Livestock and Poultry Improvement and Management

ANIMAL GENETIC RESOURCES

Livestock Information Management System

At the NBAGR, Karnal, menu driven Livestock Information Management System was developed for animal resources. All the date tables and report forms are designed in the form of a single package. The database has information on livestock population, genetic resources, infrastructure, production, products and utilization, farms, etc. Separate table has been defined for each parameter. The master tables have names and codes of fields, which are repeatedly used in other tables, and there are data tables, which are linked to master tables and contain actual data.

Poultry Informatics: Data on national poultry informatics from 18 states/UTs of the country were collected and computerized. First hand information on product specialties and further scope of progress by the Indian Poultry Industry was also collected.

- Database on Indian livestock resources, infrastructure, animal production,products and utilization available
- Evaluation and characterization of several breeds of cattle ,buffalo, sheep, goat, equines, camel and poultry completed
- Polymorphism of growth hormone gene in Karan Fries cattle and Murrah buffalo was revealed first time
- Immune response characteristic of poultry breed was used as criterion for selection
- RAPD-PCR was effective in detecting the polymorphism between breeds of cattle
- Buffalo ovary –released protein identified as marker for oestrous and pregnancy detection
- Riverine buffaloes showed farthest genetic distance from African buffalo
- Nali and Chokla sheep are genetically closer while Garole sheep is a distinct population
- Special conservation efforts are needed for Nicobari and Kashmir Favorolla poultry
- Neighbour-joining tree of Indian goat breeds with wild goats was constructed first time
- A project on molecular genetic studies of experimental brown egger population initiated
- CARI- Nirbheek and CARI- Shyama developed from Aseel and Kadakanath for backyard poultry
- A preliminary attempt was made to grow embryonic stem cells in buffalo
- Double window embryo culture system for production of embryos of turkey, developed first time in world

Livestock Information Management System

- The System has the following modules:

Master module:	facilitates entry of new records (species, breeds, states, district) in the master tables
	Data entry & updating: facilitates entry of data in data tables
Data view:	facilitates display of data available in any of the data tables
Contact:	contact addresses of organizations dealing in animal resources
Report:	facilitates retrieval of data through selection of desired parameters

Data in the Information System

- Names and codes in the master tables i.e. States, Districts, Species and breeds
- District-wise data on infrastructure and production of animals from 1990 onwards for Bihar, West Bengal, Andhra Pradesh, Karnataka, Uttar Pradesh, Orissa, Tamil Nadu, Punjab, Haryana, Rajasthan, Maharashtra, Goa, Gujarat, and Madhya Pradesh. State/UT data for Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Andaman & Nicobar, Chandigarh, Daman & Diu, Delhi, Lakshadweep and Pondicherry
- District-wise livestock population data for all the species and for all the census years from 1961 onwards. Data for 1997 has been entered for 17 states
- Breed data for all breeds of cattle, buffalo, sheep and goat
- Photographs for all the breeds of cattle, buffalo, sheep, goat and a few of sheep

Evaluation and Characterization of Breeds

Bachaur cattle: Bachaur population in Sitamarhi, Darbhanga and Madhubani districts was estimated as

Home tract of Bachaur cattle is Sitamarhi, Darbhanga and Madhubani

Dangi bulls are slow draught animals

Body measurements of Amrithmahal cattle of Karnataka, were taken

Nagpuri buffalo is famous for long horns extending up to or beyond the shoulders

Production and reproduction traits of Arunachali mithun were recorded

Age at slaughter was 8.7 months and weight 20.7 kg in Deccani sheep

Greasy wool production was 0.96–1.80 kg annually

10,948.The female population is largely available in Nepal or its adjoining areas. The floor of animal house was mostly *kutcha* (84%) and sanitary condition was poor in 59% cases. More than 90% animals were bred through natural service.

Dangi cattle: The breed is distributed in Ahmednagar, Nasik and Dang district of Maharashtra. The estimated population of the breed is 108,197. Information on physical characteristics, native environment, housing, feeding and management practices was compiled. The average lactation yield varied from 450 to 550 kg. The animals were bred through natural service (91.9%) and through AI (8.1%). The age at first oestrus was 41.3 months and inter-calving period 551.5 days. Dangi bulls are slow draught animals.

Amrithmahal cattle: Animals (14,073) maintained under field conditions at Chickmagalore, Chitradurga, Davanagere, Shimoga, Hassan and Tumkur districts of Karnataka, were surveyed. The average number of animals per household was 3.43. The body measurements of males and females below 3 years of age and above three years of age (total 2,622 animals) were recorded. Milk yield recording of 286 cows is in progress.

Nagpuri buffaloes: Survey, in the breeding tract confined to 60 villages spread over districts Nagpur, Akola, Amravati and Yavatmal, was carried out to collect information on morphological, production and reproduction parameters of buffaloes, and socio-economic status of farmers rearing Nagpuri buffaloes. The breed is reputed for very long horns extending up to or beyond the shoulders (52.86 cm in adults), flat and curved and carried back on each side of the neck. The average age at first estrus, age at first mating (female), first calving, service period, service per conception, calving interval were, respectively, 44.94 months, 45.8 months, 56.2 months, 123.7 days, 2.14 and 480.5 days.

Arunachali mithun: Under the project 7,547 mithuns of different age-groups of both the sexes were covered. Physical body measurements of adult mithuns (below 3 years), and 50 calves, were taken in three districts. The production and reproduction traits (maturity age, pregnancy period, total life span etc.) were recorded.

Deccani sheep: The breeding tract of this breed is spread in Pune, Ahmednagar, Kolhapur, Sholapur and Aurangabad districts of Maharashtra. Estimated population is approximately 149,942. The body weights at birth, 3, 6, and 12 months of age were 2.8, 9.9, 13.5 and 19.8 kg respectively. Adult body weights of males and females were 37.9 and 28.6 kg. The age at first estrus and first lambing were 9.6 and 14.1 months. The age and weight at slaughter were 8.7 months and 20.7 kg.

Changthangi sheep: The breed is distributed in Leh district of Jammu and Kashmir at an elevation of 3,340-4,560 m above mean sea level (msl). The animals are reared in the pastures up to 2,000 m above msl and the estimated population was approximately 66,822 with flock size in the range of 5-30. The chest girth, body length,

height at withers and weight in males were 70.5 cm, 66.1cm, 63.6 cm, and 30.6 kg, and in females was 75.6 cm, 64.3 cm, 65.5 cm and 34.3 kg respectively. The body weights at birth, 3, 6 and 12 months of age were recorded as 2.5 kg, 11.0 kg, 15.1kg and 21.4 kg, respectively. The greasy wool production was 0.96-1.08 kg; the staple length 9.3 cm and crimps 1.23/cm.

Malpura and Jaisalmeri sheep: Malpura sheep go for a short migration and Jaiselmeri for a long migration

Jaisalmeri sheep go for long migration from their breeding tracts

from their respective breeding tracts. Malpura and Jaiselmeri sheep are kept in open houses in the breed tract but no housing is provided during migration and no supplementary feeding, except that three loppings are provided in lean season. Data on greasy fleece production was collected for Malpura breed and is being collected for Jaiselmeri breed. Staple length was 4.47 and 4.62 cm, fibre diameter was 45.86 and 34.71 micron and medullation percentage was 58.96% and 40.21% in Malpura and Jailsalmeri breeds respectively.

Gaddi sheep and goat: Geographical and demographic distribution of the Gaddi sheep and goats were studied in Kullu, Chamba and Kangra districts of Himachal Pradesh. The migratory routes of these breeds were traced and followed for data recording. In winters, they graze in valleys and in summer go to alpine pastures. Both graze in summer but some dried grasses are given in extreme winters. Majority of Gaddi sheep (56 to 79.64%) and

Parbatsari and Sirohi goats

Parbatsari goats are light brown or dark brown colour with no patches. The breed is mixed with Sirohi breed (with light or dark brown patches) in Ajmer and Nagaur districts of Rajasthan. Surveyed flocks were 33% brown with patches (Sirohi) and 67% solid brown (Parbatsari type). Goats are reared purely on browsing resources in rangeland and hardly any supplementary feed is provided, except for the household wastes to lactating goats. Parbatsari goats have body size and body weights lower than Sirohi goats.

Sirohi goat

Parbatsari goat

Gaddi goat (52.69 to 82.28%) are white. Other colour variants may be pure black, brown or white with black/ brown patches. Horns are present in both sexes of Gaddi sheep and goat. In Gaddi sheep, body length varied from 64.7 cm to 69.3 cm and in Gaddi goat from 68.3 cm to 73.2 cm in different districts. Adult body weight varied from 29.9 kg to 34.0 kg in Gaddi sheep and 33.3 to 36.9 kg in Gaddi goats. The average live weight was 25.2 and 31.1 kg in adult male and female sheep, respectively, and dressed weights were 12.5 and 15.7 kg respectively. The corresponding live weights in Gaddi goats were 27.1 and 31.0 kg in males and females, and the dressed weight were 13.6 and 15 kg respectively. Wool is shorn three-times in a year and clip yield varied from 437 g to 696 g in different age groups of Gaddi sheep.

Gaddi sheep

Gaddi goat

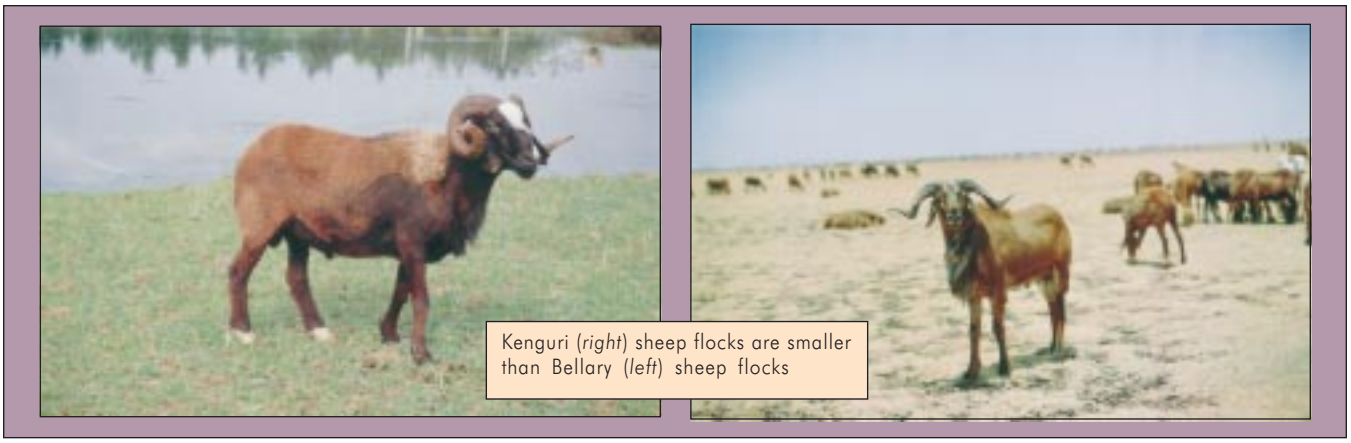
Gurej and Karnah sheep: Gurej sheep had much wider distribution but now their small population has been restricted to Gurej Tehsil of Baramullah district in the basin of river Kishan Ganga at an elevation ranging from 3,200 to 4,100 m amsl. The breeding tract of Karnah sheep breed is now restricted to Tangdar and Teetwal blocks of Kupwara district in North Kashmir at an altitude ranging from 1,260 to 2,630 m amsl. Both Gurej and Karnah sheep go for seasonal migration. They move to alpine pastures in April and come down to valleys in September-October. In both the breeds, animals are flocked in open, surrounded by logs or temporary stone wall in grazing camps on migration, but in villages these are kept in huts made of wood with *kutcha* flooring. In summer, animals of both breeds are kept on grazing. In extreme winter when no grass is available, animals are fed with boiled maize or potatoes in Gurej area and with dried grasses or hay in Karnah area. Major breeding season in both Karnah and Gurej sheep is September-October. Lambing is in March-April. Birth weight in Gurej varied from 2.43 to 2.35 kg in males and females. Body weights at 3, 6 months of age and adults were 6.68 and 6.42 kg, 16.84 and 17.15 kg and 40.59 and 38.20 kg in male and female respectively. Gurej sheep are shorn twice a year, and wool yield ranged from 317 g at 6 months to 806 g at adult age in autumn clip. Average staple length was 4.56 cm in Gurej sheep and 3.47 cm in Karnah. The average crimp/cm was 1.61 in Gurej and 1.82 in Karnah. Both the breeds are highly endangered. Four horned sheep were discovered in Gurej breed for first time in India. Their number is 14 at present.

Kenguri and Bellary sheep: Survey was carried out in the villages of Kustagi, Yelburga and Gangavati taluks of Hospet district for Kenguri sheep, and Hospet, Sandur and Bellary taluks for Bellary sheep. Kenguri (synonym: Tenguri; after the name of coat colour, 'Teng' meaning coconut) sheep are well built and large sized. The body is covered with short, dark-brown and shiny hair, which is never shorn. Animals mostly have a white patch on forehead; the white patches on some other body parts are seen rarely. About 70% breeding males are horned, females are generally polled but about 5% of the females have rudimentary/small horns. About 80% animals have wattles.

Karnah sheep

Gurej sheep

The animals are maintained in large flocks in good condition. Bellary flocks were larger compared to Kenguri flocks. Animals graze in open fields and supplementation of feed is rare. Flocks are generally purebred. Only about 5% animals were non-descript. Breeding males are selected on the basis of body size and conformation. September to November is the main lambing season and February to March the minor. Lambing rate is about 80%. Age at first lambing was 18-24 months. Ewes, on an average, produce 7-8 lambs in their lifetime. Twinning is rare in both the breeds. Bellary animals are well built and medium to large in size, and body colour comprises various combinations of white and black or black; complete white



Kenguri (*right*) sheep flocks are smaller than Bellary (*left*) sheep flocks

animals were not reported. About 90% males were horned whereas, about 25% females had horns and their horn length was much smaller compared to males. The tail is thin and short. Fleece is extremely coarse, hairy and open. Both breeds are maintained for mutton, however, Bellary sheep produce hairy and coarse fleece that can be used for making rugs etc.

Spiti horse: The distribution of the breed is confined to Lahul and Spiti, Kinnaur, Kullu, Mandi and limited areas of Kangra and Shimla districts of Himachal Pradesh. The total population was estimated as 4,000. The entire breeding tract of the Spiti horse falls in cold desert region with very little vegetation.In April – May foaling occurs followed by rebreeding, mostly during foal heat in May. The coat colour of Spiti horses range from chestnut to black, however, most of the animals were gray (36.41%) followed by black (26.01%) and brown (15.16%). Some animals (6.19%) were of bay colour pattern. Majority of animals (80%) do not have head mark, in 10.40% animals star was the most prominent marking whereas, few animals also had stripes, white face, snip and blaze marks. Similarly, limb markings were also present in few animals (28%); white fetlock (7.17%), white pastern (6.01%), white heels (4.75%) were the prominent markings. Muzzle colour pattern was — white muzzle (10.40%) or no marking (89.6%). In 40% animals, the tail was of different colour than the body, and whorls were seen in almost half of animals surveyed. The ear length, tail length, chest girth, height at withers, body length, body weight and circumference of canon was measured. The age at first estrus was 15-24 months, age at first covering 30-34 months, age at first foaling 41-46 months, and foaling interval as 345-380 days. In males, age at first ejaculate was 24 months, and age at first covering 30 months.

Mewari: The Mewari camel is well adapted to the Arawali hills. This breed is also known for the production of milk as camel milk is sold in the Mewar and adjacent Malwa region of Madhya Pradesh. Breed descriptor was prepared for this breed, and biometry of 14 body parameters was done. An adult Mewari camel has 159.27±2.61 cm body length, 196.08±3.50 cm heart girth and 194.31±2.38 cm height at withers.

Breed descriptors for camels: The breed descriptors of the Bikaneri and Jaisalmeri breeds were prepared. Information on 14 body measurements along with socio-economic status, breed and nutritional status, and other relevant data regarding camel husbandry in the breeding tract were collected.

Ankaleshwar poultry: The estimated population of Ankleshwar birds, distributed in Bharuch and Narmada districts of Gujarat, was approximately 4,500. The average flock size was 5-10. The comb shape was single and rose type. The egg shell varied from cream to brown. The egg production of the breed is 80.6 eggs/year with an average age at first egg of 181.3 days and average egg weight as

The entire breeding tract of the Spiti horse falls in cold desert region

34.3 g. The fertility was 91.3% and hatchability on fertile egg basis 92.4%. The weights of shell, albumin and yolk were, respectively, 4.8g, 16.4g and 13g. The body weights in males and females at 8 weeks, 12 weeks and slaughter (72 weeks) were 542g and 450g; 885g and 772g; 1800g and 1,578g respectively, whereas, body weight at hatching pooled over both the sexes was 28.5g.

Immunogenic, Biochemical and Cytogenetic Studies

At the Indian Veterinary Research Institute, Izatnagar, a technique for high resolution banding of chromosomes was modified based on enzyme digestion and staining for analyzing bovine chromosomes, and cytogenetic markers like translocation, trisomy X, nullisomy, etc were identified for various reproductive disorders.

Single nucleotide polymorphisms in α-lactalbumin gene in cattle: Indigenous cattle breeds of Southern India (Amrithmahal, Krishna Valley, Hallikar, Deoni, Ongole and Malnad Gidda) and Holstein crosses (HF × Sahiwal) were screened for single nucleotide polymorphisms (SNPs) in the coding sequence of the bovine alpha lactalbumin (α-LA) gene. SNPs at 772, 775, 792 and 857 positions in exon 1, and at 1231, 1264 and 1335 positions in exon 2,

Egg production is 80.6/year and body weight of males at 8 weeks of age is 540 g in Ankleshwar birds

were detected. The crystal structure of bovine α-LA provides a basis to interpret the influence of the SNPs on the structure and function of the mature protein. The first two observed SNPs S3T and F4L are located within the signal peptide sequence. The sequence and structure of the signal peptide can be expected to have a regulatory effect on the rate of lactose biosynthesis and consequently on milk production.

Polymorphism of growth hormone gene: Polymorphism of growth hormone (GH) gene with PCR-RFLP (Alu-I as restriction enzyme) was revealed for the first time in Karan Fries (26) and Murrah (23) bulls. Polymorphism was observed in Karan Fries bulls with genotypes LL and LV. Murrah bulls were monomorphic with only LL genotype. LL genotype containing KF bulls were better in terms of birth weight, 3 and 6 months body weight, libido score, mass activity, individual fresh sperm motility, post-thaw semen motility, EPD; whereas, LV genotype animals were better in reaction time, Flehmen's response, mounting stimulus, semen volume and seminal consistency. Murrah bulls with LL genotype were better than that of KF bulls in body weights, reaction time, requirement of mounting stimulus for mounting, semen mass activity, individual fresh sperm motility and post-thaw sperm motility. LL genotype of GH gene of KF bulls could be considered as an aid in selection of KF bulls under progeny testing programme for better body weights and individual fresh sperm motility.

Characterization of yak genetic resources: At the NRC on Yak, haemoglobin polymorphism of yaks was studied. Cytogenetic investigations on yaks and their hybrids were

Haemoglobin polymorphism of yaks was studied

conducted, and the normal chromosomal profile of pure yaks of Arunachal Pradesh was studied.

Immune response in poultry: In Synthetic broiler dam line (SDL) the overall mean for SRBC (sheep red blood cells) response (Log_2 of titre), CMI (% thickness), serum lysozyme (µg/ml) and IgG (mg/ml) levels were 6.203±0.112, 44.57±0.88, 4.95±0.11 and 7.08±0.14, respectively, in G_0 generation. The procedure for RAPD-PCR was standardized, and scorable bands were obtained.

Deoni cattle were screened for single nucleotide morphisms in the coding sequence of bovine alpha lactalbumin gene

The amplification procedures of BL-bII region (267 bp) and promoter regions of IFNg (670bp) and IL-2 (659 bp) genes using specific forward and reverse primers, were also standardized at the CARI, Izatnagar. The immunocompetent traits, viz. response to SRBC, serum lysozyme level, MER (mercaptoethanol resistant) and MES (mercaptoethanol sensitive) were analyzed. The two treatment groups did not differ significantly in their body weights, serum lysozyme level and antibody response to SRBC, MER and MES antibodies on 5 dpi (days post immunization).

At the Project Directorate on Poultry, Hyderabad, the immune competence of purelines was profiled primarily for breeding purposes. Adults of Vanaraja female line were randomly tested for immune response against Ranikhet disease vaccine, using ELISA. They revealed adequate protection from the disease. Profiles of immune competence were also determined using SRBC antigen in 7 test crosses, and this information was effectively utilized in selection process of breeders. Vanaraja birds fed normal diet showed better titers than those fed deficient diets. Dietary influence was apparent in the nutritionally depleted line.

Antibody titers of naked neck layers, crosses of broiler male line and dwarf, Krishibro (Pb1 × Pb2) and Pb1 × crossbred dwarf, were also determined. These profiles were useful for incorporation of information in breeding programmes.

Molecular Genetic Characterization of Indigenous Breeds

Cattle: RAPD-PCR was effective in detecting the polymorphism within as well as between Rathi and Tharparkar cattle. Within breeds, genetic similarity was higher in Rathi, and PCR-RFLP analysis revealed restricted sites for *Hae III* enzyme. PCR-RFLP analysis of insulin like growth factor binding protein 3 (IGFBP3) gene in Hariana and F × H (HF × Hariana crossbred) cattle revealed that Hariana cattle were homozygous for allele A (genotype AA) while crossbred cattle were

Genetic similarity, within breeds was higher in Rathi cattle

heterozygous (genotypes AA, AB and BB) possessing both A and B alleles.

Buffalo: A buffalo ovary-released protein (29 kDa) was identified as a marker for oestrous and pregnancy detection.A 39 kDa protein from embryos was found pregnancy specific.

Cloning and sequencing of cytochrome b gene: Cytochrome-b gene from Jaffarabadi and Murrah buffaloes was PCR amplified from the mitochondrial DNA template using deep vent DNA polymerase enzyme, and was cloned in pBluescript KS+ vector. Comparison of sequences with other buffalo species was carried out. After establishing the fact that nucleotide sequence of cyt-b showed similarity in riverine buffaloes, the full length of the cytochrome protein sequence in the gene bank was searched and downloaded. This was compared with all available sequences. An average distance tree was constructed. Riverine buffaloes showed highest degree of similarity (98%) with *Bubalus depressicornis* and *Bubalus mindorensis*. Amongst various buffalo species compared, riverine buffaloes showed farthest distance from African wild buffaloes.

