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Recent Advances in Dairy Farming, Processing and Marketing strategies

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Editors

Dr. Shahaji Phand
Dr. Sushrirekha Das
Dr. K. Sai Maheshwari

National Institute of Agricultural Extension Management (MANAGE)
(An Autonomous Organization of Ministry of Agriculture & Farmers Welfare, Govt. of India)
Rajendranagar, Hyderabad-500030, Telangana, India
www.manage.gov.in

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

Agriculture extension plays a key role in facilitating the agriculture development in any country and computers and related technologies are becoming a part and parcel of agricultural processes across the globe. Owing to the importance of advances in dairy farming, processing and marketing. India's economy is still heavily influenced by globalisation, and the dairy products produced there reflect customer preferences and wants from all over the world. These requirements include concerns with production methods like animal welfare and environmental impact, as well as product quality characteristics like traceability and product safety. To sustain their competitiveness and access to international markets, dairy farmers urgently require answers. To do this, we must innovate, and it is crucial that the sector maintain a coherent strategy and adapt to the changing nature of the individuals involved.

This book covers an array of subjects, Recent Advances in Dairy Farming, Processing, and Marketing Strategy. I would like to extend my appreciation to Centre for Extension in Agri-allied Sector (EAAS) team, MANAGE, Hyderabad for the tremendous effort in compiling this book. I also thank the authors, editors, and designers who have contributed to this ebook creation.

Dr. P. Chandra Shekara
(Director General, MANAGE)

PREFACE

The dairy business plays a significant role in the economies of many nations. Two nations having a large presence in the global dairy business are India and New Zealand. In this article, the marketing approaches used by the dairy industries in India and New Zealand will be compared and contrasted. First, a summary of the dairy industries in both nations will be given, together with information on their capacities for export. India is the largest milk producer country in the world since 1999-2000 and have shown the pathways for dairy sector development in the form of White Revolution. In the process of achieving this success, India has evolved various innovative approaches for dairy sector development, which will be an experiential learning the developing world. The participants will expose to various dairy sector development models in India like, Dairy Cooperatives, Farmers Producers Organizations and Private Player participation and investment. The International participants will expose to recent advances in dairy farming, processing companies, marketing strategies. It will help to develop better linkages in both domestic and international market.

We are really grateful to Indian Technical and Economic Cooperation (ITEC) program- an initiative of Ministry of External Affairs, Government of India for sponsoring and MANAGE, Hyderabad, for organising and publishing the book on **"Recent Advances in Dairy Farming, Processing, and Marketing Strategy"**. We also thank the resource people who provided timely and insightful contributions to this publication. We are confident that the extensive content of this book will be extremely beneficial to national and international extension workers as well as field employees from the line departments.

Editors

Shahaji Phand
Sushrirekha Das
K. Sai Maheshwari

CONTENTS

Chapter-1

AN EXPLORATORY EVALUATION ON ORGANIC DAIRY FARMING WITH STRATEGIES AND TECHNOLOGIES

S. Bindu Madhuri[1] and Raja Krishna Murthy Morla*[2]

[1]Professor, Dept. of LPM, College of Veterinary Science, Rajendranagar, Hyderabad-500 030, Telangana, India
[2]Vice President – Strategy, Monitoring & Evaluation Portfolio, Core Carbon X Solutions Pvt. Ltd., Hyderabad, Telangana, India
*Corresponding Author: rajamorlakm@gmail.com

Introduction

The organic dairy farming has grown rapidly in recent years. Customers are influenced by the belief that animals are given the best welfare standards and access to pasture when buying organic livestock products. The organic cattle industry is paying increasingly greater attention to ensuring that animals have the highest well-being possible, which is accomplished through offering improved housing conditions and preventing diseases through veterinarian prevention. The fundamental objective of these manufacturing standards, which have been developed quickly as a result of this trend, is to produce high-quality products with a focus on animal welfare. The welfare of farmer households, the availability of high-quality education for their children, the reduction of agrarian distress, and the achievement of income parity between farmers and those in non-agricultural professions all depend on increasing their income. Given the negative effects of low and unstable farm income, an important rise in farmer income is necessary for Indian farmers. Governments have implemented a number of strategies to solve these problems. The initiative to double farmer income (DFI) is one noteworthy tactic that has drawn attention. The advantages of organic dairy farming are now well-known for farmers. They are also aware that the limitations imposed by this type of farming, such as the ban on any synthetic substance, will eventually enable them to stop incurring additional costs and reduce environmental damage. Items like milk, honey, meat, eggs, etc., obtained from livestock raised on an organic field, fed naturally organic feed, and subjected to routine inspections would enable the items to earn an organic tag in the market, resulting in buyer confidence.

Thus, organic dairy farming differentiates itself by maintaining and enhancing diversity. Many specialized dairy farms, which tend to be more mono-functional in character, have converted to organic livestock farming, adding a new farming strategy to the wide range of farming techniques used in organic dairy farming. These farming techniques create various organic production conditions for cattle, which may lead to various demands on breeding technology and selective breeding technologies such as artificial insemination.

Farm planning, milk production, breeding plans, breed selection, and conception methods. On each of the subsequent three strategy options, farmers were divided into one of two groups: Low Input vs. High Input Farming; Specialized Dairy Farming vs. Multifunctional Farming; Specialized Dairy Farming vs. Multifunctional Farming; Naturalness of Breeding;

Farming with Artificial Insemination vs. Farming with Natural Service; and Intensity of Milk Production.

Organic Dairy Farming

Compared to conventional farming, which mainly integrates livestock with crop farming under subsistence farming operations with low input and low output production systems, organic farming separates its livestock from its produce. The criteria for organic production are essential because organic milk contains higher level of nutrients like omega-3 fatty acids and anti-oxidants, potentially providing additional health benefits. Producers who produce livestock sustainably have to carry out preventive health care procedures. Correct knowledge about animal behaviour can be a basis for organic systems management. Livestock must be grown on pasture more frequently due to organic rules in industrialized nations. Whether developing countries want to export conventional or organic goods, they will still need to develop reliable traceability systems. Better conditions for animal health are required, particularly when raising animals organically. Training in organic production techniques for organic and non-organic farmers is necessary to maximize the potential benefits of organic dairy farming.

Organic Farming system

1. The farm must be managed and certified as organic.
2. Feeding animals with feeds containing artificial chemicals like growth hormones and other ingredients that are prohibited by standards is prohibited.
3. Using animal feces as animal feed is forbidden.
4. Animal manures must be carefully managed or composted before being used on farms.
5. The animals' health, pest and disease resistance will be considered when breeding.
6. Only employ herbal and natural remedies.
7. To prevent contamination from outside feeds, the farm should try to manufacture most of the feeds on-site.

Organic Livestock Production System

1. Clear guidelines and processes that can be checked.
2. Increased focus on animal welfare.
3. Growth stimulants in nature, animal offal, prophylactic antibiotics, or any other changes should not be used regularly.
4. Almost 80% of animal feed must be produced per organic standards, without synthetic pesticides or fertilizers on vegetation or grass.

Recent Advances and Trends

The productivity and long-term viability of organic cattle production have increased. Organic dairy farming has shown extraordinary growth at various research and scientific implications levels. One must guarantee a thorough balance between the soil and cattle in order to get the maximum possible return from organic livestock farming. A major improvement in the consumer health index has resulted in a reduction in exposure to hazardous substances and careful monitoring of the growth of organic produce. Through cultural, biological, and technological advances, organic livestock production attempts to produce food safe for the environment and free of chemicals. Waste products like animal waste can be utilized as insect repellents and manures. A pest deterrent and a growth stimulant are possible uses for cow urine.

Utilising waste from farming effectively enables farmers to reduce other extravagances and lessen their reliance on external synthetic soil amendments. A number of demanding factors, such as the effects on the environment, the impact on public health, market potential, safety and dietary requirements, animal welfare, and social sustainability, are currently used to compare conventional and organic dairy cow production.

Organic produce frequently costs more than conventional produce due to its increased nutritional value and freshness. However, the cost has never enormously affected the wider organic market's long-term performance. Food and product demand that are organic is increasing substantially. International retailers are taking advantage of this opportunity to grow their clientele and revenues. Organic livestock production is an essential element of sustainable rural development. The organic production model generates more beneficial and durable externalities than the conventional method. The demand for organic dairy products results from consumer desire for healthier and more environmentally friendly solutions. The organic production method makes money and promotes the long-term sustainability of agro ecosystems. Farmers have access to active farms, stable income, and employment options. Another crucial element of the livestock industry is the active role that organic livestock farming plays in promoting a better economy that reflects the way of life in rural areas. Cattle farming on pasture has a major beneficial impact on the environment. Due to the interrelated nature of these systems, they frequently produce positive improvements, including increased carbon sequestration, greater pasture quality, and less fire risk. The farm's effective use of its water resources is another essential aspect to take into account. In rural locations where the availability of water is constantly in doubt, many farming methods are employed. Organic farming methods have proven to be more water-efficient in terms of consumption and retention in the field, leading to the development of drought tolerance. Organic agroecosystems are more resilient to devastating pests, diseases, and climate change and have greater agro-biodiversity. The GWP (global warming potential) of organic livestock systems is reportedly lower than that of the conventional model.

The non-organic farms double the feed price while raising their grain supply. When it comes to long-term economic sustainability, organic dairy cow farms beat conventional ones. The physical condition of the animals is an important consideration while using various cutting-edge agricultural practices. Involving various livestock units in the organic model would help to improve the general welfare of cattle in this way. It has been noticed, for instance, that organic cattle had decreased rates of calf death, mastitis reports, and premature births. Furthermore, it causes minor respiratory issues and tail sores in pigs grown using normal techniques when pasture-based and low-input, organic livestock systems are more reliable for society and the environment. Since the majority of the population lacks access to safe food sources, it is important to take into account how organic food sources can help people develop good eating habits. In order to address the issue of food insecurity as rapidly as possible, it is essential to educate farmers about various sustainable farming strategies.

Approach and Methodology

This study aimed to look into present and future farming techniques for rearing organic animals. To achieve this, a standardized, brief questionnaire was used to gather information from 126 organic dairy farmers in Telangana State. For qualitative information on organic dairy farming, business diversification, milk production intensity, and breeding naturalness, data from various sources such as stakeholder interviews, literature reviews, and web data has been collected. Field surveys are used to find out how farmers feel about sustainable livestock practices and key challenges in the adoption of new technologies.

Dairy Farming Processing and Marketing Strategies

Demand for organic dairy products has increased recently as people prioritize their health, the environment, and animal welfare. The term "organic dairy" refers to a variety of items produced using techniques that prioritize the welfare of animals and the environment, such as milk, yogurt, cheese, and butter. These goods are healthier for consumers because they don't include artificial hormones, antibiotics, or pesticides.

Due to recent developments, organic dairy improves dairy products' production, quality, safety, and sustainability, and technology is crucial for the dairy industry. Farmers and processors can use technology to cut costs, increase output, and satisfy customer and market demands. Despite the use of feed management systems, robotic milking machines, and health-tracking devices, technology has an impact on the dairy industry. Real-time monitoring and optimization of the health, diet, behaviour, pregnancy, frequency of milking, and milk output of cattle is possible with these devices. This may increase milk production, decrease disease rates, and enhance animal welfare. Using techniques like supercooling, pasteurization, freezing, and preservation improves the quality and freshness of milk. By lowering the microbial load, adulterants, and shelf life of milk, these techniques can stop or delay the deterioration of milk. Utilize applications and programs that can measure numerous quality metrics at various levels of the supply chain to determine the freshness and purity of milk.

Technology enhances supply chain systems by utilizing tools like blockchain, cold chain management, and inventory control. By assuring prompt distribution, cold chain management, and inventory optimization, these systems help improve the dairy supply chain's transparency, traceability, and efficiency. Through channels like mobile apps, internet, and social media, technology can help with communication along the supply chain.

Solving Greenhouse Gas Emissions from Livestock

Emissions of greenhouse gases (GHGs) are a serious environmental problem facing the world. While several industries are involved in this problem, the cattle industry has emerged as a major player responsible for a sizeable part of GHG emissions. It is crucial to address this issue and look into creative solutions as we work to create a sustainable future. In this research study, we will investigate the problem of livestock-related GHG emissions and consider various solutions, including innovative technologies, to lessen their negative effects on the environment.

A significant share of GHG emissions is caused by dairy farming. Methane (CH_4) and nitrous oxide (N_2O), created during enteric fermentation in manure management, are the main offenders. These hypothetical greenhouse gases are much more likely than carbon dioxide (CO_2) to be contributing to global warming. Finding sustainable methods to lessen the environmental impact of livestock production or farming is essential as demand for animal products rises in response to population increase and shifting dietary habits.

Promotion of Sustainable Livestock Practices

1. **Improved Feed Efficiency:** Reducing enteric fermentation and methane emissions can be achieved by improving the nutritional value of animal feed. Research and development efforts can be directed at creating feed additives that can enhance

digestion and lower methane output while maintaining the health and well-being of the animals.

2. **Methane Capture and Utilisation:** Methane emissions from livestock manure can be captured and used to minimize greenhouse gas emissions. Anaerobic digesters, for instance, can turn manure into biogas, which can then generate energy and heat, reducing fossil fuels and reducing the environmental impact of livestock operations.
3. **Precision Livestock Farming:** The production of livestock can become more effective and sustainable with the help of technology and data-driven methods. Farmers can optimize feed intake, reduce waste, and lower GHG emissions using sensors and advanced analytics to monitor animal health, nutrition, and behaviour.
4. **Agroforestry and Silvo pasture Systems:** Grazing areas can reduce GHG emissions by incorporating trees and bushes. The additional benefits given by agroforestry and silvopasture systems include raised soil health, carbon sequestration, and biodiversity preservation. These integrated strategies minimize the environmental impact of animal production while promoting sustainable land use practices.
5. **Alternative Protein Sources:** The dependence on conventional animal farming can be reduced by exploring and promoting alternative protein sources. To fulfill the rising need for protein, environmentally friendly and sustainable options include plant-based protein alternative products, cultured milk, dairy products, meat, and insect-based protein.

Collaboration and Policy Initiatives:

Collaboration across a variety of parties is necessary to address the issue of GHG emissions from livestock. The government, researchers, farmers, and industry participants should collaborate to create and implement regulations that encourage sustainable practices, provide monetary support for implementing emerging technologies, and promote information exchange and capacity building.

Revolutionizing Organic Livestock Farming Technologies:

Precision livestock farming is one technology that is altering how we raise animals. There have been tremendous advancements in the livestock industry over time. By combining the potential of IoT, AI, and Big Data, Precision Livestock Farming (PLF) transforms traditional livestock farming into a highly productive, data-driven, and sustainable sector.

1. **The Essence of Precision Livestock Farming**

Precise Livestock Technologies used in farming range from wearables and smart sensors to sophisticated data analytics systems. These tools give farmers the ability to track the health, behaviour, and nutrition of people, animals, and crops in real-time, allowing proactive decision-making and early intervention. The welfare of animals is improved, and there is less chance of disease outbreaks as potential issues are quickly identified and resolved.

2. **Empowering farmers with Data**

Livestock Precision Farming gives farmers strength by giving them useful insights from massive amounts of data. Farmers can improve feed management, spot outliers in behavior, and spot early indicators of illness by utilizing AI and data analytics. The operational effectiveness, cost-cutting, and overall productivity of cattle operations are all increased by this data-driven system.

3. **Enhancing Animal Welfare**

Farmers place great value on the welfare of their livestock, and Precision Livestock Farming plays a crucial role in improving animal welfare. PLF enables farmers to detect stress indicators, evaluate social dynamics, and improve living conditions by monitoring individual animals. Animals are more productive, healthier, and happy as long as they are given personalized attention.

4. **Sustainability and Environmental Stewardship**

Breed preservation requires sustainable livestock husbandry, which PLF actively supports. PLF lessens the environmental impact of livestock operations by optimizing resource allocation—including feed and water—and minimizing waste. As a result of being able to precisely monitor animal nutrition and health, fewer antibiotics and other treatments are required, lowering the possibility of antibiotic resistance and encouraging ethical agricultural methods.

5. **Overcoming Challenges and Enabling Innovation**

Although PLF has a lot of potential, it will only succeed if farmers, technology companies, and researchers work together. The cattle sector needs to overcome cost, interoperability, and data privacy issues. To further overcome restrictions and realize its full potential, PLF technology must constantly innovate and develop.

6. **The future of Livestock Farming**

The need for effective and sustainable food production systems will increase as the number of farmers increases. Precision livestock farming offers a solution to satisfy these needs while protecting the environment and the well-being of the animals. Farmers can enhance productivity, reduce waste, and contribute to a more sustainable and secure food future by adopting PLF.

Conclusion

The organic dairy market size was growing significantly, and consumer awareness will drive the dairy management market. The market will receive support from the rising disposable income as a result of being willing to spend on organic food. Sales in developed markets are likely to remain high, supported by increased consumer awareness. Further, the purchasing power is relatively high, which will help market growth. Technological advancements allow for the most efficient use of individual cattle production potential by focusing on their health, monitoring milk quality, effectively managing farms, increasing productivity, and supervising breeding. These advantages are increasing dairy farmers' interest in technologically advanced livestock management products and, as a result, their adoption in the dairy industry. Mitigating the environmental impact of GHG emissions from livestock is a complex challenge for our planet's future. Promoting sustainable livestock practices, leveraging technology, and fostering collaboration make significant strides in reducing the carbon footprint of the livestock sector. We must prioritize and invest in innovative solutions to ensure a more sustainable and resilient future for our environment and our food system.

Precision Livestock Farming represents a transformative shift in the way we raise livestock. By harnessing the power of technology, PLF empowers farmers to make data-driven decisions, optimize animal welfare, and reduce the environmental impact of livestock farming. As the industry progresses, collaboration, innovation, and knowledge sharing will be crucial to realising the full potential of PLF. Let us embrace this exciting era of technology and innovations and work together to build a more sustainable and ethical future for livestock farming.

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Chapter-2

CONSERVATION AND LEVERAGING INDIGENOUS CATTLE BREEDS FOR AGRI- BUSINESS IN DAIRY SECTOR – AN INDIAN PERSPECTIVE

D. Srinivas

Professor & Head Department of AGB, College of Veterinary Science,
P. V. Narsimha Rao Telangana Veterinary University, Hyderabad (TS) – 500030

Introduction

India boasts one of the world's largest livestock sectors, with a significant cattle population comprising 14.7% of the global total. This sector plays a pivotal role in sustaining the livelihoods of a majority of the rural populace. The animals that belong to Descript (identified)/Non-descript (non-identified) breeds of indigenous origin are considered as indigenous animals. As per the 20th Livestock Census (Anonymous, 2019), the total number of cattle in the country was 192.49 million showing an increase of 0.8 % over the previous Census, the Indigenous/Non-descript female cattle population increased by 10% in 2019. Many indigenous cattle breeds have evolved over centuries primarily for use in draft and agricultural activities. As per the Breed Survey Report (Anonymous, 2022), In India, there are 24.9 million pure breeds, 16.9 million grades of different breeds, and 41.8 million non-descript cattle available among the indigenous cattle amounting to 74% of total cattle (Figure 1). The breeds that contribute to more than 1% population in India are Gir, Lakhimi, Sahiwal, Bachur, Hariana, Kankrej and Kosali (Table 1). India's remarkable contribution to global milk production is undeniable. In 2020, the country accounted for 22% of the world's milk output, producing a staggering 198.44 million tons. This position underscores India's significance in the global dairy landscape. Indigenous bovine breeds are a cornerstone of India's milk production, contributing an impressive 68.39% to the national total. Despite being the world leader in milk production, India faces the challenge of low milk productivity per cow per day, indicating the need for substantial improvements. To unlock the potential for higher milk productivity, it is imperative to delineate and classify the country's bovine breeds, including the nondescript varieties. Initiating genetic improvement programs is a critical step towards enhancing milk production across different cattle species in India.

India, often called the land of diversity, is home to a staggering 16.5 percent of the world's cattle population, boasting fifty-three distinct cattle breeds. These breeds are not just a source of pride but also invaluable assets deeply intertwined with the fabric of Indian agriculture, culture, and heritage. They have evolved over centuries within their respective breeding tracts, adapting to local conditions with remarkable resilience. This adaptation has endowed them with the ability to tolerate heat, resist diseases, and thrive even under extreme nutritional stress. All the cattle breeds can be classified into three categories as per their utility i.e. milk (Sahiwal, Tharparkar, Rathi, Red Sindhi and Gir), draft (Amritmahal, Hallikar, Kangayam, Khilar, Ponwar, Kherigarh and Krishna Valley, etc.) and dual purpose (Kankrej, Hariana, Gangatiri, Deoni, and Dangi, etc.). Indigenous Zebu cattle (*Bos indicus*) have some distinctive features like a prominent hump, a long face, upright horns, drooping ears, dewlap and slender legs. The prominent body colour varies from white to gray and black. Zebus experience relatively lower basal metabolic rate and a superior ability for heat dissipation in comparison to their taurine (*Bos taurus)* counterparts. Indigenous bovine breeds exhibit remarkable genetic diversity and possess a range of highly desirable attributes. Notable breeds like Gir, Ongole, and Sahiwal have been introduced in various countries due to their adaptability and robust disease-resistance traits. Indigenous cattle milk is renowned for containing A2 protein, which is considered superior to the A1 protein found in the milk of a few exotic and crossbred cattle. This distinction underscores the potential health benefits associated with indigenous cattle milk (Pundir, 2022).

India's indigenous cattle breeds are invaluable treasures deeply intertwined with the nation's cultural, agricultural, and ecological heritage. These breeds have adapted to local conditions over centuries, offering rich milk, draught power, and sustainable agricultural resources. Their significance extends beyond utilitarian roles, encompassing cultural and religious aspects. Conservation efforts, both ex situ and in situ, play a crucial role in preserving the genetic diversity of indigenous cattle breeds. By maintaining organized herds, cryopreserving genetic material, and involving local communities, we can ensure the survival and prosperity of these remarkable breeds. As we navigate the challenges of increasing milk productivity and food security, it's essential to strike a balance between modernization and the preservation of indigenous cattle breeds. These breeds possess unique genetic traits, including A2 milk production and resilience to local conditions, making them valuable assets for sustainable agriculture and dairy production in India and elsewhere by leveraging their advantages.

Importance of Indigenous cattle:

Diverse Roles:

- Beyond being milk producers, these cattle serve as a source of draught power, helping plow fields and transport goods. Their dung, a versatile resource, serves as valuable manure and fuel, contributing significantly to sustainable agriculture and energy needs in rural India.
- The milk of Indian cows holds a special place in the hearts and diets of the native population. Rich in fat content and protein, it is considered a highly nutritious and easily digestible source of sustenance. For many, it's the preferred choice, seen as both healthy and wholesome.

