1.9005	7000/-	13303.50
Oats Seed	166.98	43.66	210.64	3500/-	737240.00
Oats Grain	591.95	---	591.95	1600/-	947120.00
<b>Grand Total</b>					<b>16,97,663.50</b>

### Maintenance Section

Since 1979, Maintenance Section has been providing the services related to mechanical, electrical, civil, refrigeration and air conditioning etc.; new works addition/alterations required in the labs/Institute; maintenance of the sub-station, overhead lines, street lights, service connections maintenance of electric supply to the office area as well as residential area of the Institute; providing generator supply to office and residential area including International Girls and Boys hostels, Guest house and Scientist home in case of power failure; Liaison works with UHBVN, CPWD, Haryana State Pollution Control Board and Local Authorities; Maintenance of the water supply and sewage disposal system in the Institute; Planning and inspection of new buildings in the Institute; Operation and maintenance of ETP and other miscellaneous works of the Institute.

### Human Health Complex

The Human Health Complex (HHC) was established in 1991. It is catering to the health needs of the employees, students and retirees of NDRI and the other sister ICAR Institutes situated at Karnal. Full time Doctors for Allopathic treatment and part- time practitioners for Ayurvedic & Homoeopathic (currently vacant) systems of medical aid are available at the HHC. Well qualified & trained nursing staff, laboratory technicians and pharmacists assist the Doctors in providing the desired medical facilities. The following facilities are available at human health complex:

- » Diagnostic clinical lab well equipped with a fully automatic Haematoanalyzer and a semi-auto Biochemical analyzer.
- » All the routine blood and urine tests such as Complete Blood Count, Sugar, Malaria Parasite Lipid Profile Uric Acid etc. are carried out by trained staff.
- » X-Ray facilities for all types of common ailments.
- » Physiotherapy Unit for the benefit of the patients suffering from various chronic ailments such as lower back-ache, joint and muscular pains, etc. The Unit has a Transe Electric Nerve Stimulator (TENS) and has acquired an Ultra Sonic Electronic Massager this year for providing physiotherapy facilities to the patients.

### Experimental Dairy Plant

Experimental Dairy Plant has been set up at this Institute in 1961 with the objective of providing necessary infrastructure facilities to the scientists for the scaling up of new products/ processes developed in the laboratories on the pilot scale as well as to provide training facilities to the students in the operation of dairy plants. After meeting the requirements of research and teaching, the plant is used for converting the surplus milk into variety of dairy products. Experimental Dairy manufactured SMP (R)- 16,520.5 kg., Pasteurized Butter (200 g)- 1,972 Pkt.,

Ghee- 14,571 kg., Paneer- 37,967.25 kg., Burfi – 2,204.0 kg., Kalakand- 36,374.0 kg., Lassi (200 ml)- 1,62,535 pkts., Ice-cream (100 ml)- 1,14,664 cups, Flavored Dairy Drink (200 ml)- 3,05,173 pkts., Processed Cheese Slices (200 gm)- 1,112 pkts., Gulab Jamun Mix – 5,858.5 kg., Pizza Cheese (200 g)- 3,401 plastic container etc. during 2017-18. These products are sold through the Milk Parlour located at the institute's main entrance gate. Experimental Dairy provides practical, teaching and training facility to students and research facility to scientists of the NDRI Deemed University. It also provides training facility to outside students of various universities/colleges in the dairy field. A total no. of 56 students from several institutions were provided training during the financial year 2017-18. This self sustaining Experimental Dairy has been running under Revolving Fund Scheme since 1989-90. Revenue generated through scheme is being utilized for development of infrastructure of the Experimental Dairy Plant. It is certified under Quality management system ISO 9001-2008 and HACCP-15000 by BIS, Chandigarh. Experimental Dairy got the cleanest section award of "Swachhta Hi Sewa Campaign" (15<sup>th</sup> September to 02<sup>nd</sup> October, 2017) in the Institute. Experimental Dairy developed 03 new products Wheypro, Wheypro Choco & Cottage Cheese. and launched at Milk Parlour .

### Computer Centre

Computer centre is a central facility to provide computational support to the scientists and administration; and imparting training to students/scholars. The Computer Centre offers two Computer Science courses to undergraduate students and one course to post graduate students including Ph.D. scholars. There is a well established Computer Laboratory for students' teaching, which is equipped with state-of-the-art 64-bit i5 computer systems together with multi-function laser printers. The data processing unit of the centre has been strengthened by installing a new Line Matrix printer. These computer systems are equipped with different softwares, i.e., operating systems such as Unix/Linux, MS-Windows; and statistical/scientific computing systems like SAS 9.3 with JMP, MATLAB, WEKA, etc. Also, compilers for various programming languages are available, which include FORTRAN 90, C, C++, R, Python, Visual Studio, etc. Institute has a well established Local Area Network (LAN) system connecting all the research divisions and sections through optical fibre/UTP cabling to cover the main buildings and through ADSL switches for a few distantly located buildings, thereby providing connectivity to all the scientists, technical/administrative staff and students. The LAN has been extended to Kalki Bhawan with optical fibre cable as back bone. The whole institute's LAN has been shifted to CAT-6 media. The internet connectivity has recently been extended up to Dr. D. Sundaresan Auditorium via optical fibre cable to ensure high bandwidth to facilitate live Webcasts, presentations, etc., in front of huge audience including farmers and other dairy stakeholders.



**Dr. R. R. B. Singh, Director, NDRI giving Certificates to Participants during National Workshop on Machine Learning in Bioinformatics**

Besides this, the Centre offered internship programmes on advanced topics in soft Computing and Machine Learning using open source R Programming language, to two externally sponsored students of B.Tech. Established academic linkages for possible research collaboration with Department of Statistics & Operational Research and University Institute of Engineering & Technology, Kurukshetra University Kurukshetra; and NIFTEM Sonapat.

ASRB Online Examinations for ARS (Prelim) and NET were conducted successfully by the Online Exam Centre, ICAR-NDRI Karnal.

### Agriculture Knowledge Management Unit

The Agriculture Knowledge Management Unit (AKMU) is fully functional with the internet and e-mail connectivity through National knowledge Network (NKN) node with 1 Gbps bandwidth provided by the National Informatics Centre (NIC), Govt. of India as well as through a leased line (6 Mbps) provided by ERNET India Ltd. AKMU is equipped



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#### Document Delivery Request Send Report 2017

Name of Institute/University	Total Requests Received	Total Requests Fulfilled
Total Document Delivery Request Received and Delivered to ICAR Institutes/ State Agricultural Universities	111	103

The Library is also an active partner of Agricat (a sub-portal under WorldCat). Presently 51,216 catalogue records of Library, NDRI available on Agricat/ WorldCat and all the users worldwide participating institution may access catalogue records of National Dairy Research Institute though URL: <http://www.worldcat.org> or [www.agricat.worldcat.org](http://www.agricat.worldcat.org).

The Library digitized 3287 records of institute outputs, which includes valuable books, institutional publications, M.Sc. and Ph.D. Dissertations, reports, conference proceedings and ~ reprints etc. available on KrishiKosh-Institutional Repository of Indian National Agricultural Research System. In addition of above complete online library catalogue is also available on URL: [library.ndri.res.in](http://library.ndri.res.in) by using Koha-Library Management System.

### Communication Centre

Communication Centre has audio visual/video and photo laboratories for providing the services to the staff and students of the Institute. This centre covers all the events organized by the Institute. This centre organized exhibitions at different sister Institutes of ICAR and other research and development organizations across the country. The audio visual lab handled Sound and Projection Systems in Dr. D. Sundaresan auditorium, Pinaki hall, University committee room and Conference halls of the Institute. Besides this, audio visual lab also provided Sound and Projection Systems in play ground for students and staff activities.

The facilities of audio video editing, recording of audio video clippings on DVD and VCD dubbing and mixing were extended to students, staff and scientists for their research projects. Video coverage of events of the Institute consisting of various national Seminars, Workshops, Conferences, Cultural programmes, Cattle shows, Kisan sangosthies, Exhibitions and other functions of the Institute was carried and video films were edited.

### Model Dairy Plant

A state-of-the-art commercial Dairy Plant was established in 1996 at NDRI, Karnal through the financial assistance and installed on turnkey basis by the National Dairy Development Board. The Plant has been designed to handle 60,000 liters of milk per day and is presently running at full capacity. Model Dairy Plant is presently certified under the **Food Safety Management System ISO 22000:2005**.