Assignment of individuals: Assignment of individuals to a breed was attempted at the NBAGR, Karnal, using multilocus genotypes in 4 poultry, 3 buffalo and 2 goat breeds of India, utilizing data generated on microsatellite loci. The unknown individuals were then assigned on the basis of reference allelic frequencies of the breeds. Genetic data analysis methods like frequency method, Bayesian method, and genetic distances like Nei's standard, Nei's minimum, Nei's D_A, allele sharing and chord distance were utilized. All the individuals were assigned to the populations correctly with 100% accuracy in poultry and goat breeds. The values obtained in buffalo varied from 84 to 98%. Population exclusion method was also used with the above three methods using exclusion threshold of 0.01. The average probability of wrong assignment was very low. The likelihood method performed better than the frequency method for assignment of unknown individuals. Among genetic distances DAS and chord distance gave better assignments than the Nei's genetic distances.

Genetic distances among buffalo populations

The relationship among local buffaloes of Kerala, Bhadawari and Tarai populations was calculated using the genetic distances/ identities utilizing allelic frequencies at the NBAGR, Karnal. The Kerala buffaloes were a distinct entity and the Bhadawari and Tarai populations were genetically very close to one another. The inter-individual genetic distances were estimated using allele sharing method and the dendrogram of three buffalo populations was prepared.

Tarai buffalo

At the NBAGR, Karnal, genetic relationships based on genetic distance measures revealed close similarity between Nali and Chokla as they were grouped together first, than with Muzaffarnagri sheep. Garole appeared to be a distinct population. The result is in accordance with the geographical distribution of these four breeds of sheep.

The data of microsatellite loci was generated for indigenous poultry, buffalo and goat breeds at the NBAGR, Karnal. Data were subjected to statistical analysis to test for heterozygosity since any bottlenecked population would undergo transient heterozygosity excess. Sign-rank test, standardized differences test and Wilcoxon test were utilized in each of the three models of mutations, IAM, SMM and TPM. SMM revealed significant heterozygote excess for Nicobari and Kashmir Favorolla rejecting the null hypothesis of mutation drift equilibrium. The two populations showed recent genetic bottleneck. The Miri and Aseel poultry did not reveal significant heterozygote excess under SMM in all three tests and thus the populations are supposedly in mutation drift equilibrium. The mode shift-test revealed recent genetic bottleneck only

Pair of Kashmiri Favorolla

in Nicobari fowl. Special conservation efforts are required for Nicobari and Kashmir Favorolla poultry.

Chegu and Black Bengal goats revealed genetic bottleneck and require conservation efforts. There is a need to implement a planned breeding programme for Black Bengal goats, which are very large in number and do not seem to be facing any demographic bottleneck.

Buffalo breeds did not exhibit recent genetic bottlenecks in the conservative SMM model. However, Tarai and Kerala buffalo populations revealed genetic bottlenecks under IAM and TPM model of microsatellite evolution.

Biotechnological studies in sheep: At the Central Sheep Wool Research Institute, Avikanagar, DNA isolation protocol was standardized, and isolation of genomic DNA from Malpura, Garole, Chokla, Avikalin and Kheri breeds was completed.

Genetic variants of polymorphic traits and gene markers: Sequencing of mitochondrial (mt DNA) HVRI (hyper variable) region was carried out in 363 samples of 10 Indian goat breeds. The pattern of molecular diversity in Indian goats was analyzed by mismatch analysis. The neighbour-joining tree of Indian goat breeds along with wild goats was constructed for the first time. The Indian goats were placed into three different groups: first group – Jamunapari, Sirohi, Marwari, Pashmina; second group – Jakhrana, Black Bengal, Osmanabadi, Barbari and Kutchi; and third group – local (non-descript) goats of Mathura region. There were additional lineage observed in Indian goats indicating that considerable additional diversity exists within Indian domestic goats. Evidence for population structure and novel divergent lineage in Indian goats indicated a more complex origin for domestic goats.

Estimation of genetic relationship between Camel breeds: Blood samples from 50 unrelated individuals of Bikaneri, Jaisalmeri and Kachchhi camel breeds were collected from farm and field areas. Microsatellite loci, viz. LCA-56, LCA-66, LCA-63, YWLL-08 and VOLP –67 were amplified and analyzed. At LCA-56, LCA-66 and LCA-63 loci, respectively, 2,3, and 5 alleles were amplified in the three breeds of camel. The genetic distances between the three Indian breeds were estimated. The consensus arrived from observed data indicated close phylogenetic relationship between Bikaneri and Kachchhi breeds. The Jaisalmeri breed joins subsequently.

Marwari horse: At the NRC for Equines, breed characterization was initiated using biometrical, biochemical and molecular approaches in the potential Marwari horses. Microsatellite-based PCR studies indicated the existence of genetic variability within Marwari breed.

Genetic characterization of an egger type population vis-a-vis indigenous homogeneous chicken stocks: A project was initiated at the PDP, Hyderabad, on molecular genetics studies of an experimental brown egger population with emphasis on building of a resource-population. Various genetic sub-groups of varying genetic

Genetic variability was observed within Marwari horse breed

homogeneity within the experimental population were established, and a back-cross (BC1) population originating was developed for detailed molecular dissection.

The genomic profiling of the experimental chicken strains and the resource populations based was undertaken on the AP-PCR patterns using randomly amplified polymorphic DNA segments (RAPDs). A set of 30 random decamers was used for the analysis, out of which at least 15 were polymorphic and useful. The technique was capable of eliciting genetic homogeneity state of the purelines and the inter-strain genetic distances conclusively as conforming to the breeding history of the said lines. The technique also provided for the estimation of allelic and genotypic frequencies from amongst test samples for numerous polymorphic loci.

The genetic analysis of the above two lines was further confirmed by dice-coefficient-based similarity matrices using multiple primers. The overall intra-line genetic similarity indices varied significantly from one line to the other upon use of primer 56F, indicating that the line H was more genetically homogeneous than the Px. This fact was further ascertained by subjecting the said two lines to primer 40F and again the difference between the two was confirmed to be significantly different variant from each other. The above findings were corresponding to the breeding histories of the said two lines, which explained for the fact that the line H was closed for more number of generation than the line Px though both were subjected to almost equal intensity of selection.

Randomly amplified polymorphic DNA (RAPD) analysis was carried out on IWI,IWH,IWF,IWD and Dahlem Red layer pure lines using a series of selected primers for examining their genome level constitution and evaluating inherent population parameters. Genotypic pools for these representative pure lines were generated and profiled.The Dice-UPGMA (unweighted pair group method) results showed that IWH and IWI exhibited the highest genetic similarity (86%) to each other, while the next similar (83%) were the IWD and IWF line-pair. The Dahlem Red (brown egger) line, as expected, was singled out as an

outlier line with least genetic similarity (74 to 76%) to the lines IWH, IWI and IWD and with moderate similarity of 80% to line F. The study concluded that because of unidirectional selection for number of generations, the genetic variation within these lines has considerably reduced (in proportion with the selection intensities). It may be desirable to change the recommended combination of H and I to other possible ones, to produce commercial crosses (like ILI-80) in view of the reduced genetic distance between them *vis-a-vis* other pure lines.

Molecular genotyping of the PDP pure lines: The inter simple sequence repeat (ISSR) based polymorphism studies were attempted using random oligoes of 17 or 18 primers containing dinucleotide repeats as the core units. The AT and TA based primers failed to yield any amplicons, while the (CT) n primers gave rise to isomorphic amplicons following the ISSR- PCR. Promising leads in diversity analysis could be possible using the primers consisting of AG and TG cores. All the amplicons of ISSR analysis conformed to the expectations and parameters relevant to the distribution of microsatellite loci in the chicken genome as published from contemporary studies.

Molecular genetics and diseases resistance: At the CARI, Izatnagar, using microsatellite markers the BC1 progenies were selected for least genetic similarity with the naked neck grand sire. The BC2 progenies were generated by mating the selected BC1 individuals and White Leghorns. Two types of BC2 populations were developed. Type A BC2 population was the cross between BC1 naked neck selected males with WLH females, while mating of BC1 selected females with WLH males produced the type B BC1 population. The BC2 progenies were genotyped with 10 microsatellite marker. The BS estimates ranged from 0.44 to 1.00 in BC2 population. The overall mean genetic similarity between the grand sire and BC1 progenies in type A, type B and overall BC1 populations was 0.693 ± 0.176, 0.671 ± 0.020 and 0.682 ± 0.013 from pooled over all markers in type A, type B and overall BC1 populations respectively.

The characterization of Kashmiri commercial layer was done using biochemical, cytogenetic and molecular tools. The gene frequencies of HbA and HbD alleles were 0.86 and 0.14, respectively. Allele AlbA had lower (0.033) frequency than AlbB (0.967). The allelic frequencies of TfA and TfB alleles were 0.97and 0.83, respectively. The overall within KCL BSF estimate was 0.831±0.044, which demonstrated a higher level of genetic similarities. The KCL birds showed minimum genetic distance from IWG-WLH (0.073) and maximum from guineafowl (0.231), on the basis of pooled DNA analysis.

Conservation and Improvement

Jamunapari goat: The effective population size is an important concept in the management of threatened species like goat. The effective population size (Ne) varied from 7.3 to 48.24 over the years. The major problem is that all the males are sold at very early age and very few farmers keep a buck for breeding purpose. If required they purchase the bucks during breeding season and again sell them. Similarly, the per cent genetic diversity preserved varies from 92.3 to 98.3% in this breed. The average fertility percentage was 70.38%, ranging from 59.15 to 78.09%, and the variation over the years is because of environmental variation.

Indigenous poultry germplasm

Aseel (Peela and Kagar varieties) and Kadakanath breeds were regenerated, conserved and were utilized for the production of CARI-Nirbheek and CARI-Shyama for backyard poultry production. The body weight increased by 162 g and 134.2 g at 15th week of age in males of *Aseel* and Kadakanath, respectively. Corresponding values for females were 151.4 g and 136.7 g. A small flock of Silky having pool of other major genes was developed.

Kadaknath

Aseel

World's first turkey embryo culture chick in laboratory

Simple and efficient double window embryo culture system for production of embryos of turkey in National Fellow's laboratory was successfully carried out for the first time at the CARI, Izatnagar. These techniques could be used for transgenesis, production of chimeric birds, production of pharmaceutical proteins with egg gene promoters and will also provide appropriate tools for conserving rare and endangered poultry species.

World's first turkey embryo culture chick was developed at the CARI,Izatnagar

Marwari horses: At the NRC for Equines, Hisar, work was initiated to standardize frozen semen technique for *ex situ* conservation of Marwari horses. Various physical and biochemical parameters of the semen were defined during breeding seasons in the stallions.

Establishment of embryonic stem cells from buffalo embryos: At the Animal Biotechnology Centre of the NDRI, Karnal, a study was conducted to establish the cultural competence of morulla cells from buffalo embryos grown on mice embryonic fibroblasts (MEF) feeder layer developed from skin cells of mice embryos. The morulla cells were quiescent for first 24 hours when there was no apparent development. The cells started proliferating subsequently and tended to grow as a group of small, round and tightly adhered cell chunk, which after 4 days in culture appeared to be detaching from the feeder layer surface. The study represents a preliminary report of growing embryonic stem cells in buffaloes. Characterization of the proliferated cells for their stem cell specific markers is, however, yet to be established.

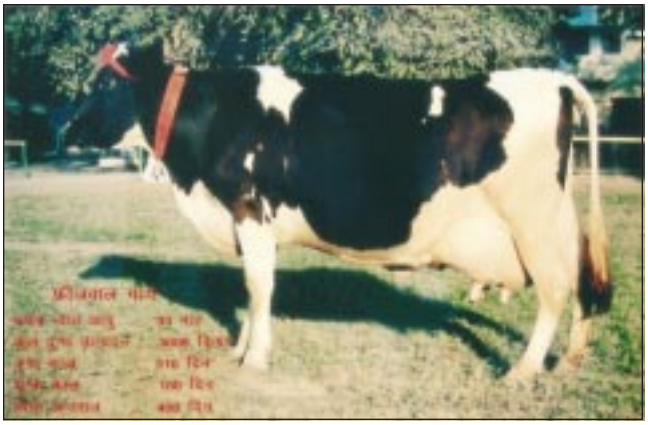
ANIMAL BREEDING

Cattle

Frieswal: The aim of this project is to develop a new cow strain called Frieswal for the country, which will produce 4,000 litres milk in a mature lactation of 300 days with 4% butter fat. This project is in operation at Project Directorate on Cattle, Meerut, in collaboration with 45 Military Farms located in different agro-climatic zones of the country. The herd strength of Frieswal females was 17,031 including 10,185 adult animals and 1,786 calves. The total Frieswal population has increased by 48% in last 3 years. More than 0.12 million doses of Frieswal semen have so far been produced at the Semen Freezing Laboratory. At present 735,089 doses of Frieswal semen are available in the gene bank.

The age and weight at first calving (AFC, WFC) averaged 1,005 days and 364 kg, respectively. Cows born at Military Farm, Lucknow,had the lowest AFC (863 days) followed by those born at Ahmednagar (893 days) and Dimapur (909). Average milk production (300 days) in the entire lactation was 2,887 and 3,081 kg, respectively. Lactation milk yield in 300 days was the highest at Military Farm, Massimpur (3,570 kg) followed by Lucknow (3,544 kg) and Ahmednagar (3,492 kg). Total milk production improved from first (2,893 kg) to second (3,066 kg) lactation and declined thereafter. Year and season of calving significantly affected lactation milk yield in 300 days and in the entire lactation. Peak yield and lactation length in Frieswal cows averaged 14.27 kg and 315 days, respectively.

Average service period, dry period and calving interval were 161, 112 and 426 days, respectively. All reproduction characteristics have shown improvement in desirable direction.Young bulls were evaluated for their genetic merit based on the first lactation (300 days) yield of their daughters. Top 10 bulls had breeding values between 2,835 and 2,926 kg. Their superiority over the herd average ranged from 136 to 227 kg i.e. 5.04 to 8.41%. The semen of these bulls is now being used on elite females for production of young male calves.



Frieswal cow—Age at first calving, 33 months; total milk yield, 3000 kg; lactation period, 310 days; dry period, 100 days; calving interval 400 days

Indigenous Breeds: The objective of this project is conservation and genetic improvement of indigenous breeds. Presently, the programme covers Hariana, Ongole, Gir and Tharparkar breeds in collaboration with the State Agricultural Universities.

- In Frieswal cows lactation milk yield in 300 days was 3,570 kg, peak yield 14.27kg and lactation length 315 days
- Genebank has 735,089 doses of semen of Frieswal bulls
- Hariana,Gir,Ongole and Tharparker breeds are being studied for conservation and genetic improvement
- Average milk yield of Murrah buffaloes was 2,928kg
- Twin lambing was 45 % and triplet was 2.5 % in Garole × Malpura cross
- Bharat Merino sheep is a promising dual type breed useful for improving both wool and weight of indigenous sheep
- Chokla, Marwari and Magra sheep are being studied for carpet wool production
- Madras Red, Ganjam, Muzaffarnagari, Nellore and Deccani sheep are being studied for mutton production
- Genetic improvement and sire evaluation are being done in Barbari and Jamunapari goats
- National Research Centre on Pigs was established at Rain, Guwahati
- Rabbit kit survival was highest in White Giant followed by New Zeland White
- White Leghorns birds were improved for egg production
- Caribro Tropicana ranked third in19th RSPPT,Gurgaon as it attained 1,750g body weight by 7-weeks of age
- CARI strain achived top position in hen housed egg production at 31st RSPP,Hessarghata
- CARIBRO- Dhanraj achieved 1,875 g at 7 weeks of age

Friswal bull—reproduction age, 24 months; adult weight, 600 kg; body length 160 cm; body height, 155 cm

Hariana cow—Age at first calving, 55 months; total milk yield, 1200 kg; lactation period, 250 days; dry period, 180 days; calving interval 500 days

Hariana bull—reproduction age, 37 months; adult weight, 500 kg; body length 150 cm; body height, 140 cm

Ongole cattle: The conception rate was the highest (65.7%) at Associated Herd, Lam, followed by at Germ Plasm (GP) Unit, Lam (59.5%) and the lowest at Associated Herd, Chintaldevi (30.09%). Under test mating in four sets 33 bulls (8+8+8+9), have so far been used and about 941 daughters were born. The semen doses available on closing date at Germ Plasm Unit were 68,412. The age at first calving averaged 53.83 months. The average lactation milk yield and peak yield were 624.92 and 3.23 kg. The highest lactation milk yield (1010.8 kg) and peak yield (3.60 kg) were recorded at Associated Herd, Chintaldevi. The dry period and calving interval averaged 301.79 and 474.83 days. Bulls of first and second sets were evaluated based on first lactation records of their daughters. Draught power varied from 0.59 to 1.00 HP among the bulls.

Hariana cattle: The breeding population comprised 813 females and 30 young bulls (above 2 years). The highest conception rate was 74.58%. Under test mating 44 bulls (9+8+9+9+9), in 5 sets have so far been used, resulting in birth of 1,158 (348 + 213 + 238 + 207 + 152) daughters. On closing date 40,456 doses of frozen semen of test bulls were available. Average age at first calving, first lactation milk yield and peak yield were 53.9 months, 1,031.70 kg and 5.91 kg, respectively. First dry period, service period and calving interval averaged 235.22, 178.63 and 474.6 days, respectively. Nine young bulls were put to training for draught took on an average 37.66 days for training.

Field Progeny Testing: Under this project semen of Frieswal bulls is being progeny tested under field conditions at the PAU, Ludhiana; KAU, Mannuthy; and BAIF, Urulikanchan.

At the Punjab Agricultural University, Ludhiana, about 7,200 inseminations were done from fourth set of bulls. Progenies born from earlier three sets of bulls have completed their first lactation records. The average age at first calving of these progenies was 37.0±0.54, 33.9±0.61 and 31.8±0.95 months, and the average first lactation (305 days) milk production was 2,711.4, 2,831.2 and 2,980.8 kg, respectively. The average fat percentage of the progenies was 3.7±0.02, 3.8±0.02 and 3.8±0.01, respectively.

At the KAU, Mannuthy, 5,036 semen doses were received out of which 3,735 doses were used for AI. About 979 pregnancies were confirmed. The average milk yield from progenies of these three sets was 2,018.79, 2,107.32 and 2,073.4 kg, respectively, and average age at first calving 1,015.96, 1,016.37 and 1,380.5 days, respectively.The fat percentage increased with the advancing stage of lactation.

At the BAIF, Urulikanchan, Pune, out of the total 3,839 inseminations, 2,641 were followed for pregnancy diagnosis and 1,223 pregnancies were confirmed. The average progeny performance for first lactation yield was 2,911.91 kg.

Buffalo

Network Project on Buffalo Improvement: Under the project, work on improvement of various buffalo breeds is being undertaken. Associated progeny testing of Murrah breed is continuing at centers located at the PAU Ludhiana, CCSHAU Hisar, CIRB Hisar, NDRI Karnal, IVRI Izatnagar, and CCBF Alamadi. Murrah breed test mating from seventh set of 12 genetically superior breeding bulls was continued up to December 2003. Average age of the bulls at the time of selection was 34.3 months. Average of dams best yield was 2,928 kg. Bull number 761 from CIRB, Hisar, ranked first with sire index of 1,988 kg based on 15 daughters spread in 6 participating centers.

A germplasm repository of more than 30,000 frozen semen doses from the progeny tested bulls, is available at various participating centers, simultaneously, more than 250,000 frozen semen doses from progeny tested bulls are also available.

Improvement in weighted average in lactation milk yield of over 0.5% was estimated from all the participating herds of Murrah over the previous year. Elite herds of Bhadawari, Godavari and Surti breeds were established. Superior bulls of Pandharpuri and swamp buffaloes were also generated at the participating centers.

Performance recording and improvement work for

Elite herd of Bhadawari buffaloes was established

Jaffarabadi (GAU Junagadh), Bhadawari (IGFRI, Jhansi), Surti (MPUAT Vallabhnagar), Nili Ravi (CIRB Sub Campus Nabha), Pandharpuri (MPKV, Kolhapur), Godavari (ANGRAU Venkataramanagudem) and swamp buffaloes (AAU, Khanapara) is also continuing under this project. These centers aim to undertake progeny testing of bulls with the participation of farmers' buffaloes for test mating.

Sheep

Reproductive efficiency of Malpura × Garole: Overall means for birth, 3-,6- and 12- month body weights were 3.07,12.86,20.55 and 32.37 kg, respectively, in Malpura lambs. The corresponding figures for Garole Malpura lambs (G × M) were 2.21, 10.26, 17.26 and 26.19 kg, respectively. Crossbreeding of Garole rams with Malpura ewes was continued. The twin lambing percentage in G × M ewes was 45.00% and triplets 2.5%.The average number of lambs born per ewe lambed was 1.5 in G × M cross and 1.02 in Malpura. The survivability of all the genetic groups were almost at par. Reproduction results in G × M ewes indicated that Garole crosses might prove to be a valuable germplasm for evolving a new prolific strain of sheep. Average litter size on the basis of total lambing obtained was 2.05. The adult survivability was 92.11%.

Bharat Merino - a promising dual breed: Bharat Merino is a promising import substitute for exotic fine wool breeds as it has expressed better growth, reproduction and survivability and wool quality almost similar to that of exotics. The annual lambing and survivability were 85.84 and 95.76%. The annual greasy fleece yield (GFY) was 2.008 kg, and the 6-monthly body weight was 22.96 kg. The hot carcass weight of lambs, kept under feedlot experiment at the age of 3-months and slaughtered at 6 months, was 10.6 kg and their dressing percentage on empty live weight was 52.53%. The Bharat Merino is getting popularity for improving wool and weight of sub temperate sheep of the country.

Network Project on Sheep Improvement

Sheep for Carpet Wool

Chokla sheep: The overall least-square means for first greasy fleece yield, adult 6 monthly and adult annual wool yields were 0.803,1.029 and 2.103 kg, respectively. Average body weights at birth, 6-months and 12-months of age were 2.72, 18.56 and 26.77 kg, respectively. Preweaning (0-3 months) and post weaning (3-6,6-12 months) daily weight gains were 109.33, 55.85 and 33.13 g, respectively. Overall survivability of the flock was 96%. Annual lambing (based on ewes available) was 86%.

Avikalin sheep for meat and carpet wool

Avikalin has the potential to be developed as dual type sheep for carpet wool and mutton production. The overall survivability was 94.15%. Birth weight of lambs was 2.73 kg. The overall means for 3-,6-,9- and 12-month body weights were 10.24,20.17,25.64 and 30.09 kg, respectively. Tupping was 98.18%. Lambing per cent on ewes available and tupped basis were 83.64 and 85.19 respectively. Overall least square means for first-, second-, adult six-monthly and adult annual greasy fleece yields were 0.682, 0.511, 0.642 and 1.400 kg, respectively. The selection differential for 6-month body weight and 6-month greasy fleece yield was 4.53 and 0.254 kg, respectively.