Producing A2 milk:

- Milk contains both whey protein and casein protein. Among these, casein protein constitutes 80% of the total protein content in milk, with the remaining 20% being whey protein. Casein in milk exists in various forms, with -casein being the second most abundant type. There are at least 13 distinct types of casein proteins. Among these, A1 and A2 casein are the two most commonly recognized varieties of -casein. Notably, indigenous or Desi cow breeds like Sahiwal, Gir, Red Sindhi, Kankrej, and others are known for producing milk that is particularly rich in A2-casein. Consequently, these breeds are acknowledged as sources of high-quality and healthy milk (Jiménez-Montenegro et al., 2022).

Draught Cattle: Guardians of Agriculture

- India's agricultural landscape, characterized by small land holdings and challenging terrains, has meant that draught animals remain indispensable. Despite the advent of mechanization, over 55 percent of cultivated areas are still managed by these reliable animals. The use of bulls for transportation remains prevalent in most Indian villages.
- Moreover, cow dung and urine are conventionally used in agriculture. Cow dung, in the form of cakes or as a source of biogas, plays a crucial role in providing energy for rural households

Cultural and Ecological Significance

- Beyond their direct utilitarian value, Indian cows are deeply entrenched in the country's cultural and ecological heritage. People share a profound emotional connection with these indigenous cattle, which play a central role in traditional sports and ceremonies.
- Festivals such as Govardhan Pooja and Gopashtami are centered around these cattle. In many religions practiced in India, including Hinduism, these cattle are considered sacred. Panchgavya, a mixture of five products of the cow—milk, curd, ghee, dung, and urine—is essential for various rituals. In many parts of India, home-warming ceremonies are incomplete without boiling cow's milk.

Conservation of indigenous cattle:

Conservation endeavors seek to uphold the potential benefits arising from genetic diversity. Consequently, it occupies a prominent position within the Global Plan of Action for Animal Genetic Resources. Various measures for safeguarding endangered breeds have already been implemented in certain countries. Presently, most conservation initiatives are concentrated in developed nations where there exists a robust collaboration between gene banks and animal breeding organizations. In contrast, in developing countries, the emphasis primarily revolves around in vivo conservation, i.e., the preservation of living populations.

It is important to recognize that livestock breeds are not merely biological categories; rather, they are products of complex social processes. Consequently, their survival hinges on their integration within the specific social contexts and production systems that gave rise to them. Thus, the conservation of ecosystems and production systems is indispensable for ensuring the survival of these breeds. Conservation methods may be categorized as in situ and ex-situ, each supplying precise advantages and demanding situations. Here's a better look at those methods:

Ex Situ Conservation:

1. **Organized Flocks/Herds:** In this method, small populations of indigenous livestock breeds are maintained in managed environments. These organized herds can be determined in research institutions, country-owned farm animal farms, zoos, and breed parks. This technique permits controlled breeding, tracking, and genetic control, making it suitable for breed development and conservation tasks. These populations function as genetic reservoirs and can be pivotal in breed regeneration efforts.

2. **Cryopreservation of Embryos:** Embryos, containing the whole genetic fabric of the breed, are cryopreserved. While this approach is particularly powerful for genetic preservation, it demands skilled personnel and large resources for embryo production and switch.
3. **Somatic Cell Banks:** Somatic cells, specifically skin fibroblast cells, are accrued and cryopreserved. Somatic mobile banking offers practicality because of clean accessibility, non-invasiveness, and no regulations primarily based on an animal's sex or age. These cells may be used to repair germplasm if important.
4. **Sperm Banks:** This technique entails the collection and cryopreservation of epididymal spermatozoa, in particular caudal spermatozoa, from slaughtered animals. It offers a speedy and price-effective opportunity for conventional semen collection and garage, casting off the want for full-size male training.
5. **Cryopreservation of Embryonic Stem Cell Lines:** Embryonic stem mobile lines may be cryopreserved and later used for producing live and genetically modified animals. This approach has programs in gene and cell healing procedures, as well as the production of therapeutic proteins.
6. **Cryopreservation of Spermatogonial Stem Cell Lines:** Spermatogonial stem cells (SSCs) can be cryopreserved and transplanted into recipient animals to repair spermatogenesis. SSC transplantation has proven successful in numerous species, aiding in the maintenance and enlargement of SSC numbers for genetic conservation and change.
7. **Storage of DNA:** DNA cryogenic garage gives a fee-effective and without problems transportable manner of retaining genetic material. It may be used for gene conservation through introgression, move-checking genetic cloth, and recreating misplaced breeds through genetic analysis (Tantia *et al*., 2022).

In Situ Conservation:

In situ conservation emphasizes the maintenance of indigenous livestock breeds within their herbal manufacturing systems and environments. The key element in in situ conservation with genetic development is choosing for traditionally valued characteristics and preserving the breed within its adapted surroundings. Herds must be managed below herbal conditions unique to the breed, exposing them to the winning area conditions. To be effective, the conservation of indigenous cattle breeds requires a comprehensive technique that combines in situ and ex-situ techniques, relying on the specific goals and available assets. These strategies collectively contribute to safeguarding the genetic diversity and cultural significance of those breeds, making sure their endured existence and sustainable contribution to agriculture (ICAR-NBAGR, 2016).

Initiatives for the conservation of indigenous cattle:

Global initiatives:

In 2007, the Food and Agriculture Organization (FAO) introduced the Global Plan of Action (GPA) for Animal Genetic Resources, which is also commonly referred to as the Interlaken Declaration. This landmark initiative marked the first globally recognized framework for the management and conservation of Animal Genetic Resources (AnGR) diversity in contemporary times. The importance of preserving Animal Genetic Resources (AnGR) biodiversity has received significant recognition and emphasis from the United Nations (UN), particularly through the establishment of the Sustainable Development Goals (SDGs) in 2015. Within these SDGs, there is a clear call for the global management of all genetic resources, including AnGR. This emphasis on genetic resource management is geared toward promoting sustainable agriculture and achieving food security on a global scale. In essence, it underscores the critical role that AnGR preservation plays in ensuring the long-term sustainability of agriculture and the availability of food resources for current and future generations.

Indian initiatives:

The Central Herd Registration Scheme started in 1963, has been continuing for Hariana, Gir, Kankrej and Ongole cattle breeds. In the scheme, owners of registered animals are provided certificates and prizes/ incentives to encourage the conservation of indigenous breeds and production of high-quality cows. All India Coordinated Research Project on Cattle, Project Directorate on Cattle (now, ICAR- Central Institute for Research on Cattle, Meerut) has taken up a genetic improvement program of important cattle breeds in collaboration with various SAUs/ SVUs, State government, and NGOs (Srivastava et al., 2019). The government of India established the ICAR-national Bureau of Animal Genetic Resources during 1984-85 and initiated the "Registration of Animal Germplasm" specifically indigenous livestock and poultry breeds in the country. The breed-wise survey was initiated during the 19th livestock census in 2012 and further elaborated in the 20th livestock census (2019). National Kamdhenu Breeding Centre, an initiative by Govt. of India has covered all NBAGR-registered breeds of cattle and buffalo for conservation, promotion, and development.

Breed societies have been initiated for some native livestock breeds in their native tract by the local livestock keepers, which ensured improvement of germplasm, strengthening of the production system and marketing of the products and benefit-sharing among the society. To provide legal safeguards for germplasm protection, notification of indigenous breeds being registered by ICAR has started in the year 2019 through the publishing Official Gazette by the Government of India. The National Gene Bank has been started at ICAR-NBAGR, Karnal, Haryana. The institute has also taken up a mission towards zero non-descript population AnGRs of India in collaboration with state and central agencies, which envisages the documentation/registration of more breeds in the national inventory. A Network Program on AnGR characterization and conservation is started to undertake the characterization and conservation of indigenous livestock and poultry genetic resources in a collaborative mode with state AHD and Veterinary/Agriculture Universities. A National Breed Watchlist-2022 has been prepared based on the 20th Livestock Census data of DAHD, GoI. The breed conservation award was initiated by the Bureau in the year 2017 and was bestowed upon individuals and institutes/organizations/NGOs etc. for their remarkable contribution to conserving the animal genetic resources of the country (Raja *et al*., 2022).

Further, the following few schemes/programs among others are in place by the GoI for the conservation and improvement of indigenous AnGRs:

1. Rashtriya Gokul Mission (RGM): Rashtriya Gokul Mission (RGM) was launched in December 2014 with an outlay of Rs 2025 crore for the development and conservation of indigenous breeds through selective breeding in the breeding tract and genetic upgradation of nondescript bovine population. It comprises components like the availability of High genetic Merit Germplasm, Extension of Artificial Insemination Networks, Development and Conservation of indigenous Breeds, etc.
2. National Programme for Dairy Development (NPDD): To strengthen or create infrastructure for quality milk production and linking the farmer to the consumer

3. National Livestock Mission (NLM): This has three submissions with one on "Breed development of livestock and poultry" focusing on the development of entrepreneurship on livestock and poultry along with promoting indigenous animal conservation and development.

By using more artificial insemination, the National Program for Bovine Breeding seeks to boost milk output (AI). Multi-purpose AI Technicians in Rural India (MAITRIs) are developed, existing AI centers are improved, AI is overseen and other methods are used to achieve this. The World Bank-backed National Dairy Plan- I seeks to boost milk production and productivity through the reinforcement of semen stations, a bull production program (progeny testing and pedigree selection), a diet balancing program and other activities to meet domestic milk demand. The government has also set up three subordinate organizations, Centre for Cattle Breeding Farms (CCBFs), The Central Herd Registration Scheme and Institute for Central Frozen Semen Production and Training. These organizations are also improving the genetics of milch animals by providing disease-free, highly genetically superior bulls for semen production and natural service for use in the breeding program being implemented by the States (Pathak *et al*., 2020). Recently, the National Institute of Animal Biotechnology (NIAB), Hyderabad has launched a chip called IndiGau, which is India's first Cattle Genomic Chip for the conservation of pure varieties of indigenous cattle breeds like Gir, Kankrej, Sahiwal, Ongole, etc. IndiGau is purely indigenous and the largest cattle chip in the world**.**

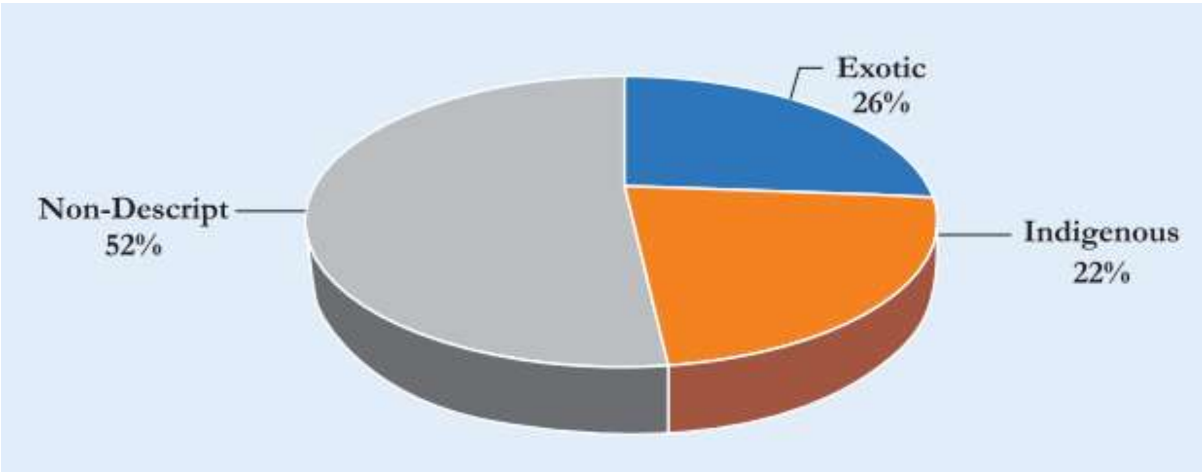

Figure 1. Percentage share of different types of cattle in India

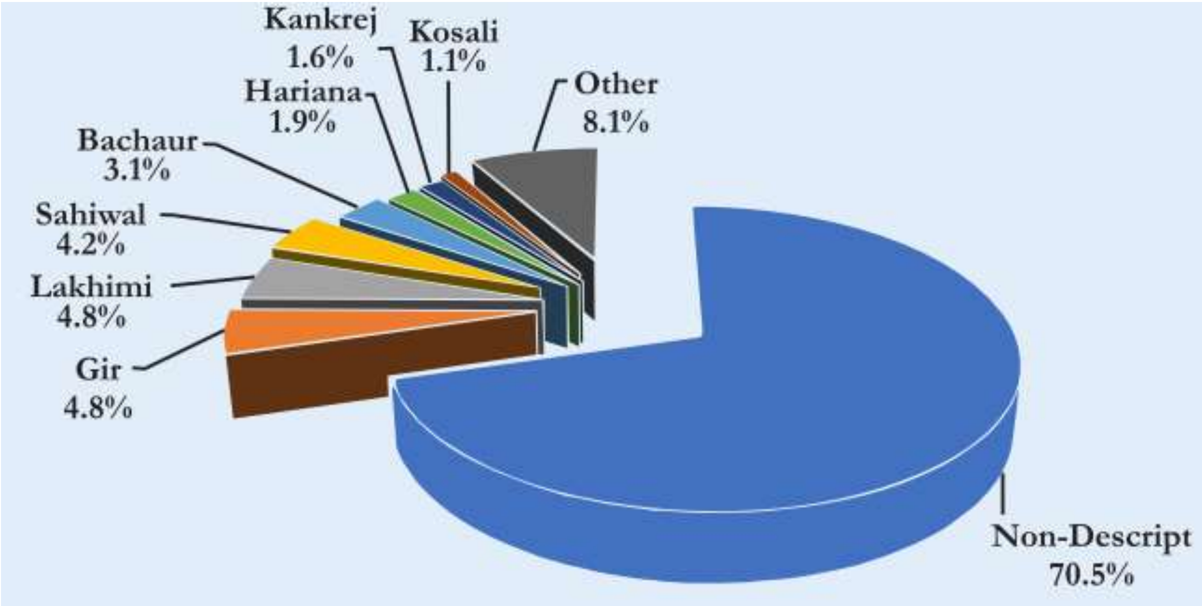

Figure 2. Percentage share of different indigenous cattle in India

Breeding strategies for the conservation of indigenous cattle

The State of the World's Animal Genetic Resources for Food and Agriculture (FAO, 2010) indicates that the vast majority of developing countries have not been successful in sustaining genetic improvement in their livestock populations. A strategic and logistical approach to sustainable livestock development is required to appropriately address the use of available AnGR and the role of genetic improvement in sustainable development, from the outset all policies, plans and programs for the livestock sector must be well-integrated and realistic livestock breeding and development strategies (Siddiky, 2018). Suitable selection procedures and breeding policies are the tools available for the improvement of dairy cattle. The States may review their respective breeding policy to prioritize the conservation of Indigenous breeds in their breeding tract and allow no cross-breeding of recognized indigenous cattle in the home tract of important and recognized indigenous breeds. A reorientation of breeding policy is to be attempted with an area-specific approach backed by appropriate programs addressing our concerns for indigenous cattle breeds through scientific selection in the breeding tracts and supply of improved germplasm to the farmers for selective/pure breeding or upgrading their local cattle (Sreenivas, 2013).

The States may delineate and identify, in their respective breeding policies, the geographical boundaries of the areas where non-descript cattle should be upgraded by crossing with bulls of indigenous breeds. Once such areas are earmarked, no cross-breeding of non-descript cattle, other than with bulls of indigenous breeds, should be permitted. Semen production facilities need to be strengthened for the production of disease-free high-quality semen from high genetic merit bulls and disseminated at the farmers' doorstep. This can be achieved by establishing infrastructure for production and selection of genetically superior breeding bulls especially in the breeding tract of indigenous cattle. Facilities of data recording for production, reproduction, growth and diseases by registering a greater number of indigenous cattle in a database for identification and evaluation of genetically superior animals are also important.

Table 1. Indigenous cattle breeds with more than 1% of the total cattle in India

Sl. No.	Breed Name	Pure (No.)	Graded (No.)	Total (No.)	% share
1	Gir	23,00,090	45,57,694	68,57,784	4.8
2	Lakhimi	66,48,519	1,80,965	68,29,484	4.8
3	Sahiwal	18,81,453	40,68,221	59,49,674	4.2
4	Bachaur	32,15,259	11,30,681	43,45,940	3.1
5	Hariana	11,79,089	15,78,097	27,57,186	1.9
6	Kankrej	15,80,802	6,34,735	22,15,537	1.6
7	Kosali	9,89,803	5,66,871	15,56,674	1.1

Promotion of Breeders organization

1. Breeding Farms

The existing state breeding farms of indigenous breeds should be declared as germplasm repositories and used for the production of bulls. Only pure breeding should be practiced at these farms.

2. Gaushala

Conservation efforts have mostly been limited to institutional farms with small herd sizes, leaving larger parts of the breeding tract neglected. There are a large number of Gaushala have quite sizable populations of purebred animals of Indigenous breeds do not have the resources to maintain and improve these animals. Such Gaushala may be supported to maintain indigenous breeds so that they can supply improved quality of germplasm for breeding. They should be provided with scientific and technical inputs and training for genetic evaluation.

Use of Science and Technology

Since the introduction of the cross-breeding program, most of the techniques and methodologies for breed improvement have been used to produce cross-bred cattle. The application of such technologies for the propagation and improvement of indigenous breeds are a relatively rare phenomenon, one of the reasons for which maybe the reluctance of the farmers, owning these breeds to accept new and established techniques for reproduction.

I. Technologies such as artificial insemination, Frozen semen production, progeny testing, embryo transfer technology should be used, after proper evaluation where ever required

II. National gene bank should maintain the germplasm in the form of semen & embryo. Regional gene banks should meet the requirements of the National gene bank.

III. Genomic selection offers many advantages in improving the rate of genetic gain in dairy cattle breeding programs. In practice, genomic selection refers to selection decisions based on genomic estimated breeding values (GEBV). These GEBV are calculated by estimating SNP effects from prediction equations, which are derived from a subset of animals in the population (*i.e.*, a reference population) that have SNP genotypes and phenotypes for traits of interest.

Creation of Public Awareness

1. Available information on different breeds should be published in the form of pamphlets, books, calendars, etc. This will create awareness and motivate farmers to conserve the important breeds.

2. Some farmers are the proud owners of the popular breeds of their area. Such farmers, if encouraged through financial & veterinary help will help in the preservation of breeds
3. Breeds shows should be arranged for local breeds and owners should be rewarded for maintaining pure local breeds. Publish success stories on local breed conservation and innovative utilization.

Leveraging the indigenous cattle breeds for exploiting the full potential

The prospects of indigenous cattle as a business opportunity in India are promising, offering a range of potential benefits for entrepreneurs and farmers alike. As India continues to be a major player in the global dairy industry and places an emphasis on sustainable and organic agriculture, indigenous cattle breeds present a viable and sustainable avenue for business development. The contemporary landscape of livestock farming has undergone a significant transformation, transitioning from an activity shaped by local conditions and environments to one dictated by market demand. As a result, the distinctive characteristics of indigenous livestock breeds, which typically have lower production levels, tend to be overlooked in the emergence of high-input-based agricultural systems. This shift has resulted in the gradual displacement of traditional multipurpose breeds in favor of high-yielding alternatives, driven by profit motives. Given that indigenous livestock, breeds cannot compete with industrialized livestock systems in terms of sheer production output, it becomes pertinent to shift the focus towards preserving their unique qualitative attributes and their potential as a source of livelihood. Fortunately, many local breeds and species possess substantial, albeit often underestimated, potential to yield products that resonate with customer preferences and demands. Recent scientific efforts in underpinning the quality attributes of Indian livestock can be exploited to augment their value and promote sustainable utilization (Rekha Sharma *et al*., 2022). Indigenous cattle play a vital role in the nation's economy by contributing to the production of milk and dairy products, supplying power through draught animals, and yielding cow dung and cow urine. Dairy farmers can enhance the value of their raw milk by producing a diverse range of processed milk items, such as skimmed milk, toned milk, standardized milk, homogenized milk, flavored milk, and condensed milk. Cow's milk serves as the base for various dairy products, including yogurt, buttermilk, butter, ghee, cheese, khoa, chhana, paneer, ice cream, lassi, and more. These products are highly nutritious and possess therapeutic properties.

The government procures cow manure from farmers and rural areas with cow ownership, fostering trade activities that create employment opportunities and bolster the rural economy. Cow dung is also utilized to enhance soil fertility and productivity, giving rise to various organic fertilizers, including cow dung compost, a natural fertilizer. Cow dung is even integrated into certain Ayurvedic medications approved for human consumption. A diverse array of cow dung products includes radiant Diwali diyas, idols of deities, nameplates, mobile stands, candle holders, flower pots, keychains, incense sticks, and her bal gulal for the Holi festival. Gomutra, commonly referred to as cow urine, is a liquid byproduct of cow metabolism, considered a boon, particularly for farmers. Cow urine is utilized in the production of insect repellents, organic and natural fertilizers, and other agricultural products. Additionally, it finds applications in the creation of soap, shampoo, incense, gaubhasma, panchagavya, vermicompost, guanylate, and insecticides (Singh, 2021).

Conclusion

The indigenous cattle breeds of India are not just animals; they are an intrinsic part of the country's heritage and rural life. The conservation and strategic utilization of indigenous cattle are not merely commendable goals; they are critical imperatives for the future of dairy farming. These remarkable bovine breeds embody centuries of co-evolution with nature and have the potential to address modern challenges while preserving cultural heritage. By investing in their conservation and leveraging their unique genetic attributes, we can navigate a sustainable path forward for dairy farming—one that respects the past, meets the needs of the present, and secures a resilient future for generations to come. The journey to harnessing the potential of indigenous cattle for dairy enhancement and conservation is not only worthwhile but also essential for a more sustainable and inclusive agricultural future.

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Chapter-3

CARE AND MANAGEMENT OF REPRODUCTIVE AND METABOLIC DISORDERS IN DAIRY ANIMALS

K. Venkata Ramana

Professor Department of VGO, College of Veterinary Science, PVNRTVU, Rajendranagar, Hyderabad, India

Introduction

The dairy animal production is very much dependent on the healthy reproductive activity and management. Hence rate of reproduction is an important factor affecting profits from dairy animals. The care of dairy female calf starts as early as from foetal age in the mother's womb. The influence of feeding of pregnant dairy animal has a great impact on the growing foetus and after birth. Similarly the feeding and management conditions of the heifer calf during the first 6 months also affect its performance like Daily body weight gain, Development of reproductive organs, Age at puberty, Age at sexual maturity, Age at first service, Age at conception, Age at first calving, Cyclicity of the reproductive system, Hormonal balance in maintaining sound and healthy reproductive functions in heifers. Management is another important factor which affects the production of dairy animals which includes feeding (balanced nutrition) and hygienic environment. Poor management leads to certain physiological conditions where in the normal health and functions of the animal are altered which may lead to Milk fever, Ketosis, Post parturient haemoglobinurea, Downer cow syndrome, Grass tetany, etc. hence good plane of nutrition, Housing, Health care may give good returns from the Dairy animals.