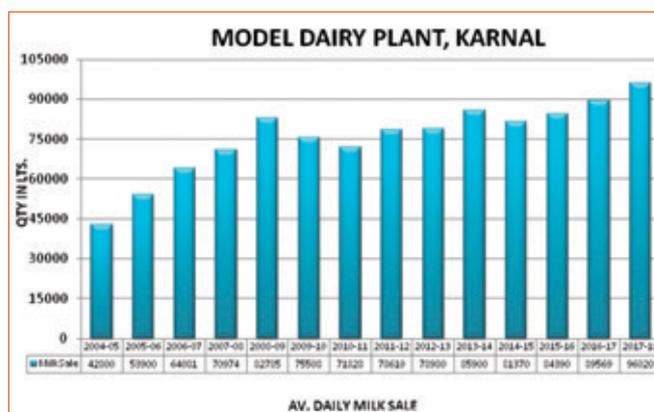
*Sh. Surendra Nath Tripathi, IAS Additional Secretary, DARE & Financial Advisor, ICAR visited NDRI on 4<sup>th</sup> Oct., 2017*

## Special Features

- » Model Dairy Plant provides Six months in-plant training to B.Tech. (DT) students of the NDRI Deemed University during the 4th year of the course curriculum.
- » The students are provided with complete infrastructure for training, which helps them in gaining sufficient experience in managing the modern commercial Dairy Plant and instils confidence in handling real life problems in production management.
- » It also provides infrastructure facilities to the scientists of NDRI for scaling up R & D concepts from laboratory scale to industrial scale under commercial environment.
- » Model Dairy Plant (MDP), an autonomous unit of ICAR, is independently managed by a committee, whose Chairman is the Director of NDRI.

## Liquid Milk Processing / Packaging

MDP is currently engaged in processing and packaging of milk for Mother Dairy in five different variants (Full Cream, Standard, Toned, Double Toned, Skim Milk and Cow Milk). MDP is presently processing / packing 90-95 TLPD of polypack Milk in all the varieties for Mother Dairy, Delhi. The plant is running in three shifts and the supplies from MDP are dispatched in the evening and morning to Delhi market and nearby cities thereby utilizing the plant to more than its full capacity.

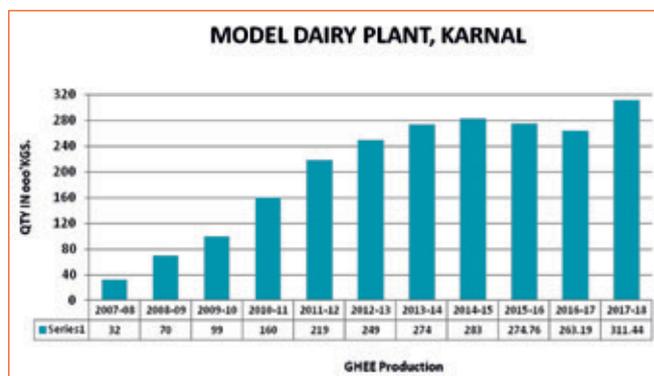


## Ice Cream Manufacturing

MDP has an agreement with Mother Dairy for processing and packing of Ice-cream in Mother Dairy brand on job work to the tune of 7000 liters per day. The ice cream manufactured at MDP is of different varieties i.e. Vanilla, Strawberry, Mango, Butter Scotch etc. and as per the requirements of Mother Dairy. MDP is also engaged in training students in manufacturing of Ice cream on trial basis.

## Ghee Manufacturing

MDP manufactures Cow Ghee from Cow Butter purchased from different State Federations and its production is taken as per demand. The average production / sale of ghee is 20-25 metric tons per month. All the Ghee manufactured at MDP is being sold through the MDP Sale Counter.



### Cheese and Paneer

MDP is also engaged in training students in manufacturing of Cottage Cheese, Processed Cheese, Paneer on trial basis. The section is operated occasionally for the purpose of taking trials and making the students familiar with the manufacturing details.

### Pinni Manufacturing

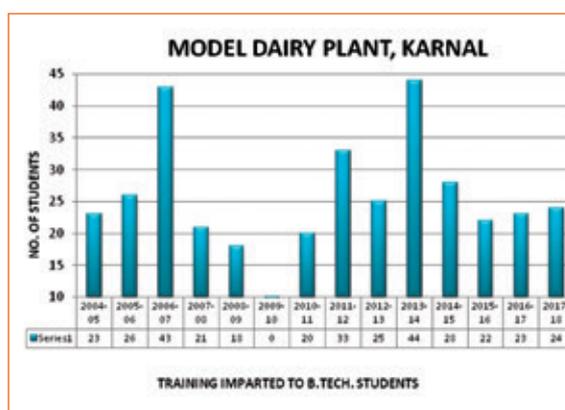
Pinni Manufacturing was launched in the thirteenth Convocation of NDRI Deemed University on 14<sup>th</sup> February 2015 and developed by the students of batch 2010-14. Total Sale of Pinni was 20.8 metric tons in the year 2017-18.

### Procurement of Milk

MDP does not have its own infrastructure for milk procurement and is receiving milk on behalf of Mother Dairy from the new generation cooperatives of Punjab and Rajasthan. The average milk procurement per day is around 85,000 to 90,000 LPD, which is sufficient to meet day to day demand of different milk variants being packed at MDP.

### Training to the Students

Model Dairy Plant provides In-plant training to the 4<sup>th</sup> year B.Tech. (DT) students of NDRI Deemed University. The students are provided with In-plant Training Manual comprising of unit wise operation covering all the sections of the Dairy Plant. Since its inception in 1996, Model Dairy Plant has provided training to twenty one batches of B.Tech. (DT) students. The student trainees are provided Rs.1500/- per month as stipend. So far, 552 students have been trained at MDP. Students are given hands on experience for plant operations and are trained to manage the shift activities of the plant under the guidance of trained technical staff. In addition to the above, students are also made to involve in other activities like KAIZENs, Small Group Activities etc. The feedback regarding Inplant Training, from the student's trained at MDP and now working in different capacities with different organizations is quite positive and encouraging.



### Highlights of MDP during 2017-18

- » Average milk dispatch per day was 96020 Lt.
- » Ghee sale was approximately 311.44 MT.
- » Pinni Sale was 20.8 MT.
- » Piston air compressor was replaced with screw compressor.
- » BLOOD Donation Camp organized by MDP and Smiling Waves (a B.Tech Students' Initiative) on 31<sup>st</sup> October, 2017 and 72 units of blood was donated by donors.



*Dr. R. R. B. Singh, Director, NDRI with the students donating blood during the camp*

# REGIONAL CAMPUSES

## SOUTHERN CAMPUS, BENGALURU

The National Dairy Research Institute was started at Bengaluru in 1923 as Imperial Institute of Animal Husbandry and Dairying. It was the forerunner institution in starting dairy education programmes to meet the manpower requirements of the dairy industry. Upon shifting the institute Head Quarters to Karnal in 1955, the establishment at Bengaluru continued as the Southern Regional Station of NDRI. The station has been catering to the research, training and extension needs of the dairy farmers and dairy industry of the southern region.

The Campus is endowed with necessary infrastructure in terms of qualified staff, farmland, dairy herd, laboratories, library, staff dispensary, hostel facilities etc. The Campus has a land area of about 46 hectares. About 16 hectares of land is utilized for the cultivation of various forage crops for meeting the feeding requirement of the dairy herd.

The Campus has good laboratory and infrastructural facilities for carrying out research work on animal genetics and breeding, dairy animal production and reproduction, screening of microbes, chemical and microbiological analyses of dairy products, testing of dairy equipments, manufacturing of various dairy products, etc. The research, training and transfer of technology programmes at the campus are carried out through different sections. To cater to the needs of the students, the library is stocked with books, journals, theses and reprints. Hostel and guest house facilities also exist at the campus for students and visitors.

### Education

The course work for Ph.D (Dairy Engg.), M.Tech (Dairy Engg.), M.Tech (DT), and Diploma (DT) are being conducted at the campus. The students in the disciplines of Dairy Technology, Dairy Chemistry, Dairy Engineering, Animal Genetics & Breeding, Animal Nutrition, Livestock Production & Management, Agricultural Economics and Agricultural Extension Education are being guided for their Doctoral and Masters' dissertation work.