Marwari sheep: At the ARC Bikaner, Marwari sheep is being improved through selection for carpet wool production. The average birth, 3-,6-, and 9-month weights were 3.02, 18.83, 22.24 and 27.70 kg respectively. The tupping percentage was 82.30. The overall least-squares means for first clip and adult annual clip were 482 and 1,185 g respectively. The overall survivability was 98.7%.

Magra sheep: At field based unit, Bikaner, the Magra sheep is being improved for carpet wool production. Four centres were established at Norangdesar, Gadhwala, Kilchu and Kodemdesar. The Kodemdesar center was identified as ram rearing centre. The average body weights at birth, 6 and 12 months and adult stage were 2.73, 19.33, 27.89 and 36.97 kg respectively. Average greasy fleece weight at 6-months of age was 991 g.

Sheep for Mutton Production

Madras Red sheep: At Kattupakkam, Madras Red sheep is being improved through selection for mutton production. Madras Red sheep is one of the important meat breeds of Tamil Nadu. The breedable ewes were identified through tattooing. Overall mean of body weight for birth, weaning, 6, 9 and 12 months were 2.86, 10.01, 15.16, 17.91 and 21.78 respectively. Pre-weaning and post-weaning daily weight gains were 80 and 43 g respectively.

Ganjam sheep: At the OUAT, Bhubaneshwar, Ganjam sheep are being improved for mutton production. Overall mean of body weights for birth, weaning, 6, 9 and 12 months were 2.48,10.52, 14.92, 19.13 and 21.35 kg for males, and 2.26, 9.45, 13.50, 17.51 and 18.95 kg for females respectively. The lambing per cent on the basis of ewes available was 77.36. Distribution of breeding rams is in progress.

Muzaffarnagari sheep: At the CIRG, Makhdoom, the

Overall survivability of Chokla sheep was 96%

The Madras Red sheep is one of important meat breeds in Tamil Nadu

Muzaffernagri sheep is being improved through selection for meat

Muzaffarngari sheep is being improved through selection for mutton production. The male lambs were selected using selection index incorporating body weight at 6 months and first 6 monthly greasy fleece yields. The least-square means for birth, 3-, 6- and 9- months body weights of lambs were 3.25, 15.35, 21.49, 26.74 and 31.42 kg respectively. Tupping was 96.64%. Lambing% based on ewes available and tupped was 95.09 and 98.43 respectively. Replacement rate was 28.46%. First 6 monthly GFY was 491 g and adult annual yield was 1,250 g. Overall survivability was 97.43%.

Nellore sheep: At the ANGRAU, Palamner, the Nellore sheep is being improved through selection for mutton production using selection index incorporating body weight at 3 and 6 months of age. Overall mean body weight at birth, weaning and 6 months of age were 2.80, 12.37 and 17.23 kg respectively. The annual tupping per cent was 96.47 and lambing per cent on the ewes available during the main season was 82.55. The mortality and culling percentages were much lower than permissible limits fixed. Selection differential for weaning and 6-month body weight were 2.2 and 2.9 kg respectively.

Deccani sheep for dual purpose: At the MPKV, Rahuri, development of elite flock of dual purpose Deccani sheep is in progress. Average body weight at birth, weaning, 6-, 9- and 12-months of age were 2.97, 13.95, 19.26, 20.13 and 22.07 kg respectively. The tupping percentage was 95.51 while the lambing based on ewes available was 85.14%. Average age of ewes at first lambing was 652 days. Overall greasy fleece yield in first, second 6 monthly and adult 6 monthly clips was 0.452, 0.403 and 0.464 kg. Overall mortality in the flock was 3.49%. The selection differential for 6 monthly body weight and GFY 1 was 4.10 kg and 0.106 kg respectively.

Goat

Jamunapari goats: Production performance in Jamunapari goats is being improved through selective breeding. About 164 elite goats were distributed for breed improvement programme to different parts of country. Jamunapari goats attained body weight of 29.60± 0.44 kg at 12 months of age, an increase of 1.85 kg over the last year. The average milk yield in 90 days was about 83.20 kg. The multiple birth percentage was 35.63%. The heritability of 9- and 12- month body weight was 0.25± 0.08 and 0.26± 0.09 respectively. The heritability estimates for 90 and 140 days milk yield were 0.27± 0.19 and 0.36± 0.20, respectively. The Government of Madhya Pradesh is using the breed for breed improvement programme, and the CIRG is supplying elite germplasm.

Barbari goats: The Barbari is one of the famous dual purpose goat breeds of semi arid zone of the country. While the breed can be successfully maintained in flock, it is also well adopted in urban area where no grazing facility is available. A flock of genetically superior goats was developed. The breed has shown 76% population growth. The breed is early maturing with age at sexual maturity of around 209± 14 days and average weight of female 15.68± 0.21 kg. The kidding interval ranged between 217± 0.25 and 335± 13.5 days. The 90 days milk production was 78.82± 1.95 litre during the year. The body weight at 9 and 12 months of age showed significant improvement over the years and increased to 20.59± 0.36 kg and 24.44± 0.46 kg, respectively, with highest individual body weight of 33.00 and 39.00 kg at 9 and 12 months of ages, respectively. The milk yield in 90 days and in a lactation period was 164.00 and 203.35 litre, respectively.

Pig

Under the All-India Coordinated Research Project on Pigs, work is being undertaken to develop upgraded pig with 75% exotic inheritance having higher litter size at birth and weaning (7.6% and 7.00%). The National Research Center on Pig, was established at Rain, Guwahati, Assam, to undertake research on various aspects of pig production, take up region specific pig improvement programme, and coordinate work at various centers of AICRP on Pigs, and to extend technical support to pig growers in hilly and backward areas.

Rabbit

Meat and fur production: New Zealand White (NZW), White Giant (WG), Grey Giant (GG) and Soviet Chinchilla (SC) were maintained in sub temperate climatic conditions at North Temperate Regional Station (NTRS),

The National Research Centre on Pig, was established to work on all aspects of pig husbandry, and give technical know how to pig farmers of tribal and hilly region

CARIBRO–Tropicana attained 815.6 ± 13.76 g body weight at 5 weeks of age

Garsa. Weaning weight (28th day) in different breeds were — 543.4 g (New Zealand White), 532.7 g (White Giant), 465.8 g (Grey Giant) and 496.2 g (Soviet Chinchilla). Pooled 84-day body weight was 1.85 kg in NZW, 1.88 kg in WG, 1.74 kg in GG and 1.77 kg in SC breed. Kit survival was 95.83% in NZW, 98.83% in WG, 99.24% in GG, and 95.23% in SC.

Angora wool production: In German Angora rabbits maintained at the North Temperate Regional Station, Garsa, the average litter weight at birth was 335 g. The average pooled wool yield of breeding flock of German Angora were 152.84, 157.49, 159.50, 165.26 and 177.89 g in I, II, III, IV and V clips, respectively. The pooled wool yield of British, Russian Angora and German × Russian Angora Cross (A-1) were 99.48, 107.25 and 95.0 in first clip; 119.28, 108.32, 113.21 in second clip; 103.57, 110.81 and 91.42 in third clip and 117.67, 107.16 and 96.42 in fourth clip respectively. The pooled staple length (cm), fiber diameter (µ) and guard hair (%) of German Angora rabbits were 6.09, 13.06 and 3.16 respectively.

Poultry

Poultry for egg: The White Leghorn strains were improved at the CARI, Izatnagar, for egg production. While H and I lines were improved for annual egg production, the G and J lines were further selected for high part period egg production and egg production up to 40th weeks of age. The random bred control population (C) was also generated and evaluated simultaneously with H and I lines. Fertility% among various selected and control strains of WLH, ranged from 81.97 to 85.68% respectively. In WLH (I and H) strains, after 26th generation of selection significant genetic gains for part period egg number were 0.83 and 1.06 eggs/generation respectively. The average significant changes per generation for ASM ranged from –0.40 to –0.66 days, for 20-week body weight 3.00 to –44.57 g and for 40-week body weight –3.36 to 4.14 g/generation respectively.

Poultry for meat: At the CARI, Izatnagar, the selection programme continued in the specialized synthetic sire lines (SML-2 and CSML) and dam lines (SDL and CSFL) to develop white and colour commercial broilers. The% fertility in SML-2, CSML and CSFL were 77.60, 77.6 and 78.69 respectively. The H% (FES) was 77.43, 77.3 and 81.8 in the respective lines. The average 5-week body weight in CSML, CSFL and SML-2 were 1,001.67±4.28, 957.74±3.43 and 1,019.61±8.59g respectively. The per cent fertility was 83.7, whereas H% (TES) and H% (FES) were 70.6 and 84.2, respectively, in SDL. The mean body weight at 5 weeks of age in SDL, CARIBRO-Tropicana, IC-3 and IR-3 were 903.5± 7.7, 815.6± 13.76, 611.53±5.86 and 613.44±-5.75 g, respectively.

Improvement of colour pureline broiler population: The genetic characterization and improvement of broiler male and female lines with respect to economic traits was continued at the PD on Poultry, Hyderabad. The performance of male line (Pb.1) was recorded up to 40 weeks of age and the least square means for 4- and 5-week body weight was 767g and 1,065g, respectively. The adults matured at 163.8 days of age and produced 66.7 eggs up to 40 weeks with the egg weight between 56.5 and 59.3g for 32 and 40 weeks of age respectively. The heritability estimates of 5-week body weight, age at maturity, egg weight at 32 and 40 weeks and egg production up to 40 weeks were, respectively, 0.46, 0.30, 0.42, 0.52 and 0.07. Egg weight showed negative genetic and phenotypic correlation with egg production. In the female line (Pb.2) of S.13 generation 4- and 5-week body weights were 723 and 1,030g respectively. The female line matured at 166.6 days of age and produced 16.4 eggs up to 40 weeks of age. The egg weight at 32 and 40 weeks of age was 54.9 and 58.7g, respectively. The heritability estimates of 5-week body weight, sexual maturity, 32- and 40-week egg weight and egg production were, respectively, 0.25, 0.26, 0.81, 0.53 and 0.14. Both the lines showed improvement for economic traits over the previous generation.

Field performance of crosses: At the CARI, Regional Station, Bhubaneshwar, chicks hybrids CARI-Debendra (CSML×RIR), CSML×B-77 and B-77×CSML, were evaluated under backyard system of rearing. Body weight of CSML×RIR, CSML×B-77 and B-77×CSML at 12th weeks of age was 936±6.99, 829±10.3, 1,130±20g, respectively. Corresponding body weight at 16 weeks of age were

CARI-Debendra were evaluated under backyard system of rearing

1,405±10.11, 1,291±12.03, 1,620±12.18g, respectively. Body weight at 20 weeks of age was 2,072±12.91, 1,893±12.24 and 2,324±17.75g in CSML×RIR, CSML×B-77 and B-77×CSML, accordingly. Body weight of B-77×CSML crossbreed was significantly higher than the other crossbred. Body weight of CSML×B-77 was lowest amongst the three crosses at all the ages of measurement. Under the backyard poultry B-77×CSML performs better for higher body weight followed by CSML × RIR and CSML × B-77.The net profit for a 5-bird unit was highest in B-77×CSML followed by CSML×B-77 and CSML×RIR.

Introgression of Naked neck gene into a White Leghorn pureline: The performance evaluation study of first back cross generation heterozygous population revealed that mean age at sexual maturity; egg weight at 28, 32 and 40 weeks of age; body weight at 20 and 40 weeks of age and egg production up to 40 and 64 weeks of age in naked neck and its normal counter parts were — 132 and 136 days; 46.77 and 46.89g; 49.09 and 48.88g; 50.62 and 50.44g; 1,347 and 1,521g; 1,606 and 1792g; 113 and 114 eggs; and 219 and 219 eggs, respectively. As compared to normal control, the naked neck line matured 4 days earlier and produced eggs that were slightly heavier, but there was no significant difference in egg production.

Dwarf gene line (dw) for tropical broiler production: The juvenile and production performances of dwarf gene line were evaluated in DG01 generation. Since the population was segregating for naked neck, a sub-population of birds carrying both dwarf and naked neck gene was produced to study the complementary effect of these two major genes on various production traits. The mean 4- and 6- week body weights were 498g and 900g in males, 445g and 762g in females and 470 g and 825g on combined sex basis, respectively. In birds carrying both dwarf and naked neck gene, the average body weight at 4 and 6 weeks of age on combined sex basis was 441g and 793g respectively. Frequency distribution of egg production up to 40 weeks of age indicated that 29% birds laid less than 50 eggs and there is enough scope for further improvement of this line. The usefulness of complementary effect of dwarf and naked neck gene in a dwarf broiler dam line was evident from the fact that the dwarf naked combination birds laid eggs which were 1-2g heavier at early ages — a major advantage that can be exploited in the development of dwarf broiler dam line with better early egg weight. Heritability of egg production was low to moderate in magnitude with the evidence of sex-lined effect in the inheritance of egg production.

Dwarf line

Economical broiler production: The comparative performance of a purebred dwarf, crossbred dwarf vis-à-vis a normal broiler dam line was studied. The pure and crossbred dwarf dams matured 17.17 and 20.81 days earlier; produced eggs, which were 2.71 and 1.76g lighter at 32 weeks, and 3.81 and 1.77g lighter at 40 weeks and produced 5.77 and 11.88 eggs more up to 40 weeks of age than the normal broiler dam line. The body weights recorded were 11.17 and 8.69% less at 20 weeks and 18.79 and 17.24% less at 40 weeks of age in purebred and crossbred dwarf dam lines, respectively, as compared to its normal counterparts. The weekly body weights up to 28 days of age were significantly higher in the commercial broilers developed utilizing normal broiler dam line. But at 35 and 42 days of age, no significant difference in body weight was observed. Between 2-4 and 2-6 weeks of age the commercial progeny developed utilizing dwarf dams (both pure- and cross- bred) were more efficient than commercial broilers developed utilizing normal broiler dam line. The cell-mediated immune response measured as response to PHA-P, indicated that there was no significant difference between genotypes. The humoral immune response measured against SRBC at fifth day post inoculation after 21, 28 and 35 days of age, did not show any significant difference between different genotypes. The immune response was the highest up to 5 days post-inoculation. These results suggested the utility of dwarf dam line for production of commercial crosses from the point of economization on feed cost, conservation of housing space and production of more settable eggs per dam.

All-India Coordinated Research Project on Poultry Breeding

Under Poultry for Egg component intra-population selection for egg production up to 64 weeks of age, was undertaken to achieve the set target of 300 eggs in layer stocks. The project included IWD and IWF strains at the ANGRAU, Hyderabad; IWN and IWP strains at the KAU, Mannuthy and GAU, Anand; and IWH and IWI strains at the CARI, Izatnagar. The response to selection for egg production was in the desirable direction in IWD and IWF strains as they laid 11 to 13 eggs more than the control up to 40 weeks of age. The hen-housed production in IWD and IWF lines was 111.6 and 109.8 eggs, respectively, by 40 weeks of age. The hen housed egg production was 31 eggs more in IWD and 39 eggs in IWF lines as compared to the control lines up to 64 weeks of age. Similarly, the hen-housed production was more by 17 eggs in IWN and 22 eggs in IWP lines over the control up to 40 weeks of age. The increase was continued up to 64 weeks but to a lesser extent (4 eggs in IWN and 13 in IWP). The same

Performance of Naked Neck gene line

At the PDP Hyderabad, the juvenile and production performance of NG.01 generation of naked neck gene line was evaluated. On combined sex basis, heterozygotes were around 36g heavier at 4 weeks of age and 50g heavier at 6 weeks of age. The control normal birds laid around 2 eggs more up to 40 weeks of age but the egg weight was less by 2.25g over the naked neck counter parts indicating favorable effect of naked neck gene on egg weight. Around 45 % of birds laid less than 50 eggs up to 280 days of age, suggesting that there is enough scope for improvement of this trait through selective breeding.

lines maintained at the Anand centre for feed efficiency, produced 115.2 and 108.4 eggs up to 40 weeks of age, respectively. As compared to the control line the hen-housed production up to 72 weeks was 49 eggs more in IWN and 32 eggs more in IWP line.

At the CARI, Izatnagar, the estimate of phenotypic response in hen-housed egg production up to 40 weeks was 1.70 egg and 1.40 eggs; for 64 week egg production, 0.85 and 1.25 eggs; and for age at first egg was 1.75 and, -1.42 days in IWH and IWI strains, respectively. The realized genetic gain estimated for 40 week egg production was 1.25 eggs in IWH and 0.99 eggs in IWI, which was statistically significant. The realized genetic gain estimated for 64-week egg production was 1.33 eggs in IWH, 1.74 eggs in IWI.

At the KAU, Mannuthy, the culling level for egg weight with selection for egg number was followed in IWN and in IWP strains. The egg weights at 28 and 40 weeks of age for IWN strain were 50.63 and 54.26g, respectively. The corresponding egg weights for IWP strain were 50.42 and 54.01g respectively. At the ANGRAU, Hyderabad, the four generations of selection for egg number to 64 weeks increased the annual egg production by 10 eggs in IWF and 31 eggs in IWD. Switching over of selection to 64 week egg number reduced the age at maturity and increased egg weight in IWN and IWP strains. The feed consumption of individual birds at the GAU, Anand, was only 107 and 109g/day for IWN and IWP, respectively, till 64 weeks of age. In this generation, the feed consumed to produce a kg egg mass was reduced by 431 g in IWN strain and 409g in IWP, as compared to the previous generation. The HDF and HFD crosses were superior and produced 293 and 282 eggs, respectively, up to 72 weeks of age. The line IWH was found to be an ideal male line for production of three-way crosses in combination with DF and FD crosses. Whenever IWK line was used in the cross the egg weight showed an improvement of 2 to 3 g. The NP and PN crosses generated at the GAU, Anand, were, respectively, superior for part period egg number and egg weight. The average egg production was 298 eggs in NP cross and 293 in PN cross combination.

The Poultry for Meat Component of the project included synthetic broiler lines CSML and CSFL and corresponding control at the CARI, Izatnagar, a synthetic dam line each at the OUAT Bhubaneshewar, PAU Ludhiana and UAS Bangalore. The development and evaluation of purebred dwarf dam line was assigned to the JNKVV Jabalpur. The dwarfing gene line was subjected to mass

Random sample laying test results

- At 31st RSPP Test, Hessarghata, Bangalore, the CARI strain achieved top position in hen-housed egg production under cage house system.This layer from CARI centre produced more than 300 eggs on hen-day basis with a feed efficiency of 1.77 kg/dozen eggs with an average feed consumption of 116g per bird/day. The average egg weight of 57.41g was also ideal from commercial point of view. In deep litter system the performance of the layer from the CARI centre ranked among the best commercial layers available in the country.
- The cross, ILM-90 developed at the KAU, Mannuthy, secured fifth position at Random Sample Test, Hessarghatta, Bangalore, and Bhubaneshwar. At Bangalore, the cross produced 266 and 287 eggs on hen-housed and hen-day basis, respectively, with an average egg weight of 57g and a margin receipt of Rs 5.01 under cage system of management. Under deep litter, this strain cross produced 299 and 288 eggs with an average egg weight of 57g.
- The Anand center participated in the tests conducted at Mumbai, Gurgaon and Bangalore. At Mumbai the cross laid 290 and 291 eggs on hen-housed and hen-day basis, respectively. The feed consumption was 98.5g/bird per day.
- The cross, ILR.90 evolved by the ANGRAU, Hyderabad, participated in Bangalore test and recorded 267 and 278 eggs on hen-housed and hen-day basis, respectively. The average egg weight was 57g with a margin receipt of Rs 7.16 under cage system of management. Under deep litter the strain cross produced 273 and 279 eggs with an average egg weight of 56g. In Mumbai the same cross laid 286 and 287 eggs on hen housed and hen day basis with a feed consumption of 102g/day. This cross has showed a high feed efficiency of 1.578 kg feed/dozen eggs.
- In RSLT at Bhubaneshwar centre, CARI strain achieved the third rank based on hen housed egg production.

Random Sample Broiler Test

- In RSPPT, Gurgaon, the CARIBRO-Dhanraj from CARI achieved 1,430 and 1,875g body weight at 6 and 7 weeks of age, respectively, with corresponding feed conversion ratio of 1.78 and 2.008. The dressing per cent at 7 weeks was 70.92%. The margin of receipt at 6 and 7 weeks was Rs 28.07 and Rs 33.20, respectively.
- Cross from PAU, Ludhiana, achieved 1,480 and 2,005 g body weight at 6 and 7 weeks of age, respectively, with a feed conversion ratio of 1.782 and 1.929 for both the ages. Dressing yield at 7 weeks of age was 72.41%.

CARI–Dhanraj

- The entry from the OUAT, Bhubaneshwar, attained a body weight of 1,325 and 1,700 g at 6 and 7 weeks of age, respectively. The corresponding feed conversion ratios were 1.930 and 2.239.
- In 19th RSPPT at Gurgaon, CARIBRO-Tropicana (cross of naked neck and frizzle broiler lines) ranked third on the basis of 7-week body weight (1,750 g) with an FCR value (0-6 week) as 1.9, dressing % as 73.1 and margin of receipt at 7 weeks as Rs 29.41.
- CARIBRO-Dhanraja ranked second in 19th RSPPT for broilers held at Gurgaon, on the basis of 6-weeks body weight (1,430g) and 7-weeks body weight (1,875 g).

selection for 5-week body weight. Egg production and hatchability were also considered for improvement, as this population is meant for the development of a suitable broiler dam line.The average body weight at 3 and 5 weeks of age in S-8 generation was 532g and 511g at 3 weeks of age in CSML and CSFL populations and 1,002g and 957g at 5 weeks of age, respectively, at the CARI centre. At the OUAT, Bhubaneshwar, work was continued on evaluation and regeneration of the synthetic dam line (SDL). The body weight at 5 weeks of age was 1,141g in males and 1,024g in females. The average egg production up to 40 weeks of age was 50.14 while at the PAU, Ludhiana, the body weight of Pb.2 at 5 weeks was 900g. At the UAS, Bangalore, evaluation and re-generation of the synthetic Pb.2 was continued. The pureline body weight of female line (Pb.2) at 5 weeks of age was 867g. The average egg production up to 40 weeks of age was 77 eggs in S-7 generation.

Rural Poultry

Performance of Vanaraja and Giriraja, is being evaluated at the AICRP Centre, Agartala. Giriraja recorded more body weight (384 to 1,389g) than Vanaraja (352 to 1,168g), at 4 and 8 weeks of age. At farm and the household level, Vanaraja birds matured earlier than

Beneficiaries of Vanaraja

Giriraja. Age at sexual maturity was highly variable and ranged between 160 to 210 days at different locations. The Vanaraja birds produced more eggs compared to Giriraja on farm (38.13 vs 32.63) and at farmers' door (29.64 vs 23.74 eggs) up to 40 weeks of age. Farmers accepted both varieties of birds and were able to generate double the amount through sale of these birds than the local birds, at any given age. Giriraja had marginally higher mortality than Vanaraja and it was primarily (30-40%) due to predators. Absence of flightiness and bulky structure were the reasons for mortality in both varieties. Farmers preferred to retain these birds for short durations for meat purposes, rather than for longer duration for egg production.