Reproductive Disorders and Their Management

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. 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.

The reproductive cycle of dairy animal includes 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 or 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 identify 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 (e.g., Chorulon, lntervet) 1500-3000 IU I/V or GnRH 10-20 µg I/M (e.g., 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. Administration of oxytocin (5-10 IU) immediately after insemination improves the conception rate, by facilitating sperm transport.
- **Luteal insufficiency**
  Progesterone hormone, 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. lf 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 luteal phase 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, where as 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 infertility.
- **Cystic ovarian degeneration:** Follicular cyst, luteal cyst, cystic corpora lutea.

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

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 $PGF2\alpha$ 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 afer, 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. Te 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.

Metabolic Disorders and their management

The term "**metabolism"** refers to the collection of all physical, chemical, and metabolic activities that take place within a live cell or organism in relation to the absorption, disintegration, or synthesis of essential organic components. Numerous metabolites that are either utilized as building blocks or destroyed and expelled from the body as waste are released as a result of metabolic activities. During metabolism, nutrients are converted into energy that is used by cells, organs, systems, or the entire organism for healthy bodily function. When one or more metabolic pathways are dysfunctional, other organ systems or the entire body may also be affected. Metabolic disease or disorder is characterized by disruption of one or more metabolic processes that are connected to the control of a specific metabolite in body fluids.

A series of ailments known as metabolic disorders of cattle affect dairy cows right after giving birth. The following metabolic abnormalities are the most frequently found in dairy cows within the first month following parturition: (1) subacute and acute ruminal acidosis, (2) laminitis, (3) ketosis, (4) fatty liver, (5) left displaced abomasum (LDA), (6) milk fever, (7) downer cow, (8) retained placenta, (9) liver abscesses, (10) metritis, (11) mastitis, and (12) bloat**.** These illnesses are referred to as metabolic disorders because they are linked to the disruption of one or more blood metabolites in ill cows. For instance, fatty liver is linked to increased non-esterified fatty acids (NEFA) and their accumulation in the liver, while acidosis is linked to increased production of organic acids (such as acetic, propionic, and butyric acids). Ketosis is also linked to increased levels of ketone bodies (i.e., beta-hydroxybutyric acid – BHBA) in the blood. For dairy cows, the transition period—which lasts for three weeks before and three weeks after parturition—is extremely important. The transition from a non-lactating to lactating state, hormonal changes, a significant decrease in feed consumption, and a change in diet from a roughage-based diet (such as hay and grass) to one high in fast fermentable carbohydrates are all connected with this time period (i.e., high-grain diets). Low rumen pH, rumen metabolism, and milk fever are all linked to lower blood calcium levels and may lead to downer cow, LDA, metritis, mastitis, laminitis, retained placenta, and bloat

What is Transition Period?

- It is period from dry off through parturition
- Late lactation
- Dry period
- Parturition
- Early lactation

Why A Transition Period

- Diets for dry cows are frequently hefty and lacking in nutrients.

- When cows freshen (milk production begins), they introduced immediately to very dense (energy rich) ration
- This could cause a lot of issues if not handled appropriately.

1. Milk Fever

Milk fever (Parturient Paresis), also known as hypocalcaemia, is a condition that can be avoided in lactating dairy and beef cows. Milk fever affects five to eight percent of cows. Usually, this disease shows up within the first 24 hours after calving. In some circumstances, it may even happen up to three days after calving. Both the immune system of the cow and neuromuscular function are significantly influenced by calcium.

The clinical signs of milk fever can be classified into three stages:

- **Stage 1:** The cow may appear agitated and tremble and tense her muscles (may go unnoticed). – reluctance to move or eat; the animal may stagger and/or develop stiff hind limbs.
- **Stage 2:** The cow will typically have a "kink" in her neck or her head curled along her flank and will be discovered lying down or sitting down and unable to get up. Poor body temperature, low body luster, hard breathing, rapid heartbeat
- **Stage 3:** Cows frequently appear to be unconscious and unresponsive. The animal will extend its legs out and lie on its side; bloat frequently occurs and regurgitation is likely: - The majority of animals in this stage will perish if untreated.

Common observable symptoms in milk fever:

1. An uneven walk is the first sign of the condition. It might be apparent during the day. When the cow eventually settles down, you will notice that her ears are cold and typically droopy.
2. Early signs include paddling with the back feet and swaying as if about to fall over if the cow is on her feet. Once she is on the ground, she will turn her head and neck to the side as if she had a kink. Her nose starts to dry up.
3. If not treated, the symptoms get worse until the cow passes out.

Nutritional precautions against milk fever

The feeding practices used both during pregnancy and right after calving directly affect the incidence of milk fever. By using the proper feeding techniques throughout the aforementioned times, milk fever can be avoided. The following feeding techniques are advised for dairy cows that produce a lot of milk in order to avoid milk fever.

Calcium restriction during the prepartum (before giving birth) period

Animal life depends on calcium for a number of processes. Calcium is an essential mineral. Calcium shouldn't ever be added before calving as a milk fever preventative measure. Dietary calcium intake should be low as well (about 20 g per day). When taken a week or so prior to calving, vitamin D considerably reduces the risk of milk fever and aids in the absorption of calcium from the digestive tract.

Magnesium supplementation

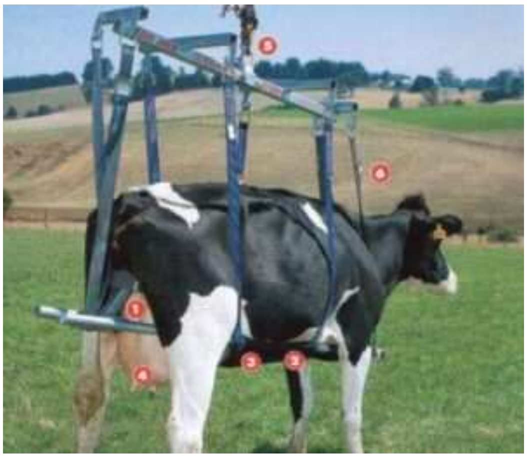
Magnesium is crucial for keeping the level of calcium in an animal's blood, which makes it indirectly responsible for the development of milk fever. Milk fever in dairy animals can be avoided by supplementing with magnesium at a rate of 15 to 20 g/day coupled with a source of readily digested carbohydrate. Magnesium should be given throughout pregnancy at a rate of 0.4% of dry matter of the diet.

Supplementation of calcium to susceptible animal after calving

Using this approach as your first line of defense against something is not advised. Given that there is a potential that calcium homeostatic pathways would be disrupted, supplementation should be done based on the caliber and calcium content of the food being delivered.

2. Downers Cow Syndrome

When a cow is unable to stand, it becomes recumbent. When a cow is lying down, it is frequently referred to as being "down," and when it has been down for a while, it is referred to as a "downer cow."



There are many causes of a downer cow, including:

1. Injury at or immediately following calving: Bone fracture or paralysis
2. Metabolic: hypomagnesaemia or milk fever (hypomag or grass staggers)
3. Mastitis or metritis are toxic diseases.

When the primary cause is eliminated but the cow still doesn't rise, it becomes a downer cow. Due to muscular and nerve injury, this failure to rise is typically noticed within 24 hours of the cow falling off her feet. Damage happens from a cow falling off its feet, which puts a lot of pressure on its muscles and nerves. Many conditions make this worse since the cow is unable to change positions to stop continuous carrying of weight. The primary causes of recumbency can be divided into 4 categories:

Metabolic:

- hypocalcaemia
- hypokalaemia
- nutritional acidosis
- ketosis
- fatty liver disease

Inflammatory:

- Acute septic metritis
- Acute mastitis
- Acute peritonitis (e.g., traumatic reticulitis/ruptured uterus)

Neurological:

- Obturator, sciatic or femoral nerve paralysis (e.g., calving paralysis is damage to L5/L6 outflow of obturator and sciatic).

Traumatic:

- fractured femur
- dislocated hip
- muscle, tendon or ligament rupture

Timings and impact (6 hours down)

- The weight of the cow causes damage to its muscles, nerves, and joints.
- It has been shown that just 2% of dairy cows treated for milk fever within six hours developed a downer cow
- If treated within Seven to twelve hours 10% of dairy cows treated for milk fever developed a downer cow.
- More than 25% developed depressive tendencies. Not treated till 18+ hours.
- Almost 50% of cows that weren't treated until after 18 hours couldn't get up.

Clinical Signs

- A cow that just had calves (usually less than 48 hours)
- Unable to stand up for some unknown reason
- Lie with your back straight (on the breast bone)
- Alert, frequently eating, drinking, and peeing and pooping
- Few attempts to stand up, but few move around on their forelimbs (creeper cows)

Diagnosis

1. Based on the above-mentioned clinical symptoms
2. Because the downer cow is an exclusionary diagnosis, a vet visit is necessary to rule out conditions like metritis, broken bones, nerve paralysis, and peculiar milk fevers.
3. Blood tests and the presence of reflexes can both be highly helpful in determining the prognosis.

Treatment

- If you're housed, move to a well-bedded yard or loose-box
- The secret to success is quality nursing care. Give the cow access to food and water in convenient, wide-based containers, shelter, and a soft surface. If the cow isn't shifting its weight, be sure you force it to do so at least twice a day.
- Raising the cow mechanically, like using a sling, can be helpful for treatment and diagnostics. To increase support if there is nerve injury, hobbling could be useful.
- Keep a watchful eye out for toxic mastitis because it can develop in cows with no history of mastitis.
- Supplement with calcium, phosphorus, and magnesium as needed
- In cases that are more serious, local disinfection and treatment are required.

Prevention

A challenging calving was the main issue in 46% of downer cows. Good calving management is therefore essential. Although there are many elements that affect good calving management, the following four are perhaps the most crucial ones:

- Create a healthy habitat that is clean, dry, and has low stocking densities.
- Verify that the cows' BCS values at calving are between 2 and 3.5.
- Keep a safe distance and avoid getting too involved.

- Recognize when to ask for and accept support.
- Pick a bull with a high grade for calving ease. Milk fever was the main reason for 38% of the downer cows. The quantity of downer cows will be drastically decreased if milk fever is prevented.

3. Grass Tetany

Hyperexcitability, muscular spasms, convulsions, respiratory distress, collapse, and death are all symptoms of hypomagnesemic tetany, a complex metabolic disturbance characterized by hypomagnesemia (plasma tMg 1.5 mg/dL [0.65 mmol/L]) and a reduced concentration of tMg in the CSF (1.0 mg/dL [0.4 mmol/L]). The loss of Mg in milk makes adult lactating animals the most vulnerable. Hypomagnesemic tetany can affect breastfeeding beef cows fed silage indoors, but most typically affects animals grazing on lush grass pastures or green cereal crops. Although it rarely happens in cattle that aren't breastfeeding, it has happened when undernourished animals were given access to green cereal crops.

Cause: The grass tetany season lasts from February to April, Typically sees a burst of new forage growth. Forages cultivated on soils that are low in magnesium, moist, or that are high in potassium and nitrogen but low in phosphorus may have very low levels of magnesium and calcium. Additionally, a lot of spring calves are born and nursing during this time of year. Cattle that are high yeilders, are most frequently afflicted by grass tetany. When the amounts of magnesium and calcium in forages are insufficient to meet the needs of cattle and cattle are not given enough magnesium and calcium supplements, grass tetany develops. Nervousness, muscle twitching, and stumbling while walking are clinical indications of grass tetany. If untreated, an infected animal may collapse on its side, go into convulsions, and endure muscle spasms.

Prevention: Magnesium levels in pasture may benefit from phosphorus fertilization. However, it is important to take into account the environmental issues related to high soil phosphorus levels. When included in the fodder regimen, legumes are frequently high in magnesium and may help lower the risk of grass tetany. The best way to prevent grass tetany is to boost diet with extra calcium and magnesium throughout the grass tetany season.

4. Hypomagnesemic Tetany in Calves

When calves are fed milk, the efficiency of magnesium absorption decreases, going from 87 percent at 2-3 weeks to 32 percent at 7-8 weeks. In 2- to 4-month-old calves being fed just milk or in younger calves with persistent scours being fed milk substitute, hypomagnesemic tetany can develop. Clinical symptoms include hyperexcitability, muscle spasms, convulsions, and death and are comparable to those of hypomagnesemic tetany in adult cattle.

Treatment

Calves: 10% solution of $MgSO_4$ 100ml S/c must be admistered right away to the calves followed by 10 grams of MgO each day orally.

5. Ketosis in Dairy Cows

The first six weeks of lactation are the most frequent time that dairy cows experience the metabolic illness ketosis. Adult cattle commonly suffer from ketosis. Early lactation is when it generally affects dairy cows and is most frequently characterized by partial anorexia and sadness. Rarely, it affects cattle in the late stages of pregnancy, when it resembles pregnancy toxemia in ewes. Along with lack of appetite, occasionally people will notice indicators of nerve dysfunction such pica, abnormal licking, unsteadiness and strange walking, bellowing, and hostility.

Cause

The primary culprit is a confluence of high energy requirements at the start of lactation and insufficient energy in the feed (e.g., poor quality silage, very coarse hay). A cow is only able to consume a certain amount of fodder each day. The animal has a net energy loss that worsens over time and lowers blood sugar levels if the energy provided by the ingested feed is less than what the cow needs. The liver transforms body tissue (protein, fat) into more glucose to supply more energy (sugar). Ketone bodies, which are harmful byproducts of this process and must be eliminated, are produced. The cow becomes ill if the blood's ketone concentration is too high.

Signs and Symptoms

The highest productive dairy cows are impacted by ketosis, which starts with extremely subtle symptoms that are first simple to ignore. Animals that are affected eat less and produce less milk. The cow seems to be dozing off and often excretes solid waste that is mucous-covered. The animal loses weight quickly (using its energy reserves) if the condition gets worse. Cattle that are ill may try to eat odd feed in addition to refusing to eat grain, concentrate, or dairy flour (coarse straw, twigs, soil, abnormal objects). Due to the increased ketone levels, the animal stands with a humpback and some exhibit a peculiar fruity to musty odor in their breath and urine. Untreated cows may exhibit strange behavior (such as staggering, circling, head pressing, continuous licking, bellowing – like Rabies!), lose their ability to stand, and have other health issues.

Clinical Findings

Reduced feed intake is typically the first indication of ketosis in cows kept in stalls. When given meals in parts, cows in ketosis frequently prefer grass to grain. The earliest indicators of ketosis in group-fed herds are typically reduced milk output, lethargy, and an abdomen that seems "empty." Physical examination reveals that cows are febrile and possibly mildly dehydrated. Rumen motility varies, sometimes being hyperactive and other times hypoactive. There are frequently no additional physical problems. In a small percentage of instances, CNS abnormalities are detected. These include unusual licking and chewing, with cows occasionally gnawing unceasingly on pipes and other nearby things.

Prevention and Control:

Late in the lactation period, when cows typically grow overweight, body condition should be controlled. It may be possible to help allocate dietary energy toward milk production and away from body fattening by modifying the diets of late lactation cows to boost the energy supply from digestible fiber and decrease the energy supply from starch. Feeding milch animals with balanced ration to the extent of nutritional requirements based on its production will prevent ketosis condition.

6. Pregnancy Toxaemia in Cow

Pregnancy toxaemia, often known as fat cow syndrome, mostly affects cows who were previously well-fed and in good physical condition in late pregnancy when their food intake is reduced. In the latter two months of pregnancy, over-fat pregnant cows given insufficient nutrition may develop a condition similar to pregnancy toxaemia (twin lamb illness) in sheep.

Cause of the disease

In the form of glucose, pregnant cows need a lot of ready energy to support their growing calves. There are two sources for this. The meal that is ingested through the rumen is first converted to glucose in the liver. Second, fat stores are released and transported in the circulation to the liver where they are converted to glucose by the liver. To make up for the shortfall that usually happens during pregnancy, when energy demands are high, this is a typical process.

Signs and Symptoms to look out for in Cattle

- Pregnant
- A lesser or nonexistent hunger
- melancholy and depression
- Separate from the herd. 5. Nasal breathing. 6. A sweet, acetone-like odor can be detected on their breath. 7. Neurological symptoms (staggering, aggression, delirium)
- Downer cows become recumbent 2–2 weeks before they pass away.
- Death

Prevention

Nutritional control is key to prevention. At calving, cows should be in good condition (condition score of 3 or higher), and the post-calving feed supply should be of adequate quality and quantity to prevent significant condition loss in the lactating cows.

- silage: 10 to 11 kg fresh per head per day
- good hay: 3.5 to 4.5 kg per head per day
- grain: 3.0 kg per head per day
- cottonseed meal: 2.5 kg per head per day
- grain and white cottonseed: 1.25 kg of each per head per day. About 1% calcium should be fed with grain and cottonseed supplements.

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Chapter-4

CHEMICAL QUALITY ANALYSIS OF MILK & MILK PRODUCTS AND TESTS FOR CHECKING ADULTERATION IN DAIRY PRODUCTS

M. SahityaRani
Assistant Professor, Department of LPT,
PVNRTVU, Hyderabad, India

Introduction

Analysis of milk and milk products is done to know the composition, quality and the quantity of ingredients required in manufacturing the product. Chemical analyses are performed for several reasons: (1) truth of labelling (2) food safety (3) compliance with food regulations (4) farmer payment (5) to provide compositional information to manufacturing personnel for adjustment of process parameters (6) herd improvement (Evers and Hughes, 2002). The chemical composition of milk and its physico-chemical characteristics provide scientific basis for process of milk and manufacture of products. Milk is valued commercially for two parameters - fat and solids nonfat (SNF). The SNF largely consists of proteins, lactose and minerals. The term total solid (TS) refers to the quantity of SNF plus fat present in milk. To determine the quality of a product, tests for acidity, adulterants, preservatives etc. have to be carried out. Knowledge of methods, good laboratory practices and good testing skills are required in the analysis of milk and milk products (Sharma and Lal; Gandhi et al., 2020).

Liquid Milk

Buffalo milk, cow milk, goat milk, sheep milk, mixed milk, standardised milk, full cream milk, recombined milk, toned milk, double toned milk, and skimmed milk are different types of milk that are marketed as laid down under FSSAI Rules.

Dairy Products

Butter, Ghee, paneer, Chhana, Sterilised milk, Ice cream, Cream etc are subjected for chemical analysis.

Sample

Sample is defined as true representative portion of a substance from which it is collected. It should represent the source from which it is obtained. The method of sampling differs on the basis of purpose for which sample is collected.

Why sampling has to be done

- For chemical analysis
- For bacteriological analysis

Materials required

- Plunger
- Dipper-not less than 80 ml capacity
- Agitator
- Sample bottle-100,150 or 250ml capacity size of sample bottle depending on quantity of milk collected for analysis.

Procedure for sampling of milk

1. **Individual**

In case of small quantities pour milk from one container to another repeatedly for three to four times. Then collect the sample with help of dipper and pour into the sampling bottle.

2. **Milk Cans**

The milk should be properly mixed with the plunger in different directions to achieve uniform mixing of milk, then collect the sample with help of dipper.

3. **Storage tanks / Milk silos**

The tanks of capacities more than 10,000 lit. are referred to as silos. The milk should be mixed with mechanical agitators or pneumatic air compressors were the proper mixing of milk is achieved. The sample should be collected from the outlet (tap) provided to the silo in the sampling bottle aseptically. It should be properly labelled and dispatched.

4. **More than one container**

If the containers are of same capacity, the milk in all containers should be uniformly mixed with the help of plunger and collect equal quantity of sample from all containers. If the containers are of the different capacities, collect the sample accordingly.

E.g. If can A is of 10 lit. Capacity and can B is of 20 lit. Capacity then withdraw 100 ml from A and 200 ml from B.

Polypacked / bottled milk

Pick up two to three packets/bottles at random from the distribution center then label it, pack in the ice box and dispatch to the laboratory immediately.

Composite Sample

- The amount of milk collected from the source for a period of several days is referred to as composite sample. The composite sample is preserved at room temperature by adding preservatives to prevent spoilage until it is analysed.
- The result of analysis gives an average figure for total amount of milk received during the period.
- The preservatives include mercuric chloride, potassium dichromate, formalin (36%), chloramphenical, sodium azide etc.
- Mix the milk thoroughly from each milking bottle with a plunger and transfer a proportionate amount into a rubber stoppered sample bottle.
- Then label it and dispatch.

Precautions to be taken

1. For chemical examination, the sampling equipment should be clean and dry.
2. For bacteriological examination, the equipment should be properly sterilized by one of the following method. The sample should be collected aseptically and refrigerated until analysis.
   a. By heating in hot air oven for 2 hrs at 160^0C
   b. Autoclaving for not less than 15 min at 120^0C
3. Under field condition, equipments may be sterilized by immersing in boiling water for 5 min.
4. Rubber stoppers should be properly sterilized
5. For bacteriological examination, avoid the air space
6. Sample bottles examined for flavor should be closed by grease-proof, non-absorbent stoppers so that no deleterious odour or taste is imparted.

Platform Tests

Milk produced under unsanitary condition and exposed to various atmospheric condition for long periods may prone to microbial attack which ultimately lowers the keeping quality. Such milk is not suitable for processing into various milk products. Hence it is important to assess the milk quality by employing various tests on milk receiving platform.

Clot on Boiling (COB) test

It is the quick test to determine the developed acidity and the suitability of milk for processing.

Materials required

- Milk sample
- Test tubes (5 ml)
- Test tube holder
- Water bath
- Pipette

Procedure

1. Transfer 5 ml of milk sample to the test tube.
2. Place the tube in boiling water bath and hold for about 5 min.
3. Remove the tube and rotate it gently in an almost horizontal position and observe for presence of any precipitated particles.

Interpretation

- Presence of any precipitated particles is an indicative of positive result.
- The instability of milk on boiling may also be due to high protein content (colostrum) and high salt content (Mastitis).

Alcohol test

This test is used for rapid assessment of stability of milk to processing, particularly sterilization and condensing. The principle of this test is similar to that of clot on boiling test. In this test instead of heat, alcohol is used to obtain clotting. This test aids in detecting milk such as colostrum, milk from animals in late lactation, milk from animals suffering from mastitis.