Short term Training Programmes are being imparted in Dairy Processing, Quality Assurance, Dairy Production and Extension for the students, dairy farmers/ entrepreneurs and personnel from Co-operative Federations and Private Organisations. Besides, In-plant training and In-lab training are provided to the UG and PG students of other Colleges/Universities. PG students of other Universities are also guided to carry out their Project Work.

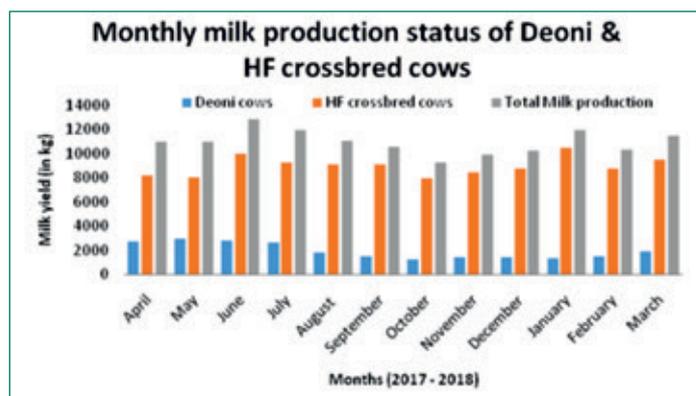
### Scholarships and Fellowships

The Ph.D. and M.Tech. Students are awarded with ICAR-NDRI Fellowship and external fellowship as shown below:

Scholarship/Fellowship	Ph.D. Students	Masters Students
NDRI Fellowship	23	27
ICAR-SRF/JRF	-	03
UGC Fellowships	03	-
Rajiv Gandhi National Fellowship	02	-
Prime Minister Fellowship Scheme	01	-
DST - INSPIRE	01	-

### Livestock Research Centre

The Livestock Research Centre (LRC) of the station has Deoni (132), Malnad Gidda (28) and Holstein Friesian crossbred cattle (73). The total milk production of the herd during the year (2017-18) was 1,31,688.0 kg. The average daily milk yield of the Deoni and HF crossbred cows were 4.0 and 12.0 kg, respectively.



### Reproductive Performance of Deoni and Crossbred Cows at Southern Campus (2017-18)

Primiparous/Heifer Cows*	Deoni	Crossbred
Age at first insemination (months)	34 (27)	22 (18)
Age at first calving (months)	44 (26)	34 (16)
Multiparous Cows**	Deoni	Crossbred
Days to first insemination	83 (20)	82 (13)
Service period (days)	117 (18)	102 (11)
Calving interval (days)	400 (21)	354 (11)

Figures in parentheses indicate the number of animals.

\*Primiparous cows inseminated during 2008-17 (Deoni) and 2014-2016 (crossbred).

\*\*Multiparous (Deoni and Crossbred) cows calved during 2016-2017.

Forage Production Section is involved in cultivation of quality fodder crops to meet out the fodder requirement of herd section and is also involved in providing trainings and demonstrations of cultivation of fodder varieties to farmers and trainees. Root slips of different fodder varieties were also distributed to farmers.

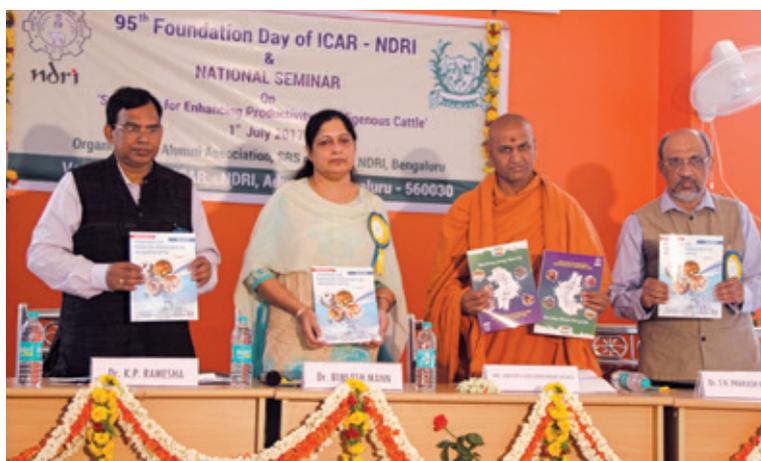
### Major Events

- Winter School on "Innovative Approaches for Conservation and Improvement of Indigenous Bovine Genetic Resources in Modern IPR era under Changing Climate Scenario" was organized from 8<sup>th</sup> to 28<sup>th</sup> November 2017 for 20 participants from different parts of the Nation.



Group photo of participants with faculty of Southern Campus

- World Milk Day was celebrated at Southern Campus of ICAR-NDRI, Bengaluru on 1<sup>st</sup> June 2017 in association with Indian Dairy Association (South Zone) and Alumni Association of ICAR-NDRI, Bengaluru.
- Commemorating the 95<sup>th</sup> of Foundation Day of ICAR- National Dairy Research Institute, a National Seminar on “Strategies for Enhancing Productivity of Indigenous Cattle” was organized on 1<sup>st</sup> July, 2017 at Southern Campus of NDRI Bengaluru.



*A lecture compendium being released*

- Southern Campus, Bengaluru arranged farmers' interaction meet on the eve of live telecast of Honourable Prime Minister, Shri. Narendra Modi Ji's address at the Krishi Unnati Mela 2018 on Doubling Farmer's Income by 2022 at Indian Agricultural Research Institute, Pusa, New Delhi on 17<sup>th</sup> March, 2018. Prior to the live telecast of Honourable Prime Minister's address, farmers interaction meet was organized on “Indigenous dairy cattle production” and “Scientific Dairy Farming”.

## SUCCESS STORY

- Under “Rashtriya Gokul Mission-Mass Embryo Transfer Programme of Indigenous Breeds of Cattle” scheme of Department of Animal Husbandry Dairying and Fisheries, Ministry of Agricultural and Farmers Welfare, Government of India, Embryo transfer (ET) in Deoni cattle was organised jointly by Central Frozen Semen Production and Training Institute, Hessarghata (DADF) and Southern Campus of ICAR-NDRI, Bengaluru from 2<sup>nd</sup> and 3<sup>rd</sup> October, 2017. During the programme, five Deoni animals were super ovulated and a total of 23 embryos were collected and transferred to surrogate cows at the NDRI farm. A record of 14 embryos were produced from a single donor cow No 377 aged 13 years 6 month (7<sup>th</sup> lactation, with best lactation yield of 1595 kg). The embryo transfer programme was very successful.
- Southern Campus of ICAR-NDRI, Bengaluru in collaboration with milk co-operative societies of Ramnagara taluk organized a mass estrus synchronization and insemination of dairy cattle with sexed semen at Ramnagara district of Karnataka State on 4<sup>th</sup> March, 2018 with the aim to have birth of large number of elite female calves so that the milk production can substantially be increased. A total number of 155 healthy heifers and cows in 1<sup>st</sup> lactation selected based on body condition score were dewormed, supplemented with minerals and subjected to CIDR-GnRH estrus synchronization protocol so that all the animals are in estrus on 4<sup>th</sup> March, 2018. On that day, the benefits of using sexed semen, protocols for achieving high conception rates with sexed semen under field conditions, do's and don't's while using sexed semen and management practices for care and upkeep of calves born out of sexed semen were explained to field Veterinarians and farmers. The programme was attended by about 9000 dairy farmers.



## EASTERN CAMPUS, KALYANI

The main objective of establishing the Eastern Campus of ICAR-NDRI, Kalyani is to identify the major constraints of dairy production in eastern and north eastern India and to offer solutions through research and extension activities to these problems. The research work undertaken at this campus is mainly strategic and applied in nature and the thrust of research is to improve the socio-economic condition of dairy farmers of this region.

The Eastern Regional Station was established at the Central Dairy in Calcutta. in 1964 and was shifted during 1966 to Kalyani, Nadia district; about 50 km north of Calcutta and was located in the Administrative Building of Kalyani University. The Regional Animal Nutrition Research Centre of the I.C.A.R. till then located at Haringhata, West Bengal, was merged with the ERS of NDRI with effect from June 1, 1968. In 1978 the Government of West Bengal granted 100 acres of land at Kalyani where cattle sheds, forage unit, staff quarters etc. were gradually built up. The Station built its own laboratory building and the entire station started functioning within the same campus from May, 1987.

