All India Animal Husbandry Officers' Workshop cum Training Program on
"Enabling Extension Functionaries to Address Field Level Problems in Animal Husbandry"

(October 26-29, 2015)

Sponsored by:
National Institute of Agricultural Extension Management (MANAGE), Hyderabad

Organized by:
Division of Dairy Extension
ICAR - National Dairy Research Institute
Karnal - 132 001, Haryana
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Foreword

Animal Husbandry is an important complimentary enterprise to crop production since time immemorial. Many innovations have been introduced in India in both technological and social dimensions in order to bring about a complete transformation in the socio-economic conditions of 70 million household who earn their livelihood from livestock enterprises. The infrastructure so far created in terms of veterinary institutions and manpower added value to the extension delivery system. Field extension functionaries carry out enormous tasks and responsibilities to make livestock enterprises more profitable. New kinds of stakeholders are emerging for catering the requirement of peri-urban and urban areas and animal holding pattern among landless rural households is also increasing.

While field extension functionaries look after traditional animal rearers, they also need to focus new clients including potential entrepreneurs. They encounter numerous problems in their day to day extension delivery including demands of farmers such as price fixation for milk, adulteration of dairy products, escalating input costs, climate change effects, subsidies/incentives etc. Extension functionaries need to be periodically updated about schemes and strategies in tackling various issues. This All India Animal Husbandry Officers’ Workshop cum Training Program on Enabling Extension Functionaries to address Field level problems in Animal Husbandry is being organized by MANAGE in collaboration with NDRI, Karnal with a view to address these issues. I hope that the compendium of training notes which is prepared for this program would be immensely useful for everyone who is involved in promoting animal husbandry as a promising and profitable occupation.

V. Usha Rani, IAS
(Director General, MANAGE)
Animal Husbandry & Dairying plays a vital role in securing livelihood for millions of rural and urban households. While farmers adopting technologies due to influence of knowledge driven by multiple extension strategies, they also tend to face numerous problems at field level which significantly affect the productivity and profitability in animal husbandry. This requires to be addressed through generating income and employment by providing immediate solution along with enabling strategies in order to motivate the farmers especially educated rural youth and women towards dairy farming. A four days All India Animal Husbandry Officers’ Workshop cum Training Programme on “Enabling Extension Functionaries to Address Field Level Problems in Animal Husbandry” will be organized in the Division of Dairy Extension at NDRI, Karnal from October 26-29, 2015 in collaboration of National Institute for Agricultural Extension Management (MANAGE), Hyderabad with emphasis on capacity building of field functionaries in the recent developments in the dairy sector to disseminate the latest technologies, innovations and extension methodologies for effective transfer of scientific information to the stakeholders as per their needs.

The workshop cum training programme will provide an opportunity to Animal Husbandry & Dairy Development Officers of different states to discuss the emerging problems and issues of dairying under field conditions with the scientists and develop strategies to handle these field related problems.

The efforts of the organizers from NDRI and MANAGE deserve appreciation. I congratulate and welcome all the participants, who have joined this Programme from various states of the country. I also convey my best wishes for the success of this Programme.

(A.K. Srivastava)
PREFACE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad in collaboration with the Dairy Division Extension Division, National Dairy Research Institute, Karnal (Haryana), is organizing a four day All India Animal Husbandry Officers’ Workshop cum Training Programme on “Enabling Extension Functionaries to Address Field Level Problems in Animal Husbandry” from October 26-29, 2015. The training programme is designed to orient extension functionaries on various issues of field problems current scenario of livestock sector and familiarize them with various extension management approaches and models of entrepreneurship development in livestock sector. The organizers hope that the participants will benefit greatly from the four day deliberations and interactive sessions.

The All India Animal Husbandry Officers’ Workshop cum Training programme will provide an opportunity to Animal Husbandry / Dairy Development Officers of the states to discuss the emerging problems and issues of dairying under field conditions with the Scientists and develop strategies to handle these field related problems. This workshop will also be attended by Senior Officers from department of Animal Husbandry of different states. Based on discussion, a policy paper will be published which will be useful to scientists, field workers, Govt. and policy makers in finalizing a roadmap for solutions of various issues and field problems faced by the stakeholders of dairy farming in India.

Without the benevolence of Hon’ble Director and Vice Chancellor, NDRI Dr. A. K. Srivastava, no programme would be successful. He has always been a constant source of motivation, support and guidance, to make this training programme possible. We fall short of words to express our gratitude to him.

We express our heartfelt gratitude to Hon’ble Director General, MANAGE, Smt. V. Usha Rani, IAS, for giving emphasis for promotion allied sector extension management and for keen interest in networking with various related research organization like NDRI, for the benefit of the farming community. We thank immensely Director General, MANAGE for continuous guidance and for sponsoring the programme.

We express our sincere thanks to Dr. R.K. Malik, Joint Director (Research), NDRI, for kind cooperation and help for the success of this programme.

Editors
## CONTENTS

1. Entrepreneurship Development in Rural Areas through Specialized Dairy Farming  
   *Gopal Sankhala, H.R. Meena and Khajan Singh*  
   1

2. Breeding Policies and Programmes for Improvement of Cattle and Buffaloes in India  
   *Dr. A K Chakravarty and Dr. Avtar Singh*  
   7

   *Dr P S Oberoi*  
   14

4. Extension Management-Recent Initiatives  
   *Dr. N. Balasubramani*  
   20

5. Clean Milk Production  
   *Gopal Sankhala, H. R. Meena, B. S. Meena and Kiran R*  
   30

6. Effective Disposal and Utilization of Dairy farm Waste  
   *S.S. Lathwal and Indu Devi*  
   35

7. Climatic variability and extreme weather events: impacts on livestock productive and reproductive performance and amelioration strategies  
   *S.V. Singh*  
   40

8. Major Reproductive Problems of Dairy Animals and Practices for Improved Reproductive Efficiency  
   *A. Kumaresan*  
   52

9. Effect of feed supplements, minerals and vitamins on animal production  
   *S.S.Thakur and M.S.Mahesh*  
   60

10. Fodder Production and Preservation  
    *Rakesh Kumar and Magan Singh*  
    70

11. Developments in Value Added and Fortified Dairy Products  
    *Ashish Kumar Singh, Sanket Borad, Neelam Upadhyay*  
    84

12. Quick tests for checking adulteration in dairy products  
    *Rajan Sharma, Bimlesh Mann, Satya K and Dhiraj Kumar Nanda*  
    89

13. Artificial Insemination and Sexed Semen for Animal Husbandry Development  
    *T.K. Mohanty and M. Bhakat*  
    94

14. Vaccination Schedule in Livestock and Production Disease  
    *Dr. Kriti Dua*  
    102

15. Judicious Use of Antibiotics in Veterinary Practice  
    *V. K. Dumka*  
    105
16. Treatment and Control of Bovine Mastitis  
   *Dhiraj Kumar Gupta*  
   Page 109

17. Commercial Goat Farming in India  
   *M. Bhakat, T.K. Patbandha, T.K. Mohanty, A. Singh and S. Mondal*  
   Page 115

18. Making dairy farming profitable through precision farming  
   *HK Verma and RK Sharma*  
   Page 123

19. Farmers Farm School: A Grass Root Approach for Strengthening Farming community  
   *B.S. Meena and H.R. Meena*  
   Page 128

20. Mobile based Text & Voice Messaging services for Livestock Keepers  
   *H R Meena, G.S. Sankhala and B.S. Meena*  
   Page 132

21. Burning issues in animal husbandry sector of India  
   *K. Ponnusamy, Khajan Singh and N. Balasubramani*  
   Page 136
Entrepreneurship Development in Rural Areas through Specialized Dairy Farming

Gopal Sankhala, H.R. Meena and Khajan Singh
ICAR-National Dairy Research Institute, Karnal - 132 001

Dairying and agriculture are bound together by a set of mutual input-output relationships. Dairying is not an adjunct to the crop-mix of Indian farms, but an integral part of the total farming system. Dairy development has important role in not only generating employment and enhancing livelihood opportunities of rural people but also improving the nutritional standard of the people. Dairy Industry in India is one of the fastest expanding in the world. The demand for milk is tremendous, and is growing not only in cities but also in small towns and rural areas. Over the past two decades, dairy farming has grown from this largely unorganized activity, into a vast organized industry, that encompasses not only increased production of milk and milk products, but also the breeding of higher yielding cattle, and the scientific rearing of cattle and production of cattle feeds.

Now India is the largest milk producer in the world with over 106 million tones of milk. A government policy for milk and milk products, coupled with emergence of Amul type cooperatives has changed the scenario of dairy farming in the country. Despite the robust trends in the dairy development of the country, milk productivity is still less than one-fourth of the productivity being relived in many developed countries. The major concerns facing the dairy sector in the area of milk production are: large number of unproductive animals and low milk productivity of dairy animals.

The average milk yield per milch cattle has been reported around 987 Kg per lactation in India as compared to 7038 Kg per lactation in USA and more than 9291 Kg per lactation in Israel (Hegde 2006). Limited usage of right quality and quantity of feed to the dairy animals and inadequate health care infrastructure are other important issues. The manufacturing of milk products is concentrated mainly in milk surplus States. The top five states viz. Uttar Pradesh, Punjab, Rajasthan, Maharashtra and Gujrat together account for more than 50% of national production. About 75% of milk is consumed at the household level which is not a part of commercial dairying, loose milk has a larger market in India as it is perceived to be fresh by most consumers. Hence commercialization of dairy farming as a business activity is the need of the hour.

Dairy Farming in India

Dairy Farming is one of the largest business in India next to agriculture. The All India Summary Reports of the 17th Livestock Census released in July 2006 points out that India possesses the largest livestock populations in the world after Brazil. It accounts for about 56 per cent of the world's buffalo population and 14 per cent of the cattle population. It ranks first in respect of buffalo and second in respect of cattle population, India ranks first in the world in milk production, which rose from 17 million tonnes (mt) in 1950-51 to around 100 million tonnes (mt) by 2006-07 (Economic Survey 2006-2007).

Livestock rearing and dairying has been going on in the country form time immemorial but is not at all being done scientifically. Secondly it is also seen that a dairy farmer is not aware of the economics of his day-to-day business. This is because dairying has been a traditional form of business, which is being carried on by generations together. The pattern particularly of the feeding and management has been quite the same for a long time. Most of the farmers having dairy animals have very little or no idea about the daily expenses involved in raising the animals. Some are even unaware of the fact that the feed cost comprises of more than 80% of the total cost of raising the animals as fodder is grown in own land and manage the herd by family labour thus never bothered about its cost. Most of the farmers keep 2-3 dairy animals and sell milk in kg or litres as against quintals and tonnes in the case of field crops thus dairying business goes virtually unnoticed and seen as a subsidiary farming activity. But it is milk that provides farmer the liquidity to meet day-to-day household expenses and an effective insurance against drought or crop failure.

At the same time it is imperative that the approach to dairy farming needs to be changed by way of educating farmers by guiding them both practically as well as commercially which will help them to economise their methods enabling them to make better dairy entrepreneurs. Raising productivity of dairy farms and
mitigation of their production risks requires the availability of improved breeding services, targeted preventive animal health care and better feeding strategies. Trends in developed nations show intensification and commercialisation of dairy farming in order to reap the benefits of economies of scale. Thus by enhancing milch animal quality and holding size within smallholder farming systems, will enable better utilization of available resources. It will enormously improve production and enhance viability dairy farming.

**Emergence of Commercial Dairy Farming**

One emerging trend in the Indian dairying scenario is the growing number of the commercial dairy farms in the urban and peri-urban areas of the metros and big cities. These dairies mainly cater to the needs of the urban consumers. Their average herd size ranges from small size dairy farms (having 10 to 20 milch animals), medium size dairy farms (having 21 to 50 milch animals) and large size dairy farms (having more than 50 milch animals). Realizing growing importance of commercialisation, the livestock sector needs to meet the challenges of globalization, in terms of organized production and marketing.

Majority of commercial dairy farmers keep milch cattle and buffaloes with characteristics of good milch breeds having high production potential (Holstein Friesian and Jersey breeds of cattle and Murrah buffaloes are mostly favored by commercial dairy farmer along with crossbreed cattle like Karan Swiss and Karan Fries). In fact commercial dairy farms keep on replacing the animals by buying new milch animals of good breeds of cattle (Gir, Sahiwal, Red Sindhi and Haryana) and Buffaloes (Murrah, Surti and Jaffarabadi). In some states like Haryana and Punjab cattle and buffalo breeding is the main occupation and business of majority of the dairy farms and farmers. Realizing the advantages of economics of scale and dairy farming as an agri-business opportunity farmers have stared up commercial dairy farms many parts of country. The Punjab Farmers Commission in association with Dairy Development Department has been giving impetus for setting up of Hi-tech commercial dairy farms and clean milk production. They have tie up arrangements with number of banks for credit arrangement under concessional terms. Such initiatives lead to establishment of setting up of more than 500 commercial dairy farms in Patiala, Ropar, Sangrur, Ludhiana, etc and have played a major role in increasing the milk production and procurement. Many of the commercial farms have adopted the latest technology of milk production. A Chennai based company viz. Hastun Agro has launched “Project White Gold” in Tamilnadu under which it encourages ordinary five acre farmer to establish a commercial dairy unit of 25 animals with captive fodder production and selective mechanisation (Renganathan et al.).

A commercial farm of mixed type (cross breed cows and buffaloes) should be preferred. The essentials for success in dairy farming include proper choice of animals, suitable housing and sanitation, clean milk production through the year, availability of feed and fodder, scientific management practices on the farm. The protective feeds i.e. By Pass fat and By Pass protein is essentially required for high yielding dairy animals for productive and reproductive growth and high returns on the organized farms. However very few such farmers are providing such type of feeds to their animals. The economics of whole dairy animal management depends upon its economic feeding. By growing fodders like lucerne or berseem preparing feed mixtures and concentrates for animals at dairy farm one can reduce cost on feeding. The housing condition of the livestock greatly affects the health and productive performance exotic and cross breed cattle which are more prone to diseases as their immunity level is low.

**Dairy Entrepreneurship Vis-à-Vis Commercial Business Activity**

Entrepreneurship development in rural areas is now being considered as a means to achieve socio-economic enhancement of rural people and overall development of rural economy. Dairy entrepreneurship can be one of the important subsidiary occupations for most of the farmers in rural areas. Since agriculture happens to be mostly seasonal in nature, thereby providing employment opportunities for the people on seasonal basis, there is a possibility of finding employment for many persons throughout the year through dairy farming. Even more profits can be earned through dairying, depending upon the breeds of animal, managerial skills and marketing. Dairy farming can also be taken up as a main occupation around big urban centres, wherein the demand for milk is high. Modern and well-established scientific principles, practices and skills should be used to obtain maximum economic benefits from dairy farming.

The demand for milk and milk products is expected to grow at a very rapid rate due to population growth, urbanization, increase in income levels and changes in food habits. This increase in demand for dairy products will put increasing pressure on dairy production systems, traditional breeds and feeding practices are
likely to give way to higher-yielding breeds, associated intensification of production systems, increased disease risks, animal health issues and a greater reliance on concentrates. Dairy farming can be adopted by farmers and rural youths as an enterprise on commercial lines, so more production ought to be derived from animals with the help of improved dairy farming practices. The perspective dairy entrepreneurs should be given training on various aspects of dairy farming like breeding, feeding, housing, healthcare and management, and also on clean milk production, processing and value addition to milk and milk products. Dairy farming on commercial lines can help the farmers in suicide prone area of Vidarba in Maharashtra and Andhra Pradesh where farmers are committing suicide due to failure of cash crops.

Now farmers are realizing the importance of dairy farming as a business activity and establishing commercial dairy farms with about 20 milch animals and then gradually increasing size of the dairy farm with use of scientific dairy farming practices which includes captive feed production, nutritive feed supplements, disease diagnosis, mechanized milking and clean milk production. Detailed information about the organized dairy farms and opportunities for trainings on various aspects of commercial specialized dairy farming is available with the:

- Agricultural/Veterinary universities of various states
- State department of Animal Husbandry
- Krishi Vigyan Kendras
- Agriculture Technology Information Centre (Kisan call centre helpline - 1551)
- Indian Veterinary Research Institute, Izatnagar, Bareilly
- National Dairy Research Institute (NDRI), Karnal (Haryana) - for training on rearing of dairy animals processing of milk and manufacture of various milk products.
- Training by non-governmental organizations that are active in dairying and livestock sectors (e.g. BAIF, PRADAN etc.).

Most of the state governments are also promoting the commercial dairy farming as an entrepreneurial activity for farmers and rural youths. Punjab and Haryana holds a special place in the field of milk production and it is truly known as the ‘Milk pail’ of the country. These States has a vast potential of self employment generation in the sector of Animal Husbandry & Dairying. Realizing importance of this of Haryana Government started Hi-Tech commercial Dairy scheme as a new plan scheme from 2008-09 for self employment generation in dairy sector by establishing of Hi-Tech dairy units.

Briefly the major objectives of the scheme are as under:-

(i) Clean Milk Production being scientifically managed & reared.
(ii) Creation of data bank of quality germplasm - step toward formation of breed Associations
(iii) More employments - as a result of shift from 1-2 Milch animals to large commercial dairies.

To boost up the milk production, fodder production and generation of more & more employments in the dairy sector, it is proposed to establish bigger dairies with minimum of 20 or more milch animals.

At Chitale dairy farm at Bhilawadi in Sangli district of Maharashtra, and in 12 satellite farms in the vicinity, sport radio frequency ID (RFID) tags, so that the company can monitor and control every aspect of their lives that has a bearing on their output. The farm has a unique feeding system that feeds the buffaloes correctly. The animals can never eat more than a certain programmed portion of daily ration at one time. The national average of buffalo milk yield in the country is 800-1000 litres in 300 days. At the Chitale dairy farm, with better management practices, the dairy farm has successfully achieved 2,500 to 4,000 litres of milk per lactation. The organized dairy farms like Chitale dairy farm can be useful model for the dairy entrepreneurs who are interested in taking dairy farming as commercial business activity.

Capacity Building of Entrepreneurs vis-à-vis Dairy Farmers

- Training: Enabling dairy farmers to become successful dairy entrepreneurs by providing training on upkeep and maintenance of high yielding dairy animals, calf rearing and feeding, breeding, healthcare and management aspects of dairy animals.
• **Education:** Empowering dairy entrepreneurs by providing timely information and knowledge about scientific dairy farming practices. Organizing various short term courses on dairy entrepreneurship, dairy business management, processing of milk and milk products, animal nutrition etc.

• **Dairy Business Management:** Providing Knowledge and training about maintenance of dairy farm records, farm business cash record and measures of farm income and profit efficiency to help in rational decision making in dairy business management.

• **Processing of Milk and Milk Products:** Training programmes should be organized to provide on-hand experience and knowledge about processing of milk and preparation of milk various products to make dairy entrepreneurs self-reliable.

• **Exposure Visits:** Arranging field visits of perspective dairy entrepreneurs to various commercial dairy farms, milk processing plants and successful dairy entrepreneurs.

**How to Start a Dairy Farming Unit**

One needs to decide first on the aims and objective of the farm. Every year there should be a progressive aim for breeding (including number of animals to be maintained) and production.

- Visit dairy farms that run on commercial basis and have a discussion with experienced farm owners, analyze every event logically and, if needed, consult with local Veterinarians for more information.
- If you plan to manage the farm on your own, look for opportunities to work for an existing farm for a minimum period of six months.
- Start with about 20 high yielding cows and buffaloes and gradually increase the size of dairy farm.
- Always purchase animals in batches, such that when first batch is in late stage of lactation second batch should be purchased in order to maintain uniformity in production level thought the year, thereby maintaining continuity in milk production vis-a-vis income. This will ensure availability of adequate funds for maintaining the dry animals.
- Location of the dairy farm should be near cities or milk factories to take the advantage of remunerative prices.
- Good quality of green fodder should be grown in the field and quality concentrates and feed mixture should be prepared on farm to lower the cost of milk production.

**Selection of Animal**

While purchasing cows and buffaloes for commercial dairy farm we have to select healthy animal known for economic milk production. Selection of a dairy animal is an art. A dairy farmer should build up this with experience and practice. Following guidelines will be useful for selection of a dairy animals.

- Select healthy, high yielding animals with the help of veterinary doctor, animal husbandry officer, experienced dairy farmer etc.
- Selection of the milch breed is very important and thus area specific breeds should be selected. Selection should be done based upon breed characteristics, fertility and milk producing ability.
- Always prefer freshly calved animals in their second/third lactation while purchasing animals. Before purchasing, ascertain actual milk yield by milking the animal three times consecutively.
- Preferably purchase dairy animals from organized farms as pedigree record is generally maintained in organized farms which reveal the complete history of animal.
- The dairy animals should be purchased in two batches and preferably equal proportion of cows and buffaloes should be maintained on a dairy farm.
- Identify the newly purchased animal by giving suitable identification mark (ear tagging or tattooing).
- Vaccinate the newly purchased animal against disease.
• Keep the newly purchased animals under observation for a period of about two weeks before mixing with animals in the herd on dairy farm.
• Follow judicious replacement of old and unproductive animals in a herd in order to maintain profitability of dairy farm.

SWOT Analysis of Dairy Farming

India’s dairy sector is expected to double its production in the next ten years in view of expanding potential for export to Europe and the West. Moreover with WTO regulations expected to come into force in coming years all the developed countries which are among big exporters today would have to withdraw the support and subsidy to their domestic milk products sector. Thus there is urgent need to increase milk production to fill this gap and to exploit the export-potential. In emerging global competitiveness, the present trend of dairy industry from being 'production-oriented' needs to be changed to a 'market/consumer-oriented' approach. Organized/commercial dairying is still in its nascent stage. At this juncture, its time to do SWOT analysis (strengths, weaknesses, opportunities and threats) of dairy farming as commercial business activity.

Strengths

• Dairy farming is eco-friendly and does not cause environmental pollution as compared to other industries.
• Requirement of skilled labour is relatively less.
• Dairy product market is active round the year.
• Minimum investment on inventory. (No need to stock raw materials in huge quantities.)
• Entire establishment can be shifted to a new location (if need arises e.g. natural calamities, change in market place etc.)
• One can insure animals. (to reduce the economic losses due to disease outbreak, theft etc.)
• Less energy requirement. Biogas plant fed with cow dung can supply maximum energy to meet farms day to day requirement. Decomposed slurry of such plant can also be effectively used as organic manure.

Weakness

• Breeding of animals and getting expected milk yield is a biological phenomenon, which depends upon various factors.
• Inadequate management of feeding, herd health and lack of quality control in various stage of production can cause major loss affecting the profitability of the entire venture.
• Lack of financial, technical and infrastructural support in form of veterinary clinics, quality semen and bulk cooling units etc.
• One needs to decide first on the aims and objective of the farm. Every year there should be a progressive aim for breeding (including number of animals to be maintained) and production.
• Non availability of pedigree records and information regarding breeding, calving and milk production record.
• People are now more health conscious and prefer to take milk and milk products in their daily diet.
• Food industries are also adding milk and milk products in the functional foods.
• Opportunities
• India today is the lowest cost producer of per litre of milk in the world
• WTO regulations expected to come into force in coming years all the developed countries which are among big exporters today would have to withdraw the support and subsidy to their domestic milk products sector
• Urban market for milk products is expected to grow at an accelerated pace.
• Increasing trend towards specialized and commercial dairy farming as an business activity.
Threats

- Reduction in area under fodder cultivation as a result of shrinking of cultivable land due to urbanization and industrialization.
- Large number of unproductive bovine population.
- High interest rate on finance affecting viability of dairy farming
- Inadequate management of feeding, herd health and lack of quality control in various stage of production can cause major loss affecting the profitability of the entire venture.
- Dairy farming besides good planning requires hardworking, reliable and alert manager.
- Indiscriminate crossbreeding leading to high susceptibility to diseases and resulting economic losses to dairy farmers.

Processing of milk at farm level:

Agriculture is the foundation of Indian economy on which almost 70% of the population depends. Having achieved near self sufficiency in primary agriculture (grains, sugar cane, fruits, vegetables and milk, etc.) the country must now focus attention on secondary agriculture. The secondary agriculture provides value addition to agricultural products, creating facilities for primary processing and stress management in agriculture and adds value to the basic agro commodities to allow farmers to get better returns from their harvest. It also creates new job opportunities in the rural sector which improve agriculture based rural economy.

Dairying as livelihood option for rural areas of the country and there is a need to enhance the income of farm community and generate the employment opportunities for unemployed rural youth by value addition in milk so that they become a dairy entrepreneur to fulfill the demands of growing urban population. Moreover, rural housewives may also prepare the various milk products for their domestic needs especially on festival occasions when there is hue & cry in the media regarding the adulterations.

Conclusion

Livestock rearing and milk production being an adjunct to mainstream crop agriculture but today, when there is a greater attention to our rural economy, the dairy sector offers big opportunity to transform our economy by bringing prosperity to the rural sector. Dairy entrepreneurship through specialized dairy farming can be main source of sustainable livelihood and income generation to farmers and rural youths. By increasing on-farm fodder yields, relying less on expensive market feeds and selective mechanization (use of chaff cutter, and milking machines to save on labour), milk production costs can be reduced. Commercial dairy farms nearer to the cities and milk factories can prove an asset for achieving the above goals.

Considering the sheer size to which dairy industry has grown today, there is a need to rescue dairying from a narrow ‘subsidiary/residual’ approach and view it as an independent business in itself. Commercialized dairy farming for producing more milk round the year of high quality is the only solution for the viability of dairy industry in the present National and International dairy scenario. Realizing this, the Government of India has attached special importance to development commercial dairy farming. Progressive states like Punjab, Haryana, Gujarat and Maharashtra are promoting schemes for promoting Hi-tech commercial dairy farming and clean milk production among dairy entrepreneurs in their state. The commercial banks also provide finance to establish a dairy farm at low interest rate which allow and motivates farmers to take dairy farming as a business activity on commercial basis. The commercial dairy farming is perhaps an idea deserving of support whose time has come. By commercial dairy farming, one is not talking of the farms with 500-plus cattle like in US or New Zealand and other western counties. As such models are obviously unsuited for India, both from an economic cost as well as socio-political angle. The sustainable and economically viable dairy farming, which would generate income and self-employment opportunities through entrepreneurship, is the need of the day for ensuring livelihood sustainability for millions of farmers and youths in rural areas.
BREEDING POLICIES AND PROGRAMMES FOR IMPROVEMENT OF CATTLE AND BUFFALOES IN INDIA

Dr. A K Chakravarty\textsuperscript{1} and Dr. Avtar Singh\textsuperscript{2}

\textsuperscript{1}Principal Scientist & Head \textsuperscript{2}Principal Scientist
Dairy Cattle Breeding Division
ICAR- National Dairy Research Institute, Karnal-132001

India is the agricultural country in which more than 70 % population depends on agriculture and allied sectors. Livestock sector is an integral component of agriculture and alone contributes about 25.6 % of total output of agriculture sector and 4.11% of total GDP because the country is a rich repository of bovine genetic resources. According to 19th Livestock Census (2012), Govt. of India, the total livestock population in India was estimated as 529.7 million of which 190.90 million cattle and 108.7 million buffaloes contributing about 37.28 % and 21.23% of total livestock population. Of the total cattle population, 151 million are indigenous cattle and 39 million are crossbred cattle resulted through crossing exotic dairy breeds primarily Holstein Friesian and Jersey with mostly indigenous descript / non-descript cattle. There are 39 and 13 registered breeds of cattle and buffaloes which constitute about 20-25% of total cattle and buffalo population of the country. The large population of non-descript cattle and graded buffaloes are distributed mainly in small herds of 2-3 animals and reared by small and marginal farmers of different socio-economic conditions under diverse agro-ecological regions of the country.

India is the largest producer of milk in the world with milk production of 137.7 million tons (2013- 2014). However, the per capita availability of milk in India is very less (299 g/day). Rapid increase in human population and looking into the demand of milk (191mt) in India by 2020, the Ministry of Agriculture and Farmers Welfare, Government of India (2013) has laid down the re-orientation of breeding policy for cattle and buffaloes and key programmes for genetic improvement of cattle and buffaloes in the country.

BREEDING POLICY FOR CATTLE

\begin{itemize}
  \item Selective breeding of defined indigenous breeds of cattle having high milk yield, and those with excellent draft abilities, will be promoted to improve their production and reproduction potential. This will help their proliferation, conservation and genetic upgradation. Efforts will be made to import semen of these breeds if necessary, to avoid/ reduce inbreeding. Intrusions of crossbreeding in their defined breeding tracts will be totally avoided.
  \item Cross-breeding of non-descript and low producing cattle with high yielding exotic breeds suitable for respective agro-climatic conditions, will be encouraged in selected areas having adequate facility for feed and fodder, management, health and marketing facilities etc.
  \item Up-gradation of non-descript and low producing cattle with defined indigenous cattle breeds in resource deficient areas and the breeding tracts of defined indigenous cattle breeds would be encouraged.
\end{itemize}
BREEDING POLICY FOR BUFFALO

Buffalo development will aim at improving milk production and to hasten growth, maturity and multiplication.

- Selective breeding of established native buffalo breeds.
- Up-grading low producers through breeding with defined high milk yielding buffalo breeds will be undertaken.
- Up-grading of non-descript buffalo population with improved indigenous breeds will be considered, where appropriate.

NATIONAL PROJECT FOR CATTLE AND BUFFALO BREEDING

Department of Animal Husbandry & Dairying, Ministry of Agriculture, Government of India has initiated a major programme “National Project for Cattle and Buffalo Breeding” (NPCBB) in 2000. The NPCBB envisages genetic up-gradation and development of indigenous breeds on priority basis. The objectives of the project were as follows:

(a) To arrange delivery of vastly improved artificial insemination service at the farmers doorstep.
(b) To progressively bring under organized breeding through artificial insemination or natural service by high quality bulls, all breedable females among cattle and buffalo within a period of 10 years, and
(c) To undertake breed improvement programme for indigenous cattle and buffalo breeds so as to improve their genetic qualities as well as their availability.

IMPORTANT CONSIDERATIONS FOR IMPLEMENTATION OF BREEDING POLICY AND PROGRAMME

- Production of breeding males having high genetic potential will be essential element of the breeding policy and programme for each breed of cattle and buffalo.
- Formation of Breed Societies/ Associations by involving farmers for improvement of indigenous breeds of cattle and buffalo and identification / registration of animals having good genetic potential would be promoted by providing financial, technical and organizational assistance.
- To focus on the neglected natural mating system and to produce quality disease free high genetic merit bulls for natural service through implementation of massive pedigree selection programmes and progeny testing programmes.
- For the purpose of cross-breeding, semen of progeny tested bulls would be used as far as possible.

The implementation of national cattle and buffalo breeding policy and programmes for the genetic improvement of large population of low producing non-descript indigenous cattle and graded buffaloes however, is hardly able to follow in different states due to many reasons. It is increasingly being felt that the country should develop strategic planning so that available bovine genetic resources in different agro-ecological zones of the country are exploited judiciously to ensure sustainable improvement of these breeds. Therefore, breeding strategy based on agro-climatic regions and animal production systems needs to be developed.
Breeding strategies

Before developing sustainable breeding strategies for improvement of the productivity of a particular breed/genetic group in a particular agro-climatic region, it is imperative to have comprehensive details of population dynamics of the breed, management and existing breeding policies and programme following including farmer/breeder’s perceptions and socio-economic and ecological aspects of production. It may also examine agriculture and livestock production systems, available feed and fodder resources, animal breeding organizations and different breed improvement programmes. All India Livestock Census contains information only on sex, age and infrastructure for their implementation. The actual population of each breed and their geographical distribution is not included even in latest 19th All India Livestock Census (2012). Breed-wise census is therefore necessary for developing breeding and management strategies for maximizing productivity of each breed and to take steps for their conservation and management.

Based upon the collected and collated information of the area/region on all above aspects, following breed and region specific animal breeding strategies can be planned for genetic improvement of cattle and buffaloes under different animal production systems.

1. Improvement of non-descript indigenous cattle through crossbreeding with superior exotic dairy breeds

The most rapid and effective approach to genetically improve the largest proportion of cattle population which is non-descript will be through crossbreeding with exotic dairy cattle breeds (Holstein Friesian and Jersey) particularly in milk shed areas around peri-urban and industrial towns where large market exists for fluid milk and milk products and round the year adequate amount of green fodder and quality feed resources are available. Past experiences of crossbreeding with exotic dairy cattle breeds like Holstein, Brown Swiss and Jersey has shown it would be an effective tool for bringing rapid genetic improvement in milk production of non-descript cattle. Holstein Friesian has generally been recommended as the improver breed in milk shed plain areas. Jersey should be the improver breed in hilly terrain and coastal areas. The optimum level of exotic inheritance in crossbred cattle should range between 50 and 62.5 per cent.

As a result of various research and development programmes on crossbreeding in dairy cattle particularly crossing non-descript cattle with high yielding exotic cattle breeds over the year has proved to be the quickest and most effective method for improving milk production. Till 2012, through an effective breeding programme, 39 millions crossbred cattle comprising of half-bred cattle and with higher level of exotic inheritance crossbred cattle have been produced at organized farms and in rural and peri-urban households in different agro-climatic zones of the country. The crossbreeding has given relatively good results mainly under semi-intensive and intensive animal production systems. Accordingly, breeding policy for further genetic improvement in large existing crossbred cattle population under semi-intensive and intensive animal production systems is suggested as follows:

Under intensive and semi-intensive animal production system, especially in milk sheds of large consuming markets of fluid milk, it is advisable to restrict exotic inheritance between 50 and 62.5% in crossbred cattle. Therefore, the F1 crossbred females under semi-intensive production system should be bred with the semen of genetically superior preferably progeny-tested, crossbred bulls having exotic inheritance between 50% and 62.5% and produced through inter-se mating among crossbred animals.

Intensive (high input-high output) animal production system is mostly adopted by resource rich farmers in milk shed areas around peri-urban and industrial towns where a large market for fluid
milk and milk products exists and adequate quantity of quality feed and green fodder is available. Under intensive production system, higher levels of exotic inheritance between 62.5 and 75% can be sustained. The F1 females in the field should be bred with genetically superior (preferably progeny tested) bulls of exotic breeds to produce progeny with 75% exotic inheritance. Further, the progeny tested crossbred males having exotic inheritance between 50 and 75% produced through inter-se mating can be used to sustain the exotic level between 62.5 and 75%. For selection of crossbred bulls as well as import of frozen semen of genetically superior exotic bulls, the selection criteria should be the milk yield and milk constituents especially fat and protein percentages.

The crossbreeding of non-descript zebu cows using semen of exotic dairy cattle breeds has resulted in enhancing milk production of non-descript cows significantly and reduction in age at first calving, calving interval in first generation crossbred progenies. To sustain the improved productivity of crossbreds and to check the decline in performance in subsequent generations, requires a well implemented breeding policy along with availability of quality breeding bulls in sufficient numbers, infrastructure for AI and animal health inputs, effective delivery of services, programme monitoring and regulatory mechanism.

2. **Improvement of Non-descript cattle through grading with superior indigenous breeds**

The local non-descript, low producing cattle reared mainly under Low input-low output animal production system across different agro-climatic zones should be improved through grading with superior indigenous breeds where storage, transport and marketing facilities of processing milk and milk products are poor.

The non-descript cattle constituting more than 75-80% of total cattle population under this production system. The large population of local non-descript, and low producing cattle can be genetically improved by grading up using high genetic merit pedigreed bulls of superior indigenous cattle breeds like Sahiwal, Tharparkar, Rathi, Red Sindhi, Gir, Deoni, Hariana, Ongole, Kankrej etc. available in the breeding tract. These improver breeds are being maintained on several organized government and non-government farms for production of breeding bulls. It will be necessary to improve these facilities and ensure that necessary facilities for their breeding feeding and health cover are available on institutional farms in the breeding tract.

So far the impact of breed improvement programmes initiated earlier through grading up the local non-descript cattle with superior indigenous breeds has not been very encouraging. This may be due to non-availability of adequate number of high genetic merit (pedigreed or progeny tested bulls) of indigenous breeds, generally low production levels of indigenous breeds, irregular and short term breeding plan which could not wean away the farmers/breeders from using scrub bulls locally available for breeding their cows. Therefore, this system of bringing genetic improvement has not made any appreciable impact in improving the production of local non-descript cattle to improved breeds.

Therefore, for successful implementation of grading up programme of non-descript cattle with improved indigenous breeds need to be out-sourced for production of quality frozen semen and AI infrastructure networking should be strengthened. The bulls to be used for this purpose initially should be selected as the sons of superior elite dams from organized or farmer herds and institutional farms. The elite dams milk yield record should be more than 2500 kg in first lactation and 3000 kg in other than first lactation yield for milch breeds of Sahiwal, Rathi and Gir and more than 2000 kg in first lactation and 2500 kg in other than first lactation yield for dual purpose cattle breeds e.g. Hariana, Kankrej and Ongole. These bulls should subsequently be evaluated for their genetic merits based on performance.
of their progeny, through networking for organized farms and village herds preferably using open nucleus breeding system.

3. Improvement of well defined indigenous cattle breeds through selection

To meet the huge requirement of superior bulls of well-defined indigenous cattle and buffalo breeds and multiplication of their quality germplasm for upgrading and enhancing the productivity of vast non-descript cattle as well as transforming them into well-defined purebreds, it is necessary to undertake large-scale genetic improvement programmes in different zebu cattle breeds in their respective breeding tracts through selection under progeny testing programme. The animals relatively with high producing ability belonging to well-defined indigenous dairy and dual purpose cattle breeds are generally maintained under intensive production system on institutional organized farms and under semi-intensive management system followed under progressive farmers’ herds.

In the past, various projects / programmes for bringing genetic improvement of indigenous cattle and buffalo breeds through selection have been undertaken generally on small sized and single herd basis in an isolated manner. These programmes could not contribute towards identification of adequate number of genetically superior bulls. Further, these programmes generally resulted in small genetic progress over the years in most of the herds of indigenous cattle breeds. This could be due to small population size, absence of selection intensity of male and female animals, poor replacement rate and more involuntary culling of cows on the basis of traits other than milk production, unplanned breeding programme and poor monitoring. Therefore, it is suggested that the breed specific networking of organized farms and farmers/breeders’ herds should be developed to form a large network of associated herds for undertaking large scale progeny testing of breeding bulls. The closed herds could also be opened through two-way flow of superior germ plasm from the breeding tract to nucleus herds and vice-versa. Thus, with the adoption of open nucleus breeding schemes with or without MOET will enhance genetic gain not only on organized herds but also in cooperating farmers’ herds.

Therefore, the existing herds of well-defined breeds need to be strengthened further and be used as elite herds for production of superior bulls. The areas of the country where the indigenous cattle breeds need to be improved through selection are: Gujarat state for Gir and Kankrej, Rajasthan state for Rathi and Tharparkar; Haryana, part of Punjab, Western UP and Rajasthan for Sahiwal, Andhra Pradesh and Maharashtra for Ongole and Deoni. Through selection it is expected that genetic improvement can be achieved ranging from 1 to 1.5% per annum on organized farms and 8-10% per annum in farmers’ herds in initial generations. The genetic progress can be further enhanced especially using ONBS with the application of new reproduction biotechnology viz. sexing of embryos. Such breed improvement programme must form taskforce for monitoring the germplasm production, performance recording, evaluation and selection of high genetic merit young bulls and testing their genetic merit through networking both at organized herds including progressive gaushalas maintaining indigenous breeds as well as farmers’ herds under field conditions.

4. Improvement of descript buffalo breeds through selection

The relatively high yielding buffaloes of well-defined buffalo breeds are maintained under intensive production system at organized farms and under semi-intensive management system in resource rich farmers’ herds in the breeding tract of different buffalo breeds. To exploit the large degree of genetic variability between and within the buffalo breeds, the genetic improvement of buffalo herds in the country can be brought through selection within breeds. For some breeds open nuclear breeding system combining institutional/ organized herds and the farmers’ herds could be
initiated in a network mode using nucleus herd having genetically superior breeding females for production of superior breeding bulls.

For effective implementation of such programmes particularly on large scale, existing organized farms of Murrah, Surti, Mehsana, Nili Ravi, Pandharpuri and Jaffarabadi buffalo breeds should be strengthened and linked for production of breeding bulls with high genetic merit. Surti, Mehsana and Jaffarabadi is recommended to be the breed of choice in Gujarat. Surti is recommended to be the breed of choice in Rajasthan. Murrah is generally the breed of choice in the states of Punjab, Haryana, Western UP and Andhra Pradesh. A few pockets in Punjab bordering with Pakistan where programme for Nili Ravi should be undertaken. Pandharpuri is recommended to be the breed of choice in Southern Maharashtra. The genetic improvement in indigenous buffalo breeds for higher milk production, reduction in age at maturity, reduction in service period, dry period and calving interval will lead to higher economic returns to the farmers. Through networking a number of herds of a particular breed, it is expected that genetic improvement in milk production can be achieved ranging from 1 to 1.5% per annum in herds at organized farms and 3-4% per annum in farmers’ herds through introducing elite male germplasm.

5. Improvement of non-descript buffaloes through grading with improver buffalo breeds

The low producing non-descript buffaloes are generally reared under zero input-low output to low input- medium input production system in areas where feed and fodder resources and milk and animal marketing facilities are moderately available. The production potential of low producing non-descript buffaloes can be increased rapidly through mating with superior bulls of improved breeds like Murrah Surti and Mehsana. Surti is recommended for Karnataka, parts of Gujarat and Rajasthan, Nili Ravi in a few pockets of Punjab bordering Punjab province of Pakistan, Murrah for Haryana, Punjab, parts of western Uttar Pradesh and Andhra Pradesh. In other parts of the country where better feed and fodder resources are available, Murrah is recommended for grading up of non-descript buffaloes. This programme is expected to increase the milk production of non-descript buffaloes by 2 to 3 times in early generations of grading up. The grading up of non-descript buffaloes yielding on an average 500 kg with genetically superior buffalo bulls having genetic potential of 2000 kg or more will yield to an average of 1250 kg in first generation. Thus through grading up with superior breeds in five to six generations, the low producing non-descript buffaloes can be replaced with relatively high producing buffaloes conforming to the characteristics of well-defined respective breeds.

6. Selection of superior animals and multiplication of their germplasm

Methodologies developed for selection of females based upon their expected producing ability and young males based on their expected predicted difference using pedigree information, physical attributes, seminal profile and subsequently evaluating them on the basis of their progeny performance could be utilized for improvement of cattle and buffalo herds maintained at organized farms of central/state governments and other developmental agencies. For bringing effective genetic improvement, rigorous selection must be ensured on the basis of milk production of cows and buffaloes maintained at institutional farms. It is very important to increase the herd replacement rate and minimize involuntary culling on the basis of reasons other than milk production. For this, scientific herd management practices including suitable housing, adoption of reproductive health management package and practices, adequate availability of quality feeds and fodder, timely disease diagnosis and prophylactic health control measures need to be employed to minimize the economic losses. Since large proportion of genetic gain raised through proper selection of superior breeding bulls, it should be ensured that the young breeding bulls are the progenies of proven bulls and elite
females. The young breeding bulls should subsequently be progeny tested on large test mate population through associating multiple organized herds or farmer herds. Elite cows for nominated mating may be chosen from organized herds and from farmers’ herds through developing proper performance recording system under field conditions.

For implementing the strategies in undertaking large scale programmes on genetic improvement as well as conservation on widely distributed population of cattle and buffaloes in the country, we require huge number of genetically superior breeding bulls along with adequate networking of infrastructure as about there is a gap of 70 million doses of semen production and supply in the country. Production of such a large number of bulls/bull calves selected on the basis of performance of elite pedigreed dams and progeny performance is an uphill task in the absence of animal registration and performance recording system under field conditions. Though the Networking/ co-ordinating programme has been initiated under ICAR for Sahiwal and Murrah breed, however breed specific models on Networking of institutional cattle and buffaloes organized farms and large progressive farmer’s herds for testing of large number of bulls with performance recording and progeny testing of bulls with active participation of farmers need to be developed and widely implemented.