Materials required

- Test tube (10 ml)
- Pipette (5 ml)
- Test tube stand
- Reagents
- Ethyl alcohol (75% v/v or 68%w/v, density 0.8675 g/ml at 27^{0}C)

Procedure

1. Place 5 ml of well mixed milk sample in a test tube and add equal quantity of alcohol.
2. Mix the contents of the test tube by inverting several times.
3. Observe for presence of flakes or clots.

Interpretation

- The presence of flakes or clots denotes positive test. Such milk is not suitable for manufacture of evaporated milk which has to be sterilized to ensure its keeping quality.
- A negative test indicates low acidity and good heat stability of the milk sample.

Alizarin- alcohol test

This test is similar to alcohol test and the incorporation of alizarin dye helps to detect the appropriate percentage of acidity.

Materials required

- Test tube
- Pipette (5 ml)
- Test tube stand
- Reagents
- Alizarin solution - 0.2% in ethyl alcohol.

Procedure

1. Transfer 5 ml of well mixed milk sample into a test tube.
2. Add equal amount of alizarin solution
3. Mix the contents of the test tube by inverting several times.
4. Note the colour of mixture and presence of flakes or clots. Also note the size of flakes whether small or large.

Interpretation

Colour	Size of the flakes	Approximate acidity (% LA)
Lilac	-	Upto 0.14
Pale Red	-	0.14 to 0.17
Reddish Brown to Brown	Small flakes	0.17 to 0.20
Brownish yellow to yellow	Large flakes	Over 0.20

- If acidity has not developed and the milk is coagulated- it indicates the presence of rennet producing bacteria (sweet curdling).
- Mastitic milk (alkaline in reaction) when mixed with alizarin alcohol solution, a violet or purple colour is produced.

Sediment test

This test reveals the extent to which visible insoluble matter has gained entrance to the milk. This is an indicative of cleanliness of milk with respect to visible dirt. This test is carried out by allowing a measured quantity of milk to pass through a fixed area of filter disc and comparing the sediment left with the prepared standards.

Determination of pH

It gives measure of true acidity in milk. As the acidity increases pH value decreases and vice versa. The pH of the milk is determined rapidly by using digital pH meter.

Procedure

1. Standardize the pH meter by using buffer solutions.
2. Then insert the pH meter into the sample and record the reading.

Interpretation

- The pH of normal milk is around 6.6-6.8.
- Average cow milk gives pH of 6.6 and buffalo milk 6.8.
- pH over 6.9 is considered as suspicious.
- In case of mastitis the pH of milk will be more than 7.

Organoleptic Tests

Organoleptic tests are widely used in all dairies. The evaluation of quality of milk is by use of human sense of olfaction and eyes. They include visual appearance, smell and flavor. The flavor of the milk is a blend of sweet taste of lactose and salty taste of minerals, both of them are mask down by proteins. The flavor is contributed by phospholipids, fatty acids and milk fat. Milk should have pleasant smell. The taste of normal milk is pleasant and mild. It absorbs the off flavor from the surrounding. Milk obtained from cow occasionally may have off flavor which may be attributed by some feed stuff. E.g. Silage. The microbial multiplication in milk produces off flavor - is good indication.

The presence of dirt, dung, hair particles, oil specks and other particulate matter is clear cut indication of non-practicing of clean milk production. An experienced person can pick out bad samples with high degree of accuracy.

The organoleptic tests should be conducted soon after removing the lid of each container.

Procedure

- Smell the milk.
- Observe the appearance.
- Check the lid after removal and the container as soon as it is emptied and record your observation.

Proximate Analysis

Determination of Moisture Content.

The moisture content of the sample is the measure of percentage moisture lost due to drying at a temperature of 105ºC. The samples (2g) each was weighed (W1) into a pre-weighed crucible (W0) which was dried in hot drying oven at105ºC for 3 hours, then the crucible was removed, cooled in a desiccator and weighed. The process of drying, cooling and weighing was repeated until a constant weight (W2) is obtained. The weight loss was calculated using the equation and all values were recorded for each sample.

$$\% \text{ moisture} = \frac{w1-w2}{w1-wo} \times 100$$

Where: W1 = Initial weight of the sample W2 = Weight of the dried sample W0= Weight of empty crucible.

Determination of Ash Content

The direct heating method was used to determine the ash content. Each milk samples (10 g) was measured into a crucible of known weigh separately; the samples were burnt to ash in a muffle furnace for 5hours at 550ºC until all the organic matters are burnt leaving a white residue. They were cooled in a desiccator and the weights of the ashes were determined. All values were recorded.

$$\% \text{ Ash} = \frac{W2-W0 \times 100}{W1-W0}$$

Where: W0 = weight of empty crucible W1 = Weight of milk sample + crucible, W2 = weight of ash + crucible

Determination of Protein Content

The macro Kjeldahl method was used to determine the crude protein content. The method is based on the principle of digestion, distillation and titration to calculate percent Nitrogen content of milk sample. 1ml of milk sample was introduced into the digestion flask.

Potassiumsulphate (10 g), one tablet of sodium sulphate (catalyst) and 20ml of concentrated sulphuric acid were added to the digestion flask. The flask was placed on the digestion block in fume cupboard and subjected to heat until frothing ceases giving a clear solution. The mixture was allowed to cool and was diluted with 90ml of distilled water and 80ml of 40% sodium hydroxide was added plus few anti-bumping granules. The solution was allowed to boil. Then, 50ml of saturated boric acid was prepared and poured inside a 100ml beaker with the addition of 1ml of Bromocresol indicator and the boiling solution was distilled into the beaker until it reaches 100ml. Then, 50ml of the stirred solution was titrated with 0.1N HCl until a wine color appeared. The nitrogen in the sample was then determined.

$$N (\%) = MHCl \times T \times 0.01401 \times 100$$

Where: M= molar concentration of acid and T = titre value

% Crude protein = % Nitrogen × 6.25

Determination Fat Content

The Soxhlet solvent extraction method was used to determine the fat content. Each of the milk sample (2 g) was weighed (W0) into a porous thimble and covered with a clean white cotton wool. Petroleum ether (300 ml) was poured into an extraction flask, which was previously dried in the oven at 105ºC, cooled and weighed (W2). The porous thimble was placed inside the Soxhlet and all apparatus assembled together. The extraction was done for 3hours. The thimble was removed carefully and the extraction flask placed in a hot water bath so as to evaporate the petroleum ether and then dried in an oven at a temperature of 105ºC to completely free the solvent and the moisture. It was cooled in a desiccator and reweighed (W1). The same experimental procedure was repeated for all samples. All values were recorded.

$$\% \text{ Fat} = \frac{W1 - W2}{W0} \times 100$$

Where: W0 = weight of Sample in gram, W1 = weight of flask + oil, W2 = weight of the flask.

Determination of Crude Fibre Content

The crude fibre was determined as the fraction remaining after digestion with standard sulphuric acid and sodium hydroxide under careful controlled condition. Five grams (5 g) each of the measured milk samples were used. The fibre sample was weighed into 500 ml prepared sulphuric acid solution. The mixture was boiled for 30 minutes, refluxed 3 times by boiling water and was followed by the addition of 100 ml prepared sodium hydroxide. The beaker was heated and the boiling was allowed to continue for another 30 minutes. Finally, the fibre was extracted and was dried by moistening with small portion of acetone which was allowed to drain. The sample in the crucible was incinerated at 550ºC for 3hours until all carbonaceous matter was burnt. The crucible containing the ash was cooled in the desiccator and the weight was taken.

$$\% \text{ Crude fibre} = \frac{W1 - W2}{W} \times 100$$

Where: W = weight of sample used W1 = Weight of sample and crucible before ashing W2 = Weight of crucible and ash.

Determination of Carbohydrate Content

The carbohydrate content was determined by method of difference. The values were calculated using equation

CHO = 100 - % (ash + protein + fat +crude fibre + moisture).

Determination of Fat %

Determination of fat% in milk plays major role as the fixation of price of milk and some of the dairy products are based on the fat percent of milk. It also helps to detect the adulteration of milk like watering and skimming of milk.

Methods of determination of Fat

1. Gravimetric method
    - In this method the fat% is estimated by extraction with various solvents.
2. Volumetric method

    This includes
    - Gerber's test
    - Babcock test
3. Electrometric method
    - In this method fat% is estimated by use of electronic milk-o-tester.

Advantages

- Small quantity of milk is required.
- Measures fat% accurately.
- Man power required is less.

Gerber's Acid Test

Principle

This test is carried out by treating the milk with certain amount of gerber's acid of known specific gravity and a small amount of alcohol which facilitates the separation of fat. The gerber's acid dissolves the non fat substances in the milk and amyl alcohol reduces the surface tension and reduces the tendency of burning of fat.

Materials required

- Milk sample
- Milk butyrometer
- Milk pipettes (10.75 ml)
- Gerber's centrifuge
- Stopper and stopper pin (key)
- Butyrometer stand.
- Tilt measure bottle or automatic tilt measure (1 ml)
- Tilt measure bottle or automatic tilt measure (10 ml)

Reagents required

- Gerbers acid (prepared by mixing 1 ml of distilled water and 9 ml of concentrated sulphuric acid)
- Amyl alcohol

Procedure

1. Place the butyrometer in butyrometer stand.

2. Take 10 ml of gerbers acid with tilt measure bottle or automatic tilt measure and pour into butyrometer.
3. Mix the milk sample properly and transfer 10.75 ml of milk sample into the butyrometer with the help of milk pipette slowly through the wall of butyrometer.
4. Add 1 ml of amyl alcohol into the butyrometer
5. Close the neck of butyrometer with the stopper without disturbing the contents.
6. Mix the contents of butyrometer thoroughly by inverting butyrometer stand several times until all the curd particles has been dissolved.
7. Then place the butyrometers in the centrifuge tubes and centrifuge approximately 1100 rpm for 3-4 min.
8. Then remove the butyrometers from the centrifuge tubes carefully without disturbing the contents and read the column of fat on the scale of butyrometer.
9. Adjust the position of fat column with the help of key and note the fat percentage.

Determination of Total Solids and Solid Non Fat (SNF) in Milk

Total solids in milk refer to that portion of milk which is left after complete evaporation of moisture from the milk. It includes fat, proteins, lactose and minerals of milk. The total solids in milk without its fat content constitute SNF. It includes protein, lactose, minerals and other constituents.

Determination of Total Solids and Snf by using Lactometer

Principle

When a floating body is immersed in a fluid, it displaces the volume of the fluid equal to the weight of the floating body.

Materials required

- Milk sample
- Lactometer
- Lactometer jar
- Petri plate
- Dairy thermometer

Procedure

1. Fill the lactometer jar with well mixed milk sample up to its brim.
2. Note the temperature of the milk with the help of dairy thermometer.
3. Place the lactometer in the lactometer jar and allow it to float freely.
4. Note the reading of lactometer without any parallax error, which is referred to as OLR (observed lactometer reading).
5. Then calculate the CLR (corrected lactometer reading).

Calculations

CLR= OLR ± 0.1 for every 1^0F raise or fall from 68^0F.

$$\text{Specific gravity} = 1 + \frac{CLR}{1000}$$

$$\% \ SNF = \frac{CLR}{4} + 0.22F + 0.72$$

$$\%TS = \frac{CLR}{4} + 1.22F + 0.72$$

Determination of Total Solids in Milk by Gravimetric Method

Materials required

- Milk sample
- Shallow flat bottomed dishes (aluminum alloy, nickel, Stainless steel, silica)
- Analytical balance
- Hot air oven
- Pipette
- Desiccator
- Steaming water bath
- Tongs

Procedure

1. Weigh accurately the clean, dry empty dish with lid.
2. Pipette out 5 ml of well mixed milk sample into the dish and weigh with lid.
3. Place the dish without lid, in a boiling water bath.
4. After 30 minutes remove the dish, wipe the bottom and transfer to a well-ventilated hot air oven maintained at 100^0C.
5. After 3hrs, cover the dish and immediately transfer it to a dessicator and allow it to cool for about 30 minutes and weigh.

Calculation

$$\text{Total solids \% by weight} = \frac{100w}{W}$$

w = weight in grams of the residue after drying

W= weight in grams of the prepared sample taken for the test.

Determination of Titratable Acidity

Titratable acidity test is employed to ascertain the keeping quality of milk and its stability towards application of heat. Though the titratable acidity of the milk is not a true measure of lactic acid present in milk, but in practice gives good indication of quality of milk.

Principle

It is based on the end point titration. A known volume of sample with indicator is titrated against the known strength alkali and end point is determined.

Materials required

- White porcelain basins or small beaker 50 ml
- Pipette 10 ml
- Burette with stand
- Stirring rod.

Reagents

- Standard sodium hydroxide solution 0.1N
- Phenolphthalein indicator solution

Procedure

1. Take 10 ml of thoroughly mixed sample with the help of pipette and transfer into beaker.
2. Add 2-3 drops of phenolphthalein indicator solution and stir the contents with glass rod.
3. Take 0.1N NaOH into the burette and note the initial reading.
4. Titrate the contents against 0.1N NaOH solution drop by drop until pale permanent pink colour is achieved. Note the final reading.
5. The difference between initial reading and final readings gives the volume of 0.1N NaOH consumed.
6. Repeat the procedure and take average volume of two samples.

Calculations

$$\text{Titratable acidity (\% LA equivalents)} = \frac{0.009 \times \text{Vol. of 0.1N NaOH consumed}}{\text{Wt. of the sample}} \times 100$$

$$\text{Wt. of the sample} = \text{Volume of the sample} \times \text{Specific gravity}$$

Detection of Adulterants and Preservatives in Milk

Adulteration is defined as either addition or removal of one or more valuable constituents of milk partly or completely or adding foreign substances. Detection of adulteration is important to safe guard the health of consumer and also to promote fair and healthy marketing system of milk and dairy products.

Milk is commonly adulterated by

1. Reduction of fat
   - Addition of water.
   - Skimming of milk.
2. Addition of Thickening agents after dilution with water to restore consistency, viscosity and total solids content.
3. Addition of colouring matter to restore colour lost by skimming or diluting or to make naturally looking poor milk to appear rich.
4. Addition of synthetic milk to full fill the market supply.

Test for detection of added water

Adulteration of milk with water is most common practice in our country.

Addition of water to milk is detected by many methods like

- Determination of Specific gravity of milk.
- Determination of milk fat.
- Determination of Total solids of milk.
- Nitrate test.
- Freezing point determination.
- Determination of refractive index of milk.

$$\text{Estimates SNF content of milk sample of water added} = \frac{A-B}{A} \times 100$$

A- Standard SNF

B- SNF of milk sample

(Buffalo milk-9, Cow milk-8.5)

$$\text{\% fat removed} = \frac{A-B}{A} \times 100$$

A- Standard fat%

B- Fat% of milk sample

Tests for detection of Thickening agents in milk

Detection of Cane sugar

- Take 10 ml of milk into a test tube
- Add 0.1g of resorcinol powder and mix thoroughly
- Add 1 ml of conc. Hcl and mix well
- Place the tube in boiling water bath for 5 min and observe the colour.

Inference

Development of rose red colour indicates the presence of cane sugar.

Detection of Gelatin

- Take 10 ml of well mixed milk sample.
- Add equal quantity of acid mercuric nitrate solution and mix well.
- Add 20 ml of distilled water and mix well.
- Allow it to stand without any disturbance for 10-15 minutes.
- Filter the solution through filter paper.
- Take 2-3 ml of filtrate and add small amount of picric acid solution and observe for the change in colour.

Inference

Yellow precipitate or cloudiness indicates the presence of gelatin.

Detection of Starch

- Take 10 ml of well mixed milk sample in a test tube and boil it.
- After cooling the sample, add 1 ml of 5% iodine solution.

Inference

Development of blue color indicates presence of starch in milk.

Detection of skim milk powder

- Take 50 ml of milk sample in two centrifuge tubes
- Centrifuge the tubes at 3000 rpm for 30 minutes and decant the supernatant carefully.
- Add 2.5 ml of conc.HNO_3 to dissolve the residue and dilute the solution by adding 5 ml of water.
- Then add 2.5 ml of liq NH_3 and observe.

Inference

Presence of skim milk powder imparts orange colour with nitric acid.

Detection of Sodium bicarbonate (Rosalic acid test)

- Take 5 ml of milk in a test tube
- Add 5 ml of alcohol and few drops of 1% (w/v) alcoholic solution of rosalic acid, mix and observe.

Inference

If the carbonates are present, a rose red colour appears whereas pure milk shows brownish discolouration.

Detection of Urea or Synthetic milk

Synthetic milk is a mixture of water, pulverized soap or detergent, sodium hydroxide, vegetable oil, salt and urea. The ingredients of synthetic milk are calculated in such a way that the fat and SNF% are similar to the genuine milk. But in health point of view, it is highly dangerous and objectionable. Sometimes to increase the SNF content of milk, sugar, starch, wheat flour and rice flour are added.

Procedure

- Take 5 ml of milk in a test tube and add 0.2 ml urease and 0.1 ml of 0.5% bromothymol blue. Mix the contents.

Inference

Development of distinct yellow color indicates addition of Urea.

Tests for Detection of Preservatives In Milk

Detection of Formalin (Hehner test)

- Take 10 ml of milk in a wide mouthed test tube and pour 5 ml of conc.H_2SO_4 carefully through the wall of test tube so that it forms a layer at bottom, without mixing the milk.

Inference

A violet or blue colour at the junction of two liquids indicates presence of formaldehyde.

Detection of Hydrogen peroxide

- Take 5 ml of milk in test tube
- Then add 5 drops of 2% paraphenyline diamine solution.

Inference

Development of blue colour indicates the presence of Hydrogen peroxide.

Determination of Efficiency of Pasteurisation

In general, phosphatase test is used to judge the efficiency of pasteurization of milk either by batch holder process (63^0C for 30 min) or by the High Temperature Short Time (HTST method) where holding of milk at 72^0C for 15 sec is done. This test helps to indicate the presence or absence of the enzyme phosphatase which is naturally present in raw milk, and destroyed by pasteurization temperatures. When the heat treatment is less than specified above, some phosphatase enzyme remains active. The pasteurized milk sample should be tested within 48hrs after pasteurization and the samples should be at a temperature not exceeding 5^0C.

Principle

The phosphatase enzyme in the milk readily hydrolyses Di-sodium P-phenyl phosphate to p-nitrophenol which exerts yellow colour in alkaline solution, determined by calorimetric test.

Materials required

- Lovibond all-purpose comparator with stand.
- Standard discs giving 0,6,10,18,42 or 0,6,10,14,18,25,42 readings.
- Test tubes fitted with rubber stoppers.
- Milk sample.

Reagents

Buffer solution

Dissolve 3.5g of sodium carbonate (analytical grade) and 1.5g of sodium bicarbonate in 1000 ml of distilled water.

Substrate

Disodium p-nitrophenyl phosphate not less than 95% pure.

Buffer substrate

Transfer 0.15g of substrate into 100 ml measuring cylinder and make upto the mark with buffer solution. (The solution should not be stored for long periods, but may normally be kept in refrigerator for up to one week).

Procedure

1. Take 10 ml of buffer substrate solution in each of two test tubes and heat to 37^0C-38^0 C by placing in a water bath.
2. Add 2 ml of milk sample to one of the test tubes containing buffer substrate solution.
3. Add 2 ml of blank control to the second test tube.
4. Close the test tubes with rubber stopper and invert to mix the contents thoroughly.
5. Incubate the test tubes at 37^0C-38^0C and read the yellow colour.
6. After 30 min, return to the bath and take the second reading after incubation for a further 90 minutes.
7. Compare the colour developed using lovibond all-purpose comparator or use of any other calorimetric method to detect the intensity of yellow colour developed.

Interpretation

Disc reading after 30 minutes incubation	Interpretation
0 or trace	Properly pasteurised
6	Doubtful
10 or more	Under pasteurised

Disc reading after 2 hours incubation	Interpretation
0-10	Properly pasteurised
10-18	Slightly under pasteurised
18-42	Under pasteurised
42 & over	Gross under heating of milk or raw milk

Note: The 30 minutes test will reveal any serious fault in pasteurization, but to enable minor errors to be detected, readings shall be taken after further incubation for 90 min.

Test for Sterilized Milk

When milk is heated to sterilizing temperatures (104^0C-110^0C), the whey proteins gets precipitated completely. The test is made by adding sufficient ammonium sulphate to precipitate other substances, such as casein and heating the filtrate. If the milk has not been heated to 100^0C for atleast short time, the whey proteins remaining in solution will be revealed by turbidity in the heated filterate.

Materials required

- Test tube
- Test tube holders
- Whatman filter paper No.12
- Milk sample

Reagents

- Ammonium sulphate

Procedure

1. Weigh accurately 4.0g of ammonium sulphate into 50 ml conical flask.
2. Measure 20.0ml of milk sample and pour into the conical flask containing ammonium sulphate.

3. Mix properly such that ammonium sulphate is completely dissolved.
4. Leave for not less than 5 min and then filter through whatman filter paper No.12 into a test tube.
5. Collect atleast 5 ml of the clear filterate and transfer the tube to a beaker of cold water.
6. When the tube is cool, examine the contents for turbidity under day light.

Interpretation

Milk which shows no sign of turbidity has been satisfactorily sterilized.

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Chapter-5

CLIMATE RESILIENT DAIRY FARMING

Prabhat Kumar Pankaj*[1], JVNS Prasad[2] and Vinod Kumar Singh[3]

[1]Principal Scientist (LPM);
[2]Project Coordinator, AICRP-DA;
[3]Director ICAR-Central Research Institute for Dryland Agriculture,
Santoshnagar, Hyderabad – 500 059 (Telangana), India
*Corresponding author: pankaj.pk@icar.gov.in

Introduction

Climate change is a potent threat to dairy farming, especially under extensive systems. Dairy farming heavily emits methane which is 25 times more potent than carbon-di-oxide in terms of global warming potential. Climate-resilient dairy farming involves rearing dairy animals and producing milk in a way that minimizes climate change's harmful effects. Due to climate change, droughts, floods, and heatwaves are more frequent and severe, impacting dairy farming in terms of milk production, reproductive efficiency and sustainability. Droughts diminish fodder crop output, while excessive rainfall damages pastures and pollutes water. Other concerns for dairy farming include climate change-exacerbated water scarcity, disease risk, market and supply chain vulnerability. Dairy farmers are implementing climate-resilient farming strategies to respond to these problems and climate change so as to make dairy operations more sustainable and reduce their carbon footprint. Dairy research and innovation also help to develop climate adaptation and mitigation methods and technology which are complimentary options in farming.