The research at Eastern Campus is being conducted in the area of Animal Nutrition (1964 – till date), Dairy Chemistry and Bacteriology (1972-1976), Animal Breeding (1977-till date), Soil Science (1977-1985), Dairy Economics and Dairy Extension (1977- till date), Forage Production and Livestock Production and Management (1986 – till date). The Animal Biotechnology Section started functioning during 2005. The Animal Physiology and Reproduction Laboratory was also established in 2013-14. Goat Farm was also established in 2014-15 in a small scale for research, education and training purposes. Krishi Vigyan Kendra-II, Nadia District of West Bengal was sanctioned in 2016-17 for establishment in the Campus of ERS-NDRI, Kalyani.

The Eastern Campus has infrastructure facilities like Research Laboratories, Cattle Herd, Fodder Farm, Library, Computer Section, Academic Cell, Hostels and Guest House, Estate Section etc.

Keeping in view the enormous demand for milk in the eastern region, low milk production potential of the native stock, shortage of feed and fodder resources and diversified agro-climatic and socio-economic conditions; this research station has a great role to play in the field of dairy development in this region.

The Library contains 1818 books, 4078 volumes of bound journals and other periodicals in the field of Dairying. Besides, Annual Reports of different Institutes and proceedings of various workshops and seminars are also available for reference. Presently Indian Journals are subscribed for students and Scientists.

The computer center facilitates the maintenance of database and analysis of research data. The institute has Internet connectivity through VSAT and NKN, which are useful for searching literature and references. The cell is facilitating the practical of DAHD students.

### Events & Extension Activities

- Under the aegis of KVK-II of Nadia district 'New India Manthan-Sankalp-se-Siddhi Programme' was celebrated on 24<sup>th</sup> August, 2017. The experts deliberated several technologies which can enhance the farm income on sustainable basis. A pledge on this occasion was also taken up. Around 100 farmers participated in the programme.



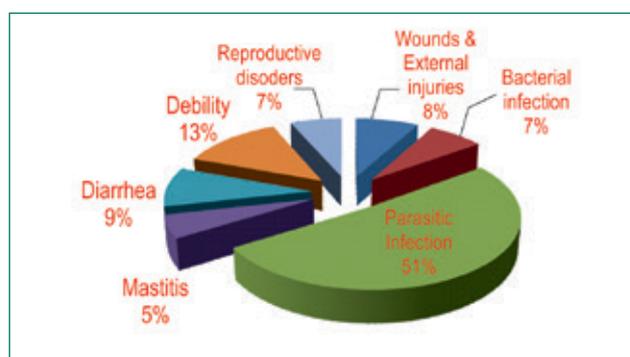
*Dr. Tapas Mondal, MP addressing at Sankalp-Se-Siddhi Programme*

- Eastern Campus of ICAR-NDRI, Kalyani organized one “Farmers-Scientists interaction session-cum-Training Programme” after live telecast of Honourable PM’s speech in ‘*Krishi Unnati Mela*’ at ICAR-IARI, New Delhi on 17<sup>th</sup> March, 2018. On this occasion, one interaction session was also organized for the farmers and scientists delivered lecture on Scientific Dairy Farming and Animal Management. Farmers from Nadia district showcased organically produced vegetables during the programme. Tribal dairy farmers also participated in the programme.
- ICAR-IVRI, Eastern Regional Station, Kolkata organized “Kisan Mela-cum-Technology Demonstration” in collaboration with Eastern Regional Station (ERS) of ICAR-NDRI, Kalyani, West Bengal on 24<sup>th</sup> March, 2018. Various Institutes including ICAR-IVRI, ERS, Kolkata; ICAR-CIFRI, Barrackpore; ICAR-CRIJAF, Barrackpore; KVK-Ashok Nagar under WBUAFS, Kolkata; Ashamone, Kalyani (Nadia)-a self help group and NGOs actively participated in the Kisan Mela by putting their exhibition stalls. Interaction session-cum-Quiz competition was organized in which farmers actively participated. About 380 visitors including students, farmers and farm women participated and benefitted in the Kisan Mela.
- Eastern Campus, Kalyani organised different on-farm and off-farm extension activities for transfer of technologies in relation to scientific dairy animal production.



*Veterinary services being carried out in a village*

- The Campus provided day-to-day service on treatment of ailing animals, deworming, vaccination, AI etc. in the adopted villages (Muratipur and Dakshin Chandamari).
- In the adopted villages (Muratipur and Dakshin Chandamari), veterinary health care facilities were provided to the dairy farmers. Extension scientists of the campus visited farmers’ home and solved the problem related to their animals. Through the ‘*Dairy Vikas Kendra*’ at Muratipur village Artificial Insemination of 183 animals was done. The success rate (calf born basis) of these AI was 49%. A total of 925 animals were treated from the village centre. Treatment of animals was done free of cost. In the adopted villages nine vaccination and Veterinary Health Camps were organized in order to control the emerging infections in their livestock. From these camps, 618 animals were treated and vaccinated and a total of 237 farmers were benefitted by these camps. The pattern of different diseases/ailments in the livestock of adopted villages is being shown in the following diagram.



*Pattern of different diseases/ ailments of livestock*

- Eastern Campus of ICAR-NDRI participated in several exhibitions and erected exhibition stalls in different parts of West Bengal and Eastern states of India for technology demonstration related to the dairy animal production. Some of the major fairs in which ERS participated were ‘*Krishi Mela*’ organized at Motihari, Bihar during 18<sup>th</sup> - 19<sup>th</sup> April, 2017, ‘*Pashudhan Vikas Sammelan*’ organized at Keshari Block, Motihari during 28<sup>th</sup> - 29<sup>th</sup> October, 2017, ‘*Krishi Mela*’ organized by Shisrhi Farmers’ Club at Shisrhi, Jhargram, W.B., Mela organized by W.B. University

of Animal and Fishery Sciences at Kolkata on 10<sup>th</sup> January, 2018, 'Kisan Mela-cum-Technology Demonstration' jointly organized by ICAR-IVRI-ERS, Kolkata & ICAR-NDRI-ERS on 24<sup>th</sup> March, 2018 at Eastern Campus of NDRI, Kalyani. The stall of Eastern Campus of NDRI got first prize in the 'Kisan Mela-cum-Technology Demonstration' organized at NDRI, Kalyani campus.



- Two training programmes on "Artificial Insemination and Veterinary First Aids" were organized Eastern Campus of NDRI, Kalyani. The duration of the training programmes was 32 days. In the first batch, 13 candidates from Bihar and West Bengal participated from 18<sup>th</sup> July to 18<sup>th</sup> August, 2017. The second batch (17 candidates) of the training was sponsored and nominated by AMUL and Kisan Milk Union which was done from 27<sup>th</sup> March to 27<sup>th</sup> April, 2018.



*Hands on training in progress*

- Two training programmes on 'Scientific Dairy Farming' were organized. A total number of 25 trainees from different parts of West Bengal, Bihar and Uttar Pradesh participated. One training programme on 'Scientific Goat Farming' was also organized for 13 farmers from West Bengal.
- A total number of 19 visiting teams comprising of 641 visitors (farmers, unemployed youths, students etc.) visited the Institute Farms; majority of whom were small holder dairy farmers. The visitors came through several institutes/ organizations like FACC of Bidhan Chandra Krishi Viswavidyalaya, Jawahar Navodaya Vidyalaya, ICAR-IVRI, NIFT- Kolkata, Serampore College, Aelis, Barrackpore, ATMA, Kalna-1, Purba Bardhaman, Bolpur Manob Jomin (NGO), Sumurati Krishi Kendra and several farmers groups from different parts of West Bengal also visited the campus.





*Farmers showing keen interest in Azolla farming*

### Extension Activities in the Tribal Dominated Areas of West Bengal

- During the year 2017-18, three vaccinations cum deworming camps were organized and 367 farmers were benefited in Birbhum and Jhargram districts. Vaccination was done for dairy animals, goats and poultry birds. Several inputs, like fodder seeds, mineral mixture, rooted slips of perennial grass etc. were distributed to the tribal farmers. Treatment of ailing animals was also done in the camps. Eastern Campus of NDRI, Kalyani distributed 440 chicks among 44 tribal farmers from Birbhum and Jhargram district of West Bengal. Apart from that, 246 kg of mineral mixture was distributed among 397 tribal farmers.