Giriraj birds attained 1, 168 g body weight at 8 weeks of age

Germplasm for backyard/free range farming: In male parent line, the production performance of S-4 generation was measured at the Project Directorate on Poultry, Hyderabad. The production performances were analyzed separately for high, medium and low SRBC titres. Better production was recorded in the low titre group, followed by medium and high titre groups. The birds from high titre group matured late and were lighter in weight at both 4 and 6 weeks of age. The mean egg production up to 40 weeks of age and egg weight at various ages was also significantly higher in the low titre group as compared to medium and high titre groups. Egg production improved by 11 eggs as compared to the previous generation. The mean SRBC titre in high,

medium and low groups was 9.81, 7.15 and 2.75 log2 units, respectively. After completion of 40 weeks of age, parents for the next generation were selected to produce S-5 generation. Fertility was 90.33% and hatchability on total and fertile eggs set was 73.02 and 90.03%, respectively. The birds of low titre group were slightly heavier compared to the medium and high titre groups. After 6 weeks, proportionate number of birds was selected and the average intensity of selection was 0.416 for body weight and 0.52 for shank length.

Development of female parent line for production of suitable germplasm for backyard farming was undertaken on multi-colour meat type birds. Egg production did not show any significant change compared to the previous generation but egg weight significantly improved by 2-3g during laying period. The naked neck genotype had slight advantage (1.5 eggs more) over its normal counter parts for egg production up to 40 weeks of age. The heritability for egg number was low to moderate in magnitude with evidence of maternal effect. Based on 40 weeks production, shank length and antibody titres against sheep RBC, parents were selected to produce the S-3 generation. Fertility was 92.06% and hatchability on total and fertile egg set was 73.80% and 87.37%, respectively. During selection at 6 weeks of age, due importance was given for juvenile body weight and shank length, and required body weight in the terminal cross remained acceptable for backyard farming.

Evaluation of crosses developed for rural poultry production: Based on the juvenile performances, 4 crosses were identified for development of dual type of birds and 3 crosses for development of predominantly layer type of birds. Production performances recorded up to 40 weeks of age indicated that White Legorn × Dahlem Red could be utilized for commercial exploitation as a brown egg layer type of stock. The two-way cross Dahlem Red × Vanaraja pure line or its reciprocal cross could be utilized as a crossbred female line for production of commercial Vanaraja utilizing Cornish as a male line.

Dahlem Red

Dahlem Red, compared to the corresponding control line, laid 5 eggs more, with comparable egg weight. More than 30 % birds laid over 100 eggs up to 40 weeks of age. Egg mass was lowly heritable as that of egg production. Egg mass was negatively correlated with age at sexual maturity, egg weight at 28 and 32 weeks of age, but positively correlated with egg weight at 40 weeks of age, body weight at 20 and 40 weeks of age and 40 week egg production. This indicated that any attempt to improve egg mass up to 40 weeks of age will bring concomitant improvement in both egg production and egg weight. The magnitude of association of egg mass with egg production was comparably quite higher than that with egg weight, indicating that egg production is more important than egg weight in determining egg mass in chicken.

Female line (Dahlem Red)

SUCCESS STORY

Caribro-Tropicana

A heat tolerant broiler stock, which can perform better with least inputs, under hot and humid conditions, for a tropical country like India was much needed for a long time. The scientific efforts were made in this direction at the CARI, Izatnagar, and two major genes, viz. the naked neck and frizzle were introduced in synthetic broiler stock. These naked neck and frizzle broiler stocks were crossed to develop CARIBO-Tropicana, which has both naked neck and frizzle phenotype. At the home farm juvenile body weights at 3, 5, 6 and 7 weeks were 526, 914, 1,300, and 1,800 g, respectively. Outside farm, mean body weights and FCR at 6 and 7 weeks, dressing per cent and livability at 7 weeks were 1,280 and 1,750 g, 1.9 and 2.11,and 73 and 97%, respectively.

Quail

The selection programmes were continued to improve the egg type and broiler quail lines. In 12th generation the overall means of fifth week body weight in broiler quail line CARI Uttam, were 194.65±0.89g (males) and 201.03± 0.67g (females). The body weight of CARI Pearl, after eighth generation of selection in layer quail line, were 139.70± 1.27 (males) and 153.06± 1.23g (females). The 18th week egg production and egg weight were 65.08±0.53 and 11.89±0.4g respectively.

Guinea Fowl

The improvement programme in guinea fowl varieties continued for 12-week body weight and general immuno-competence traits. The average body weight at 12th week in Lavender, Pearl and white varieties were 754.69 ± 4.21, 904.59 ± 6.50 and 848.31 ± 5.99 g respectively. Performance of guinea fowl was better under the semi-intensive rearing system than the intensive rearing. The divergent selection continued in guinea fowl for developing the lines having high and low titre against SRBC. In S4 generation the HA line revealed significantly higher titre (7.14 ± 0.16) than LA line (5.68 ± 0.15).

ANIMAL HEALTH

Foot-and-mouth Disease

Significant achievements in molecular epidemiology and antigenic analysis were made. A large number of FMD outbreaks due to type 'O' followed by type A were recorded in most of the states in endemic form specially during winter and early summer (Oct-April). In the North Eastern states, type A caused most of the outbreaks followed by type O. Type Asia- 1 accounted for very small number of outbreaks. Reverse transcription, polymerase chain reaction and cycle sequencing are routinely used for

obtaining the nucleotide sequence of the FMDV field isolates. In type O, the new strain, which overtook Pan-Asia strain re-established itself as the predominant strain in FMDV type O outbreaks in India. In Asia-1, the previously identified novel subgroup (>10% nucleotide divergence) within the widely circulating lineage was responsible for disease outbreaks in both cattle and buffaloes and was present in six states in the country. Type A outbreaks were encountered due to involvement of two different genotypes identified previously. The field isolates of type O and Asia-1 in two-dimensional micro neutralization test were antigenically related (r > 0.4) in relation to the respective vaccine strains. In type A, majority of the isolates showed divergence with vaccine strains in relation to genetic and antigenic make-up. Selection of some of the new candidate vaccine strains for serotype is in progress. Antigenic variation occurs both in the presence and in absence of antibodies. These results have strong implications on efficacy of the vaccine, as the antigenic variants generated in partially immune animals can evade hosts immune response. In addition, serial passaging of the vaccine and challenge strains, which are usually required for vaccine production and testing, may result in the generation of variants, which may affect the immunogenicity of the vaccine strain.

The complete nucleotide (nt) sequence of a foot-and-mouth disease virus (FMDV) Asia–1 vaccine strain (IND 491/97) was determined and compared with more established vaccine strain IND 63/72. It revealed that all portions of the genome of two viruses are variable and supported the previous finding of their belonging to separate lineages of Asia-1 virus. Seromonitoring of post vaccine immune response is important to assess the efficacy of a vaccine. During the period under report ~2900 sera samples (paired/ post vaccination/post infection/random sera) that were subjected to determination of anti-FMDV antibody titers using liquid phase blocking ELISA, revealed that compared to previous year more animals had protective titre following vaccination. The national repository of the Project Directorate on FMD has 1,120 (714-type O, 212-type Asia-1, 180-type A and 14-type C) field isolates recovered from various parts of the country.

To differentiate the vaccinated animals from the naturally infected FMD carrier animals, a non-structural protein 3AB of FMD virus was identified, cloned and expressed for production of viral protein, which is having a good potential for differential diagnosis as a serological reagent in an ELISA system.

Extraction of RNA genome and RT–PCR (reverse transcriptase–polymerase chain reaction) of the virus specific sequences can be accomplished without eluting the virus from vaccine. Competitive PCR with an internal standard may help in quantification of the genome in terms of number of molecules. Use of RNA as an internal standard is ideal compared to DNA competitors. However, the transcribed RNA has to be free from DNA contamination. To achieve this, poly (A) was cloned at the 3' end of the 430 bp fragment of the competitive plasmid construct. The construct was transcribed and the RNA was

- Vaccine for bluetongue virus is under trial
- Diagnostic test developed for porcine reproductive and respiratory syndrome (PRSS) in pigs
- An indigenous killed vaccine using EHV-1 strain showed better immune response than commercially available vaccine
- PCR-ELISA developed for differential diagnosis of capri-pox virus
- PCR is the test of choice in regard to surveillance and monitoring of camel surra or trypanosomiasis
- Non-isotropic DNA probe developed for detectin of swine fever
- A primer pair was synthesizes to detect duck plague virus detection by PCR
- Genomics research was conducted on causal agents of economically important diseases
- Diagnostic kits were developed for rinderpest and peste des petits ruminants
- Live attenuated vaccine developed for peste des petits ruminants
- Recombinant antigen based diagnostics developed for detection of bovine viral diarrhoea virus

SUCCESS STORY

Diagnostic kits for the sero-surveillance and diagnosis of rinderpest and PPR

Diagnostic Kit for Rinderpest (RP)

Rinderpest had been one of the most important viral diseases of cattle and small ruminants since long. A monoclonal antibody based competitive ELISA kit was developed which specifically detects antibody to rinderpest virus and not to the PPR virus. The kit is ideally suitable for active sero-surveillance (disease surveillance) and sero-monitoring (vaccine antibody monitoring) of rinderpest virus antibodies. World Reference Laboratory (WRL) of *OIE* has validated this kit. Rinderpest specific competitive ELISA test is the only accepted system globally for rinderpest antibody detection where International trade is involved on livestock and livestock products. The kit is commercially viable,and is based on all the critical reagents developed indigenously. The production cost of this kit is 1/4th compared to the one commercially available.

Diagnostic kit for *Peste Des Petits Ruminants* (PPR)

PPR is one of the important viral diseases of small ruminants associated with high rate of mortality. The clinical surveillance can be done using a sandwich-ELISA kit, which is comparable to other international kits. Competitive-ELISA kit for PPR sero-surveillance and sero-monitoring is ideally suited for vaccine sero-monitoring and monitoring of antibodies to natural infection. The test is commercially viable and can be used for monitoring of PPR virus antibodies. The production cost of this kit is 1/5 compared to the one available commercially.

purified by oligo dT column. The purified RNA was used as competitor RNA in RT/PCR. Standard curve was prepared using the known concentration of RNA purified from virus preparation.

cDNA for bovine gamma interferon gene was synthesized from mRNA and cloned into yeast transfer vector pPIC 9k. This was subsequently, electroporated into yeast cells and the recombinant cells were induced for expression. SDS-PAGE analysis of the cell supernatant revealed specific protein band of 32kDa, which refers to the molecular weight of BGIF dimer. This was further confirmed by sequencing the BGIF gene being tried as a genetic adjuvant.

SUCCESS STORY

Diagnostics for detection of Bovine Viral Diarrhoea (BVD) virus

The NS3 (p80) antigen is a non-structural protein, which is largely conserved among the pestiviruses infecting animals. Therefore, this antigen is routinely used for detection of antibodies against BVDV, which is one of the economically important viral diseases of ruminants world-wide. Precise detection of BVDV antibodies in sera of cattle and buffaloes was possible by using recombinant antigen based ELISA. Till now, detection of BVDV antibodies was being carried out using kits.

Software for Animal Disease Monitoring and Forecasting

- India.admasEpitrak–Dynamic Interactive Veterinary Epidemiology Software to store, transmit, retrieve and generate Disease Forecasts, Epi reports, graphs and maps
- Offline module of above software for State Animal Husbandry Department, Field, databank and NATP.
- Online module for NADRES with website development (www.wbadf-nadres.org)

The survey was conducted for studying the prevalence of nationally important animal diseases like IBR (21%), brucellosis (16.52%), PPR (15%), bluetongue (44%) and other diseases.

Animal Diseases Monitoring and Surveillance

National sero-epidemiological surveys were conducted for brucellosis and IBR. The overall incidence of brucellosis was 14.72% and of IBR 18.86%.

About 350 isolates of leptospira were maintained and diagnosis was given for leptospirosis on referred samples from animals and human cases.

The Institute has also collected national disease database for the past 15 years and meteorological and agro-ecological data from all the agro-climatic zones of the country. As a part of National weather based animal disease forecasting for 15 animal diseases, forecasting was made with 75 to 98% accuracy of prediction for various agro-climatic zones. This formed the basis for animal disease forecasting for future and also the development of NADRES (National Animal Disease Referral Expert System).

Blood Protista

The immuno-protective glycoproteins of 34 and 29 kDa were isolated from the larvae of *Hyalomma anatolicum anatolicum* vector of bovine tropical theileriosis, and *Boophilus microplus* vector of bovine babesiosis. Immunization of experimental crossbred cattle by isolated antigens was simulated with application of insecticides and tick challenge. Data were analyzed statistically for active seasons of these two ticks and significant protection was achieved against them. A 40% reduction in the frequency of application of insecticides was noted. Besides the effect on tick biology, a partial reduction in the growth rate of *Theileria annulata* ticks feeding on immunized calves was observed.

Haemorrhagic Septicemia

Collection and serotyping of different isolates of *Pasteurella multocida* resulted in identification of various serotypes from cattle, buffaloes, sheep, goat, pig, chicken, quail, duck, lion, tiger, dog and leopard. All the field isolates were characterized by biochemical test,

Genomics Research In Animal Health

- P32 gene (969 bp) of goat-pox virus, Mukteswar isolate; goat-pox virus Uttarkashi isolate and sheep-pox virus Rumanian FANAR Station were completely sequenced and submitted to NCBI *GenBank* with accession number AY159333, AY382869 and AY38684.
- VP2 (2926bp), VP5 (1538bp) and VP7 (1156 bp) gene of bluetongue virus, serotype 23 (Rahuri isolate) was completely sequenced.
- Nucleocapsid (N) (1575 bp), phosphoprotein (P) (1657 bp), matrix protein (M) (1466 bp), and haemagglutinin (H) (1852 bp) genes of peste des petits ruminants virus (vaccine virus) were completely sequenced.
- Complete genome sequencing of foot-and mouth-disease virus (FMDV) – Asia I Indian isolate (IND 63/72) was determined (Gi/32140992/gb/AY304994) and the viral was of 8161 bases.
- To elucidate the genetic variability of bovine viral diarrhoea virus (BVD), six representative isolates were studied in N-pro (autoprotease) gene.
- The entire nucleocapsid protein gene (ORF 7) of PRRSV virus was amplified by PCR, gene was cloned in pGEM-T easy vector, and nucleotide sequence was carried out to confirm the sequence.
- Complete genome of one lightly virulent infectious bursal disease (IBD) virus was sequenced and submitted to EMBL database under accession numbers AJ 427340 for segment A and AJ 496637 for segment B. Sequence analysis revealed that Indian virus was close to very virulent viruses reported from Europe and Asia.
- Sequence data were generated from nine hog cholera virus from clinical samples and three vaccine strains from E2 gene regions for molecular epidemiology.

SUCCESS STORY

Development of live attenuated vaccine for *Peste des Petits Ruminants* (PPR)

The annual loss due to PPR in the small ruminant population of 200 million is approximately Rs 1,800 million in India. Rinderpest vaccine though provides protection against PPR, but cannot be used in India in this phase of rinderpest eradication campaign, which does not allow vaccination of animals against rinderpest. Therefore, there was a need for a homologous vaccine to protect small ruminants against PPR infection. The vaccine developed is a vero cell based live-attenuated indigenous vaccine, and is safe for use even during pregnancy. The vaccine induces antibodies even at 1/100th of recommended dose. The duration of immunity is over three years. The vaccine was safe, potent and acceptable. There is a huge potential for export of PPR vaccine to countries having PPR.

antibiotic sensitivity pattern, toxin production and pathogenicity studies.Polymerase chain reaction (PCR) assays, viz. *P.multocida* specific-PCR, HSB-PCR, serogroup-A specific PCR and multiplex capsular PCR typing system, were successfully used for the rapid identification and capsular serogrouping of field isolates directly from bacterial colony, bacterial culture lysate, mixed colony and infected clinical materials.Molecular typing techniques viz. REA, REP-PCR, ERIC-PCR, RAPD-PCR, ribotyping and AFLP were carried out on all isolates to study the homogeneity/heterogeneity at molecular level. HS and fowl cholera outbreaks were also investigated effectively by using conventional and molecular techniques to unravel the mysteries of disease outbreaks under natural conditions.

A low volume saponified HS vaccine against cattle and buffaloes was developed, which is currently under trial. Bivalent saponified vaccine comprising serotypes B:2 and A:1 showed satisfactory results at 6 months post-vaccination challenge test. The repository on *P.multocida* isolates now has more than 300 isolates.

Gastro-intestinal Parasitism

PCR-based identification techniques were standardized for identification of species specific gastrointestinal parasites from faecal samples of cattle, goat and yak. The primer for identification of *Oesophagostomum coumbianum, O. venulosum* and *Bunostomum trigonocephalum* was developed for the first time. For development of primer, one gene sequence from ribosomal DNA of the parasite was downloaded from NCBI gene library (www.ncbi.nlm.gov.in). The primer was developed using primer premier software. Other primers sequences were collected from the published documents.Temperature ranging between 25-33ºC and rainfall more than 600 mm during rainy season favoured gastrointestinal nematodiasis in sheep and goat as indicated by seasonal worm burden in sheep and goat.

In ELISA, sera of sheep infected with benzimidazole-resistant strain of *Haemonchus contortus* showed peak OD value at 4-week post infection with partially purified adult somatic antigen, whereas with excreatory secretory antigen of *H. contortus*, it was observed at fifth week PI. In ELISA cross-reactivity was recorded with experimental sera (1:100) of goat infected with *Paramphistomum epiclitum* and adult somatic antigen of *H. contortus*. In western blotting 25.5 kDa polypeptide was recognized by experimental sera of sheep at third week PI.

Bluetongue (BT)

Serum samples (313) received from different parts of the country were screened for BT antibodies in agar gel precipitation test and 51 serum samples were found positive for BT antibodies. A c-ELISA was adopted to screen the serum samples collected from different animals for the presence of BT antibodies. Agarose gel precipitation kit was also developed to use it in field for screening of antibodies against BT virus.The culicoides samples were characterized mostly as *Culicoides actom, C. oxystoma, C. imicola* and *C. clavipalpis*.An RT-PCR based assay to type the isolates of BT was also standardized for BTV-1 and BTV-23 only. The genomic RNA of all the BT virus isolates collected from different parts of the country revealed the standard 10 genomic segments in RNA-PAGE analysis.A repository of different serotypes of BT virus originated from various animal species belonging to different geographical regions of the country, was established. RT-PCR assay was standardized to detect the BT virus isolates using the VP-3, VP-7, VP-5, NS-1 and NS-3 specific primers and exhibited satisfactory results. The full length of VP5 and VP2 genes of BT virus serotype 23 was sequenced, and the sequence data would help in the molecular epidemiological study of BT virus.

An inactivated, concentrated and saponin gel adjuvanted vaccine was formulated using vero-cell adapted BT virus 18 (Bhopal isolate), which is currently under trial in experimental sheep.

Exotic Diseases

Enzyme immunoassay and nucleic acid based diagnostic tests for the detection of porcine reproductive and respiratory syndrome (PRSS) in pigs were developed. The entire nucleocapsid protein gene (ORF 7) of PRRS virus (PRRSV) (DK 111-92, European type) was amplified by PCR from a clone. The gene was cloned into pGEM-T easy vector and nucleotide sequencing was carried out to confirm the sequence. It was subcloned into expression vector pTriex -2 Neo. Plasmids containing inserts in desired orientation were transformed into Origami (D3) plac1 competent cells for expression of the recombinant protein. The induced cell lysates and pellets were analyzed by SDS-PAGE. The recombinant protein was present in soluble form in the cell lysate. The presence of His tag and the specificity of the recombinant protein were

confirmed by western blot analysis. The fusion protein was purified by affinity chromatography using nickel columns. The recombinant antigen was tested for use in indirect-ELISA to detect antibodies to PRRSV in pigs. Preliminary optimization study using referral positive and negative sera was encouraging. This will greatly reduce the cost of diagnosis of PRRSV, which at present is being done with imported ELISA kits.

Aujeszky's disease (pseudorabies), an economically important disease of swine, is caused by alpha-herpes virus. Serum samples collected from various parts of the country were screened for the presence of antibodies to pseudorabies virus. Sera samples from pigs and rabbits showed antibodies. Sera samples screened from sheep, goats, cattle and buffalo, however, did not show antibodies. The infection is prevalent mainly in *desi* and crossbred pigs maintained under backyard conditions. Dot-blot hybridization and polymerase chain reaction were standardized for detection of pseudorabies virus infection using reference clones spanning the regions of *Bam*H-1 fragment -7 and *Kpn*-1 fragment C of the pseudorabies virus.

The hybridoma clone specific for BIV 'gag' antigen, was used to produce single chain fragment variable (ScFv) DNA by PCR using primers specific for heavy chain and light chain region of mouse immunoglobulin gene. The ScFv DNA was cloned in expression vector pCANTAB for production of recombinant antibodies (soluble form in HB2151 strain and phage displayed form in TG1 strain of *Escherichia coli*). The recombinant antibodies were reactive with 'gag' antigen of BIV in ELISA.

Cattle and Buffalo

A new design of external fixator, a hybrid construct of circular and linear fixators was designed using two circular rings and two opposing detachable side bars (vertical) fixed to each ring. The fixation of 2-ring hybrid constructs was relatively easier than that of 4-ring fixator, more so in radius. It provided more rigid fixation than 4-ring circular fixator, as indicated by early full weight bearing and fracture healing with relatively less callus formation in radial and tibial osteotomies in four bull calves weighing about 200 kg. A unilateral dynamic axial fixator (DAF) comprising a single side bar with two clamps (movable) on either end was developed using stainless steel. It provided satisfactory reduction but immobilization failed in the immediate post-operative period because of bending of pins and comminution of bone fragments. The bilateral DAF comprising two side bars with two movable clamps (in each side bar) with multiple holes in each clamp was developed and tested for fixation of radial osteotomy. It was easy to apply and provided very rigid immobilization of bone fragments with full weight bearing and functional recovery of the limb.