Climate change and its impacts on animal agriculture are of growing concern due to the sector's significant contributions to greenhouse gas emissions, land use, and other environmental issues. Animal agriculture, particularly the production of beef, dairy, and other ruminant animals, is a major source of greenhouse gas emissions. Livestock emit methane during digestion (enteric fermentation), and manure management also produces methane and nitrous oxide. These gases are potent contributors to global warming. Apart from this animal agriculture is a leading driver of deforestation and land use change, especially in regions like the Amazon rainforest. Clearing land for grazing and growing animal feed crops contributes to habitat destruction and biodiversity loss. Animal agriculture is water-intensive, requiring large amounts of water for drinking, cleaning, and feed production. Water scarcity, exacerbated by climate change, can impact the availability and sustainability of water resources for livestock farming. The cultivation of feed crops for animals, such as soy and corn, is resource-intensive and can lead to deforestation, soil degradation, and increased greenhouse gas emissions. Climate change can disrupt the availability of water for irrigation and affect crop yields.

Rising temperatures and more frequent heatwaves can cause heat stress in animals, affecting their well-being and productivity. This is especially concerning for cattle, poultry, and swine. Climate change can influence the distribution and prevalence of diseases and parasites that affect animals, leading to increased health challenges and the need for more veterinary care and disease control measures.

To address the climate impact of animal agriculture, there is a growing emphasis on mitigation strategies. These include improving animal genetics, nutrition, and health to reduce emissions per unit of product, implementing sustainable manure management practices, and reducing food waste. There is growing interest in alternative protein sources, such as plant-based proteins and cultured meat, as more sustainable and climate-friendly options compared to traditional animal agriculture. Adopting sustainable farming practices, including rotational grazing, agroforestry, and organic farming, can reduce the environmental footprint of animal agriculture. Governments and international organizations are increasingly implementing regulations and policies to address the environmental impacts of animal agriculture. These may include emissions reduction targets, land use regulations, and incentives for sustainable practices.

Addressing the climate impact of animal agriculture involves a multifaceted approach that includes changes in production methods, shifts in consumer behavior, and supportive policies and incentives. The goal is to reduce emissions, conserve resources, and promote more sustainable and climate-resilient practices in the sector. Ongoing research and innovation are essential for developing technologies and practices that reduce the environmental impact of animal agriculture and enhance its resilience to climate change.

Climate change and dairy

Climate change poses a significant environmental challenge in addressing global issues such as hunger, malnutrition, disease, and poverty. The agricultural sector is particularly susceptible and responsive to the impacts of climate change because to its reliance on regional climate factors such as precipitation, temperature, and other related variables. In order to address the difficulties presented by climate change, it is imperative for the agricultural sector to adopt a "climate smart" approach. This entails the sustainable enhancement of agricultural output and incomes, as well as the adaptation and fortification of resistance against climate change. Additionally, efforts should be made to minimize or eliminate greenhouse gas emissions, whenever feasible. Despite the acknowledged significance of Climate-Smart Animal Agriculture (CSAA), the diffusion and adoption of climate-smart technology, techniques, and practices within the dairy farming sector remain a continuing and arduous endeavor. The criticality is in the adaptation of climate-related knowledge, technology, and practices to suit the specific local conditions. This process involves facilitating collaborative learning among farmers, researchers, and extension workers, as well as extensively disseminating techniques that promote Climate Resilient Dairying (CRD). The implementation of site-specific assessments is necessary in order to determine the appropriate dairy technologies and practices required for comprehensive rural development. The extension service has the potential to play a significant role in assisting farmers in addressing the many effects of climate change. This may be achieved by employing a suitable approach to raise awareness and educate farmers about the diverse solutions available for adapting to and mitigating the consequences of climate change in the dairy industry.

Climate change has the potential to impact dairy farming in various aspects. These include the productivity of milk, both in terms of quantity and quality. Additionally, dairy management practices may be affected due to changes in the quantity and quality of feed and fodder. Environmental effects, such as alterations in rainfall patterns, temperature, reduction in crop diversity, and changes in morbidity and mortality rates, may also be observed. Furthermore, adaptation strategies may be necessary as organisms within the dairy farming system may become more or less competitive. For instance, the cultivation of drought-tolerant varieties of fodder or the use of tillering maize could be considered as potential adaptations. In order to address the intricate obstacles presented by climate change, it is imperative for the agricultural sector, encompassing forestry and fisheries, to adopt a "climate smart" approach. This entails the sustainable enhancement of agricultural productivity and incomes, the adaptation and fortification against climate change impacts, and the reduction or elimination of greenhouse gas (GHG) emissions, whenever feasible. The implementation of Community-Driven Development (CRD) initiatives has a significant role in advancing the attainment of sustainable development goals.

The integration of the three components of sustainable development, namely economic, social, and environmental, is achieved by the simultaneous consideration of food security and climatic challenges. The framework consists of three primary components: effectively enhancing agricultural output and incomes in a sustainable manner; adapting to and fortifying against the impacts of climate change; and, if feasible, mitigating and eliminating greenhouse gas (GHG) emissions. Extension providers can significantly contribute to the support of Community-Based Rural Development (CRD) through several means. These include the development and dissemination of technology and information, enhancing the ability of farmers, facilitating and brokering relationships, and providing advocacy and policy support. Rural Advisory Services (RAS) play a significant role in facilitating the achievement of Climate Resilient Development (CRD) by effectively communicating climate information and technologies related to production practices for climate adaptation. This is accomplished through the implementation of innovative strategies, including the utilization of paravets, clinics, and participatory video methods (as demonstrated by Digital Green's case study in India). Additionally, RAS initiatives encompass the establishment of climate-smart villages, the provision of climate training sessions, and the organization of workshops, among other activities.

According to the Intergovernmental Panel on Climate Change (IPCC) study in 2007, it was revealed that the agricultural sector is responsible for around 13.5% of world greenhouse gas (GHG) emissions. Similarly, the Indian Network for Climate Change Assessment (INCCA) report in 2007 stated that agriculture contributes 18% of the total GHG emissions in India. According to a report by FAO in 2006, it was found that the agricultural animal industry contributes to roughly 18 percent, or nearly one fifth, of greenhouse gas emissions caused by human activities. The current era presents a significant worry regarding the sustainability of farming in light of the changing climate scenario. The available data indicate that agriculture is directly accountable for the annual emission of approximately 5100-6100 megatonnes (Mt) of carbon dioxide equivalents (COe). This emission level is roughly equivalent to that of the global transportation sector. Furthermore, agriculture contributes a disproportionate amount of two potent greenhouse gases, namely nitrous oxide (N_2O) and methane (CH_4). A significant proportion of anthropogenic methane emissions, estimated at over 47 percent, can be attributed to agricultural practices. Similarly, agricultural activities contribute to around 58 percent of nitrous oxide emissions caused by human activities. From this standpoint, a variety of methodologies encompassed by the term "climate resilient dairy (CRD)" have the potential to enhance milk production, bolster the dairy industry's resilience to climate change, and mitigate greenhouse gas (GHG) emissions. Climate-smart dairy production practices contribute to the global effort to meet future milk demand without exacerbating emissions. In the context of climate change, prioritizing adaptation becomes paramount. This may entail the utilization of enhanced breeds of dairy animals that possess the capacity to withstand elevated temperatures, arid conditions, and other related challenges. Various steps are necessary to mitigate the environmental impact of the cattle industry on climate change. Some potential strategies for mitigating greenhouse gas emissions in the livestock sector encompass enhancing production and feed systems, cultivating novel ruminant breeds with reduced methane output, implementing emissions-reducing techniques for manure management, and integrating livestock and crop systems to minimize waste and enhance soil fertility. Enhanced grazing management practices have the potential to significantly enhance animal nutrition and mitigate greenhouse gas emissions. Additionally, it is imperative to take into account the necessity of modifying feeding regimens and enhancing pasture management practices. The process of adapting to both short-term climatic variability and long-term climate change necessitates the implementation of improved risk management strategies, such as the establishment of insurance programs and the provision of enhanced weather forecasts to farmers. There are various strategies available that can address the diverse demands and requirements of livelihoods and agro-ecological systems, while also making a positive contribution to the overall greenhouse gas balance in the dairy sector. Cattle are recognized as a significant contributor to the emission of methane, a potent greenhouse gas.

The majority of methane is produced within the rumen of a cow, which serves as its first stomach. This methane is generated through the activities of microbial organisms that participate in the degradation and fermentation processes of grass and other dietary components. The majority of the methane produced by dairy cows is subsequently released into the atmosphere. A single dairy cow has the capacity to generate hundreds of liters of methane throughout a 24-hour period, amounting to over 100 kilograms over the span of a year. Cattle waste and urine, land use change, cattle feed production, and the collection, processing, and distribution of milk contribute to a significant increase in emissions. The outcome of our analysis reveals that the acquisition of one liter of fresh milk is accountable for around 3 kilograms of greenhouse emissions, which translates to somewhat more than half a kilogram every normal glass of milk. The direct impact of most consumers on this substantial ecological footprint may appear insignificant. Indeed, while it is true that the transportation of milk from the store to one's residence and the electricity consumption associated with refrigeration contribute to the overall environmental impact, their combined contribution constitutes less than ten percent of the total impact. One area where a significant reduction in the lifecycle emissions of milk can be achieved, particularly through a substantial impact, is through minimizing waste. In addition to this, the use of enhanced manure management practices also facilitates the mitigation of nutrient losses by vaporization, primarily contributing to the decrease of methane (CH_4) and nitrous oxide (N_2O) emissions. However, the primary obstacle in the adoption of climate wise dairy farming practices lies in its execution, particularly among smallholder dairy producers. The region also faces significant obstacles, including inadequate land management methods, limited knowledge and information, insufficient training

opportunities for effective dairy farming practices, and a lack of access to essential inputs, tools, equipment, and finance facilities. The suitability of climate smart dairy farming practices varies between regions due to a multitude of contextual factors. However, in order to preserve the sustainability of dairy farming and food security in the face of a changing climate, it is imperative to implement climate-smart techniques in dairy farming with careful consideration.
Impact of climate change on livestock productivity.

Livestock assumes a significant role within the agricultural sector of emerging nations, with its contribution to the agricultural gross domestic product (GDP) up to 40%. The demand for foods derived from animals on a global scale is experiencing growth, indicating that there will be a necessity for the livestock industry to undergo expansion (FAO, 2009). The deleterious impacts of harsh weather have a negative influence on livestock. The impact of climatic extremes and seasonal variations in herbage quantity and quality on the welfare of livestock, as well as their subsequent effects on production and reproduction efficiency, have been highlighted by Sejian (2013).

The sustainability of livestock systems on a worldwide scale is significantly jeopardized by the presence of climate change. As a result, the process of adjusting to and reducing the harmful consequences of harsh climates has been a significant factor in addressing the climatic influence on cattle (Sejian et al., 2015a). It is widely acknowledged that climate change would likely exert a significant influence on livestock performance in various places, with prevailing predictive models indicating a predominantly negative impact. Climate change can exhibit itself as abrupt fluctuations in climate over a relatively little period, typically spanning a few years, or as more gradual alterations that occur over the course of several decades. In general, climate change is commonly linked to a progressive rise in the Earth's average temperature on a worldwide scale. Multiple climate model forecasts indicate that the average world temperature might potentially increase by 1.1-6.4 °C by the year 2100, compared to the temperature recorded in 2010. One of the challenges confronting cattle is to weather extremes, such as the occurrence of significant heat waves, floods, and droughts. Furthermore, it has been seen that extreme occurrences not only lead to reductions in productivity, but also contribute to mortality among animals (Gaughan and Cawsell-Smith, 2015). Animals possess the ability to acclimate to high-temperature environments; nonetheless, the physiological responses that aid in their survival may have adverse effects on their overall function. This article aims to assess the negative consequences of climate change on livestock productivity. When the temperature rises to the upper 20s Celsius (80s Fahrenheit), the manifestation of heat stress effects may become apparent. Initially, the bovine exhibits signs of lethargy and perspiration, accompanied by a decrease in the depth and an increase in the frequency of respiration. When ambient temperatures rise to the range of 30 degrees Celsius, cows may exhibit signs of panting and have a significant decline in their milk output. In the absence of alleviation from high temperatures, bovines may succumb to mortality. Modern dairy cows exhibit a heightened vulnerability to heat stress due to their elevated feed intakes, larger body proportions, and accelerated development rates, resulting in an increased production of metabolic heat. Heat stress has the potential to compromise the immune system's functionality and facilitate the transmission of infections such as mastitis. In the past, the adverse effects of hot weather were only observed among cows residing in warm and tropical regions. However, the escalation of temperatures in higher latitudes, encompassing the United States, Canada, and Europe, has augmented the vulnerability of cattle in these areas as well.

The adverse impacts of elevated temperature on feed consumption, reproductive processes, and overall performance in several livestock species have been comprehensively studied and are reasonably well-established. For instance, optimal performance for a variety of livestock species, including cattle, sheep, goats, pigs, and poultry, is often observed within a temperature range of 10 to 30°C. However, as the temperature rises by 1°C beyond the baseline, it has been observed that all species exhibit a decrease in their feed intake ranging from 3 to 5 percent. Undoubtedly, this phenomenon will exert significant and extensive impacts on both the quality and quantity of cattle species. The rise in temperatures will have significant implications for pasture quality, leading to adverse effects on cattle productivity on a large scale. Waterlogged soils may make pasture land less productive and significantly more sensitive to damage by grazing. During periods of excessive precipitation, farmers are compelled to extend the duration of indoor confinement for their livestock, resulting in an increased dependence on supplementary cow feed. In periods of excessive precipitation, both the accessibility and caliber of forage and feed might be compromised, leading to increased expenses and diminished milk production. Undoubtedly, numerous regions across the globe face the potential hazard of experiencing significant declines in forage quality due to the combined effects of forthcoming climate change impacts and an atmosphere enriched with carbon dioxide.

Direct effects of climate change on cattle

The primary and noteworthy consequence of climate change on livestock output is the direct influence of heat stress. Heat stress imposes a substantial economic cost on milk producers due to its negative impact on milk component and milk production, reproductive efficiency, and animal health. Hence, the anticipated rise in atmospheric temperature, as projected by several climate change models, may have a direct impact on animal function.

Indirect effects of climate change on cattle

The majority of production losses are mostly attributed to the indirect consequences of climate change, particularly the decrease or unavailability of feed and water resources. The phenomenon of climate change possesses the capacity to exert influence on various aspects related to forage production, including both its quantity and reliability. Additionally, climate change has the potential to affect the quality of forage, the water requirements for cultivating forage crops, and the overall patterns of vegetation on extensive rangelands. Over the course of the forthcoming decades, crops and forage plants will persistently encounter higher temperatures, increased levels of carbon dioxide, and unpredictable variations in water availability caused by alterations in precipitation patterns. The unfavorable effects of climate change can have significant implications for various aspects of grassland ecosystems, including productivity, species composition, and overall quality. These impacts extend beyond the production of forage and can also affect other ecological functions of grasslands (Giridhar & Samireddypalle, 2015). The variability in rainfall distribution during the growing season in various global locations will have a significant impact on fodder production. Given the observable consequences of climate change, it is anticipated that cattle production systems will predominantly experience adverse effects rather than favorable ones. Climate change has a significant impact on the demand, availability, and quality of water resources. Variations in temperature and weather patterns can exert an influence on the characteristics of precipitation, such as its quality, quantity, and spatial distribution, as well as on the dynamics of snowmelt, river discharge, and groundwater availability. Climate change has the potential to induce heightened levels of precipitation, resulting in increased peak run-off and diminished replenishment of groundwater resources. Extended periods of low precipitation can lead to a decrease in the replenishment of groundwater, a reduction in the volume of water flowing in rivers, and ultimately have an impact on the availability of water resources, agricultural practices, and the supply of drinking water. The impact of water restriction on animal physiological balance results in a reduction in body weight, diminished reproductive rates, and a weakened immune system, as documented by Naqvi et al. (2015). Further investigation is required to assess the susceptibility of water resources to the impacts of climate change, with the aim of facilitating the formulation and implementation of adaptation measures in the agricultural sector. Furthermore, the occurrence of developing diseases, such as vector-borne diseases, as a consequence of climate change, would lead to significant economic ramifications.

Impact of climate change on cattle production

According to Gaughan and Cawsell-Smith (2015), cows who experience heat stress exhibit a decrease in feed intake and an increase in water intake. Additionally, there are alterations in their endocrine condition, which subsequently elevate their maintenance requirements, ultimately resulting in poorer performance. The presence of environmental stressors has been observed to have a negative impact on the body weight, average daily gain, and body condition of livestock. The milk output experiences significant declines, leading to notable effects on milk quality. These effects include a decrease in fat content, lower levels of lower-chain fatty acids, solid-non-fat, and lactose contents. Additionally, there is a documented increase in palmitic and stearic acid contents. Typically, animals with higher levels of output experience a greater degree of impact. The presence of extended stressors can potentially result in decreased productivity. The prospect of sustaining or augmenting present output levels inside an increasingly inhospitable climate is not a viable long-term solution. It may be more logical to consider the utilization of adapted animal breeds, although with reduced output levels and lower input costs, rather than attempting to introduce "stress tolerance" genes into non-adapted breeds (Gaughan, 2015).

Impact of climate change on cattle reproduction

Thermal stress exerts an impact on reproductive systems. The conception rates of dairy cows have been shown to decrease by approximately 20-27% throughout the summer season. This decline in fertility can be attributed to heat stress, which negatively affects the expression of oestrus in cows. Heat-stressed cows tend to exhibit poor oestrus behavior, primarily due to lower secretion of oestradiol from the dominant follicle. This decrease in oestradiol secretion is a consequence of the low luteinizing hormone environment that develops in heat-stressed cows. The occurrence of heat stress leads to a decrease in reproductive efficiency, which can be attributed to alterations in ovarian function and embryonic development. These alterations manifest as a reduction in the ability of oocytes to be successfully fertilized and subsequently grow into viable embryos (Naqvi et al., 2012). The growth of oocytes in cows is compromised by heat stress, which leads to alterations in the release of progesterone, luteinizing hormone, follicle-stimulating hormone, and the dynamics of the ovaries during the oestrus cycle. Heat stress has been found to be correlated with the hindrance of embryo development and an elevation in embryonic mortality in cattle. The presence of heat stress during pregnancy has been observed to impede the growth of the foetus and perhaps elevate the risk of foetal loss. Heat stress might potentially lead to changes in the secretion of hormones and enzymes that play a crucial role in regulating the function of the reproductive tract. The process of spermatogenesis in males is negatively impacted by heat stress, potentially due to its inhibitory effects on the proliferation of spermatocytes.

Impact of climate change on cattle adaptation

To regulate body temperature within physiological boundaries, animals experiencing heat stress employ compensatory and adaptive mechanisms to restore homeothermy and homeostasis. These processes are crucial for survival, but can potentially lead to a decrease in productive capacity. The assessment of stress levels in cattle can be inferred by examining the relative alterations in physiological responses, such as respiration rate, pulse rate, and rectal temperature. Thermal stress has an impact on the hypothalamic-pituitary-adrenal (HPA) axis. The stimulation of somatostatin by corticotropin-releasing hormone may potentially serve as a crucial mechanism underlying the observed decrease in growth hormone and thyroxin levels in animals experiencing heat stress. The animal species that exhibit successful adaptation to hot climates have undergone genetic modifications that confer cellular protection against elevated ambient temperatures. The utilization of functional genomics in the process of identifying genes that undergo up- or down-regulation in response to a stressful event has the potential to facilitate the identification of genetically superior animals that possess enhanced stress coping abilities. Additionally, this approach can contribute to the development of therapeutic drugs and treatments that specifically target the genes affected by stress, as highlighted by Collier et al. (2012). Research examining genes implicated in the cellular acclimation response using microarray analysis or genome-wide association studies has provided evidence suggesting that heat shock proteins play a significant role in facilitating adaptation to thermal stress.

Impact of climate change on cattle diseases

The climatic variables that have the most substantial impact on animal disease epidemics are temperature and rainfall fluctuations. The heightened temperatures and increased precipitation, specifically during winter seasons, will amplify the likelihood and prevalence of animal diseases. This is due to the prolonged survival of specific species, such as biting flies and ticks, which act as carriers for these diseases. The known occurrences include the migration of disease vectors, such as those responsible for malaria and cattle tick-borne diseases including babesiosis, theileriosis, and anaplasmosis. Additionally, the transfer of Rift Valley fever and bluetongue disease into Europe has also been seen. The prevalence of certain extant parasitic diseases may potentially escalate, or their geographic distribution may expand, in response to a rise in rainfall. This phenomenon has the potential to facilitate the proliferation of diseases among animals, including ovine chlamydiosis, caprine arthritis (CAE), equine infectious anemia (EIA), equine influenza, Marek's disease (MD), and bovine viral diarrhea. Numerous diseases with quick emergence persist in their propagation across expansive regions. In addition to the occurrence of wet winters and heightened intensity of rainfall events, there exists a concealed yet significantly perilous risk of sickness. Dairy cows are regarded as economically significant livestock, prompting farmers to employ various measures to ensure their optimal welfare. In spite of the implementation of preventive measures, illnesses such as Foot and Mouth have caused significant devastation to livestock populations in recent times. The identification of Blue Tongue in British animals in 2007 elicited significant apprehension within the general population. The aforementioned viral disease is transmitted by midges and had surfaced in the region of North Western Europe in the preceding year. The rapid spread of the phenomenon is primarily observed under settings characterized by high temperatures and humidity. The outbreak that occurred in 2006 has been linked to the regional warming trends observed over the preceding five decades. The occurrence of disease outbreaks, such as foot and mouth disease or avian influenza, has a significant impact on a substantial population of animals. Moreover, these outbreaks exacerbate the deterioration of the environment and have adverse effects on the health and livelihood of nearby communities.

Liver flukes are a type of flat parasitic worms that primarily impact bovine and ovine species. Even a mild infection has the potential to impair liver function and decrease productivity, whereas a severe infection can result in mortality for the host organism. The life cycle of these parasites is dependent on the excretion of eggs by adult flukes residing in the liver of a cow, which are then expelled along with the animal's feces. When temperatures above 10 degrees Celsius, the eggs undergo rapid development, resulting in the emergence of the initial tiny mobile stage of the parasite. Subsequently, these organisms actively seek and initiate infection in the water snails that are prevalent in several moist, low-lying grassland areas. Parasites exhibit rapid growth and multiplication among the snail population, with their development being accelerated in warmer conditions. Following a period of around six weeks, the second mobile stage is discharged, dispersing across the vegetation. Subsequently, these stages transform into infective cysts, remaining dormant until they are ingested by a passing cow or sheep. The proliferation of liver fluke parasites and associated water snail vectors has been observed in several nations due to the occurrence of elevated temperatures and increased instances of grassland flooding. The future possibility of more severe summer droughts has the ability to restrict certain places, while a pattern of elevated temperatures and intensified rainfall events poses a risk of amplifying the distribution and consequences of liver flukes.