- Four scientists-farmers' interaction sessions were organized. A team of scientists and experts of Eastern Campus of NDRI, Kalyani interacted with the farmers (with dairy/goat and other animals) on the following areas: Scientific animals rearing practices, mastitis management and control measures, vaccination and deworming protocol, fodder production and feed resource development, breeding strategies, Infertility/aneastrous/repeat breeding management and calf rearing and heifer management.



Experts also delivered lectures on various aspects of animal husbandry practices through Santiniketan Doordarsan and All India Radio (AIR) for mass communication during the camp period. One training programme was also organised under TSP during 5<sup>th</sup> – 7<sup>th</sup> September, 2017 in which 14 tribal farmers from Jhargram district of West Bengal participated. Regular dissemination of information pertaining to scientific dairy farming, to the tribal farmers was done by using SMS portal developed by the Eastern Campus of NDRI, Kalyani.

## Extension Activities in the North Eastern States

- During the year 2017-18, four North Eastern states of India namely, Meghalaya, Tripura, Sikkim and Mizoram were covered under NEH programme of NDRI. Several visits were arranged and inputs such as veterinary medicines, mineral mixture, concentrate mixture, fodder seeds, livestock, extension literatures etc. were distributed among the farmers. In the scientists-farmers interaction sessions several aspects of animal husbandry were explained to the farmers of the North Eastern States.
- Two camps were organized in Mizoram state by collaborating with Central Agricultural University (CAU), Aizwal. Several inputs like Chicks (3300 Nos.), Piglet (51 Nos.), Mineral mixture (242 kg), Vitamin supplement (4 Ltr.), Poultry Feed (200 kg), Pig feed (650 kg), Cattle Feed (600 kg) etc were distributed among 385 farmers.
- Two visits were organized in the state of Tripura during the year 2017-18. Scientists farmers interaction sessions-cum-veterinary health camps were also organized during these visits. Several inputs like Chicks (1500 No.), Black Bengal Goat (50 No.), Mineral mixture (800 kg), Poultry feed (600 kg) etc. were distributed among 356 farmers. Apart from these programmes, regular SMS in Bengali language pertaining to various aspects of scientific dairy farming are being send to the registered farmers from Tripura.
- In the state of Meghalaya, one session of interaction with farmers was organized. In that session, several inputs like Chicks (500 No.), Piglet (20 No.), Broiler pre-starter (200 kg), Crumbo strater (400 kg), Crumbo poultry feed (400 kg), Varaahar pellet (1500 kg) were distributed among the farmers. Farmers were exposed to the knowledge of different facets of scientific dairy farming. A total of 111 farmers from Meghalaya were benefitted by these interventions.
- One visit of the state of Sikkim was organized in which veterinary health camp cum Scientists-farmers interaction session was organized. Inputs like Mineral mixture (525 kg), Cattle feed (4750 kg), Calcium supplements (50 lit) were distributed among farmers. A total of 91 farmers were benefitted by the intervention provided by Eastern Campus of ICAR-NDRI, Kalyani.



## Organization of Trainings for NEH Region

Training on "Scientific dairy farming" for 16 farmers from Tripura was organized from 11<sup>th</sup> – 14<sup>th</sup> September, 2017. Farmers from Tripura got exposure about scientific dairy farming and they were also acquainted with day-to-day activities of ICAR-NDRI, ERS farm. Exposure visit of trainee farmers were also arranged in RRS of CIFA and DT Faculty of West Bengal University of Animal and Fishery Sciences.

## Sports and Cultural Events Organized

Sports events for the students of Eastern Campus of ICAR-NDRI, Kalyani was organized. Athletic events comprising 100 meter race, relay race, long jump, shot put and other sports such as volley ball, cricket and badminton matches were also conducted for the students of the campus during February and March, 2018. Annual cultural programme was also organized on the students.



## Livestock Farm

### Annual Performance of Herd Maintained at Eastern Campus (1.1.17-31.12.17)

Particulars	Jersey Cross
Herd strength as on 31-12-2017	242
Total milk production (kg)	209446
Av. no. of cows' in milk/day	67
Av. no. of cows' in dry/day	25
Wet average (kg)/day	8.64
Herd average (kg)/day	6.32
Age at first calving (month)	34.00
No. of animals inseminated	124
No. of animals pregnant	63
Conception rate (%)	51.00
Service period (days)	108
Inter calving period (days)	426
Mortality (%)	4.96

### Milk Production Performance of Herd Maintained at Eastern Campus

Months (2017)	Milk Production (kg.)	Wet Average (kg.)	Herd Average (kg.)	Average FAT %	Average SNF %
January	16224.5	9.22	6.51	4.97	8.67
February	16243.5	9.59	6.91	5.04	8.66
March	20117.0	10.10	7.36	5.07	8.66
April	19918.0	9.89	7.34	4.92	8.80
May	19176.5	9.11	6.76	4.86	8.94
June	17422.0	8.58	6.31	4.91	8.93
July	17574.0	8.52	6.10	5.00	8.91
August	16440.0	8.10	5.64	5.03	8.91
September	16777.0	8.14	6.00	5.08	8.92
October	17397.5	7.92	6.00	5.18	8.98
November	16602.5	7.53	5.80	5.22	9.12
December	15553.0	7.00	5.10	5.41	9.24
Total Milk	209446.0				
<b>Overall Average</b>	<b>17453.83</b>	<b>8.64</b>	<b>6.32</b>	<b>5.06</b>	<b>8.90</b>

## Forage Farm

Forage Farm section is engaged in cultivation of quality fodder crops in about 27-30 hectares area and manages harvesting and supply of fodder crops either chaffed or unchaffed to the Cattle Yard. Besides cultivation of fodder crops, the Forage Section also has a mini workshop for regular servicing of agricultural machinery including tractors, chaffcutter etc. There is a small vermi-compost unit used for training and demonstration purpose. There is an agri-meteorological observatory where regular observations are taken for various meteorological parameters like relative humidity, max. and min. air temperature, soil temperature at different depth, wind speed and direction, Rainfall etc. There are more than 1000 plants of teak, shesham, mango, coconut etc. growing around the Institute premises. Mango and guava based agro-forestry have been developed in the ERS campus. Every year staff of ERS used to plant several saplings of different useful species in the campus. Besides, there is a fodder herbarium for training and demonstration purpose. The Forage Section has necessary facility for covering the theoretical and practical part of training on fodder crop production.

### Production of Different Fodder Crops at ERS Fodder Farm during (2017-18)

Sl. No.	Type of fodder	Quantity (Quintals)
1	Maize/Maize + cowpea	4234.35
2	Sorghum/sorghum+cowpea/sorghum + rice bean	5319.90
3	Oats /oats+mustard	3401.70
4	Berseem/berseem+mustard	2739.75
5	Sole cowpea/sole rice bean	473.15
6	Hybrid Napier grass/Guinea grass/Para grass	467.80
7	Coix	046.00
	<b>Total</b>	<b>16682.65</b>

## Radio Talk

Radio talk telecasted in Krishi Kothar Aasar, All India Radio, Kolkata.

Sl. No	Title of the Programme	Date of Broadcast	Expert/Talker
1.	Garur Projanan : Samashysa-or-Pratikar	27th July,2017	Dr. Mohan Mondal
2.	Pure and clean milk production	31st uly,2017	Dr. Dilip Kr. Mandal
3.	Sobuj Gokhadyar Chas	10th August, 2017	Sh. Alokesh Goswami

## SUCCESS STORY

Mr. Kalyan Koley came in contact with Eastern Campus of ICAR-NDRI, Kalyani and got information about scientific goat farming. He was exposed to several technical details of fodder production, nutrition aspect of goat farming and he was trained in Artificial Insemination of goat. He started '**Sanjivani Farm**' at Harit in Hoogly district of West Bengal with the technical support from Eastern Campus of ICAR-NDRI, Kalyani. The scientists of Eastern Campus provided assistance in frozen semen technology for AI in goat. He is getting around 51% success rate in goat AI at field conditions. He got **IIM-Invent Award** and also bagged **Smart 50 Award** from IIM Kolkata. Now he is providing training to other farmers in establishing goat farms and supporting them through his experience gained from the Eastern Campus.

# BUDGET AND EXPENDITURE

The financial outlays in terms of actual expenditure for Grants for the year 2017-2018 was ₹ 21570.59 lakhs and the sanctioned budget for Grants in 2017-2018 was ₹ 21596.40 lakhs. These figures include the financial outlays for Regional Stations.