National Project on Cattle and Buffalo Breeding initiated by Department of Animal Husbandry & Dairying, Govt. of India and National Dairy Plan Phase-I programme initiated under NDBD, Anand aims the production of sizeable number of genetically superior bulls, freezing of the requisite number of doses of semen, the supply of semen at the doorsteps of the farmers and to promote the conservation and genetic improvement of indigenous breeds of cattle and buffalo. Progeny testing and Pedigree selection programme being implemented under Dairy Plan Phase-I programme to meet the demand of germplasm of high genetic merit bulls for frozen semen stations across the country. The nine progeny testing programme on three breeds of cattle and two breeds of buffalo being implemented across Punjab (Murrah), Gujarat (Murrah, Mehsana and HF crossbred), Uttar Pradesh (Murrah), Karnataka (HF Pure), Andhra Pradesh (Jersey crossbred) and Tamil Nadu (Jersey crossbred) under NDP Phase-I. For promoting and conservation of indigenous breeds of cattle and buffalo, NDP Phase-I also initiated four pedigree selection programme covering four indigenous breeds of cattle in Gujarat (Gir, Kankrej and Jaffarabadi) and Rajashtan (Rathi).

7. **Incorporation of New generation Technology in breeding programme**

The emerging reproductive techniques such as multiple ovulation embryo technology, sexing in cattle and large scale cloning of high pedigreed proven bulls offer possibilities for faster multiplication of superior germ plasm and may facilitate to achieve the target of producing large number of superior bulls calves/bulls and thereby reducing the gap of adequate number of quality semen doses in the country. Emerging developments in the areas of molecular genetics has also opened the new possibility of identifying and using the significant genetic markers related to reproduction and production performance for genetic improvement of cattle and buffaloes. The marker-assisted selection (MAS) will be the new generation tool to be developed and used in breeding programme for enhancing the rate of genetic progress of desired traits of Indian cattle and buffaloes. This could be of great use in which the procedures of conventional selection have limitations in achieving efficiency or the results have-not been satisfactory. The use of molecular techniques involves new opportunities and new challenges for building and using more predictive and effective statistical models for livestock improvement. Therefore, integration of molecular markers with conventional breeding involving information on pedigree and progeny performance will be able to increase the rate of genetic progress besides reducing the cost of the breeding programme in the country.
Preparation of Techno-Economic Feasibility Report of a Dairy Project, using computer simulated model

Dr P S Oberoi
NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL-132001

Dairy farming is an economically viable activity under specific conditions. The enterprise can be started with few thousand rupees and can grow gradually. Family labor and locally available low cost feed resources can improve its profitability. Early returns make this venture economically more viable. Genetic potential of the stock selected in terms of higher milk production and lower diseases incidence has tremendous effect on the economy of dairy farming. Dairy farming has a promising future in rural development activities of the country, especially in poverty alleviation programs through livestock development, and can boost the rural economy of the country. In view of the daily requirement of fresh milk and uses of other value added products, milk and existing market for its products will continuously grow. In order to undertake the project one must prepare a project report after analyzing the techno–economic feasibility of the project.

Planning different types of Dairy farming projects, premeditated with different objectives and targets demands sound knowledge of dairy production and other related aspects. Formulating a project plan requires various steps. A techno-economic feasibility study for the proposed Dairy-farming project considering available resources and markets is an essential and crucial step. The feasibility study under varied conditions, especially under diverse market price structures and other conditions must be undertaken before a project is started. “Computer simulating modeling,” using realistic basic technical and cost related input data, is very handy and versatile tool to visualize, analyze and compare the different projects, virtually in no time. Not only this, the modeling also can facilitate managers in planning and directing his future plans of work with respect to the livestock farming.

PREPARATION OF VIABLE PROJECT FOR FINANCE:

In order to obtain financial assistance for dairy project a techno-economic feasibility report is written and presented to the financial institute. The scheme or project report normally includes all the relevant facts and figures together with economic analysis required to assure the project for its technical feasibility and economic viability before it is financed. Financial institution studies the technical feasibility taking into account various technical parameters considered for preparing the reports and bank ability considering return on investment, repayment schedule and security aspects.

In India loan from banks with refinance facility from national bank for agricultural and rural development (NABARD) is available. For obtaining loan the farmer/entrepreneurs should apply to the nearest branch of commercial, co-operative or regional rural bank in the prescribed application forms, which is available in the above, mentioned banks. Guidance of agriculture field officer/technical officer or the manager of the bank can also be taken in preparation of the project report. For project with very large outlays detail project reports should be prepared as per the requirements of the bank.

Under lending terms bank normally defines the rate of interest, security, repayment period of loan, maximum possible cost of purchase of animals/equipments and margin money i.e. contribution of entrepreneurs in the total cost of the project. The margin money for small farmer is normally less as compared to medium and larger farmer (normally 5%, 10%, and 15% for small, medium and large
farmers respectively). Bank rates are charged as per the overall guidelines of RBI (normally 11-12% p.a.). Security is as per NABARD /RBI guidelines issued. Repayment period depends upon gross surplus in the financial analysis and preferably within 5-6 years with a grace period of one year. The repayment of loan is made quarterly/half yearly or annually. Financial institute as per its landing terms expects insurance of all the livestock of the project. Once the bank official ensures the techno-economic viability of the scheme, the bank normally sanctions the loan.

**TECHNO-ECONOMIC FEASIBILITY REPORT PREPARATION:**

Techno-economic feasibility report of a dairy project should be prepared as per the topics mentioned below.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction of the project (give current scenario of dairy farming, scope etc. in the proposed area)</td>
</tr>
</tbody>
</table>
| 2       | Location and address of the proposed project  
Objective of the project (specify, self employment/ additional income generation etc.) |
| 3       | Personal details of the entrepreneurs (give following details:  
Status of the entrepreneurs (individual/partnership/co-operative society.  
Category: large/ medium / small/ land less  
Experience of entrepreneurs: agriculture/ dairy farming etc.  
Financial status (give existing loan liabilities and assets etc.)  
Education and technical qualification  
availability of family labor  
Management capabilities (mentioned self management or hired management) |
| 4       | Investment plan (give item wise and year wise investment plan on housing, equipment and livestock etc and giving total outlay) |
| 5       | Economic analysis for economic viability (give detail of livestock strength, technical parameters and rates (purchasing and selling rates) considered for economic analysis, expenditure and income statement, gross profits, cash after disbursing loan installment and loan interest, repayment schedule, return on investment etc. (Detail for this is given on subsequent text under the heading “Computer Simulating Modeling techniques for Techno-Economic Feasibility Analysis” |
| 6       | Summary & conclusion (based on economic analysis parameters indicates the techno-economic viability of the project etc.) |

The report can be submitted to the financial institution for securing loan. Even if loan is not required an entrepreneur must prepare a techno-economic feasibility report. This will help him in studying the feasibility of the project in a specific situation. Further while executing the project the report will help in it's monitoring by comparing technical and economical parameters achieved and targeted in the project. He must receive practical training from competent training imparting organization/progressive farmer. Local Krishi Vigyan Kendras / state agriculture universities ATIC NDRI may also be contacted.

It is highly desirable that before starting a dairy unit an entrepreneur should collect relevant facts and figures about the new enterprise for techno-economic feasibility analysis.

**COMPUTER SIMULATING MODELING TECHNIQUES FOR TECHNO-ECONOMIC FEASIBILITY ANALYSIS:**

The computer models are indispensable tools for farm managers, in monitoring, future planning and appropriate decision-making for running an enterprise efficiently and economically.
The computer models assist a planner or entrepreneur to take up or discard the proposed scheme the modeling tool also help in monitoring and modifying the existing plan with changing environment specially with changing market scenarios.

Realistic basic information on various technical aspects of dairy farming, existing and expected costs and prices of raw and finished products as well as other on other economic parameters are the basis of the simulating modeling technique. The success of the models results largely depends on the truthfulness of the above-required information. Uttermost care should be used while collecting and compiling the information. There is always need to cross verification of the information collected for the modeling from different sources before incorporating in the structure of the model.

Computer based spreadsheet programs like Microsoft Excel program can be used for structuring the model, through interlinking logistically the various steps required to prepare a techno-economic feasibility plan. Using the available technical information on dairy production, available costs and prices various models using Microsoft Excel programs models for dairy farming has been developed for small-scale to medium-scale farmers. One such model is illustrated below. (The model can be obtained through e-mail, by sending request to the author (psokullu@yahoo.co.in).

TECHNO-ECONOMIC FEASIBILITY STUDY OF DAIRY FARMING UNIT USING COMPUTER SIMULATED MODEL (Twenty CROS-BRED COWS DAIRY UNIT MODEL)

RESULTS AT GLANCE:

<table>
<thead>
<tr>
<th>Year</th>
<th>1) CAPITAL REQUIRED (Rs)</th>
<th>2) RETURN ON CAPITAL INVESTMENT (%)</th>
<th>3) BC RATIO</th>
<th>4) ANNUAL CASH BALANCE AFTER DEBT SERVICE (Rs)</th>
<th>5) INCOME IF FAMILY LABOUR USED/YEAR (Rs)</th>
<th>6) AVERAGE INCOME/MONTH IF HIRED LABOUR (Rs)</th>
<th>7) AVERAGE INCOME/MONTH IF FAMILY LABOUR (Rs)</th>
<th>8) TOTAL GAINS (paid loan + F. Income + gain in Cow Unit)</th>
<th>9) COST OF MILK PRODUCTION (Rs)</th>
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<tbody>
<tr>
<td></td>
<td>Year-1</td>
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<td>Year-4</td>
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A) PRODUCTION PARAMETERS CONSIDERED AND LIVESTOCK STRENGTH:

<table>
<thead>
<tr>
<th>Size of the Dairy Unit (Cows)</th>
<th>20</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>Year-5</th>
<th>AV.</th>
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</thead>
<tbody>
<tr>
<td>Total Estimated animal units (Including calves)</td>
<td>22</td>
<td>24</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>24.72</td>
<td></td>
</tr>
<tr>
<td>Total lactating cows units</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
Average daily milk yield of cow purchased: 14.00

Increase in Milk Production Over Previous Year in %: 2 2 2 2 2.00

Inter-calving period (Months): 14

Culling Rate%: 20

### B) MILK PRODUCTION PROJECTIONS

<table>
<thead>
<tr>
<th>Year</th>
<th>Total number of expected lactations/ year*</th>
<th>Expected Milk yield/Lactation</th>
<th>Total milk production (lit)</th>
<th>Minus milk for feeding calves (lit) (300Lt/calf)</th>
<th>Milk available for sale (lit)</th>
<th>Daily availability of milk for sale</th>
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</tr>
<tr>
<td>3</td>
<td>17.1</td>
<td>4370</td>
<td>74909</td>
<td>5143</td>
<td>69766</td>
<td>191</td>
</tr>
<tr>
<td>4</td>
<td>17.1</td>
<td>4457</td>
<td>76407</td>
<td>5143</td>
<td>71264</td>
<td>195</td>
</tr>
<tr>
<td>5</td>
<td>17.1</td>
<td>4546</td>
<td>77935</td>
<td>5143</td>
<td>72792</td>
<td>199</td>
</tr>
</tbody>
</table>

### C) TECHNICAL PARAMETERS AND COST OF PURCHASED MATERIAL & SALE PRICES CONSIDERED:

<table>
<thead>
<tr>
<th>Market price of cow considered on per liter average daily yield (Rs)</th>
<th>5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated cost/cow (Rs)</td>
<td>70000</td>
</tr>
<tr>
<td>Estimated Housing, other structures + Equipments cost @90% /cow unit (Rs)</td>
<td>63000</td>
</tr>
<tr>
<td>Estimated capital Investment /cow unit (Rs)</td>
<td>133000</td>
</tr>
<tr>
<td>Estimated total capital (Rs)</td>
<td>2660000</td>
</tr>
<tr>
<td>Rate Of Interest</td>
<td>14</td>
</tr>
<tr>
<td>Margin money (%)</td>
<td>33</td>
</tr>
<tr>
<td>Owners Capital</td>
<td>877800</td>
</tr>
<tr>
<td>Loan (Rs) =</td>
<td>1782200</td>
</tr>
</tbody>
</table>

### Loan Calculation:

\[
\text{Loan (Rs)} = \text{Estimated total capital (Rs)} \times \frac{\text{Margin money} \%}{100}
\]

\[
= 2660000 \times \frac{33}{100} = 877800
\]

### Loan Repayment:

\[
\text{Annual Increase in Feed Cost, Milk Selling prices & wages %} = 3.00 3.00 3.00 3.00 3.00
\]

\[
\text{Milk Selling Price (Rs)/Lit. :} = 35.00 36.05 37.13 38.25 39.39 37.16
\]

\[
\text{Purchase price of Green Fodder (Rs)/KG:} = 2.00 2.06 2.12 2.19 2.25 2.12
\]

\[
\text{Purchase price of Straw (Rs)/KG:} = 5.00 5.15 5.30 5.46 5.63 5.31
\]

\[
\text{Purchase price of Concentrate (Rs)/KG:} = 21.50 22.15 22.81 23.49 24.20 22.83
\]

\[
\text{Contractual labor Wages /cow unit/year} = 10000 10300 10609 10927 11255 11593
\]

\[
\text{Number of manager/supervisor hired} = 1 1 1 1 1 1
\]

\[
\text{Supervisors (If required) salary / annum} = 120000 123600 127308 131127 135061 139113
\]
### D) EXPECTED SALE PROCEEDS

<table>
<thead>
<tr>
<th></th>
<th>Unit Cost (Rs.)</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>Year-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I) Milk</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35.00</td>
<td>2340000</td>
<td>2462112</td>
<td>2590514</td>
<td>2725528</td>
<td>2867491</td>
</tr>
<tr>
<td><strong>ii) Misc. Sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal unit sold (culled) 20% of total animal unit</td>
<td>35000</td>
<td>152600</td>
<td>166600</td>
<td>182000</td>
<td>182000</td>
<td>182000</td>
</tr>
<tr>
<td>Value of Surplus Heifers/cows (after 3 yr.) sold</td>
<td>63,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>216000</td>
<td>216000</td>
</tr>
<tr>
<td>Male calf (disposed of within 2 months)</td>
<td>50</td>
<td>429</td>
<td>429</td>
<td>429</td>
<td>429</td>
<td>429</td>
</tr>
<tr>
<td>Female Calf 50% disposed within 4-6 months</td>
<td>7500</td>
<td>32143</td>
<td>32143</td>
<td>32143</td>
<td>32143</td>
<td>32143</td>
</tr>
<tr>
<td>Insurance Claim cows (75% cost, of 2% mortality)</td>
<td>52,500</td>
<td>21000</td>
<td>21000</td>
<td>21000</td>
<td>21000</td>
<td>21000</td>
</tr>
<tr>
<td>Cow dung/animal unit</td>
<td>1500</td>
<td>32700</td>
<td>35700</td>
<td>39000</td>
<td>39000</td>
<td>39000</td>
</tr>
<tr>
<td><strong>iii) Total Sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2578871</td>
<td>2717983</td>
<td>2865086</td>
<td>3216099</td>
<td>3358063</td>
<td></td>
</tr>
</tbody>
</table>

### E) EXPECTED OPERATIONAL EXPENDITURE

<table>
<thead>
<tr>
<th></th>
<th>Unit Cost (Rs.)</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>Year-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ist year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Fodder cost @ 20kg/animal unit</td>
<td>2</td>
<td>318280</td>
<td>347480</td>
<td>379600</td>
<td>379600</td>
<td>379600</td>
</tr>
<tr>
<td>Straw @ 4Kg/animal unit</td>
<td>5</td>
<td>159140</td>
<td>178952</td>
<td>201359</td>
<td>207400</td>
<td>213622</td>
</tr>
<tr>
<td>Concentrate for milk production @ 3Kg/Lit</td>
<td>21.5</td>
<td>516000</td>
<td>542110</td>
<td>569540</td>
<td>598359</td>
<td>628636</td>
</tr>
<tr>
<td>Concentrate maintenance @ 0.5Kg/animal unit</td>
<td>21.5</td>
<td>85538</td>
<td>96187</td>
<td>108230</td>
<td>111477</td>
<td>114822</td>
</tr>
<tr>
<td>Medicines &amp; AI etc.</td>
<td>2000</td>
<td>43600</td>
<td>47600</td>
<td>52000</td>
<td>52000</td>
<td>52000</td>
</tr>
<tr>
<td>Rent/leasing cost for land for Shed etc/A.unit.</td>
<td>2000</td>
<td>43600</td>
<td>47600</td>
<td>52000</td>
<td>52000</td>
<td>52000</td>
</tr>
<tr>
<td>Contractual labor Wages /cow unit/year</td>
<td>10000</td>
<td>218000</td>
<td>245140</td>
<td>275834</td>
<td>284109</td>
<td>292632</td>
</tr>
<tr>
<td>Salary of supervisor/annum</td>
<td>120000</td>
<td>120000</td>
<td>123600</td>
<td>127308</td>
<td>131127</td>
<td>135061</td>
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<tr>
<td>Insurance premium cows only</td>
<td>4</td>
<td>56000</td>
<td>56000</td>
<td>56000</td>
<td>56000</td>
<td>56000</td>
</tr>
<tr>
<td>Electricity charges@ 2500 /animal unit/year</td>
<td>2500</td>
<td>54500</td>
<td>59500</td>
<td>65000</td>
<td>65000</td>
<td>65000</td>
</tr>
<tr>
<td>Other misc. charges@2500/animal unit</td>
<td>2500</td>
<td>54500</td>
<td>59500</td>
<td>65000</td>
<td>65000</td>
<td>65000</td>
</tr>
<tr>
<td>Replacement cost of animal unit culled</td>
<td>70000</td>
<td>280000</td>
<td>280000</td>
<td>280000</td>
<td>280000</td>
<td>280000</td>
</tr>
<tr>
<td>(a) Total operating cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating surplus (Total sale - Operational cost)</td>
<td>629714</td>
<td>634315</td>
<td>633214</td>
<td>934027</td>
<td>1023690</td>
<td></td>
</tr>
<tr>
<td>(b) Dep. On shed machinery &amp; Equipments</td>
<td>10</td>
<td>126000</td>
<td>113400</td>
<td>102060</td>
<td>91854</td>
<td>82669</td>
</tr>
<tr>
<td>Total Exp. (a+b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F) NET PROFIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                      | 503714         | 520915  | 531154  | 842173  | 941022  |          |
### G) RETURN ON CAPITAL INVEST. (%)

| Year | 18.94 | 19.58 | 19.97 | 31.66 | 35.38 |

### H) BC RATIO

| Year | 1.24 | 1.24 | 1.23 | 1.35 | 1.39 |

### I) COST OF MILK PRODUCTION (Rs)

| Year | 31.04 | 32.17 | 33.45 | 33.31 | 33.20 |

### J) LOAN DISBURSEMENT AND PAYMENT SCHEDULE

<table>
<thead>
<tr>
<th>Year</th>
<th>Loan</th>
<th>Interest</th>
<th>Instalment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1782200</td>
<td>249508</td>
<td>356440</td>
<td>605948</td>
</tr>
<tr>
<td>2</td>
<td>1425760</td>
<td>199606</td>
<td>356440</td>
<td>556046</td>
</tr>
<tr>
<td>3</td>
<td>1069320</td>
<td>149705</td>
<td>356440</td>
<td>506145</td>
</tr>
<tr>
<td>4</td>
<td>712880</td>
<td>99803</td>
<td>356440</td>
<td>456243</td>
</tr>
<tr>
<td>5</td>
<td>356440</td>
<td>49902</td>
<td>356440</td>
<td>406342</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### K) CASH BALANCE AFTER DEBT SERVICE

<table>
<thead>
<tr>
<th>Year</th>
<th>Open. Surplus</th>
<th>Payments</th>
<th>Cash balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>629714</td>
<td>605948</td>
<td>23766</td>
</tr>
<tr>
<td>2</td>
<td>634315</td>
<td>556046</td>
<td>78268</td>
</tr>
<tr>
<td>3</td>
<td>633214</td>
<td>506145</td>
<td>127069</td>
</tr>
<tr>
<td>4</td>
<td>934027</td>
<td>456243</td>
<td>477784</td>
</tr>
<tr>
<td>5</td>
<td>1023690</td>
<td>406342</td>
<td>617349</td>
</tr>
</tbody>
</table>

### L) CASH BALANCE IF FAMILY LABOUR EMPLOYED (Rs)

<table>
<thead>
<tr>
<th>Year</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>Year-5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>361766</td>
<td>447008</td>
<td>530211</td>
<td>893020</td>
<td>1045042</td>
</tr>
</tbody>
</table>
Introduction

Livestock plays an important role in the socio-economic life of India. With a large human population and about 250 million economically strong potential consumers, the domestic demand for these food products are increasing rapidly, the demand often exceeding the supply. In the last 50 years, India has developed a strong and professionally competent technical, marketing and business manpower in Livestock production and Information Technology. This is an added advantage over many developing countries of Asia and Africa. Availability of competent and comparatively low-cost manpower in India is a great asset which is attracting foreign investors. It is estimated that almost 18 million people derive their livelihood from livestock.

The livestock economy penetrates sections of rural society both vertically and laterally, supposedly more equitably than land holdings. However, it is a matter of growing concern that despite 70% of India's livestock being owned by landless, marginal and small farmers, recent studies across India indicate that over half of all these households are 'non-livestock owners,' challenging the well entrenched notions of livestock being more equitably distributed than land.

Extension Focus required in the issues of Livestock Sector

There have been dramatic changes in livestock population and composition over the past five decades, many of which have negatively impacted the poor. While total population and density of livestock has increased over time, the number per rural household has declined. There was a drastic decline of bullocks post the eighties, with the share of farm animals in power supply declining from 71% in 1961 to less than 23% in 1991. The 59th round of the NSSO (National Sample Survey Organisation) reports that working cattle in rural areas declined by 25% between 1991-92 and 2002-03. There has been a corresponding shift in composition of the bovine population from cattle to buffalos.

Change in livestock population and composition has varied across different landholding categories, with the decline in livestock holding being sharpest amongst landless households. Surprisingly only 15-20% of households own sheep and goat.

The green revolution agriculture policy directly impacted the livestock economy in extremely negative ways. Mechanization replaced bullock power; hybrid mono-crops resulted in reduced stalk size, diversity and quality of crop-residue; and chemicals and pesticides polluted the environment, thereby compromising the health of humans, animals and plants. Finally, water-intensive crops and fodder varieties consumed water far in excess of what the agro-eco regions could replace/ recharge. This was a major reason for the collapse of traditional water harvesting and water management systems in the dry lands, which were perhaps the only source of drinking water for all village and migratory livestock, apart from their other traditional uses.

The global demand for livestock products is expected to increase by over 60 percent by 2050. FAO estimates present global livestock populations at around 22 billion poultry, 1 billion pigs, 1.6
billion cattle and buffalo, 2 billion sheep and goats. Those populations are needed to satisfy today's demand for such products, so the livestock sector is under significant pressure to greatly increase the amount of safe, nutritious feed available to animals to provide the products needed in the future. Providing animals with adequate, balanced diets, free of toxins and contaminants is essential to enhancing their productivity and welfare.

Perhaps the most critical problem is the acute scarcity of fodder (in terms of quality and quantity) and water for the greater part of the year, resulting in reduced productivity of animals and high rates of disease and death. Fodder and water insecurity forces many farmers to sell their valuable and productive animals at distress rates during summer, only to repurchase them at exorbitant prices at the onset of monsoons.

Limited livestock ownership amongst the poor and landless households might further reduce their stakes in common property/natural resources, which is not only inadequate but also reduces their coping ability particularly in vulnerable dry land contexts.

Land reforms often translated into distribution of public grazing lands, even as the landlords continued to possess fertile lands. The landless were given the uncultivable land, and the village lost its common grazing spaces. Shrinking CPRs pushed more and more livestock into the forests areas. Forestry and so-called wasteland plantation programmes further reduced grazing access.

Many of the waste lands were actually grazing lands used by the village poor, the landless or migratory pastoral herding communities but seldom have these ‘grazing’ needs been carefully considered in ‘wasteland development’ programmes. Another major problem leading to further degradation and depletion of our fodder resources has been the treatment of natural grasslands and pastures in typically the same way as forests have been treated: excessive protection and exclusion of local communities and their livestock.

Dry land regions also traditionally harboured the ‘grasslands’ of India, providing pasture/grass for some parts of the year. In these harsh climates with minimal precipitation, sustained agriculture through the year is extremely difficult and it is livestock which has historically played an important role in people's livelihoods.

Livestock are better and more efficient utilisers of the available biomass. They contribute to the grasslands by dispersing valuable grass seeds, keeping unnecessary weeds in check and by fertilising the soil with their dung and urine. As natural grasses are not available throughout the year, migratory or semi-migratory systems of livestock rearing are practiced, particularly by the pastoralists and, sometimes in acute water and fodder scarce situations, also by farmers who are engaged in more settled mixed crop-livestock farming.

Livestock production systems, in the country can broadly be described under four categories: pastoral, forest-based, mixed crop-livestock and industrial/commercial production systems. While the former three have existed and evolved in the country since time immemorial, the presence of the latter is a relatively recent phenomenon which draws upon a system that evolved in the developed countries. Mixed crop-livestock farming and pastoralism are the two common production systems found across our rainfed agriculture zones. In the former, farmers derive their livelihood somewhat equally from agriculture and livestock; in the latter, people's livelihoods depend primarily upon their livestock, which are exclusively maintained on grazing.

Presently, only a very small fraction of the livestock sector exists as industrialized systems. Examples include commercial poultry farms, dairy farms and a few commercial goat and pig farms.
While industrial systems permit reduction of costs of production due to economies of scale, their social, environmental and public health costs may prove expensive in the long run. Industrial systems require conversion of good agricultural land that can feed humans to fodder plots to feed animals. They accelerate the conversion of natural forests and grass-lands to pasture. History is witness that the process of industrialization in the developed world has wiped out poor farmers, small enterprises and local breeds. About 90% of cattle in the USA and 60% of all European cattle belong to one breed. Broiler and layer chicken in organized farms across the world rely on less than half a dozen breeds, although there are 606 breeds of chicken worldwide.

Animal diseases reduce the production potential of livestock and cause enormous economic loss. There are number of diseases such as rinderpest, foot-and-mouth disease, haemorrhagic septicaemia, mastitis, brucellosis, tuberculosis, black quarter, etc. that affect the livestock production in India. The recent outbreak of bird flu in India demonstrates the pressures of global trade and its reflecting impact on small holders. Thus, prevention and control of diseases have been a major concern of India's livestock research and extension system.

Based on the above situation, the small livestock producers of our country have to be facilitated to enable them to overcome the problems faced by them in the livestock sector and gain benefit from this huge demand and to compete with emerging organised industries. In this regard, small livestock producers should be integrated vertically with livestock food processors through contract farming, improve the efficiency of their operations and the productivity of their animals through forming them into commodity interest Groups, providing better veterinary advisory services etc.

The type and magnitude of the problems vary with various factors such as socio-economic conditions of the livestock keepers, type of enterprises, availability of the extension services etc. The problems however, can be effectively handled only through demand driven and client specific extension system.

**Demand Driven Approaches**

*Demand-driven* is a relatively recent label for a notion that has been around since people began to write about extension as an academic discipline and educational practice (Scarborough *et al.* 1997). It captures the idea that the information, advice and other services offered by extension professionals should be tailored to the expressed demands of the clients or recipients of the service: not just to their “needs” as identified by various stakeholders (government, corporations, scientists, extension professionals), but the things they say they want. Until the current reforms of public agricultural extension began in the 1990s, making extension demand-led was commonly seen as a question of techniques and methods. Tools like the Problem Census (Crouch 1991) were developed for identifying what clients wanted. However, operationally there has always been a tension within public sector services between what the client wants to learn and what the government wants the client to know and do. This tension is typically resolved by enshrining the principle of being responsive to clients in the job description of extension professionals and the operational procedures of the organizations within which they work. Still, the main line of their accountability has remained to their line manager and, ultimately, to the government department that pays their salary. Hence, more than specific techniques and methods, focus should be on making institutional changes, which will lead extension service providers to be more responsive to what clients want. In most cases, this involves changing the distribution of power and responsibilities among three key sets of actors in the extension system: (a) clients, (b) those who deliver the service, and (c) government.
**Five major things to bring demand driven extension**

First, making government extension services demand-led requires a major change in organizational culture and professional attitudes. This requires training and a change in operational procedures and will not be achieved overnight.

Second, giving clients a substantial measure of financial control is more likely to lead to responsiveness than exhortation and training alone. If this is combined with cost sharing, there will be motivation on both sides to ensure that services respond to demand.

Third, the institutional structures established to achieve responsiveness could have far-reaching positive benefits in terms, for example, of the capacity of farmer organizations to engage in a broader range of development initiatives.

Fourth, moving to more demand-led extension is not a cheap option, and there is no guarantee that on a simple economic calculation the benefits will outweigh the costs.

Fifth, setting up demand-led arrangements that give a voice to resource-poor and less well-educated farmers, is a major challenge.

One question is that: “To what extent should extension services be demand-led?” The most demand-led situation is one where clients voluntarily pay the full cost of services they receive, whether as individuals or collectively as part of a group or association. In such cases, those providing services must respond to clients’ requirements or they will soon be out of business. But in Governments sponsored extension services, Government invest in extension because they expect it to contribute to the achievement of policy goals, ranging from stimulating the rural economy and enhancing food security, to protecting the environment and alleviating rural poverty. In such contexts, extension can never be entirely demand-led--government will always have an agenda. The challenge is to establish institutional arrangements that ensure clients receive advisory and other services that satisfy their own demands within parameters compatible with government policy (Garforth et al. 2003).

The extension process used to initiate a demand driven extension is similar to learning cycles. It has been described in six steps with easy to use tools for each step for extension functionaries to use in the field. Once Veterinary Extension Functionaries have been established they should use the same steps in conducting further learning process. The steps within approach include:

1. **Introduction of the Village Extension System**
   Prior to initiating any production related activity, the concept of the VES is introduced. This describes the steps to be taken and their own responsibility to scale up activities following the learning process.

2. **Training Needs Assessment (TNA) - Keep It Short and Simple (KISS)**
   Farmers prioritize and analyze their problems, and identify skills needed to address these.

3. **Constraints Analysis for a production process**
   This supplements the TNA-KISS, helping farmers to identify the underlying cause of production problems, taking account of the roles of both men and women.

4. **Success, Implementation Failure and Training Needs**
   Assists the production group to examine progress made towards their original objectives through their learning process and decide on further actions to be taken.
5. **Farmer to Farmer Exchange**

Farmers from the production group analyse the results of the learning project and decide on follow-up activities. This involved other interested farmers as well as those in the original production group.

6. **Extend Village Extension System**

The initial learning is evaluated by all villages, new activities planned and upscaled in large scale

**Extension Reforms in India to facilitate Demand Driven Extension:** The National Agricultural Technology Project (NATP) was launched with the assistance of World Bank to address specific system constraints, weaknesses and gaps that remained un-addressed by previous research and extension projects. There are many system constraints and weaknesses in the extension system like Multiplicity of technology transfer systems, Narrow focus of the agricultural systems, Lack of farmer focus and feedback, Inadequate technical capacity within the extension system, Need for intensifying farmer training, Weak research and extension linkages, Poor communications capacity among the functionaries and departments, Inadequate operating resources and financial sustainability etc.

Innovations in Technology Dissemination (ITD) component, in particular, was expected to test new innovations in technology dissemination with restructured institutional and operational arrangements resulting in delineation of future direction of the extension system and, at the same time, bridge Research-Extension-Farmer-Market (R-E-F-M) linkage problems that currently constrain the flow of appropriate technology to farmers.

The main goal of ITD component of NATP was to increase farmer input into program planning and resource allocation especially at block level and to increase accountability of stakeholders. Further, it was also to increase the coordination and integration so that thrust areas such as farming system innovations, farmers' organizations, technical gaps, natural resource management could be more effectively and efficiently implemented.

An autonomous institution — Agricultural Technology Management Agency (ATMA) has been established in these project districts as a registered society representing various stakeholders, including farmers, in project planning and implementation under the guidance of the National Institute of Agricultural Extension Management (MANAGE), Hyderabad.

During the pilot testing, NATP was found to be a cost effective and sustainable extension system with the following thrust areas:

- Focus on farms and the farming systems
- Integration of efforts of multiple service providers
- Ownership of the Agricultural Technology System (ATS) by key stakeholders
- Technological interventions in the form of intensification and diversification of the farming systems
- Value addition and marketing intervention
- Empowerment of the farming community
- Multiple communication and information support.

Based on the success of extension reforms, now, it has been up-scaled to all the developmental districts across the country. The Key Extension Reforms promoted under the new institutional mechanism are as follows
• Decentralized decision making through new institutional arrangements in the form of ATMA Convergence of line departments at block and district level and allocate the funds on gap filling mode
• Multi agency extension strategies. Encourage private sector in extension activities and minimum 10% allocation for the private sector
• Broad-based extension delivery in the form of Farming System Approach (FSA) Group approach to extension Farmers Organisations & Farmers Interest Groups
• Mainstreaming Gender in extension activities, a minimum 30% allocation
• Sustainability of extension services through minimum 10% beneficiary contribution Bottom-up planning in the form of Strategic Research and Extension Plan

The onus of translating these into action is with the ATMA, created in each district which consists of all the line departments. The responsibility of ATMA is to bring together researchers, extensionists of agriculture and allied departments, farmers and other stakeholders (including NGOs, corporate and private sectors), on the basis of joint diagnostic studies, district extension plan and recommendations for expanded adaptive research to introduce innovations in technology dissemination matching to local needs and situations. The purpose of Extension Reforms is to promote new institutional arrangements and operational procedures – not merely strengthen the existing extension system. One of the important goals is to decentralize decision making to the district level and deliver demand driven extension through the creation of Agricultural Technology Management Agency (ATMA). A second goal is to increase farmer input into programme planning and resource allocation, especially at the block level, and to increase accountability to stakeholders. A third major goal is to increase programme coordination and integration, so that the programme thrusts such as Farming System Innovations, Farmers’ Organizations, Technology gaps and Natural Resource Management can be more effectively and efficiently implemented.

Rashtriya Gokul Mission

This mission is proposed to be implemented on 100% grant-in-aid basis with an amount of Rs. 500/- Crores during the 12th Five-Year Plan. It will be implemented with an allocation of Rs. 150/- Crores during the year 2014-15. Rashtriya Gokul Mission will be implemented through the “State Implementing Agency” (SIA) viz Livestock Development Boards. Further, the ‘State Gauseva Ayog’ would be given the mandate to sponsor proposals to the SIAs (LDBs) and monitor implementation of the sponsored proposals. All the agencies as well as stakeholders, having a role in indigenous cattle development will be the “Participating Agencies”.

The cattle genetic resource of India is represented by 37 well-recognized 'Indigenous Breeds'. Indigenous cattle, in India, are robust and resilient; and, are particularly suited to the climate and environment of their respective breeding tracts. They are endowed with qualities of heat tolerance, resistance to diseases and the ability to thrive under extreme climatic stress and less than optimal nutrition. Indigenous cattle are well-known for their quality of heat-tolerance and ability to withstand extreme climatic conditions. Studies of impact of Climate Change and effect of temperature rise on milk production of dairy animals indicate that temperature rise due to global warming will negatively impact milk production. Due to their unique characteristics of heat tolerance, tick and pest resistance, resistance to diseases and the ability to thrive under extreme climatic conditions, these 4 animals have
been imported by several countries including USA, Brazil and Australia for development of heat-tolerant & disease-resistant stock.

Most of the 'Indigenous Breeds' possess A2 allele of Beta Casein, as compared to Exotic Cattle, which are known to possess higher frequency of A1 type allele. Reportedly, A1 milk is possibly associated with some metabolic disorders like diabetes, heart diseases etc; while A2 milk (produced by Indigenous Breeds) does not have any such association. The indigenous dairy breeds with potential for development as commercially viable milch cattle in a shorter time frame are: Sahiwal in Punjab; Rathi and Tharparkar in Rajasthan; and Gir and Kankrej in Gujarat. If these breeds are selectively crossed with bulls selected through sibling and progeny testing the F-1 off-springs would be commercially viable. In this manner, the entire population of the breed can be upgraded over a few generations.

**Objectives of the Scheme:**

a) To undertake breed improvement programme for indigenous cattle breeds, so as to improve the genetic makeup and increase the stock.

b) To enhance milk production and productivity of indigenous bovines.

c) To upgrade non-descript cattle using elite indigenous breeds like: Gir, Sahiwal, Rathi, Deoni, Tharparkar, Red Sindhi, etc.

d) To distribute disease-free, high genetic merit bulls of indigenous breeds for natural service.

**Components of the Scheme:** “Rashtriya Gokul Mission” will have the following components:

a) Establishment of Village level Integrated Indigenous Cattle Centres viz “Gokul Gram”
   - in the breeding tracts and
   - near metropolitan cities for housing the urban cattle.

b) Strengthening of bull mother farms to conserve high genetic merit Indigenous Breeds.

c) Establishment of ‘Field Performance Recording’ (FPR) in the breeding tract.

d) Assistance to Institutions/Institutes which are repositories of best germplasm.

e) Implementation of Pedigree Selection Program for the Indigenous Breeds with large population.

f) Establishment of Breeder’s Societies (Gopalan Sangh)

g) Distribution of disease-free high genetic merit bulls for natural service.

h) Incentive to farmers maintaining elite animals of indigenous breeds.

i) Heifer-rearing program.

j) Award to Farmers (“Gopal Ratna”) and “Breeders’ Societies” (Kamadhenu)

k) Organization of ‘Milk Yield Competitions’ for indigenous breeds.

l) Organization of Training Program for technical and non-technical personnel working at the Institute/Institutions engaged in cattle development.

**Gokul Gram Project**

**Objectives:** The proposed “Integrated Indigenous Cattle Centres” – “Gokul Grams” would be established under the Rashtriya Gokul Gram Mission with the objective of conservation and development of indigenous bovine breeds in the country. **Gokul Gram** will be set up in:

a) The Native Breeding Tract of an indigenous bovine breed and
b) On the suburbs of Metropolitan and large cities (for urban cattle) with the following aims:

- To promote indigenous cattle rearing and conservation in a scientific manner.
- To enhance productivity of indigenous breeds and increase economic returns from animal products in a sustainable manner.
- To propagate high genetic merit bulls of indigenous breeds.
- To encourage appropriate technology for use of Draught Animal Power.
- To provide balanced nutrition and integrated animal health care.
- To optimize modern Farm Management practices and promote Common Resource Management.
- To promote Green Power and Eco-technology.

_Gokul Gram_ would be established as an “Integrated Cattle Breeding Centre” for the development of indigenous breeds, apart from serving as a source for supply of quality breeding stock to the farmers in the breeding tract. Some of these will also be established in the vicinity of Metropolitan and large cities, in order to house urban indigenous cattle.

**Strengthening Infrastructure for Quality & Clean Milk Production**

This scheme was started during the year 2003-04 (Oct 2003) for the Tenth Five-year Plan. It is being continued during the 11th Five-year Plan as merged scheme together with ‘Intensive Dairy Development Program’ (IDDP) during 2013-14.

**Objectives of the scheme**

- Creation of necessary infrastructure for production of quality milk at the farmers level up to the points of consumption
- Improvement of milking procedure at the farmers level
- Training and Strengthening of infrastructure to create mass awareness about importance of clean milk production.

**Implementing Agencies**

It is being implemented through the State Government by District Cooperative Milk Union / State level Milk Federation.

**Ration Balancing Program**

A program initiated by NDDB to educate the farmers on balanced feeding of their dairy animals. Farmers feed their animals based on their traditional knowledge and information passed through generations with crop residues, locally available one or two feed ingredients like brans, oil-cakes, _chunnies_, grains etc. and seasonally available green fodders. They rarely offer mineral mixture to their animals or in a very less quantity of 25g to 50g per day. This leads to an imbalance of protein, energy and minerals in their ration. Therefore, it is necessary to educate farmers on feeding of balanced ration. NDDB, has developed a software that can be used on desktops, laptops, netbooks, tablets as well as phones. With the help of this software balanced ration is formulated considering the animal’s profile, i.e. cattle or buffalo, age, milk production, milk fat, and feeding regime etc. and milk producers are advised to adjust the quantity of locally available feed ingredients offered to their animals along with
area specific mineral mixture. Farmers feeding balanced ration in different regions of the country have experienced an increase in their net daily income in the range of Rs 15 to 25 per animal.

**Benefits of Ration Balancing Program:**
- Proper use of locally available feed resources at possible least cost
- Increases milk production with more fat and SNF
- Increase in net daily income
- Improves reproduction efficiency
- Reduces inter-calving period and increases productive life of animals
- Improves the general health of animals
- Improves the growth rate in growing calves, leading to early maturity.

**‘Ovulation Synchronisation’**

The National Dairy Development Board (NDDB) has successfully implemented its ‘ovulation synchronisation’ program in Guntur and Krishna districts of erstwhile State of Andhra Pradesh. The program formulated to solve the problem of huge time gap in buffalo breeding was implemented. These buffaloes had a record of long post-partem anoestrum, which meant that they took a long time for the ovulation cycle to kick in. NDDB has also provided infrastructure, plant and processing facilities, education, training and awareness program to farmers from village to district level, thus adding to the value chain in the dairy co-operatives

**DIPA Programmer (Progeny-testing Program)**

Objective of this program is to obtain breed of high yielding milch-animals locally under the program of improvement of milch-animals/animal breed as well by endorsing cow bulls/buffalo bulls, e.g. *Sumul Animal Genetics at National Level* … wherein, an “Elite herd” are being formed in which high profile animals are being reared & inseminated with selected mating or inseminated by proven bull semen dose under the “DIPA SCHEME” (A progeny testing program of NDDB) of *Sumul Dairy*. Due to the programs like this, high-yielding animals are being produced.

**Multi-Pronged Program**

In a bid to raise milk productivity and ensure remunerative prices to dairy farmers in Odisha, National Dairy Development Board (NDDB) has launched a multi-pronged program involving cooperatives. Therefore, there is considerable scope to increase coverage and provide greater market access to small milk producers of the state. Under NDP-I, seven sub-projects of three Implementing Agencies have been approved. NDP-I would emphasize on Rational Balancing Program (RBP), Fodder Demonstration and Village Based Milk Procurement System (VBMPS). With a coverage of 600 villages, local resource persons would be providing ration balancing advisory services to 44,000 milch animals and adding about 6000 additional milk producers are to be enrolled of whom 50 per cent would be women. Stating that NDDB’s efforts are geared towards involving more women in collective business and governance. Strengthening existing dairy cooperatives, formation of women dairy cooperatives and increased participation by women in existing cooperatives would be emphasized.
**Rechristened PURA**

The scheme launched from Thrissur and Malapuram districts of Kerala is rechristened as new PURA (Provision of Urban Amenities in Rural Areas), which is aimed at creating physical infrastructure in rural areas of the country in the Public-Private Partnership mode. It is well known fact that GDFP promotes the production and marketing of safe, quality-assured milk and dairy products, which is highly impossible without having proper infrastructure.

**Summary**

The decentralized institutional mechanism and a well-defined process have been established to identify and implement the Research and Extension gaps in the agriculture, livestock and other sectors. The extension reforms will be very much useful to the Animal husbandry department to identify the critical gaps in the livestock sector, develop suitable action plan, dovetail other state and center sector schemes to bring professionalism in demand driven extension.

Milk contains approximately 86% water, 4.7% sugar (lactose), 4.1% fat, 4.2% protein and 1% minerals. It supports the growth of micro-organisms and thus is prone to contamination. The purpose of milking a dairy cow is to obtain milk that is fit for human consumption. Milk from the udder of a healthy cow contains very few bacteria and to ensure that it remains fresh for long it should be handled under conditions of good hygiene. Unclean milk can be a source of disease to the consumer, rejected at the market and so is a loss to the farmer, does not keep for long and is not good for processing.

**Milking**

Milking is the key operation on a dairy farm; it depends on the income derived. Milking is an art requiring experience and skill. Milking should be conducted gently, quietly, quickly, cleanly and completely. Cows remaining comfortable yield more milk than a roughly handled and excited cow. Maintenance of clean condition in the milking barn results both in better udder health and production of milk that remains wholesome for longer time. The act of milking should be finished within 5 to 7 minutes, so that the udder can be emptied completely so long as the effect of oxytocin is available. Complete milking has to be done, lest the residual milk may act an inducer for mastitis causing organisms and the overall yield may also be less.

The milking procedure is the first step in obtaining clean milk. At the farm this starts with ensuring the cow to be milked is healthy.

**Equipment**

- Use seamless aluminum or stainless steel cans for milking and storing milk. Plastic Container is difficult to clean.
- Clean utensils immediately after milking or after emptying milk: rinse with cold Water, scrub with a brush using hot water with detergent then rinse with cold water.
- Place upside down on a rack and dry in the sun.
- Store utensils in a safe, clean and well ventilated room.