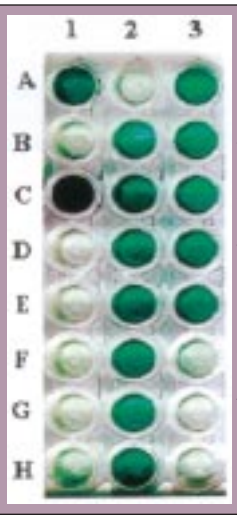
Fixation of bilateral dynamic axial fixatory in the radius of a bull calf showing good functional weight bearing by the animal

Equine

An indigenous killed vaccine using local EHV-1 strain (Hisar-90-7) emulsified with mannide mono-oleate elicited significantly better immune responses than commercially available vaccines. Major components of *Lawsonia inermis* exhibiting antitrypanosomal activity were identified using a solvent system containing chloroform and methanol under HPLC system. Sero-monitoring of diseases among indigenous equines in India against equine influenza, equine infectious anaemia, *Salmonella abortus equi* and glanders using 353 sera samples from across the country, revealed negative status. The 422 sera samples collected from Katra (Jammu) revealed that 52 sera samples were positive for EHV-1 and 108 samples for *Babesia equi* infections.

Sheep and Goat

PCR-RFLP technique for differential diagnosis of sheep-pox and goat-pox from other viral conditions causing similar lesions and also for differentiation of the specific disease due to sheep pox virus in sheep and goat-pox virus in goats, was developed,and it is targeted to attachment and fusion gene of the capripox virus. A multiplex PCR targeted to attachment gene of pox viruses was developed for differential diagnosis, which was more sensitive, and simpler than the PCR-RFLP technique. For the diagnosis of PPR, a PCR-ELISA was standardized with known quantity of peste des petits ruminants virus using N-gene specific biotin-labeled probe. The PCR-ELISA was 100-times more sensitive than a monoclonal antibody

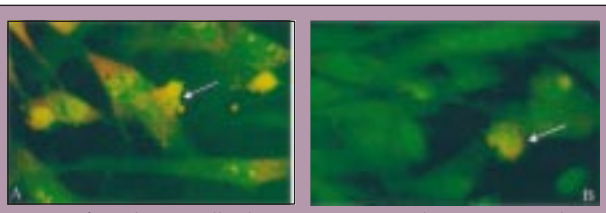


PCR-ELISA for the detection of PPR virus in the clinical samples Well A-1 PPRV positive control; B1-PPRV negative control; C1-positive (kit), D1-Beta actin PCR control; E1 to H3- (Remaining wells) Nasal swabs collected from day 0 to day 19 from goats experimentally inoculated with PPRV. The green colour indicates the PPRV positve samples while absence of green colour indicates PPRV negative samples. PCR-ELISA detected the PPRV in nasal wabs from day 5 (B2) to day 16 (E3) and negative for PPRV from day 17 (F3) onwards in experimentally infected goats

based sandwich-ELISA for the diagnosis of PPR. The test is specifically useful for disease diagnosis at an early stage and in the later stage of PPR infection compared to conventional diagnostic techniques.

Camel

The IgG fraction of rabbit anti-camel serum was purified through protein G counter, to develop anti-camel conjugate. This purified IgG was coupled with horse-radish peroxides enzyme used as conjugate. ELISA was



IBDV infected CEF cells showing apoptotic changes (A) nuclear fragmentation and release of apoptotic bodies (B) membrane blebbing

used to analyze blood samples for detection of trypanosoma antibody. Some of the higher ELISA sample could not show any active infection which otherwise also showed no amplification on polymerase chain reaction. This may be due to effective responses against chemotherapy advocated. In these animals the level of antibody still persists even after the elimination of infection. Thus PCR was considered as the test of choice in regard to surveillance and monitoring of camel surra or trypanosomosis.

Swine

A non-isotopic DNA probe using PCR based diagnostic technologies, was standardized for the detection of classical swine fever (CSF). A cold probe for detection of CSF viral genome in spleen, lymphnodes and tonsils of CSF infected pigs, was also developed. The probe can be used as a diagnostic tool to identify CSF virus and study the epidemiology of the disease.

Poultry

Duck plague is difficult to be monitored and controlled because the virus establishes an asymptomatic carrier state that is detectable only during periods of intermittent virus shedding. To detect the viral genome by PCR, a primer pair (Forward: 5'-GGC TGG TAT GCG TGA CAT-3'; reverse: 5'-GTA TTG GTT TCT GAG TTG GC-3') was synthesized based on the published sequence of DNA polymerase gene of DPV. PCR was standardized for detecting the viral sequences from tissue culture fluids, isolated DNA and heat-denatured virus. Four different isolates were tested using the specific primers.

To understand the infectious bursal disease virus (IBDV) pathogenesis, the non-structural protein VP5, both complete and C-terminus truncated, gene was amplified through RT-PCR and cloned in expression vector pBK-RSV. Transfection of vero and chicken embryo fibroblast (CEF) cells with these gene constructs resulted in expression of VP5 proteins, which could be confirmed with SDS-PAGE and western blot analysis. Further, transfection resulted in morphological changes in the cells. It is concluded that besides C-terminus, other regions in IBDV-VP5 are also involved in virus induced cell death.

ANIMAL NUTRITION AND PHYSIOLOGY

ANIMAL NUTRITION

Data base of animal feed resources: The availability and requirement of animal feed resources for all the districts of Karnataka state was worked out. The total ruminant livestock units (RLU) in the Karnataka state remained unchanged over the last three censuses, but cattle and sheep population decreased in most of the districts. Population of cattle was highest followed by sheep, goats and buffaloes. The overall availability of feed resources in the state was 40.3 million tonnes (crop residues 29.9 million tonnes, greens 7.8 million tonnes and concentrates 2.6 million tonnes). Crop residues constituted the major share of the dry matter and for the state as a whole, sugarcane tops accounted for the largest contribution for the crop residues (32%) followed by maize stover and rice straw. Even though in the state the overall dry-matter availability (7.98 kg /RLU/day) was sufficient, a wide variation was observed across the districts. The feed resources availability in Karnataka increased over the last 15 years, consequently increasing the potential dry-matter availability to the ruminant livestock population.

Feed resources availability: The crop cutting survey data appear to be the most ideal source for obtaining authentic grain-straw ratio. A common grain - straw ratio for the entire state / country for any particular crop is not feasible due to varietal differences and crop growing conditions. However, data generated for Karnataka state

- Potential dry-matter availability has increased in Karnataka
- Grain straw ratio could be used to determine dry fodder availability
- Cellulase gene from *Ruminococus albus* cloned in *Escherichia coli*
- Feeding of chaffed maize improved body weight in crossbred calves
- Orphinomyces Sp.(C-14) improved nutritive value of wheat straw based diet
- Rumen acetic, propionic, butyric and isovaleric acid estimation method developed
- Ragi straw better source of dry matter, crude protein and fibre
- Area-specific micro-nutrients supplementation improved heath and reproductive efficiency of buffalo
- Chelate minerals preparation technology developed
- Vitamin E and carotene are lost after fodder preservation

have showen that a grain - straw ratio of 1:1.2 to 1.8 for paddy, 1:1.5 to 1.8 for maize, 1:2.0 to 2.3 for ragi and 1:2.7 to 3.0 for groundnut, could be used for estimating dry fodder availability.

Cattle

Genetically modified bacterium develoed for treatment of roughages: Ruminococcus albus, an anaerobic cellulolytic bacterium, produces highly active cellulolytic enzymes. Studies were conducted to—prepare a genomic library of *Hind* III fragments of *Ruminococcus albus* DNA in *Escherichia coli*, screen the recombinants for cellulase activity, isolate the cellulase gene, and study its expression in *E. coli*. The cellulase gene from *Ruminococus albus* was cloned in *E. coli*. The gene cloned encoded the activity of endo-B-1, 4 glucanase. The maximum activity of this enzyme was in the periplasmic protein fraction in *E.coli.*

Total mixed rations (TMRs): Total mixed rations (10) were formulated by blending roughage to concentrate in the proportion of 50:50. Roughage component comprised equal parts of wheat straw and green fodder (maize/oats) on dry matter (DM) basis. To partially replace mustard-cake in ration numbers 6-10, 1% urea was added. The effective DM degradability ranged from 43.23 (TMR 10) to 48.3% (TMR 8), at 0.05 outflow rate effective OM degradability was highest in TMR 6 (48.03%), CP degradability was highest in TMR 10 and 3. On the basis of *in sacco* DM, CP degradability and cost of ration TMR 2 (wheat grains 25, maize grains 10, deoiled rice bran 22, mustard-cake 40, mineral mixture 1.5 and common salt 1.5 parts – group 1) and TMR 7 (wheat grains 30, maize grains 12, deoiled rice bran 27, mustard-cake 27, urea 1, mineral mixture 1.5 and common salt 1.5 parts – group 2) were selected for further studies along with another standard ration (group 3). CP of rations varied from 19.5 to 21.81% and EE from 4.62 to 5.11%. Rumen fermentation of TMRs indicated that group 3 had the lowest NH_3-N concentrate (13.2 mg/dl) and higher TVFA concentrate (10.4 meq/dl) than remaining groups.Total bacterial count was the highest in group 2 (11.1×10^{11}) and total protozoal count was the highest in group 3 (4.3×10^5). Average daily gain (g) in group 3 was the highest (788.6) followed by group 2 (688.6) and group 1 (609.3). DMI (kg) /kg BW gain was lower in group 3 (5.89) than group 1 (6.35) and group 2 (5.97). CPI g/kg BW gain was higher in group 3 (895.2) than group 1 (848.6) and group 2 (862.5).

- Dairy cattle nutrition survey was conducted different agro eco zones and nutritional remedies were suggested for sustainable milk production
- Low cost non-cereal ration developed for buffalo
- Citric acid and neem bark powder prevented fungal infestation of stored feeds
- Methane production was lowest on sorghum feeding and high on maize feeding
- Sheep manure improved biological yield of fodder production
- Prosopis juliflora replaced barley in sheep diet satisfactorily
- By-products based kid starter ration developed
- Feed pellets developed usin leaves of subabul,neem,ber,peepul,sirus,mulberry and desi babul
- Entolobium timbova eliminated rumen protozoa
- Improved pasture has better biomass,energy,crude protein compared to natural pasture
- Milk replacer containg CP24% is cheaper than mother's milk
- Decaffeinated tea waste suitably replaced wheat bran up to 50% level in pig feed
- Mulberry fed rabbits showed better crude protein digestibility than robinia fed
- Leaf samples of local trees of Arunachal Pradesh analyzed for minerals and nutrients composition
- Approximately 15 species of of rumen ciliates identified in mithun
- Nutrient requirement of various avian species updated
- Methionine supplemented red sorghum diet improved growth in birds
- Feed supplement zeosil plus countered the adverse effect of aflatoxin
- Metabolizable energy regulated body weight gain and helped in achieving optimum gains

Thresher-cum-treatment unit for improvement of poor quality straws

A machine was fabricated to treat poor quality straws for improving their nutritive value. Farmers can thresh and treat straw simultaneously in their field without increasing extra labour cost and without wasting any extra time. This is fitted with electric motor but can also be driven by tractor/diesel engine with slight modification. For urea-ammonia treatment of wheat straw, 4% urea and 50% moisture is required. So a provision is made for 200-litre capacity water tank, and accordingly urea is dissolved in relation to output of wheat straw from thresher. Generally, in 1 hr 6-8q of wheat straw is passed out from this device. Moreover, molasses, mineral mixture, salt, yeast, etc. can also be used for treating/improving the poor quality roughages.

An indigenously fabricated thresher cum treatment unit for improvement of poor quality straws

Improving Energetic Efficiency in Ruminants

Manipulation of rumen fermentation and kinetics: A model to predict the kinetic rate of digestion and related parameters based on cell wall intake (25-7%) of animals,

was developed. This information will help in diet formulation. The quantitative data collected for digestion kinetics and nutrient pools based on the levels of cell-wall intake would enable to minimize the error component in prediction and also to improve predictability through graphical means.

Conservation of biological energy: Feeding of chaffed green maize decreased the energy expenditure by 27%/kg dry matter intake (DMI), and the DMI was higher by 24% as compared to feeding unchaffed maize. The bolicount/ kg DMI was reduced by 7.42%, and there was significant increase in body weight of crossbred cattle because of feeding chaffed maize. Chaffing had a beneficial effect on energy expenditure, dry matter intake and body weight gain in crossbred animals by lowering the time spent on chewing per kg dry matter intake.

Utilization of cottonseed hulls: Cottonseed hulls, showed higher protein, fiber, lignin and bulk density than wheat straw in growing crossbred calves. It could be incorporated in complete diets (CP 12%, TDN 55%) up to 60% level. Processing of cottonseed hulls based complete diet in flaked diet appeared to be advantageous in terms of its handling and transportation.

Bioenriched soya and cottonseed hulls: Crude protein value was higher in bioenriched hulls of soybean (TSBH) and cottonseed (TCSH). Total mixed ration (TMR) was prepared by taking wheat straw and concentrate in ratio of 60:40 for *in vitro* digestibility studies. In TMR, the roughage part (wheat straw) was replaced by TSBH or TCSH in proportion 33, 66 and 100%. Improvement in digestibility was more in TSBH compared to TCSH. Soybean hulls were better than cottonseed hulls because their palatability was poor than soybean hulls. Treatment had no effect on milk yield, and dry matter intake during 50 days of observation.

Influence of ruminal fungi on in-vitro degradation of cereal straws: Ruminal fungal isolates, *Orpinomyces* sp. C-14, *Piromyces* sp. C-15, *Orpinomyces* sp. B-13 and *Anaeromyces* sp. B-6, were incubated anaerobically in finely milled cereal straws as the source of fermentable carbon with and without strained rumen liquor (SRL). These had no significant effect on the degradability of the substrate along with SRL compared to SRL free environment. Double log dose (10^6 cfu ml^{-1}) of the isolates compared to single log dose (10^3 cfu ml^{-1}) had maximum degradability of straw after 48 hr with maximum acetate production in all the treatments, followed by a decrease in propionate and butyrate

- Krishibro chicks performed well even on low lysine diets
- Natural agents minimized production losses due to aflatoxin in feeds and improved cellular immune response
- Optimum calcium and phosphorus supplements did not affect the growth or bone mineralization
- Sesame and sunflower protein –meal resulted in lean broiler meat

Ranking of top feeds

On the basis of composition, *in sacco* kinetic parameters for nutrients, *in vitro* gas production data and the estimated DOM, ME and intake potential, the ranking of the top feeds is as follows:

very good — *Leucaena leucocephala, M. azedarach, Zizyphus jujube*
good — *Carissa spinarum, Z. nummularia, Hippophae rhamnoides*
average — *Ficus raxburghii, Robinia pseudoacacia*
poor — *Quereus incana.*

production. Strain C-14 appeared to be a better fungal isolate for *in vitro* degradation of cereal straws.

Growth rate of crossbred calves increased by 15.73% with the fungal culture (*Orpinomyces* sp. C-14) administration along with wheat straw based complete feed mixture. Per cent feed efficiency also enhanced by 14.1% and nutrient digestibility including that of crude fibre increased significantly with the weekly administration of culture. TDN of wheat straw based complete feed mixture also increased significantly. Rumen pH (7.01 vs 7.18), NH_3-N (7.93 vs 15.52 mg/100ml) were lower, whereas TVFA (13.02 vs 11.57 mM/100 ml), total-N (109.2 vs 84.0) and TCA-N (87.97 vs 57.50 mg/100 ml) were higher significantly in fungal culture administered group, indicating more microbial protein synthesis.

Quantification of the toxins: A bacterial strain (Gram-negative bacillus) was isolated by enrichment from the soil from the vicinity of the *Ageratum* plants. The organism utilized precocene I as well as II, the latter was utilized to a higher extent. Methods were standardized and validated for the quantification of tannins and their biodegradation products.Method for estimation of acetic, propionic, butyric, and isovaleric acids produced in the rumen, was validated and standardized.

Environmental pollutants and toxic elements: Fluoride was higher in both borewell and open well water (4.3-5.9 ppm) in Gadag district of Karnataka. High fluoride in drinking water was not reflected in blood plasma and milk samples. Calcium levels in blood plasma of animals were very low suggesting the interference of fluoride on calcium utilization. Adult cattle were more affected with symptoms of joint enlargement and lameness.

Detoxification of aflatoxins in feeds: Drying at 120°C for 2-3 hr resulted in maximum aflatoxin reduction in compound cattle feeds. Exposure of contaminated feed to sunlight (27-37°C) reduced aflatoxin in feed linearly with increased duration of drying in sunlight.

Strategic supplementation for increasing animal productivity

Micronutrients: Ragi straw was a better source of crude protein, calcium, phosphorus, magnesium, zinc and

manganese as compared to paddy straw.Digestibility of dry matter, crude protein and fibre was significantly higher in cows fed ragi straw. Utilization of most of the micronutrients was superior in animals fed ragi straw. Calcium has to be supplemented while feeding paddy straw as sole roughage to dairy cows as this may be one of the limiting micronutrients for milk production.

Macronutrients: Optimum level and source of limiting nutrients in the form of supplements is essential for enhancing digestibility of cereal crop residues. On farm trial by strategically supplementing maize grains (50%) in place of wheat bran showed that the milk yield increased by 1.24 litres/cow/day and the feed cost reduced by Rs 2.80/cow/day. This increased income by Rs 15.23/cow per day to the farmer.

Preparation of chelated minerals

The chelated minerals are more bioavailable to animals than inorganic resources and improve productivity of animals. Protein from milk whey and soybean were used to prepare chelated minerals.These proteins were subjected to enzymatic hydrolysis to break them into small peptides and free amino acids. The mixture was filtered using ultrafiltration to remove all unhydrolyzed proteins and bigger peptides. The permeate was made to react with some essential trace minerals i.e. Cu, Mn, Zn at some specific pH and temperature. After chelation, the unbound minerals were removed using reverse osmosis process and the mixture was dried and ground. Pancreatin, a mixture of enzymes from pig pancreas was better for the hydrolysis of soy protein and this protein source was more suitable for production of chelates. The chelates produced by this procedure contain about 10-11% mineral, 40-45% crude protein and 35-37% total ash. The chemical composition of these chelates was quite similar to the imported ones.

A village level model was developed and tested for improving the reproductive efficiency of crossbred cattle in IVLP adopted villages. Strategic supplementation of area-specific micronutrients could improve the general health and reproductive conditions in 90% animals as perceived by the farmers. Supplementing deficient minerals either through area-specific mineral salts or through feeds rich in these minerals corrected almost 80-90% of the reproductive problems, resulting in increased productivity and profitability.

Tannins profile in some agro-industrial byproducts: Total phenols, non-tannin phenols, condensed tannins, hydrolysable tannins and total tannin phenol were analyzed in mango seed kernel, *babul* pods, *vilayati babul* pods, *sal* seed-meal, *mahua* seed-cake, tea waste, tamarind seed-meal, *babul chuni* and cottonseed-cake. Total phenols and hydrolysable tannins were the highest in *babul* pods. Mango seed kernel and *sal* seed-meal contained medium level of tannins, total phenols and hydrolysable tannins. *Babul* pods contained the highest condensed tannins followed by tamarind seed-meal, cottonseed-cake and *mahua* seed-cake.

Losses in fodders during preservation: Berseem and oat were processed and preserved as hay, while maize and sorghum were stored as silage. The loss of ß-tocopherol in berseem hay was 57.12, 72.76. 84.50 and 90.87% in the first, second, third and fourth month, respectively, while the loss of ß-carotene was 31.50, 44.36, 59.51 and 70.10% in the respective 4 months. Similarly in oats, the losses of vitamin E and ß-carotene in 4 months were 88.50 and 73.62% respectively. The losses of the vitamin E in maize and sorghum silage after 4 months were 78.44 and 76.54%, whereas, in ß-carotene, losses were 58.99 and 56.61% respectively.

Dairy Cattle Nutrition Survey

Dairy cattle nutrition survey was conduted in Agro-ecological region-9 (Indo-Gangetic Plains: Patna and Gaya), -12 (eastern plateau comprising Chattisgarh and southwest Jharkhand), -13 (Chhota Nagpur Plateau of Bihar, western parts of West Bengal, Eastern Ghats of Orissa and Bastar region of Chhatishgarh) and -19 (eastern coastal plain, extending from the delta of Cauvery to the Gangetic delta). Survey reports revealed some common practices in these areas:

- Landless farmers maintain only *desi* non-descript cattle and/or buffalo mainly on grazing, cut grass, straw, kitchen, vegetable and fruit wastes collected from various sources. Hardly any concentrate is fed.
- Marginal and small farmers maintain *desi* cattle and buffaloes mainly on home grown feeds and grazing and/or cut grass. Green fodder is available in the form of natural vegetation. Animals are sent for grazing in fields during day time and stall fed in the morning and evening with small amount of dry fodder, kitchen wastes, cut grass and sometimes tree leaves. Lactating cows and buffaloes are supplemented with small amount of home made concentrate (cake/wheat bran/maize/rice bran/*dal chuni*). Mineral mixture is not fed but salt is fed only occasionally. Cultivation and feeding of green fodder is hardly practiced by this group of farmers. A few small farmers maintain crossbred cows.

Landless farmers maintain only *desi* cattle

- Large landholders keep *desi* cattle, crossbred cows (both Jersey and Holstein crosses) and buffaloes. Cut grass, kitchen wastes and straws were fed. These farmers cultivate maize, cowpea, oat, berseem, sorghum etc. though quantity of cultivated greed fodder feeding is very low (3-10 kg) depending on season and area under cultivation. They also feed branded ready mix concentrate mixture to cattle.
- Kitchen wastes constitute a good part of the daily ration of animals in the villages. It contains unutilized vegetable parts of the kitchen, surpluses of the kitchen, rice gruel and also vegetable wastes, fruit wastes etc. The following nutritional remedies are recommended for sustainable milk production:
- Cultivation of low cost green fodder
- Nutritional enrichment of straw with urea
- Supplementary feeding of balanced concentrate mixture from locally available feed ingredients.

Micro minerals profile of some commonly fed roughages

Samples of green fodders and dry roughages were collected by the NDRI, Karnal, from farm and farmers' field of Amargarh, Gorgarh, Shekhupur, Mahmadpur and Nabipur villages located in Karnal district of Haryana. These samples were analyzed for iron, copper, zinc and manganese. Zinc was invariably deficient in all the roughages screened, whereas copper was highly deficient in paddy straw.

	Average mineral content (mg/kg DM)				
	Fe	Cu	Zinc	Mn	I
Wheat straw	250.35	26.80	17.08	41.74	1.25
Paddy straw	114.1	2.02	16.74	128.21	1.11
Berseem	453.07	17.91	36.56	84.72	0.71
Oats	422.75	18.51	32.61	97.66	0.60
Jowar	208.20	13.0	17.53	73.67	0.78
Maize	169.45	12.14	18.18	55.91	1.10

Buffalo

Low cost ration: Low cost non-cereal rations based on complete feed diets utilizing poultry droppings, urea and molasses along with cheaper byproducts like deoiled rice bran (DRB), were tried in buffaloes. Studies were also conducted by feeding maize/sorghum silage as basal diet along with non-conventional concentrate mixture containing DRB, urea and molasses Growth, and nutrient utilization in buffaloes fed non-conventional ration was satisfactory and at par with control group. The cost of feeding or the cost per kg body weight gain was about 20-30% less as compared to control group.