## Financial Outlays & Expenditure during 2017-18

NDRI (including Eastern Campus, Kalyani)

(₹ in lakhs)

Sr. No.	Head	Grants	
		Budget	Expenditure
1.	Grant in Aid : Capital	381.20	378.84
2.	Grant in Aid : Salaries	6725.12	6722.96
3.	Grant in Aid : General	12278.95	12268.07
	<b>Total</b>	<b>19385.27</b>	<b>19369.87</b>

Southern Campus, Bengaluru

(₹ in lakhs)

Sr. No.	Head	Grants	
		Budget	Expenditure
1.	Grant in Aid : Capital	58.00	69.82
2.	Grant in Aid : Salaries	1231.58	1231.57
3.	Grant in Aid : General	921.55	899.33
	<b>Total</b>	<b>2211.13</b>	<b>2200.72</b>



## Revenue Generation

The Revenue Receipts of the Institute and the Regional Campuses for the year 2017-2018 were ₹ 981.15 lakhs.

Sl. No.	Head	Amount (Rs. in lakhs)
1.	Sale of Milk/Farms Produce	453.06
2.	Sale of Livestock	53.77
3.	Income from Royalty/Sale of Publication/Advertisement	0.71
4.	License Fee	96.33
5.	Interest Earned on Loans and Advances	29.66
6.	Leave Salary and Pension Contribution	13.43
7.	Analytical and Testing Fee	2.91
8.	Application Fee from Candidates	0.40
9.	Diploma Charges	0.82
10.	Receipt from Services Rendered	3.01
11.	Interest Earned on Short Term Deposits	54.76
12.	Interest Generated from Internal Resource	92.38
13.	Miscellaneous Receipts	179.91
	<b>Total</b>	<b>981.15</b>

## Position of Manpower at NDRI, Karnal and its Regional Campuses as on 31.03.2017

Type of Posts	Existing		
	Approved by D/o Expenditure	In position	Vacant
Scientific	195	157	38
Administrative (Group A&B)	36	30	06
Technical	362	186	176
Administrative (Group Non-gazatted)	129	97	32
Supporting	758	402	356
<b>Total</b>	<b>1480</b>	<b>870</b>	<b>610</b>



*National Library Building*

# राजभाषा कार्यकलाप

भारत सरकार की राजभाषा नीति के अनुसरण में राजभाषा हिंदी के प्रचार, प्रसार एवं कार्यान्वयन हेतु संस्थान में वर्ष 1979 में राजभाषा एकक की स्थापना की गई। संस्थान में राजभाषा नीति, नियमों एवं व्यवस्थाओं के नियमानुसार अनुपालन एवं कार्यान्वयन के लिए संस्थान के राजभाषा एकक में वर्ष 1988, 1989 एवं 2011 में क्रमशः हिन्दी अनुवादक, सहायक निदेशक एवं उप निदेशक के पद सृजित किए गए। राजभाषा एकक द्वारा संस्थान के अधिकारियों, वैज्ञानिकों, प्रशासनिक कर्मचारी, तकनीकी कर्मचारी आदि को राजभाषा हिंदी में कार्य करने के लिए प्रोत्साहित करते हुए हर संभव सहयोग भी प्रदान किया जा रहा है। संस्थान के राजभाषा एकक द्वारा निम्नलिखित विवरणानुसार विभिन्न गतिविधियों का आयोजन किया गया।

- » संस्थान में गठित संस्थान राजभाषा कार्यान्वयन समिति की वर्ष में चार तिमाही बैठकें आयोजित की गईं। इन बैठकों में राजभाषा कार्यान्वयन के क्षेत्र में संस्थान की प्रगति का आंकलन किया जाता है एवं भावी कार्यक्रमों हेतु कार्ययोजना तैयार कर उन्हें कार्यान्वित किया जाता है।
- » राजभाषा नियम 1976 के नियम-11 का अनुपालन करते हुये संस्थान द्वारा सभी प्रकार के मानक फार्मों एवं स्टेशनरी सामान आदि को द्विभाषी रूप में प्रयोग करना सुनिश्चित किया जा रहा है।
- » राजभाषा के प्रगामी प्रयोग को सतत् बढ़ाने एवं कर्मचारियों की सरकारी काम-काज में राजभाषा के प्रयोग में होने वाली झिझक को दूर करने के लिए 7 हिन्दी कार्यशालाओं का आयोजन किया गया इनमें 92 अधिकारियों एवं 64 कर्मचारियों सहित कुल 156 कर्मचारियों को प्रशिक्षण प्रदान किया गया।
- » संस्थान में दिनांक 14.9.2017 से 15.10.2017 तक हिन्दी चेतना मास का आयोजन किया गया। दिनांक 14 सितंबर 2017 को हिन्दी दिवस समारोह एवं 16.10.2017 को राजभाषा पुरस्कार वितरण समारोह का आयोजन किया गया। इस अवधि में संस्थान में कुल 5 प्रतियोगिताएं, दिनांक 14.9.2017 को हिन्दी गीतगायन, 19.9.2017 को हिन्दी शोधपत्र पोस्टर, 22.9.2017 को हिन्दी कार्यशाला, 25.9.2017 को हिन्दी निबंध लेखन एवं 06.10.2017 को हिन्दी आशुभाषण प्रतियोगिताओं का आयोजन किया गया। राजभाषा पुरस्कार वितरण समारोह में विभिन्न राजभाषा प्रतियोगिताओं के 139 विजेताओं को प्रशस्ति प्रमाणपत्रों से सम्मानित किया गया।



- » वर्ष 2016-17 की वार्षिक मूल हिन्दी टिप्पण एवं आलेखन प्रतियोगिता में प्राप्त हुई 11 प्रविष्टियों में से नियमानुसार 10 सुपात्र कर्मचारियों को नकद पुरस्कार एवं प्रमाण पत्रों से पुरस्कृत किया गया। इसी प्रकार वर्ष 2017-18 की प्रतियोगिता के लिए प्राप्त हुई 10 प्रविष्टियों में से नियमानुसार सभी 10 कर्मचारियों को नियमानुसार पुरस्कृत किया गया।