Effect of climate variability and change on cattle status

The impact of climate on livestock can manifest in both direct and indirect ways (Adams et al., 1999; McCarthy et al., 2001). The performance of animals, including growth, milk production, wool production, and reproduction, can be directly influenced by many climate parameters such as air temperature, humidity, and wind speed. The climate can also exert an influence on both the amount and quality of feedstuffs, including pasture, forage, and grain. Additionally, it can impact the severity and spread of illnesses and parasites among cattle. The cattle productivity in India has been significantly impacted by vector-borne diseases that are recognized to be influenced by climatic conditions (Ford and Katondo, 1977). The potential consequences of climate change include the amplification of the transmission of current vector-borne diseases and parasites, as well as the introduction and dissemination of novel diseases.

Climate change and fluctuation can potentially impact the desirability of cattle. According to Niggol and Mendelsohn (2008), the financial gains derived from livestock, the quantity of livestock per agricultural establishment, and the profits generated per individual cattle exhibit a significant degree of susceptibility to climatic conditions. Specifically, the income generated from livestock experiences an increase for small-scale farms in response to rising temperatures, whereas conversely, it declines for larger-scale farms. The vulnerability of livestock systems can be exacerbated by the depletion of resources caused by climatic extremes. This can further compound existing factors that already impact livestock production systems, such as rapid population and economic growth, increasing demand for food (including livestock) and related products, as well as conflicts arising from limited resources like land tenure, water, and biofuels. The potential loss of animal assets due to climate risks in rural communities has the capacity to precipitate a descent into chronic poverty, hence exerting a long-lasting impact on livelihoods.

The effects of climate change are contingent upon precipitation patterns, which have a direct influence on the productivity of crops and grasslands, hence impacting the overall net income derived from livestock (Niggol and Mendelsohn, 2008). There exist three probable theories. There are three notable phenomena that occur as a result of increased rainfall. Firstly, farmers tend to transition to cultivating crops. Secondly, grasslands undergo a transformation into forests, hence diminishing the availability of suitable grazing areas for a majority of animal species. Lastly, augmented precipitation levels contribute to a higher occurrence of specific animal diseases (Niggol and Mendelsohn, 2008).

Adaptation and mitigation strategies to climate change/variability

The aforementioned solutions are designed with the objective of enhancing the resilience of dairy operations in the face of climate change, while simultaneously mitigating their impact on greenhouse gas emissions. The adaptation strategies employed in dairy farming encompass various aspects such as heat stress management, enhanced water management, selective breeding for climate resilience, diversification of feed, efficient pasture management, disease surveillance and control, as well as the utilization of weather forecasts and risk assessment techniques. Mitigation strategies in the context of dairy farming encompass several measures aimed at minimizing negative environmental impacts. These measures include the reduction of methane emissions, effective management of manure, enhancement of energy efficiency, minimization of water and feed waste, adoption of conservation tillage practices, utilization of alternative feed sources, as well as the implementation of afforestation and agro-forestry techniques. By effectively incorporating both adaptation and mitigation methods, dairy farmers have the potential to bolster the resilience of their operations in the face of climate change, while also playing a role in mitigating greenhouse gas emissions within the agricultural sector. The implementation of these endeavors is crucial for ensuring the enduring viability of the dairy sector amidst a dynamic climate, as well as for effectively tackling the wider complexities associated with mitigating climate change. The use of climate-smart dairy farming methods, such as the enhancement of nutrition and the management of manure, has the potential to effectively mitigate methane emissions.

By employing these measures, dairy farmers have the potential to mitigate their susceptibility to the consequences of climate change, all the while upholding a sustainable and efficient dairy enterprise. Furthermore, the implementation of climate-resilient techniques in dairy farming has the potential to effectively mitigate greenhouse gas emissions and foster a broader sense of environmental sustainability. In general, there is a positive correlation between the welfare of dairy cows and a decrease in greenhouse gas emissions. Given the potential consequences of climate change, such as heightened heat stress, it is imperative to explore various strategies that can aid animals in managing or mitigating the adverse effects of heat stress. These methods hold promise in minimizing the impact of climate change on animal responses and overall performance. Various managerial strategies can be employed to mitigate the impact of thermal stress:

1. **Genetic Approach**

It is logical to engage in the practice of selectively breeding cows that predominantly or entirely originate from Holstein lineage in order to enhance milk production. One potential drawback is that increased milk production may be accompanied by a trade-off in other favorable characteristics, such as heightened fecundity. Holstein cows, characterized by their substantial body size and rapid metabolic rate, exhibit an inherent predisposition towards increased milk production. However, this physiological trait also renders them more susceptible to heat stress, thereby heightening their vulnerability to overheating. Numerous indigenous breeds possess valuable adaptive features that have undergone significant development over an extended duration, encompassing tolerance to extreme temperature, humidity etc, tolerance /resistance to diseases and adaptation to survive, regularly produce/ reproduce in low/ poor management conditions and feeding regimes.

Hence, Genetic approach to mitigate the climate change should include measures such as

1. Identifying and strengthening the resilient local genetic groups
2. Genetic selection for heat tolerance
3. Identification of genes responsible for disease tolerance, heat tolerance, ability to survive in low input conditions and using it as basis for selection of future breeding stock.
4. Breeding management strategies: Local climate resilient breeds of moderate productivity should be promoted over susceptible crossbreds.

The implementation of additional processes for the selection and incorporation of genetic features, such as heat tolerance, increased yields, or disease resistance, holds the promise of producing climate-smart milk. The primary difficulty lies in identifying the optimal combination that is most suitable for the distinct geographical areas and unique conditions of various dairy farms amidst a dynamically evolving climate. In the context of livestock rearing in India, several factors contribute to reduced accuracy of selection and subsequently lower rates of genetic gain. These factors include small flock sizes, significant variations in rearing conditions and management practices both between and within flocks, absence of systematic livestock identification, insufficient recording of livestock performances and pedigrees, and limitations associated with the subsistence nature of livestock rearing, where monetary profit is not the primary objective. Nevertheless, it is important to note that regionally adapted breeds exhibit significant variability, and the most exceptional individuals within these breeds possess considerable productive capacity. Hence, the examination of livestock populations that have not been previously subjected to systematic selection is expected to yield expedited outcomes in order to establish a foundation stock with high genetic value for nucleus flocks.

For genetic improvement to achieve success, it is typically necessary to implement concurrent enhancements in diet, health, and management practices. Nevertheless, although enhancements in these alternative aspects of livestock production yield immediate advantages and involve continuous costs, genetic enhancement is enduring and is inherited from one generation to the next automatically as long as the enhanced animals are utilized for breeding and their offspring are preserved for subsequent breeding.

3.1. Nutritional Adjustments

In addition to considerations regarding cow welfare and genetics, the production of climate-smart milk necessitates a comprehensive evaluation of the entire dairy production chain. If the introduction of a novel feed effectively mitigates livestock methane emissions, but concurrently results in more greenhouse gas emissions during its own production, the overall climatic advantage becomes nullified. Cereals and crops possess carbon footprints, and when utilized as fodder for cattle, these emissions contribute to the overall life cycle emissions associated with the milk that is ultimately consumed. In the majority of instances, it is important to note that the reduction in methane emissions from dairy cows through the implementation of enhanced feed practices will generally surpass the emissions generated by the feed itself. In the developing world, a significant proportion of rangeland cows rely on wild-grown fodder as their primary source of nutrition, which is generally unsuitable for human consumption. These herds of browsing animals are efficiently producing milk using grain that has a 'zero carbon' impact. However, there is a significant release of methane emissions during the process, which contributes to a substantial carbon footprint overall. The feed consumption of animals during periods of temperature stress is notably reduced compared to when they are in a state of comfort. Therefore, it is imperative to prioritize the provision of a diet that is rich in nutrients. This approach will effectively mitigate the negative impact of elevated temperatures on production losses. Additionally, it is advisable to incorporate feed options that generate minimal heat during the process of digestion. The desired outcome can be attained by implementing the following measures:

- Incorporation of dietary fat at level of 2 to 6% will increase dietary energy density in summer to compensate for lower feed intake.
- High-fiber diets generate more heat during digestion than lower fiber diets.
- Using more synthetic amino acids to reduce dietary crude protein levels.
- Feeding of antioxidant (Vitamin A, C & E, selenium, Zinc)
- Addition of feed additives/vitamins and mineral supplementations
- Allow for grazing early in the morning or later in the evening to minimize stress.
- Concentrate mixture (18% DCP and 70% TDN) prepared with locally available feed ingredients should be supplemented to all categories of animals. When no green fodder is available, addition of vitamin supplement in concentrate mixture helps in mitigating heat stress.
- Further, in extreme conditions, energy intake becomes less compared to expenditure as the animal has to walk more distance in search of grazing resources which are poor in available nutrients. Hence, all the animals should be maintained under intensive system with cut and carry of available fodder. The concept of complete feed using crop residues (60%) and concentrate ingredients should be promoted for efficient utilization of crop residues like red gram stalk, etc. Further, productivity and profitability from ruminants can be increased by strengthening feed and fodder base both at village and household level with the following possible fodder production options.

4. **Managemental interventions:**
   1. **Water supply**: Animals must have access to large quantities of water during periods of high environmental temperatures. Much of the water is needed for evaporative heat loss via respiration to help them cool off. Hence, provision has to be made for supply of continuous clean, fresh and cool water to the animals. Cleaning the feeding trough frequently and providing fresh feed will encourage the animals to take more feed. Splashing the cool water over the animals at regular intervals during the hot period will reduce the heat stress.
   2. **Feeding time**: Providing feed to the animals during cool period i.e. evening or night will improve the feed intake by the animals. Likewise, providing additional drinking

water supplies and shifting feeding times, so that cows are not all feeding during the hottest parts of the day, will cut heat stress risks.

3. **Stocking density**: Reducing the stocking density during hot weather will help the animals in dissipating the body heat more efficiently through manifestation of behavioural adaptation.
4. **Shade**: The use of shades is an effective method in helping to cool animals.
5. **Provision of vegetative cover** over the surrounding area will reduce the radiative heat from the ground.
6. **Provision of elongated eaves** or overhang will provide shade as well as prevent rain water from entering the sheds during rainy season.
7. **Ventilation**: increasing the ventilation or air circulation in the animal sheds will aid the animals in effective dissipation the heat. Many introduced shading in feeding, drinking and corral areas to give cows plenty of opportunities to seek respite from the sun when they need it.

IV. Manure management

Cow manure is recognized as a significant global methane source, and both cow manure and cow urine contain high levels of nitrogen, so contributing to the release of nitrous oxide, a potent greenhouse gas. Enhanced management of manure and urine can transform the challenge of animal waste into a beneficial opportunity for dairy farmers. The feces can be collected in areas where cows gather, such as cattle sheds and outside milking parlors. This mitigates the potential hazard of the object being carried away by runoff during periods of intense precipitation or releasing significant quantities of ammonia into the atmosphere during periods of high temperature. The trash that is gathered is afterwards regarded as a valuable input for the process of anaerobic digestion, which involves intentionally producing and capturing methane for the purpose of utilizing it as an energy source. Numerous agricultural establishments have already adopted this practice, wherein biogas is utilized for various purposes such as heating structures, generating energy, or even injecting it into the broader gas distribution network. The residual materials derived from the anaerobic digester possess commendable properties as a soil amendment, serving as a viable alternative to synthetic fertilizers when applied to agricultural fields. In situations where anaerobic digestion is not a viable solution, the practice of segregating manure and urine into enclosed storage facilities frequently mitigates issues related to air and water pollution. Despite efforts to mitigate its climatic impact, methane production is still expected to occur. Various strategies have been proposed to address this issue, including aerating the manure, minimizing storage times, and employing methane destruction techniques such as flaring. These measures aim to reduce the environmental consequences associated with methane emissions. The dietary composition of cows can also have an impact on the emissions of waste. Paradoxically, the utilization of nitrate supplements that hinder the growth of gut methanogens in cows may inadvertently enhance the generation of nitrous oxide in their manure and urine. This phenomenon has the potential to merely shift the environmental impact of milk production from one aspect, namely methane emissions, to another, namely nitrous oxide emissions. The ultimate significant prospects for implementing climate-smart milk production practices on farms are to the use of manures and fertilizers, as well as the grazing patterns of cows in their respective fields. Optimizing the time and quantities of manure and fertilizer application is crucial in order to maximize the use of nitrogen content by grass or crops, while simultaneously minimizing potential losses to the atmosphere and aquatic bodies. To mitigate the negative environmental impacts associated with cow behavior, it is advisable to implement certain measures. These include avoiding waterlogged areas and streams, regularly relocating feeders and drinkers, and strategically positioning field gates at the summit of slopes, where drier conditions prevail. By adopting these practices, soil compaction and the detrimental effects of soil disturbance can be minimized, consequently reducing pollution and greenhouse gas emissions.

V. Other interventions

A. Revival of common property resources (CPRs): CPRs need to be reseeded with high producing legume and non-legume fodder varieties at every 2-3 years intervals as a community activity. Further, grazing restriction till the fodder grows to a proper stage and rotational grazing as community decision would improve the carrying capacity of CPRs.

B. Intensive fodder production systems: Growing of two or more annual fodder crops as sole crops in mixed strands of legume (Stylo or cowpea or hedge Lucerne, etc) and cereal fodder crops like sorghum, ragi in rainy season followed by berseem or Lucerne etc., in rabi season in order to increase nutritious forage production round the year.

C. Short duration fodder production from tank beds: Due to silt deposition, tank beds are highly fertile and retain adequate moisture in the soil profile for cultivation of short season fodder crops like sorghum and maize during winter and or summer.

D. Year-round forage production systems: Cultivation of a combination of suitable perennial and annual forages for year round nutritious fodder supply using limited water resources. It consists of growing annual leguminous fodders like cowpea or horse gram, etc. inter-planted with perennial fodders like Co-3, CO-4, APBN-1 varieties of Hybrid Napier in monsoon and inter-cropping of the grasses with berseem, lucerne, etc. during post-monsoon season.

E. Use of unconventional resources as feed: The available waste products form food industries like palm press fibre, fruit pulp waste, vegetable waste, brewers' grain waste and all the cakes after expelling oil etc., and thorn-less cactus should be used as feed to meet the nutritional requirements of animals.

F. **Agro-forestry**: Out in the fields there is often an opportunity to use the natural shading and shelter provided by trees to increase hot weather resilience dairy cows given such shaded areas have shown reduced panting and heat stress symptoms. Tree shelterbelts around fields can reduce the impacts of extreme weather events, including storms, intense rainfall, and extremes of heat and cold. Some farmers have extended the benefits of livestock agroforestry to include extra forage for the animals, a source of biofuel for energy generation, and even as a natural filter for pollutants - the trees can help reduce nitrate leaching to drainage streams and capture ammonia emissions to the atmosphere.

Specific mitigation measures

The overproduction of methane within the rumen of dairy cows has detrimental effects on both the environment, particularly in terms of climate change, and the dairy farming industry. The microorganisms responsible for methane production, known as methanogens, utilize the carbon dioxide and hydrogen produced during the fermentation and digestion of feed. The breakdown of recalcitrant dietary materials, such as straw, leads to an elevated production of hydrogen, thus resulting in an increase in methane emissions. The provision of superior feeds and forages to dairy cows can consequently result in a reduction of methane production and an increase in milk production. Numerous feed and forage varieties have been evaluated in relation to the methane emissions they generate. Enhancing the quality of feed continues to be a prominent strategy in endeavors to enhance livestock output and mitigate the environmental impact associated with carbon emissions. However, a significant number of farmers lack the means to obtain improved feed options, while others face challenges in managing the dietary intake of their cattle due to extensive grazing practices, so rendering effective control over their feeding habits very difficult. Dairy farmers that possess meticulous control over their herds' food and have access to cutting-edge feed mixes have additional resources at their disposal within the arsenal of methane reduction strategies. Higher quality feeds can alter the digestive process by reducing the reliance of methanogens on hydrogen production. Additionally, various feed additives can be employed to redirect the hydrogen supply or specifically target the methane-producing microorganisms. The effects of including tea, garlic, seaweed extracts, cinnamon, curry spice, and oregano are manifested by their direct inhibition of methanogens. Certain additives, such as nitrate and sulphate, function by engaging in competition with methanogens for the limited hydrogen resources within the rumen of cows. The outcomes of these additives can be quite remarkable, resulting in reductions of methane emissions by more than 75%. These entities may also have a limited lifespan. However, over an extended period of exposure, the methane-producing microorganisms frequently develop resistance to the impacts of the additions. Excessive utilization of nitrate additions may potentially exhibit harmful effects on the bovine population. Lipids, particularly those abundant in fatty acids such as sunflower oil, possess the capacity to mitigate methane emissions and minimize the thermal output associated with the process of digestion. Dietary fats can be obtained from several natural sources, such as algae. In addition, they circumvent numerous public health concerns linked to synthetic methanogen inhibitors, such as antibiotics. For instance, monensin, an antibiotic commonly employed in livestock feed to enhance growth and reduce methane emissions, is prohibited in Europe due to apprehensions regarding the proliferation of antibiotic resistance. The utilization of antibiotics in combating diseases is an area where their significance in promoting climate-smart milk production is less contentious. In conjunction with enhanced veterinarian care and animal health extension services, the provision of livestock medicines can significantly enhance the capacity to withstand illnesses and parasites that would otherwise pose a threat to cattle. A cow that is in good health and contentment tends to exhibit greater resilience to climate-related challenges and emits fewer greenhouse gases.

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Chapter-6

STRATEGIES TO ENSURE CONTINUOUS SUPPLY OF GREEN FODDER AND SILAGE FEEDING

M. Kishan Kumar[1], Ch. Rama Krishna[2]

[1]Professor and University Head, Department of LPM, College Of Veterinary Science, Hyderabad-500030, Telangana, India
[2]Assistant Professor (Agronomy), Department of LPM, College Of Veterinary Science, Hyderabad-500030, Telangana, India

Introduction

Livestock contribute to 25.6% of all agricultural GDP and 4.11 percent of the overall GDP. There are three primary types of livestock production methods in India. In rural households, a nimals are housed in close quarters and fodder is either grown on the property or bought from the market. Large herds of animals are kept on commercial farms and on rangelands. India has a large number of livestock populations so there is competition with human and the land for food and feed. On the other hand there is increase in the Urbanization, industries installation, water logging and salinity results in decrease availability of land for fodder cultivation. The production yield per animals is enhanced by production of good quality fodder (Makkar, 2016). The country's fodder supply is insufficient to support the current demand of the domesticated animal population, and the fodder and forage that are available are often of poor quality. India accounts for more than 530 million animal population which is the world's largest (Roy *et* al., 2019). About 65-70 per cent of total cost in animal production incurred for animal feeds (Kumar *et* al., 2016). India now has a net shortfall of 30.65% green fodder, 11.85% dry fodder deposits, and 44 % concentrate feed (Ravi Kiran *et al.*, 2012). Green and dry forage requirements will reach 1012 and 631 million tonnes respectively, while green and dry fodder shortfalls will continue to be 18.43 percent and 13.20 percent in 2050. Past statistics show an annual increase of 1.69 percent in fodder supplies and a 4.6 percent increase in domesticated animals. During the lean period May-June and November-December, there is a shortage of green fodder throughout the country. We can use the different innovative concepts in a multidisciplinary way to deal with and increase fodder production to meet the feed and fodder requirements of domesticated animals.

Table.1: Demand and supply estimates of dry and green forages (Million tonnes)

	Available	Requirement	Deficit	Deficit%
Green fodder	387.3	1006	618.7	61.5
Dry fodder	437.9	560	122.1	21.8
Concentrate	42	79.4	37.4	47.1

IGFRI vision 2050

Major Constraints in Fodder Production
1. Most of the farmers in India is landless and have a small piece of land
2. Land holding of dairy farmers:
a. Dairy farms with no land. b. Dairy farms with low land. c. Dairy farms with adequate lands.
3. Farmers is not aware of proper production techniques
4. Land utilization pattern and crop production system
5. The seasonal variation in weather or climate is mainly responsible for the inadequate fodder production.

Continuous supply of green fodder

Mostly the dairy animals are kept in intensive production system. The major sources of forage production in India are irrigated areas and forest grass lands. The quality of forage production at sowing and harvesting time is very important than absolute production of dry matter. The quantity of forage varies according to animal status such in maintenance, pregnancy and lactation. So farmer produce or purchase daily use forage regularly. In India particularly sorghum in *Kharif* and berseem in *rabi.* Lucerne, cowpea, oat, maize, and pearl millet are some of the other cultivated fodders. Among the perennial grown forages like napier-pearl millet hybrid, guinea grass, and para grass some of the important fodder crops details given below

Kharif Fodder Crops

Sorghum (*Sorghum bicolor)*

Sorghum is locally known as jowar. This is very important and useful fodder crop. It provides palatable green fodder over a longer period than maize and millet. Its green fodder contains 8-10% protein, 70% carbohydrates, minerals, nitrogen free extract, and crude fat. Basically sorghum is a tropical plant, but it has adapted to climatic conditions in temperate zone. It can with stand heat and drought. This crop requires 2 ploughings with a cultivator along with planking. The optimum seed rate per hectare is 20-25 kg for fodder production. Fodder crop is usually sown by broadcast method. Sorghum is sown for fodder from March to September is recommended. The best time for harvesting fodder is at the 50% heading stage (flowering stage). It can yield around 35-40 t/ha single cut and around 100 t/ha for multi cut green fodder.

Maize (*Zea mays*)

It is locally known as *makka.* It is very important fodder crop. Staggered planting from Feb-Sep helps cope with the fodder scarcity problems faced in May-June and Oct-Nov. The green fodder contains 6-8% protien, 0.30% fat and 5.27% fiber. It is extensively sown in irrigated and rain fed areas. The main field is prepared by ploughings and planking three times to eliminate clods and weeds. Drill 2 bags each of DAP and urea per hectare at sowing. For a fodder crop, 50-60 kg/hectare of good quality seed is sufficient. The optimum time for sowing is ranges from 3rd week of March to mid September. Fodder is harvested after 60-75 days after sowing. Fodder yield varies from 40-50 t/ha.

COWPEA (*Vigna unguinculata*)

It is an important leguminous summer fodder. Cowpea makes an extremely important, nutritious and balanced fodder when mixed with maize, sorghum and millet. It improves the soil fertility by fixing nitrogen from air. The green fodder contains 15.56% protein, 2.32% fat and 30.64% crude fiber. The cowpea is a tropical plant and thrives under warm and humid conditions. Two-three ploughings each followed by planking are required to prepare a good seed bed. To improve yield 2 bags of DAP per hectare may be applied at sowing. For fodder crop 30-40 kg/ha seed is sufficient. Sowing is carried out in lines. The proper time of sowing ranges between mid-March to July. Fodder is ready within 50-60 days after sowing. The best time cutting is the time of pod formation, when the fodder is full of nutrients. An unmixed crop of cowpea normally yields about 30-40 tons/hectare.