**Milking**

Milking is the most important activity in a dairy farm. Milk can be extracted either by hand or by machine. Hand milking is an art, which is improved with practice. Alveolar cells synthesize milk, which is stored in the gland cistern. The sphincter muscle at the tip of the teat (teat sphincter) control milk let down. For efficient milking, teat should be of moderate size, symmetrical and enough tension of the sphincter muscle.

**Practical aspects of milking:**

Milk synthesis and secretion is continuous unless interfered with by pressure from the filling of the gland cistern (this explains why more milk is extracted by frequent emptying (milking) to ensure pressure does not built up). The ejection of milk from alveolar lumen is under influence of oxytocin (hormone).
Steps for clean milk production

The cow:

The cow should be well fed with a diet well balanced with forage and concentrates to ensure high production of good quality milk. Feeding very high amounts of concentrates and low amounts of forages results in milk with low butter fat. On the other hand feeding too little concentrates leads to low milk yield.

An unhealthy cow will feed less and produce less milk. Cows should always be kept healthy and clean as sick animals can transmit diseases like tuberculosis and brucellosis to milk consumers. If a cow is suspected to be sick, a qualified veterinary practitioner should be contacted immediately. Milk from a cow that is being treated with antibiotics should not be consumed or sold until the withdrawal period is over. Farmers are encouraged to vaccinate their animals against brucellosis. Animals should also be checked periodically for all types of contagious diseases and treated promptly in case they are infected.

Mastitis is an inflammation of the mammary glands in the udder caused by infection with disease-causing bacteria which can be controlled by observing general hygiene and proper milking procedure.

Milking Parlour:

- A milking shed (parlor) which can be permanent or movable should be constructed. It should be located away from any smells.
- The floor of shed should be clean and dry and if possible have a cement floor for ease of cleaning.
- The shed should be cleaned after every milking and animals kept off outside milking time.

Milker:

The Milker Should

- be healthy and clean
- Maintain short nails and hair (for ladies, cover the head when milking)
- Never smoke during milking time
- Milk quickly and completely without interruptions

Cow Handling & Preparation:

The cow is brought to the milking parlour as calmly as possible. Frightening the animal at this stage has a negative effect on milk let down due to release of adrenaline (hormone) which has a negative effect on milk letdown.

1. Feed the cow it's production ration (this is optional depending on the feeding system) - This calms the animal and stimulates milk letdown.
2. Restrain animal - tie hind legs above hock joint in the form of loose knot should be used to safeguard both animal and man (applicable only for hand milking).
3. Wash hands with soap and clean water before milking. Dry hands with towel.
4. Test for mastitis using a strip cup - strip first few rays of milk into strip cup from each quarter and observe for any abnormalities. If mastitis is detected, the cow should be milked last.
5. Wash udder with warm clean water with disinfectant using a clean towel. Warm water also stimulates milk let down. Dry udder using a dry towel.

6. Apply milking jelly - prevents cracking of teats and eases milking (for hand milking only)

7. Milk quickly and completely by squeezing the teat, do not pull. Milking each cow should take 7–10 minutes at most.

8. Use clean containers for milking.

9. After milking: Strip the animal - getting last drops of milk from udder to avoid incomplete milking (can lead to mastitis).

10. After milking dip the teats in a teat dip (disinfectant to ensure that bacteria do not gain entry milking (can lead to mastitis).

**Pre-dipping**

- Pre-milking sanitation can be achieved by pre-dipping the teats with a sanitizing product such as 0.5 % iodine.
- At least three-fourths of each teat should be covered with pre-dip solution. Pre-dip must remain in contact with the teat for 30 seconds before drying
- Teats only should be dried with a single use cloth or paper towel.
- The teat should be vigorously dried with special attention paid to the teat end

**Actual Milking**

Once the pre-milking cleans the milk passage, actual milking can be started. Full hand method is the best as it is most kind to the teats. The milker should be clean. After milking teats has to be dipped into a bactericide to minimize the risk of infection. The practice of dipping of fingers into the milk and then wetting the teats to soften them is not recommended. Care has to be taken that animals are not allowed to sit soon after milking, because the teat canal remains open for some time.

**Proper cleaning of milk equipment**

**Milk cans**

Immediately cans are emptied of milk they should be cleaned as follows:

- Rinse with cold water.
- Scrubbing with brush and warm detergent (any un-perfumed liquid soap will do).
- Rinse with cold water.
- Sterilize (sanitize) with boiling water or steam if available or use dairy sanitizing solution such hypochlorite or commercial brand preparations in accordance with manufacturer's instructions.
- Dry cans on a drying rack. Exposure to sunlight will enhance killing off bacteria during drip drying of cans.

**Milking machines**

Milking machines should be cleaned according to recommended practice:

- Rinse with cold water.
• Use the “cleaning-in-place” (CIP) method where detergent in hot water is circulated in the system.
• Rinse with hot water. Timely replacement of worn out rubber parts should be undertaken regularly.

Cleaning and sanitation of milk transportation equipment
Transport of larger quantities of milk requires insulated bulk tankers. These are very expensive and require special additional equipment like pumps which should also be thoroughly cleaned by the “cleaning-in-place” (CIP) method. Milk transportation equipment should be properly cleaned and sanitized because milk provides an ideal medium for growth of bacteria. Select detergents and sanitizers that will not corrode the material from which the equipment is made. Cleaning and Sanitizing are complementary processes.

Milking System (service and maintenance)
• For a continuous trouble free operation with high quality milk regular maintenance and exchange of wear and tear parts is necessary.
• A serious supplier and installer will offer a scheduled plant service to give the required maintenance.
• Such a service will include dismantling and a complete cleaning of the plant, exchange of all required wear and tear parts according to established time limits, checking of all essential functions and parameters and a complete test run.
• Such preventive scheduled services will markedly reduce operational breakdowns that by experience always will be more costly in the longer perspective.
• A preventive service works as an assurance and reduces production losses and gives peace of mind.

Milk Storage
Store the milk without chemicals in a lockable cool and clean place. Do not mix warm (morning) milk with cool (evening) milk; deliver to the collection centre separately or cool the warm milk before mixing.

Milk Preservation
Milk is highly perishable hence it should be preserved to ensure it is safe for human consumption at the home and that it reaches the processor and/or final consumer in good condition. The success of any preservation method is highly dependent on hygiene conditions under which the milk was produced. Hence milk produced from a healthy cow, milked by a healthy milker using clean equipment will be clean and more likely to keep long. Milk can be preserved using the following simple methods:

Cooling
Cooling milk slows down the growth and activity of germs and hence prevents spoilage.
Milk can be cooled through:
• Keeping under a shade
• Dipping the containers with milk in a cold water bath, flowing stream of cooling tank
• Keeping the milk in a refrigerator
• Using a charcoal cooler
• Using cooling rings: if cool (10°C or less) running water is available, you can pass it through a perforated ring so that it flows over the cans
• Using an electrical cooling tank. When cooling milk, loosen the lids of the cans to allow the air to escape, and make sure no water gets into the milk. Cover the cooling tank with a lid to protect the milk from insects and dust

Heating

Heating kills many bacteria and heated milk will keep longer. It also gets rid of harmful microorganisms that could transfer diseases from the cow to humans. The best method of heating milk (to retain the taste and avoiding off-flavors) is to immerse the milk can in boiling water for at least 30 minutes. Milk to be consumed at home should be boiled, using a large pan or other cooking container. Milk can be heated to a certain temperature and kept at that temperature for some time to kill germs, then cooled. This is called pasteurization. A thermometer is required for monitoring the temperatures. Milk can also be subjected to low heat treatment. Heat the milk to 65°C then cool.

Chemicals

Chemicals can be used to preserve milk but only on advice from the collecting centre because it is important to use the correct types and amounts. Use of chemicals is illegal in some countries and only milk delivered to a dairy plant should be preserved with chemicals. Nevertheless, chemicals allow un-cooled milk to keep longer even in high temperatures and, if used correctly, chemicals have little effect on the physical quality of the milk.
Effective Disposal and Utilization of Dairy farm Waste

S.S. Lathwal and Indu Devi

Principal Scientist (LPM) and Research Scholar
Livestock Research Centre, ICAR-N.D.R.I., Karnal

Environmental friendly disposal and utilization of animal manure is a significant challenge to the livestock industry. Animal waste contains many beneficial constituents that if recycled effectively, can be used as fertilizer for crops, fodder for animals and to produce energy. Animal manure is rich in nitrogen, phosphorus and potassium. In addition to providing supplemental nutrients for crop growth, manure has several beneficial effects on soil properties. Application of organic waste decreases the bulk density of the soil by increasing both the organic fraction of the soil and the stability of aggregates. Organic wastes also improves water filtration rate, water holding capacity and the hydraulic conductivity of the soil. All these properties of animal waste will be available only if they are carefully managed. If not they might cause detrimental effects on the environment. The most common environment concern with animal wastes is that it affects the atmospheric air with offensive odors, release of large quantities of CO₂ and ammonia which might contribute to acid rain and the green house effect. It could also pollute water sources and be instrumental in spreading infectious diseases. If the disposal of water is not properly planned it might create social tension owing to the release of odours and contamination of water sources. Proper disposal and returning of nutrients back in the soil without pollution and spreading of diseases/pathogens, is required for efficient utilization of wastes on large farms. Converting animal waste into energy can be a triple-hitter: It not only helps reduce waste going to landfills or from being released as gas into the atmosphere, but saves energy and money.

Two types of animal waste are produced:

(i) Solid waste (dung): About ninety percent of manure is currently handled as a solid (e.g., in pastures or stacks on dry lots) but this portion produces only about twenty percent of total methane emissions from manure.

(ii) Slurry or liquid waste: Liquid manure management systems such as lagoons, ponds, tanks, or pits, handle a much smaller portion of total manure but comprise 80 percent of total methane emissions from manure. Liquid management is the more cost-effective option for manure management at large farms.

Different methods for disposing solid waste and slurry are used. Handling and utilization of slurry is more difficult. Various methods for the disposal of these wastes along with its efficient utilization are shown in Fig. 1.

![Figure 1. Farm waste disposal and utilization](image-url)
Solid manure (cow dung) contains:

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<tr>
<td>Moisture</td>
<td>77 per cent</td>
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<tr>
<td>Organic matter</td>
<td>20 per cent</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.32 per cent</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.14 per cent</td>
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<tr>
<td>Potassium</td>
<td>0.30 per cent</td>
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<tr>
<td>Calcium</td>
<td>0.40 per cent</td>
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Utilization of these nutrients by proper technique is highly desirable for efficient utilization of the animal wastes.

**Various techniques used are:**

1. Composting.
2. Biogas production (anaerobic fermentation).
3. Aerobic oxidation in ditches/Lagoons/lakes.
4. Direct application in field.
5. Use as fish feed in fish ponds.
6. For growing algae (diluted slurry).
7. Other techniques (less popular) recycling as filler in animal feed (i.e. poultry waste in cattle feed, etc.).

**Out of the above mentioned techniques most commonly employed are:**

(i) Composting
(ii) Biogas production (anaerobic fermentation)
(iii) Direct application or application of slurry after aerobic oxidation.

**Disposal of Manure:**

Frequency of Removal of Manure: Twice daily

**Solid Manure:**

By means of wheel barrow and shovel, disposed into a pit for decomposition. Such manure will return 75 per cent of its fertilizing value to soil. Manure pits should be about 200 meters away in a place where no foul smell would pass through buildings. The production of manure from each dairy cow is about 20 kg per day. The volumetric capacity of fresh manure is 700 to 900 kg/cu.m described by R.G. Linton.

**Collection of Manure:**

Construction of manure pits depends upon the management practice followed in a farm. The first method may be in which manure along with other waste is flushed together and in the second method the solid and liquid wastes are separated and used as manure.

The first method can be adopted in places where there is plenty of water to be forced and also in buffalo farms where the dung voided is watery in consistency. In these types of Animal sheds a U-shaped gutter or drain should be located longitudinally to the long axis of the shed. Outside the
shed the liquid manure from each shed can be connected to a main shed preferably a closed one. The main drain leads the liquid water to a liquid storage tank from where it can be pumped to agricultural lands for manuring. In the latter method where solid and liquid manure are separated, a special pit has to be constructed to allow the solid waste to get decomposed. The pit should be far away from water sources, animal and human habitations to avoid fly menace and spread of diseases. While planning for constructing a pit due attention should be given to the labor required in transporting and the mode by which the manure will be shifted to the pit.

**Composting:**

In composting pile of solid waste is collected in pit 1.5 m deep and 3×4 meter dimension or large as per requirement (3 cubic meter/adult animal units) as per one design (Allnutt design described by R.G. Linton). This design has two pits with walls on all three sides covered on top with temporary roof to prevent desiccation, and alternative filing and emptying has been suggested.

The front side should have a gutter which should be filled with cresol and water to control fly breeding and the front side should have a vertical sliding shutter to prevent debris falling into the gutter. The manure should be dumped and well packed in each compartment separately. While one is filled and packed, fermentation and decomposition occurs in the other which was filled earlier. The manure should be turned periodically to ensure uniform decomposition; this also enhances the destruction of larvae of parasites that are normally present in the dung.

During composting frequent mixing of waste is required. The manure from other livestock farms like sheep, goat, pig and poultry can be decomposed in the similar manner. After piling within 24 hours temperature rises to 50°C and within 3-8 days it reaches to 70°C. Thereafter it falls to 50°C. C: N ratio and moisture are important in this process.

**Vermicompost: A Bonus for Livestock Farmer**

Vermicompost is organic manure produced from the cast of earth worms especially Eisenia, Eudrillus, Perionyx, Dolvin species from agriculture and livestock waste. It is rich in N, P and K with several micronutrients, enzymes (proteases, amylases, lipase, cellulose and chitinase), plant growth hormones (auxins, cytokinins and gibberellins) and some nitrogen fixing bacteria (Pseudomonas, Actinomycetes, etc.) which enrich the nutritive value of vermicompost. Though vermicompost is not comparable with chemical fertilizer but its application in soil improve soil structure, texture, water holding capacity, facilitates aeration and prevents soil erosion, thereby healthy, non toxic and tasty food can be produced from soil without any hazardous effect on health of human beings and animals.
The method of preparation is very simple and cost effective, which can be easily adopted by rural farmers for their benefit. Further, vermicomposting, as a technique, can effectively handle the huge amount of waste from agricultural and livestock source. This will undoubtedly add to prosperity of rural people by providing a healthy, wealthy and worthy environment.

**Biogas Production:** (Anaerobic fermentation) This is one of the best methods for waste disposal and utilization and extensively exploited in Japan and China. In this process organic matter is converted into volatile fatty acids which is in turn by the action of anaerobic bacteria (methanogenic bacteria) is converted to CH₄ and CO₂. The slurry is valuable product for using in fields. Biogas is captured and burned to power the farm and/or generate electricity to be sold back to the power supplier. Capturing and using the methane prevents its discharge to the atmosphere, where it has 21 times more global warming potential than CO₂.

![Figure 2.1: The Anaerobic Digestion Process](image)

**Figure 3. Anaerobic digestion process**

**Aerobic Oxidation:**

Slurry can be disposed by keeping it in shallow ditches, lagoon, and lakes. BOD (Biological oxygen demand) per acre is generally 20 for proper oxidation. Large areas are required and periodically solid sludge has to be removed. Upper water is used for irrigation after mixing with fresh water or directly also.

**In a Liquid Form by Means of Lagoon:**

Lagoon is a body of water like a small pond where in liquid manure is discharged and digested by bacterial action. In this method fertility value of manure is wasted but helps in saving of equipment and labor which may compensate the loss. Pens are scraped and washed daily with water under pressure 75 lbs./sq” inch and 500 gallons water per hour. This is run into lagoon which should hold at least one week accumulation of manure @ 20 kg/cow/day.

**Bacterial Action in Lagoon:**

(i) Aerobic:

By aerobic bacteria in the presence of air/oxygen.
(ii) Anaerobic:

By green algae which use carbon dioxide, nitrate and other nutrients and in turn gives off oxygen for aerobic bacteria for oxidizing waste materials. Anaerobic bacteria also take over to decompose the waste materials which may produce undesirable odor too.

**Water in Lagoon.** Should be kept filled with water.

**Depth of Lagoon.** Approximately two meters.

**Size of Lagoon.** @ 6.5 m$^3$/cow.

**Location.** 200 meters away from sties and prevent direction of prevailing winds.

**Precautions:**

(i) Provide safety fence around lagoon to make dog and child proof.

(ii) Make the bottom leveled and impervious.

(iii) Clean the lagoon once in 5 to 8 years or when necessary to remove accumulated sludge if filled up to depth of one meter.

**Direct Application of Waste in the Farm Land:** When large farm land not in productive use is available then direct application of solid waste by spreading or slurry by sprawling can be carried but this method is not an efficient method of utilization of farm waste due to loss of nutrients, problem of pathogens and sometimes causing toxicities to the plant grown on this type of land.

**Conclusion:**

In India as most animals are reared in close association with human dwellings, due care should be taken to ensure for hygienic maintenance of cattle shed. It is on public health interest that the manure should be promptly disposed and utilized in a proper way to conserve the manurial quality and also to prevent spread of diseases through insect vectors. The main principles of effective waste management of effluent are: effective recycling and reuse of effluent where feasible disposal, where its use is not practicable, in a manner that will not cause adverse short or long term environmental impact. The development and implementation of a whole farm plan is a fundamental consideration for sustainable management of dairy shed effluent.
Climatic variability and extreme weather events: impacts on livestock productive and reproductive performance and amelioration strategies

S.V. Singh
Dairy Cattle Physiology Division
ICAR-National Dairy Research Institute, Karnal-132001 (Haryana)

Abstract

Global warming is likely to impact productivity of livestock due to their sensitivity to temperature changes. Air temperature, humidity, wind velocity and solar radiation are the main climatic variables that affect livestock productivity and reproduction in tropical climate. In the present paper sensitivity of cattle and buffaloes to extreme weather events/ sudden temperature (Tmax, Tmin) and temperature humidity index (THI) change have been described. A sudden change (rise or fall) in maximum/minimum temperature during summer and winter season was observed to negatively affect the normal physiology, growth, milk production and reproduction of cattle and buffaloes. The decline in minimum temperature (>3°C) during winter and increase (>4°C) during summer than normal average temperature were observed to decrease milk production up to 30% on the next or subsequent days after extreme event(s). The return of animals to normal milk production/growth/physiology depends on severity and time period of thermal stress/extreme event occurrence. Lower THI showed relatively small effect on milk production and growth performance. Studied also showed that the lactation period of animals shortened during extreme summer when THI were more than 80 and reproductive functions were affected adversely. Heat stressed buffaloes, exotic and crossbred cattle did not exhibit estrus or exhibited estrus symptom for short period. Both milk production and reproductive functions of livestock species including cattle and buffaloes are likely to be further affected negatively due to expected higher global warming effects/extreme events in future. Mitigation strategies i.e. adaptation, shelter modification and feeding strategies should be developed to overcome the possible negative impacts of extreme events/climate change on productive and reproductive performances of livestock species.

Introduction

Cattle, buffalo, sheep, goat and birds are homeotherms and are sensitive to thermal stress. Studies showed that the negative effects of hotter summers will outweigh the positive effects of warmer winters on production efficiency of animals. Higher the ambient temperature increases, the more the animal's production decreases. IPCC predicted an annual mean surface temperature rise by 3 to 5°C (A2 scenario) and by 2.5 to 4°C (B2 scenario) up to the end of century, with more pronounced warming in the northern parts of India (IMD, Pune), which would cause a drastic decline in livestock productivity. Temperature and humidity interact to cause stress in animals. Higher the temperature and humidity, the greater will be the stress and discomfort to animals and the more will be the reduction in the animal's ability to produce milk, gain weight and reproduce. The number of
days it takes for cows to reach their target weight in dairy and meat animals and milk production and conception rate in cattle/buffaloes decreases depending upon severity and duration of stress. As a result of rapid global warming, milk and meat production are projected to decline in a warmer world (Hatfield et al, 2008). The projected increases in air temperatures will negatively affect confined animal operations, increasing production costs as a result of reductions in performance associated with lower feed intake and increased requirements for energy to maintain healthy livestock. These costs do not account for the increased death of livestock associated with extreme weather events such as heat waves. Nighttime recovery in physiological functions is an essential for survival, when animals are stressed by extreme heat. A feature of recent heat waves is the lack of nighttime relief and which causes the deaths of livestock species. (Hatfield et al, 2008). Warming also affects/help in survival of parasites and disease pathogens. The earlier arrival of spring and warmer winters allow greater proliferation and survival of parasites and disease pathogens (Hatfield et al, 2008). Changes in rainfall distributions are likely to further lead to spread vector borne diseases due to higher humidity. Heat stress reduces animals’ ability to cope with other stresses, such as diseases and parasites due to lower immunity status. Sustaining livestock production would require modification of shelter system to reduce thermal stress on animals, using the understanding of the chronic and acute stresses that livestock will encounter to determine the optimal modification strategy (Singh and Upadhyay, 2008 and Hatfield et al, 2008). Changing livestock species as an adaptation strategy is a much more extreme, high-risk, and in most cases, high-cost option than changing crop varieties. Accurate predictions of climate trends and development of the infrastructure and market for the new livestock products are essential for making this an effective response.

Climate and Climate Variability in India

The climate of India is mainly dominated by the high temperature (April to September). The whole year can be divided into four seasons based on the similar meteorological conditions viz. (i) Winter season (January and February) (ii) Hot weather season (March to May) (iii) hot humid season (June - September) (iv) Post monsoon season (October to December). Year to year deviations in the weather and occurrence of climatic anomalies/extremes in respect of these four seasons are:-

(i) Cold wave, fog, snow storms and avalanches
(ii) Hailstorm, thunderstorm and dust storms
(iii) Heat wave
(iv) Tropical cyclones and tidal waves
(v) Floods, heavy rain and landslides, and
(vi) Droughts

The cold and heat waves are the major threats to the livestock productivity in different parts of India. The occurrence of these events during different years of last hundred years (1901-1999) is given the following tables 1 and 2. After 2000, heat waves further intensified in different parts of India. According to the Glossary of Meteorology (AMS, 1989) heat wave is “a period of abnormally uncomfortable hot and usually humid weather of at least one day duration, but conventionally lasting several days to several weeks”. An operational definition often used for a heat wave is three to five successive days with maximum temperatures above a threshold.

Cold wave/wind chill are the apparent temperature felt on the exposed animal’s body owing to the combination of temperature and wind speed. As wind velocity increases, heat is carried away
from the animal’s body at a faster rate, driving down both the skin temperature and eventually the internal body temperature below their normal temperature and to a state of hypothermia.

**Table1. Number of cold waves recorded in different states of India in different years**

<table>
<thead>
<tr>
<th>State</th>
<th>Years and number of extreme events</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bengal</td>
<td>2</td>
</tr>
<tr>
<td>Bihar</td>
<td>7</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>21</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>11</td>
</tr>
<tr>
<td>Gujarat, Saurashtra &amp; Kutch</td>
<td>2</td>
</tr>
<tr>
<td>Punjab</td>
<td>3</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>-</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
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</tr>
<tr>
<td>Maharashtra</td>
<td>-</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>9</td>
</tr>
<tr>
<td>Orissa</td>
<td>4</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>2</td>
</tr>
<tr>
<td>Assam</td>
<td>1</td>
</tr>
<tr>
<td>Haryana, Delhi &amp; Chandigarh</td>
<td>-</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>-</td>
</tr>
<tr>
<td>Karnataka</td>
<td>-</td>
</tr>
<tr>
<td>Telangana</td>
<td>-</td>
</tr>
<tr>
<td>Rayalaseema</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: De et al; 2005

**Table2. Number of heat waves recorded in different states of India in different years**

<table>
<thead>
<tr>
<th>State</th>
<th>Years and number of extreme events</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bengal</td>
<td>76</td>
</tr>
<tr>
<td>Bihar</td>
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<tr>
<td>Uttar Pradesh</td>
<td>27</td>
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<td>Rajasthan</td>
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<tr>
<td>Gujarat, Saurashtra &amp; Kutch</td>
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<td>Punjab</td>
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<tr>
<td>Himachal Pradesh</td>
<td>-</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
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<td>Maharashtra</td>
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<td>Madhya Pradesh</td>
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<tr>
<td>Orissa</td>
<td>25</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>21</td>
</tr>
<tr>
<td>Assam</td>
<td>-</td>
</tr>
</tbody>
</table>
Haryana, Delhi & Chandigarh
Tamil Nadu
Karnataka
Telangana
Rayalaseema

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haryana, Delhi &amp; Chandigarh</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>5</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Karnataka</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Telangana</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rayalaseema</td>
<td>31</td>
<td>2</td>
<td>28</td>
</tr>
</tbody>
</table>

Source: De et al; 2005

**Projections of Climate Change over India for the 21st Century**

Based on modeling and other studies, the following changes due to increase in atmospheric GHG concentrations may arise from increased global anthropogenic emissions:

- As per IPCC, annual mean surface temperature rise by 3 to 5°C (A2 scenario) and 2.5 to 4°C (B2 scenario) by end of this century. The warming will be more pronounced in the northern parts of India as per the simulation studies carried by Indian Institute of Tropical Meteorology (IITM), Pune.

- Indian summer monsoon (ISM) is a manifestation of complex interactions between land, ocean and atmosphere. The simulation of ISM’s means pattern as well as variability on inter-annual and intra-seasonal scales has been a challenging ongoing problem. Some simulations by IITM, Pune, have indicated that summer monsoon intensity may increase beginning from 2040 and by 10% by 2100 under A2 scenario of IPCC.

- Changes in frequency and/or magnitude of extreme temperature and precipitation events. Some results show that fine-scale snow albedo influence the response of both hot and cold events and that peak increase in extreme hot events are amplified by surface moisture feedbacks.

**Climate change and availability of feed resources:**

As per the IPCC (2007) report, climate change will further negatively impact the Indian agriculture and would adversely affect livestock production in the India (Dinar et al. 1998). Due to poor availability of good quality of feed and fodders in India (3.4% area under pasture), animals are generally maintained on poor quality grasses available in the pastures or are stall-fed, mainly on crop residues. As per the Govt. of India (2002) estimate, India is already deficit in feed and fodder viz. dry fodder (22%), green fodder (62%) and concentrates (64%). These shortages would be further aggravated by the adverse effects of global warming/climate change on agricultural/fodder crops.

Adverse consequences of climate change would be more visible on livestock species in areas where high ambient temperature could be associated with decline in rainfall, increased evapotranspiration or increase in the incidence of droughts. A drought in 1987, affected over 168 million cattle in India, due to decline in feed and fodder availability and serious water shortages. In one of the worst drought affected state of Gujarat, 18 million cattle out of 34 million were reported to have died before it rained the next year. A 1999–2000 drought in the arid state of Rajasthan in the north-western part of the country, which is highly drought-prone affected 34.5 million cattle; in the subsequent year about 40 million cattle were affected by drought (CSO 2000). The draught damaged 7.8 million ha of cropped area in the state and fodder availability fell from 144 to 127 million tons. Any increase in the frequency and intensity of droughts in the arid and semi-arid regions in India would perhaps have the greatest impact on the pastoral families, as they have to migrate to arable areas to secure their livelihoods.
Effect of long term and extreme events on milk production and reproduction in India:

The impact of temperature rise/change was assessed on milk production of cattle and Murrah buffaloes and a decline in milk production was observed with a rise in THI and $T_{\text{max}}$. Analysis of the potential direct effects of climate change in 2020/2050 and global warming on summer season milk production of Murrah buffaloes indicated that a rise of 1.0 or 1.2°C during March-August for India (Region 23- HADCM3 A2/B2 scenario) will marginally effect milk production but temperature rise of more than 2°C over existing temperatures for time slices 2040-2069 and 2070-2099 will cause higher incidence of silent estrus, short estrus and decline in reproduction efficiency of buffaloes. Animals with limited water access will experience warming effect more than that of buffaloes dissipating heat by water wallowing (Upadhyay et al. 2009).

A sudden rise in $T_{\text{max}}$ during summer and a fall in $T_{\text{min}}$ cause a negative impact on milk yield of cattle (Fig.1). The increase in $T_{\text{max}}$ (>4˚) than normal during summer and decline in $T_{\text{min}}$ (>3˚c) during winter was observed to impact the milk production negatively in crossbred cattle and buffaloes. The decline in yield varied from 10-30% in first lactation and 5-20% in second and/ or third lactation. The extent of decline in milk yield was less at mid lactation than either late or early stage. The negative impact of sudden temperature change i.e. cold wave or heat wave on milk yield of cattle/ buffaloes were not only observed on next day of extreme event but also on the subsequent day(s) after extreme event, thereby indicating that $T_{\text{max}}$ increase during summer and $T_{\text{min}}$ decrease during winter cause short to long term cumulative effect on milk production of cattle and buffaloes. The return to normal milk yield took 2-5 days with a variable response. The decline in milk yield and return to normal yield after and extreme event was also dependent on subsequent day(s) $T_{\text{max}}$ and $T_{\text{min}}$. The $R^2$ was non significant and very low for cool period observed during Feb-April / Sept-Nov and actual affect on milk production was minimum. This indicated that low THI (<75) had a relatively small effect on milk production performance. The lactation period of buffaloes were shortened by several days (3-7) during extreme summer when THI was more than 80. The expressions of estrus and reproductive functions were also negatively impacted. Excessively distressed buffaloes with higher rectal temperature (more than 40 °C) did not exhibit estrus or exhibited estrus symptoms for short duration that often remained undetected (Upadhyay et al. 2009).

Global extreme events and their impacts on animal performance and survival:

Extreme weather event that adversely impacted livestock includes the severe heat waves of 1995 and 1999 in the Midwestern states which caused nearly 5,000 animals deaths in each year (Busby and Loy, 1996; Hahn and Mader, 1997; Hahn et al., 2001). Major death losses in the United States and elsewhere e.g. dairy cows in southern California, 1977 (Oliver et al., 1979); feedlot cattle in Nebraska, 1992 (Hahn and Nienaber, 1993), and 1999 (Mader et al., 2001). A 1995 (July 10-15) heat wave in the Midwestern United States resulted in more than 4000 feedlot cattle deaths in Iowa and Nebraska, as well as numerous human deaths in Chicago and elsewhere. During this heat wave event, there were extended periods during five days of the heat wave (July 10-14) when the THI values were 84 or above. One contributing factor to the cattle losses was the continuous exposure to THI values above critical threshold, so there was no opportunity for recovery in physiological functions at night (Scott et al., 1983). Accompanying higher solar radiation loads (clear to mostly clear skies) and low to moderate wind speeds were further contributing factors in the area of highest risk. For cattle in other locations with 20 or more daily THI-hrs in the “Emergency” category (THI 84) for only one or
two days, the animal heat load was apparently dissipated with minimal or no mortality (Hahn, 1999). The economic toll from this heat wave event for cattle feeders in Iowa alone was estimated to be $28 million as a result of death and performance losses (Smiley, 1996). Retrospective analysis of hourly climatic records during the 1995 heat wave event was used to evaluate characteristics of heat waves (e.g., intensity, duration, recovery time) that cause feedlot cattle deaths; the results, in terms of daily THI-hrs at or above the Livestock Weather Safety Index (LWSI) thresholds for the Alert, Danger, and Emergency categories, provide a valuable approach to environmental management practices (Hahn and Mader, 1997). This THI-hrs analysis of the 1995 heat wave and others have reinforced the LWSI thresholds for categories of risk, and support an environmental profile for single heat wave events that create conditions likely to result in deaths of Bos-taurus cattle in feedlots: 15 or more THI-hrs per day for three or more successive days at or above a base level of 84 (Emergency category of the LWSI) with minimal or no nighttime recovery opportunity. Death losses can be expected if shade, precautionary wetting, or other relief measures are not provided during such conditions. Conditions in the “Danger” category of the LWSI also may cause mortality in highly vulnerable animals (e.g., new entrants to the feedlot; those at or near market weight; animals not yet acclimated to hot weather; sick animals, especially with respiratory problems). Successive heat waves with intervening cool periods can create excessive heat loads and potentially lethal conditions for cattle even when the conditions during secondary heat waves are comparatively moderate. This is likely a result of increased feed intake during the cool periods. It should be further noted that costs associated with death losses, while drastic, are often greatly surpassed economically by performance losses (growth, efficiency) of surviving cattle (Balling, 1982).

In the Northern Plain states, with greater than normal snowfall and wind in the winter of 1996/1997, up to 50% of the newborn calves and over 100,000 head of cattle were lost in many areas (Mader, 2003). In the winter of 2000/2001 (Hoelscher, 2001), feedlot cattle efficiencies of gain and daily gain decreased approximately 5 and 10% from previous years as a result of late-autumn and early-winter moisture combined with prolonged cold stress conditions. In January 2007, Colorado faced the most severe snow storm in the past sixty years, causing decreased hay supplies and large death losses to livestock. The exceptional drought in Southern High Plains that began in the fall of 2010 and continued for a year caused incredible losses as calves were placed early in feedlots, culled at much higher rates than normal, or moved to regions where grass and hay are more readily available.

Cattle mortalities also increase during periods of extreme heat stress (Hahn, 1985). Heat stress can decreased dry matter ingested and increase dry matter digestibility (Lippke, 1975) and decrease the rate of weight gain (Mitlohner et al., 2001). But the extent of production loss is often difficult to estimate because heat stress effects are typically hidden among high natural and managerial sources of variation (Linvill and Pardue, 1992). Animals exposed to cold weather require more energy to maintain their body reserves and to maintain their body temperatures (Vinning, 1990). In the winter, the influence of wind can have a negative impact on cattle performance and its effects are magnified when combined with cold temperatures. One way cattle compensate for colder weather is to increase feed intake. However, cattle have a physical limit on how much they can consume. Once that point is reached, they will need higher quality feeds and supplements to compensate for the increased energy requirement.

Deng, et al. (2007) use the Temperature Humidity Index (THI) to analyze the impact of weather on dairy cow production in the southeast, where summer temperatures are high with high relative humidity. The THI index is used to account for the interaction between temperature and humidity. They reported that milk yields decline as the rectal temperature increased, and with the same high
temperature, cows exposed to low humidity performed better than those exposed to high humidity. THI can be calculated using Johnson (1963) formula as follows:

\[ \text{THI} = 0.72 \times (\text{tdb} + \text{twb}) + 40.6 \]

**Where:** tdb and twb are dry bulb and wet bulb temperatures (°C) respectively

Heat stress begins to occur in dairy cattle/buffaloes when the THI is > 72. Some of the signs that the dairy cattle and buffaloes exhibits with the increases in THI, range from mild changes in metabolism and milk production to animals death depending upon the stress levels.

For assessing the cold stress, the Wind Chill Index (WCI) is used to indicate the cold stress levels on animals. Wind chill is the apparent temperature felt on exposed skin of animals due to wind speed. The following formula (Paul Allman Siple and Charles Passel) is used to calculate WCI, when temperatures fall below 45°F.

\[ \text{WCI} = 0.0817 \times (3.71 \times \text{wind}^{0.5} + 5.81 - \text{wind} \times 0.25) \times (\text{TD} - 91.4) + 91.4 \]

Where temperatures are between 46°F and 59°F, the following formula is used.

\[ \text{CSI} = \left[ \frac{\text{TD} - 45}{14} \right] \times \text{TD} + \left[ \frac{59 - \text{TD}}{14} \right] \times \text{WCI} \]

Where WCI = Wind Chill Index, wind = wind speed in miles / hour, CSI = Cold Stress Index and TD = Dry Bulb Temperature (°F)

The combined effects of temperature and wind are often expressed as a wind chill index. The wind chill index, rather than ambient temperature, is used to estimate effective temperature when considering the severity of cold stress. For example, when the temperature is 20°F with no wind, the wind chill index is 20°. At the same ambient temperature, 5, 15 and 25 mph winds would result in a wind chill index (or effective temperature) of 13°, 4° and -7° F, respectively. By any means reducing the exposure of animals to wind will dramatically reduce cold stress. In general, a cow’s energy requirements increase 1% for each degree the wind chill is below 32°F. For a wet cow, the increased energy requirement begins at 59°F and increases 2% for each degree drop.

Table 3: Probabilities of extremely warm, wet and dry seasons 2080–99 suggested by IPCC GCM model projections in Asia (in per cent)

<table>
<thead>
<tr>
<th>Sub region</th>
<th>Season</th>
<th>Extreme warm</th>
<th>Extreme wet</th>
<th>Extreme dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>DJF</td>
<td>96</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>MAM</td>
<td>98</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>JJA</td>
<td>100</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SON</td>
<td>10</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>South</td>
<td>DJF</td>
<td>99</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>MAM</td>
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<td>32</td>
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<td>JJA</td>
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</tr>
<tr>
<td></td>
<td>SON</td>
<td>100</td>
<td>39</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: DJF: December to February, MAM: March to May, JJA: June to August, SON: September to November. Source: Adapted from Christensen et al. (2007).

**Climate change and animal adaptability:**

Weather and extreme events have adverse effects on several aspects of animal production (Upadhyay et al; 2007). There is a range of thermal conditions within which animals are able to
maintain a relatively stable body temperature by means of behavioral and physiological means (Bucklin et al; 1992). Heat stress results from the animal’s inability to dissipate sufficient heat to maintain homeothermy. High ambient temperature, relative humidity and radiant energy compromise the ability of animals to dissipate heat. As a result, there is an increase in body temperature, which in turn initiates compensatory and adaptive mechanisms to reestablish homeothermy and homeostasis. These readjustments generally referred to as adaptations, may be favorable or unfavorable to economic interests of humans, but are essential for survival of the animal (Stott, 1981).

Thus, an increase in air temperature, such as that expected in different scenarios of climate change, would affect directly animal performance by affecting animal heat balance. There are four modes of energy transfer i.e. radiation, conduction, convection and evaporation, which is governed by physical laws. Several physical parameters control heat transfer by each mode. Air temperature affects energy exchanges through convection and evaporation (Hahn, 1976). When temperature increases, evaporation becomes the most important way of heat loss, since it does not depend on a temperature gradient (Shibu et al. 2008). Under that circumstance the combination of temperature and humidity acquire more relevance, since increased humidity enhances temperature effects. The comfort limit depends on level of production. Animals producing at higher level are more sensitive to heat stress (Johnson, 1987; Singh and Upadhyay, 2008, 2009). Not only intensity of stress, but also the length of the daily recovery period is important in determining animal responses (Hahn et. al; 2001 and Upadhyay et. al; 2007).

**Animal diseases**

Global warming is likely to cause an increase in animal diseases that are spread by insects and vectors. Higher temperature and humidity will favor spread and growth of insects/ vectors. Incidences of both protozoan and viral diseases affecting livestock will spread in susceptible population. Incidence of protozoan diseases like Trypanosomiasis and Babesiasis are likely to increase in high producing crossbred cattle and may be higher in future. Some of the viral diseases may also reappear and affect both small and large ruminants’ population. Frequency and incidence of mastitis and foot diseases affecting crossbred cows and other high producing animals may increase due to increase in number of stressful days. Climatic conditions favorable for the growth of causative organisms during most part of the year due to temperature rise will facilitate spread of diseases in other seasons and also increase area for their spread.

**Mitigation strategies to overcome the effects of climate change:**

Since climate change could result in an increase of heat stress, all methods to help animals cope with or at least alleviate the impacts of heat stress could be useful to mitigate the impacts of global climate change on animal responses and performance. Three basic managemental tools/ schemes for reducing the effect of thermal stress have been suggested (Kumar et al; 2009):

(a) Physical modification of the environment;
(b) Development of genetically less sensitive breeds and
(c) Improved nutritional and managemental practices.

**Physical modification of the environment.** The methods for micro environment modification include: shades, ventilation, combination of wetting and ventilation. Shades are the simplest method to reduce the impact of high solar radiation/ climate change. Shades can be either natural
or artificial. Tree shades have proved to be more efficient (Hahn, 1985). If sufficient natural shade is unavailable, appropriate shelter should be constructed. Different aspects concerning design and orientation of shades and different roofing materials have been suggested by different workers for different agro climatic condition for various species of animals. Shades are effective in reducing heat stress/ physiological responses in the dairy animals (Singh and Upadhyay, 2008, 2009). The protected animals show lower physiological responses (RR, PR, RT & ST) during afternoon and yield more milk and protein (Singh and Upadhyay, 2009). The artificial shade structure did not differ from tree shades in terms of the effects on animal well-being (Valtorta et al, 1997). Proper ventilation in a shelter is important for the relief from heat stress, if possible, natural ventilation should be maximized by constructing open-sided constructions (Bucklin et al; 1992). Forced ventilation provided by fans is a very effective method for lowering the temperature (Kumar et al; 2009). An effective way of cooling dairy cattle and buffaloes are spray evaporative cooling. Several cooling devices viz.: mist, foggers and sprinkling systems are available. However, the single use of a sprinkling and fan system for 30 minutes before milking has proved to be useful to relief dairy animals from heat stress in terms of efficiency to reduce the impact of heat waves under a grazing system (Valtorta et al; 2002).

**Managemental strategies during heat stress for improving productivity:**

- Increase number of feedings/day particularly during morning, afternoon and night hours i.e. feeding during cooler hours to reduce SDA of feeds.
- Maintain energy intake with decreased dry matter intake.
- Increase dietary protein density to compensate lower intake.
- Increase dietary mineral concentration (Na, K etc.).
- Ratio / balance of cations (Na & K) and anions (Cl & S) are also important.
- Feeding Total Mixed Ration (TMR) should be preferred over component or separate ingredient feeding.
- Well balanced TMR- diet formulation at optimum fibre level- encourages DMI; minimize rumen fermentation fluctuation & pH declines.
- Feed supplementation of antioxidants as vitamin E and Selenium.

**Additional means of reducing Heat Stress effects:**

- Selective crossbreeding- The exotic breeds of cattle which are more heat tolerant due to more sweat gland density (Jersey) should be given more preference over less heat tolerant (Holstein Friesian).
- Selection of heat tolerant animals with in breed for future breeding programmes.

**Summary**

Summer weather challenges agriculture and animals in many regions of the world, whether as a result of current natural variability or potential global change. A consequence of thermal stress associated with summer/ winter conditions reduces animal’s performance and in some cases, death from extreme events (e.g., heat waves/ cold waves). In terms of environmental management, the impacts can be reduced by recognizing the adaptive ability of the animals and by proactive application of appropriate counter-measures (sunshades, evaporative cooling by direct wetting or in conjunction
with mechanical ventilation, etc.). Quantification of the impacts of normal summer/ winter weather and potential global change allows livestock producers to gain a better understanding of the magnitude of production and death losses in both situations. Projected economic losses resulting from climate-induced reductions in production may justify mitigation through changes in management practices. Specifically with regard to potential climate change, the capabilities of livestock managers to cope with the effects are quite likely to keep up with the projected rates of change in global temperature and related climatic factors. However, coping will entail costs such as application of environmental modification techniques, use of more suitably adapted animals, or even shifting animal populations. Assessment of potential economic impacts associated with global change on key areas of animal agriculture needs to be made available for use in allocating strategic adjustments and resources to minimize adverse effects on socioeconomic stability.

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ASAS, ADSA, DesMoines, IA.


The demand of milk and milk products in India is projected to increase to 191.3 MMT in 2020. At the existing rate of growth in milk production, in the next years, supply is likely to fall short of the demand. To fill the gap we need to improve the individual animal’s productivity, which would need interventions at genetic, nutritional and managemental levels. The ‘calvable’, but “uncalved” population of milch animals account for approximately 10% of the total breedable population. If these milk “producible, but not producing” animals could be given due attention to make them pregnant, then the annual milk production of the country can be increased by at least 10%. The profitability of milk production from cattle and buffaloes depends to a large extent on the efficiency of reproduction. Maximizing reproductive efficiency requires the matching of genotypes to the production environment, together with appropriate husbandry practices, in order to ensure that the intervals from calving to conception are short and the rate of conception to natural or artificial breeding are high. The reproductive cycle of dairy animal include follicle development and maturation, onset of oestrus, successful coitus/insemination, ovulation, fertilization, implantation, development and delivery of normal foetus and its membranes, proper uterine involution and cleansing, resumption of ovarian cyclicity and estrus expression. In a lifetime, 8-10 such cycles are expected to occur in dairy animals. Anything interfering with the routines of this cycle makes the animal infertile. The common reproductive problems can be divided into some major categories which include functional disorders, infectious disorders, genetic disorders and other miscellaneous disorders. The major reproductive disorders that are economically important are repeat breeding, anestrus, retention of foetal membranes and uterine infections. These are discussed here in detail.