Detoxification of aflatoxins: Citric acid and neem bark powders prevented fungal infestation of feeds during the storage.

Methane emission: Murrah lactating buffaloes (3 groups) were fed green berseem and wheat straw (90:10), or green berseem + wheat straw + concentrate (59:17:24) or wheat straw +concentrate (38:62) on DM basis. CH_4 emission per kg DMI was higher on diet containing higher percentage of NDF, and average methane emission per kg DMI was 17.47 g/c.

Metabolisable energy (ME) and methane production: Methane production was studied in heifers fed maize and sorghum fodder during July; and green oats, berseem and maize silage as the main fodder from January to March (winter). Total methane production in female calves was lowest on sorghum feeding. Digestibility of maize and sorghum fodder during rainy season was 59.93±1.92 and 51.49 ±1.81. The methane value per kg of DDMI was 13.52, 14.76, 26.76 and 16.19 on oats, berseem, maize and sorghum feeding. Every meal intake of metabolizable

Dairy cattle management practices in Nadia, West Bengal

In the co-operative and non-co-operative villages, majority of sheds had tile roof and dairying was mostly found with the mixed farming community. Percentage of brick floor was more in co-operative villages and was mostly found with the landless farmers. Shed having no walls was commonly seen in co-operative villages and was mostly found with the landless farmers. During winter such sheds were covered by polythene sheets to protect animals from cold. Cattle shed having tile roof, brick floor and no walls appeared to have some positive impact on milk production.

Package of Practices for Management of Dairy Cows

The following package of practices was developed for management of dairy cattle in the Nadia District of West Bengal:

- The newborn calf should be fed colostrum within 1 hr of the birth. It is helpful for the survivability and growth of the calf
- Disinfection of the naval chord soon after birth reduces the chance of infection and increases survivability of the newborn calf
- The calves should be protected from extreme weather conditions by appropriate shelters
- The cattle should be provided with adequate green fodder
- Full hand and dry hand milking should be practiced for maintaining better udder health
- Routine deworming and vaccination should be undertaken to ensure better health and productivity
- Open shed with tile roof and brick floor is suitable for the cattle in the study area

energy resulted in 3.87, 4.51, 8.08 and 4.04 g of methane, respectively. Methane production per kg DDM (digestible dry matter) did not differ among oats, berseem, sorghum, however the values were high on maize feeding.In male animals methane produced per kg of dry matter consumed was higher on maize fodder as well as on maize silage.

Sheep

Fodder production and nutritional studies: Dry matter yield of cenchrus at harvest was higher in two-and three-tier system of land use in comparison to open space. Application of sheep manure resulted in increase in growth and yield parameters and dry matter production of both, cenchrus and pearl millet. Planting methods and moisture conservation measures significantly influenced the survivability of fodder trees. *Babul* registered the higher survivability. Inside V ditch planting of fodder tree sapling recorded the highest survivability in comparison to without contour bunds. The highest survival of tree species was recorded with pond mud plus sheep manure. The highest dry fodder yield of sorghum variety HG-75 was obtained in association with *ardu*, which was significantly higher to *neem* and *babul* association with any of the varieties.The maximum increase in production of grain, straw and biomass was with fertilization to both (crops and *aonla*). Cowpea-oat gave maximum green fodder. Sheep manure produced the highest green and dry forage with application of 5 tonnes/ha in comparison to no sheep manure.The yield of moth (grain and dry fodder and biological yield) was not affected due to association of fruit trees. The grain and dry fodder yield and biological yields on moth increased significantly because of sheep manure @ 10 tonnes/ha.

Housing and nutrition: Studies on effect of housing on nutrient intake and utilization during different seasons showed that during grazing the diet had 42.0, 85.8 and 91.9% dry matter during monsoon, winter and summer, respectively, and the CP was 13.4, 9.8 and 14.8%, respectively. Physiological responses of sheep housed under shed and open corral indicated no difference in rectal temperature and skin temperature both during morning and evening hours in all seasons. The energy expenditure during monsoon in morning hours was 36.05 vs 36.88 k cal/hr but during evening hours, they spent more energy in shed (53.58 K cal/hr) vs open corral (49.64 K cal/hr) indicating sheep are more comfortable in open during monsoon.

Newer feed resources: Under hot arid region, the effect of replacement of maize/barley with *Prosopis juliflora* pods in the diet of sheep showed that digestibility of feed DM increased with increase in level of pods in the diet but feed intake and daily gain was not affected. *P. juliflora* pods were found as good substitute of barley in the diet of sheep. Comparative growth performance of weaner lambs on feed containing *pala* leaves and groundnut fodder in different rations showed that feed intake was not affected by the type of roughage and its level in the diet. Groundnut fodder at 60% roughage did not affect live weight gain but at 70% level higher gain and higher DM digestibility was recorded.

Protein and mineral contents of buffalo colostrum

Protein was 6-7 times more and other essential minerals (like Ca, P, Zn, Mn, Fe) were 3-7 times more in the first day buffalo colostrums compared to that of normal milk, thus boost the nutritional needs growth of the new born calf.

Studies on production of lignin degrading enzymes by *P. sanguineus* revealed that the enzyme levels ranged between 1.33 to 18.49, 0 to 1.97, 52.49 to 392.00, 0 to 153.70 and 0 to 69.44 units per 20 ml of culture fluid respectively for Lip, RNNR oxygenase, *Laccase*, MnP and peroxidase. The data suggested that a longer time of fermentation may be needed to obtain higher degree of lignin degradation associated with higher level of lignin degrading enzymes.

Goat

Complete feed pellets were developed using tree leaves (subabul, neem, ber, *peepal*, sirus, mulberry and *desi babul*) and concentrates. Forest tree leaves (*Entrolobium timbova*) were used to eliminate rumen protozoa (defaunation) for higher growth rate of goat kids. Three goats per hectare could be maintained on natural pasture of *Heteropogan* type grass and bushes like *hens*, *hingota*, *khadyar*, *anni* and *gokhru;* and 8 goats/ha could be maintained on improved pasture (*subabul*, *desi babul*, *brij babul* and *anjan* grass). There was 2.6-, 3.3- and 8.0- folds increase in harvestable biomass, energy and crude protein, respectively, on improved pasture as compared to the natural pasture.

By-products based kid starter ration

Rations containing different CP and TDN (Ration 1:18CP-65TDN; ration 2:18CP-70 TDN; Ration 3:20 CP-65 TDN; Ration 4:20 CP-70 TDN) were fed to kids.Following observations were made:

1. Body weight at the fourth month of experimental feeding was recorded similar in all the groups
2. Average daily gain (ADG) in all four treatment groups was statistically similar
3. Total volatile fatty acids (mm 01/100 ml SRL) in the rumen liquor were maximum in group 1 and minimum in group 4
4. Starter rations 2 and 3 were more economical. Maximum by-products were used in these rations and ration 3 had minimum cost of feed per kg body weight gain as compared to other rations.

Fodder conservation: Berseem fodder was conserved in the form of hay and silage and hay was found superior to silage.

Economic ration: The ration having CP 12%, TDN

60%, was recommended for post weaned Barbari kids (4-9 months of age) keeping in view of the higher quality and quantity of meat production from kids fed this ration.

Milk replacer/substitute for pre-weaning goats: Palatable milk replacers were developed. Feed conversion efficiency was recorded better in milk fed kids, however, kids were maintained well in replacer fed groups.Replacer containing up to 24% CP was cheaper than mother's milk. For high yielding does, surplus milk may be diverted for human consumption, if this replacer is used for rearing such kids.

Nutrition in rangeland

The nutrient intakes of sheep on range land indicated that the dry matter intake of dry, pregnant and lactating sheep was 1,195, 1,569 and 1,081 g /day during monsoon, and 456, 651 and 505 g/h/day during winter. Average digestible crude protein (DCP) intake of sheep in dry, pregnancy and lactation stages was 45.34,56.92 and 52.33g/head/day during monsoons and 24.02, 39.19 and 27.29/head/day during winter. Sheep diet constituted of *Tribulus terrestiris* (8.90%), *Indigofera cardifolia* (16.24%), *Crotolaria burhia* (12.64%), *Satha* (16.91%), *Zizyphus nummularia* (11.40%), *Dactyloctenium aegypticum* (21.81%), *Melilotus indica* (9.31%) and other native grasses, during monsoon. During winter, *Crotolaria burhia*, *Zizyphus numularia*, dead litter and *Azardirachta indica* leaves constituted 9.75, 40.34, 24.61 and 23.94% of the diet. The average daily gain of male and female lambs was 118 and 113 g during 0-3 months of age. Lambs born during September - October attained higher weaning weights (15.80 kg) than those born in spring (11.70 kg). These lambs were supplemented with 100-150g commercial concentrate mixture, dry and green *khejri* leaves and weeds harvested from the crop fields.

Crop based animal production system

Among the four grazing systems (rotational, deferred rotational, continuous and cut and carry), deferred rotational grazing system is the best in terms of biomass and animal production.

Saline water tolerant silvipasture

Desi babul survived well under irrigation with saline water, grasses like napier and anjan, and fodders like barley and oats were most tolerant under saline water irrigation.

Camel

Camel production and management system: Purpose of camel rearing varies significantly in different agro-ecological zones of Bikaner and Pali districts of Rajasthan. The camel keeping patterns significantly influenced the feeding management system in both Bikaner and Pali. The incidences of migration were more in Pali (65.00%) as compared to Bikaner (56.52%) region. The camel rearing practices of Bikaner and Pali region were significantly influenced by categories of farmers of that area. In Bikaner region seasonal migration was maximum whereas in Pali region prolonged migration was maximum. In both types of migration cases, short distance (up to 50 km) covered was more in Bikaner region, whereas long distance covered (more than 50 km) was more in Pali area. In both regions camel rearing was considered to be a way of revenue.

Equine

Balanced ration for equines: Nutritional imbalance is a widely prevalent problem of equines in India. This limits its performance and reproduction. Majority of equines is deficient in some kind of nutrient, and it is largely due to ignorance at farmers' level. Balanced ration could be prepared from local farm produce of the area. The feed back from the farmers indicated improvement in the health, reproduction and performance of their equines because of adoption of balanced feed recommended by the scientists of the NRC on Equines.

Pig

At the Centres of AICRP on Pigs, locally available feed stuff were identified for pigs to minimize production cost. Requirement of fish-meal in the ration could be replaced with silk worm pupae or cuttle fish waste silage. Similarly, decaffeinated tea waste was also found suitable to replace wheat bran up to 50% level.

Rabbit

In Soviet Chinchilla rabbits feed gain was best in group fed 50 g concentrate but deteriorated with increasing level of concentrate supplementation.Mulberry (*Morus alba*) and robinia (*Robinia psuedoacaia*) leaves were evaluated as rabbit feedstuff. Digestibility of nutrients indicated highest digestibility of DM, CF, EE, NFE and cellulose (70.1, 33.05, 32.46, 81.29 and 62.77%) in diet containing mulberry leaves. The digestibility of crude protein in mulberry fed group was significantly higher than robinia fed rabbits.

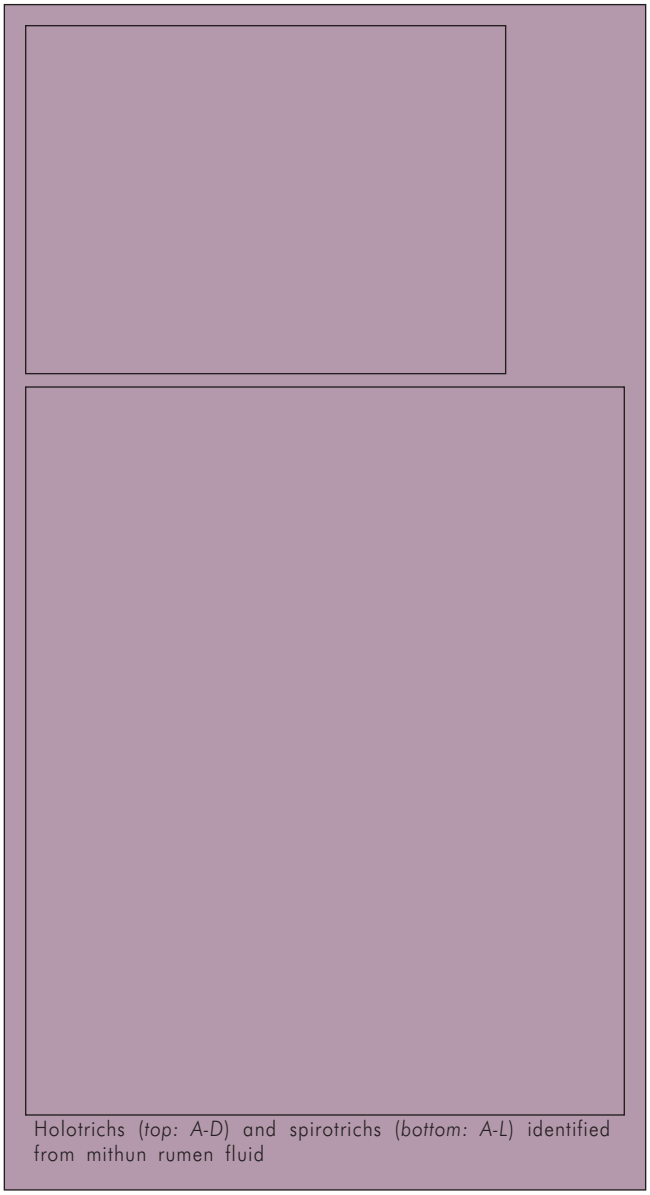
Yak

Leaf samples from locally available trees were collected from different parts of West Kameng and Twang district in Arunachal Pradesh and Sikkim. A herbarium is under process. These samples were analyzed for OM, CP, EE, CF, NDF, ADF, ADL, total ash and NFE etc. The palatability of

different locally available tree fodders was studied. SGOT, SGPT, SAP, glucose and protein etc. were estimated. Plant species (14) were identified in this grassland of which five were from Poaceae family (from SeLa, 4242m above msl). The chemical composition (% of DM) of the mixed pasture grass was 11.9,1.65, 22.89, 45.96, 8.71 and 7.84 for CP, EE, CF, NFE ADL and silica respectively.

Mithun

Mithun rumen fluid: The pH, total N_2 (mg/ 100 ml), TCA precipitated N_2 (mg/ 100 ml), total soluble N_2 (mg/ 100 ml), ammonia N_2 (mg/ 100 ml) and TVFA (meq/ 100 ml) of rumen fluid of mithuns were, respectively, 5.83 ± 0.10, 91.00 ± 14.20, 61.25 ± 7.48, 29.75 ± 7.54, 20.80 ±3.61 and 8.15 ± 0.05. The total rumen ciliates count (× 10^5/ ml), count of holotrich (× 10^5/ ml) and spirotrich (× 10^5/ ml) were 1.435 ± 0.210, 0.029 ± 0.017 and 1.405 ± 0.207, respectively. Approximately 15 species of rumen ciliates were identified.



Holotrichs (*top: A-D*) and spirotrichs (*bottom: A-L*) identified from mithun rumen fluid

Poultry

Updating nutrient requirements of poultry: A dietary energy level,CP, lysine, methionine and threonine for pullets (during 12-20 weeks of age) and layers was suggested for birds.

Nutrient requirements

	Kadakanath		Aseel		CARI
	Pullets	Layers	Pullets	Layers	Priya
Dietary energy requirement (kcal ME/kg)	2,500	2,600	2,700	2,600	2,850
CP (%)	14	16	14	14	14.6
Lysine (%)	0.66	0.86	0.67	0.70	0.62
Methionine (%)	0.30	0.31	0.30	0.30	0.28
Threonine (%)	0.54	0.63	0.55	0.54	0.56

NRC (1994) levels of amino acids and energy (3,200 Kcal ME/kg) were optimum for naked neck broiler chicks for better growth and feed efficiency in hot climates.

The dual-purpose CARI Debendra starting chicks need 1% calcium and 0.35% available phosphorus in their diets for optimum skeletal status. Significantly better phosphorus utilization was at 50 and 75% depletion of dietary phosphorus during finishing phase of broiler chickens. Vitamin E @ 300mg/kg to broiler chicks, 10 days prior to sacrifice improved the keeping quality of meat. Higher dietary levels of vitamin E (225-300 IU/kg) were more effective in retarding oxidative deterioration of quail meat stored at –18°C. Dietary supplementation of vitamin E did not affect egg production performance but egg weight increased with increase in dietary vitamin E.

New feed resources for poultry: Inclusion of 30% w/w pearl millet, 5% w/w rapeseed-meal and 10% w/w sunflower seed-meal or 30% pearl millet, 10% rapeseed-meal (RSM) and 10% sunflower seed-meal (SSM) replaced maize and soybean-meal (SBM) and proved an economic ration for broiler production. Sorghum (replacing 75% maize) along with 10% RSM and 5% SSM or 10% RSM and 10% SSM (w/w) resulted in economic broiler production. Addition of methionine to diets containing red sorghum replacing maize, improved growth. Raising starting chickens on diets containing pearl millet and/or sorghum replacing maize partially or completely (50 and 75%, respectively) or sunflower seed-meal and mustard-meal replacing soybean-meal partly were economical.

Augmenting nutritive value of poultry feeds: An apparent improvement was observed in shell thickness and egg production on sodium bi-carbonate supplementation.Feeding live cultures of *L. acidophilus* or *S.cerevisae* substrates @100 g/kg diet enhanced the nutrient utilization and immune response with reduced serum cholesterol content in quail broilers.

Feed supplements: The feed supplement zeosil plus

Control of obesity in broiler breeders

Decrease of ME input by 10 and 20% significantly reduced weight gain by 11 and 20%, respectively, compared to the controls. By increasing ME input by 10%, the body weight improved by 14% over controls.Restriction of ME significantly delayed sexual maturity by 10 days (162-172 day) between the two extreme levels of feeding. But, the egg production remained statistically unaffected. However, with higher egg number the feed conversion efficiency per kg egg mass was better at the end of 56 weeks of age in the group fed 10% less ME. ME could be utilized as the primary nutrient to regulate body weight to a desirable level in grower phase and, achieve optimum performance.

was beneficial in counteracting the adverse effect of 0.5 ppm level of aflatoxin and it helped partially in reducing the toxicity. The birds fed diets fortified with zeosil plus had these pathological lesions but with less severity. Addition of zeosil plus was effective in protecting birds from FEN (50 ppm) toxicity.

Impact of VFA and lactic acid feeding on GIT in broilers: Chicks were offered different VFAs and LA in drinking water *ad lib*. Initially (one week of age) the weight gain was significantly lower in all VFAs and LA treated groups. Significant differences in pancreas weight were seen that narrowed as the age of chicks advanced. Feeding of propionic acid and acetic acid at an early age (1 week) resulted in significant increase in pH of chyme in all segments.This difference also narrowed in all segments except jejunum as the age advanced (3 week) and by 6 weeks of age no significant difference in pH in intestinal segments was noticed. Protein was higher in jejunum at 7 days of age. DNA in all the 3 regions declined with age. DNA and RNA between regions were dependent on age. RNA of jejunum decreased with age. Propionic and acetic acid affected growth of certain segments of GIT at an early age and weight gain in broilers.

Dietary requirement in colour broilers: The parents of colour broiler, viz. Krishibro, showed optimum performance during juvenile age with low dietary inputs of energy, protein and methionine. Serum protein increased significantly as the level of lysine increased from 0.8 to 1.0% but further increase of lysine level to 1.2% showed no change. Liver fat was significantly low and liver protein was significantly higher at higher levels of lysine supplementation. Male and female line chicks of Krishibro performed well even on the lowered level of lysine (0.8%) than that is normally prescribed (1.2%). The dietary levels of Ca and NPP did not affect body weight gain, feed intake and feed conversion efficiency. Serum alkaline phosphatase activity decreased when Ca and NPP were increased, whereas no differences were seen with further raise in Ca and NPP levels. The levels of two elements did not affect bone strength and its Ca and P contents. Copper in pancreas increased with the enhancement of Ca and NPP supplementation in contrast to manganese (Mn) which was higher at the lowest and highest levels of Ca and NPP, respectively. Mn in kidney also showed a similar response. Cu of liver also increased at the highest level of Ca and NPP. The pure line chicks did not require more than 0.45 and 0.225% of Ca and NPP, respectively, for showing optimum performance. However, certain variations noticed in mineral profile of vital organs suggested that retention of trace minerals was dependent on dietary levels of Ca and NPP.

Vanaraja chicks require low Ca and P: Ca requirements for optimum growth were between 7.3 and 7.5g/kg, while for leg strength and leg health, the levels were, respectively, 8.7 and 8.8g/kg diet. The NPP level of 2.5g was adequate for growth.

Effect of natural agents on losses due to aflatoxin in broiler: Spirulina platensis, blue green algae, (SPN) @ 0.02% in diet significantly improved body weight gain in AF fed groups (300ppb), and was similar to that of control group at early age (32 day) but at the market age (45 day) it was lower than the control. Feed conversion efficiency and leg scores remained unaffected. *Spirulina* improved ready-to-cook yields in AF groups, while no effect was seen on the weight of liver, giblets, spleen and abdominal fat. Immune response to sheep red blood cells and PHA-P improved by SPN, indicating a positive effect of the algae on immunity and carcass traits. Dietary supplementation of *Saccharomyces cerevisiae* (SC) at 0.1% level showed no effect on body weight gain and feed intake in broilers fed AF (300ppb), while beneficial effects were seen on cellular immune response (PHA-P), serum cholesterol concentration, weights of liver and kidney, dressing yields and liver fat content. Esterified-glucomannan (EGM), an extract from the cell wall of *Saccharomyces cerevisiae*, at 0.1% level in diet significantly increased body weight (10.6%) and feed intake in birds fed AF (400ppb). The activity of gamma glutamyltransferase in serum was the highest in toxin fed group and intermediate in the group fed EGM-supplemented AF feed. EGM showed no effect on protein concentration while cholesterol level improved moderately as it was statistically similar to both the AF and control groups. EGM supplementation to the AF group increased the thymus weight, which was intermediate to those of AF and control groups and showed no influence on any slaughter parameter, except for marginal reductions in the weight of gizzard, giblets and kidney.

Optimization of Ca and P in broiler diet: The recommended levels of Ca (10g/kg feed) and phosphorus (4.5g/kg) were, respectively reduced by 40 and 33% (6 and 3 g/kg feed) with no loss in growth or bone mineralization. Ca and P levels in broiler diets could be further reduced to 5 and 2.5g/kg feed, respectively, but only after fortifying with cholecalciferol (1,200 ICU/kg) or supplementation with lactic/citric acid. The excretion

levels of Ca, P and trace minerals (Mn, Fe, Zn and Cu) declined by 30%, minimizing the pollution due to these minerals. The reduction in Ca and P reduced the cost on feed by Rs 200/tonnes.