Rabi Fodder (Winter Crops)

Berseem or Egyption Clover (*Trifolium alexandrium)*

Berseem is major winter fodder crop and is successfully grown under irrigated conditions and to some extent in the entire country. Berseem is a Multicut harvest fodder crop rich in phosphorus and calcium. Being palatable and readily digestible, it is relished by all animals its dry matter contents includes 18.3% protein, 2.8% phosphorus, 2.6% calcium and a rich source of vitamin A. It supplies abundant nutritious fodder in repeated cuttings from November to May. It is commonly cultivated in canal irrigated areas of the country. The land should be given 2 – 3 ploughings to make it soft and well pulverized. One bag of DAP is per acre is an economical way to meet its fertilizer requirement. Seed rate is 15-20 kg per hectare of healthy quality seed should be broadcast in standing water. Sowing time is from the last week of September to the first week of October is the best time for sowing but for late variety can be sown up to mid November. The first cut is ready in 50 – 60 days after sowing. Subsequent cuttings are available at 30 – 40 day intervals throughout the season. New varieties yield around 45-55 tons green fodder per hectare.

Lucerne (*Medicago sativa)*

Lucerne is a multicut, perennial legume forage crop. Lucerne contains protein 18-21% (dry basis), carbohydrates 11%, fat 8%, and fiber 30%. It provides green fodder throughout the year, especially during the two periods of fodder scarcity in the country, May-June and October-November. It does best under conditions of low rainfall and high sunshine. A good seedbed is prepared with turning plough followed by 3-4 cultivations and planking. 2-3 bags of DAP per hectare are sufficient. Seed rate is 15-20 kg/ha in lines 45 cm apart in good irrigation condition. A crop sown between October to November gives a good fodder return. The first cutting should be taken three months after sowing. Later cuts may be taken after an interval of 5-6 weeks. On average in six cuttings per year 65-75 t/ha.

Oats (*Avena sativa*)

Oat is an important winter fodder crop sown as sole crop or together with berseem. Oat is single cut crop and supplies fodder over a shorter period of time. The oat plant contains protein 9.23%, fat 3.56%, fiber 30.44%. The leaves and grains are high in carotene and carbohydrates. Oats provide nutritious fodder to all animals particularly horses and mules. When mixed with berseem oats provide balances feed to milch animals. The plant grows in cold and moist conditions. Clay loam soil produces the best crop. It requires 3-4 ploughings with a local plough along with planking to prepare a fine and pulverized seedbed. To get good yield it requires 2 bags of DAP and 2 bags of urea should be applied at the time of sowing. Recommended seed rate for fodder is 75 kg/ha. Sowing should be done in rows 20 cm apart. Early planting starts by the end of September and continues until mid-December. Harvesting is done when 25-30% of the heads have formed usually gives the best yield. It can yield around 6-8- t/ha green fodder.

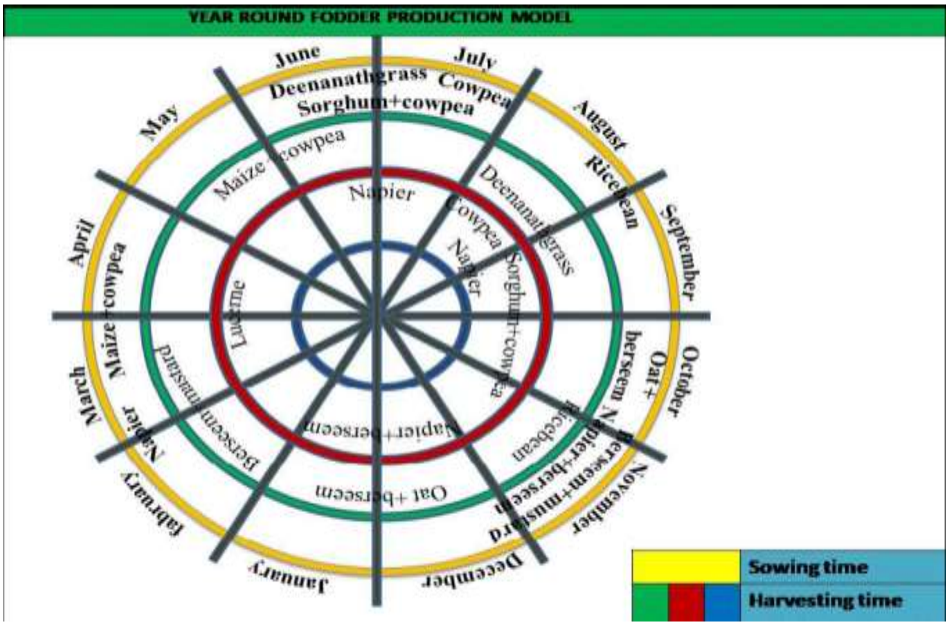
Table.1. Cropping systems of year-round fodder production

Sr. no.	**Crop sequence**	**Green fodder yield (t/ha/year)**
1	Napier x Bajra hybrid + Cowpea – Berseem	260
2	Maize + Cowpea MP Chari + Cowpea Berseem + Japanese rape	197
3	MP Chari + Cowpea Berseem + Japanese rape	184
4	Cowpea MP Chari + Cowpea Berseem + Japanese rape	176
5	Napier x Bajra hybrid + Cowpea Berseem Cowpea	255

To make a whole year fodder plan we have to know about the requirement of the animals according to season, the fodder crop which is available in a season, the approximate yield of the fodder per acre or hectare. To make the planning better we have to choose leguminous fodder and multi cut verities of fodder. The animal requirement is very necessary to calculate, because fodders are main feed of the animals. The fodder requirement varies with the age and production status of the animal. The maintenance requirement can be only fulfilled from fodders. For stall fed animals the key role is to feed ad-libitum. A buffalo or cattle one animals unit requires 0.5-0.6 acre land for fodder cultivation in a season. The requirement of green fodder will vary according to the live body weight of the animal. On an average 8-10 % of live weight of the animal is to be provided in the form of green fodder. An adult Cattle weighing 400 kg body weight will consume 32-40 kg green fodder. Out of the total requirement of green fodder one third of green fodder is to be provided as Leguminous fodder and remaining two third is to be provided as non leguminous fodder. For an example a mini dairy with 10 cows and 5 calves will require green fodder as follows 10 Cows x 35 kg/day x 365 days = 127.75 tonnes.

5 Calves x 20 kg /day x 300 days = 30.00 tonnes.

- Totally approximately 150 tonnes /year.
- Leguminous fodder : 50 tonnes
- Non leguminous fodder: 100 tonnes.
- To produce the above quantity of green fodder the land area is to be worked out based upon the type and variety fodder crops that are cultivated.
- Co5 variety yields 150 tonnes /acre/year Lucerne yields 80 tonnes / acre means two third acre is to be allotted for production of Co5 grass and 60 cents are to be allotted Lucerne to get sufficient fodder to meet the requirement of 10 cattle with its 5 followers.



Year round fodder production model -Kumar *et* al 2022

Alternate Land Use System: Agroforestry

It is essential to explore for alternative land use systems that integrate the concerns for productivity, resource conservation, environmental protection, and profitability. This is because cultivable areas are under constant pressure, while grazing pastures are already deteriorating. Technologies used in agroforestry, such as silvopasture, hortipasture, etc., show potential for producing feed as well as bio remediating damaged ecosystems. Silvopastures combine trees with pasture and/or animals. Woody perennials are introduced consciously, methodically, and scientifically, ideally with a focus on their utility as fodder. Under poor soil, water and nutrient situations where cropping is not possible such systems can serve the twin purposes of forage and firewood production and ecosystem conservation. It has been possible to increase land productivity from 0.5- 1.5 t/ha/year to > 10 t/ha/yr (10-year rotation) by developing silvopastures. Now, concept of hortipasture is also finding applicability with the farmers for utilizing their degraded lands. The additional forage availability through such systems is likely to reduce grazing pressure and thus have important environmental implications. Efforts to design silvopasture systems to produce > 15 t/ha/year through species introduction, planting geometry, canopy manipulation and sustainable management through in situ grazing or cut and carry system are continuing.

Fodder Preservation

Fodders are very important source of livestock feeding. Due to change in the weather the availability of fodder is drastically reduced, so the production of animals also reduced. In India there are two periods of fodder shortage i.e., May – June and October – November. However very large amount of fodder is produced before these two periods such as February to April and July to September. In these days surplus fodder can be preserved as a hay and silage making, so it shows the year round fodder supply.

Silage Production

The main principle of silage production is to store the fodder crop and exclude oxygen or store the fodder aerobically. In anaerobic conditions the microorganisms ferment the carbohydrates and produces organic acids, mainly acetic acid and lactic acid with very less amount of butyric acid. The fermentation continues pH of 3.6 – 5.0. In India for silage making maize, sorghum and oats are suitable crops for silage making. Silo is an airtight structure which is designed for storage and preservation of silage crops. There are three types of silo.

Pit Silo:

A pit is dug in the ground, which is plastered with mud or concrete material.

Trench / Bunker Silo:

This type of silo is made on flat soil surface. The side walls and floor is made with concrete. After filling, the silo is sealed with mud, or polythene sheath.

Silage Poly Bags:

It is new innovation and becoming popular because it does not need construction and maintenance. These bags are temporary and good for one use. It keeps air tight and preserves the contents of silage.

Method of Silage Making

The type of silo according to local conditions is selected for the making of silage. The wall of silo is lined with the sheet of polythene. At the proper stage of maturity the fodder should be harvested. The fodder is chopped in 2-3 cm length.The silo is filled in layers uniformly.The compaction of fodder in silo should be properly done. The compaction is done with tractor in case of big silo.The polythene or mud plaster should be used to seal a silo.For the increasing of protein contents of silage 2 % urea solution or molasses can be used.

Ensiling Process

- As the fodder is harvested, chopped, compacted, and sealed the process of ensiling started. It has four steps or phases;
- The aerobic phase is started as the silage is sealed and the oxygen which is trapped in forage pieces is release by respiration of the aerobic bacteria and yeasts. The enzymes of the plant become active.
- The fermentation phase started as the oxygen is released and the conditions become aerobic. In this phase the lactic acid producing bacteria is increasing and pH is reduced 4. To encourage the lactic acid fermentation 2-3% molasses is mixed during storage.
- This is the stable phase. In this phase pH is decreased, the water and air is not entered in this phase the lactic acid bacteria start decreasing. In this phase maintain the air tight seal to protect the silage from spoilage. Once the silo is opened by rodents or for feed out the spoilage begins. This result in the increase of pH. The main principle to use silage additives is produce feedstuff with a greater nutritive value, reduction of losses associated with ensiling.

Fermentation Inhibitors Acids may be used for direct acidification. Formic and propionic acid can be used.

Fermentation Stimulants Grains, molasses whey, urea, ammonia have been added in silage at ensiling.

Characteristics of Good Silage

The general appearance of the silage is good indication to expect its nutritive value.

Colour: the bright or light green or green brown color according to fodder ensile shows good quality silage.

Smell: The lactic acid odor is good but with no butyric acid odor.
Texture: The firm texture with softer material not easily rubbed from the fiber.
pH: the pH around 4 is good.

Advantages of Silage Making

- Most of the nutrients in fodder can be preserved
- Silage nutritional value remains unchanged during the entire feeding period.
- Silage is the most economical source of feed because it prevents wastage of the less favored parts of fresh herbage (such as stem).
- Silage requires less storage space than hay, and cannot be destroyed by fire.
- Silage improves the digestibility of protein in herbage and it preserves most of the vitamins.

Disadvantages of Silage Making

- Extra labour is required.
- Not well suited for intermittent use.
- If improperly stored the losses will be high
- Considerable costly equipments are required for harvesting and storing of silage.

Hay Making

The fodder which is harvested during growing period and preserved by drying and used during the days of feed shortage. The fodder is harvested during optimum stage of maturity. The principle involved in hay making is to reduce the water contents of fodder from 65 – 85% to 20% or less. In India Lucrne and Berseem are suitable leguminous fodder crops for hay making. In hilly area natural grass pasture also can be harvested for hay making.

Method of Hay Making

- The fodder crop which is used as hay making should be mowed as early as possible after reaching early bloom stage of maturity and as circumstances allow.
- Efforts should be made to select the rain free weather for harvesting. Minimum of 2 – 3 days are required for good drying weather are necessary for hay curing. So weather forecasts are very necessary in hay making.
- Conditioning of harvested fodder crop can reduce the drying period. In this procedure fodder is passed to set of rollers to crack open the stems thus facilitate drying.
- To avoid excessive shattering losses and over exposure to sun harvested fodder should be raked before complete drying.
- To facilitate drying turning of windrow is done.
- When the fodder is sufficiently dry baling should be done. Round and square bales can be made. Store the bales in the damp proof store house.

Characteristics of Good Hay

- **Leafiness:** the hay which has high leave to stem ratio is considered good.
- **Color:** the desirable color of hay is bright green, brown color is undesirable.
- **Aroma:** the aroma from hay should be pleasant.
- **Moldiness:** hay should not be moldy

Advantages of Hay Making

- In hay most of the moisture is has been removed so there is low transport cost.
- Good quality hay leads to desirable DMI by animals.

- The fodder which is surplus in the season can be conserved and used in the days of feed shortage.

Disadvantages of Hay Making

- Hay making requires optimum weather conditions.
- The digestive and crude protein value of hay is not sufficient for maintenance plus production.
- If the is not sufficiently dry and is stored, it can be damaged by fire.
- If hay is containing excessive moisture the mold can grow on it.
- If fodder is improperly harvested then the loss of leaves can occur. So most nutritious part of fodder is loss.
- If the harvested fodder or hay is given excessive exposure to sunlight then it causes loss of nutrients as carotene.
- If harvested fodder or hay is rained during the drying period then water soluble nutrients are loss.

Strategies for improving quality of forages

Urea treatment of low grade roughages:

Treating low quality crop residues such as wheat or teff straw, maize residue, or bagasse with urea is an easy method to increase digestibility and productivity of animals. Generally, 5 kg of urea is mixed with water and used to treat each 100 kg of crop residue resulting in a mixture with about 30% moisture.

Urea molasses mineral block

Urea molasses mineral block is prepared by mixing urea, molasses, mineral mixture and other ingredients in a suitable proportion. It is a readily available source of energy, protein and minerals for the dairy animal. Supplementing an animal with UMMB would provide adequate quantity of these nutrients and slow ingestion of urea leads to efficient microbial protein production and improved digestibility.

Conclusion

The profitability and production continuity of the dairy industry depend heavily on a steady supply of fodder. So to make the dairy business profitable and avoid from the undesirable fodder shortage, you have to plan the fodder availability round the year. Utilizing the technologies for producing fodder and storing extra during the season can aid in the success of your year-round fodder plan. Fodder scientists can focus to create novel, highly productive varieties of fodder and suggest effective techniques for raising fodder output and develop new and high yielding verities of fodder and introduce efficient ways to increase fodder production.

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Chapter-7

GOOD DAIRY FARMING PRACTICES IN RELATION TO ANIMAL HUSBANDRY ENTREPRENEURSHIP DEVELOPMENT

Cherala Harikrishna

Professor, Department of LFC, College of Veterinary Science
P.V.N.R. Telangana State Veterinary University
Rajendranagar, Hyderabad - 500 030, India

Introduction

The documented evidence showing that the domestication of animals happened more than 10,000 years ago and dogs followed by goats are probably the first animals to be domesticated, later the age old man began to domesticate large animals such as cattle and horses for labour and transportation. Livestock played major role in culture and civilization of different societies. Now they are playing key role in rural livelihoods and economy of different countries including India. Seventy percent of the world's rural poor rely on livestock for livelihoods. Rural India is mainly dominated by small holder farming systems.

Livestock giving food security for around 830 million food deprived people in the world and 130 million small holders in India, 43% of which are women. People in developing countries know that livestock are critical for sustainable development. The world's cows, sheep, goats, pigs, poultry and other farm animals are the mainstay of livelihoods across the developing world. These animal products provide people with basic livelihoods, income, food and nutrition. The other benefits of livestock to human kind include dung (fuel, cow dung wood and cow dung bricks) manure (to enrich the soils with nutrients and organic matter), traction (for ploughing farm land) and energy (methane gas) for house hold cooking and electricity production.

Seventy percent of the world's livestock (18.5 billion heads) are in developing countries and the share is growing. India with 533 million livestock including, 301.50 million bovines, 213 million small ruminants and 728 million poultry is producing 221.06 million tons of milk, 9.29 million tons of meat and 129.60 billion eggs. However, the demand for animal sourced food is increasing both quantitatively and qualitatively. These dramatic ongoing changes open new opportunities for a more sustainable and equitable future for small food producers, processors and traders. According to an estimate investment of one rupee in livestock sector multiplies to about 5 rupees in South Asia. Overall with the right support, small scale livestock production systems can play a major role in achieving some of the sustainable development goals such as no poverty, zero hunger, nutrition and health, equity and environment.

During the past five years, the milk and meat sectors are growing at about 6 per cent, annually. The government of India is now pegging on livestock to increase the economy from the current value of US $ 3 trillion to US $ 5 trillion by the year 2025. National Dairy

Development Board (NDDB) is rolling out more than Rs. 8000 Crore plan for white revolution for increasing milk production and milk processing. Under "Make in Rural India Initiative" NDDB will provide the financial assistance to private dairy units for processing in order to double the milk processing capacity by the year 2025, increasing the outreach in the unexplored market and improving milk quality at the milk collection centres. besides this Government of India is also taking measures to improve the meat and egg production through small ruminants and backyard poultry since the growth rate in meat and egg sector is more than 5 and 10 percent respectively. In fact Government of India approved Rs. 15,000/- Crore in the financial year 2020-21 for infrastructure development in dairy, poultry and fishery sector.

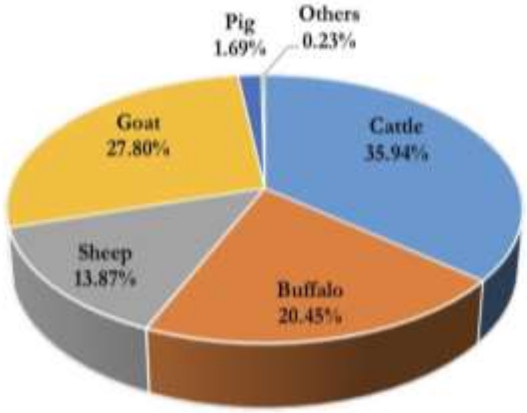


Fig.1 Distribution of Livestock Population in India (2019)

Good Dairy Farming Practices

The Livestock rearing is one of the most important economic activities in the rural areas of the country contributing significantly to the national economy. The success rate depends on maintenance of animals in 70:30 ratio for milch to dry animals at any given point of time in the dairy farm. Hence, selection of dairy animals plays significant role in sustainability, viability and profitability apart from continuing in the enterprise for which meticulous planning, coordination and execution play vital role. Good practice for dairy farmers is about implementing sound practices and appropriate management techniques on dairy farms is termed as *Good Dairy Farming Practice.* These practices must ensure that the milk and milk products produced are safe and suitable for their use, and also to ensure sustainable dairy farm enterprise, which is viable into the future, from the economic, social and environmental perspectives. Dairy farmers are in the enterprise of producing food for human consumption, hence they must be confident in the safety and quality of the milk they produce.

Good dairy farming practices underpins the production of milk that satisfies the highest expectations of the food industry and consumers. The international framework to ensure the safety and suitability of milk and milk products is contained in the Codex Recommended International Code of Practice – General Principles of Food Hygiene, recognizes that dairy farmers are an integral part of a larger dairy food production and processing chain and that all participants in the chain - dairy farmers, suppliers to dairy farmers, milk carriers and haulers, dairy product and food manufacturers, distributors, retailers and consumers - should be part of an integrated food safety and quality assurance management system. Dairy farmers can play their part by ensuring that good dairy farming practices are implemented at the farm level.

Good dairy farming practices also ensures that the milk is produced by healthy animals in a manner that is sustainable and responsible from the animal welfare, social, economic and environmental perspectives. Therefore, implementing good dairy farming practice is good risk management for the short and long term future of the dairy farming enterprise in a sustainable manner that underpins the future of dairy farming on a local, national and international scale.

Objectives for Good Dairy Farming Practices:

Main Objective: Safe, quality milk is produced from healthy animals using management practices that are sustainable from an animal welfare, social, economic and environmental perspective

Good Practices: Animal Health, Milking Hygiene, Nutrition, Animal Welfare, Environment and Socio-economic management.

1. Animal Health:

➢ **Establish the herd with resistance to disease:**

- Choose breeds and animals well suited to the local environment and farming system
- Determine herd size and stocking rate based on management skills, local conditions and the availability of land, infrastructure, feed, and other inputs
- Vaccinate all animals as recommended or required by local animal health authorities Enhance herd disease resistance / reduce stress.