1. REPEAT BREEDING (RB)

A repeat breeder cattle of buffalo is defined as one that has apparently normal genitalia without any abnormal discharge from genital tract and with normal estrous cycle and estrous period but fails to conceive after three consecutive inseminations/services with fertile semen/bull. To consider cattle/buffalo as repeat breeder, it should be ruled out that there is no clinical infection and the insemination was done with good quality semen at proper time by qualified personnel. Since RB is a syndrome and may be due to multi factorial etiology, no single technique or method can be used to diagnose the cause. Examination of the suspected animal at various intervals may be useful to rule out certain conditions and to indentify the underlying cause.

Managemental and therapeutic approach

Once the animal is considered as repeat breeder, the cause should be identified. Since RB is a syndrome and may be due to multi-factorial etiology, no single technique or method can be used to diagnose the cause. Examination of the suspected animal at various intervals may be useful to rule out certain condition and to identify the underlying Cause.
**Ovulation abnormalities:** Normally ovulation takes place at 10-12 hrs after the end of oestrus in cattle and buffaloes. Abnormalities in ovulation include delayed ovulation and anovulation. The differential diagnosis between delayed ovulation and anovulation can be made by examination per rectum of ovaries of suspected animal on the day of oestrus day 2 and day 10-12 of the oestrus cycle. If the follicle is present on all three examinations, the case is diagnosed as anovulation, while if the follicle is present on first and second examination and a corpus luteum (CL) at the same place on and examination, the case is delayed ovulation. Once diagnosed, delayed/anovulation can be treated by administration of LH or hCG (eg. Chorulon, Intervet) 1500-3000 IU or GnRH 10-20 µg (eg. Receptal, Hoechst) on the day of estrus.

**Subclinical infections:** In subclinical infection of the reproductive tract, there may not be any visible abnormalities in discharge except from occasional whitish flakes, and animals experience normal cycle length. Because of these subclinical infections, uterine environment is altered, which may interfere with embryo survival. White side test can be used to some extent to identify subclinical infection. In this test, to 1 ml of genital discharge, 1 ml of 5% NaOH is added and heated up to boiling. Appearance of yellow colour indicates infection. Uterine infection can be treated with wide range of antibiotics, antiseptics, hormones and other alternative therapies. Post insemination antibiotic therapy is found quite useful in this.

**Defective gamete transport:** It may be due to abnormalities in tubular genital tract or hormonal imbalance. This can be easily diagnosed using the phenosulphonpthalene (PSP) infusion test. Several reports suggest that administration of oxytocin (5-10 IU) immediately after insemination improves the conception rate, by facilitating sperm transport.

**Luteal insufficiency:** Progesterone, secreted by CL, is essential for embryo survival. If the CL is not compositely formed, or if it is not functioning adequately, it leads to failure of pregnancy. If other causes are ruled out, a RB animal can be suspected for this condition and can be treated with GnRH or hCG, 2-3 days after insemination to improve the CL formation, at mid cycle to stimulate accessory CL information or at around day 17 to prevent the CL regression.

Fixed time insemination: In sub-estrus buffaloes and cattle, PGF₂α can be used to bring the animal into estrus, and insemination can be done at fixed time. Single dose PGF₂α can be administered at 16-5 days of estrous cycle or to those animals, which have mature CL as assessed by rectal examination. Double injection of PGF₂α at 11 days interval can also be employed and it avoids the rectal palpation of CL. Fixed time insemination at 72 and 96 hr after PGF₂α administration may yield higher conception rates.

Clitoral stimulation: Mechanical stimulation of reproductive tract by massaging clitoris after AI has been shown to improve conception rate by hastening the surge of luteinizing hormone and ovulation.

2. **ANESTRUS**

Delayed sexual maturity in heifers (prepubertal anoestrus) and absence of ovarian activity after parturition is commonly encountered in buffaloes. Heifers should be managed properly to attain puberty before 18 months of age so as to obtain first calving at 2.5-3 years of age for economic reasons. Body weight attainment is more important than the age for onset of puberty. If the animal fails to exhibit estrus for longer period, excepting during pregnancy, called as anoestrus, affects the economy by prolonging the calving interval. This condition is generally observed after parturition (post partum anoestrus) especially under field conditions.
Factors associated with anestrus

Under feeding: In heifers, under feeding delays the onset of puberty and sexual maturity, whereas in adults, it is characterized by irregular estrous periods and anestrus. Under feeding for prolonged period causes failure of proper follicular development, leading to follicular atresia along with loss of sexual desire or production of weak young ones.

Protein and Vitamin deficiency: Protein and Vit. A deficiency adversely affects reproduction in most species. Vitamin A deficiency is characterized by keratinization of epithelium, degeneration of placenta, fetal death, abortion and retention of foetal membranes.

Mineral deficiency: The deficiencies causing anestrus in cattle and buffaloes are mostly limited to phosphorus and trace elements. The usual symptoms of phosphorus deficiency are delayed onset of puberty in heifers and failure to exhibit estrus in cows. Copper, cobalt, manganese and iron deficiencies are not uncommon and their deficiencies may affect normal reproduction.

Hormonal disturbances: Most of the hormonal disturbances causing infertility are secondary to basic nutritional, hereditary and other stress factors. It should always be remembered that indiscriminate use of hormones itself may lead to fertility.

Diagnosis

It is very important to rule out pregnancy before treating the animals for acyclicity. Body condition of the animal along with thorough gynecological examination can aid in prompt identification of underlying cause(s). Ovaries and tubular genitalia should be examined in detail and two successive examinations at an interval of 10-11 days are recommended. While examining, the following conditions have to be kept in mind.

1. Ovarian agenesis (Heifers; incidence very low) 2. Ovarian hypoplasia 3. Smooth, small ovaries with no palpable structures (true anestrus) - confirmed by two examinations of ovary at 11 days interval. 4. Large ovary(s) with fluctuating area (>2.5 cm) - Cystic ovary. 5. Corpus luteum in one or both ovaries - may be due to silent estrus, but pregnancy to be ruled out.

Therapeutic approach

Successful treatment depends upon accurate diagnosis. For ovarian agenesis or ovarian hypoplasia, there is no treatment. Some cows with completely smooth non-functional ovaries do not show always encouraging results when hormones are used. Therapy for these cows should aim at correcting the underlying nutritional deficiencies or other systemic diseases.

a) Follicle stimulating hormone (FSH): As the name indicates, the physiological role of this hormone is to induce follicular growth. Once follicular growth is induced, the estrogen secreted by the developing follicle induces an endogenous Luteinizing hormone (LH) surge for ovulation. But, in several cases of anestrus, administration of FSH alone would not benefit, as ovulation is not ensured. Administration of LH or hCG after 48-72 hrs of FSH is also necessary to favour ovulation.

b) Progesterone: Administration of progesterone mimics the presence of corpus luteum and induces follicular growth and ovulation when withdrawn. There are several methods of administration of this hormone viz. oral, intra-vaginal, injection and ear implants.

b) Combination of hormones: Several combinations of above said hormones (eg. progesterone releasing intravaginal device-PRID; Norgestomet ear implants) are also used to augment fertility in anestrus cattle and buffaloes. Recently, administration of GnRH and PGF₂α has been reported to
induce estrus within 3-5 days of treatment. There are several protocols for induction of estrus in no cyclic animals, viz. Ovsynch, Heatsynch, Provsynch etc. Our experience indicates that conditioning the buffalo heifers with proper deworming and supplementation of vitamins and minerals improve the response to estrus induction protocols.

3. RETENTION OF FETAL MEMBRANES (RFM)

Retention of fetal membranes (RFM) is defined as the inability of a cow to shed the fetal membranes even after 12h of parturition. RFM predisposes cows to different peri-partum diseases that includes but not limited to, mastitis, metritis and ketosis, and directly decrease the milk yield and disease resistance. The reproductive consequences of RFM are due to postpartum metritis and include an increase in the service period, days open, calving to conception interval and calving interval.

Preventive management of RFM

Proper growth rates resulting in heifers calving at desirable body weight and selection of calving ease sires are the most important management considerations for prevention of RFM in heifers. The strategy should focus on maintaining a healthy, contented and active cow prior to, during and after parturition. A balanced, limited ration during the 6-8 week dry period, sufficient daily exercise, sufficiently large, clean and comfortable calving areas and proper sanitation during the calving period minimize the chances of RFM and infection.

- Selenium supplementation, dietary or parenteral.
- Intramuscular injections of Vitamins A & D, 4-8 weeks prior to calving, if deficient.
- Maintenance of calcium: phosphorus ratio between 1.5:1.0 and 2.5:1.0.
- Administration of either Oxytocin (20-30 IU) or PGF₂α immediately after calving.

Therapeutic management of RFM

The basic goal in any treatment of RFM is to return the cow’s reproductive tract to a normal state as quickly as possible. There are generally two methods of managing retained placenta, when no systemic involvements are present- manual removal and natural separation.

- Manual removal should be avoided, because of possible injury to the delicate lining of the uterus resulting in uterine infection and associated complications.
- Try to detach the placenta by applying slight tension externally to the fetal membranes.
- Allow the membranes to separate naturally with or without the use of medication. Hormones such as PGF₂α and oxytocin may be used to hasten the process.
- Use of intra uterine infusions should be minimized and systemic treatment with long acting antibiotics like Ceftiofur is advisable.
- Partial retention may go unnoticed until complications such as metritis or pyometra develop. These animals should be examined and can be systemically treated with antibiotics and locally with intrauterine medication (if unavoidable) by a veterinarian.

4. INFECTIOUS DISORDERS ((UTERINE INFECTIONS)

Uterine bacterial contamination in cattle is a dynamic situation, with regular contamination, clearance of bacteria and spontaneous re-contamination during the first few weeks after parturition, rather than just contamination at the time of calving. A normal postpartum cow resolves uterine
infection by rapid involution to the uterus and cervix, discharge of uterine content, and mobilization of natural host defenses, including mucus, antibodies and phagocytic cells. If the immune status of the animal is altered, then the established uterine infection would continue to persist resulting in development of metritis of varying degrees.

Predisposing factors

The risk factors that have been previously established for uterine infections include abnormal length of gestation, stillbirth, twins, assisted parturition and RFM. Prepartum health status of the animal plays a major role in predisposing the animal to development of post-partum uterine infection.

Nutrition: The energy requirements for maintenance and pregnancy of dairy cattle increase during the last month pre-partum, but during this time feed intake may be reduced. If the animal is not provided with energy dense diet it will lead to several complications that could predispose the animal for development of metritis during post-partum period. The protein requirement for growth of conceptus also increases as pregnancy advances. It is important to maintain adequate levels of calcium, selenium, and vitamins A and E in the diet of cows.

Environment: The effects of any stress are amplified in the transition period and attention should be paid to cow comfort, stocking rates and cooling in hot climates. During calving and few days after, the cervix is dilated and the uterus, which is already irritated from the calving process, is exposed to a variety of infectious agents in the environment.

Assistance during calving: The cows should be assisted while calving, only if it is absolutely necessary. Unnecessary and improper assistance increases the chance of developing uterine infection. Interfering too early in the calving process may cause more problems than it solves. To avoid calving difficulty, it should be ensured that heifers have grown to adequate size before they are inseminated. Semen from calving-ease sires should be used for virgin heifers.

Peri-partum complications: The major production disorders during peri-partum period are milk fever, ketosis and displaced abomasum. The peri-partum risk factors important for development of uterine infection include mainly dystocia, milk fever and RFM. Other risk factors for metritis include stillbirth, twin births, primiparity and winter season.

Biomarkers for prediction of metritis

Behavioural markers: The feeding pre-partum time and bouts could be used as a behavioral maker for predicting the development of metritis, since the cows that develop metritis post-partum showed significant reduction in feeding time and bouts during pre-partum period (from 2 weeks before calving).

Biochemical markers: During peripartum period, the non-esterified fatty acids (NEFA), β hydroxy butyric acid (BHBA) concentrations and plasma NEFA: total cholesterol ratio have been shown to be significantly higher in metritic cows compared to normal cows. In developed countries “on-spot” diagnostic kits have been developed based on the biochemical markers for the early detection of complications.

3P management strategy

1. Prepartum feeding and health care: The nutritional needs of the cow are satisfied throughout the dry period with special attention to protein, energy, vitamins and minerals. It is critical that dry cows do not lose weight during the dry period. Adequate tissue levels of proper vitamins and minerals must be present prior to calving and throughout the postpartum period if uterine health
is to be maintained. However, it should be ensured that the cows are not over-conditioned. The desirable range of BCS (1 to 6 scales) during dry off and calving in cows and at calving in heifers is 3.5 to 4.5. The marked body condition loss from the dry to near calving periods results in the increased occurrence of postpartum metabolic and reproductive diseases. The over-conditioned cows spent less time feeding during transition period and increase susceptibility to metritis.

2. Peri-partum care: Common calving difficulties including dystocia is due to various factors and uterine inertia. Cows with these problems should be handled properly by qualified personnel so that minimal damage occurs to the genital organs. RFM predisposes cows to different peripartum disease that include but not limited to, mastiffs, metritis and ketosis, and directly decrease the milk yield and disease resistance. To obtain better post-partum fertility, it is necessary to keep the incidence of metabolic diseases within the permissible level, since these diseases increase the risk of developing postpartum metritis in dairy cows. Among the metabolic disorders, milk fever is a problematic periparturient disease, as a result of its association with 8 other periparturient disease processes and its negative effect on postpartum DMI. The transition cow management should focus on prevention of the negative effect of the inadequate nutrition (negative energy balance-NEBAL, protein imbalance, vitamin, micro-elements and mineral insufficiency) and to improve BCS, in order to allow a normal reaction of cows for the reproductive treatments.

3. Post-partum follow up: Management practices focused to ensure good health or prevent serious post-partum disease conditions are very important in managing reproductive performance. In most of the cases the infection is diagnosed when it becomes clinical, which leads to more investment on therapy and takes more time to cure. The protocol for post-partum follow up should focus on early disease detection by frequent animal observation and monitoring. The practice of monitoring rectal temperature for at least the first 10 days post-calving is to be strictly implemented to identify the possible problematic cows at an early stage. Depending upon the visual appraisal (bright and alert or dull and depressed) and body temperature, further evaluation (rectal/vaginal) is to be decided. Depending upon the results of each evaluation criteria, a set protocol is to be established for therapeutic applications. The current approach in addressing retained placenta and metritis in dairy cattle is to monitor body temperature and cow behavior. If a cow’s body temperature exceeds 39.5°C, then a systemic antibiotic is administered. Procaine penicillin or Ceftiofur (long acting) are approved for treatment of metritis and have been found to be efficacious. NSAIDs may also be used in combination with systemic antibiotics, if deemed necessary based on animal evaluation.

GOOD PRACTICES FOR OBTAINING HIGH CONCEPTION RATE WITH AI

Frozen semen quality: Superior quality frozen semen is an integral part of AI programme. In order to achieve high post thaw semen quality, it is essential to obtain high quality fresh semen. Quality semen from authorized and certified semen stations should be used for insemination.

Semen storage, transfer and retrieval: Once frozen, exposure of straws to temperatures above -130°C and recoiling results in irreparable sperm cell damage. This results in reduced sperm motility, viability and acrosomal integrity. Progressive motility of sperm is required for transport of spermatozoa from the site of deposition to the site of fertilization, while acrosomal integrity is essential for membrane specific recognition and binding of sperm with ovum. Hence, it should be ensured that the canister containing semen is well below the top of the tank neck.
**Handling of straws and thawing:** The straws should be removed from LN₂ container using a tweezers/forceps as quickly as possible (within 3-5 seconds) and shake to remove excess nitrogen. There are several methods of thawing ranging from ice water to 75°C for 12 seconds and thawing in water at 37°C for 30 seconds is generally advocated and the straws should be fully dipped in water. After thawing, the straws should be wiped gently to remove water. If the air bubble is located in the single plug (laboratory seal) side of the straw, then it can be cut with dean scissors. If it is located in the middle of the straw, it should be moved towards the single plug side by shaking gently before cutting. The straw should be gently placed in the gun and elided into the sheath and the sheath should be secured with the gun tightly using ‘O’ ring. Before loading, the AI gun should be warmed. There should be no gap between the cut end of the straw and the sheath otherwise part of semen may remain in the sheath thus reducing the number of spermatozoa per insemination.

**Selection of female for insemination:** Improper detection of estrus is the biggest bottle neck in artificial breeding under field conditions especially in buffaloes. It is essential that insemination should be done at proper estrus to obtain high CR. Though the owner/herds man of the animal to be inseminated claim that the animal is in estrus, it should be confirmed by clinical/gynecological examination. The arborization pattern (fern pattern) of cervical mucus can be used to predict the optimum time of insemination.

**Time of insemination:** Thumb rule under field condition is that, if the animal exhibits beginning of estrus signs in late night or early in the morning, it should be inseminate in the evening of same day. If the estrus signs start at late morning/afternoon/evening then the animal should be inseminated next morning. But, in case of buffaloes, recent reports suggest that the period from end of estrus to ovulation is longer than that of cows. Hence, buffaloes can be inseminated in the late heat for better conception rate.

**Method of insemination:** All efforts to make AI successful using proper collection, handling and processing of semen are worthless, if insemination is not properly carried out. The cow or buffalo to be inseminated should be restrained well; otherwise there is every chance to damage the uterus by AI gun and/or improper deposition of semen leading to poor CR. Before introducing the gun, perineum and vulval area of the animal has to be wiped properly to avoid infection carried through the gun. Insemination gun should be inserted at 30-45° angle after opening vulval lips to avoid urethral opening. In case of frozen semen, the site of deposition is the body of uterus, just next to the internal os of the cervix. After withdrawing the gun, uterus can be massaged gently as it may hasten the sperm transport.

**EPILOGUE**

Reproductive disorders and associated infertility among cattle and buffalo pose serious economic loss to farmers in terms of low returns and veterinary expenses. Sincere and concerted efforts are required to apply promising reproductive technologies at field conditions in large scale to maximize the reproductive efficiency of milch bovines. This requires matching of genotypes to the production environment, together with appropriate husbandry practices, in order to ensure that the intervals from calving to conception are short and the rates of conception to natural or artificial breeding are high. For better economic efficiency and competitive superiority of dairy farming, a thorough knowledge on reproductive efficiency indicators, their application in the routine farm operations and overall improvement of specific reproductive parameters are at most important.
REFERENCES


Effect of feed supplements, minerals and vitamins on animal production

S.S.Thakur and M.S.Mahesh

Dairy Cattle Nutrition Division
ICAR- National Dairy Research Institute, Karnal (Haryana)

Introduction

Livestock feeding in India largely relies upon abundantly available agricultural by-products like cereal straws and stovers. These feeds are characterized by very low protein, available minerals and vitamins besides very low in palatability and digestibility. Therefore, supplementation of critical nutrients or additives to the basal diet is necessary. Moreover, in milking animals, several critically essential nutrients/additives are largely ignored and if supplemented, milk yield can be augmented depending on the extent of deficiency. Feed additive is an ingredient or combination of ingredients added to the basal diet to fulfill the specific need. They might not be essentially be nutrients by themselves, but they might help in utilization of more nutrients from the basal diet. This article briefs about various feed additives, minerals- and vitamin supplementation to dairy animals mainly under Indian context.

Exogenous enzymes

Enzymes are supplemented to improve utilization of fibre in ruminant diets. Commonly used enzymes like cellulose and xylanase in 50:50 (w/w) ratio at 1.5 g/kg DM of 45% wheat straw based total-mixed ration (TMR) significantly improved digestion of cellulose and hemicellulose by 5 percentage units, thereby enhancing milk yield to the tune of 1 kg in lactating Murrah buffaloes without influencing dry matter intake (Shekhar et al., 2010). Similarly, a combination of cellulase-xylanase-β-glucanase at 12,800-12,800-0 IU/g to sheep fed 50% maize stover based TMR increased ruminal volatile fatty acids and ammonia nitrogen concentration (Vijay Bhasker et al., 2013). Others have used exogenous fibrolytic enzyme at 1.25 mL/kg DM and found increased nutrient digestibility while milk performance was decreased because of lowered DMI in Holstein cows (Eun and Beauchemin, 2005). Appropriate enzyme combinations for use in Indian condition may have a great implication in improving ruminant productivity under crop residue-based fibrous diets by means of enhancing nutrient utilization (Shelke et al., 2010).

Branched chain fatty acids

The branched chain volatile fatty acids (BCFA) like isobutyric, 2-methyl butyric and isovaleric acids are produced during normal fermentation of feeds in the rumen at a level of ~5% of total volatile fatty acids (TVFA). These are considered to be the essential nutrients/growth factors for many cellulolytic bacteria. When sodium salts of isobutyric acid was supplemented at 0.75% of wheat straw-based diet (10% CP) in crossbred calves, there was an increased TVFA concentration with minimum ammonia nitrogen, whereas nutrient digestibility, nitrogen balance and growth performance was increased (Misra and Thakur, 2001). Recently, in separate experiments, Liu et al. (2013) and Zhang et al. (2015) obtained positive results in the form of increased digestibility of cellulose and hemicelluloses with minimum methane production when isovalerate and 2-methylbutyrate, respectively were
supplemented at 16.8 g/d for steers maintained on corn stover based low protein diet. These prove that BCFA supplementation benefits rumen fermentation and thus digestion in ruminants.

**Rumen protected amino acids**

As metabolisable protein (MP) is the truly available source of amino acids for milk production, it is important to ensure ideal amino acid balance in MP. In India, majority of undegradable protein source used are of plant origin, which are mostly deficit in essential amino acid methionine. Therefore, rumen protected forms of methionine and lysine are supplemented to achieve their desirable ratio of 1:3 in the MP.

A growth trial involving crossbred calves supplemented with 2 g rumen protected methionine (RPM) (net 0.78 g RPM deliverable) and 17 g rumen protected lysine (RPL) (net 3.70 g RPL deliverable) for a period of 90 days showed higher protein digestibility, nitrogen balance and hence growth rate than unsupplemented control group (Sai et al., 2014). Furthermore, in growing buffaloes, these supplemental amino acids exhibited protein-sparing effect when incorporated to 12% protein diet (Gami et al., 2015). In lactating crossbred cows, supplementation of 5 g rumen protected methionine and 20 g rumen protected lysine, improved milk yield by 2 kg/d (Amrutkar et al., 2015). Thus, these studies demonstrated positive response of supplemental amino acids for growth and lactation performance under Indian situation.

**Rumen protected choline**

Choline is trimethyl quaternary amine involved in the transport of fat from liver and necessary for the synthesis of phosphatidylcholine. It is a biological methyl donor needed for transmethylation and is particularly helpful in treating fatty liver condition postpartum. A daily supplementation of 54 g of rumen protected choline 40 days prepartum to 120 days postpartum revealed higher milk yield by >3.5 kg along with higher fat, protein and milk choline levels in crossbred cows (Amrutkar et al., 2015).

**Niacin**

Niacin is one of the B complex vitamins supplemented in ruminant diet especially for lactating cows and during thermal stress conditions. It has been known to alleviate negative energy balance during early lactation thereby minimising the incidence of ketosis and increasing milk production (Khan et al., 2014). Niacin specifically stimulates rumen protozoal population. Cattle supplemented with 6 g/d of niacin can cope-up summer stress as it acts at both systemic and cellular levels to cause vasodilation. Beneficial effects of niacin and nicotinamide supplementation have also been documented in buffaloes in straw-based diets (Ghosh et al., 2003).

**Herbal additives**

Herbal additives or botanicals are used as natural additives containing an array of phytochemicals like alkaloids, saponins, tannins, glycosides, essential oils, phytoestrogens, glucosinolates etc. and generally a mixture of several herbs are used rather than a single one to obtain desired effect (Singhal and Thakur, 2005). These are used in livestock diets to improve intake, performance, health status and mitigate methane emissions. Feeding of babul (Acacia nilotica) pods (18% tannin) improved functional value of milk as tannin metabolites get secreted into milk which are known to possess diverse biological activities/health benefits (Barman, 2004). A daily supplementation of Shatavari (Asparagus
*racemosus* at 50 g significantly augmented milk yield up to 10% in cows and buffaloes (Tanwar *et al.*, 2008), while *guduchi* (*Tinospora cordifolia*) at 60 g/d prepartum and 120 g/d postpartum improved immunity and reproductive performance of crossbred Karan-Fries cows (Mallick and Prakash, 2011). Moreover, polyherbal product containing nine herbs improved rumen fermentation, digestion and decreased methane emission at 1000 ppm levels (Jain *et al.*, 2013).

**Ionophores**

These are carboxylic polyether antibiotics of which monensin, lasalocid, salinomycin etc have been investigated as feed additive in ruminants. Main effects include enhancing propionate production in rumen, decreasing protein deamination, thereby eliciting protein-sparing action, decreases lactic acid production (bloat), selectively inhibit gram-positive rumen bacteria, increases nitrogen retention in growing animals, improve feed efficiency and reduces methane emission. In some experiments, milk yield was improved up to 10% when monensin was included at 20-35 ppm in the diet (Ipharraguerre and Clark, 2004).

**Microbial supplements**

Microbes used as feed additives are mainly in the form of probiotics or direct-fed microbials, which confer health benefits by supporting the activity of beneficial gut microbes. Lactic acid bacteria are commonly used to control calf diarrhoea (scouring) whose mechanism of action is through lowering pH, competitive exclusion of pathogenic microbes, secretion of antibiotic like substances, enhancing immunity etc. Few examples include:

- **Bacteria** (*Lactobacillus* and *Enterococcus* spp.)
- **Fungi** (*Aspergillus oryzae*) and zoospores (*Neocallimastix, Orpinomyces, Piromyces* etc)
- **Yeast** (*Saccharomyces cerevisiae*)

In case of adult ruminants, live yeast culture is used, which in majority of studies nutrient digestibility and increased milk yield (Mc Allister *et al.*, 2011). Recently, bacteria isolated from rumen like *Selenomonas* sp. are also being used as microbial supplement for cattle (Ahmed *et al.*, 2014).

**Buffers**

High yielding cows in the early lactation receiving high concentrate diet (50% and above) may experience acidosis or sub-acute ruminal acidosis (SARA) when rumen pH falls below 5.5 (normal pH: 6.7-6.9), which depresses fibre digestion. Therefore, buffers like sodium bicarbonate at 0.75 to 1.5% of DM is added in the concentrate mixture. In addition to stabilising rumen fermentation and intake, buffers also help overcome milk fat depression in cows. Other salts like magnesium oxide and calcium carbonate, potassium carbonate can also be effectively used as buffers (Erdman, 1988).

**Dietary cation-anion difference**

Dietary cation-anion difference (DACD) is a way to balance the electrical charges of cation and anion in the diet as these charges affect blood buffering capacity and blood acidity in cows. DCAD refers to the numerical difference between the sum of certain dietary cations (positively charged ions like sodium and potassium) and certain anions (negatively charged ions like chloride and sulphates) (Kaur, 2010).
A negative DCAD in the diet (anionic diet) of -100 to -200 mEq/kg DM is recommended 2-3 weeks prepartum as a prophylactic measure for milk fever. This can be achieved by supplementing about 100 g of ammonium chloride and 100 g of magnesium sulfate.

A positive DCAD in the diet (cationic diet) of +350 to +450 mEq/kg DM is suggested for fresh cows and early lactation in order to effectively buffer the excess VFA produced in the rumen thereby facilitate to maintain adequate DM intake and milk production. Similarly, positive DCAD diets (+150 to +250 mEq/kg) are recommended during heat stress and for growing cattle (Kaur, 2010; Suman and Kaur, 2015).

**Urea-molasses mineral block (UMMB) licks**

As cereal crop residue-based rations that are deficient in available nitrogen for maintaining minimum rumen fermentation, providing UMMB licks enable supply of critical nutrients like nitrogen and minerals needed to maintain rumen functions (Table 1). As a result, DM intake and digestibility increases along with higher microbial protein flow to the intestines. A UMMB lick of 3 kg, manufactured by hot or cold process, is sufficient for a week for an animal. Attraction of flies and disfigurement are limitations besides occasional toxicity.

**Table 1. Composition of UMMB prepared by hot process**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Urea</td>
<td>15</td>
</tr>
<tr>
<td>Molasses</td>
<td>45</td>
</tr>
<tr>
<td>Mineral mixture</td>
<td>10</td>
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<tr>
<td>Calcite powder</td>
<td>8</td>
</tr>
<tr>
<td>Sodium bentonite</td>
<td>3</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>15</td>
</tr>
<tr>
<td>Common salt</td>
<td>4</td>
</tr>
</tbody>
</table>

Adapted from: FAO (2007)

**Minerals: their role and supplementation**

Mineral elements play an important role in animal system and are therefore required for normal production, reproduction and health as they perform several functions (structural, catalytic, physiological and regulatory). Minerals required by livestock are categorised as

- Macro minerals (Calcium, Phosphorus, Magnesium, Sodium, Chlorine, Potassium and Sulphur)
- Micro/trace minerals (Copper, Zinc, Manganese, Iron, Cobalt, Iodine, Selenium, Chromium, Molybdenum, Fluorine, Arsenic, Nickel, Vanadium etc)

Description of essential mineral elements, their function, deficiency and common feed sources are presented in Table 2.
### Table 2. Mineral supplementation for livestock

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Function</th>
<th>Concentration in the diet</th>
<th>Deficiency symptoms</th>
<th>Common feed sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>Bone and teeth formation, blood clotting, muscle contraction, 0.12% in milk and 0.23% in colostrum</td>
<td>0.65-0.80%</td>
<td>Milk fever in adult cows, rickets in calves, slow growth and bone development, decreased milk production</td>
<td>Leguminous forages, limestone (38%) and dicalcium phosphate (20%)</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Bone and teeth formation, energy metabolism, component of DNA and RNA, phospholipid synthesis, 0.09% in milk</td>
<td>0.35-0.45%</td>
<td>Bone fragility, poor growth, depraved appetite (pica), reproductive failure (anestrous)</td>
<td>Cereal grains, grain by-products (bran), oil seed meals and dicalcium phosphate (18.5%)</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Enzyme activator, found in skeletal tissue and bone, important for muscle relaxation, cofactor in second messenger systems in cell communication</td>
<td>0.25-0.35%</td>
<td>Irritability, hypomagnesaemic tetany (cows), milk tetany (calves), increased excitability</td>
<td>Magnesium oxide (54-60%), magnesium sulphate (10-17%) and forages</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>Acid-base balance, muscle contraction, nerve transmission</td>
<td>0.28-0.45%</td>
<td>Craving for salt, reduced appetite, severe cases follow incoordination, weakness, shivering and death</td>
<td>Common salt (40%) and sodium bicarbonate</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Acid-base balance, HCl production in abomasum</td>
<td>0.28-0.35%</td>
<td>Craving for salt, reduced appetite</td>
<td>Common salt (60%)</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>Rumen microbial protein synthesis, found in cartilage, tendons and amino acids</td>
<td>0.20-0.22%</td>
<td>Growth retardation, decreased milk production, reduced feed efficiency</td>
<td>Elemental sulfur, sodium sulphate (10%), potassium sulphate (28%), protein supplements and legume forages</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Maintenance of electrolyte balance, enzyme activator, muscle and nerve function</td>
<td>1.0-1.6%</td>
<td>Decreased feed intake, loss of hair glossiness, lower blood and milk potassium</td>
<td>Legume forages, oat hay, potassium chloride (50%) and potassium sulphate (41%)</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>Synthesis of thyroid hormones, regulation of basal metabolic rate</td>
<td>0.45-0.60 mg/kg</td>
<td>Goitre in calves</td>
<td>Iodised salt, potassium iodide (69%) and potassium iodate (58%)</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Part of haemoglobin and many enzymes</td>
<td>50 mg/kg</td>
<td>Nutritional anaemia</td>
<td>Forages and grains</td>
</tr>
</tbody>
</table>
Copper (Cu) Needed for the synthesis of haemoglobin, part of many enzymes 12-16 mg/kg Severe diarrhoea, abnormal appetite, poor growth, coarse graying hair coat, osteomalacia Copper sulphate (25%)

Cobalt Part of vitamin B₁₂, needed for growth of rumen microbes 0.11 mg/kg Failure of appetite, anaemia, decreased milk production, rough hair coat Cobalt sulphate and cobalt chloride

Manganese (Mn) Growth, bone formation, enzyme activator 45-55 mg/kg Delayed signs of estrus, poor conception Manganous oxide (52-62%) and manganous sulphate (27%)

Zinc (Zn) Enzyme activator, influences immune response 45-55 mg/kg Decreased weight gains, lowered feed efficiency, skin ailments Forages, zinc oxide (46-73%), zinc sulphate (22-36%) and zinc methionine

Selenium (Se) Component of glutathione peroxidase, cellular antioxidant functions with vitamin E 0.3-0.5 mg/kg White muscle disease in calves, retained foetal membranes Oil cakes, forages, sodium selenite

Molybdenum (Mo) Part of enzyme xanthine oxidase - Loss of weight, emaciation, diarrhoea Widely distributed in feeds

Adapted from Risco and Retamal (2011)

**Supplementation of minerals to practical diets**

In order to overcome the deficiency and to prevent mineral inadequacy, supplementation in the form of mineral mixture (Table 3) is advised to all category of animals. Along with basal diet, mineral mixture should be supplemented daily at the dose of 30 g to calves and dry cows, 50 g to low producers (10 kg milk/d), 60 g to medium producers (15 kg milk/d) and 80-100 g/d to high yielders (20 kg milk/d) and buffaloes. Alternatively, mineral mixture can also be added to concentrate mixture at 2 kg for every 100 kg mixture.

**Table 3. BIS specifications for mineral mixture**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, % By mass, max</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Calcium, % by mass, min</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Phosphorus, % by mass, min</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Magnesium, % by mass, min</td>
<td>5</td>
<td>6.5</td>
</tr>
<tr>
<td>Iron, % by mass, min</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Salt, % by mass, min</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>Iron, % by mass, min</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Iodine, % by mass, min</td>
<td>0.02</td>
<td>0.026</td>
</tr>
<tr>
<td>Copper, % by mass, min</td>
<td>0.06</td>
<td>0.077</td>
</tr>
<tr>
<td>Manganese, % by mass, min</td>
<td>0.1</td>
<td>0.12</td>
</tr>
<tr>
<td>Cobalt, % by mass, min</td>
<td>0.009</td>
<td>0.012</td>
</tr>
<tr>
<td>Fluorine, % by mass, max</td>
<td>0.05</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Vitamins

Vitamins are essential dietary compounds required in small quantities for normal cellular metabolism. In ruminants, some vitamins are provided in diet and some are synthesised by ruminal microorganisms.

Typically, high yielding dairy cow diets are supplemented with specific amounts of the fat-soluble vitamins (mainly vitamin A, D and E). Of the water-soluble vitamins, none has dietary requirements for ruminants as majority are synthesised by rumen microbes, although this may not be sufficient for high yielding cows. The biological role and recommended daily feeding of fat- and water-soluble vitamins for lactating cows is presented in Table 4.

Table 4. Vitamins in the diet of lactating cows

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Function</th>
<th>Deficiency</th>
<th>Requirement*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fat soluble</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (retinol)</td>
<td>Vision, gene transcription, immune function, reproduction, bone metabolism, epithelial integrity, antioxidant activity</td>
<td>Night blindness, calves born blind</td>
<td>110 IU/kg BW (NRC, 2001) or 100000 IU/d</td>
</tr>
<tr>
<td>D₃ (1,25 dihydroxy cholecalciferol)</td>
<td>Calcium homeostasis, induction of calcium binding protein for intracellular Ca transport, secretion of insulin and prolactin, muscle function and immune response</td>
<td>Rickets in young and osteomalacia in adults</td>
<td>20,000 IU/d</td>
</tr>
<tr>
<td>E (α tocopherol)</td>
<td>Antioxidant, involved in innate immunity and phagocytic cell activity</td>
<td>Muscle dystrophy, uterine diseases, retained placenta, risk of mastitis, impaired neutrophil function</td>
<td>2000-4000 IU/d in first 3-4 weeks postpartum followed by 1000 IU/d</td>
</tr>
<tr>
<td>K (quinine)</td>
<td>Synthesis of blood clotting proteins</td>
<td>Delayed blood clotting and internal bleeding</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td><strong>Water soluble</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₁ (Thiamin)</td>
<td>Coenzyme role in energy metabolism, synthesis of neurotransmitters, passive transport of Na in nerve impulses</td>
<td>Polioencephalomalacia (cerebrocortical necrosis)</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>B₂ (Riboflavin)</td>
<td>Component of flavin adenine dinucleotide (FAD) and flavin adenine mononucleotide (FMN), transfer of H in cellular reactions</td>
<td>-</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>B&lt;sub&gt;3&lt;/sub&gt; (Niacin)</td>
<td>Coenzymes of nicotinamide, NAD and NADP, role in carbohydrate, protein and lipid metabolism, causes vasodilation</td>
<td>Dermatitis, hepatic lipidosis</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>B&lt;sub&gt;6&lt;/sub&gt; (Pyridoxine)</td>
<td>Pyridoxal phosphate participates in metabolism of carbohydrates, amino acids and lipid metabolism, incorporation of iron into haemoglobin, antibody production</td>
<td>Reduced growth, dermatitis, alopecia, anaemia, neurological symptoms, immunosuppression</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>B&lt;sub&gt;12&lt;/sub&gt; (Cobalamin)</td>
<td>Cofactor in single-carbon transfer, propionate metabolism and incorporation into TCA cycle, RBC synthesis, neural integrity</td>
<td>Deficiency occurs if diets are deficient in Co or if rumen microflora are destroyed, loss of myelin in nerve cells, causes megaloblastic anaemia, poor appetite, weakness</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>Folic acid</td>
<td>Cofactor, cell division, DNA methylation</td>
<td>Megaloblastic anaemia, neural tube defects in newborns</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>Biotin</td>
<td>Cofactor for carboxylase enzymes, involved in TCA cycle, gluconeogenesis and fat synthesis, participates in the production and deposition of keratin in horn and hooves</td>
<td>Dermatitis, weakness, paralysis of hind legs, reduced integrity of hoof and horn tissues</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>Component of coenzyme A, activation of fatty acids for oxidative metabolism in the mitochondria</td>
<td>Impaired fatty acid metabolism, increased ketogenesis and metabolic acidosis</td>
<td>Synthesised by rumen and intestinal microbes</td>
</tr>
<tr>
<td>C (Ascorbic acid)</td>
<td>Cofactor for enzyme activity, antioxidant, regenerates vitamin E, synthesis of collagen, phagocytic activity of leukocytes, synthesis of carnitine and adrenal cortical steroids</td>
<td>Deficiency is rare, impaired synthesis of collagen</td>
<td>Synthesised from glucose by the liver</td>
</tr>
<tr>
<td>Choline</td>
<td>Phospholipid synthesis, cell membrane integrity, absorption and transport of fatty acid and cholesterol, synthesis of acetylcholine and transmethylation reactions</td>
<td>Hepatic lipidosis, ketosis</td>
<td>Not a typical vitamin. No requirements established although beneficial effects are observed when rumen protected forms are fed at 15-50 g/d</td>
</tr>
</tbody>
</table>

Adapted from Risco and Retamal (2011); * As specified by NRC (2001)

**Conclusion**

Supplementation minerals and vitamins are essential as they are nutrients required for various physiological functions thus impacting livestock productivity. Furthermore, out of several feed
additives discussed, specific one may be considered depending on the type of dietary situation and requirement as per production level.

References


INTRODUCTION

For food security in India livestock production and agriculture are complementary to each other and both are crucial for farmers with small and marginal holding. In mixed crop-livestock production system, dairy production contributes 20 to 50% of family income. The share of livestock for underprivileged marginal and landless livestock owner is as high as 70 to 80% during drought year. India is gifted with the largest livestock population in the world. It accounts for about 57.3 per cent of the world’s buffalo population and 14.7 per cent of the cattle population. There are about 71.6 million sheep and 140.5 million goats in the country. Farmers of marginal, small and semi-medium operational holdings (area less than 4 ha) own about 87.7% of the livestock. Hence development of livestock sector would be more inclusive. The livestock sector achieved an average growth rate of 4.8 per cent during the Eleventh Five Year Plan (Economic Survey, 2012-13) and it contributed 3.6 percent of national GDP during the Eleventh Plan. India, the largest producer of milk in the world, is set to produce over 137 million ton milk during 2012-13. The value of output of milk is Rs. 3,05,484 crore in 2011-12, which is higher than the value of output of paddy and wheat.

The average milk yield of cattle in the world and Europe is about 2040 kg and 4250 kg per lactation respectively, the average milk yield of Indian cattle is about 1000 kg. While genetic improvement and health care are the prerequisites for sustainability, efficient feeding and marketing will help in increasing the profitability, because 65-70% of the total cost of livestock farming is attributed to feeding. With feeding of good quality forage, particularly leguminous fodder, feeding of concentrate can be reduced significantly. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. The demand of green and dry fodder will reach to 1012 and 631 million tonnes of by the year 2050 (Table-1). At the current level of growth in forage resources, there will be 18.4% deficit in green fodder and 13.2% deficit in dry fodder in the year 2050. To meet out the deficit, green forage supply has to grow at 1.69% annually.

Table 1. Demand and supply estimates* of dry and green forages (million tons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Demand Dry</th>
<th>Demand Green</th>
<th>Supply Dry</th>
<th>Supply Green</th>
<th>Deficit Dry</th>
<th>Deficit Green</th>
<th>Deficit as %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>508.9</td>
<td>816.8</td>
<td>453.2</td>
<td>525.5</td>
<td>55.72</td>
<td>291.3</td>
<td>10.95</td>
</tr>
<tr>
<td>2020</td>
<td>530.5</td>
<td>851.3</td>
<td>467.6</td>
<td>590.4</td>
<td>62.85</td>
<td>260.9</td>
<td>11.85</td>
</tr>
<tr>
<td>2030</td>
<td>568.1</td>
<td>911.6</td>
<td>500.0</td>
<td>687.4</td>
<td>68.07</td>
<td>224.2</td>
<td>11.98</td>
</tr>
<tr>
<td>2040</td>
<td>594.9</td>
<td>954.8</td>
<td>524.4</td>
<td>761.7</td>
<td>70.57</td>
<td>193.0</td>
<td>11.86</td>
</tr>
<tr>
<td>2050</td>
<td>631.0</td>
<td>1012.7</td>
<td>547.7</td>
<td>826.0</td>
<td>83.27</td>
<td>186.6</td>
<td>13.20</td>
</tr>
</tbody>
</table>

(Source- Vision,2050, IGFRI)
The deficit and supply in crude protein (CP) and total digestible nutrients (TDN) are given in Table 2. The situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded animals. The available forages are poor in quality, being deficient in available energy, protein and minerals. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on land and fodder resources.

Table 2. Demand and availability estimates of CP and TDN (million tons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Requirement CP</th>
<th>Requirement TDN</th>
<th>Availability CP</th>
<th>Availability TDN</th>
<th>% Deficit CP</th>
<th>% Deficit TDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>60.04</td>
<td>347.8</td>
<td>42.95</td>
<td>271.3</td>
<td>28.47</td>
<td>21.99</td>
</tr>
<tr>
<td>2020</td>
<td>62.58</td>
<td>362.5</td>
<td>47.18</td>
<td>290.5</td>
<td>24.60</td>
<td>19.87</td>
</tr>
<tr>
<td>2030</td>
<td>67.01</td>
<td>388.2</td>
<td>53.09</td>
<td>320.2</td>
<td>20.78</td>
<td>17.52</td>
</tr>
<tr>
<td>2040</td>
<td>70.19</td>
<td>406.6</td>
<td>57.61</td>
<td>342.8</td>
<td>17.92</td>
<td>15.69</td>
</tr>
<tr>
<td>2050</td>
<td>74.44</td>
<td>431.2</td>
<td>61.92</td>
<td>364.5</td>
<td>16.81</td>
<td>15.47</td>
</tr>
</tbody>
</table>

(Source- Vision, 2050, IGFRI)

Rapid industrialization and mining areas has caused shrinkage of grazing and fodder producing lands. Due to non availability of quality green fodder throughout the year, milk producers are forced to utilize extra concentrates for optimum milk production. On account of this cost of milk production is higher in such areas. The current milk production level can be sustained and enhanced by better feeding strategies and year round green fodder production through Intensive year round green production rotations and fodder preservation techniques.

YEAR-ROUND FORAGE PRODUCTION THROUGH INTENSIVE YEAR ROUND GREEN PRODUCTION ROTATIONS

Overlapping cropping systems developed to fulfill the needs of dairy farmers for green fodder throughout the year and for small farmers requiring maximum forage from a piece of land. It consists of raising berseem, inter-planted with hybrid Napier in spring and intercropping the inter-row spaces of the grass with cowpea during summer after the final harvest of berseem (Table 3). This system was found superior to multiple crop sequences both in terms of production and economic returns. The hybrid Napier could be successfully replaced with relatively soft and palatable perennial grasses like Setaria and guinea grass and berseem with lucerne wherever required.