Effect of sunflower and sesame protein meals on broiler meat: Soybean-meal was replaced up to 67% with sesame-meal and 100% with sunflower meal, without affecting the growth and carcass yields. These two protein sources also decreased cholesterol (1.9 to 48.5%) and triglycerides (22.3 to 23.3%) in serum, liver fat (26 to 28.1%), excretion of nitrogen (30.4 to 36.7%), fat (29.2 to 35.8%), calcium (14.6 to 28.8%) and phosphorus (30.4 to 48.0%) compared to broiler fed soybean-meal. A combination of sesame (33%) and soybean-meal (67%) had complimentary effects to improve broiler performance more than those fed only soybean-meal as the source of protein.

PHYSIOLOGY

Cattle

Ionophore feeding effect on calves: Supplementation of monensin sodium provided nutritional and metabolic advantage to the calves over non-supplemented calves. The supplemetation of monensin sodium @ 200 mg/day for 75 days resulted in significantly higher average daily gain. Feed conversion efficiency, glucose, blood urea nitrogen (BUN) and insulin were higher in the treatment group as compared to control group.

Buffalo

Laboratory tests for bull fertility testing: A laboratory procedure to accurately predict fertility of breeding bulls at an early age, which will help in selection of breeding bulls, is being developed. *In-vitro* fertility evaluation for 4 bulls of set VII is in progress. Cleavage rates in 229 *in-vitro* matured oocytes with semen of these bulls ranged from 65 to 85% for individual bulls, which needs to be correlated with field fertility results.

Improvement of semen cyropreservation: Effects of altered osmolarity of the extender and stage of glycerolization following diluting of semen, were studied. The glycerolization done at room temperature during initial stage of semen dilution, prior to cooling, reduced the incidence of post-thaw backward motility of spermatozoa to negligible level as compared to 40-60% in most of the ejaculates which were glycerolized after cooling to 5°C. The modified protocol reduced rejection rate of ejaculates by 20%.

Sterols and in vitro *capacitation and acrosome reaction of buffalo spermatozoa:* Cholesterol efflux is the earliest event initiating cell signaling events like rise in C_{AMP}, rise in intracellular pH, Ca^{+2} and expression and suppression of membrane bound enzymes. *In vitro* standardization of buffalo sperm capacitation vis-à-vis the cholesterol efflux was achieved. The cholesterol efflux was also substantiated by using radio labeled (3_H cholesterol) spermatozoa and by transmission electron microscopy. The buffalo sperm capacitation was inhibited by enriching media by exogenous cholesterol and also by using media devoid of cholesterol acceptor like BSA. These effects were also studied by replacing the BSA with cyclodextrins in the medium. Intracellular Ca^{+2} (2.3-times) and intracellular pH (0.16 units) increased during normal capacitation while no such changes took place in presence of medium containing high cholesterol. Ca ATPase inhibitor quercetin addition reduced the time for *in vitro* capacitation in the normal medium. But addition of quercetin in cholesterol enriched medium did not achieve the normal capactiation. Cholesterol efflux seems to be the crucial event accompanying the early phase of buffalo sperm capacitation to affect the membrane fluidity.

Embryo resource generation: Use of different sera (foetal bovine serum, buffalo serum and steer serum) in the culture media significantly increased the maturation and fertilization rates in *in vitro* maturation and fertilization of buffalo oocytes. No differences in the maturation and fertilization rates were observed between the different sera supplementation. Heparin, caffeine and calcium ionophore significantly affected individual motility, viability, head to head agglutination and sperm-oocyte attachment. The combination of heparin and caffeine or calcium ionophore resulted in maximum head-to-head agglutination and sperm-oocyte attachment.IGF-I @200 ng/ml was optimum for *in vitro* maturation of buffalo oocytes. IGF-I at different levels did not stimulate the motility of buffalo frozen sperm, but stimulated the protein uptake by the sperm and phosphorylysis in seminal plasma.

- Milk progesterone profile revealed reproduction status of cattle that helped in timely remedy of reproductive disorder in animal
- Laboratory procedure developed to accurately predict fertility of bulls helping in selection procedure
- Improvement in cryopreservation helped in reducing rejection rate of ejaculates by 20%
- Physiological basis of thermo-adaptability in different age groups of goats studied
- Estrogen,progesterone,T3,T4 and cholesterol estimated during various physiological stages
- Synchronization of estrus in Malpura ewes resulted in 75% ovulation
- Scientific management practices reduced loose housing system calf mortality
- Causes of reproductive failures in camels were studied to improve reproductive efficiency in camels
- Camel lactoferrin has dual fuction
- AI and pregnancy diagnosis perfected in equines
- Yaks were successfully induced into heat
- Elements estimated in muscles of yak
- Enzyme immuno assay was developed for determination of growth hormone in mithun
- Antibiotics reduced bacterial count in foam of quails
- Acetylcholine esterase activity at central nervous system was found affected due to immobilization stress

Embryonic losses: intra uterine protein profile and hormone receptors: Role of uterine proteins and hormone receptors in signalling between conceptus and mother was studied.The level of protein and RNA was more in the uterine fluid during luteal phases as compared to follicle phases. Acid and alkaline phosphatase activities were more during luteal phases. Buffalo uterus obtained from slaughterhouse revealed that the estradiol receptor concentration was high in follicular phase compared to luteal phase. The rising concentration of estradiol receptor concentration in peripheral plasma shortly before estrus may be the physiological cause of increased concentration of estradiol receptor in the follicular phase. The low concentration of receptor during later half of estrous may reflect saturation of available binding site by proestrus estrogen surge. Progesterone may either reduce the uptake of estrogen by cell nucleus or it may affect the later stages of receptor protein synthesis once estradiol has entered into the nucleus.

Reproductive status monitoring in buffaloes by milk progesterone determination

Milk progesterone was assayed from samples collected twice weekly from lactating buffaloes for monitoring their reproductive status.

Estrus: Milk progesterone profiles revealed estrus 37%. The incidence of unobserved estruses was the highest in April (70%) followed by May (58%), June (55%), August (47%) and July (43%). The lowest incidence of unobserved estruses was recorded from December (10.9%) to February (22.2%). The overall incidence of anovulatory estruses was 9%. Incorrect AI was recorded in only 4 animals (2%).

Cyclicity: Out of 27 animals for which milk progesterone profiles were monitored beginning immediate postpartum, cyclicity had commenced at 68.27±9.9 days postpartum. An animal was declared acylic when it had exhibited constantly low milk progesterone concentrations over at least 5 weeks after initial cyclicity commencement postpartum. The incidence of acyclicity was 8%.

Pregnancy/non-pregnancy: Animals calving in the first two quarters of the year (Jan-March and April-June) had significantly higher service periods. Buffaloes calving in July-Sep and Oct-Dec had lower service periods.

Therapeutic application: The milk progesterone analysis and reproduction was also useful in identifying animals suffering from cystic ovarian conditions, abnormal cyclicity, etc., and were referred for timely treatment.

Goat

Thermo-adaptability in different age groups: Rectal temperature of the Marwari male kids (average age of one month) in the morning in the first month of birth was 1.46°C higher than the rectal temperature of bucks. The rectal temperature of the kids remained higher than that of bucks up to about 9.5 months of age. After that the rectal temperature of the kids stabilized almost equal to the rectal temperature of the bucks. The respiratory rates of the kids in the morning at 1.0, 1.5 and 2.0 months of age were 95.45, 37.42 and 26.33% higher than that of bucks. The mean respiratory rate of the kids was higher up to the age of 5.5 months compared to bucks. The heart rate of the kids in the morning at one month of age was 147.00±10.48 against 72.78±2.94 in bucks. The heart rate declined up to 7.0 months of age in kids and then it stabilized almost equal to the heart rate in the bucks. In kids heart rate in afternoon was higher up to 5 months of age then it decreased from 11.15 to 21.08% up to the age of 7 months and after that heart rate of kids was similar to that of bucks.

Hormonal and biochemical profile during various physiological stages

- Estrogen decreased after conception, and remained low up to 60 days of gestation period. Estradiol started increasing from 75 days of gestation period and remained higher up to 142 days of gestation period. Estradiol was 335.70±38.08 pg/ml on the day of kidding. Significant rise in estradiol during mid pregnancy is attributed to placental synthesis of estrogen.
- Progesterone was lowest on the day of oestrus, highest on ninth day of oestrus cycle, and increased on conception. The progesterone up to 45 days of gestation ranged from 2.92±0.22 to 3.48±0.27 ng/ml, which further increased up to 90 days of gestation. After that it decreased up to 142 days of gestation period. Progesterone was 0.59±0.06 ng/ml on the day of kidding.
- T_3 was highest (2.42 ± 0.8 ng/ml) on the day of estrus, lowest (1.87 ±0.9 ng/ml) on fifth day of estrus cycle, and decreased up to 1.31±0.29 ng/ml during first month of gestation. It decreased up to three months of gestation period but started increasing from fourth month of gestation, and attained the highest level on day of kidding. It remained high up to one week of postpartum period, and decreased up to one month of lactation.
- T_4 was lowest (59.55± 6.02 ng/ml) on ninth day of oestrus, while it was highest (112.78±1.60 ng/ml) on the day of oestrus cycle, and decreased up to 95.50±9.82 ng/ml during first month of gestation. It decreased up to three weeks of prepartum period, but slightly increased at two weeks prepartum. On day of kidding it decreased to the lowest level (38.50±4.20 ng/ml). During postpartum it increased, and attained the level of 77.30±5.51 ng/ml after one month of lactation.
- Cholesterol remained static throughout oestrous cycle. During fifth month, cholesterol significantly decreased and attained significantly low level on day of kidding. During lactation, it further decreased significantly.
- Activity of transaminases was significantly high during the follicular phase. On day of estrus, SGPT was

significantly low (2.91 ± 0.61 units/ml), while SGOT attained significantly high on day of oestrus. Transaminases remained significantly low up to third month of gestation. Activity increased significantly during fourth month, thereafter, it decreased in fifth month. It attained significantly highest level on day of kidding, thereafter, it declined throughout lactation period.

- Zinc was significantly higher on day of mating, it decreased during first month of gestation period, and remained low up to third month of gestation period. It increased significantly during fourth month of gestation period and remained high up to first week of postpartum period. Thereafter, it decreased and attained significantly low level after one month of lactation.
- Copper level increased from third month of gestation and attained significantly higher level in the middle of fourth month of gestation. Thereafter it decreased and remained low up to first week of lactation. It attained significantly higher level during second week of lactation and remained high up to one month of lactation.

In-vitro *production of caprine oocytes: In vitro* maturation and fertilization of caprine oocytes were done using oocytes collected from ovaries of slaughterhouse and a cleavage rate of 10% was obtained.

SUCCESS STORY

Fat lamb production technology

Production of fat lamb is a promising commercial mutton production program that can prove a boon for meat industry. Malpura weaner lambs (2 months age) achiev 25 kg body weight at about 5 months of age under intensive feeding on composite ration of the ratio of 60 concentrates and 40 roughage. The major advantage of this technology is that sheep owners need to rear the animals only for about 5 months and not for the whole year. Further, farmers will get the handsome profit after 5 months and this profit would be at par

or even more than when the lambs that are reared for 12 months under extensive grazing system. By considering all the inputs required for raising the lambs to attain finishing weight of 25 kg, it is estimated that net profit of about Rs 370/lamb on slaughter basis and Rs 100 on live animal sale basis can be obtained. These figures are based on prevailing prices in local market. This technology would be helpful to the clientele for reducing the time period from 12 to 5 months in getting almost same profit per animal in addition to avoiding the mortality risk and unnecessary rearing of lambs up to yearling stage.

Fertility trial in sheep

A fertility trial was conducted for one cycle in 28 adult Malpura ewes using freshly diluted semen samples obtained from 4 Garole rams. Ewes exhibiting natural estrus on previous evening and were inseminated in next morning with 0.1 ml of freshly diluted semen by single per-os insemination. Thirteen ewes returned to oestrus in the second cycle and 15 lambed.

Sheep

Estrus was synchronized in Malpura ewes by injecting two doses of PGF. First group was given PMSG (folligon @ 200 IU (1 ml/ewe)) on day 8 post first PGF injection and FSH (ovagen @ 2.7 mg (3 ml) /ewe in four doses over 2 days), and second group received PMSG on day 8 post first PGF injection and GnRH (receptal @ 1 ml/ewe) at the onset of estrus.This resulted in ovulation in 75% ewes in both group. Cooling of ram spermatozoa under controlled conditions prior to controlled freezing was beneficial for post-thaw survival of ram spermatozoa.

Camel

Environmental stress and shelter management: Under loose housing system calf mortality could be reduced by adopting scientific management practices during calving and care of neonate. Semi-intensive management was better than intensive condition for calf and adult camel management because of higher time involvement in feeding and other related activities and less time involvement in idling like activity. Temperature humidity Index was lowest under thatched roofed open type *kuchcha* shelter followed by loose housing and asbestos roofed close type concrete shelter. Thatched roofed open type *kuchcha* shelter and loose housing were better than asbestos roofed close type concrete shelter.

Improvement of reproductive efficiency: Female camels, which were administered hCG to induce ovulation after ascertaining the follicle in the ovaries, were

Improvement of working efficiency of camel

Trials were conducted on recently designed camel-drawn agricultural implement viz. 3x2 dish harrow and 5- tyne cultivator. Total working time before fatigue with harrow and cultivator for 4 camels averaged 42.93 ± 2.32 and 43.26 ± 2.06 min, respectively. The best performance of individuals recorded were 61.27 ± 5.02 and 57.85 ± 2.63 min, respectively. The force exerted in pulling these implements averaged 127.02 ± 4.94 and 164.57 ± 6.50 kg, respectively. The land ploughed averaged 1,730.48 ± 79.40 and 1,569.5 ± 76.76 m^2. These implements were rather heavy for camels to pull upon and need redesigning. The pulling force needs to b e

SUCCESS STORY

Generation of electricity (Light) by camel cart

Camel cart is an important means of communication/ transport in desert and areas adjoining the desert. Since last few year there is an immense increase in road accidents involving camel carts. The main factor responsible for the increase in accidents is absence of light reflectors on camel carts. The National Research Centre on Camel, Bikaner, has devised a system by which traditional two wheel camel cart is decertified like other motorized vehicles. In this device a 22 inch diameter pulley is attached/fitted with the scan of camel cart wheel. This pulley is attached to mother small pulley of 5 inch diameter which enables the small pulley to revolve at 4.5 times of the revolving

speed of camel cart wheel, on the axis of small pulley one more pulley of 22 inch diameter is attached which in turn is connected by v- belt to small pulley of dynamo. This enables the pulley of dynamo to revolve at 22 times than the speed of camel cart wheels. Thus dynamo can revolve at 450 to 600 rpm which can produce 3-4 ampere of electric current, which is used to charge a 12 volt 25 amp battery fitted on the camel cart. This battery is sufficient for two head lights and two indicator rear lights with a total consumption of 12 volts and 1.5 ampere. This charged battery could be used by farmers to arrange lights in the remote Dhanis/villages where electricity is not available. This will help in doing the domestic work and studies in the night. The battery once charged can serve for 20-22 hours. The total cost of this system comes around Rs 2,000 to 2,500.

inseminated with either diluted-cooled or fresh undiluted semen. Pregnancy could not be established with diluted and cooled semen, whereas the pregnancy rate was low with undiluted semen. Consistent higher levels of P_4 were considered to be indicative of pregnancy. The results indicated that 5/33 inseminations resulted into successful pregnancy while 17/33, 8/33 and 3/33 were indicative of failure of ovulation, fertilization and embryo survival, respectively. High incidence of failure of ovulation may be because of oversized follicles or follicles in which degenerative processes might have initiated prior to administration of hCG. High failure of fertilization may be because of viscous form of camel semen, which might probably play role of sperm reservoir and protect viability of spermatozoa in the female genital tract by entrapping sperms. Insemination with diluted and cooled semen might disturb this property of semen resulting into failure of conception. High incidence of failure of ovulation and failure to deposit sperms in its natural entrapped viscous form are the major problems in AI in camel. Further improvement may be possible by selecting appropriate follicular size before administration of hCG and AI.

Camel lactoferrin has dual function: Camel lactoferrin is the first protein from the transferrin superfamily that displays the characteristic function of iron binding and release of lactoferrin and transferrin simultaneously. To establish the structural basis of this striking observation, the purified camel lactoferrin was crystallized. The overall structure of camel apolactoferrin folds into two lobes, which contain four distinct domains. The iron binding and releasing behaviour of the N-lobe of camel lactoferrin is similar to that of the N-lobe of human lactoferrin, whereas that of the C-lobe resembles those of the C-lobes of duck and hen apo-ovotransferrins. Hence, it correlates with the observation of the N-lobe of camel lactoferrin losing iron at a low pH (4.0-2.0) as in other lactoferrin. On the other hand, the C lobe of camel lactoferrin loses iron at higher pH (7.0-6.0) like transferrin suggesting its functional similarity to that of transferrin. Thus, camel lactoferrin can be termed as half lactoferrin and half transferrin.

Equine

The technologies for cryopreservation of good quality jack semen along with method for artificial insemination and pregnancy diagnosis were perfected at the NRC on Equine, Hisar. A serum-based ELISA based on detection of equine chorionic gonadotrophin (eCG) was standardized for pregnancy diagnosis in equines. The results of ELISA were at par with the rectal examination and ultrasonographic results. Inter-and intera-assay variability was worked out. Fluoride concentration in 22.96% of samples was more than WHO recommended physiological limits (0.20 ppm) in serum. Similarly, the sub-clinical lead toxicity was observed in 66.8% animals and 19.5% animals had toxic blood lead level (>0.50ppm). Majority of equines (78%) had normal cadmium concentration in their blood.

Role of equines as draught power in rural economy

The equine being an important animal for draught and transport, plays a significant role in rural economy and constitutes main source of income for sizeable underprivileged section of the society in many parts of the country. It also holds special position in livestock both for civil and military purposes in view of its multifaceted utility. Mules are used extensively for pack and transportation by the military forces and civilian in the hills and inaccessible terrain. Superior mules in terms of greater strength and size will be helpful in improving the socio-economic status of marginal farmers. There is an urgent need for development of mules in the field in an organized manner so that work efficiency of mules and ultimately economic returns of farmers can be enhanced.

THE JAIVIGYAN PROJECT ON HOUSEHOLD FOOD AND NUTRITIONAL SECURITY FOR TRIBAL, BACKWARDAND HILLY AREAS

Improved Livestock productivity in Tribal backward and Hilly areas

Vanaraja eggs and meat – For food and nutritional security in four NEH states

A project on backyard poultry farming in four NEH States was sanctioned under Jaivigyan Mission Mode project (MM.II['I-3) to ensure production of chicken eggs and meat at household level, for food and nutritional security. Vanaraja was utilized for this purpose by the four ICAR units located in Manipur, Mizoram, Nagaland and Arunachal Pradesh. At each centre eggs were set for hatching and, the chicks of Vanaraja were reared under confinement up to 6 weeks of age to provide protection from weather, predators, diseases and nutritional deficiencies. They were then supplied in small numbers to beneficiaries belonging to low and middle-income groups, besides unemployed youth and women.

The fertile eggs and day old chicks were also sold. The entire process of poultry farming at domestic level provided eggs for consumption and disposal, regeneration of chicks, sale of chicks and disposal of adults for meat purposes. Consumption of eggs and meat improved the nutritional status while disposal of the same provided supplementary income. On an average, each bird earned Rs 190 and Rs 27,738 were generated from the sale of birds. Fertile eggs were sold between Rs 5 to 10/egg and for table purposes between Rs 3-5.

Yak

Timing of ovulation was determined during spontaneous estrus. Induction of estrus was attempted in female yaks by ovsynch protocol and out of 8 animals, 7 were successfully induced in to heat. This protocol will have tremendous utility in setting time of artificial insemination in yak.

Concentration of Ca, Mg, Na, K, Zn, Fe, Cu and Mn were determined in different muscles of yak.

Mithun

Growth hormone determination: Enzyme immunoassay (EIA) for mithun growth hormone (GH) determination was developed and validated. Biological validation was conducted on mithun calves by injecting synthetic bovine growth hormone releasing factors (GRF: @ 10 mg/ 100 kg body weight intravenously). The peak value of GH 443.5 ng/ ml reached after 15 min of GRF administration in treated calves. The basal level of plasma GH in control animals was higher than any other livestock so far reported. To determine the possible interference of plasma with the assay sensitivity, bovine GH standard in various amounts of plasma (0, 12.5, 25 and 50 ml) were run in an assay. There was no difference in the absolute binding sensitivity among 12.5, 25 and 50 ml plasma volumes. The measurable range of GH was between 10 to 125 ng/ml and covered all possible physiological variations.

Poultry

Effect of antibiotics on cloacal gland of quail: Orally given ciprofloxacin or pefloxacin @ 10mg/kg body weight for 12 days gradually reduced foam production and area of cloacal gland in treated sexually active adult male Japanese quails. Foam significantly reduced at midnight (24:00) when compared with noon (12:00). Bacterial counts of foam drastically reduced in both ciprofloxacin and pefloxacin treated groups of Japanese quail, indicating the involvement of bacteria in foam synthesis mechanism. Ciprofloxacin was superior to the pefloxacin based on the residual effect of the drug in different tissues after tenth day of withdrawal of treatment. Mechanism of action of ciprofloxacin appears to be different from pefloxacin.

Interaction of cholinergic and nitrinergic systems under stress: AChE activity and nitric oxides (nitrite and nitrate) were studied in brain and serum samples of male Japanese quails. AChE activity was significantly higher in L-NAME group as compared to the control and SNP treated groups. The membrane bound AChE activity of the SNP and L-NAME groups decreased significantly over the control. Serum AChE activity showed similar trend. The end products of nitric oxide (nitrite and nitrate) in the brain and serum did not show any significant differences among the control and treated groups.

The brain tissues of birds kept under normal, acute stress (immobilized once for 2 hr) and chronic stress

(immobilized every day for 2 hr), were studied. The AChE activity (membrane bound plus cytosolic) in acute group was significantly low compared to the control and chronic groups. AChE activity increased significantly after 5 days of chronic stress, which subsequently dropped to the normal level (equal to control group). The acute stress did not cause any change in the cytosolic AChE activity. Prolonged stress for 10 and 15 days reduced the cytosolic AChE activity significantly. The metabolites of nitric oxide (NO_2 and NO_3) did not show any significant change in acute and chronic stress groups. Immobilization stress, one of the sevear types of stress in birds, affected the acetylcholine esterase activity at central nervous system level. This clearly indicated that the cholinergic system is very much involved in stress-mediated physiological responses.