- » वर्ष 2016-17 की "वैज्ञानिक तथा तकनीकी विशयों की मूल हिंदी लेखन प्रतियोगिता" के अंतर्गत 38 वैज्ञानिकों/तकनीकी अधिकारियों आदि को नकद पुरस्कार एवं प्रमाण पत्रों से सम्मानित किया गया।
- » हर वर्ष की भाँति संस्थान की वार्षिक गृह पत्रिका "दुग्ध गंगा" एवं तिमाही न्यूज लैटर "डेरी समाचार" को पूर्णतः हिन्दी में प्रकाशित किया जा रहा है।
- » संस्थान के वैज्ञानिकों से प्राप्त वैज्ञानिक एवं लोकप्रिय लेख, छात्रों के शोध सारांश, वार्षिक प्रतिवेदन, प्रशासनिक पत्र, परिपत्र, ज्ञापन, विभिन्न समारोहों की प्रेस विज्ञप्ति, गणमान्य अतिथियों, मंत्रियों आदि के संबोधन, व्याख्यान एवं अन्य सामग्री का अनुवाद कार्य इस एकक द्वारा किया जाता है।
- » गैर हिन्दी क्षेत्रों से अध्ययन हेतु आए एम.एससी./एम.टैक./पीएच.डी. के छात्र जिन्हें मैट्रिक स्तर तक हिन्दी का ज्ञान नहीं है उन्हें हिन्दी शिक्षण का कार्य इस एकक के स्टाफ द्वारा दिया जाता है।
- » राजभाषा एकक द्वारा वैज्ञानिक तथा तकनीकी शब्दावली आयोग द्वारा प्रकाशित "बृहत प्रशासनिक शब्दावली" की प्रतियाँ संस्थान के कर्मचारियों को उपलब्ध कराई गई हैं। संस्थान में अंग्रेजी/टाइपिस्टों/आशुलिपिकों को हिन्दी टाइपिंग सीखने हेतु निरन्तर प्रोत्साहित किया जा रहा है तथा डेस्क प्रशिक्षण के द्वारा कंप्यूटर पर हिन्दी टाइपिंग सिखाई जा रही है।
- » संस्थान के निदेशक, नगरस्तरीय नगर राजभाषा कार्यान्वयन समिति, करनाल के पदेन अध्यक्ष भी हैं। अध्यक्ष नराकास एवं निदेशक, भाकूअनुप-राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल की अध्यक्षता में समिति की दो बैठकें, प्रथम बैठक दिनांक 9.6.2017 को एवं दूसरी बैठक दिनांक 9.11.2017 को संपन्न हुई हैं। नराकास की छमाही बैठकों में करनाल में स्थित 68 केन्द्र सरकार के कार्यालयों, उपक्रमों, निगमों, अनुसंधान संस्थानों, विश्वविद्यालयों, लिमिटेडों तथा राष्ट्रीयकृत बैंकों आदि के प्रशासनिक अध्यक्षों, वरिष्ठ अधिकारियों, राजभाषा अधिकारियों एवं प्रतिनिधि अधिकारियों द्वारा प्रतिभागिता की जाती है। इन बैठकों में भारत सरकार, राजभाषा विभाग के प्रतिनिधि अधिकारी भी शामिल होते हैं। समिति द्वारा समिति के रूटीन प्रकार के कार्यों के अलावा अध्यक्ष नराकास एवं संस्थान के निदेशक महोदय के मार्गदर्शन में संस्थान के राजभाषा एकक के प्रभारी मय नराकास समन्वयक एवं सचिव नराकास द्वारा समिति के सदस्य कार्यालयों को राजभाषा के प्रचार, प्रसार एवं कार्यान्वयन हेतु समय समय पर मार्गदर्शन एवं सहयोग भी प्रदान किया जा रहा है। समिति द्वारा छमाही बैठकों में सदस्य कार्यालयों के प्रधानों एवं प्रतिनिधियों की सहमति से निर्णित अनुसार विभिन्न राजभाषा गतिविधियों का आयोजन किया गया। नराकास के तत्वावधान में 18.7.2017 को हिन्दी श्रुतलेखन, 22.8.2017 को हिन्दी लघुकथा लेखन, 7.9.2017 को हिन्दी निबंध, 14.9.2017 को हिन्दी देशभक्ति गीतगायन, 25.9.2017 को हिन्दी टिप्पणी एवं मसौदा लेखन, 12.10.2017 को हिन्दी शब्दावली, 29.11.2017 को हिन्दी मुहावरा/लोकोक्ति लेखन, 1.12.2017 को हिन्दी पैराग्राफ श्रुतलेखन, 15.2.2018 को हिन्दी नारालेखन, 16.2.2018 को हिन्दी वाक्यांश अनुवाद, 14.3.2018 को हिन्दी निबंध, 19.4.2018 (पूर्वाहन) को वाक्य अनुवाद, 19.4.2018 (अपराहन) को हिन्दीतर कर्मचारियों के लिए निबंध आदि प्रतियोगिताओं का आयोजन किया गया तथा उक्त 07 प्रतियोगिताओं के 46 विजेताओं को नकद पुरस्कार एवं प्रमाणपत्रों से सम्मानित किया गया।



हिन्दी शोधपत्र पोस्टर प्रदर्शन प्रतियोगिता का आयोजन

# SWACHCHH BHARAT ABHIYAN: CLEAN & GREEN NDRI

Swachchh Bharat Abhiyan is a mission led by the government of India to make India a clean India. To realize Gandhi Ji's dream of a Clean India, NDRI is supporting this drive of the Government of India by organizing cleanliness campaigns, talks on cleanliness, awareness camps, etc. in the Institute campus and in the adopted villages. The Institute focuses on spreading awareness about better sanitation and hygiene practices and disseminating information about the importance of cleanliness, through various programmes. The residents of the Institute's campus and the villagers were also educated to make the campaign truly effective and successful.



*NDRI Staff and students taking pledge*

## Sewa Diwa

ICAR-NDRI celebrated Sewa Diwas under "Swachchhta Hi Sewa" Campaign on 17<sup>th</sup> September 2017. A Swachchhta Pledge was also administered to all the employees and students of the Institute. Further, a series of cleanliness drives including cleaning and sweeping of offices, corridors and premises, weeding out old records, disposing of old and obsolete furniture and junk materials was taken up. Individual chambers, offices, laboratories and the corridors were cleaned. Laboratories were also re-organized, by discarding old chemical solutions, samples etc.



*Swachchh Bharat Abhiyan is in progress*

*Sewa Diwas* was also celebrated at Eastern Campus of ICAR-NDRI, Karnal, Kalyani wherein, Scientists, Technical Officers, Administrative and students participated and a cleanliness drive was organized in different parts of the campus. On this occasion, participants also moved a campaign for spreading the message of cleanliness in their surroundings. Special attention was given to clean the lawns and portico in front of administrative building, feed milling plant, cattle yard and roads in different parts of the campus. Entire staff of the campus enthusiastically participated in the programme, while contributing via 'Shramdan' activities.

*Sewa Diwas* was celebrated at Southern Campus of ICAR- NDRI, Bengaluru on 22<sup>nd</sup> September 2017 by planting tree saplings. On this occasion, a "Sasyagraha Vana" was inaugurated by the Union Minister of Parliament Affairs and Chemicals & Fertilizers, Govt. of India.



*Shri Ananth Kumar Hon'ble Union Minister addressing gathering at Southern Campus of NDRI*

## Swachchhta Pakhwada

NDRI celebrated Swachchhta Pakhwada under "*Swachchh Bharat Abhiyan*" programme of the Institute during 22<sup>nd</sup> September to 2<sup>nd</sup> October, 2017. All the scientists, technical officers, administrative, financial, supporting staff and students of the Institute participated in this cleanliness drive and cleaned up NDRI premises, Sector- 12 (Sunday Market area and constructed a common toilet there for public use, Uchani lake of Karnal district etc.. After cleaning the allotted area, participants collected the garbage and disposed at dumping ground. In addition with this, an awareness campaign was also organized in adopted villages of NDRI regarding the importance of the cleanliness drive. NDRI organized a cleaning campaign on massive scale. More than 2200 employees and students of this Institute together took the task to clean every nook and corner of 1400 acre area of NDRI. Residents of NDRI were sensitized for the making their surroundings clean. The employees of NDRI launched several campaigns jointly with villagers to implement the Hon'ble Prime minister's call for National Sanitation Campaign (Swachchh Bharat Abhiyan) nearby Karnal district.



*NDRI employees cleaning Sunday Market Area in Sector-12 Karnal and Dr. R. R. B. Singh, Director NDRI with the employees after cleaning the area*

Swachchhata Pakhwada was also organized under "*Swachchhata Shramdan*" programme on 2<sup>nd</sup> October, 2017 at Southern Campus by cleaning both the sides of the stretch of Hosur main road in front of the campus. Awareness drive for cleanliness was also carried out in the surrounding residential colonies of the campus.



*A view of cleanliness drive*

## Awareness Campaigns

A team of extension scientists also organised awareness campaigns in the adopted villages of the Institute. The team sensitized the villagers about the importance of cleanliness and to keep the villages neat and clean. The emphasis was given for wider adoption of the bio-waste management towards processing of bio-wastes into clean and environment-friendly bio-fuels & organic manures. Awareness was also created among the farmers enrolled with the "Farmers' Farm School" about the importance of sanitation. KVK also sensitized the farmers and farm women to keep the surrounding environment neat and clean during campaign drives and training programmes.

## Clean and Green Drive

The plants planted last year in the campus area were being jointly taken care of the Institute Staff and the Estate Section of the Institute. Dairy Extension Division of NDRI, organized meetings with farmers, farm women and village youth and emphasis was given on maintaining clean environment, healthy lifestyle and sustainable livelihood in rural area. The villagers were also sensitized about climate resilient technologies and approaches. The interactions were followed by tree plantations in adopted villages. A team of extension scientists/technical officers also interacted with the villagers and emphasized on the need for cleaning and sanitizing of the sheds. They also advised the dairy farmers/farm women to follow the practices associated with 'Clean Milk Production'. Farmers were also asked to provide the clean water to animals for prevention of stomach disorders and internal parasites. The farmers were educated about the prevention of mastitis in the dairy and significance of maintaining health & hygiene at the household-level, in the rural areas.

Southern Regional Campus of ICAR-NDRI, Bengaluru in collaboration with Adama Chetana Foundation, Bengaluru organized "Tree Plantation Programme" on 7<sup>th</sup> May 2017 as part of Green Bengaluru drive launched by the Foundation. During the programme, seventy two tree saplings of various traditional varieties were planted in the Campus.