Table 3 Round-the-year fodder production systems

<table>
<thead>
<tr>
<th>Crop sequence</th>
<th>Green fodder yield (tonnes/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napier x Bajra hybrid + Cowpea - Berseem</td>
<td>260</td>
</tr>
<tr>
<td>Maize + Cowpea – MP Chari + Cowpea – Berseem + Japanese rape</td>
<td>197</td>
</tr>
<tr>
<td>MP Chari + Cowpea – Berseem + Japanese rape</td>
<td>184</td>
</tr>
<tr>
<td>Cowpea – MP Chari + Cowpea – Berseem + Japanese rape</td>
<td>176</td>
</tr>
<tr>
<td>Napier x Bajra hybrid + Cowpea – Berseem – Cowpea</td>
<td>255</td>
</tr>
</tbody>
</table>

The intensive cropping systems when managed properly using modern techniques of soil and crop management are able to yield 180 - 300 tonnes of green fodder (30 - 55 tonnes dry fodder) per ha/year. Some of the intensive cropping systems have been suggested for different regions.
North Zone

Maize + Cowpea – Sorghum + Cowpea (two cuts) – Berseem + Mustard.
Sudan grass + Cowpea – Maize + Cowpea – Turnip – Oats (two cuts).
Hybrid Napier or Setaria inter-planted with cowpea in summer and Berseem in winter (9 -10 cuts/year).
Teosinte + Cowpea (two cuts) – Carrot – Oats + Mustard/Senji (two cuts).

Western and Central Zone

Bajra + Guar (Clusterbean) (two cuts) – Annual Lucerne (6 cuts).
MP Chari + Cowpea (2 cuts) – Maize + Cowpea - Teosinte + Cowpea (2 cuts).
Hybrid Napier or Guinea or Setaria grass inter-planted with Cowpea in summer + Berseem in winter (8-9 cuts/year).
Hybrid Napier or Guinea or Setaria grass interplanted with Lucerne (8-9 cuts/year).

Southern Zone

Sorghum + Cowpea (3 cuts) – Maize + Cowpea – Maize + Cowpea.
Hybrid Napier or Guinea or Setaria grass inter-planted with Lucerne (8-9 cuts) or Hybrid Napier + Subabul / Sesbania (9-11 cuts/year).
Sudan grass + Cowpea (3 cuts) – M.P. Chari + Cowpea (three cuts).
Para grass + Centro (Centrosema pubescens) (9-11 cuts/year).

Eastern Zone

Maize + Cowpea – Teosinte + Rice bean (2 cuts) – Berseem + Mustard (3 cuts).
M.P. Chari + Cowpea – Dinanath grass (2 cuts) – Berseem + Mustard (3 cuts).
Para grass + Centrosema pubescens (8-9 cuts/year).
Hybrid Napier or Setaria grass inter-planted with Subabul or Common Sesban (Sesbania sesban) (9-10 cuts/year).

YEAR-ROUND FORAGE AVAILABILITY THROUGH FORAGE PRESERVATION

SILAGE-MAKING

Silage-making is a management tool that allows producers to match feed resources (forages, crop residues, agro-industrial by products, etc.) with feed demand for a dairy herd. The basic function of silage-making is to store and preserve feed for later use with minimal loss of nutritional qualities. Silage making is less dependent than hay-making on good weather conditions and can be extended to a great variety of forage crops (corn, sorghum, immature cereal grains, etc.) and locally available agro-industrial by products (sugar beet pulp, brewers grain, etc.). Difficulties arose when silage making was extended to other forage crops that are less easily preserved as silage, in particular legumes. Silage making has become an important tool for producers to manage crop production and dairy herd feeding programs in many production systems around the world. However, silage making requires considerable capital and labour investments on the farm; it also demands a fairly high level of technical expertise. The understanding of how ensiling works to preserve a crop by fermentation...
is important. This knowledge is key to making the best management decisions for minimizing the inevitable losses that occur when fresh feed resources are ensiled and preserved for long periods of time in a silo.

Forage preservation as silage is a key component of high input systems. It has allowed producers to intensify the productivity of the land and the productivity of the cows independently from each other. As silage making allows storage and preservation of feed resources for months, if not years, producers can focus on two separate objectives: 1) To maximize yield of digestible nutrients (energy, protein, etc.) per hectare of land; 2) to maximize milk production per cow throughout the year. Thus silage making gives producers a feed inventory that can be used to plan a detailed feeding program for the herd.

**Advantages of silage-making**

Silage making is a tool for producers to achieve whole farm management goals. Silage making has some distinct advantages compared to grazing or hay-making. For example, silage making allows:

- Intensification of forage production (i.e., increased yield of forage per hectare);
- Minimization of risk factors associated with weather conditions (rainfall losses) when trying to harvest high quality forages. For example, compared to hay-making, silage making shortens the time between cutting wider range of weather conditions, and risk of dry matter losses due to rainfall is minimized;
- Improvement of the producer's control over cutting dates and optimal stage of maturity at harvest;
- Minimization of loss of leaves and other small plant parts of high quality in the field;
- Storage of non-forage feeds that cannot be preserved as hay, such as agro-industrial by products;
- Stable composition of the feed (silage) for a longer period (up to 5 years);
- Plants can be harvested at optimal phase of development and are efficiently used by livestock.
- Reduction of nutrient loses (below 10%) which in hay may amount to 30% of the dry matter.
- More economical use of plants with high yield of green mass;
- Better use of the land with 2-3 crops annually; Requires 10 times less storage space compared to hay;
- Silage is produced in both cold and cloudy weather;
- The fermentation in silage reduces harmful nitrates accumulated in plants during droughts and in over-fertilized crops.
- Allows by-products (from sugar beet processing, maize straw, etc.) to be optimally used;
- Maize silage has 30-50% higher nutritive value compared to maize grain and maize straw; 2 kg of silage (70% moisture) has the equal nutritive value of 1 kg of hay.

**Limitations and drawbacks of silage making**

Silage making also has some limitations or drawbacks that need to be taken in mind-
1. Silage making requires high capital investment. Harvesters are needed to chop the forage, tractors or other heavy equipment are used to pack the silage, storage facilities (silo structures) may be expensive, and additional equipment may be required to remove silage from a silo;

2. The management of silos is sometimes difficult on the farm because once a silo is opened, silage should be removed on a daily basis (to minimize loss of nutritive value). Adjusting the number of silos and their dimension to the expected feed out rate for a given herd size is difficult. Usually, only large herds can afford to feed out of different silos of varying forage qualities for different groups of animals on the farm (heifers, dry cows, lactating cows, etc.);

3. Once silage is removed from a silo, it becomes unstable (because of exposure to oxygen) and tends to spoil within a day or two (especially in warm weather conditions with well-preserved silages);

4. Silage cannot be marketed easily (difficult to transport long distances);

5. Loss of nutrients during storage in a silo is unavoidable and may be high if the silage is not prepared properly.

**PRINCIPLES AND PRACTICES OF SILAGE PRESERVATION**

As a forage crop is cut, harvested and stored, loss of dry matter (quantity) and nutritional quality inevitably occur. These losses are due to enzymes that degrade the plant after it has been cut. Thus the goal in silage making is to stop enzymatic reactions and minimize loss of energy, protein and other nutrients. Thus silage making can be defined simply as a method of forage preservation in which most of the energy, protein, and other nutrients that were in the original plant remain in a form that can be efficiently utilized by cows. A more technical definition, “Silage is a method of feed resource preservation- which is based on the removal of air (oxygen) from a mass of feed to promote the fermentation of sugars into lactic acid by lactic-acid bacteria causing an increase in acidity (a reduction in pH) which inhibits further silage degradation by: plant enzymes (primarily protein degrading enzymes); undesirable bacterial species (enterobacteria, clostridia), yeast and molds; and the lactic acid bacteria themselves”.

As silo is filled, each load of freshly chopped forage is packed to expulse as much air as possible from the growing mass of silage. The absence of oxygen allows lactic acid bacteria to grow by converting sugars (simple sugars and starch) into lactic acid, a strong organic acid. As lactic acid bacteria grow, lactic acid accumulates in the ensiled mass and the acidity increases, that is, pH drops. As pH declines, the degrading actions of plant enzymes and undesirable bacteria (clostridia and enterobacteria), yeast and molds are slowed. When pH is sufficiently low (pH of 3.8-4.2 in corn silage and pH of 4.2-4.7 in alfalfa silage) most degrading enzymes are inhibited and the growth of lactic acid bacteria is also inhibited. Thus the goal in silage-making is to exclude oxygen from the forage mass in order to promote the fermentation of sugars by lactic acid bacteria and drop the pH as rapidly as possible to stop all forms of degradation activity.

**Suitable forage crops to be preserved as silage**

The chemical composition of a forage crop or agro-industrial by-product plays an important role in determining the ease with which lactic acid fermentation can take place; and thus the ease with which a particular feed can be preserved as silage. It is easier to ensile forages that have: A high
level of fermentable sugar; a low level of protein; a low buffering capacity; ideal dry matter content at ensiling time.

As indicated in Table 1, corn is preserved as silage more easily than grasses or alfalfa because of its high sugar content, low protein content and low buffering capacity. In contrast, alfalfa is more difficult to ensile well because of its low sugar content and high buffering capacity, which is due in part to its high protein content. Thus the higher the quality of alfalfa, the more challenging it is to ensile successfully.

Table 1: Chemical composition and buffering capacity of typical forage crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water soluble carbohydrate (g/kg DM)</th>
<th>Crude protein (% DM)</th>
<th>Ratio wsc/cp</th>
<th>Buffering capacity (mEq/kg DM)</th>
<th>“Aptitude” for silage preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>80 - 300</td>
<td>80 - 100</td>
<td>1.0 – 3.0</td>
<td>150 - 300</td>
<td>High</td>
</tr>
<tr>
<td>Grasses</td>
<td>35 - 300</td>
<td>100 - 160</td>
<td>0.4 – 1.8</td>
<td>250 - 550</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>20 - 150</td>
<td>140 - 200</td>
<td>0.1 – 0.75</td>
<td>350 - 650</td>
<td>Low</td>
</tr>
</tbody>
</table>

Stage of growth

Crops should be cut at a proper stage of maturity as it is the most important factor for controlling the silage quality. The appropriate stage of growth for cutting different fodder crops for silage making is Sorghum - Flowering to dough stage; Maize - Milk to dough stage; Oat - 50% flowering to dough stage; Grasses - Early flowering stage

The “right” dry matter content

The dry matter content of silage strongly influences the type of fermentation that takes place in a silo. Losses of dry matter in effluents occur when silage dry matter content is less than 25%. On the other hand, too much dry matter makes it difficult to pack and expulse the oxygen from the silage mass. The “ideal” dry matter content of the forage depends on the type of silo (which influences the mode and level of level of compaction that can be achieved). The recommended levels of dry matter in forages at ensiling are- 30 to 40% for bunker silos; 35 to 50% for tower silos; 40 to 50% for wrapped round bales.

Often, wilting a green forage for 24 – 48 hours to increase dry matter is highly desirable, because wilted silage requires less lactic acid production and will stabilize at a higher pH level than silage that has a lower dry matter content. This is the case because higher dry matter content increases the concentration of soluble dry matter in the silage, and the resulting increase in osmotic pressure inhibits bacterial growth. Thus fermentation stops in wilted silage because of the high acidity, high osmotic pressure combination (rather than high acidity alone in silage with lower dry matter content). Thus wilting has a “sparing” effect on the level of sugar and the level of fermentation needed to stabilize the silage. As a result, wilting is particularly important when the ensiled forage is a legume, which has a relatively low level of fermentable sugars as compared to grass or corn.

Methods of controlling fermentation

There are several ways in which the clostridial type fermentation can be checked. One of the commonly used practices is to increase the dry matter of the herbage. In ensiled crops containing 30% or more dry matter, crop ensile satisfactorily. Promotion of lactic acid fermentation is important.
pathway for controlling clostridial growth. Other method of controlling fermentation is by addition of preservatives and additives. Carbohydrates in the forages may be naturally occurring or may be added as a separate ingredient such as molasses obtained as sugar industry byproducts, which acts as a fermentable substrate.

Additives for effective ensiling of nutrients

Various types of additives can be used to improve or inhibit the fermentation or supplement nutrients needed by ruminants to be fed as silage. Propionic acid, formaldehyde, etc. have been used to increase the rate of lactic acid fermentation and produce stable silage. Carbohydrate sources such as molasses, whey, yeast and other energy-rich ingredients have also been used as additives to increase the fermentation and feeding value of silage. Common additives are as follows,

**Molasses:** Some green forages such as legumes and certain grasses are rather low in sugar content. Adding molasses definitely improves the quality of silage by increasing lactic and acetic acid production. It also increases the palatability and nutritive value of the silage. Molasses may be added (3.5 to 4 per cent of the green weight of the forage) in either liquid or dehydrated form. Molasses and starches when added in the form of grains supply the silage bacteria with ample food so that fermentation proceeds normally.

**Urea:** Adding urea at a level of 0.5 per cent of fresh forages is recommended. The very idea of adding urea is to enrich the silage with nitrogen as cereal forages are mostly deficient in this element.

**Limestone:** This is calcium carbonate and may be added at a level of 0.5 to 1.0 per cent to maize silage to increase acid production. It neutralizes some of the initial acids as they are formed allowing the lactic acid bacteria to perform longer and to produce more desirable acids.

Sodium metabisulphite: Sulphur dioxide (SO₂ a gas) is a very good antibacterial preservative. It also improves carotene content.

**Organic acids:** Propionic and formic acids are used for enhancing preservation of forages without the loss of palatability. These are costly and when added, the following guidelines may be observed: Add 1 per cent propionic acid to the forage in the field at the time of harvest or at the chopper. Limit the presence of oxygen by using a sound well built silo. Prevent dilution of organic acid treated silage by rain and cover it with plastic when it is stored outside.

**Bacterial cultures:** Silage preservatives containing cultures of acid-forming bacteria like Lactobacillus acidophilus, Torulopsis sp., and Bacillus subtilis, are added to silage crops. The basis for including these as a preservative is to provide an inoculum or to increase the number of bacteria for helping rapid fermentation.

Silos

The different types of silos generally used are: (i) pit silo, (ii) tower silo, (iii) trench cum bunker, (iv) trenches, and (v) drum and PVC silo. The silo must provide a solid surface to permit consolidation of the ensiled material and elimination of air. It must protect the silage from water. In India, pit silo is the most common.

Chopping

Crop should be chopped before ensiling. For good silage, the shorter the chop length, the better is the quality. Chopped silage is more palatable to livestock and has little chance of secondary fermentation.
Filling of silo

Silo should be filled rapidly and should not be left open. It should be sealed as soon as possible. Packing is important to create anaerobic conditions. It should be thoroughly pressed so that no air pocket is left in the silo otherwise chances of mould formation will be there which will spoil the silage. After filling, silo should be covered with polythene sheet followed by that of a layer of soil, etc.

Removal of silage

After 45 days of ensilage, the silage can be removed for feeding to animals. Care should be taken in removing the silage from silo. It should not be allowed to deteriorate after the silo is opened for feeding. Covers should be kept firmly in place as long as possible and the minimum face should be exposed at one time. The sugars, proteins and lactic acid present in the silage are subject to attack by mould growth and oxidation as some air is allowed to fermentation and causes loss of feeding value and intake by the animals.

Silage quality

Silage quality is determined mainly by the odour, physical state, pH, ammonical nitrogen, volatile acids and lactic acid. For desirable fermentation, the forage should be rich in water soluble sugar (more than 5% on dry-matter basis). A good-quality silage should have the following characteristics: (i) pH 4.5-5.0, (ii) ammonical nitrogen of total N – less than 10% of total N, (iii) butyric acid- less than 0.2%, (iv) lactic acid -3 to 12%

CHANGE IN FORAGE COMPOSITION IN A SILO

Loss of soluble carbohydrates and proteins

As dry matter is lost during silage-making, forage composition also changes. The changes in dry matter composition are due primarily to the fact that the most valuable nutrients (soluble carbohydrates and proteins) are also the first to be lost during respiration and fermentation and in the effluents (juices). Fiber on the other hand remains essentially unaffected by the naturally occurring fermentation process in a silo. Thus the overall effect of these losses is to increase the proportion of fiber; the percentage of both the acid detergent fiber (ADF) and neutral detergent fiber (NDF) tend to be higher in silage than in freshly cut forage.

Changes in the protein (nitrogen) fractions

Silage-making change the protein fraction of forages. Respiration is responsible for protein breakdown. As plant cells die after cutting, proteolytic enzymes break down large proteins into smaller soluble compounds including: peptides, amino acids (the building blocks of proteins) and ammonia. In addition, enterobacteria have proteolytic enzymes that remain active even after the pH has dropped to 5.0. Thus most of the protein degradation that takes place in a silo occurs within the first 24 to 72 hours (Phase 1 and Phase 2 of silage fermentation). By the time pH is about 4.0, proteolytic enzymes have lost 65 to 85% of their activity. Consequently, a rapid drop in pH is desirable to reduce the amount of protein breakdown in a silo. Nevertheless, recent research indicates that as much as half of the total nitrogen in alfalfa silage may be in the form of non-protein nitrogen. The extensive breakdown of alfalfa protein in a silo may be a factor in limiting milk yield in high producing cows (Broderick, 1995). Some scientists have proposed the use of ammonia content as one indicator of adequate silage fermentation. For example, grass silage containing less than 5% of total nitrogen in the form of ammonia might be classified as excellent. In contrast, silage that undergoes
clostridial fermentation might contain more than 35% nitrogen in the form of ammonia and thus would be classified as poor (Vanbelle, 1985).

Although limiting protein solubilization and ammonia production in a silo is desirable, one should realize that this process is relatively similar to what happens in the rumen of a cow after ingesting silage. Not all soluble protein and ammonia produced in the silo are necessarily lost. Ammonia and amino acids are needed for microbial synthesis in the rumen. Another nitrogen transformation that may occur during hay or silage-making results from the browning reactions that take place when excess heat is produced. Excess heat cause chemical reactions that combine amino acids with plant sugars (usually derived from hemicellulose) to form a compound resembling lignin. This reaction results in increased levels of acid detergent fiber (ADF) and acid detergent insoluble protein (ADIP). Excess heat is an indication of aerobic degradation due to the presence of air (oxygen) in a silo.

HAY MAKING

Conservation of high-quality forages by drying is termed as hay making. The principle of hay making is to preserve nutritional value of forages through drying it to a level at which the activity of microbial decomposers is inhibited. In India, sunlight is available in abundance, which enables farmers to dry the green forage in open sunlight and thus making hay more economical. The hay making leads to reduction of moisture content to 10-20%, which inhibits the enzyme activity in the plant to be conserved. Thin stemmed cereal crops like sorghum, oat, guinea grass, range grasses, range legumes particularly *Sylosanthes*, *Siratro*, lablab bean, and all the cultivated legume fodders like berseem, lucerne, and cowpea are suitable for hay making. Leguminous forages have high buffering action and high nitrogen content, and hence are more suitable to be conveniently conserved as hay. Hay making is relatively more convenient and easy for Indian farmers. It can be done by sun drying. During inclement weather, hay making may be done by drying under shade or artificial drying through solar energy. Harvested forage particularly thick stemmed should be chopped and spread over the ground for sun curing and the layers should be changed every day to prevent any sort of fermentation or bacterial growth. After it is well dried (dry-matter content at the time of storing should be around 85-90%), this can be stored for feeding during the lean periods. Thin stemmed crops including legumes can be dried without chopping while thick stemmed fodders like sorghum, maize and bajra (pearl millet) require chopping or crushing before they are allowed to dry.

Factors affecting the quality of hay

The following factors affecting the quality of hay are important and should be given due consideration: plant species, stage of harvest, leaf : stem ratio, chemical composition, physical form, and deterioration during storage.

Hay refers to grasses or legumes that are harvested, dried and stored at 85-90 percent dry matter. In other words, Hay refers to a forage plant when preserved through reducing the moisture content to the level at which tissues are dead nor dormant. High quality hay is green in colour, leafy and pliable and free from mustiness. When harvested in the proper physiological stage of growth and well cured to 15 per cent or less moisture at the time of storing, hay can be utilized as an excellent feed for dairy cattle, particularly when fodder is scarce or pasturage is insufficient.

Principles of hay making

The principle involved in hay making is to reduce the water content of the herbage so that it can safely be stored in mass without undergoing fermentation or becoming mouldy. This must be
accomplished in such a manner that the hay is not leached by rain and that the loss of leaves is kept at a minimum.

**Requisites of good quality hay**

- Good hay should be leafy. It has been found that leaves are richer in food value compared to other parts of the plant. The leaves are generally rich in proteins, vitamins and minerals. Loss of leaves in hay making would mean deterioration in feeding value of the ultimate product.
- It should be prepared out of herbage, cut at a stage nearing maturity, preferably at the flowering stage when it has the maximum of nutrients. Delay in cutting would mean losses of a part of nutrients which would be used up by the plant in seed formation.
- It should be green in colour. The green colour of leaves indicates the amount of carotene which is a precursor of vitamin A.
- It should be soft and pliable.
- It should be free from dust and moulds.
- It should be free from weeds and stubbles.
- It should have the smell and aroma characteristic of the crop.
- The moisture percentage in hay should not exceed 15 percent.
- Hay of average quality will usually have 25-30 per cent crude fibre and 45-60 percent TDN.
- Hay is primarily feed to cattle, buffalo, horse, sheep and goat. Very little of hay of any kind is ever fed to swine.

**Types of hay**

The hay depending on the various ways of processing can be divided into the following categories. Jungle hay, Sundried hay, Barn dried hay, Dehydrated fodders ETC.

- Jungle hay and Sundried hay mostly refer to the field curing.
- Barn refers to a simple roofed farm building for storing hay.
- Hay is baled in the field and brought to the barn.
- Driers are also used for dehydration.
- Two types of driers are available Low temperature driers, 80 to 180°C and High temperature driers, 300 to 600°C.

**Legume and non-legume hay**

Legume hay :- Good legume hay has many characteristics that make it of special value to the dairy cattle. It has a higher percentage of digestible nutrients. It has more of digestible proteins because of the high protein content. Furthermore, the proteins of legumes are of superior quality as compared to proteins from other plants. Well - cured legume hays are higher in vitamin contents. They are particularly rich in carotene and may even contain vitamin D. They are also a rich source of vitamin E. The legume hays are particularly rich in calcium and are generally palatable. Among various leguminous fodder crops lucerne, berseem, cowpea and soybean hays are considered first.
Non-legume hay:- Non-legume hays made from grasses are inferior to legume hays. They are, as a rule, less palatable and contain less proteins, minerals and vitamins than the legume hays. Non-legume hays have the advantage over legume hays because their output per hectare is more than that of legume hays and the former can be grown easily.

Mixed hay:- Hay prepared from mixed crops of legumes and non-legume is known as mixed hay. The composition of such a kind of hay will depend on the proportion of the different species grown as a mixed crop.

Steps in hay making

- Selection of crop and suitable stage of harvest:
  - The quality hay can be prepared from the forages having soft and pliable stem. Oat is the best crop for hay making as the crop has soft and pliable stem. Annual and perennial grasses are also suitable for hay making. Legumes are also used for hay making but the problem of leaf shattering should be taken care of by careful handling. Berseem, lucerne, cowpea, pillipesera etc., can be used for hay making.
  - The crop should be harvested during the day time after the dew has dried off so that plants when spread over the ground may dry evenly. Another factor which needs attention is that the field should not be wet, otherwise uniform drying will not be effected.
  - The crop cut early is higher in protein, lower in crude fibre, contains more of vitamins, is more palatable and leaf shedding will be less. The best time for cutting a crop for hay making is when it is one-third to a half in blossom.

- Selection of suitable method of drying:
  - Quantity of crop available (For a small quantity forage, skilled operation and costly structures would be unsuitable).
  - Duration for which forage is available for hay making (If forage supply is continuous for the hay making at least 300 days in a year, then the dehydrators may be worthwhile).
  - Relative humidity (Field curing is not suitable for hay making if the relative humidity is high which may cause moulds/fungi).
  - Intensity of rains (Rain causes loss of nutrients due to leaching. Continuous rains combined with high relative humidity pose a serious problem for hay making).
  - Atmospheric temperature (The intensity and duration of bright sunshine hours decide the atmospheric temperature. During the hot weather period of March-April to May-June, hay making through sun drying is very convenient and efficient).
  - Cost of installation (The choice of barns or dehydrators depend on the cost of it. Simple field curing during summer months is cheap and best for the poor farmers with few animals).
  - In curing, it is necessary that the herbage should be saved from bleaching by the sun and as far as possible, leaves preserved from shattering. The maximum quantity of
moisture should be evaporated, so that it can be stored without generation of heat and consequent loss of nutrients.

- For reasonably rapid curing and production of high quality hay, it is best to let the herbage lie in the field for a few hours until it is well wilted or about one-fourth to one-third cured. It should be raked into small loose heaps known as windrows. If good weather continues, the hay is cured in windrows alone.
- When the weather is such that the hay cures slowly, turning may also be necessary. Besides field curing, hay can be cured by hanging the herbage on tripods, and on farm fences.
- In artificial curing, the material is placed in a suitable chamber where it comes in contact with heated air and exposure is regulated depending on the material and the temperature.

Losses of nutrients in hay making

Some nutrients are always lost in field curing of hay, but under favourable conditions this loss is not too much. Drying of green forage at ordinary temperature reduces its digestibility. If the plants are dried without fermentation or bleaching, they contain a high percentage of nutrients.

- Due to Late cutting: Late cutting means greater lignification and lower carbohydrate and protein digestibility. One disadvantage of early cutting is that we get low yield and high moisture content of the forages meant for hay making.
- By shattering: The loss due to shattering of leaves and finer parts in hay making is of importance, especially in the case of legumes. The leaves are much richer in digestible nutrients than the stem and hence losses by shattering materially decrease the nutritive value of hay. To avoid these losses, hay should never be overdried or handled during warm periods of the day.
- Loss of Vitamins: In the process of drying, much of the green colouring matter containing carotene, a precursor of vitamin A is lost with bleaching. In general, the carotene content of freshly cured hay is proportional to the greenness. With severe bleaching, more than 90 per cent of carotene may be destroyed.
- Losses in Fermentation: In fermentation of hay, some of the organic nutrients like starch and sugars are oxidized into Co2 and water. If drying is prolonged because of unfavourable weather conditions, changes brought about by the activity of bacteria and fungi may occur. Mouldy hay is not only unpalatable but also may be harmful for animals as well as for persons handling the hays due to the presence of mycotoxins. Very often such hays contain actinomycetes, responsible for the allergic condition in man known as “Farmer’s Lung”. One of the ways to prevent the development of mould growth is to spray propionic acid uniformly on entire hay. In general, it is not uncommon to find patches of mouldy hay in a stack resulting from uneven drying.
- By Leaching: If hay is almost cured and is exposed to heavy and prolonged rains, especially when it is in the field, severe losses may occur through leaching. Unless the rain is so heavy as to soak the material, losses by leaching will not occur. For this reason losses will be much less even in heavy rain if the hay is in good sized windrows.
Storage of hay

Hay is usually stored in stacks in this country. Care should be taken that the hay is in a good and dry condition before it is stored. It should be stacked in a shady place where there is no danger of fire. The stacks should be made at an elevated place. Machines are also available for baling the hay. Baled (a large package or bundle) materials occupy less space.

Brown hay

Sometimes because of very unfavourable weather conditions, good hay cannot be obtained by the ordinary method of curing. Under such circumstances, hay is allowed to dry until about 50 per cent moisture has been removed and then it is packed in stacks or piles. Fermentation takes place and the hay may become very hot, the temperature however, should not be allowed to exceed 80°C. There are great losses in the nutritive value on account of fermentation. These losses range from 30 to 40 per cent. Such hay is often quite palatable.

Bailing and densification

The transport of dry grass occupies voluminous space and takes lot of time to transport resulting into higher costs. Bailing and densification of dry grass helps in reducing the volume and could be transported economically and efficiently. By using these techniques, the hay could be transported from excess producing areas to deficit areas especially during the calamities of drought. Wheat straw (bhusa) could be added with 20% molasses and then densified and bales can be prepared to increase the digestibility of feed intake. Densified block of wheat straw, molasses and urea could be developed through high density bailing machine. The average density of wheat straw and stubble block obtained thus would be 398 kg/m3 and 355.0 kg/m3, respectively. Moisture level of admixture was maintained at 20% for densification. The optimum ratio of physical composition of straw block is 78:20:2 (wheat straw: molasses: urea).

Production of complete feed blocks

Complete feed blocks could also be prepared by densifying machine. Nutritive value of forage is enhanced through mixing with molasses and blending with leguminous fodder, concentrate mixture, minerals and vitamin additives. The composition of complete feed blocks included wheat straw (40%), molasses (20%) dry leaves of berseem (20%), concentrate mixture (19%) and mineral mixture and vitamin additives (1%).

Preservation in the form of leaf meal

Preparation of leaf meal out of top feeds and leguminous forages as an animal feed stuff because of high concentration of protein of high biological value and other nutrients such as carotene and minerals. There exists a big deficit of concentrate in the country to the tune of 60% and this deficit can be partially bridged by replacing the concentrate feeds by leaf meals. Leaf meal production technology is simple as well as profitable enterprise for the farmers. Crude protein content (% DM basis) in leaf meals of important forage crops are as follows – Leucaena leucocephala (18-21%), Sesbania sesban (18%), lucerne (20-21%), Stylosanthes sp. (12-18%), Ziziphus nummularia (13-16%). The leaf meal of leguminous forages are also known to have rich content of essential amino acids such as lysine, leucine, isoleucine, threonine, methionine, cysteine, valine, histidine, and arginine. A lot of scope exists in establishing a production, processing and marketing chain for its popularization in
different parts of the country. One lucerne leaf meal production plant started in 1977 at Udmalpet near Coimbatore produces more than 15 tonnes of leaf meal per month. The set-up consists of a chaff cutter feeding sun dried lucerne to a powdering mill for grinding and collection of sieved leaf meal. Farmers around Palladam (Tamil Nadu) have organized through a co-operative to grow and supply lucerne to the leaf meal plant. The arrangement assures regular cash income for small holder farmers through a well developed production, processing and marketing chain. Furthermore, utilization of such meals has grain-saving effects

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Developments in Value Added and Fortified Dairy Products

Ashish Kumar Singh, Sanket Borad, Neelam Upadhyay
Principal Scientist & I/c Business Planning & Development Unit
ICAR-National Dairy Research Institute
Karnal-132001

1.0 Introduction

Dairy sector has major share in agricultural GDP and played a major role in our quest for food and nutritional security. India contributes to about 17% of global milk production with over 139MT in 2014-15, which is expected to reach 146 MT by the end of 2015-16. The projected demand of milk is 175 MT by 2020, which offer newer opportunities for marginal and small dairy farmers. Statistics and predictions related to growth of Indian dairy sector has generated a great amount of interests among the milk producers and pace for adoption of scientific dairy farming practices has increased. However, the pace of value addition is slow and majority of milk is consumed at the producer's level itself as liquid milk. Only 33 percent of milk is processed in the form of pasteurized milk, traditional dairy products, skim milk powder (SMP), beverages and other high value added products. Organized dairy industry handle only 17% of the milk produced in the country. However, in last few years demand for processed dairy products specially health beverages, fermented milks, probiotics, cheeses, casein and whey protein concentrate (WPC) etc. has increased both in domestic and international market. At the same time, liquid milk though remained a major form of consumption, is no longer a profitable proposition. It has necessitated the diversion of milk for the development of value added dairy products to meet the requirements of various stakeholders.

2.0 Indian Dairy Sector: Fact File

Even though, India has made a remarkable growth in milk production, the achievement is considered insignificant when it is viewed against the challenges faced by the dairy sector. Huge cattle and buffalo population in the country, very low productivity of milch animals, lack of feed and fodder, longer calving interval, reproductive problems and huge expenditure involved in planning and implementation of various dairy development programmes. On the milk procurement and processing front, fragmented milk production, lack of cold chain, poor emphasis on value addition at processors level and also under-utilization of large installed capacities of dairy plants appears to be major bottleneck.

The role of dairy cooperatives in milk marketing has been appreciable in the past, but it is facing tough competition in terms of procurement price and marketing cost from the private plants and the milk suppliers. Being highly perishable commodity marketing of milk requires a strong base of infra-structural development in terms of roads, transport, cold chain etc. that will have a definite impact in reducing the wastage and maintaining quality of milk and milk products delivered. Unorganized sector consisting of milk vendors and halwai’s handle almost 80 percent of the milk produced in the country. It resulted in Majority of dairy products are manufactured by halwai’s and belongs to traditional dairy products (TDP’s) segment. TDP’s are important component of our tradition, ceremonies and money spinner for millions of people involved in their business. As liquid milk is no longer an economical proposition, there is need for “diversification” towards high value-added dairy products. In such context, TDP’s, dairy beverages, fermented milk products, western dairy
products (cheese, frozen desserts), dairy ingredients and functional dairy products could be of great significance. Market growth rate for some of these products is in the range of 15-20% per annum. The cost of milk production is among the lowest in the world. With increasing demand for milk and milk products, both for consumer and industrial market, technological advancements in dairy sector, implementation of FSSAI act, availability of best quality plant, machinery and packaging systems and government initiatives, offers emerging opportunity for Indian dairy sector.

3.0 Milk Nutrients for General Well Being

With changing life-style, there has been increase in the number of chronic diseases at alarming rate. Despite the top most producer of milk globally, the per capita availability of milk is quite variable across the length and breadth of nation. The consumption pattern of milk and milk product also vary from region to region and the highly imbalance might also have contributed significantly towards the malnutrition. India has attained the first rank in numbers of persons suffering or prone to diabetes, cardiovascular diseases (CVDs) and cancer. Moreover, incidences of infectious diseases are also on rise. One of the common reasons for these diseases could be attributed to impaired or weak immune system. Role of milk nutrients specially the minor milk proteins such as β–Lactoglobulin, α-Lactalbumin and lactoferrin, in modulating the immune system is well documented. However, how different processing interventions affect the nutritional and therapeutic virtues of milk nutrients is a matter of thorough investigations. Thermal treatment not only effective in improving the digestibility of milk proteins, but heating of milk is also known to produce various intermediates as Maillard reaction products. Many of these maillard reaction products have been identified with anti-oxidant potential; on the other hand these also have been implicated in allergic responses and carcinogenesis. Therefore, research investigations pertaining to processing induced changes on nutritional and therapeutic potential of various categories of processed dairy products should be initiated. Better availability of added nutrients in milk and milk nutrients has offered newer opportunities for the fortification of bioactive such as essential fatty acids, micronutrients and therapeutic amino-acids. Recent findings related to anti-obesity and anti-carcinogenic role of Conjugated Linoleic Acids (CLA) in animal models have suggested the enrichment of CLA content in milk and milk products. Enhancement in CLA level through dietary manipulation or processing mediated interventions would appears promising. Milk mining through advanced technological interventions (separation technologies) has enabled us to isolate the wide array of components present in milk and so far more than 500 compounds have been identified so far. Recent developments in clinical sciences also contributed significantly in elucidating the mechanisms associated with therapeutic virtues of these molecules.

4.0 Value Added Dairy Products for Indian Market

4.1 Traditional Dairy Products

Traditional dairy products (TDP) constitute the major share of processed dairy products in India. There are more than 150 different variants of indigenous dairy products in our country which are relished by consumers. Globally, the value added to the milk through processing, product manufacture and marketing is nearly twice the price paid to the milk producers. The profit margin in indigenous dairy products is 200%. The art of manufacturing indigenous dairy products such as khoa, dahi, paneer, chhana etc. is quite old and lot of variation exists. Growth rate in indigenous dairy products is in the range of 15-20% per annum. Demand of few primary processed products like khoa and chhana by large scale sweet manufacturers. The indigenous dairy products suffer with the problem of non-uniformity, poor shelf-life, absence of well defined packaging system and no apparent health
benefits because of their high calorific value. However, development of machinery caters to batch-type production such as scrapper assisted milk desiccation machine, continuous khoa making machine, conical process vat, ghee and paneer processing lines has assisted in their small and medium scale production. Innovations in terms of product formulation by using artificial sweeteners, fat replacers and adoption of newer packaging materials as well as system may offer an edge to entrepreneurs. In the present era changing life-style and increasing purchasing power has forced the food industry to offer convenience or ready-to-use foods with enhanced shelf life, attractive packaging, and added nutritive value.

4.2 Fermented Dairy Products

In recent past demand for dahi and milk based fermented products has also increased because of increasing . About 7% of the milk produced in India is used for the manufacture of fermented dairy products. The size of the dahi (both in organized and unorganized) market is estimated to be around Rs. 500 crore. Of this only 5% constitutes the organized sector. Micro-dairies and households produce approx. 85-90% of the Dahi consumed in India. It is a complex market characterized by ignorance of modern technology such as DVS® cultures, combined with poor transportation and energy infrastructure. Traditionally in India, Dahi holds cultural symbolism in many Indian homes and is a part of the traditional Indian meal. About 90% of the household consumed homemade dahi, however the scenarios is changing fast with the introduction of cup/packaged dahi. However, the micro dairy segment has been unaware about the latest technology and process to upgrade their dahi production and quality. The product (DVS-Direct to Vat Starter) is highly suitable for home and small scale dahi production.

India is one of the fastest growing markets for cheese with annual growth pegged at 20% with a total consumption of about 7,000 tons a year according to Agri-Commodity Federation. With one of the largest consumer bases in the world, cheese could be a multi-million dollar industry in India. Indians are consuming 3 million pizzas a month and it is number is expected to rise by 30-40% within a year’s time. Therefore, there is great scope for the manufacture of mozzarella cheese at small scale from buffalo milk. Moreover, Indian palate prefer fresher varieties of cheeses, hence cottage cheese, feta cheese and quarg cheese could be promising categories of fresher varieties of cheese.

4.3 Designing of Novel Dairy Foods with Non-Dairy Bioactive and Ingredients

Fusion trend has also influenced the dairy food formulations and blending of raw materials from different food groups either for better nutritional status or for the improvement of quality of resultant product has gained momentum in last few decades. Development of low calorie and / or no fat products required substantial alteration in formulations and removal of milk fat and sugars or salt have numerous undesirable consequences on quality attributes of finished products. Search for fat, sugar and salt replacers have resulted in availability of various alternatives, which could be effective in minimizing or completely eliminating these macromolecules. Inulin, Fructooligosaccharides (FOS), Simplesse (modified whey protein), Oatrim (oat based fat replacer) and certain modified starches are fast becoming the essential ingredients in functional dairy products such as yoghurt, yoghurt drinks, ice creams, cheeses, spreads etc. Availability of safety and toxicity data related to these ingredients also enhance consumer faith in products based on these ingredients. Inulin and other non-digestible polysaccharides also have well documented health benefits, acting as prebiotic by assisting the proliferation of bifidobacteria and lactobacilli and improving the overall gastrointestinal health. Other claimed benefits include increased calcium absorption with positive effects for bone health,
a lowering of serum lipids with relevance for heart health, a positive effect on feeling of satiety with potential positive consequences for weight management, a potential effect to enhance resistance to infections and to stimulate the immune system. Phytochemicals, novel plant metabolites could be an ideal substrate for the manufacture of functional dairy foods. Among more than 1000 phytochemicals few such as carotenoids, flavonoids, phytosterols, phytoestrogens, glucosinolate and soluble fibres have been utilized in certain dairy products. These phytochemicals primarily act as antioxidants and perform putative functions mainly in life-style associated mortality and morbidity including CVD, diabetes and cancer. Phytosterols exhibit anti-inflammatory, anti-neoplastic, anti-pyretic and immune-modulating activity. In the body, phytosterols can compete with cholesterol in the intestine for uptake, and aid in the elimination of cholesterol from the body. Saturated phytosterols appear to be more effective than unsaturated ones in decreasing cholesterol concentrations in the body. These actions reduce serum or plasma total cholesterol and low-density lipoprotein (LDL) cholesterol. In mammals, concentrations of plasma phytosterol are low because of their poor absorption from the intestine and their faster excretion from liver, and metabolism to bile acids, compared to cholesterol. Phytosterols have been successfully incorporated in yoghurt, cheese, dairy spreads and milk beverages.

4.4 Probiotic Dairy Foods:

The major focus in development of milk based therapeutic products has been towards the incorporation of probiotic microorganisms that harbour our gastro-intestinal (GI) tract and are frequently associated with health promoting attributes. Probiotic foods contain viable probiotic microorganisms in requisite number in suitable matrix and their viability & metabolic activity should be maintained through processing, packaging, storage till it is consumed. The global probiotic products market generated $15.9 billion in 2008. More than 500 probiotic F&B products have been introduced in the past decade. These products have received varying levels of success, mostly in congruence with their overall health benefits. A number of scientific publications are emerging on selection, incorporation of probiotic cultures in dairy products and impact of unit operations on their viability during processing. The survivability of probiotics in complex GI tract and demonstrated health benefits in consumers is of great concern among researchers and processors. Several factors have been reported to influence the viability of probiotics in dairy foods and their subsequent implantation in host intestine. Certain processing and formulation interventions have been found to be effective in enhancing the viability of probiotics.

Through In-vitro and In-vivo trials the possible mechanisms for therapeutic aspects of probiotics have been revealed. These mechanisms are mainly related to anti-microbial activity, anti-mutagenic & anti-carcinogenic effect, modulation of immune response, anti-diarrheal and anti-allergic reactions. However, variations exist in outcome of such investigations under different approaches that have been adopted to evaluate the functionality. The establishment of associated health benefits by consuming a certain probiotic dairy products through in-vivo assays is critical for the further success of this segment of functional foods. It has prompted newer initiatives at various forums to develop a guideline for efficacious investigations of probiotics for bringing the synergy among agencies involved and create confidence among consumers. The aim of the present chapter is to review the important group of probiotic microorganisms that have potential to be utilized for development of novel dairy foods including fermented milks, yoghurt, cheese, ice cream, composite dairy foods etc. The innovations that have been attempted to enhance the survivability probiotics across the value chain is dealt in depth. The review will also focus on mechanisms that are associated with therapeutic effects of probiotics with special reference to dairy products and their validation through In-vivo investigations.
5.0 Issues Related to Technological Aspect of Novel Dairy Foods

Designing of suitable diet with desired nutrients and pharmacologically-active components to meet the diverse needs of consumers is quite a daunting task. The healing power of milk nutrients is known for centuries and recent scientific investigations have proved the disease preventing or alleviating properties of milk nutrients. Several species of Lactic acid bacteria (LAB) assist in maintenance and improvement of gut health besides providing several other health benefits. It has been exploited all over the world for the development of probiotic dairy foods. Now the time has come when characterized indigenous probiotic microflora with proven technological and therapeutic attributes should be made available for the manufacture of novel probiotic dairy product. Although, probiotics have already started cementing their place in global dairy market, but many mysteries and health claims associated with probiotics needs to be addressed carefully.

Further, milk mining for the isolation of such bioactive molecules through appropriate technological interventions has gathered momentum in recent past. Traditional dairy products (TDP) which comprise the largest segment of processed dairy products also needs a face-lift through innovations in formulations and processes to reduce the fat and sugar levels without affecting their consumer acceptability. Newer ingredients and processes like membrane processing, high pressure processing (HPP) and supercritical fluid extraction (SCE), offer newer opportunities in delivering “wholesome” dairy products. Delivery of bioactive components in dairy products and its stability during the entire value chain is another major challenge.

6.0 Validation and Safety Issues

Appropriate validation studies through in-vitro, in-vivo or clinical trials have always been a great concern in investigating the mechanisms associated with functional food consumption and also determining the safety and toxicity. The optimal levels of the majority of the biologically active components currently under investigation have yet to be determined. In addition, a number of animal studies show that some of the phytochemicals (e.g. allyl isothiocynate) for their cancer-preventing properties have been shown to be carcinogenic at high concentrations. Designing of suitable animal and clinical investigations require multidisciplinary approaches including experts from diverse fields. The benefits and risks to individuals and populations as a whole must be weighed carefully when considering the widespread use of physiologically-active functional foods. Knowledge of toxicity of functional food components is crucial to decrease the risk: benefit ratio.