Enhanced egg production in birds: Effect of immunization of chicken prolactin by administering Vaso active intestinal peptide (CVIP) and bromocryptine through feed, on egg production was studied. Birds immunized against CVIP had higher egg production than control. Providing bromocryptine @ 350 mg per 60 kg of feed yielded higher egg production and was cost effective.

DAIRYING AND ANIMAL PRODUCTS TECHNOLOGY

Milk and Milk Products Technology

Whey based jaljeera drink: Whey based jaljeera drink was standardized using stabilizer, sugar, jaljeera powder and clarified cheese/paneer whey. The addition of synthetic lemon flavour further increased the flavour of jaljeera drink. The whey jaljeera drink contained 14-15% total solids and 0.5-0.7% proteins. The in-bottle pasteurized whey jaljeera drink remained acceptable for 2 months at 25°C. The manufacture of jaljeera-whey drink will not only solve the problem of whey utilization effectively but also bring the valuable nutrients of whey such as minerals and water-soluble vitamins into human food chain.Whey based jaljeera drink was also developed in dried form to increase the convenience of the product. The instant dried formulation is based on spray dried whey powder, sugar, jaljeera spice mixture, citric acid, stabilizer and had very good shelf stability with good reconstitution property.

Whey based lassi: Lassi of acceptable quality was prepared from a blend of cheese whey and buffalo milk. Whey was used to a concentration of 60% using suitable stabilizing salts. Concentrations of whey above this level led to thin consistency in the product. The lassi thus prepared had normal flavour and was of acceptable quality. The value addition of lassi in terms of enhancement of its nutritive value and as a possible means of utilizing maximum quantities of liquid whey, which otherwise, would have to be processed and treated using extremely expensive techniques, offers an alternative to dairy entrepreneurs.

Symbiotic yogurt: The compatibility of probiotic strains of *L. acidophilus* (*L. acidophilus* NCDC 291 and *L. acidophilus* NCDC 13) with two combinations of yogurt starters (*L. bulgaricus* NCDC 09 and *S. thermophilus* NCDC 74; *L. bulgaricus* NCDC 305 and *S. thermophilus* NCDC 311) was studied to select a suitable *L. acidophilus* strain. The growth and activity of *L. acidophilus* NCDC 13 was studied in the presence of different concentrations of inulin, oligofructose and honey (0%, 0.5%, 1%, 3% and 5%) at 6 hr interval up to 24 hr. Use of inulin at 3% level resulted in better growth and acid production. A symbiotic yogurt was developed by incorporating *L. acidophilus* NCDC 13 at 1% level and inulin at 3% level. The sensory evaluation of the product showed better acceptability than the plain and probiotic yogurt. Viability of *L. acidophilus* NCDC 13 in the symbiotic preparation was higher than that of probiotic yogurt during refrigerated storage for one week. Therefore, inulin and *L. acidophilus* NCDC13 can be a good combination for symbiotic application. The effectiveness of this symbiotic preparation and its beneficial effects in humans have to be confirmed by *in vivo* studies.

Dahi stimulates immune system and protects against enteric infection: Peroral administration of dahi stimulated the release of α-galactosidase both in peritoneal fluid and in the supernatant of macrophage cultured *in vitro*. The release of α-glucuronidase was however, unaffected by dahi feeding. The activities of α-galactosidase and α-glucuronidase in the intestinal

- Whey-based jaljeera drink developed
- Whey based lassi provided an alternative to dairy entrepreneurs
- Inulin @3% resulted in better growth and acid production in symbiotic yogurt preparation
- Dahi stimulates immune system and protects against enteric infection
- Twin-screw plasticizer developed for production of ghee-based butter
- Model developed for pore membrane formation
- Low fat/sugar free frozen dessert developed for diabetic patients
- Energy audit developed for identifying the potential for improvements in energy efficiency in model dairy plant
- Curd rice production method developed
- Assays standardized for detection of antibiotic residues
- Withdrawal of milk for 3 days after antibiotic treatment ensured safe milk ffor consumption
- Mineral composition of goat milk was studied
- Milk and milk products technology developed for yak milk
- Process standardized for soft cheese preparation from camel milk
- Chevon pickle has good market potential
- Alcoholic extract of garlic helped in making chicken skin – meat cutlet
- Broiling and pressure cooking were effective in reducing residues of DDT,BHC and malathion in spent hen tissue

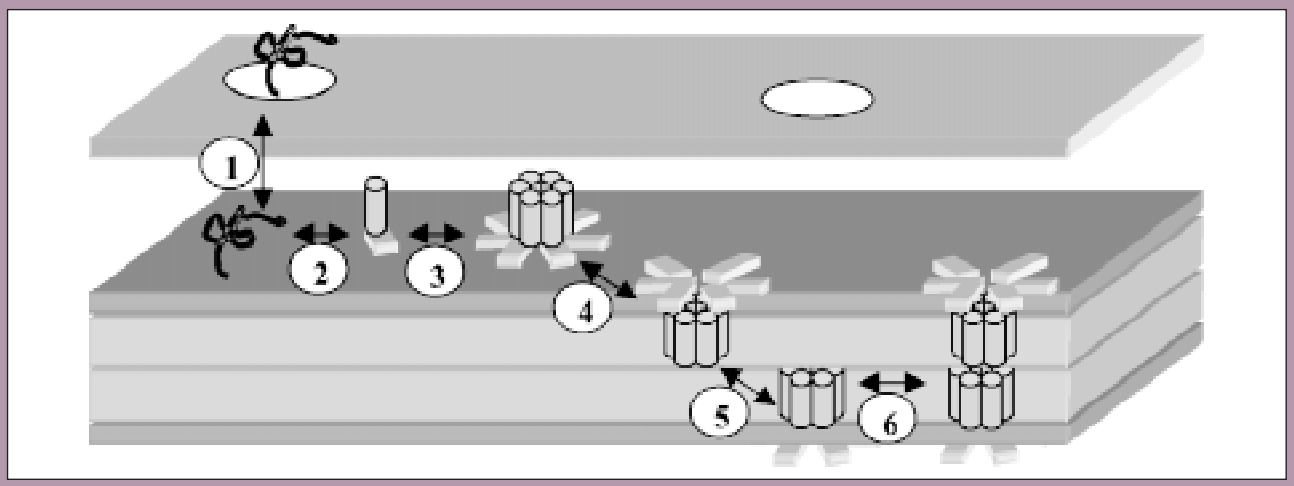
secretions of mice were also not significantly affected by peroral administration of dahi. There was a significant increase *in vitro* phagocytic activity of macrophages from dahi-fed mice. There was a sharp rise in the level of anti *Sh. dysenteriae* antibodies in the intestinal fluid at day 2 post-challenge in dahi-fed mice, and remained significantly elevated at day 5 and day 7 post challenge. The colonization of *Sh. dysenteriae* in liver and spleen decreased significantly in dahi-fed animals compared with the control.It was concluded that dahi has a good immunostimulatory effect and also helps to protect against enteric infection.

Cooling and working of butter mix using twin-screw system: A twin-screw plasticizer for the mechanized production of ghee-based butter, was developed. The effect of the operating parameters (the screw speed and discharge temperature of the product) on the mass-flow rate, residence time and cooling rate were optimized on the basis of compositional, rheological and structural characteristics of the product. The screw speed of 20 rpm and product discharge temperature of 6°C were the best for efficient plasticization of the butter-mix.

Frozen dessert technology for diabetic patients: Low fat/sugar free frozen dessert was developed by using artificial sweeteners and bulking agents. Artificial sweeteners namely aspartame, Acesulfame, sucralose and sodium saccharin were also tried. The frozen dessert with 5.0% fat, 12.5% MSNF, 9.9% maltodextrin, 9.3% sorbitol, 1.5% WPC, 0.35% stabilizer and 400 ppm aspartame was selected on the basis of sensory quality using D_6 Hokes design (Response Surface Methodology). Both maltodextrin and sorbitol are necessary to get the desirable body and texture, while sweetness can be compensated by addition of artificial sweeteners. The cost of production of developed frozen dessert was Rs 29.88/100 ml. Product kept well for 90 days.

Mechanization of burfi making: Towards the development of continuous burfi making machine, a new rotor assembly of SSHE was designed and developed for providing two skewed blades and two flat blades. The skewed blade angles selected were 20°, 30° and 40° and speed chosen were 100, 140 and 180 rpm. Minimum product accumulation was at maximum skewed blade angle and maximum rpm. The product had pastiness and

Model for membrane pore formation



Class IIa bacteriocins from Gram-positive lactic acid bacteria kill their target through pore formation in the cell membrane of sensitive bacteria. Understanding of this mechanism of action will help in the design of bacteriocin analogues with desired inhibitory spectrum in the desired pH range. A class IIa bacteriocin comprises an N-terminal sheet, a central hinge and a C-terminal amphiphilic either á-helix or â-sheet. N-terminal â-sheet has a claw of positively charged residues hanging from its bottom face, tyrosine and asparagine extending laterally in opposite directions, forming a bidentate arm. In the proposed model for pore formation, monomeric random coil bacteriocin diffuses into the periplasmic space (step 1) and folds into functional form (step 2). Amphiphilic C-termini of folded monomers associate to form a cylindrical complex resulting in outer hydrophilic surface and buried hydrophobic residues (step 3). On one end of the complex, â-sheets associate through their bidentate arms resulting in a planar ring containing positively charged claws on the bottom face, which attaches the complex onto negative membrane surface. With the planar ring remaining attached, the C-termini folds back through a rotation in the hinge region resulting in reversion (i.e. inside out) and concomitant insertion of the cylinder into the outer monolayer of the lipid bilayer (step 4). This result in water filled pore that could span only outer monolayer because the length of C-terminus in these bacteriocins is just enough to span the lipid monolayer. In the subsequent step, some of the half pores translocate across to inner monolayer to form inner half pore (step 5). Two half pores in each monolayer may occasionally align coaxially to form a conducting channel, thereby causing dissipation of proton motive force and leakage of small intracellular substances, and death of sensitive bacteria (step 6).


Yak milk paneer


Yak milk dahi

Yak milk lassi

Yak Milk and Milk Products Technology

Technologies were developed for different products from yak milk.

- Starter culture for production of yak milk *dahi*
- Production of good quality of yak milk *dahi* with higher shelf life and flavored milk
- Production of yak milk paneer and mixed milk paneer
- Utilization of paneer whey as pineapple flavored whey beverage

Small yak milk processing unit were established for production and marketing of yak milk products (*dahi*, paneer, lassi and pineapple flavored whey beverage). The unit is also used for training of yak herdsmen and women.

uncorked flavour. The preheating to 90°C for holding time of 15 min gave best attributes of product.

Large scale production of curd rice: Curd rice was prepared by mixing culture inoculated milk and cooked rice and incubating it at 37°C for 14-16 hr. This fresh curd rice had 0.54% acidity and 88 × 10^{4}/g lactic acid bacteria count. The curd rice packed in polystyrene cups and stored at 37°C had an acidity of 0.68% and lactic count of 10^{3} × 10^{4} / g at the end of 5 days up to which the product remained acceptable. The curd rice stored well up to 8 days at 5°C.

*Goat milk:*Zinc content was higher in Jamunapari and Barbari goat milk than Sirohi and Marwari breeds. Variations between morning and evening samples were more in Jamunapari and Barbari than Marwari and Sirohi. Morning samples of Barbari revealed highest (3.045mg) and evening samples had lowest (1.847mg) concentration of manganese. Copper content was highest (0.444mg) in morning samples of Jamunapari and lowest (0.258mg) in Marwari. Iron content, which varied from 2.702 – 3.308 mg, irrespective of breed, was higher in evening than that in morning milk samples.

Camel milk soft cheese: Process was standardized for the preparation of camel milk based soft cheese. Camel milk cheese contained as per cent moisture 61.07 ± 4.29, total solid 38.99 ± 4.22, fat 9 ± 1.53, acidity 0.068 ± 0.01 and yield of cheese was 12.17 ± 0.64%.

Meat and Meat Product Technology

Raw chevon quality: Meat composition of kids and lambs reared under intensive system revealed that kids meat (age 9 months) had low fat and total cholesterol than lambs (age 6 months). Sirohi meat has less fat and cholesterol than Barbari kids meat. Chevon quality of spent Marwari goats was compared with lamb meat and

Energy audit in model dairy plant

Thermal and electrical energy consumption during processing for milk processing, ice creams and ghee, were estimated and thermal energy losses through condensate were calculated.During milk processing the steam consumption per 100 liters of milk, right from milk reception to pasteurization was 2.8 kg with an equivalent energy of 1,808.44 kcal. Power consumption per 100 liters of milk was 1.668 kwh. Steam consumption per 100 liters of ice cream mix was 12.1 kg with an equivalent thermal energy of 7,831.28 kcal. Power consumption per 100 liters of mix was 19.12 kwh. During ghee preparation average steam consumption per 100 kg of ghee was 42 kg, with an equivalent thermal energy of 2,7300 kcal. Electrical energy consumption per 100 kg ghee was1.302 kwh.Thermal energy losses through condensate and equivalent savings by recovering these losses were expressed in terms of boiler fuel oil and in terms of rupees. These losses in milk processing, ice cream and ghee preparation were 8.3%, 5.14%, 10.05%, respectively. Equivalent saving in terms of fuel oil would be 4.72 kg, 1.135 kg and 2.03 kg/day, respectively. Savings per annum for these three products would be approximately Rs 38,616.

Quantitative losses of eggs and poultry meat

The magnitude of losses of eggs at layer farms, wholesalers, retail markets, egg processing units, cold storage and household (consumer) levels were 0.96%, 1.28%, 3.10%, 1.09%, 1.42% and 3.2%, respectively, which together constituted an overall loss of 11.05% between farm and kitchen. The losses were relatively more in summer than that in rainy season or winter. Loss of broilers due to mortality between 5 to 7 weeks of harvesting (marketable age) maximum at retail level (2.24%) followed by at broiler farms (1.16%) and wholesale level (0.40%), whereas, at household consumers' level, loss of poultry meat was negligible.

their combinations (50:50). The a_w, pH and total cholesterol content (mg/100g) of lamb meat were 0.995, 5.74 and 62.63. Spent goat meat had a_w 0.995, pH 5.88 and cholesterol content 48.13 mg/100g.

Goat

Chevon samosa: Chevon *samosa* using spent goat meat was prepared. Semi-fried and deep fat fried *samosa* were packed under vacuum and atmospheric conditions and stored at –20°C for evaluating physico-chemical, microbiological and organoleptic changes at monthly intervals for 4 months. Freshly prepared product had SPC log 4.62 in semi-fried and log 4.48 in deep fat fried *samosa*. Coliforms were log 0.55 in semifried and absent in deep fried *samosa*. *Lactobacilli* were log 0.33 in semifried and not detected in deep fried *samosa*. Yeast and mold counts were <log1.0 and psychrotrophs bacteria present were well below the permissible limits in cooked meat products.

Chevon nuggets: Lamb meat nuggets revealed high yield (87.18%) compared to 81.52% for spent goat meat. Nuggets had a_w of 0.988. The cholesterol was 136.25 mg for lamb meat nuggets, 120.11mg for combination meat and 110.02 mg/100g for spent goat meat. Nuggets using spent goat meat, lamb and their combination (50:50) was prepared, packed under vacuum and ordinary conditions and stored at –20°C for evaluating physico-chemical, microbiological and organoleptic changes at monthly intervals for 4 months. Freshly prepared product had SPC log 3.99 in lamb nuggets, 4.07 in goat meat nuggets and their combination had 4.34 CFU/g. Coliforms and lactobacilli were not detected. Yeast and molds and psychrotrophs bacteria were well below the permissible limits in cooked meat products.

Chevon kofta: Chevon *kofta* packed under vacuum and without vacuum in HDPE and stored at –20±2°C, could safely be stored for 4 months without significant change in physicochemical, microbiological quality and organoleptic scores except decline in general appearance at latter period of storage, irrespective of packaging methods.

Chevon patties: Chevon patties vacuum packaged using HDPE on quality and shelf-life of chevon patties stored at 4±1°C revealed that vacuum packaging had definite advantage in preserving the sensory quality of patties than ordinary packaging but did not help in extending the shelf life beyond 15 days as it was mainly contaminated by microbial growth.

Poultry

Chicken meat spread: Processing technology for the preparation of chicken spread from spent hen meat was developed. The chicken meat spread from spent (culled) hen meat had desirable spreadability and acceptability. Addition of 0.5% sodium tripolyphosphate (STP) and 100ppm α-tocopherol acetate in the formulation improved emulsion stability and inhibited lipid oxidation as measured by TBA assay. Vacuum-packed product in PFP laminate had shelf life of 12 and 60 days under refrigerated (4-5°C) and frozen (-18°C) storage, respectively.

Storage stability of poultry meat products: Incorporation of alcoholic extract of garlic at 2% level (w/v) in unspiced minced meat base containing processed chicken skin at 10% level resulted in delicious chicken skin-meat cutlet. The finished product remained acceptable till 14 and 28 days under refrigerated (4±1°C) and frozen (-18±1°C) storage, respectively.

Poultry meat preservation by phyto-products: Aqueous garlic extract at 4.0% (w/v) or ethyl alcoholic extracts of cinnamon and clove at 0.4% (w/w) and 0.15% (w/w) respectively, in combination with *Lactobacillus acidophilus* enhanced the shelf-life of minced chicken meat up to 7-8 days. The spice extracts in combination

Microbial inhibitory substances (antibiotic residues) in cow and buffalo milk

Tetracycline, gentamycin, ampicillin, amoxycillin, oxy-tetracycline, cloxacillin and penicillin are the common antibiotics used in dairy animals in Bangalore and surrounding areas. Misuse of the drugs by veterinarians and the farmers not being aware of the need to discard milk from animals treated with antibiotics could be of great concern to public health. Microbial disc and test diffusion assays were standardized for detection of ampicillin, erythromycin, lincomycin, gentamycin, ciprofloxacin, penicillin, streptomycin, tetracycline and oxy-tetracycline. Charm II test was also standardized for confirmation of b-lactams, tetracycline and aminoglycoside residues in milk. Incidence of presence of drug residues in milk from individual animals was 2.4% in cows, while all the milk samples from buffaloes were negative for antibiotics. Absence of these residues in buffalo milks may be because buffaloes are more disease resistant. Analysis of milk samples from organized and unorganized farms had b-lactams or tetracycline residues 5.3 and 2.2%, respectively. Penicillin and ampicillin contamination was observed in 3.9% tanker milk supplies and tetracycline contamination in 0.61% of market milk samples. Withdrawal of milk for 3 days after the cessation of antibiotic treatment ensured safe milk to public consumption.

Chevon pickle

The technology for chevon pickle from spent goats was developed. Goat chevon pickle is a shelf-stable value added meat product prepared using precooked spent goat meat. Pickle has pH 4.77; SPC and halophiles log<4.00; yeast and mould counts log £1.00 cfu /g. At ambient temperature, it is acceptable up to 6.0 months of storage. Product is highly acceptable among the meat eaters. The yield of chevon pickle was 23.34% on slaughter weight basis, 58.93% on carcass

weight basis and 102.83% on separated meat weight basis. Cost of production at laboratory scale was Rs 80.0/kg. The technology, which is based on traditional taste and method, is expected to be readily acceptable by even small-scale meat processors/ entrepreneurs. The product has good market potential in towns, cities and for defense forces in remote and difficult areas where fresh goat meat availability round the year is limited. This technology has been transferred to an NGO and further efforts are on to popularize it.

SUCCESS STORY

Batter-breaded egg albumen rings

Albumen rings are egg snack food and can be popularized as egg snacks at fast food outlets. A process of preparing albumen rings was standardized. Albumen rings were prepared by blending chicken egg albumen with 5% rice flour and 0.5% salt, and steam cooking at ambient pressure for 5-6 min. The rings battered in 25% wheat flour and 15% black gram flour coating mixture was most acceptable and had a formulation cost of Rs 68/ kg.

with *Lactobacillus acidophilus* culture also exerted synergistic potent antimicrobial effect against *A. hydrophila*.

Residues of BHC, DDT and Malathion in Spent Hen Tissues: BHC level in spent hen muscle ranged from 0.04 to 0.07ppm, and in liver and adipose tissue 0.3-0.7ppm and 0.07-0.15ppm, respectively. BHC was higher (50%) in adipose tissue during July-Sep. The level of DDT was 0.05-0.3ppm in muscle, 0.3-0.7ppm in liver and 0.1-0.2ppm in adipose tissue. DDT was found mostly from July to Sep. Malathion in muscle and liver tissues varied from 0.05 to 0.1ppm, and it was not detected in adipose tissue. This pesticide was more in muscles (20%) than in liver (10%). Broiling for BHC, DDT, and pressure-cooking against malathion were effective in reducing the residues of these pesticides in meat.

SUCCESS STORY

Handloom woven blankets

Handloom woven blankets had the effective softness, good colour combination which otherwise is not possible to be manufactured from Indian wools that are coarse having hetero and hairy types fibers. The blending was carried out with fine wools of around 20μ and staple length below 50 mm having insignificant heterotypic fiber component. The blended yarns prepared in the ratio of 70:30 and 50:50 of native and crossbred sheep wools were spun on woollen system and approximately 2.5±0.5 nm yarns prepared. After dyeing the yarns, the blankets of stripe and check designs were prepared on handlooms and a standard weight of approximately 2.5 kg was obtained. During milling and raising operations the short and fine fiber of the crossbred wools imparted the desired softness and warmth. These were than marketed and found wide acceptance. The cost of blanket was around Rs 285/ piece, and is cheaper as compared to market blankets of around Rs 450 to Rs 500 of similar quality. The technology is capable of producing low cost, attractive and quality produce.

Yak

In raw yak meat moisture was 74.82 – 78.15%, protein 19.10 – 22.50%, fat 1.20 – 1.97% and ash 0.96 – 1.16%

Wool Technology

Wool quality: Reflectance, fluorescence and total T values of wool samples, collected from Magra sheep (male and female) of institute, Bikaner Mandi and field area, were estimated. Bikaner Mandi wool samples had higher lusture. Chokla wool samples (125) from institute revealed average fiber fineness 29.7 m, CV 42%, hetero fibers 11% and hairy fibers 8%. March clip wool has less medullation than September clip. Four lots of Magra and Marwari sheep wool collected from the ARC, Bikaner (each 50 kg) were processed on woolen spinning system. Yarn of 4 nm linear density was prepared having a twist of about 120/m.

Wool carpets: Three types of carpets prepared from commercial wool, commercial yarn and experimental yarn, were subjected to subjective evaluation by different 10 judges. It was Commercial wool and commercial yarn carpets obtained higher value than that of experimental yarn carpets. ❑