*Planting of saplings at Southern Campus of ICAR-NDRI, Bengaluru*

# MEERA GAON MERA GAURAV (MGMG)

The Scheme had been initiated at the Institute-level (as per the directives of the Council) since August-September 2015. At present, a total number of 29 teams comprising of 4 Scientists each from different disciplines of the Institute have been involved in carrying out the programme (MGMG) in 145 villages [@ 5 Villages per team] in the vicinity of the Institute. The major objective of this innovative initiative is to promote the 'Direct Interface' of Scientists with the farmers to hasten the lab-to-land process, while providing the farmers with the required information, knowledge and advisory services on a regular basis via adoption of villages. During the year (2017-18), various teams of the Institute visited nearby villages and carried out various activities such as Interface Meetings, Sangoshties, Trainings, Demonstrations, Mobile-based Advisory Services, Literature support, Awareness created on different topics such as Health and hygiene, Balanced feeding of dairy animals, Importance of girls' education, Purchasing only Indian items to promote indigenous products, Eco-friendly celebration of festivals, Preparation of Milk products & Value-addition, Winter management techniques for crops and animals, 'Scientific Dairy Farming' practices and Swachhh Bharat Abhiyan. Under this programme, following activities were carried out by the Institute.

Sl. No.	Name of activity	No. of activities conducted	No. of farmers participated & benefitted
1.	Visit to village by teams	43	2005
2.	Interface meeting/ <i>Goshties</i> / Training	35	1635
4.	Demonstrations conducted	157	1065
5.	Mobile based advisories (No.)	199	1690
6.	Literature support provided	16	1370
7.	Awareness created	52	2110
8.	Input support provided	24	677
	<b>Total</b>	<b>526</b>	<b>10552</b>



*Inspecting the udder of a cow*



*Advice being given to the farmers for improved Livestock-rearing practices*



*Discussion with Sarpanch and farmers*



*Observing the fodder being cultivated by the Farmers*



*Monitoring the living-conditions of the dairy animals being possessed by the farmers*

Southern Campus of NDRI, Bengaluru identified a cluster of villages in Bengaluru Rural Districts and six groups of scientists, comprising four scientists from different multi-disciplinary teams were formed to conduct the baseline survey and further implementation of need based institute interventions and other developmental activities on regular basis under Mera Gaon Mera Gaurav Programme.

Eastern Campus of NDRI, Kalyani implemented 'Mera Gaon Mera Gourav' programme in selected villages. Visits were organized in villages namely Majhdia, Saguna and Charsarati. Villagers were updated about recent development in the field of dairy farming and extension literatures, mineral mixture as well as veterinary medicines were distributed among farmers. SMS pertaining to vaccination against FMD, HS and BQ and information about Anthrax disease were disseminated through SMS portal developed by Eastern Campus of NDRI, Kalyani.



*A team of extension scientists of Eastern Campus, Kalyani visiting animal houses maintained in rural area*



# ACHIEVEMENTS AT A GLANCE



## Research Projects

Externally Funded	:	70
In-house	:	77
Contract Research	:	6



## Publications

Research Papers/ Review Articles	:	422
Research Papers > 7 NAAS Rating	:	124



## IPR & Technology Transfer

Patent Filed	:	04
Patent Granted	:	03
New Technologies Developed	:	12
Technologies Commercialized	:	15



## Human Resource Development

B. Tech.	:	27
M.Tech./M.Sc./M.V.Sc.	:	146
Ph.D.	:	104
Dip. in (DT)	:	26
Dip. in (AH&D)	:	17



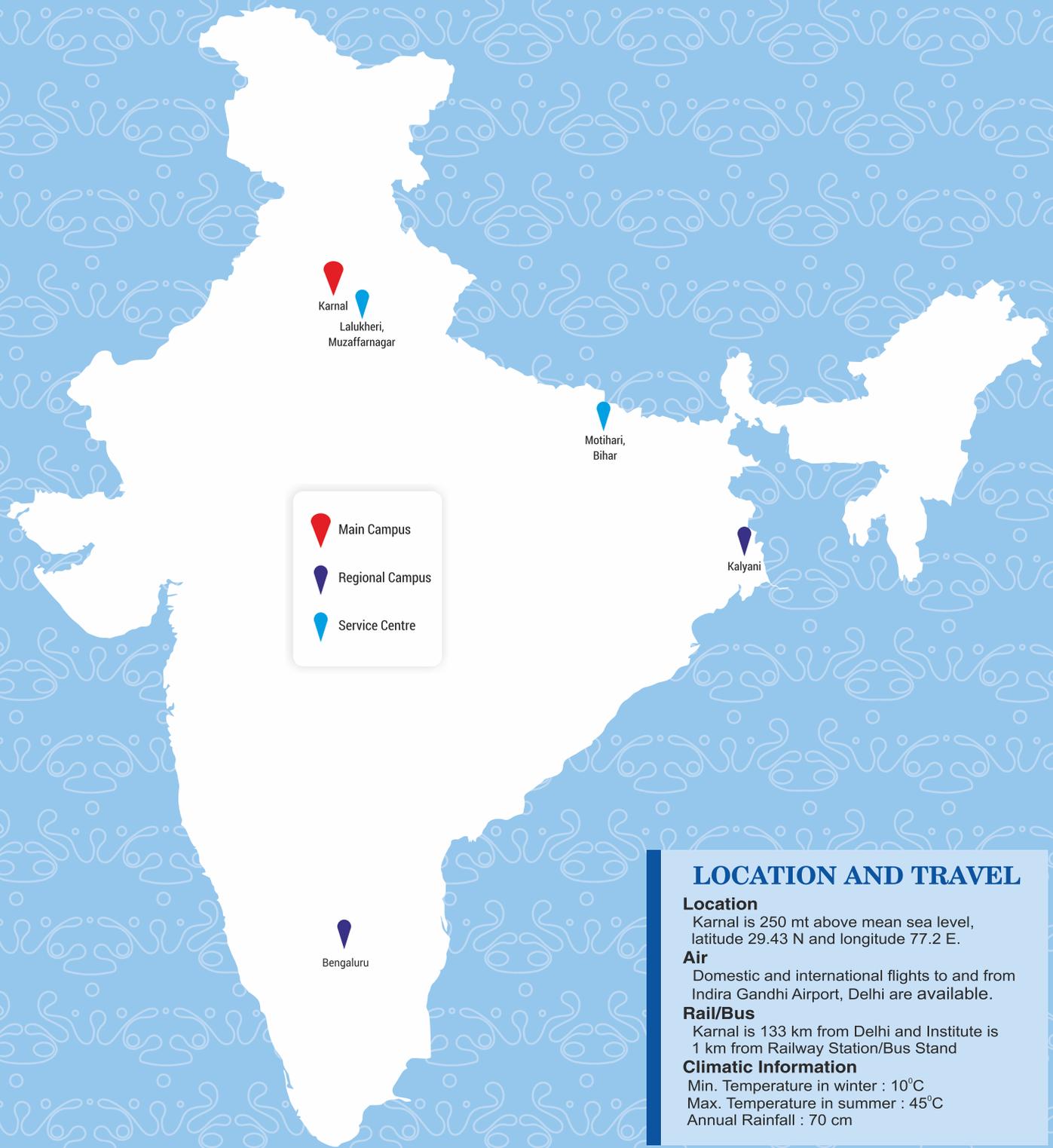
## Capacity Building

Entrepreneurs Develop. Prog.	:	14
Ventures Initiated	:	07
Incubatee Enrolled	:	15
Trainings Organised	:	18
Students Trained	:	150



## Services to Farmers

Kisan Sangoshthies	:	34
Trainings	:	175
Veterinary Camps	:	40
Advisory Services Provided	:	5045
National Dairy Mela	:	1



## LOCATION AND TRAVEL

### Location

Karnal is 250 mt above mean sea level, latitude 29.43 N and longitude 77.2 E.

### Air

Domestic and international flights to and from Indira Gandhi Airport, Delhi are available.

### Rail/Bus

Karnal is 133 km from Delhi and Institute is 1 km from Railway Station/Bus Stand

### Climatic Information

Min. Temperature in winter : 10°C  
Max. Temperature in summer : 45°C  
Annual Rainfall : 70 cm

**ICAR-NATIONAL DAIRY RESEARCH INSTITUTE**  
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