7.0 Conclusion

Milk production has increased and the scope of dairy as an enterprise based on processing and product manufacture has found scientific and economic base. There is a need to standardize and scale up processing mechanism and the transfer of technology for commercial production of these products. There is an urgent need to modernize this sector to produce high quality products with long shelf life. Hygienic and eco friendly packaging as a means of product protection will have immense contribution in making the Indian dairy industry. Mounting evidence supports the observation that dairy based foods containing physiologically active components may enhance health. Health-conscious consumers are increasingly seeking functional foods in an effort to control their own health and well-being. There is lot of scope for introducing milk based health foods in India market.
Quick tests for checking adulteration in dairy products

Rajan Sharma, Bimlesh Mann, Satya K and Dhiraj Kumar Nanda

Dairy Chemistry Division
ICAR- National Dairy Research Institute, Karnal – 132 001 (Haryana)

The menace of adulteration has taken serious proportion as highlighted by many media reports as well as by the report of Food Safety and Standards Authority of India (FSSAI). During festival as well as summer season when there is short supply of milk, the electronic media is flooded with reports of adulteration of milk and milk products. Although, India is largest milk producer in the World with 140 Million MT (2013-14) of milk production per annum, the scarcity of milk is felt during lean season and festival days. Compositional differences in milk are exploited by unscrupulous persons to adulterate milk. Perhaps, addition of water to buffalo milk is most commonly practiced. The image of milk has been considerably deteriorated due to the reports of its adulteration with harmful chemicals such as fertilizers, ammonium salts, potassium sulphate, caustic soda, detergents, urea etc. Media reports indicate the adulteration of milk with ‘milk-like-preparation’ – the so called synthetic milk. Table 1 indicates the type of common adulterants of milk and motive behind their addition to milk. The problem of milk adulteration has also been noticed in many other parts of the world. Table 2 present a data of type of adulterants used in other countries.

Table 1. Common adulterants reported in milk and their purpose

<table>
<thead>
<tr>
<th>Nature of chemical/adulterants</th>
<th>Name of adulterants</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>Sucrose, Glucose, Starch, Maltodextrin</td>
<td>To falsely increase the total solids To mask the addition of water</td>
</tr>
<tr>
<td>Salts and fertilizers</td>
<td>Urea, Ammonium sulphate, NaCl etc.</td>
<td>To falsely increase the total solids To mask the addition of water</td>
</tr>
<tr>
<td>Neutralizers</td>
<td>NaOH, Na₂CO₃, NaHCO₃ etc.</td>
<td>To mask the increase in acidity and to prevent coagulation of milk during heating</td>
</tr>
<tr>
<td>Preservatives</td>
<td>Hydrogen peroxide, Formalin, Boric acid etc</td>
<td>To fraudulently elongate the shelf-life of milk</td>
</tr>
<tr>
<td>Detergents</td>
<td>Liquid detergents, Washing powders etc</td>
<td>To emulsify the extraneously added fat/oil</td>
</tr>
<tr>
<td>Water</td>
<td>Water/Pond water/</td>
<td>To increase the volume of milk</td>
</tr>
<tr>
<td>Extraneous fat/oil</td>
<td>Vegetable fats/oils/Refined oil</td>
<td>To increase/substitute fat content of milk</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Soya milk, Cheese whey, Synthetic milk</td>
<td>To substitute milk with cheaper milk-like ingredients</td>
</tr>
</tbody>
</table>

Table 2. Adulterants reported in milk of other countries

<table>
<thead>
<tr>
<th>Name country/region</th>
<th>Type of adulterant reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan, Bangladesh, Sri Lanka</td>
<td>Water, Urea, detergent, formalin, H₂O₂, Neutralizers, Starch, Flour, vegetable oil, formalin, quaternary ammonium (QAC) compounds, Cane sugar, sorbitol, salt, boric acid, hypochlorite</td>
</tr>
<tr>
<td>China</td>
<td>Melamine</td>
</tr>
<tr>
<td>Brazil</td>
<td>Water, Neutralizers, Sodium citrate, non-acid cheese whey, synthetic milk</td>
</tr>
<tr>
<td>Europe</td>
<td>Cheese Whey, Milk fat adulteration Species adulteration of Milk</td>
</tr>
</tbody>
</table>
Methods for detection of adulterants in milk and milk products

The rapid tests for the detection of adulterants in milk are required as these tests will act as deterrent for unscrupulous persons involved in unscrupulous activities as well as a tool in the hands of FSSAI officials to eradicate the menace of adulteration. At present, the methods which are being used for the detection of adulteration in milk are mainly drawn from those listed in Bureau of Indian Standards (IS: 1479 (Part 1-1960, Reaffirmed 2003) or other publications being brought by National Dairy Research Institute (NDRI), Karnal. Many of these methods have been modified by researchers, quality control personnel working in dairy laboratories and other commercial laboratories. Many organizations including NDRI, Karnal, National Dairy Development Board (NDDB), Anand and other private firms have come up with easy-to-carry kits for detection of adulterants in milk. In all these commercially available kits, the methodology used has been mainly adopted from BIS or NDRI Publications. It is also true that, unscrupulous people are finding more innovative ways to adulterate milk with cheaper ingredients. In the last decade, the adulteration of milk with milk-like-preparation popularly known as ‘synthetic milk’ has surfaced.

NDRI is working proactively for developing various analytical techniques and simpler methodology for the detection of adulteration in milk and milk products. A kit developed in the Division of Dairy Chemistry for the detection of various adulterants in milk is in high demand among dairy professionals and public analysts across the country. The kit contains reagents for detection of 12 adulterants in milk viz., neutralizers, urea, pond water, starch, sugar, glucose, maltodextrin, salt, formalin, ammonium compounds, hydrogen peroxide, hydrogenated vegetable oil, etc. In the past, a rapid method developed, at the Institute, for the detection of addition of vegetable/refined oil in milk has been validated and adapted by Bureau of Indian Standards (BIS). Similarly, the qualitative and quantitative methods developed for the presence of added urea in milk has been adapted by BIS. A simple test developed for the detection of the presence of added urea in milk has been included in the analytical methods recommended by FSSAI. Recently, a new colour based test has been developed for the rapid detection of detergent in milk. NDRI is also working in the development of strip based tests for detection of various adulterants in milk and a significant development has occurred in this direction.

Detection of common adulterants in milk – recent development

Chemical methods

Strip based tests for rapid detection in of adulteration milk: Five different paper based strip methods have been developed for the rapid detection of neutralizers, urea, glucose, hydrogen peroxide and maltodextrin in milk using the concept of dry chemistry. These strip based method involves either dipping the strip (neutralizer and urea) in milk sample or applying a drop of milk on the developed strip (glucose, hydrogen peroxide and maltodextrin) followed by visualization of colour. The colour of the strip changes to deep red in milk containing neutralizers (immediately) and urea (after 2 min) while in pure milk samples, the strip retained its original yellow colour (Patent application No. 3472/DEL/2013). In case of glucose and hydrogen peroxide detection in milk, the strip colour changes to deep pink in adulterated milk samples either immediately (hydrogen peroxide) or after 5 min (glucose) while the strip retained its original white colour in case of pure milk. Maltodextrin detection strip (Patent application No. 2097/DEL/2014) changes to yellowish green colour after 5 min in case of adulterated milk samples while in case of pure milk strip remained white in colour. The strip based tests have been validated at third party laboratory as well under filed conditions. The sensitivity of the
strips has been established and limit of detection of the developed strip in milk was 0.04% for NaOH (0.06% Na₂CO₃ 0.1% NaHCO₃); 0.08% for urea (total urea); 0.03% for glucose; 0.005% for H₂O₂ and 0.05% for maltodextrin. The developed strips were easy to use and require just one step wherein either they are dipped in milk sample or a drop of milk sample is applied to the prepared strip followed by visualization of change in colour. In all cases, sensitivity of the prepared strips was found better than the existing wet chemistry based tests. The shelf-life of strips is 8 months at room temperature for neutralizer, 4 months at refrigeration temperature for urea, 2 months for hydrogen peroxide, glucose and maltodextrin. The technology of strip based tests is available for commercialization.

**Detection of Detergent in Milk:** Detergents are considered as the essential component of the formulation being used for the preparation of synthetic milk. Because of ease in availability of anionic detergent, these are being used for emulsification of added fat of non-milk origin. The other ingredients being used for synthetic milk formulation are urea, salt, soda, sucrose, vegetable oils, skim milk powder, water etc. The liquid thus formed has the appearance of genuine milk (i.e. colour, consistency) and it is reported to be used for the adulteration of dairy milk from 5 to 10%. The detection of detergent in milk is therefore essential for checking the adulteration of milk with synthetic milk. A qualitative rapid and sensitive test for detection of detergent in milk has been developed. The method is primarily based on the ionic interaction between the anionic detergent and cationic dye. Anionic detergents have a property to form a complex with cationic dyes. The solubility of dye and dye-detergent complex differs significantly as dye-detergent complex is relatively less polar in comparison to dye alone. Formation of dye-detergent complex between cationic dye and anionic detergents and subsequently its extraction into the hydrophobic solvent is the major principle behind the developed method. The method is sensitive to detection 20 mg of detergent in 100 ml of milk. The test can detect all brands of detergent available in the market and sensitivity varies with different brands of commercial detergent. The method has been validated at Punjab Biotechnology Incubator, Mohali – a NABL accredited laboratory. The test can detect all brands of commercial detergents available in the market. The test is nearly five times more sensitive than paper chromatographic method. The results are available in 2 min. The test does not require any equipment and the cost of ingredient used for preparation of test reagent is very low. The technology of this test (Patent Application No. 3677/DEL/2011) is available from NDRI, Karnal.

**Instrument based methods**

In recent times two different types of equipments have been launched for the rapid detection of adulterants in milk. In the first type of equipment named MilkoScreen™, the detection is based on the concept of FT-IR (Fourier Transform infrared spectroscopy) has been used. The machine has been launched by IndiFoss Analytical Ltd. Ahmadabad (www.indifoss.com) which is part of FOSS, Denmark. The machine has been claimed to detect urea (≥ 0.25%), melamine (≥ 0.1%), ammonium sulphate (≥ 0.1%), sucrose (≥ 0.7%) and water (≥ 20%). In the second type of equipment launched by Rajasthan Electronics and Instruments Ltd. Jaipur, named “EMAT (Electronic Milk Adulteration Tester)”, the principal of detection is based on identification of specific ions of adulterants in milk sample. The machine has been claimed to detect urea (≥ 0.1%), salt (≥ 0.2%), liquid soap (≥ 0.2%), detergent (≥ 0.3%), caustic soda (≥ 0.3%) and hydrogen peroxide (≥ 0.3%).

**Adulteration of milk products**

Among the milk products, ghee is the most common milk product being adulterated. Because of high cost of milk fat and availability of look-alike cheaper substitutes (vegetable oils, hydrogenated vegetable oils), ghee is frequently adulterated. The other milk products which are being adulterated
in this country are khoa, khoa based sweets, paneer etc. Table 3 indicates the types of adulterants reported to be added in various milk products.

**Table 3. Adulterants added in various types of milk products**

<table>
<thead>
<tr>
<th>Milk product</th>
<th>Adulterant (s) reported to be added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghee</td>
<td>Vegetable oil hydrogenated vegetable oil, animal body fat, designer oil, mineral oil etc.</td>
</tr>
<tr>
<td>Paneer</td>
<td>Edible and non-edible oil, starch etc.</td>
</tr>
<tr>
<td>Khoa and khoa based sweets</td>
<td>Edible and non-edible oil, starch etc.</td>
</tr>
<tr>
<td>Milk Powder</td>
<td>Maltodextrin, whey powder</td>
</tr>
</tbody>
</table>

The tests has also been developed for the detection of adulteration of milk products such as ghee, khoa and paneer etc. The adulteration detection tests developed for the milk either has been validated or modified for their application in products like khoa and panerr. For the detection of vegetable oil in ghee, a simple chemical method has also been developed. Due to the natural variation in the composition of milk fat and also due to the range of available cheap adulterants (body fats as well as vegetable oils), a combination of tests needs to be applied for confirming the purity of milk fat. Apart from the conventional tests (e.g Reichert Meissl value and Butyro-refractometer reading), new generation of tests such as Apparent Solidification Time (AST), Opacity Test, TLC, HPLC etc have been developed at this Institute. In recent times, using the concept of solvent fractionation technique have been developed for combating the menace of adulteration wherein after enriching the adulterant in a particular fraction, conventional tests are applied for ascertaining the presence of adulterant.

**Conclusion**

Milk and milk products, since time immemorial, have formed an important part of our diet. Milk is naturally designed as a nutrient dense food source that nourishes and provides immunological protection for mammalian offspring. The media reports about adulteration of milk and milk products certainly would discourage the consumption of milk and thus would deprive people of such a valuable healthy commodity. Although, methods exist for detection of common adulteration in milk, every dairy industry in India is not using these methods at reception dock. The reason may be a long list of adulterants and problem is further aggravated by entry of new adulterants. The industry at times finds it difficult to screen every tanker/can of milk for all the listed adulterants as most of the methods involve chemists as well as investment in the form of reagents/glassware. Consumers in the country are also demanding simpler tests with which they can ascertain the quality of milk they buy. The existing milk adulteration detection methods are based on the wet chemistry which essentially requires mixing of milk sample with liquid reagents and at times boiling. For avoiding hassles of purchase of chemicals and preparation of reagents, kits for detection of adulterants are now manufactured and are commercially available. Even these kits are not to be used at house-hold level. The development of such strip based tests is need of the hour as use of such kits will provide results in short duration and results can be interpreted by simply observing colour change of strip by naked eye. Also there will not be requirement of skilled person of applying the test at house-hold level. Research organizations and private industry should work together to develops such types of tests.
References


Introduction

The introduction of artificial insemination (AI) has considerably enhanced the scope of propagating the superior germplasm of domestic animals. The genetic improvement of important livestock species and disease control are of fundamental importance to the success of livestock industry. In this sense, artificial insemination (AI) is the most important first generation biotechnology tool contributing to the advancement of modern animal production. Through AI, ejaculate from a genetically superior male can be used to impregnate multiple females to maximize the distribution of favourable genes. As well, AI eliminates physical contact between animals, thus limiting the spread of sexually transmitted diseases. Successful semen cryopreservation enhances these advantages of AI over natural breeding. Long-term storage facilitates semen transport over distances, permits the quarantine of semen, and enables extended use of superior germplasm, even after the sire's death. semen cryopreservation is an established industry worldwide, particularly for dairy cattle for last several years. Genome resource banking to preserve the biodiversity of endangered species or valuable transgenic lines also would benefit from sperm cryopreservation.

The Artificial Insemination industry as we know it today is much complex and sophisticated as compared to its beginning when mere 5 or 6 cows, in heat, at the same location, could be served with unextended ejaculate of a bull immediately after collection. Subsequent developments in equipment and semen processing methodologies have offered vast potentials for covering a large number of breedable animals across time and space. Though the principles underlying the various steps in the cryopreservation process are not thoroughly understood and require much to be done as nearly half of the spermatozoa are rendered immotile yet the success rate of frozen semen is not very different from that of fresh semen. Nevertheless, successful preservation of semen from any species could be achieved by maintaining viability of spermatozoa from its collection till its use for insemination.

For many mammals; however, effective semen cryopreservation is not a reality because a large number of sperm are apparently infertile following freezing and thawing. Compared to fresh, 8 times more cryopreserved bovine sperm were required to achieve equivalent fertilization rates in vivo. The fertility of cryopreserved semen reduced to unacceptable levels with vaginal or cervical insemination. Interest in conserving transgenic lines has stimulated a surge of effort toward mouse sperm conservation; however, in vitro fertilization rates with cryopreserved epididymal sperm were, at best, 62% that of unfrozen controls.

At present, it is generally accepted that the consequences of sperm cryoinjury caused by the cryopreservation procedure are impaired transport and poor survival in the female reproductive tract. This concept has led to the routine use of oviductal insemination by laparoscopy rather than vaginal or even transcervical insemination in sheep. Similarly, surgical insemination of cryopreserved porcine semen directly into the oviducts achieved fertility rates comparable to those with fresh semen. When
the interval between insemination and ovulation is reduced, fertilization rates increase, supporting the hypothesis that sub-lethal cryodamage is an effect of the freeze-thaw procedure.

**Preservation of semen**

The story starts as early as 1776 when Lazzaro Spallanzani first noticed that spermatozoa could be temporarily immobilized by cooling. As early as 1918, Ivanow, one of the pioneers of physiology of mammalian sperm, stressed the possibility of extending bull semen, storing and transporting it at +2 0C and using it for artificial insemination. Earlier developments aimed at finding out optimal storage temperature as well as extender media, extension rates. Subsequently developments led to the points i) slow lowering of sperm temperature to a level where the functional activity is reduced to a low but reversible state, ii) addition of various substances to the semen, which supply nutrients, and to some extent control the metabolic events. Developments in cryobiology initiated in the 1949 by Luyet and co-workers in USA and Nard in Germany and subsequent chance discovery of cryoprotective effect of glycerol in 1949 by Polge, Smith and Parkets led to the rapid strides in the development of technologies for the preservation of biological materials and for frozen bull semen. The protective effect of egg yolk against cold shock, chilling of spermatozoa, during cooling from body temperature to +5 C was also already recognised in the use of liquid semen. Lipoprotein fraction of egg yolk is apparently the active components of protection. Cold shock results in reduction in the number of motile spermatozoa, release of enzymes in movement across the membrane and lipid loss. Lecithin (Phosphatidylcholine) is probably an active component of egg yolk, which might be responsible for its protective effect against cold shock.

Basic Concepts: Damage to the sperm cell during freezing and thawing is caused by three primary factors, viz., a) internal ice crystal formation, b) change in solute concentration due to the withdrawal of water from the suspension medium (solution effect), and c) interaction of these factors. Further the effect of these factors on the cell is also influenced by the level and type of cryoprotective agents, osmolarity as well as pH of the extender and the freezing rates. With slow cooling rates there is much injury due to the solution effect whereas rapid cooling is associated with much of intracellular ice formation. Maximum spermatozoon survivability is expected at cooling rates somewhere between the two extremes. To achieve better success in cryopreservation one has to develop a suitable processing strategy the will minimize the damage to the sperm cells caused by these factors.

**Freezing Technology:**

Successful freezing and post thaw recovery requires consideration of the various points viz., a). Extension in the medium possessing the prerequisites of maintaining the osmolarity, buffering capacity maintaining pH, organic material materials (egg yolk etc.) to provide protection against cold shock, cryoprotective agents (glycerol etc), simple sugars as energy source as well as additional cryopreservative, antibiotics to arrest microbial growth b). Optimum cooling rates c). Glycerolisation/ Equilibration d) Packaging types e) Freezing rates e) Thawing rates.

After collection, neat semen is either extended partially, or may be held for that interval at 30C during semen evaluation. Semen should initially be extended with dilutors at the room temperature and cooling be started as soon after collection as possible, cooling should be slow. Decline in temperature to +5 0C (about 0.3 0C per minute) seems to be favourable in possibly minimizing the consequences of cold shock.
Semen collection:

There is a great variation in semen quality traits between bulls and even within bulls. The possible reasons of poor quality semen could be congenital or age related. It may or may not be heritable. The role of semen collector is very important. He must closely observe the sexual/ psychological behaviour of the bull in terms half mounts required, type of dummy/mount device and also temperature of Artificial Vagina. A bull constantly giving poor quality semen should be culled. However, occasional poor quality of semen from a bull, which has been generally giving good quality and quantity of semen, will reflect to, bull preparation, inadequate stimulus, disturbance/distraction, and faulty collection equipment. The length of the AV should be such that the semen is deposited in cone so that semen moves quickly to the collection tube. Lengthier AVs may result in deposition of semen in the liner. It has been shown that exposure to semen to 45°C and above results in loss of sperm viability. Further sperm cells are susceptible to cold shock. This could result due to collection of semen in cold vial especially in winter months. Further health condition of male could also be reflected through the evaluation of quality & quantity of semen. Keeping the above in view the semen collection of bull should not be considered only mechanical act. The fitness of bulls, proper monitoring of its whims & fancies must be considered for a good harvest from the bull.

Packaging of semen

Packaging of semen for freezing is another vital aspect, which should be considered for better conception & economy. Initially semen is packaged for freezing in glass ampoules having a capacity of 1 ml and 1/2 ml. Plastic straws were subsequently introduced and their constant refinement by the French workers resulted in development of half ml. followed by .25 ml French straw. Conception rate was dramatically improved by 4-6% when shift was made from ampoule to straw. A marginal improvement- (around 1%) was observed when French medium straw was replaced by mini straw. Change in ampoule to straws resulted in increase in storage capacity to 5 folds. Using mini straw further doubled storage capacity.

Freezing Methods

During freezing, ice formation and concentration of osmotically active substances (electrolytes and non-electrolytes) are important events affecting the spermatozoa. Addition of glycerol minimizes the damage due to freezing injury. Glycerolisation technique and equilibration need to be addressed in terms of a) optimum level of glycerol b) Temperature when glycerol to be added c) How glycerol to be added? d) Time period for which semen should be in contact with Glycerol prior to freezing. Optimum level of glycerol depends upon the type of extender used. Egg yolk based extenders are optimized by 6.0 - 7.5 % glycerol level. While milk dilution containing 10-13 % (v/v) glycerol is best. Addition of Glycerol to the bull semen at 5 0C is the usual practice in most of the laboratories. Addition of glycerol in a stepwise fashion by adding glycerol over a period of time is preferred adding it in one installment. However, single step dilution at room temperature (20-25C) is now being used with similar results. In general, optimum equilibration time or exposure time of sperm cell to glycerol at 5 C has been found to vary from 4 to 12 hours. However, it is important that the glycerolated fraction of diluter be at the same temperature as the non-glycerolated portion containing semen.

Freezing Rates: Freezing rate is much influenced by several factors i.e. geometry of package, glycerol level, thaw rate etc. Slow freezing is detrimental regardless of thaw rate utilized. Post thaw motility is depressed most when semen is frozen at the slow rate and also thawed slowly.
The common method of freezing semen in straws is to cool the straws in static liquid nitrogen vapour. Straws are arranged in a horizontal rack at 5°C in a cold handling cabinet then placed in nitrogen vapour. A grill is placed at a depth of minimum 30 cm. below the brim of the wide mouthed liquid nitrogen container and liquid nitrogen is kept at the grill. Racks are usually having a height of 4 cm. The vapour temperature at the level of straws is nearly -100 to -140°C. Within 8 to 9 min. the inside straw temperature reaches -140°C. Straws are then collected and plunged into liquid nitrogen for storage. However, development of freezer has improved the precision of freezing of spermatozoa from 5°C to -140°C.

Handling semen in storage and on the farm:

System of semen processing does not end with the freezing of doses. Storage of straws may be so arranged that the doses can be quickly sorted in batches, bull wise and for the despatch to various AI Centres or farms for subsequent utilization. If the doses are exposed to environmental temperature permitting them to reach -80°C to -100°C, irreversible injury to the sperm cell can occur. This injury is thought to be due to recrystallization of frozen semen. Though the straw offers us many advantages primarily due to its geometry, yet the thermal errors in handling the straws may also lead to rapid rise in semen temperature due to the same high surface to volume ratio. It is therefore, important to have procedures closely in tune with the thermal requirements for optimum semen handling in storage. Handling semen doses in nitrogen vapour is safe only if the vapour is sufficiently cold and the exposure are of short duration. Use of exhaust fans to remove vapour to improve the vision into storage tanks will greatly increase the temperature of exposed doses. Bubbling nitrogen or cold nitrogen through the tank will accomplish the same task safely.

Thawing:

Finally the rate of thawing used on the farm has important bearing on the viability of spermatozoa. The optimum thawing rate should be assessed with respect to the entire semen processing system. To avoid the recrystallization, thawing should be rapid. Thawing rate depends on thermal history of frozen semen, type of packaging, duration, and ambient temperature. The commonly used method of thawing frozen dose is to plunge it into warm water. Time allowed for this depends upon the temperature of water and the packaging system. Under field conditions thawing is done at a temperature of 35-37°C water (15 sec.). Though experimentally higher thaw rates have shown improved viability, yet very fast rates can not be recommended in the field at present because slight errors in terms of prolonged exposure to high temperature can cause overheating of sperm and hence loss of viability.

Several ways have been attempted to shift the gender ratio for a calf crop in animal husbandry, but the idea of sex selection to favor male or female offspring has been researched since the advent of artificial insemination. In India, the need to preselect the gender of the young one is gaining much importance day by day especially in dairy cattle and buffaloes. With the decreasing land productivity, crop yield and other feed resources one hand and steady increase in demand and consumption of high quality dairy product on the other hand, there is an urgent need to expand the genetic merit of our cattle and buffaloes. In 2012 India’s population reached more than 120 million and is increasing day by day. In order to meet food demand associated with this population growth it will be necessary to produce pre-sexed livestock by sperm or embryo sexing; which offer a promising breeding strategy to meet the increased demand for food production and nutritional security. So far it has been demonstrated that the application of sexed bovine sperm using AI is effective in altering the
sex ratio and rapidly expanding dairy herds carrying high genetic value animals. Thus, the practical application of sexed sperm in indigenous cattle and buffalo breeding would be of great interest both in biological and economic terms. Besides the long-term benefit, farmers can profit directly from the use of sexed spermatozoa by producing optimal proportions of males and females in their animal production systems. The use of sexed spermatozoa increases the rate of genetic progress, especially in combination with genomic selection of sires and easier culling decisions. It also has the potential to improve herd management and reduce the incidence of dystocia by avoiding male calves. But, superior male can be produced by sex sorted spermatozoa from superior dam, which will be a great boost for semen station which is the need of the hour for increasing the frozen semen productivity in the country. Increased biosecurity can be attributed to keep a herd closed by not purchasing as many animals from outside for replacement.

Sperm Sexing

Several attempts have been made to develop a method that efficiently separates bovine semen into fractions containing higher concentrations of X- or Y-bearing sperm. These technologies include sex specific antibodies, centrifugation, and flow cytometry. Of these attempts, the only method proven to be commercially viable is flow cytometry till date. In the recent years, there have been several advances in computer science, biophysics, cell biology, and applied reproductive physiology, which has led to development of systems that could accurately measure fluorescent signals emitted by the spermatozoa treated with specific fluorescent dyes. This development obviously showed the way to measure the small difference in DNA content between X and Y chromosome-bearing sperm. Till date flow cytometry sorting method is not 100% efficient, but it does shift the ratio to about 85 to 90 percent of the desired sex. As with any other market-driven technology, sex sorting may evolve to become more efficient and less costly and research are being continuously taken up to fine tune the technology to reach maximum efficiency and accuracy in developed countries (Rath et al., 2012).

Most of the studies on fertility of sex sorted bull spermatozoa have been carried out in highly organized farms in abroad. In cattle, the conception rate of AI using sexed sperm, with one tenth the sperm number of non-sexed sperm, is around 70–80% of those achieved by non-sexed sperm in heifers. The most important variables in the extent of use of sexed semen are pregnancy rate and the cost per straw, whereas the economic benefit will greatly depend on the baseline fertility of the herd and other key management factors. However such studies on crossbred and buffalo bulls are very limited.

Since, cattle slaughter is banned nearly all over India, half of the calves (i.e., male calves) produced through artificial insemination are of little use in terms of either future breeding bulls or bullocks in the agricultural fields as a source of farm power. Majority of the farmers are such that their conscience does not allow them for rearing for meat & selling them for slaughter. Farmers rear these calves till the dams are in milk for the letdown process of the milk and become restless as they do not contribute anything on the agricultural farm thereafter. We certainly need a technology to significantly reduce the ratio of birth of male-calves on the farms for sustainability of dairy farming.

Importance of sperm sexing

- To produce calves of desired sex in dairy cattle and buffaloes.
- Production of unwanted cattle males can be minimized as they can’t be slaughtered in India.
• Production of superior breeding bulls as country has limited elite cattle and buffalo bulls (< 0.1% of total).
• Combination of super-ovulation and insemination with sexed semen further increases the desired calf crop.
• Replacement and expansion of herd can be done quickly.
• Replacement costs can be reduced.
• To ensure required number of daughters production for progeny testing programme in shortest time, thus increased genetic gain.
• In in-vitro fertilisation programs, one dose of sexed sperms can be used to produce many embryos of desired sex.
• Increased biosecurity and lower disease risk.
• Selective culling.
• Reduce dystocia cases by preventing production of male calves.

**AI strategies with sex sorted sperm**

The conception rate depends on the bull fertility, quality of semen, semen preservation; semen handling during AI, site of deposition, sperm dosage and skill of the inseminator. In conventional system there is requirement of 8-10 million viable progressive motile sperm at the time of AI. With 50% post thaw motility, 20 million viable motile sperm should be packed initially before cryopreservation. Reduction in sex sorted spermatozoa to 2 million viable motile sperm leads to pregnancy depression by 15-20% as compared to conventional system. Researchers have tried various sperm doses (2-20 million) with sex sorted sperm for artificial insemination and results in lower pregnancy rate as compared to conventional system. The findings of fertilization with AI of sex sorted spermatozoa are conflicting in nature with different doses and different protocol of AI in heifers. Use of 2 million viable spermatozoa with sex sorted spermatozoa in regular AI is not viable and economical due to low conception rate. Peoples have successfully used sex sorted spermatozoa in Multiple ovulation embryo transfer, In-vitro fertilization, Gamete intra-fallopian transfer and Sperm intra-fallopian transfer in different species. Recently Grossfeld *et al.* developed a device to transfer the very small volume (30μl, 10^5 sperm) of sperm in bovine oviduct and achieved 41.2% pregnancy in field condition.

In Indian condition there is need to standardize the lower dosage of spermatozoa, site of deposition for AI with good conception rate in our conventional system. There is also immense requirement to develop instruments to transfer sex sorted spermatozoa non-surgically and to train the skilled manpower in above area to achieve good results. The main target should be focused to use of sex sorted spermatozoa in good quality heifers and the cows with excellent reproductive and productive performance to achieve good results.

**Drawbacks associated with sperm sexing and use of sexed sperm under Indian condition**

- Commercial availability of the sorting technology.
- Lower sorting speed and efficiency.
- High cost of maintenance.
- Higher cost of sexed semen.
- Lack of skilled manpower.
• Lack of good quality ejaculates from indigenous cattle and buffalo
• Low conception or pregnancy rates
• Lack of availability superior bulls with good fertility
• Delayed sexual maturity of heifers
• Sperm from some bulls had higher tolerances for sorting, freezing and thawing than from other bulls
• Lack of availability of sexed semen
• Lack of awareness about sex semen to farmers

The major problem is that it needs highly specialized, non-portable equipment which is quite costly for routine use.

**Economic impact of sexed semen:**

Technique is most promising for animal husbandry sector. One such machine cost around 40 to 50 million rupees (4 to 5 crores) and royalty for each dose of semen produced is to be paid also. If cost is reduced and use of this technique in India is standardized it will increase genetic gain at faster rate.

In Indian condition conception rate will not go beyond 35% in the current scenario as frozen semen conception rate averages in organized herd are around 50%. Further from an ejaculate 30% sperm will be rejected during the sexing process due to non detecting precisely for difference in DNA content and out of the detected sperm 50% will be Y bearing; so semen doses harvesting from a high merit bull will be reduced by 70 percent through this technology. There will be a reduction of 15 to 20% conception rate through use of sexed sperm technology from the conventional frozen semen conception rate. Even though the speed of sorting has greatly increased during this time period, each individual spermatozoon still needs to be assessed and sorted accordingly. Several improvements have recently made sperm sorting more efficient and less harmful for spermatozoa. However, new strategies are also under development which will definitely reduced the wastage and improve the conception rate through use of these technologies in near future.

**Conclusion**

The success story of semen cryopreservation has been one of apparent early success in 1949 followed by decades of marginal improvement in cattle. However, it is becoming increasing clear that even when membrane-intact, motile spermatozoa are recovered after thawing, these cells are functionally very different from fresh spermatozoa. If frozen-thawed semen is to be used in the same way as fresh semen, and be able to achieve high fertility rates from intrauterine or even intra-vaginal insemination, without very careful monitoring of the female cycle, it will be necessary to substantially improve techniques for freezing-thawing. A greater understanding of the causes of cryo-injury and the effects of temperature, osmotic and oxidative stresses on sperm membranes are required in order to preserve the natural heterogeneity of a semen sample and to limit pseudo-maturational changes in the cells. There is little evidence to indicate that bull spermatozoa are unique and good reason to hope that it will not take another 50 years to fulfil the potential of frozen semen in a wide variety of species.

Slaughter of cow is banned in most of the states in India. Extra males are very difficult to dispose. So sex selection towards female will help in producing near about 92 to 95% female and strengthen the food production and nutritional security. Production of superior male through sex selection will further contribute in improving the production potentiality of dairy animals. Practically, not much
work has been done in this direction in our country. Even in developed world, research efforts on the subject came about after flow cytometry and cell sorting became available as a handy tool. Lot of research need to be carried out to develop this technique in our country in collaboration with other laboratories to make it feasible in our country. Because of the expense involved with sorting sperm, research has focused on developing improved sorting technology in term of more sperm/sec and on methods to inseminate females with reduced sperm dosage per unit (1.8 X 10⁶) compared to conventional AI (8 to 10 X 10⁶ viable progressive motile sperm at the time of AI). So with 50 to 60% viability after post thaw in a standard dose of straw around 20 X 10⁶ viable motile sperm packed initially before cryopreservation. Use of sex sorted spermatozoa with lower doses in combination of Multiple ovulation embryo transfer, In-vitro fertilization, Gamete intra-fallopian transfer and Sperm intra-fallopian transfer may help to overcome the lower fertility problem. The sex sorting through flowcytometry is refining day by day by increasing the speed of sorting but the fertility results are still questionable. The lack of availability of technology and negative impacts on fertility limiting use of sex sorted spermatozoa throughout the world. Introduction of inert gold nano particle and harmless deflection technique will improve quality and fertilizing capacity of sex sorted spermatozoa. The success of sperm sexing technologies depends on simple, efficient and highly accurate technology having practical and economical feasibility with less deleterious effect on germplasm.
VACCINATION SCHEDULE IN LIVESTOCK AND PRODUCTION DISEASE

Dr. Kriti Dua

Vaccination is one of the most important and cost-effective methods of preventing infectious diseases of animals. To date, no other method in veterinary medicine has had such an impact in reducing morbidity and mortality and increasing the overall well-being of animals. In veterinary medicine, vaccines have played an enormous role in the development of the modern livestock industry through the efficacious and cost-effective control of infectious diseases.

Vaccination is administration of vaccine (antigen derived from infectious agents) to an animal so that specific immune response is mounted and animal becomes resistant to infection. The immune response is of two types, namely humoral immunity involving the synthesis and release of antibodies (B Lymphocytes) into the blood and other body fluids, and cell mediated immunity involving the production of sensitized T-lymphocytes, which have the antibody on their cell surfaces. Currently, the majority of bacterial and viral vaccines are either live attenuated or killed. Live attenuated vaccines are very efficient in inducing long-lasting immunity through cell-mediated and humoral immunological responses, however these vaccines present a potential risk for pregnant and immunocompromised animals as their potential to revert back to virulence has been constantly questioned. Inactivated vaccines cannot replicate and are, therefore, not infectious. However, they lack the ability to induce a robust immunological response, especially cell-mediated responses.

Vaccination in bovines

Large animal are to be routinely vaccinated against various infectious diseases occurring commonly in outbreak form. There is no single universally accepted vaccination schedule, but vaccine to be used depends on the prevalence of that disease in particular area or farm. The vaccination against Foot and Mouth disease (FMD), Hemorrhagic Septicemia (HS), Brucellosis and Black Quarter (BQ) should be carried out regularly in bovine population, however, depending on the prevalence of the disease in particular area or farm, vaccination against theileriosis, rabies or anthrax can be done. The schedule to be followed depends on the vaccine used, manufacturer’s instructions and veterinarian’s own choice. Suggested vaccination schedule for bovine is given in Table 1. The first injection of any vaccine can be given at any age over and above the manufacturer’s guidelines but booster and repetition doses to be given exactly at the recommended time interval. In general, there should be a gap of 14-21 days between two vaccines used. Various commercial vaccines (Table 2) are available in the market which protects the animals from infectious diseases. Some are multivalent vaccines (Raksha biovac, Raksha triovac, Raksha HS and BQ combined vaccine) which contain antigens against different infectious agents and protect the animals against many diseases.

Points to be considered during vaccination:

- Vaccinate all the animals at the same time.
- Use separate disposable needle for each animal.
- Maintain the cold chain and store the vaccine in a refrigerated or thermos flask covered with ice.
- Check the expiry date of the vaccine and consult a veterinarian during vaccination.
Always use the vaccine manufactured by reputed company.
Vaccinate the animals during the cool hour of the day.
Vaccinate only the healthy animal. Do not vaccinate sick animal.
Maintain the proper record of vaccination given to animals.

Table 1. Suggested Vaccination Schedule for Bovine

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccination</th>
<th>Revaccination</th>
</tr>
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<tbody>
<tr>
<td>3 Month</td>
<td>Rakshavac T (Theleriosis) only for crossbred cattle</td>
<td>Every year</td>
</tr>
<tr>
<td>4 Month</td>
<td>Clovax/ Raksha Ovac (Foot and Mouth Disease)/Raksha Biovac (Foot and Mouth Disease and Haemorrhagic Septicemia)/ Raksha Triovac (Foot and Mouth Disease, Haemorrhagic Septicemia and Black Quarter)</td>
<td>Every Six Months</td>
</tr>
<tr>
<td>Six Month</td>
<td>HS alum precipitated vaccine /Raksha HS (Haemorrhagic Septicemia), BQ Vaccine/ Raksha BQ(Black Quarter)</td>
<td>Every Six Months</td>
</tr>
<tr>
<td>Four to Eight Months (serologically negative female animals)</td>
<td>Brucella abortus Strain 19 vaccine/ Bruvax (Brucellosis)</td>
<td></td>
</tr>
</tbody>
</table>

Note:
- If clovax/ Raksha ovac has been used then use HS alum precipitated vaccine /Raksha HS and BQ/Raksha BQ at six months age.
- If Raksha biovac/ triovac is used then no need to vaccinate with Clovax/ Raksha Ovac at four month and HS alum precipitated vaccine /Raksha HS and BQ vaccine at six month
- Vaccination against anthrax and rabies can be done depending upon prevalence in the particular area

Table 2. Commercially available vaccines

<table>
<thead>
<tr>
<th>S No</th>
<th>Trade Name</th>
<th>Manufacturer</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacterial vaccines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haemorrhagic septicaemia (HS)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>HS alum precipitated vaccine</td>
<td>Punjab Veterinary Vaccine Institute (PVVI, Ldh)</td>
<td>Immunity within 7 days: so can be used in outbreaks</td>
</tr>
<tr>
<td></td>
<td>Raksha HS vaccine</td>
<td>Indian Immunologicals</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Black Quarter (BQ)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>BQ vaccine</td>
<td>PVVI, Ldh;</td>
<td>Can be used in outbreaks</td>
</tr>
<tr>
<td>2</td>
<td>Raksha BQ vaccine</td>
<td>Indian Immunologicals</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Brucellosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Brucella abortus strain 19 vaccine</td>
<td>Bruvax (Indian Immunologicals)</td>
<td>Not used in male calves and advanced stage of pregnancy.</td>
</tr>
<tr>
<td>2</td>
<td>Brucella abortus strain RB-51 vaccine</td>
<td>Bruvax Delta (Indian Immunologicals)</td>
<td>Recommended only for cows not for Buffaloes</td>
</tr>
<tr>
<td><strong>Anthrax</strong></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
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<td>---</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Raksha Anthrax vaccine</td>
<td>Indian Immunologicals</td>
<td>One month prior to the time the disease usually occurs and vaccinate annually</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Viral vaccines</strong></th>
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<tbody>
<tr>
<td><strong>Foot and Mouth Disease (FMD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Clovax FMD oil adjuvant vaccine</td>
<td>MSD animal health</td>
</tr>
<tr>
<td>2</td>
<td>Raksha-ovac FMD oil adjuvant vaccine</td>
<td>Indian Immunologicals</td>
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<table>
<thead>
<tr>
<th><strong>Rabies vaccine</strong></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Raksharab</td>
<td>Indian Immunologicals</td>
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<table>
<thead>
<tr>
<th><strong>Parasitic vaccines</strong></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td><strong>Theileriosis</strong></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Rakshavac T</td>
<td>Indian Immunologicals</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th><strong>Multivalent vaccines (containing antigens against different infectious agents)</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Raksha Biovac</td>
<td>Indian Immunologicals</td>
</tr>
<tr>
<td>2</td>
<td>Raksha Triovac</td>
<td>Indian Immunologicals</td>
</tr>
<tr>
<td>3</td>
<td>Raksha HS+BQ</td>
<td>Indian Immunologicals</td>
</tr>
</tbody>
</table>
Judicious Use of Antibiotics in Veterinary Practice

V. K. Dumka

Department of Pharmacology and Toxicology, GADVASU, Ludhiana

Antimicrobial resistance is a growing problem in nearly every infectious disease, but the extent and rate of increase of the problem varies widely with different pathogen–drug combinations. High incidence of antimicrobial-resistant bacteria of animal origin such as *E. coli* and Enterococci is commonly encountered in people living in close vicinity of animals like farmers, workers in slaughter house and animal-origin food handlers. Contaminated meat is a common source of spread of bacterial resistance from animals to man. Several resistant pathogenic bacteria from intestines of animals such as *Salmonella* and Campylobacter cause zoonotic infections in man. The non-pathogenic bacteria of animals transmitted to man are also a potential source of resistance genes for human pathogenic bacteria besides the zoonotic bacteria. The incidence of vancomycin-resistant bacteria which is very difficult to control, was much lower in human population in countries where the drug was not used in animals. It was a startling revelation that antimicrobial use in humans contributes little to the emergence and development of antimicrobial-resistant *Salmonella*. It is likely that the majority of antimicrobial-resistant *Salmonella* in humans is the result of antimicrobial drug use in food-producing animals.

The object of any therapeutic regimen is to obtain optimum drug concentrations in various body fluids and tissues and to maintain these until the infection has subsided. The pharmacokinetic and pharmacodynamic characteristics of the drugs to be used must be considered for computing dose rates of the antimicrobial agents to ensure desired therapeutic outcome. Increasing resistance to antimicrobial agents is of growing public health concern. Resistance not only makes treatment of individual animals more complicated and more expensive; it also compromises the effectiveness of disease control programs for those infections where effective case detection and treatment are central to the prevention of disease transmission.

The greatest threat to the use of antibiotics is the emergence and spread of resistance in pathogenic bacteria that consequently cannot be treated by previously successful regimens. In veterinary medicine, development of bacterial resistance against antibacterial drugs has restricted the use of several drugs including novobiocin, rifampin, streptomycin and some fluoroquinolones. Shortly after the introduction of each new antimicrobial compound, emergence of antimicrobial resistance is observed. This antibiotic resistance can cause a potent risk to human and animal population with common bacterial infections, those once easily treated with antibiotics. Some strains of bacteria have evolved into superbugs that have an alarming potential to spread and cannot be killed easily by antibiotics. The recent report on superbug that is claimed widespread, fast spreading and resistant to most antibiotics has necessitated the urgency to give a serious thought on the means to cope up with the problem of drug resistance.

Antimicrobials are valuable therapeutic agents and have a crucial role in controlling bacterial disease in animals. Their clinical utility can be enhanced with sound clinical judgment and appropriate dosing principles. Extensive use of antibiotics has led to bacterial resistance to many modern antibiotics. Transmissible antibacterial resistance is the major cause of concern as it can lead to the rapid spread of antibacterial resistance and has proven difficult, if not impossible, to eradicate. When an animal is treated with an antimicrobial drug, a selective pressure is applied to all bacteria exposed
to the drug. The greatest challenge is the probability that most pathogenic bacteria that threaten animal and human health will soon be resistant to all known antibiotics. Bacteria that are susceptible to the antimicrobial are killed or their growth is inhibited, while bacteria that have the ability to resist the antimicrobial proliferate more rapidly. Microbes can also become resistant when resistance genes are transferred from resistant bacteria to susceptible ones. Thus, antimicrobial agents may increase the prevalence of resistant bacteria among both target pathogens and normal bacterial flora.

A chromosomal mutation in bacteria leading to multiple antibiotic resistance is responsible for several clinical isolates resulting in resistance to a variety of antibacterial agents. Antibiotic resistance determinants may be vertically or horizontally spread in natural microbial communities. Wide spread resistance developed in animal pathogens against sulfonamides is a consequence of its extensive use in human and veterinary medicine over many years. A significant source of antimicrobial-resistant food borne infections in humans is the acquisition of resistant bacteria originating from animals. The emergence of drug-resistant bacterial populations following exposure to antimicrobial drugs and can occur from human, animal, and agricultural uses. Lactic acid bacteria widely used as probiotics or in starter cultures have the potential to serve as a host of antibiotic resistance genes with the risk of transferring the genes in many lactic acid bacteria and other pathogenic bacteria. In the past studies on selection and dissemination of antibiotic resistance have focused mainly on clinically relevant species. However, recent researchers have speculated that commensal bacteria including lactic acid bacteria may act as reservoirs of antibiotic resistance genes similar to those found in human pathogens. The main threat associated with these bacteria is that they can transfer resistance genes to pathogenic bacteria. Genes conferring resistance to tetracycline, erythromycin and vancomycin have been detected and characterized in *Lactococcus lactis*, Enterococci and Lactobacillus species isolated from fermented meat and milk products. In recent years, concerns about the use of antimicrobial products in food-producing animals have focused on human food safety because foods of animal origin are vehicles of food borne disease in humans. Food-producing animals can become reservoirs of bacteria capable of being transferred on food. Food-carrying resistant bacterial pathogens can cause human illness and subsequent therapeutic failure to mitigate these infections.

**Selection of antibiotics for therapy**

Antibiotics can be used either prophylactically or therapeutically. The same basic principals must be considered to initiate a therapy.

**Drug Factors:** Activity of the drug against the pathogen. Its ability to reach the site of infection in therapeutic concentration. Whether it is bacteriostatic or bactericidal against the known or suspected pathogen since cidal activity is required for certain infections. Its available routes of administration whether it is appropriate for the patient. Its adverse effect profile. Drug interactions. Its dosing frequency since acceptance of drug is greater with two or less dose per day. Whether the formulation is stable at various temperatures. Some antibiotic suspensions require refrigeration to remain stable. Cost of therapy including cost of medication, administration, monitoring, complications, treatment failure and the cost of re-treatment.

**Bacterial factors:** Antibacterial therapy is effective only for bacterial infections. So it is important to restrict the use of antibiotics to situations where bacterial infection is either known to be present or is highly probable. Prescribing antibiotics for viral infections should be discouraged because it is ineffective, costly, produce unnecessary adverse effects and contributes to antibiotics resistance. Once bacterial infection is confirmed or suspected, it is important to identify the infecting organism(s)
in order to make a rational antibiotic choice. If the infecting organism is not known it is possible to make a reasonable guess about the likely pathogen based on probabilities e.g. UTI is due to *E.coli* is about 80% of the cases. Cellulitis in limbs is due to *Str. Pyogenes or Staph aureus*. For making a guess about likely pathogen it is important to know: the site of infection; details about the host, including age, underlying illness and other predisposing factors; the usual trends of susceptibility. In selected cases, it is appropriate to start antibiotic therapy without identifying the pathogen (for e.g. in most cases of cellultes). In other cases, where the pathogens cannot be reliably predicted or in patients with severe illness, appropriate specimens should be collected before starting antibiotic therapy and culture sensitivity test must be performed.

**Host Factors:** Several host factors need to be considered before selecting an antibiotic for a given infection. Site of infection: it is important that the antibiotic reaches the site of infection at a concentration above MIC in all cases and above the MBC in certain infections such as meningitis or brain abscess like cefotaxime, cefipime, chloramphenicol. Many antibiotics have difficulty in penetrating the prostate gland for treating chronic bacterial prostatitis. UTI must be treated by drugs that are excreted via the kidneys in active form. Route of administration: Oral route is preferred in human beings but in animals parental extravascular route is preferred. Parental therapy is necessary if digestive tract is non-functional, in case of hypotension, when immediate effect is desired e.g. in life threatening infections, or absorption from GIT is not complete to achieve therapeutic concentration at site of infection. Topical route is appropriate for selected local infection e.g. bacterial conjunctivitis. Drug allergies Intact renal and hepatic functions – since antibiotics are cleared by kidneys and liver. Combination therapy – since some antibiotics show adverse drug interactions. Age: Since certain antibiotics are contraindicated in neonates (sulfa, ceftriaxone), very young (tetracycline, fluoroquinolones) and pregnant women (metronidazole as it is mutagenic).

**Therapy with combined Antimicrobial Agents**

The simultaneous use of two or more antimicrobial agents has a certain rationale and is recommended in specifically defined situations. Selection of an appropriate combination requires an understanding of the potential for interaction between the antimicrobial agents. Such interactions may have consequences for both the microorganism and the host eg. macrolides inhibit cyt P450 which is required for metabolism of theophylline. If both drugs are used simultaneously to treat asthma the toxicity of theophylline is increased. Since various classes of antimicrobials exert different actions on microorganisms, one drug has the potential to enhance or inhibit the effect of another. Similarly, combination of drugs that might rationally be used to cure infections may have additive or supra additive toxicities eg. vancomycin or tobramycin when given alone have minimal nephrotoxicity, but when given in combination they cause marked impairment of renal function.

**Prevention of antimicrobial resistance and future responsibilities**

Minimizing the emergence of antimicrobial-resistant bacteria in animals and their subsequent spread to humans through the food supply is a complex problem requiring a coordinated, multifaceted approach. The adoption of modern disease control and surveillance techniques is critical if an increase in the incidence of antibacterial resistant staphylococcal infections parallel to that seen in humans is to be avoided in animals. Despite the remarkable rate of the development of new antibiotics, the emergence of drug-resistant bacteria continues unabated. It is important to use these agents wisely to maintain their usefulness for the future. Quantitative studies are also needed to assess how certain withdrawal periods observed for antimicrobial residues in food-producing animals would impact on
the prevalence or dissemination of resistant organisms in the gut microflora of the treated animals. Further research is required to establish firm guidelines to improve the detection of methicillin-resistant *Staphylococcus aureus* (MRSA) in animals. This will enable the early identification of carrier animals on admission to veterinary clinics and hospitals. Such information will greatly improve diseased animal care and ensure directed treatment to limit the use of drugs approved in food animal species.

It becomes our responsibility of ensuring that the use of antimicrobial drugs in food-producing animals does not result into adverse health consequences in humans. In food animal pharmacology, microbial resistance will continue to dominate antimicrobial use, although vaccination approaches should reduce the diseases they are used to treat. Unfortunately, unlike the clearly defined mechanism for ascertaining the toxicological safety of drug residues in food, no such predictive models currently exist to precisely estimate the rate and extent of bacterial resistance that may emerge from the use of antimicrobial drugs in food-producing animals. Despite the current lack of such models, certain information can be generated to support a pre-approval antimicrobial-resistance safety assessment. If antimicrobial use remains at a high but constant level, there will be continuing increases in the prevalence of resistance, and if all antimicrobial use ended suddenly, resistance may decline but will not end immediately. In infections for which emergence of resistance during treatment is a concern, low-dosing or non-compliance of proper dosage regimen is often a risk factor and increased dosing would presumably reduce resistance.
TREATMENT AND CONTROL OF BOVINE MASTITIS

Dhiraj Kumar Gupta
Assistant Scientist
Department of Veterinary Medicine
College of Veterinary Science, GADVASU, Ludhiana

Mastitis classically is defined as inflammation of the mammary gland which arises in response to injury for the purpose of destroying or neutralizing the infectious agents and to prepare the way for healing and return to normal function. This is one of the most costly diseases of dairy cattle resulting in the reduction of milk yield and quality. Current annual economic losses due to mastitis in India have been estimated to be Rs. 7165.51 crore that include Rs. 4151.16 crore and Rs. 3014.35 crore due to subclinical and clinical mastitis, respectively (Bansal and Gupta 2009). The average incidence of subclinical mastitis has been found to be 49% in cows and 28% in buffaloes. Similarly, clinical mastitis is prevalent in 7% of cows and 4% buffaloes. Besides this, 17% of the cows and 8% of buffaloes have been suffering from various udder and teat lesions such as udder/teat warts, bovine ulcerative mammitis, udder impetigo and teat chaps etc. These lesions pre-dispose the animal to mastitis and cause a great discomfort at milking and hence markedly decrease the milk yield. Subclinical mastitis though in apparent causes 10-25% loss in milk production whereas in clinical mastitis there may be total loss of milk. Besides this, presence of mastitis causative organisms and antibiotic residues in milk following therapy of mastitis poses a major threat to the consumer health. Another important and inevitable fact is the adverse effects of mastitis on the compositional and keeping quality of milk and milk products. Mastitis results in increase in the somatic cell count (SCC) and bacterial load of milk. The European Union has set up a threshold of 400,000 cells/ml of milk from healthy quarter of a cow. The high SCC in mastitis milk has lipolytic effect on fat and there is increased tendency for rancidity of milk and milk products. Also, the mastitis milk with total bacterial count of more than 100,000 cfu/ml could release hydrolytic enzymes, which spoil the milk and milk products. It has been also observed that mastitis milk inhibits the growth of starter bacteria and results in decreased cheese production.

ETIOLOGY OF DISEASE

The disease is mainly caused by bacterial organisms, which are frequently present in the close vicinity of animals. The causative agents are categorized into two groups; the contagious organisms such as Staphylococcus aureus and Streptococcus agalactiae which frequently present on teat and udder skin of animal, and transmitted form one animal to another animal at the time of milking through milking utensils, milker’s hands and cups of milking machine. The other group comprised environmental organisms such as coliforms and Streptococcus uberis, which are frequently present in dung, animal bedding, manure, soil, feed stuffs, uterine discharges and urine etc., may be transmitted to animal at any time, even in-between the milkings.

DIAGNOSIS OF MASTITIS

In its clinical form, disease may be diagnosed well by the classical signs of inflammation and visible alterations in milk consistency, colour and appearance etc. The changes in levels at which certain components in the mammary secretion are present are commonly employed in identifying the disease.
at its subclinical level. A variety of diagnostic tests for mastitis are available which differ markedly with respect to sensitivity, specificity, simplicity, rapidity and cost. Among these, Bromothymol blue (BTB) card, Sodium lauryl sulphate (modified California mastitis test) and Electrical conductivity tests are simple and economical tests that can be performed as cow-side tests at the field level.

**Bromothymol blue card test:** It is based on the principle that in mastitis, the pH of milk rises due to entry of bicarbonate salts from blood into milk. Depending upon the health status of quarter and hence pH, the colour of the dye changes from yellow (normal) to greenish-yellow (+), green (++) and blue (+++) when a drop of quarter milk is placed on the card. But, this test has comparatively less sensitivity.

**Sodium Lauryl Sulphate (SLS) test:** It is based on the principle that reagent ruptures somatic cell releasing cellular proteins (DNA) that results in gel formation, and depending upon the degree of gel formation the reaction is scored as 0, Trace, 1, 2 and 3. Thus, this test gives the indirect estimate of milk somatic cell count. This test could be used with high accuracy for estimation of milk SCC ($r = 0.84$).

**Electrical conductivity test (EC):** The ions in milk conduct electricity, such that any change in concentration of ions is reflected as a change in conductivity. Dissociated, inorganic salts such as sodium, chloride and potassium are the main contributors to conductivity. The EC is moderately influenced by milk constituents such as protein and fat, which reduces the conductance of ions. The normal mean EC values were found much less in buffaloes (3.91 mS/cm) than in crossbred cattle (5.41 mS/cm). Also the discrimination ability for EC to differentiate between healthy and mastitis quarters was found more in cattle (75.54%) than in buffaloes (66.0%). In overall, based on mean values, it is found that there is difference in conductivity of 0.5 to 1.5 mS/cm between the healthy and mastitis quarters. The EC could be measured by digital conductivity meters, which are easily available in the market. Even, hand-held battery operated digital conductivity meters are available for use as cow-side test.

**TREATMENT OF MASTITIS**

*In vitro* testing of milk samples revealed that drug sensitivity pattern of mastitis organisms goes on changing from time to time and place to place or farm to farm. At present, under local dairy conditions we found amoxicillin+sulbactum, gentamicin, ceftriaxone+sulbactum are much effective drugs. So, treatment should be given preferably based on culture and sensitivity test. In acute or per acute cases, there is no time for these tests, so the therapy in such cases is based on the past data of herd infection and sensitivity reports. However, before starting therapy in such cases, the milk sample should be invariably taken and put to culture sensitivity so that the therapy may be changed if needed in the light of sensitivity report. Moreover, it may also be made clear that there is no surety that *in vitro* sensitivity determination will correlate with the *in vivo* treatment results. For example, enrofloxacin that shows high *in vitro* sensitivity and is pharmacologically considered to distribute well in the udder clinically proved to be less efficacious against staphylococcal mastitis because of its inability to kill intracellular organisms. On the other hand, amino-glycosides (gentamicin and neomycin) that are considered to have poor distribution in the udder, *in vivo* proved very much effective in treatment of clinical mastitis. The organism involved in mastitis also affects the efficacy of treatment. Streptococci respond well, staphylococci less and coliforms are difficult to treat due to severe per acute reaction. However, enrofloxacin could be best recommended for treatment of per acute mastitis caused by coliforms.
For improving treatment following considerations are worthwhile.

1. **Location and pathology of causative organism**

   a) *Streptococcus agalactiae* and *Streptococcus dysgalactiae* are present in milk and living epithelial cells.

   b) *Staphylococcus aureus*, *Streptococcus uberis* and *Acanthobacterium pyogenes* infect the deep tissues of gland.

   c) Coliform organisms cause simultaneous infection of udder and other body organs.

2. **Selection of antibacterial agent**

   Treatment of mastitis involves systemic antibiotics or intramammary infusions. Ideally systemically administered antibiotics must reach udder and should achieve minimum inhibitory concentration (MIC) in milk and parenchyma. Thus, pharmacologic agents which are nonionoized, lipid soluble and have low protein binding are predicted to reach the target tissue more efficiently. Also, the concentrations gradient, which serves as driving force for drugs in to tissue and secretions, is a function of drug's total dose and frequency of administration. Thus higher dose rate or frequency, is the concentration gradient pushing the drug in to udder.

   **Distribution of antibiotics in udder post-intramammary administration**

<table>
<thead>
<tr>
<th>Good</th>
<th>Moderate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>Benzyl Penicillin</td>
<td>Aminoglycosides</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>Cloxacillin</td>
<td>Polymixin</td>
</tr>
<tr>
<td>Penethamate</td>
<td>Cephoxazole</td>
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</tr>
<tr>
<td>Novobiocin</td>
<td>Cephalonium</td>
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<tr>
<td>Erythromycin</td>
<td>Tetracyclines</td>
<td></td>
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<tr>
<td>Nitrofurans</td>
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<tr>
<td>Tylosin</td>
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</tbody>
</table>

3. **Route of administration**

   Selection of the route of antibacterial gent is not only important because of treatment cost but treatment success also. The route of treatment is governed by degree of severity of mastitis, infective agent involved and milk yield of the affected quarters. Accordingly parentral therapy with or without intramammary infusion is preferred in acute clinical mastitis because of the simple reason of poor and uneven distribution of drug as a result of compressed and blocked duct system owing to inflammation. Intramammary route is accepted route of choice for subclinical and mastitis with local signs. However, Staphylococcal mastitis is an exception. This organism is tissue invader and is located in interstitial tissue, micro abscesses and intra cisternally in neutrophils, macrophages and epithelial cells, therefore parentral therapy should be preferred. It is advantageous to combine systemic and local therapy in treating acute clinical non gangrenous *S. aureus* mastitis.

4. **Duration of therapy**

   A course of 5 days treatment produces higher bacteriological cure rates than 3 day course of treatment.
5. **Severity of the infection**

For taking specific therapy, clinical mastitis is generally divided into three forms viz., per acute, acute and chronic form.

**Peracute mastitis:** It is generally caused by coliforms and it occurs commonly around calving but may develop at any time during lactation. The disease is usually sudden in onset: the cow may appear normal at one milking and at the next milking shows pronounced signs including anorexia, rise of temperature, depression, shivering and rumen stasis. Inflammatory signs in the udder may be minimal at this time and swelling may be detectable only after the udder is milked out. Later, the quarter is swollen and hard, the teat may be thickened, oedematous, hot to touch and sensitive. In the early stages, the milk may appear normal or faintly watery. Subsequently it may be serous and contain tiny particles. In severe cases it may become blood tinged. Recommended therapy includes the following:

- Removal of bacteria, toxins and inflammatory exudates from the mammary gland by frequent milking and even oxytocin injections (20-30 IU I/M) may be given
- Appropriate antibacterial therapy to start with systemic administration that may be later (after 12-24 h) supplemented with suitable intramammary infusion.
- Fluid therapy; dextrose saline solution (10-20 L in first hour, up to 60 L in severe cases) to restore vital body fluids, dilute toxins and counteract acidosis. Even 5% sodium bicarbonate (150-250 G) with first 3-5 L of fluid may be given.
- Systemic glucocorticoids, Dexamethasone @ 1-3 mg/kg IV or IM once or may be repeated after 8-12 hours.
- Calcium borogluconate 20% @ 500 ml IV to counteract hypocalcaemia induced by endotoxin. Administer with care as such therapy may have damaging effects on the heart in animals that are in shock.
- NSAIDs reduces pain and inflammation, and restores appetite
- Antihistaminic drugs and multivitamins

**Acute mastitis:** In this form there is no systemic reaction. Primarily changes are observed in milk, which may contain flacks, become watery or thick, and sometimes may contain blood. The udder may become swollen and hard. The line of treatment includes use of antibacterial drugs plus calcium and multivitamin therapy. The combination therapy i.e. intramammary plus parenteral works well than the alone parenteral or intramammary. The important recommendations in mastitis therapy are (i) Use antibacterial on need for recommended time i.e. at least for 5 days (ii) Use appropriate dose and dosing interval (iii) Stick to the recommended milk withdrawal times. Depending upon the sensitivity report following combination may be used:

<table>
<thead>
<tr>
<th>Option</th>
<th>Parenteral</th>
<th>Intramammary infusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gentamicin sulphate 3-5 mg/Kg IV or IM twice daily</td>
<td>Gentamicin sulphate 100-150 mg twice daily or commercially available intramammary preparations of neomycin for 3 days</td>
</tr>
<tr>
<td>2.</td>
<td>Ampicillin sodium 20 mg/Kg IV followed by 10mg/kg IM twice daily</td>
<td>Cephapirin sodium 200 mg at every milking for 3 times or cloxacillin sodium 200 mg at every milking for 6 times</td>
</tr>
<tr>
<td>3.</td>
<td>Sulfadiazine/ trimethoprim 25 mg/Kg IV or IM od</td>
<td>Amoxycillin sodium 62.5 mg or Hetacillin potassium 62.5 mg every milking for 6 times</td>
</tr>
</tbody>
</table>
4. Erythromycin lactobionate or tylosin tartrate 10 mg/Kg IV followed by 5 mg/Kg IM bid
   Erythromycin 300 mg at every milking for 6 times
5. Ceftiofur 3-5 mg/kg IM bid
   Ceftiofur 100 mg
6. Sulfamethazine sodium 100 mg/Kg IV followed by 50 mg/Kg IV
   Option 3 or procaine penicillin 1 Lac IU at every milking for 6 times

**Chronic mastitis:** A case is considered chronic when (i) there is formation of fibrotic cord inside teat canal (ii) there is thick pus discharge, not responding to treatment (iii) there is frequent reoccurrence of mastitis in the same quarter. The treatment/surgery of chronic mastitis is not rewarding. Rather such cases should be isolated from the milking herd or the affected quarter may be permanently dried-off by producing a chemical mastitis. Infusing 30-60 ml of 3% silver nitrate solution or 20 ml of 5% copper sulphate solution can do it. If a severe local reaction occurs, the quarter should be milked out and stripped frequently until the reaction subsides. If no reaction occurs, the quarter is stripped out 10-14 days later. Two infusions may be given.

**CONTROL OF MASTITIS**

Mastitis control is a comprehensive program that includes good milking and environment hygiene, use of properly functioning milking equipment, application of teat dipping, proper identification and treatment of mastitis cows, use of dry therapy and sound nutritional program. Worldwide, many dairy farmers have adopted these procedures and produce high quality milk. The important features of a successful mastitis control programme are:

**Minimising the source of infection:** Infection can be prevented by maintaining optimal environmental and milking hygiene, segregation and prompt treatment of clinical mastitis cases, culling of carriers and drying off of chronically infected quarters. The adoption of hygienic measures depends upon the epidemiology of the causative organisms. For example in case of contagious organisms, which are transmitted from one to another animal through the milking equipment and milker's hands, proper washing of udder, cleanliness of milker’s hands/milking machine clusters in between each milking and post-milking teat dipping in germicidal solution will reduce the infection to a great extent. On the other hand, for the organisms that come from the environment e.g. to prevent coliforms mastitis animal environment should be kept clean by frequent removal of dung, proper drainage, and adequate milking and feeding space should be provided.

**Elimination of existing udder infections:** It is achieved by *Dry therapy*. The dry therapy is done at the end of lactation (after last milking) with a long acting antibiotic intramammary preparation that maintains effective drug concentration for 6-8 weeks i.e. throughout the dry period. It not only eliminates the subclinical infections of previous lactation but also prevents new IMI and increases the milk production by about 8-10%. In addition it improves the milk quality at calving and prevents the occurrence of clinical mastitis cases during dry period and around calving. Now dry therapy preparations such as Spectramast-DC are available in India.

**Prevention of new intramammary infections (IMI):** It is achieved by *Post milking teat dipping*. The teats of all the lactating cows and dry cows (during first 10-14 days of dry period) are dipped regularly after every milking in a germicidal solution. The recommended teat dips are

1. Iodine (0.5%) solution + Glycerine @ 15% of iodine solution
2. Chlorhexidine (0.5%) solution + Glycerine @ 06% of chlorhexidine solution

The iodine teat dip is found best as it also treats various types of teat lesions and injuries.
Increasing the udder resistance to mastitis: Future trends in mastitis control are aimed at increasing the immunity of udder to mastitis pathogens. This can be achieved by use of non-specific (cytokines/ proper nutrition) and specific (vaccination) immunomodulators.

Nutrition: Even slightest deficiencies of certain vitamins (Vit E, C, A and β-carotene) and micro-nutrients (Cu, Se, Zn, Co) are reported to have detrimental impact on the efficient functioning of immune system. Vitamin A is involved in maintaining a functional epithelium that provides a physical barrier to the entrance of pathogens. β-carotene also referred as pro-vitamin A enhances the immune function and disease resistance. Zinc supplementation prevents the infection by strengthening the skin and stratified epithelium (keratinocytes) of teat canal. The biological role of Cu is exerted through a number of Cu containing proteins including ceruloplasmin and superoxide dismutase (SOD). Similarly, vitamin E and the Se containing enzyme glutathione peroxidase (GSH-pX) also act as integral part of the antioxidant system. Studies have shown that supplementation of cows during dry period and around calving (first 8-10 weeks) with the following nutrients per head per day proved beneficial in preventing mastitis/ lowering milk SCC.

- Vitamin 53000 IU + Beta-carotene 300 mg
- Zinc-methionine (180-360 mg Zn, 360-720 mg methionine)
- Copper @ 20 ppm i.e. about 200 mg
- Vitamin E 1000 IU during dry period and 500 IU for lactating cows
- Selenium @ 3 mg during dry period and 6 mg during lactation

Cytokines: Cytokines include interferons, interleukins, colony stimulating factors (CSF), and a variety of other proteins that modulate the activity of immune cells and thus enhance the phagocytic cell functions in the udder. It has been shown that interferon treated cells exhibit significantly more phagocytosis and intracellular killing of Staphylococcus aureus. Interleukins enhance the production of local antibodies and accelerate the involution process that will further promote resistance to mastitis during the dry period. Similarly, the granulocyte-macrophage CSF significantly increases the chemo tactic and bactericidal activities of mammary gland neutrophils.

Vaccination: The effective immunization against mastitis has been a goal of mastitis researchers for many years. But, the nature of disease creates a number of unique challenges for the production of successful immunity against mastitis. Commercially, few mastitis vaccines are currently available in developed world for immunization against mastitis caused by Staphylococcus aureus and E. coli. Several studies have evaluated these; the outcomes have been inconsistent and confusing to interpret. However, it is generally accepted that S. aureus vaccine have limited ability to prevent new infections and clinical mastitis cases. The best use of the vaccine is the reduction of chronic infections rather than prevention of new infections. The use of vaccine against coliforms mastitis has been considered efficacious even though the rate of intramammary infection is not significantly reduced in vaccinated animals but because they significantly reduced the severity of clinical disease. Its role may be expected as one the component of mastitis control programme, but alone its use may not be giving much hopeful results.
COMMERICAL GOAT FARMING IN INDIA

M. Bhakat, T.K. Patbandha, T.K. Mohanty, A. Singh and S. Mondal
Artificial Breeding Research Centre, ICAR-NDRI, Karnal

Introduction

Goat (Capra hircus) is considered as the first ruminant to be domesticated by human beings between 10000 and 6000 years before Christ (BC) in South-western Asia (Iran and Iraq). Goat significantly contributed to the national economy by providing meat, milk, skin, fibers, manure etc. Goats also contributed appreciably to nutritional security of rural livelihood by providing animal protein through meat and milk. In India, about 24 breeds of goats have been identified phenotypically and registered at National Bureau of Animal Genetic Resources, Karnal. The goat population, during last decade remains almost similar; the population increased by 3.10% during the year 2003-2007, but decreased by 3.82% during the year 2007-2012, with present population of 135.2 million (19th livestock census, 2012). Goat contributed 5.05 million tonnes milk (3.67% of total milk production i.e., 137.685 million tonnes) and 0.97 million tonnes meat (15.56% of total production i.e., 6.235 million tonnes) during the year 2013-2014 (BAHS, 2014). Goats are generally managed under extensive production system followed by semi intensive production system, where only night shelter is provided. However, now-a-days farmers are taking more interest for rearing under intensive production system for commercial purposes.

Scope and limitation of commercial goat farming

There is huge scope for goat rearing in India as goat meat and milk are widely accepted by peoples belonging to all religions. Goats are reared for multipurpose such as meat, milk, hide, fibre and manure. Goat meat has high demand in India which accounts Rs. 380-450/kg presently. There is also belief that goat milk has medicinal values and cost around Rs. 100-1000/liter in northern India during Dengue outbreak, but there was no scientific proof exists as well as no planned scientific study has been done till now. Goat milk owing to easier digestibility and high nutritious value has great demand for young children, older people and patients with digestive disorder (Kumar et al., 2012). Further, the increasing purchasing power of middle class and lower middle class people enhances demand of goat meat. Hence, goat rearing in India for commercial purposes is feasible due to great demand of meat and milk.

Goat rearing in India has certain limitations such as lack of genetic improvement programme, lack of health care facilities, limited feed and fodder resources and marketing problems etc. In addition, inefficient and inappropriate production systems and poor strategies for improved natural resource management and inadequate support have led to low productivity of small ruminants. The level of adaption of breeding, feeding and nutrition and health related techniques by the farmers are not satisfactory (Devendra, 2001). Though, India is gifted with 24 breeds of goat, the performance is not upto the expectation level due to low growth rate. Goats are being blamed by the forest people for deforestation, land degradation and harmful to the environment. But scientific study revealed that these species are less harmful to the environment (ICAR, 2008). Scientific approach to livestock rearing is missing among professional breeders and farmers involved with goat husbandry.
Goat farming has multifarious added advantage as it requires less housing facility, less management and labour, higher prolificacy, improve the soil fertility, easily managed by women and children, good export market for goat skin, high quality clothing can be manufactured by Mohair and Pashmina, provide transport power in high altitudes, control the bush and undesirable forbs, high dry matter and fibre digestibility capacity, managed under integrated system in case of small holder and nomadic system as well as commercial farming system in case of large flock. Goat milk has medicinal value and it is easily digestible due to smaller fat globules and is less allergic. Goat is playing an important role in nutritional security, employment of unemployed youth, income generation and risk coverage.

![Trend in goat population (1951-2012)](image)

**Indian goat breeds**

India is gifted with 24 breeds of goat (Table 1); breeds from Himalayan region particularly Chegu and Changthangi are famous for fiber (pashmina) production in addition to meat and skin. Black Bengal breed is known for best quality meat production and Beetal and Jamnapari breeds are mostly reared for dual purpose i.e. both milk and meat. The detail classification of goat breeds according to utility is presented in Table 2 (ICAR, 2008).

**Table 1: Registered Indian goat breeds**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Breed</th>
<th>Home tract</th>
<th>Sl. No.</th>
<th>Breed</th>
<th>Home tract</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attapady</td>
<td>Kerala</td>
<td>13</td>
<td>Kutchi</td>
<td>Gujarat</td>
</tr>
<tr>
<td>2</td>
<td>Barbari</td>
<td>Uttar Pradesh &amp; Rajasthan</td>
<td>14</td>
<td>Malabari</td>
<td>Kerala</td>
</tr>
<tr>
<td>3</td>
<td>Beetal</td>
<td>Punjab</td>
<td>15</td>
<td>Marwari</td>
<td>Rajasthan</td>
</tr>
<tr>
<td>4</td>
<td>Black Bengal</td>
<td>West Bengal</td>
<td>16</td>
<td>Mehsana</td>
<td>Gujarat</td>
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<tr>
<td>5</td>
<td>Changthangi</td>
<td>Jammu and Kashmir</td>
<td>17</td>
<td>Osmanabadi</td>
<td>Maharashtra</td>
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<tr>
<td>6</td>
<td>Chegu</td>
<td>Himachal Pradesh</td>
<td>18</td>
<td>Sangamneri</td>
<td>Maharashtra</td>
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<tr>
<td>7</td>
<td>Gaddi</td>
<td>Himachal Pradesh</td>
<td>19</td>
<td>Sirohi</td>
<td>Rajasthan and Gujarat</td>
</tr>
<tr>
<td>8</td>
<td>Ganjam</td>
<td>Orissa</td>
<td>20</td>
<td>Surti</td>
<td>Gujarat</td>
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<td>9</td>
<td>Gohilwadi</td>
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<td>Jakhrana</td>
<td>Rajasthan</td>
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<td>Konkan Kanyal</td>
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<td>Jamunapari</td>
<td>Uttar Pradesh</td>
<td>23</td>
<td>Berari</td>
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</tr>
<tr>
<td>12</td>
<td>KanniAdu</td>
<td>Tamilnadu</td>
<td>24</td>
<td>Pantja</td>
<td>Uttarakhand &amp; Uttar Pradesh</td>
</tr>
</tbody>
</table>

(Source- http://www.nbagr.res.in)
### Table 2: Classification Indian goat breeds based on utility

<table>
<thead>
<tr>
<th>Meat &amp; Skin</th>
<th>Meat, Milk &amp; Skin</th>
<th>Meat, Hair &amp; Skin</th>
<th>Meat, Pashmina &amp; Skin</th>
<th>Milk, Meat &amp; Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Bengal</td>
<td>Barbari</td>
<td>Bakharwal</td>
<td>Chegu</td>
<td>Beetal</td>
</tr>
<tr>
<td>Ganjam</td>
<td>Tellicherry</td>
<td>Gaddi</td>
<td>Changthangi</td>
<td>Jamnapari</td>
</tr>
<tr>
<td>KannaiAdu</td>
<td>Osmanabadi</td>
<td>Gohilwadi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sirohi</td>
<td>Konkan Kanyal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surti</td>
<td>Kutchi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mehsana</td>
<td>Marwari</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zalawadi</td>
<td>Sangamneri</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jhakhrana</td>
<td>Khasi (Assam hill)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pantja</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source- ICAR, 2008)

### Commercial Goat farming economic analysis under field condition

The contribution of goats towards nutritional and food security is immense for landless labourers, small and marginal farmers. However, productivity of Indian goat is not upto the optimum level and it is very low under the prevailing traditional production system. Goats are primarily maintained under extensive system of vegetation and adoption of improved production management practices in the farmers’ flock is very low. Further, shrinkage of grazing land is another factor that compromised the performance. Hence, there is urgent need to exploit the performance of goat under intensive and semi-intensive rearing system using improved management. This could further meet the increasing demand of chevon and overcome the demand and supply gap (Kumar, 2007).

It has been reported that commercial goat rearing under intensive and semi-intensive rearing system results positive net returns. The intensive study of commercial goat farming in India was conducted by Kumar (2007) during 2005-06 and reported that initial flock size is most important factor for success of a commercial goat-farming project and minimum number should be 50 breeding goats. He selected 18 commercial goat farms and grouped to small (<100), medium (100-500), and large (>500) flocks. The major initial investment in commercial goat farming included purchase of breeding stock and construction of sheds and structures. Total investment per breeding goat in small, medium and large categories was estimated to be Rs 5083, Rs 3419 and Rs 6015, respectively. Feed and fodder accounts major cost of rearing goat on commercial farms i.e. about 59% of variable cost. Miscellaneous expenditure (on electricity, insurance, prophylaxis and treatment of animals) for small, medium and large category size was observed to be Rs 130, Rs 102 and Rs 225, respectively with average expenditure Rs 183 per doe per annum. Unlike the traditional flocks, where fixed cost was 10-15% of the total cost, the fixed cost and variable cost in commercial goat farming constituted 35.36% and 64.64% of the total cost, respectively. The total cost per doe/year in small, medium and large categories was worked out to be Rs 2354, Rs 2137 and Rs 2527, respectively. The gross return from goat farming comprised maximum from the sale of animals (90 per cent), followed by manure and milk. Annual net returns per goat for small, medium and large category size were Rs 371, Rs 652 and Rs 494, respectively; however, it did not reveal the real picture. The net return when calculated individual basis it revealed that, the annual net returns per goat were quite satisfactory in 39% of goat farms (Rs 968 to Rs 2069), while in 28% farms it was negative due to higher cost of rearing per...
doe and low market prices. Moreover, about 33% of goat farms had a positive net return but needed to increase to make the business economically viable and sustainable. Further, Prabu et al. (2011) calculated net return from goat farming in Tamil Nadu with average flock size 23.85. Total investment per goat was observed to be Rs 2423.45 where animal cost accounts 80.9% (ranged between 78-84% depending on land holding capacity). Fixed and variable costs are high; 31.65% fixed cost and 68.35% variable cost. Gross return per goat was observed to be Rs 1910.02 and net return per goat excluding family labour was Rs 1216.76, where the major share was contributed by sale of animals. Economic analysis of these above two studies indicated that commercial goat farming will sustain well in India if managed properly with advanced managerial practices.

**Housing management**

Goats do not require any scientific housing system; even simple houses are often inadequate in terms of design, materials and size. However, inadequate housing structures create hygienic problem and thereby compromised health and welfare. The farmers should give more importance to space allowance, shelters from climatic extremes, ventilation and lighting facilities while constructing houses for goats. Reduction of feeder space significantly reduces behaviour particularly feeding time and resting time (reduced by 5-8% and 6-13%, respectively) in goats (Sevi *et al.*, 2009). In addition to recommended space allowance, stocking density also plays a crucial role for improving health and welfare of goats. The ISI (1986) recommended maximum group size of 60 for adult ewe or doe per pen and for lambs or kid should be 75 animals per pen. Proper litter management could improve the welfare and health of goats at higher stocking density but not beyond the recommended level. In higher stocking density, litter should be treated with bentonite (@0.5 kg/m\(^2\) of litter) to control the concentration of microorganisms in the air and milk, and degrading process of nitrogen present in urine (Sevi *et al.*, 2009).

There should be adequate lighting facilities for goat pens; a 25 W lighting facility (fluorescent or incandescent bulb) is sufficient to provide light for 10 m\(^2\) floor space or 60 W is suffice for 25 m\(^2\) floor space (ISI, 1986). Light intensity should be taken into care otherwise very low (10 lux) or high (1000 lux) light intensities lead to increased frequency of abnormal behaviours in young ones (Sevi *et al.*, 2009). Ventilation in goat pens plays crucial role for maintaining performance of goats. The primary aim to provide proper ventilation in sheep and goat pen is to remove ammonia gas developed from excreta decomposition and fermentation. Ventilation also affects thermal exchanges between animal's body surface and the environment, maintains optimum relative humidity, and control level of noxious gases and airborne particles (Sevi, 2005; Thomas *et al.*, 2013). According to Thomas *et al.* (2013) the recommended standard degree of purity of air for animal houses should not be < 96.7% which means air should not contains >3.3% of air once breath. Based on this assumption the requirement of fresh air supply per hour for goat house should be 13 m\(^2\). If wind speed is 5 km/hr then inlet and outlet size must be 4-5 m\(^2\) for goat house (Thomas *et al.*, 2013).

**Feeding**

Goats consume about 3-4% dry matter based on their body weight, and in lactating goats it may be as high as 5-7% depending on production potential. The daily ration of growing kids should be adjusted to achieve body weight between 50-100% per day. The growth rate is less in small breeds like Black Bengal but higher in larger breeds like Jamunapari and Beetal etc. (Balaraman, 2013). The kids should be weaned after 3 months and can be reared with cut grass or hay with provision of protein rich supplements. The requirement for a 50 kg doe is 1600g dry matter containing 670g TDN and
55 g DCP. As a thumb rule the doe and buck should be given 250 g and 300 g concentrate per day for 2-3 weeks before breeding season in addition to grazing to achieve higher fertility. The advanced pregnant goats and breeding buck during breeding season should be given extra allowance of 55 g DCP, 400 g TDN, 2 g calcium and 1.4 g phosphorus in addition to maintenance requirement. For each kg of milk produced, the goat should be provided 70 g DCP, 350 g TDN, 3.0 g calcium and 2.1 g phosphorus in addition of maintenance need (Balaraman, 2013). The concentrate mixture should contain 2 per cent each of mineral mixture and salt.

**Improving nutritional value of pasture**

Goats spend more than 90% of the time browsing and hardly graze for 10% of time on surface vegetation and grazing of 2-4 goats/ha had no effect on the run off and soil loss in hot arid region of Rajasthan on normal rainy day (Singh et al., 2005). A good pasture like Anjan (*Cenchrus ciliaris*) and Stylo (*Stylosanthes hamata*) may provide sufficient grazing for 6 adult sheep/ha. On the other hand, carrying capacity of a protected grazing land is 2-3 sheep/ha per year as compared to unprotected range lands which can carry one sheep/ha throughout the year (Misra et al., 2007).

Silvi-pastoral or horti-pastoral system for goat production is now-a-days gaining more importance. Silvi-pasure farming is an integration of woody species with pasture grasses and legumes in the same piece of land where as in horti-pastoral system the woody species are horticulture plats. *Acacia tortilis*, *Acacia Arabian* (Babul), *Leucaena leucocephala* as a tree component and *Dichrostachys cinerea* as shrub components mostly used in silvi-pastoral system. Two tier silvi-pastoral system is maintained with ground grass cover and tree species as top layer. Three-tier system is maintained with three layers i.e., tree species at top, shrubs as middle and grasses as ground level. Normally tree seedlings are planted during the monsoon after a good rain followed by planting of pasture grasses and legumes. It has been reported that kids reared under silvi-pastoral system have better growth rate (35-40%) and lactating goats produce more milk i.e. 8% in one tier, 28% two tier and 64% in three tier system (Ramana et al., 2000; Rai and Rai, 2010).

**Reproduction**

Female goat attained puberty at an age of 11-13 months depending upon the body weight (60-70% adult body weight), climate and nutrition. Though libido in males developed from 4-5 months of age, but should be used for breeding at 18-24 months of age. Initially at the age of 18-24 months one buck is sufficient to serve 25-30 does and later at full maturity can serve upto 40 to 50 does. The buck with good health condition should be fit for 7-8 years of age. In goat, estrus cycle length is 17-21 days with 20 days average and duration of estrus is 36-48 hours. The major estrus sign in goat is restless, tail wagging and frequent bleating. The other signs are swelling and slight reddening of genital openings and discharge of mucus. The time of insemination/mating should be towards end of estrus, generally 24th to 36th hr after onset of estrus. Gestation period in goat is about 145-153 days. Natural service is not sufficient to disseminate the superior germ plasm in short duration to a wider population. Hence, artificial insemination with liquid or frozen semen is best method to improve the superior germ plasm especially in intensive system of production to control reproduction in conjugation with accurate progeny testing, to improve the production of milk, meat and hair. Further, AI also reduces the chance of transmission of genital diseases. However, the success of AI program in goat depends upon proper management of semen collection, storage and use. In goat semen may be extended 1:2 to 1:20 using suitable extender. The dose rate should be 120 million for cervical insemination while for laparoscopic
insemination it should be at least 1 million sperm per insemination to achieve better result. Further, one ejaculate can be extended up to at least 20-40 doses if packed in straw (Bujarbaruah and Kumaresan, 2013).

Artificial insemination (AI) has an important role in goat breeding and it depends on scientific management of semen collection, preservation, storage and use. Seminal plasma of goat contains wide variety of components that have detrimental effect on spermatozoa. Goat semen collected into tubes containing extender improves the quality. The active factors in seminal plasma affects preservation of goat semen in different seasons are little understood in tropical conditions and especially in exotic crossbred goats. Goat sperm freezability improves when sperm is frozen in a trehalose-egg yolk extender containing an adequate concentration of sodium dodecyl sulfate (SDS) with better pregnancy and kidding rate. Artificial insemination (AI) with fresh, chilled or frozen thawed semen is a basic tool in goat breeding at institution level, however, commercial use of frozen thawed semen has been relatively limited due to many handicaps in small ruminants especially lower conception rate compared to natural service, general awareness and necessary qualified inseminator are the restrictive factors of frozen semen. Successful transcervical artificial insemination in goat with high conception rate (61%) can be achieved. Semen frozen in winter months with better freezable quality can be used during breeding season i.e. June and July. So there is a need to overcome these problems, popularize, and to develop simple and viable insemination technique that can be trained to existing inseminators in the country and genetic improvement can be done successfully.

Health management

Health management is a major concern under commercial goat farming so that kid and adult mortality should be below 10 and 5%, respectively. However, under field conditions the mortality of kid and adult is as high as 40 and 20%, respectively. Though, small ruminants under intensive and semi-intensive management are well protected from adverse climate, alteration of micro environment and management significantly affects the health status and as well as their welfare. Lack of exercise or over eating under intensive system result fatty animals. In addition, wet and dirty floor increases the hoof lesions and lameness. On the other hand, animals when managed under semi-intensive system are more prone to endo- and ecto-parasitic diseases, which subsequently reduce growth, production and reproduction performance, together with skin lesions (Caroprese et al., 2009; Sevi et al., 2009). Regular deworming or dusting with suitable medicines of animals should be done at 3-4 months interval depending on the prevalence. Mastitis is another health problem in lactating goats which increases susceptibility of suckling young to diseases. Intensively and semi-intensively managed animals are kept under confinement, so there is more chance of disease spread from infected animal to healthy ones. Hence, proper isolation of diseased animals could prevent spread of diseases under commercial goat farming.

Further, regular vaccination against most prevalent disease could also reduce the risk of disease outbreak and detail of vaccination schedule is given in Table 3. Further, farmers should be well aware about the availability of vaccines and other health facilities. Farmers should have simple veterinary kit comprised of antibiotic (100 ml bottle and 100 g powder for wounds), healing oil, fly repellant oil or ointment, needles, surgical blade, iodine (100 ml), syringe (20 ml), cotton, bandage, clinical thermometer, plastic gloves etc.
Table 3: Vaccination schedule for goat

<table>
<thead>
<tr>
<th>Disease</th>
<th>Age</th>
<th>Dose and route</th>
<th>Booster dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and Mouth disease (FMD)</td>
<td>3 - 4 months</td>
<td>1 ml S/c</td>
<td>3-4 weeks after first injection and repeat twice annually (March &amp; September)</td>
</tr>
<tr>
<td>Peste-des-Petitis Ruminant (PPR)</td>
<td>3 - 4 months</td>
<td>1 ml S/c</td>
<td>Every 3 years</td>
</tr>
<tr>
<td>Goat Pox</td>
<td>3 - 4 months</td>
<td>1 ml S/c</td>
<td>3-4 weeks after first injection and repeat annually.</td>
</tr>
<tr>
<td>Haemorrhagic Septicemia (HS)</td>
<td>3 - 4 months</td>
<td>2 ml S/c</td>
<td>3-4 weeks after first injection and repeat annually.</td>
</tr>
<tr>
<td>Enterotoxaemia (ET)</td>
<td>3 - 4 months</td>
<td>2 ml S/c</td>
<td>3-4 weeks after first injection and repeat once/twice in a year.</td>
</tr>
</tbody>
</table>

(Source- Singh and Islam, 2014)

Conclusions

Goat farming for commercial purpose has huge scope and demand in India as purchasing power of majority of people is increasing. Goat milk has beneficial effect to the vulnerable sections of people such as children, old persons and patients. However, lack of availability of good genetic resources, breeding policies, health facilities, feed and fodder resources, marketing problems are major constraint for commercial goat production. Augmentation of grazing land by silvi or horti pastoral system could supply the required nutrients of goats for maintenance, production and reproduction. Supplementation of concentrate during fodder scarcity period will be helpful to achieve better growth and milk yield. Further, scientific housing, feeding, breeding and health management could improve productive and reproductive performances of goats under intensive production system.

References


http://www.nbagr.res.in
Making dairy farming profitable through precision farming

HK Verma and RK Sharma

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana

Dairy farming in India is as old as mankind. The best breeds of buffalo- Murrah and Nili Ravi belong to this area. Still people are doing dairy farming as a subsidiary occupation to agriculture because beside providing quality food and regular income, it provides cushion effect and has risk mitigation potential in case of crop failure.

The colonization of agriculture land due to exploding human population and land division from generation to generation reduces the land holding status amongst the farmers. These farmers are having less than 2.0 acre of cultivable land and are categorized as small and marginal farmers. Now to sustain /earn their livelihood, these farmers are making their subsidiary occupation i.e. dairy farming as their prime occupation as increasing human population and their education level create more demand of quality milk like milk and curd etc. Presently the landless, small and marginal farmers are holing about 70-75 per cent of the total livestock and producing major chunk of milk produced in India.

Moreover the dairy farming has following advantages which make it more lucrative:-

- The demand of milk will always go up, so there is no chance of market dip.
- The family labour can be engaged in the business. Even women alone can run this venture successfully.
- It creates an opportunity for self employment.
- It acts as reserve bank. Farmer can sell or purchase the animal(s) as and when required.
- If scientifically managed, there is no risk of failure.
- There is regular income flow from sale of milk and other subsidiary products. Extra income can be generated from implanting biogas plant, vermin composting, value addition etc.
- Various schemes and subsidies by different departments are there for promoting dairy farming.

But the beginners, small and marginal farmers have some constraints which put rider in their progress like feed and fodder deficit, lack of scientific knowledge on management and health aspects. By making following measures, these farmers can earn more profit in their dairy farming venture. The systematic approach can be like that:

1. **Acquiring technical skills**

   This step is must for each and every farmer as ignorance or less knowledge cannot compete with the scientific knowledge at any level. For profitable dairy farming, the farmer must have knowledge of scientific management of animals including seasonal management, shed construction, measure for animals comfort, balance feed at each and every stage of animal’s health management including vaccination, deworming, disease preventive measures, clean milk production, latest trend and technologies and value addition.

   Some time a very little and unexpected thing is affecting the production performance of the animals, for example water adequacy. There are many incidences where water inadequacy is the main
culprit for fewer yield of the animals. So knowledge is very essential. One can have this knowledge by attending various training programmes organized by Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana or some other National Institutes/Training Centres. One point I must emphasize here is that these trainings must be attended regularly as every time farmers get something new from them beside revision of their earlier knowledge.

2. Keeping high performing animals

Majority of the farmers are holding milch animal having average milk production of 7-15 kg per day. Ruminant animals eat dry matter according to their body weight. Suppose two animals having weight of 600 kg and are producing 10 and 25 kg of milk per day. So, the second animal is more profitable as it will consume the feed near about same as that of first one but will produced more milk. So always keep animal with high genetic potential. Therefore, one should keep buffalo/ indigenous cow with daily milk yield of at least 10 kg and crossbred of 15 kg.

3. Shelter Management

Animals should be kept in such a way that they should feel comfortable. The environment should be stress free. Research showed that mounting activity in cows was reduced by almost half when cows were kept on concrete as opposite to softer floors while the duration of oestrus activity was reduced by 25 per cent. Housing arrangement, concrete floors without adequate bedding and feet and leg problems are other factors associated with lowered detection of heat and reduced fertility in herds. Cows do not have enough space to interact with their herd mates once on heat, making detection more difficult. In many cases, slippery floors in barns without bedding (because of straw shortage) affect reproduction. The excessive use of concentrate feeds in the ration of lactating cows along with the prevalence of concrete floors increase the frequency of cows with sore feet among herds. These cows dislike being mounted on coarse floors. They will exhibit fewer stands resulting in poor heat detection. Consequently, they will have significantly longer calving to service and calving to conception intervals.

4. Environmental Management

Among all environmental stressors, the temperature and the relative humidity are the major factors, which affect the reproductive performance of dairy cows. One aspect of the temperature effects is heat stress, which is caused by high ambient temperature and aggravated by high relative humidity. The temperature-Humidity Index (THI) is a widely used tool to assess the impact of heat stress on dairy cows.

Hyperthermia after breeding compromises uterine environment with decreased blood flow to the uterus and increased uterine temperature, which can lead to implantation failure and embryonic mortality. These effects are thought to be associated with the production of heat-shock proteins by the endometrium during heat stress and reduced interferon-tau production by the conceptus. Moreover, heat stress can affect endometrial prostaglandin secretion causing abnormal luteal activity leading to premature luteolysis and embryo loss.

The management of heat stress and its effects through environmental modification involves reducing heat gain via solar and thermal radiation and high ambient air temperatures. This may be reasonably accomplished with shade and evaporative air cooling. A reduction in DMI (dry matter intake) is the primary reason milk production declines during heat stress periods. At the same time
DMI decreases, maintenance cost of the cow increases in an attempt to maintain body temperature and thus, the overall availability of nutrients and energy for milk production is decreased. The most effective feeding management strategy to minimize production losses during heat stress periods is to provide a cool, comfortable environment by shading, sprinkling and/or forced air flow. The concentration of all nutrients will need to be increased in diets as DMI decreases during heat stress. The ration should be properly balanced, and generally the energy density should be increased in the summer to help compensate for decreased dry matter intake of the cow.

5. Health Management

Many specific reproductive health problems, such as the true anoestrus, ovarian cysts, retained placenta and metritis and other diseases like mastitis, lameness or infectious diseases are quite common in dairy herds. They require a good reproductive health program, which is essential for efficient reproduction, for checking normal uterine involution and return of ovarian cyclicity. Unfortunately, this type of program is lacking in many herds where Veterinarians are usually called on an emergency basis. Anoestrus and repeat breeding were related with deworming, mineral mixture supplementation and concentrate feeding in animals. Majority of organized dairy farmers (90.00%) were having low level of stressors score while majority of unorganized dairy farmers (60.00%) were having medium level of stressors score. Environmental, nutritional, management and total stressors score of organized as well as unorganized farmers was positively correlated to the disease incidence at the dairy farms. Common infectious diseases can be easily managed through timely vaccination and adequate deworming.

6. One calf per year

This is the basic mantra for profitable dairy farming. Management of the farm/animals should be in such a way that animal must get conceived after 2-3 months of calving. To achieve this target the need of animals during pregnancy, transition period, calving and during milking should be taken care off. Balanced nutrition/feeding is the key. Majority of diseases, reproductive problems and less milk production of the animals are related with the faulty nutrition of the animals. So, farmers should always provide his animals the quality green fodder, balanced and ideal concentrate, ad lib water in proper quantity and proper proportion to extract the maximum from animal as per their genetic potential.

Suggestions for enhancing reproductive efficiency

- Efficient heat
- Breeding at the right
- Sound recording
- Comprehensive reproductive health program
- Sound nutritional program
- Adoption of heat stress relief strategies

7. Record Keeping

Record keeping is a very vital step to be taken to analyze the cost benefit ratio of the dairy farming, but a very few small and marginal farmers are doing it. Record keeping of every penny spent on inputs for dairy farming must be done along with income generated from sale of milk, animals, dung and other things related to farm. Similarly, record of pedigreed of animals, animal productive
and reproductive performance, calving, must also be kept. A pedigreed animal and their calves always get better price than non-pedigreed animal.

8. Marketing Facilities “Be a milkman-give pure-get more”

This is what I always suggest to each and every dairy farmer whosoever comes to me. Increasing awareness among masses about quality things and health concerns push the people to buy best things. People are ready to pay extra money for the quality milk. But in our state most of the milk produced by small and marginal farmers are taken away by the middle milkmen who are not the actual milk producers, but the middlemen are getting good deal of money from selling of milk and cream. There are many examples in Ludhiana itself where farmers themselves are selling liquid milk and getting good profit. Some even have hanged the sign board quoting “prove the milk adulteration and get one lakh cash award”. This gives a consumer a sense of satisfaction that he is getting pure milk. Similarly clean and untouched milk are also getting higher price and likewise organic milk and antibiotic, insecticide/pesticide free milk are catching high demand among the consumers.

9. Value addition

Value addition is a most sought after thing in dairy farming to get more profit. A spoon of culture and a little effort can fetch you an extra 15-20 rupees per kg i.e. by curd making. Similarly, paneer, cheese, khoa, skim powder and sweets are some other products one can make from milk.

Value addition of colostrum can also be done by preparing health drinks or by making panjiri from it especially at farm itself where due to synchronization of heat, calving occurs almost parallel.

10. Biogas plants

Every farmer having 5-10 animals must install a biogas plant, though the initial cost is a bit high but government is providing subsidy on its installation. If farmers are having a few animals, 2-3 farmers can collectively do this venture. Once installed, it will solve the problem of cooking gas and electricity.

Many farmers have given the gas connection to other villagers and are getting monthly charges from them. Similarly, electricity can also be produced by running generator on bio-gas, this also saves the expenses on electricity consumption. On the other hand, slurry produced from biogas plant can also be used for making farm-yard manure and vermin compost, whose demand increases day by day in lieu of growing organic farming.

11. Community farming

This is another thing the farmers can do. A group of 2-3 like-minded farmers can pool their resources i.e. animals and do all the management collectively. This helps in reducing the cost of inputs i.e. labour cost, medicine, vaccination, milking and profit is distributed among these farmers as per their share. Many big firms are entering into this arena of community dairy farming and are doing good business.

Likewise, these farmers can do other venture collectively viz.- community silage making, community biogas plant, community vermin-composting, community feed plants and many others.

Silage feeding is a very important aspect in economizing the cost of milk production. Even an individual small farmer can make the silage in bulk when there is glut of green fodder and it is a cheap
source of storing surplus fodder. He can also purchase the green fodder from the market and make
the silage. During the lean periods he can even sell this silage to the other fellow dairy farmers and
can get handsome profit besides feeding the silage to their own animals. Feeding silage during lean
period prevents the dip in milk production in this time. During lean period, milk rate shoots up due
to high demand and low production. So preventing the dip in milk production during lean period,
use of silage will keep the income flow regular.

In conclusion, the beginners and the small farmers can first start the venture through five to
ten animals. During this period, they will get enough experience for the well-being of his animals,
thereby getting profits according to the genetic potential of the animals. First two to three years in
this venture will be the incubation period, thereafter, the followers of the adult animals will also start
producing and then the farm will be run on firm footing.
Farmer Field Schools: History

The Farmer Field School (FFS) approach was first developed in 1989 by the Food and Agriculture Organization of the United Nations (FAO). It was used to train rice farmers in Indonesia on integrated pest management (IPM) programme. This approach proved to be very successful in helping to control rice pests and was quickly expanded to other countries in Asia, Africa, the Middle East and Latin America. In 1995, the FFS program began to broaden its scope beyond IPM to cover other types of agricultural production and incorporate socio-ecological conditions.

Need of Farmer Field School approach

Extension work has traditionally been seen by research and extension institutions as a mechanism to transfer technologies to farmers. This approach, however, has proved inadequate in complex situations where farmers must frequently adjust their activities to changing conditions (crop protection, soil nutrient management, animal health and production). Technology packages, delivered in a 'top-down' approach, were often too complex, expensive or poorly adapted to farmers’ needs. Extension workers realised that farmers were not sufficiently involved in identifying problems, selecting and testing options, and evaluating possible solutions. With declining government support for traditional extension work, it became clear that alternative methods were needed to identify the problems faced by farmers and to disseminate appropriate technologies. The FFS approach, in contrast, strengthens the capacity of farmers and the local communities to analyse their production systems, identify their main constraints and test possible solutions. By adding their own knowledge to existing information, farmers eventually identify and adopt the most suitable practices and technologies to their farming system and needs to become more productive, profitable and responsive to changing conditions.

Concept of Farmers Field schools

An FFS is a capacity building method based on adult education principles using groups of farmers. It is best described as a 'school without walls', where farmers learn through observation and experimentation in their own fields. This allows them to improve their management skills and become knowledge experts on their own farms. The approach empowers farmers using experiential and participatory learning techniques rather than advising farmers what to do. Farmers are encouraged to handle their own on-farm decisions in which they apply previous experiences and test new technologies. An FFS usually comprises a group of 20-30 farmers who meet regularly over a defined period of time, a crop production season for example, to validate (new) production options with the help of a facilitator. Management decisions are made at the end of every meeting on what action to take. After the training period, farmers continue to meet and share information with less facilitator contact. An FFS is a process, not a goal. It aims to increase the capacity of farmers to test new technologies in their own fields and assess results and their relevance to particular circumstances.
Farmers interact with researchers and extension workers on a demand driven basis, only asking for help where they are unable to solve a problem themselves. As an extension methodology, an FFS is a dynamic process that is practiced, controlled and owned by the farmers to help them transform their observations to create a better understanding of their crop-livestock system.

Objectives of Farmers Field Schools

FFS is not about technology but about people development. It brings farmers together for them to assess their problems and seek ways of addressing them.

Specific FFS objectives include:

1. Empowering farmers with knowledge and skills to make experts in their own fields.
2. Sharpening the farmers’ ability to make critical and informed decisions so that they can make their farming profitable and sustainable.
3. Sensitizing farmers to new ways of thinking and problem solving
4. helping farmers learn how to organize themselves and their communities
5. Enhancing the relationships between farmers, extensionists and researchers, so they work together to test, assess and adapt a variety of options within the specific local conditions.

Principles of farmers field school

There are ten principles of framers field schools

1. Learning by doing - Adults do not change their behavior and practices just because someone tells them what to do or how to change. They learn better through experience than from passive listening at lectures or demonstrations.
2. Farmer-led learning activities - Farmers, not the facilitator, decide what is relevant to them and what they want the FFS to address. This ensures that the information is relevant and tailored to their actual needs. The facilitator simply guides the farmers through their learning process by creating participatory exercises to provide farmers with new experiences.
3. Learning from mistakes - Behavioral change requires time and patience. Learning is an evolutionary process characterized by free and open communication, confrontation, acceptance, respect and the right to make mistakes. This last point is key as more is often learned from mistakes than from successes. Each person's experience of reality is unique.
4. Learn how to learn - Farmers are learning the necessary skills to improve their ability to observe and analyse their own problems and make conscious decisions. They also learn how they can educate and develop themselves further.
5. Problem-posing/problem-solving - Problems are presented as challenges, not constraints. Farmer groups learn different analytical methods to help them gain the ability to identify and solve any problem they may encounter in the field.
6. The farmer’s field is the learning ground - The field (crop production system) is the main learning tool. All activities are organized around it. In case of a livestock FFS, both the animals and the field are main learning tools. Farmers learn directly from what they observe, collect and experience in their fields instead of text books, pictures or other extension materials.
7. **Extension Workers are facilitators, not teachers** - Extension workers are called facilitators because their role is to guide the learning process and not to teach. The facilitator contributes to the discussions and aims to reach consensus on what actions need to be taken.

8. **Unity is strength** - Empowerment through collective action is essential. Farmers united in a group have more power than individuals. Also, when recognized as an active member within a group, the social role of individuals within a community is enhanced.

9. **Every FFS is unique** - Learning topics within the FFS should be chosen by the community. Training activities must be based on existing gaps in the community’s knowledge and skills and should also take into consideration its level of understanding.

10. **Systematic training process** - all FFS follow the same systematic training process. The key steps are observation, group discussion, analysis, decision making and action planning. Past FFS experience has shown that the best results are achieved with weekly meetings. Longer gaps can slow down the learning process. The length of the FFS cycle depends on the focal activity. With livestock, a full year cycle is usually needed to allow for all seasonal variations to be studied. Crop- or poultry-based FFS usually base their length on the cycle of production; from land preparation to harvesting or egg to egg respectively. FFS increasingly include marketing and processing activities which may lengthen the FFS learning cycle.

**Farmers Farm School at National Dairy Research Institute**

With this background of Farmers field school (FFS), NDRI has started Farmers farm School on August 30th, 2014, having the aim of enhancing the productivity of agricultural practices. With following specific objectives.

1. To educate the farmers on latest know-how of agricultural innovations,
2. To empower the farmers through capacity building,
3. To sustain farm family through Agricultural interventions
4. To strengthen the linkages of researcher and end users.

![Diagram of Farmers Farm School](image)
Farmer Farm School was started with farmers in Gorgarh village of Karnal district which is 21km away from NDRI. Mainly Farmer Farm School covered needy based content of a village. However, it should include based on production constraints and yield gaps of a selected village. During classes Extension professionals serve as a facilitator for the farmers to solve the most pressed problems of the village which is related to animal husbandry, dairy farming, crop farming (food grains crops), horticulture (vegetables and fruits), climate change and community development. Before going to start FFS we have collected basic data of a village (demographic and dairy farming and its allied activities) has to be taken in advance for effective conduction of a program. And also framework of FFS was discussed with village Sarpanch and groups of progressive farmers. Mainly FFS was organized on Integrated farming system (IFS) theme to achieve the better result and to get comprehensive knowledge for the farmers. Before starting the program we have listed problems which are related to agricultural practices and animal husbandry, according to that we have covered each Friday and Saturday of a week throughout a year. However, classes were conducted every Friday and Saturday of a week of a selected village for a period of one year, each FFS batch is organized with 20-30 farmers. During FFS classes every month of first Saturday animal health camp were organized and third Saturday of each month visit to different research and development institutes were organized and also quiz were conducted every month of last working class to assess the monthly progress of the farmers. At the end of the FFS each farmers were assessed, undergone examination and issued certificates.
Mobile based Text & Voice Messaging services for Livestock Keepers

H R Meena, G.S. Sankhala and B.S. Meena
ICAR-National Dairy Research Institute, Karnal

The successful uptake of mobile phone throughout the developing world has significantly impacted the economic development initiatives. Governments, private corporations and non-profit organizations are all examining the possibilities for using this new means of communicating with citizens. As per TRAI data of May, 2014, though there are about 38 crore mobile telephone connections in rural areas, internet penetration in the countryside is still abysmally low (in single digit percentage). Therefore, mobile messaging is the most effective tool so far having pervasive outreach to nearly 8.93 crore farm families. Considering that not more than 30% of rural India is mobile-enabled and few have access to the Internet, the trend clearly is that our rural mobile users are comfortable with voice, text, sound, pictures and videos. The targetable mobile phone users also have phones without Internet connectivity which increasingly used in rural areas of Africa and Asia to disseminate daily prices of agricultural commodities. By allowing communication at distance, mobile phones allow users to overcome limits of time and space. The first SMS (Short Message Service) was sent on 3 December 1992 (The Times of India, 2002). SMS is widely used to spread information from individual to individual. However, especially in the developing world, organizations and governments are increasingly using SMS to reach rural populations that could not previously be contacted. To bridge the information gap between the farmers and to build productive and competitive market, different ICT interventions support rural and under-developed markets to become efficient and productive.

Why Mobile based services?

The mobile based projects for farmers have objectives which benefit farmers, based on development agenda. These objectives have orientation for market (input, output) prices, availability status, agricultural extension, social connectivity and finally financial support systems. The projects become a source of knowledge and information transfer for farmers from agriculture scientists/extension functionaries and markets through mobiles. A working paper by Mittal et al. (2010) found that the quality of information, its timeliness, and trustworthiness are the three important features that can enable farmers to use mobile-enabled agricultural information effectively. The Indian study found that while mobiles are currently being used in ways that contribute to farm productivity, are not being used to their full potential. Swapan Kumar Dutta, Deputy Director General (crop science) of Indian Council of Agricultural Research, says this service can create alertness about crops that require less water if they get a wind of the monsoon pattern in advance. “It’s easier for them to play a larger role as they are in direct touch with rural subscribers. Service providers also need to collaborate more with agriculture scientists.

KVK has pioneered for the first time IT enabled Mobile SMS Broadcast Service aiding instant messaging from KVK to individual farmers for extending Agricultural information through SMS alerts. The service comprises sending SMS alerts on cellular phones registered at KVK by individual farmers. Weekly SMS alerts are issued on various agricultural developments like weather forecast, disease forecast and market information.
Kisaan SMS Portal:

During celebrations 85th ICAR Foundation Day, Hon’ble President of India launched a SMS Portal for farmers created by Department of Agriculture & Cooperation, Government of India on 16.07.2013. The State Governments and their field formations down to the block level (including State Agriculture Universities and KVKs) also have come forward in a big way to use this integrated Portal. Considering availability of more than 33 crore mobile connections in the rural area, Kisaan SMS Portal is likely to be very useful to farmers and all other stakeholders as timely and relevant information will be provided to farmers in their own language. Search facility (by text and by topic) for going through previous advisories has also been created to avoid duplication and contradiction in advisories. Common Service Centres set up by the Department of Electronics and Information Technology and Kisaan Call Centres are also being integrated to improve access to such web based information. SMSs to be sent to the farmers can be broadly classified into three categories, viz. information, services and advisories. The content may include information about the schemes advisories from the experts, market have been grouped based on the state, district, block and the crops/activities selected by a farmer. The system is capable of sending messages in regional languages also. The farmers can register to this service by calling Kisaan Call Center on the toll free number 1800-180-1551 or through the web portal. Farmer can give upto 8 choices for his preferred crops/activities. Animal Husbandry, Fisheries & Dairying in addition to Agriculture & Horticulture. The language choice of the farmer is also being taken based on which the language of the SMS is decided. If the mobile of the farmer does not support the regional language, option is given to receive the SMS in regional language written in Roman Script. Provision for sending Voice messages will also be started in due course for the farmers who are not familiar with SMS. Existing farmer databases of farmers available to Central as well as State Governments are being integrated with the Portal which has also been linked with the Kisaan Call Centre.

ICAR-NDRI launches mobile phone text and voice messaging for dairy farming:

A new program is trying to reach farmers in India with information on dairy animal breeding, feeding, health care, management, fodder crops cultivation, marketing and technical know-how through their mobile phones. “NDRI Messaging Portal” was launched by the Hon’ble Dr. R. S. Paroda, former DG, ICAR & secretary DARE on 14 October 2014. Presently, NDRI Disseminating advisory services on Dairy farming to 1200 farmers from six states namely, Haryana, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand and Gujrat. Presently, Indian Dairy farmers are facing many problems related to livestock diseases, reproductive disorders, feed & fodder scarcity, inadequate livestock service provider, lack of hand skill and support services, weak linkages with milk processing units, milk supply chain, transportation for animal produce and manpower. Further these constraints along with the uncertainties of weather lead to the reduction in the production. The project aims to help farmers for timely and accurate information about various animal husbandry aspects like livestock feeding, breeding, health care, management and dairy processing along with personalized advice specific to the farm based on dynamic weather parameters can be helpful for sustainable livestock production. Advisory services related to animal husbandry and dairying can now be provided to the farmers through the ubiquitous mobile phones.
Are mobile phones helping farmers?

There have been experiments in technology dissemination using ICT but the mobile applications recently started can revolutionize the information reach to the resource poor small farmers on real time basis. The content development for different clientele groups in different languages is a challenge but voice messages give an easy option for delivery and its understanding by users in case of most of the handsets. Text messages in different languages may be a limitation on some of the handsets. The cost of voice messages is higher which may be brought down with technology development. CIMMYT's agricultural economist Surabhi Mittal and IRRI's economist Mamta Mehar argue that institutional and infrastructural constraints do not allow farmers to take full advantage of this technology.

In India, agro-advisory service providers use text and voice messaging along with various mobile phone based applications to provide information about weather, market prices, policies, government schemes, and new technologies. Some service providers, such as IKSL, have reached more than 1.3 million farmers across 18 states of India. But what is the real impact of such services? Are messages available at the right time? Do they create awareness? Do they strengthen farmers’ capability to make informed decisions? Are they relevant to his or her farming context? Mittal and Mehar say there is still a long way to go. While farmers get information through their mobile phones, it is often general information irrespective of their location and crops, which is information they cannot effectively utilize. In 2011, CIMMYT conducted a survey with 1,200 farmers in Indo-Gangetic Plains and revealed that farmers’ needed information on how to address pest attacks and what varieties better adapt to changing climatic conditions. Instead, they received standard prescriptions on input use and general seed varietal recommendations. Sustainability is another problem since such agro-advisory
projects require continued financial assistance; when money runs out, the project ends and the people are again left without information, feeling cheated and without trust for any similar project that may come in the future. The main beneficiaries of the mobile phone revolution are the ones with skills and infrastructure, and the poor are thus left even further behind.

**What can be done?**

Agro-advisory providers need to develop specific, appropriate, and timely content and update it as often as necessary. Creation of help lines to provide customized solutions and enable feedback from farmers. The information delivery must be led by demand, not driven by supply. However, even when all that is done, it must be remembered that merely receiving messages over the phone does not motivate farmers to start using this information. The services have to be supplemented with demonstration of new technologies on farmers’ fields and through field trials. The development of appropriate software, content development and its authentication and farmer friendliness, reducing cost of message delivery and involvement of different players may bring an environment of efficient use of mobile services. Video calling facility may further enhance the quality of communication. When using SMS, agricultural information service providers should keep in mind to keep messages simple and to the point. It may be helpful to initially call or visit the farmer to introduce and explain any advice given via SMS, how their number was received and what future SMS content will be about. Information on schemes and programs of Government of India can help every farmer to reap benefits thus, widening the footprint of these schemes. Weather forecast can help the farmer in planning farm operation effectively. On the onset of any adverse weather condition, advice can be provided to the farmers on effective recourse to be adopted. Crop advisory will lead to the adoption of more appropriate technologies suited to local situations. Selection of suitable and better variety/breed by the farmer based on the information/advisory can be provided to him/her and also timely market information will give better bargaining power to the farmer.

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Burning issues in animal husbandry sector of India

K. Ponnusamy, Khajan Singh and N. Balasubramani*

National Dairy Research Institute, Karnal-132 001
*National Institute of Agricultural Extension Management, Hyderabad - 500 030

Introduction

Animal husbandry enterprises provide significant livelihood opportunities to rural families especially smallholders and landless who constitute over 75% of India’s livestock resources. Hence, whatever growth in livestock sector would bring prosperity to the resource with whom the livestock wealth is concentrated. According to National Accounts Statistics (2013), contribution of agriculture and livestock to GDP was 15.18 percent and 3.92 percent respectively during 2011-12. Over the year livestock’s contribution to Indian GDP is increasing.

Most of the resource poor farmers maintain different species of livestock to supplement their income. The landless usually prefer to own sheep, goat and poultry as compared to the land owners who prefer cattle and buffaloes. About 70 million rural households are engaged in the milk production, with high proportion being landless, marginal and small farmers. Among various species of livestock, cattle and buffaloes are the major contributors from this sector to the National GDP.

There is an increasing exodus of the landless households out of livestock production mainly due to reduced access to grazing resources, lack of access to non-exploitable market and credit and other services. Over the period of time, grain production and livestock production have become increasingly specialised and separated from each other. As a result of this, complimentary / supplementary role of livestock enterprise has undergone drastic change to become a competitor for grain which could otherwise be consumed by humans.

There are some limitations and challenges among poor farmers such as inadequate feed and clean and quality water resources, low productivity and limited availability of health services and poor management practices. The mainstream research and extension hardly reach these small farmers. It is being increasingly realised that technological options are not alone sufficient in bringing about sustainable change in the livelihoods of small livestock holders. Building social institutions and networks become important.

Breeding services

Delivery of animal husbandry and veterinary services for farmers are entrusted with the State Governments. The services provided by the Animal Husbandry Department to the farmers are breeding cattle and buffaloes through AI, prophylactic vaccination, treatment of sick animals and extension services to promote new schemes and technologies. However, in the absence of greater mobility in interior rural areas, most of the services were confined to the periphery of the veterinary clinics established at the block or taluk level. With the shortage of qualified veterinary graduates, most of these technical services were gradually assigned to semi-skilled livestock supervisors. In the absence of efficient services, farmers in interior areas could not take advantage of the programmes, which otherwise could have helped to improve the productivity of livestock.
The state departments of animal husbandry are providing AI services through its network of 51348 AI centres in the country. There are 54 semen production centres and 202 frozen semen banks in the country. There is increased awareness among farmers about AI. However, the demand for AI service is limited, especially among the farmers keeping non-descript animals. The AI services are mainly supply driven. It depends on availability of semen stalk in the veterinary centre. However, the demand for door step AI services is increasing among farmers keeping crossbred animals while buffaloes do not get much attention. These farmers mostly prefer services by veterinary doctors, while gopalmitras (field level trained lay inseminators) are less preferred. Overall access to breeding services is limited and wherever it is provided it is mostly by the department’s field staff or through government trained AI workers. A higher outreach of AI services was observed in villages where there are functional milk cooperatives.

Modern production systems depend heavily on a few strains thus neglecting the local breeds whose genetic potential can be improved with better quality feed and selective breeding. Financial institutions do not provide incentives and loans for indigenous stocks. Rearing of local breeds is hassle free, add-on and part time activity especially for women, requiring low investment and giving higher returns. Local breeds are hardy and have high prolificacy.

Some concerns and constraints as documented by studies are:

- Farmers are not satisfied with the quality of AI service provided by both, the government and private service providers. Some farmers do not make use of the service as it is very expensive (Rs. 200-400 per service).

- In cooperatives where crossbreeding has been adopted, indiscriminate breeding is observed leading to animals with too high exotic blood levels, making them susceptible to diseases.

- Linked to the indiscriminate upgrading of animals is the non-availability of crossbred semen at field institutions. As farmers are reluctant to “backcross” their crossbred animals, indiscriminate upgrading is the result.

- High incidence of repeat breeding in crossbred animals is observed due to the increased exotic blood level.

- Some of state semen stations are graded as C due to non-adherence to phyto-sanitary standards.

- Non-adherence to the breeding policy leads to animals with high exotic blood levels. Lack of monitoring of AI services results in high incidence of repeat breeding and increased exotic blood levels.

**Animal feeding**

Mostly farmers use feed ingredients which are readily available at their vicinity. The awareness among farmers about balanced nutrition feeding practices is low. Lactating animals are given concentrate feed, whereas dry animals do not get any feed at all. Feed manufacturers prefer to produce poultry feed which has a continuous demand in higher quantities. However, there is low focus on cattle feeds due to the low demand.
Some identified constraints are:

- Farmers lack the knowledge on the balanced feeding of animals. At the same time, they feel the cost of cattle feed is (too) high.
- Scope for producing cattle feed is limited as key ingredients like maize and cakes are generally not available in all the places. Similarly outsourcing ingredients is expensive. Hence, there are no real incentives to produce cattle feed.
- Wrong use of feed leads to unviable milk production costs.
- Low awareness level among the farmers about feeding of mineral mixtures which some time leads to repeat breeding.

**Fodder**

Availability of fodder is crucial for promotion of animal husbandry in the country. A rough estimate indicates that only 880 million tons of dry fodder is available including greens, which can meet only 35-40% of the demand. This clearly depicts that most of the livestock are being underfed. With respect to dry matter availability, over 55% fodder is available in the form of agricultural by-products and about 15 to 20% dry matter is collected in the form of dried grass from community wastelands and forests which are of inferior quality. Similarly, the concentrates required for feeding the livestock are also in acute shortage. As a result, even the high yielding animals, which are presumably well-fed, are suffering from nutritional imbalance. Presently hardly 3-4% of the cultivable area is under forage crops cultivation, in selected pockets where dairy husbandry is prospering as an important source of income. Further expansion of the area is possible only when the quality of livestock owned by farmers is improved significantly.

Constraints concerning fodder production are:

- Gradual reduction in availability of grazing lands due to their conversion for both agriculture and non-agriculture purpose.
- Small farmers owning land are not prepared to cultivate fodder, but want to use the land for food crops to improve their food security.
- Fodder demonstrations by the state departments are still low priority where the marketable surplus (at present) is still negligible. Dry fodder is mainly rice and wheat straw. Some farmers purchase straw during deficit period. Rising feed prices has been the concern with peri urban dairy farmers; leading to rise in price of milk.
- Lack of knowledge among the farmers regarding the preservation of green fodder in the form of hay and silage. This preserved green fodder can be supplied to the animals during the lean season.
- Animals suffer from mineral deficiency due to feeding of low quality cereal straw and local grasses which are low in minerals. Moreover, smallholders lack sufficient land for cultivation of fodder. Mostly farmers would not like to dispose of unproductive animals due to local sentiments, though keeping unproductive animals till their death results in an increase of the overall demand for fodder.
Animal health

There is a high demand for livestock services from farmers rearing crossbred animals who also demand doorstep service delivery. Villages closer to Veterinary health centres/ veterinary dispensaries have relatively better access to preventive health care services like vaccination and de-worming, as these dispensaries are organising regular veterinary camps in those villages only. Delivery of services is expensive for those farmers who experience difficulty in accessing livestock services even if services come from the Government. FMD is rampant in many states, as incidences are observed even after vaccination; which could be due to poor cold chain management for vaccine, low level of skills in administering the vaccination and emergence of new FMD strains. Other severe diseases are haemorrhagic septicaemia (HS) and black quarter (BQ). Mastitis is reported in crossbred cows. It is heartening to note that most of the farmers rearing cross bred cows are aware of preventive and curative aspect of diseases.

Some constraints experienced are:

- Vaccine is not reaching the site of vaccination in good quality due to ineffective cold chain management. Most of the institutions do not have refrigerators to store vaccine. Even if they are available, they mostly are not in good working condition. Hence, access to quality vaccination services is very limited.

- Due to a poor disease reporting system from the field, the true picture of disease incidence in the state cannot be developed and timely preventive actions are not taken. The slow reporting results in increased expenses on treatment for farmers.

- Livestock treatment is mostly symptomatic due to the lack of diagnostic facilities at field level.

Climate change

Although, climate change is a global issue, but it concerns every country and every sector. As a result of the changing climate, India's livestock sector expects that water and fodder will become critical factors in the future. Further, rising temperature may affect the reproductive and productive performance of the dairy animals, especially of crossbreds with high levels of exotic blood. Changing climatic conditions will severely affect the livelihoods which are based on natural resources. Livestock is blamed for releasing large quantities of methane emissions (49%-188 million tonnes of Co2-eq). Goats have aggressive grazing habit which damages natural vegetation resulting in adverse impact on climate.

Credit and insurance

In some places, banks and credit institutes show reluctance to provide loans to dairy farmers. On the other hand, there have been incidences of low repayment rates for loans especially in the dairy sector. Past experience of finance institutions on dairy cattle loaning was very discouraging since more than 90% of farmers who availed loans did not repay them. Farmers generally do not repay loan, with the hope that someday loan will be waived by the Government. The situation will not improve in near future, unless credit for dairy animals can be linked with a functional livestock insurance system.

Low demand for livestock credits from farmers having non-descript cows was observed. Neither are banks interested to provide non-subsidy linked credit, nor are farmers willing to avail credit at
a commercial rate of interest. However there is a reasonable demand for purchasing dairy animals. Farmer credit schemes like kisan credit cards are available to few farmers mainly used for crop cultivation. Both bankers and farmers prefer Government subsidy linked credit to buy dairy animals. The non-availability of interest subsidy is another hindering factor. On the other hand, the high unit cost (price) of milch animals makes banks reluctant to extend credit.

Government and NGOs promote credit linked support programmes for dairy farming. The outreach of such initiatives involving rural youth and women however is limited. Considering the market demand in villages and small urban centres, it may be worthwhile to further promote dairy enterprises involving these two vital stakeholders, but with a substantially higher outreach, though it may be ambitious to think of developing organized dairy processing facilities, when there is low marketable surplus at villages and cluster level.

Knowledge

Farmers would like to manage the livestock asset to the best of their abilities which require knowledge and skills on good livestock practices. Farmers are keen to avail skill training and extension services. Training and extension enjoyed good attention over the past years, although the impact from it is difficult to assess. Farmers seek training in the fields of animal health management, feeding, breeding, economics of dairy farming and dairy processing. Farmers in general are not willing to pay for training services. The emergence of private service providers in the livestock production sectors has given a new face to extension. While the specialised “extensionist” has disappeared, various public, cooperative and private service providers like veterinarians, para-veterinarians, AI workers, feed companies, dairy cooperative managers, milk vendors, etc. have taken over extension tasks and roles. The institutions of the Indian government, including veterinary colleges and agricultural universities, which provided training and extension in the past continue to be there, but many of them have yet to find their new role, either as coordinator and facilitator of special training or as a provider of specific technical expertise.

Some constraints and gaps identified are:

- Farmers having ND animals express limited demand for dairy training compared to farmers having high yielding animals.
- The state AH departments have a very low coverage when it comes to capacity building at field level training.
- At present different Government departments and organisations are working in the livestock sector namely Animal Husbandry Departments, Dairy Development Departments, Livestock Development Corporation and NDDB; however, coordinated efforts related to dairy development among these stakeholders are relatively weak.

Smallholder’s value chains

If efforts are put in right direction, India can easily become an important exporter of milk and milk products. Producer prices of milk are lower in India than western countries. Prospects for export of milk to neighbouring, particularly SAARC, countries, most of which are deficient in meeting their requirements with domestic production, are very promising. Achieving higher growth of the dairy sector is essential to ensure long-term inclusive agricultural growth. Productivity-led growth is the only viable option for accelerated sustainable growth of the Indian dairy sector.
The status of supporting infrastructures and their delivery is still inadequate and concerted efforts are required to bring desired improvement. The strengthening of market linkages, either through expansion of cooperatives or by facilitating contract farming arrangements, would go a long way to ensuring sustainable growth of the Indian dairy sector. Seven distinct value chain paths are observed in general across the states.

**Problems in taking up improved livestock farming**

The study undertaken by Gunaseelan (2014) in the peri-urban area of the Thanjavur district of Tamil Nadu with 120 farmers revealed that half of them sold fresh milk to the consumers followed by milk vendors and cooperative society. Education, farming income, economic motivation and milk production had positively and significantly contributed towards the variability in the adoption level of improved dairy farming technologies. Lack of grazing fields, high incident of diseases in the crossbred animals and lack of green fodder cover the most serious constraints encountered by majority of peri-urban farmer respondents.

Piggery enterprise is one of the most valued livestock enterprises in North Eastern Region of India where consumption of pork is seen in many spheres of life viz., public functions, social gathering, religious ceremonies etc. Pegu (2014) took up a study entitled “Piggery Entrepreneurship in Dhemaji District of Assam” in the Dhemaji and Bordoloni blocks of Dhemaji District with 50 farmers and 50 dealers. In Dhemaji District, piggery enterprises are an integral part of almost every household. In the recent years due to growing awareness and realization about the importance of quality meat in human nutrition, the piggery sector has become the main point of attention in the district. with input supplies becoming more easily available, combined with the fact that return on investment is quick and remunerative, piggery farming is gaining popularity in the district as a means of earning their livelihood. Further, in spite of pig and pork gaining popularity day by day, the actual farmers are not getting the remunerative price against their produce. Need of an organised market might have been in urgency today. The major constraints in taking up piggery entrepreneurship are given below:

<table>
<thead>
<tr>
<th>Constraints</th>
<th>R.B.Q value of key informants</th>
<th>R.B.Q value of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lack of Quality Breeding Stock</td>
<td>98</td>
<td>99.6</td>
</tr>
<tr>
<td>2. Lack of Training</td>
<td>44</td>
<td>88</td>
</tr>
<tr>
<td>3. Lack of Time To Reform</td>
<td>88</td>
<td>87.6</td>
</tr>
<tr>
<td>4. Lack of Proper Marketing Channel</td>
<td>46</td>
<td>67.8</td>
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<tr>
<td>5. Outbreak of Disease</td>
<td>86</td>
<td>68</td>
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<tr>
<td>6. Seasonal Fluctuation</td>
<td>84</td>
<td>57.2</td>
</tr>
<tr>
<td>7. Lack of Proper Veterinary Support</td>
<td>66</td>
<td>56</td>
</tr>
<tr>
<td>8. Lack of Easy Access To Extension Services</td>
<td>24</td>
<td>46.4</td>
</tr>
<tr>
<td>9. Scarcity of Space In Market Place</td>
<td>14</td>
<td>44</td>
</tr>
<tr>
<td>10. Lack of Linkages With Financial Institute</td>
<td>96</td>
<td>98.6</td>
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</table>

**Effectiveness of organisational communication**

The study conducted by Prasad (2014) with 200 employees of Department of Animal Husbandry and Dairying in Haryana about prevailing organisational communication indicated the highest amount of role ambiguity among veterinary livestock development assistants (VLDA) followed by VS and highest role efficacy among SDOs and DDs. The study suggested to organise computer training,
refreshers courses and periodical workshops in order to enhance the organisational communication effectiveness.

**Burning issues highlighted by various stakeholders**

1. Fixing milk MSP (Minimum Support Price) as per quality standards.
2. Treating dairy farming as part of agriculture for all purpose. For example, farmers should be allowed to start any farm enterprise in his farm without permission from government.
3. Availability of sex semen, sex embryo and high pedigree semen at district level
4. Quality control and disease free semen should be available at private semen bank
5. Availability of area specific mineral mixture as per recommendation of Scientists
6. Requirement of similar scheme for high yielding cows on the lines of Integrated Murrah Development scheme”.
7. Engaging only well equipped professional team to organise FMD vaccination programme.
8. Silage combine should be made available at ICDP centre on custom hiring basis for farmers.
9. Promotion of Pasture land at Panchayat level in villages
10. Organizing dairy Mela/Farmers fares/Cattle shows on permanently fixed dates in Haryana on similar pattern of Punjab and NDRI.
11. Establishment of feed testing laboratory/ Toxicology laboratory
12. Creating awareness to maintain Milk production round the year on dairy farm
13. Stress Management strategies in dairy animals
14. Prevention and control of Brucellosis in dairy animals
15. Repeat breeding/Infertility management
16. Tips for “Quality milk production”
17. Estimation of cost of milk production of individual farm
18. Starting dairy based value addition units on cluster basis.
19. Consulting farmers before framing of policies,
20. Technologies for by-products utilization
21. Lack of sufficient veterinary personnel
22. Bio-gas harnessing strategy
23. Creating animal zones
24. Poor quality semen
25. Cost cheap milk testing kit
26. Delay/Non-settlement of insurance claim in time
27. Requirement of a single vaccine for treating FMD, BQ and HS.
28. Making mini processing scheme of Govt. of Haryana suitable for small scale farmers
29. Need for subsidy for fodder cutting machine of high technology
30. Need for promoting a scheme on Gobar gas
31. Establishment of model dairy farm in different corners of state
32. Cheating by providing a semen of different breeds
33. Handling of more milk production in winter season
34. Need for change in attitude of veterinary doctors in attending emergency cases
35. Solutions for snake bite in dairy animals.

**Promoting the profitable livestock farming**

Low productivity continues to be key concern relating to dairy in India, which could be addressed by:

- Producers’ organization at village/cluster level should be started in order to create milk surplus pockets on the line of New Generation Cooperatives
- There should be more organized efforts related to the processing and marketing of milk and milk products
- Village level service providers should be facilitated for rendering immediate services to farmers
- Special programmes for farmers rearing ND cows should be thought of
- There should be more emphasis on technology assessment and refinement through farmer participatory mode to internalise the adoption process at micro-farming system level
- Streamlining clean milk production efforts involving youth and women farmers.
- Popularisation of good management practices which would generate surplus for marketing and better livelihoods for farm families.
- Further strengthening the institutional set up related to breeding program including partnership with private agencies and door step delivery of AI services;
- Emphasizing on both research and extension related to production and use of feed and fodder;
- Regulating and institutionalizing veterinary health services provided by individuals;
- Supporting educated youth belonging poor families to take up dairy as an enterprise activity;
- Encouraging both cooperative and private sector to focus on rain fed areas.
- Besides the above initiatives, there is a need to focus on clean milk production at farmer level and also support the informal milk sector.

**Conclusion**

In India, there is an increasing trend in demand for milk, characterized by increasing consumption of milk and rising population. Increase in consumption is attributed to higher purchasing power with consumers. But livestock will continue to remain as a livelihood option for the majority of poor in India. Dairying helps to alleviate poverty, smoothens income distribution and in the process assures a balanced development of the rural economy (Arora et al., 2006). Livestock are not merely production instruments. It is vital to see them in the context of livelihoods of the poor and their vulnerability. Hence, there is a need to have a holistic view and a collaborative effort and people-centric processes.
to have a pro-poor, pro-environment development which will produce an inclusive and sustainable growth.

References


Hon'ble Prime Minister of India Sh. Narendra Modi Presenting “Sardar Patel Outstanding ICAR Institution Award” to NDRI, Karnal