➢ **Prevent entry of disease onto the farm to maintain farm biosecurity:**

- Only buy animals of known health status (both herd and individual animals) and control their introduction to the farm using quarantine if indicated
- Ensure animal transport on and off the farm does not introduce disease
- Monitor risks from adjoining land and neighbours and have secure boundaries
- Where possible, limit access of people and wildlife to the farm
- Have a vermin control programme in place
- Only use clean equipment from a known source

➢ **Have an effective herd health management programme in place to detect animal diseases early, to prevent spread of disease among animals, to ensure food safety and to ensure traceability:**

- Use an identification system that allows all animals to be identified individually from birth to death
- Develop an effective herd health management programme focused on prevention that meets farm needs as well as regional and national requirements
- Regularly check animals for signs of disease
- Sick animals should be attended to quickly and in an appropriate way
- Keep sick animals isolated
- Separate milk from sick animals and animals under treatment
- Keep written records of all treatments and identify treated animals appropriately
- Manage animal diseases that can affect public health (zoonoses)

➢ **Use chemicals and veterinary medicines as directed to prevent occurrence of chemical residues in milk:**

- Only use chemicals approved for supply and use under relevant legislation
- Use chemicals according to directions, calculate dosages carefully and observe appropriate withholding periods
- Only use veterinary medicines as prescribed by veterinarians
- Store chemicals and veterinary medicines securely and dispose of them responsibly

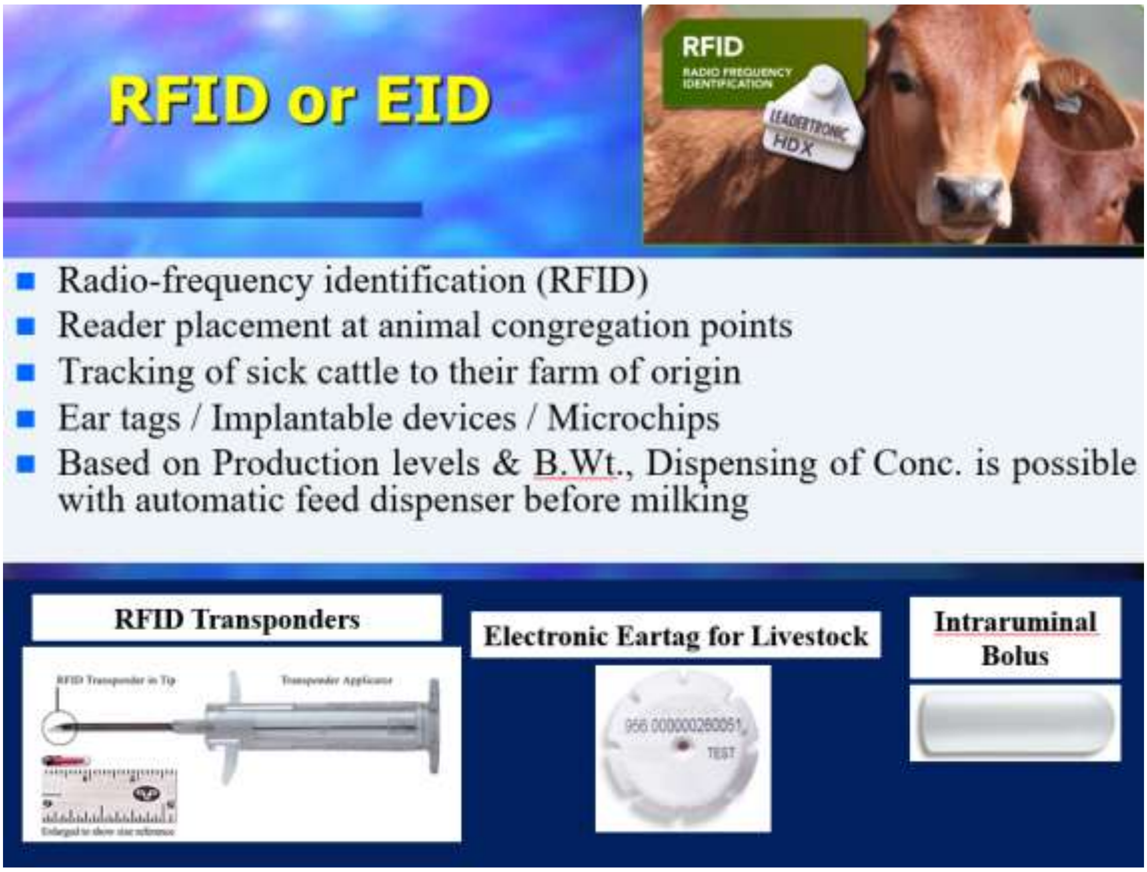


Fig. 2: Radio Frequency Identification in Farm Animals

2. Milking Hygiene

Milk should be harvested and stored under hygienic conditions. Equipment used to harvest and store milk should be suitable and well maintained.

- **Ensure milking routines do not injure the animals or introduce contaminants into milk to prepare animals for hygienic milking:**
- Identify individual animals that require special milking management
- Ensure appropriate udder preparation for milking
- Milk animals regularly using consistent milking techniques
- Segregate milk harvested from sick or treated animals for appropriate disposal
- Ensure milking equipment is correctly installed and maintained
- Ensure a sufficient supply of clean water
- **Ensure milking is carried out under hygienic conditions:**
- Ensure housing environment is clean at all times
- Ensure milking area is kept clean
- Ensure the milkers follow basic hygiene rules

- Ensure milking equipment is cleaned and, when necessary, disinfected after each milking
- **Ensure milk is handled properly after milking:**
- Ensure milk is cooled or delivered for processing within the specified time
- Ensure milk storage area is clean and tidy
- Ensure milk storage equipment is adequate to hold milk at the specified temperature
- Ensure milk storage equipment is cleaned and when necessary, sanitised after each milk collection
- Ensure unobstructed access for bulk milk collection

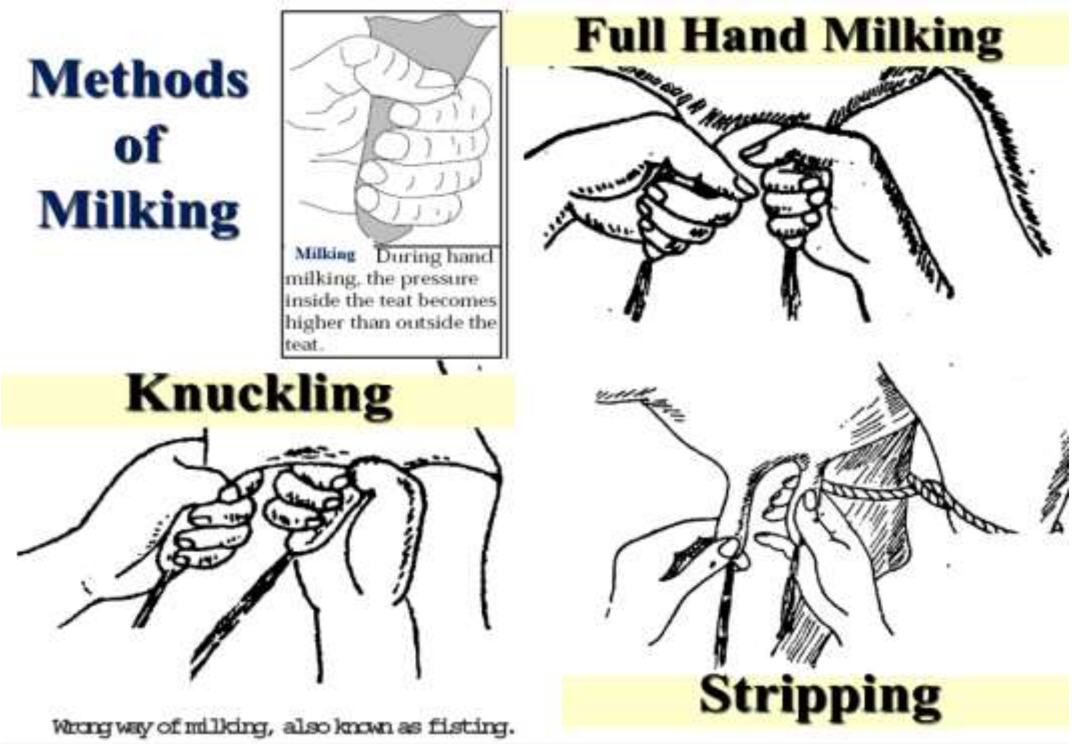


Fig. 3: Milking Methods

3. Nutrition (Animal Feed and Water)

Dairy animal is known as one of the most efficient producers of food for man. It can utilize large quantities of feed, much of which is inedible in the natural state. Economical production of milk, however, depends largely upon three main factors – the efficiency of an animal, its nutrition and management. The efficient cow/buffalo is the result of inheritance and improved breeding. Its productivity, however, depends upon the adequate inputs in terms of feed and care. Feeding of livestock is the main component of management and feed alone constitute about 65 – 70% of the total cost of production. Hence, scientific feeding is an important factor in successful livestock farming. The low product or low output of any farm is partly due to improper feeding. For getting best result from livestock farming, the feeding of animals needs planning, scientific, practical as well as economical knowledge. Animals need to be fed and watered with products of suitable quality and safety.

Nutrient requirements of Dairy Animals

The following data is used to calculate the nutrient requirements of cattle and buffaloes for maintenance and milk production in India

Table.2 Nutrient requirements of Dairy Animals

DM requirement:	
For maintenance For milk in cow (BF 4%) For milk in buffalo (BF 7%)	2.16% of body weight 0.51 kg/kg milk yield 0.74 kg/kg milk yield
Protein requirement:	
Metabolizable protein (MP) for maintenance	2.65 g /kg $W^{0.75}$
CP for milk production	96 g/kg cow milk; 124 g/kg buffalo milk irrespective of fat %
Energy (TDN) requirement:	
For maintenance	35 g/kg $W^{0.75}$
For milk in cow (4% BF)	0.33 kg/kg milk yield
For buffalo milk (7% BF)	0.48 kg/kg milk yield

FCM: Formula for converting milk with any butter fat per cent to 4% butter fat milk (FCM):

FCM (kg) = 0.4 M + 15 F

Where, M = Kg Milk

F = Kg Fat

Challenge feeding Concept for Dairy Animals

It is starting the concentrate mix (about 500 gm) feeding before 2 weeks expected date of calving (EDC) and increase it gradually to a level of 500 -1000 g for every 100 kg B. wt. High milk producing animals are fed increasing quantity of feed challenging them to produce at their maximum potential. This challenge feeding will condition her digestive system for the increased quantity of feed to provide sufficient nutrients to initiate lactation on a higher plane. This effect has been found to have higher total milk yield in the lactation. After calving to first 2 weeks of lactation start the concentrate allowance from 500 gm daily and gradually increase up to free choice level. And from 2nd week to peak yield concentrate mix given free choice.

Ten Commandments for effective feeding of dairy animals

- Feeding dairy animals on home-grown fodder, especially leguminous or a mixture of leguminous and non-leguminous would be most economical as compared to feeding them on crop residues and concentrates.
- Feeding roughages (hay or hay and silage) twice a day and concentrates or grain mixture at or before milking. Green forages are much more palatable than the hays prepared from them. Through liberal feeding of greens or silage, the need to feed concentrates can be cut down by 33 per cent. When leguminous fodder such as Lucerne and berseem is fed, the quantity of concentrates can be further cut down. However,, the greens especially leguminous fodder

should not form the entire roughage ration because of the risk of producing bloat. It should be mixed with green grasses/hay or other non-leguminous fodders/crop residues before feeding. Green fodders/crop residues must be chaffed before feeding to reduce wastage.

- Concentrate must be fed after moistening it with some water to reduce dustiness. The moistened feed should be fed the same day.
- The digestive system of a high producing dairy animal has a limited capacity and so to obtain the required nutrients, the digestibility of the ration on dry matter basis must be 65% or higher. It will enable the cow to assimilate the available nutrients in the feed.
- The cow must be "conditioned adequately before calving so as to have the needed body reserve for good milk production after calving. For this, It must calve in relatively fat condition and so must be on a fattening ration for the last two months of the dry period. It must be provided energy requirements equal to that of a cow producing about 10kg of milk a day and gain at least half a kg in bodyweight every day in the last two months of lactation. Feed at least one kg of concentrate mixture per day and in larger quantities for the high yielder.
- A dry cow is often considered as a cow which is not in a 'profit', whereas it should be considered as a cow 'preparing for profit' – and the amount of the profit depends on the through ness of the preparation. In a herd that is well managed, the dry cow rates high in priority for feed.
- A well - conditioned cow loses weight after calving, but increases her daily milk yield. In fact, if it is going to produce 10 to 12 kg or more milk a day for any length of time, it will have to lose some weight. Cows usually cannot take enough feed in a day to produce this quantity of milk for any length of time without losing weight, irrespective of how good the feed may be. The weight loss is largely from body fat stored for this purpose when it was dry. A well-grown Jersey cow may lose about 50kg in the two months after calving, while a large Holstein may lose 150 kg over the same period.
- The cow that is poorly conditioned at calving time is hardly likely to respond to additional feed inputs. In any case, her yield will be mediocre or even low. Some of the additional feed supplied will be diverted to her body conditioning. It is more expensive to fatten cows after calving than it is to fatten them before calving.
- For maximizing income, the dairy animals should be fed individually according to their individual milk yield and nutritional requirements, instead of allowing the same ration to each animal in the herd. Liberal feeding is necessary for continued high milk production and its persistency throughout the lactation.
- An abundant supply of clean drinking water must be provided at all times. It is the most essential feed ingredient. Do not permit cattle to drink water from dirty ponds, streams or tanks as it would result in increased incidence of diseases, lowered vitality and decreased milk production. Daily water intake for an animal of 300 kg body weight yielding 5 kg milk daily will be about 35 -40 litres.

4. Animal Welfare:

Success in dairying depends largely on the proper care and efficient management of the herd. All dairy operations must be planned with due regard to the comfort of the animals. An efficient welfare management for cattle will be incomplete without a well-planned and adequate housing of cattle. Improper planning in the arrangement of animal housing may result in additional labour charges and thus curtail the profit of the owner. During erection of a house for dairy cattle, care should be taken to provide comfortable accommodation for individual cattle. The principal functions of any system of housing for dairy cattle are:

- Provision of health sustaining and comfortable environment to the cows and calves
- Provision of desirable working conditions for labour and supervisory staff on the farm
- Integration of housing with feeding, watering, milking and manure handling systems

Fig. 4: Livestock Housing Assessment

Animals should be kept according to the following 'five freedoms'

• Freedom from thirst, hunger and malnutrition
• Freedom from discomfort
• Freedom from pain, injury and disease
• Freedom from fear
• Freedom to engage in relatively normal patterns of animal behaviour

Table. 3 Floor, feeding manger and watering space requirements of dairy animals

S.No.	Type of animal	Floor space/ Animal (m^2)		Feeding (Manger) space/animal (cm)	Water trough space/ animal (cm)	Mode of housing
		Area	Open area			
1	Young calves (< 8 weeks)	1.0	2.0	40- 50	10-15	Individual or in groups of below 5
2	Older calves (> 8 wks)	2.0	4.0	40-50	10-15	Groups of below 15
3	Heifers	2.0	4.0-5.0	45-60	30-45	Groups of below 25
4	Adult cows	3.5	7.0	60-75	45-60	Groups of below 25
5	Adult Buffaloes	4.0	8.0	60-75	60-75	Groups of below 25-30
6	Down calvers	12.0	20-25	60-75	60-75	Individual
7	Bulls	12.0	120.0	60-75	60-75	Individual
8	Bullocks	3.5	7.0	60-75	60-75	Pairs

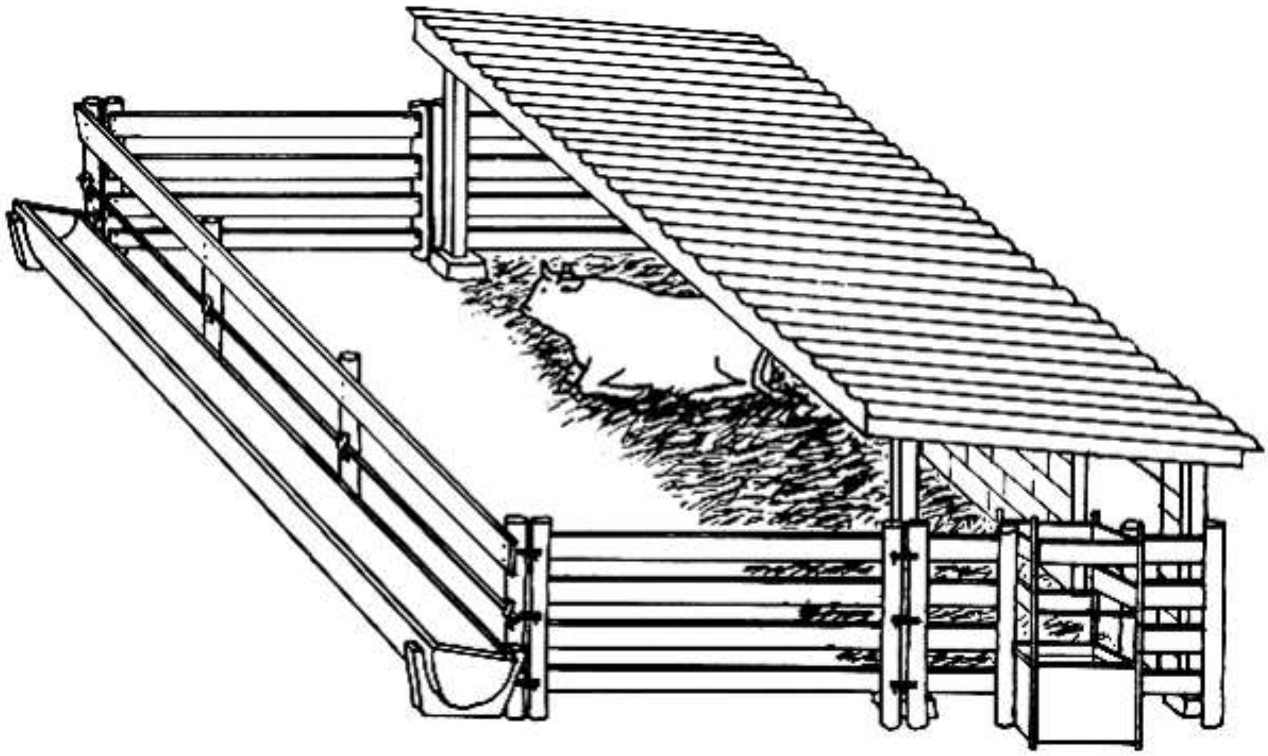


Fig. 6 Loose Housing System to get 10% more milk compared to tie animals and to avoid environmental stress

5. Environment

As we all know, consumers are concerned that the production of food is sustainable and in harmony with the environment. To meet these concerns it is important that the milk production

by the dairy farmers should meet the wider community's expectations, by using natural resources efficiently and minimizing any adverse impact on the environment. Every dairy farmer can play a role in protecting their industry and the future of their enterprise by adopting management practices that enhance the environmental sustainability of their farming system.
The good dairy farming practices for the environment are:
• Implement an environmentally sustainable farming system.
• Have an appropriate waste management system.
• Ensure dairy farming practices do not have an adverse impact on the local environment.

- **Environmentally sustainable farming system**
- Use farm inputs such as water and nutrients efficiently and sustainably
- Minimise the production of environmental pollutants from dairy farming
- Manage livestock to minimise adverse environmental impacts
- Select and use energy resources appropriately
- Maintain and/or encourage biodiversity15 on the farm
- **Have an appropriate waste management system**
- Implement practices to reduce, reuse or recycle farm waste as appropriate
- Manage the storage and disposal of wastes to minimize environmental impacts
- **Ensure dairy farming practices do not have an adverse impact on the local environment**
- Contain dairy runoff on-farm
- Use agricultural and veterinary chemicals and fertilizers appropriately to avoid contamination of the local environment
- Ensure the overall appearance of the dairying operation is appropriate for a facility in which high-quality food is harvested

6. Socio-Economic Management

Dairy farming provides economic and social benefits to farmers and their wider communities. Good dairy farming practice can also help to manage the social and economic risks to the enterprise.

- **Implement effective and responsible management of human resources**
- Implement sustainable work practices
- Employ staff based on national laws and practice
- Manage human resources effectively, ensuring that their working conditions comply with applicable laws and international conventions
- Ensure the farm working environment complies with relevant occupational health and safety requirements
- **Ensure farm tasks are carried out safely and competently**
- Have appropriate procedures and equipment in place for undertaking dairy farming tasks
- Induct and train/educate staff appropriately for their work
- Ensure staff carry out their tasks competently
- Choose competent people for training, advice and interventions
- **Manage the enterprise to ensure its financial viability**
- Implement financial management systems

- Adopt agricultural practices that contribute to the productivity and/or profitability goals of the enterprise
- Plan ahead to manage financial risks

Other Dairy Farm Management Practices are

Care and Management during pregnancy

- **Nutrition**: Provide GF (legumes) *adlibitum.*
- Avoid taking them long distances for grazing.
- Fetus development will be more during last trimester of pregnancy. Hence, extra concentrate ration may be provided.

Inadequate nutrition results in

- Pregnancy toxaemia.
- Lesser birth weight
- Increased mortality in calves
- Insufficient milk production from the dams.
- **Exercise:** Provide adequate exercise to prevent calving difficulties
- **Housing**: Pregnant animals may be kept in separate enclosures with dry bedding material.
- Keep houses/pens clean and well ventilated.
- **Drinking water** availability: Provide clean and safe drinking water.
- **Deworming**: Keep them parasite free.
- **Protection**: Protect them from dogs, predators and small children from chasing.

Care and Management of new born calf

- The care of young one starts even before its birth
- A good reception by the mother by licking all the mucous from the body of calf, establishing the affinity between both the dam and new born, otherwise dry it with clean towel.
- Be sure that all the mucous membranes or mucoid fluid are removed from nose and mouth of the new born for proper breathing. Tickle nostrils with a straw, calf sneezes violently; mucous falls down or Suck all the mucous from nostrils.
- The most critical period in life of a calf is during the 1st 48 hours. Most of problems such as chilling, weak, dry dams, cows with plugged teats and cows failing to claim their calves occur during this period.
- Pinch off umbilical cord and apply disinfect like, Tr.Iodine to prevent naval ill.
- Help the calf to reach the teats of the cow for suckling.
- Feeding of Colostrum "the 1st milk produced by the mother after parturition" within ½ an hour.
- Colostrum is rich in Immunoglobulins, which provides immunity to the lamb.
- Colostrum acts as a laxative, which helps in expulsion of the 1st faeces called as Muconeum.
- Mark the calf and give temporary tag number, record the age and number of cow, sex of calf, DOB, Birth weight etc.
- Weak calves will usually not survive, unless given assistance, i.e. place the teat in the calf's mouth and squeeze some milk into it.
- Weak calves may be encouraged to suck the milk by tickling under the base of the tail.

Raising Orphans:

- **Foster Mother Technique:**
- Cows identify their calves by smell.
- Foster mothers, immediately after calving the nostrils of cows may be rubbed with kerosene. This temporarily disturbs the sense of smell and makes it difficult to detect the difference in calves.
- Tying such cows that have lost their calves closer to the orphan calves.
- **Grafting method**:
- Putting the whole skin of the dead calf over the body of the orphan calf. An attempt by the cow to lick an orphan is an indication of success.
- **By Hand Feeding:**
- The orphan calf should be fed two or three feeds of colostrums from another cow.
- For Bottle feeding, the milk should be warmed to 36^{0}C before feeding.
- Later, other cow's milk may be substituted.
- Feed small quantity of 30 gm at 2 hours interval for few days, later the amount may be increased.

Reproductive management:

Without reproduction there will be no lactation nor replacements for the future. Therefore, the maintenance of high fertility rate is basic to the success of any dairy farming enterprise and its viability as a business. For high life time production and overall return per cow, a long life and regular reproduction are essential.

Reproduction parameters:

- **Calving rate:** Calving rate measures the number of cows calving out of total cows (%) during a specific period. This depends on actual service conception rate and embryo foetus survivability.
- **Services per conception:** A cow may need one or more services before she is settled. When the semen is of high fertility and the cow is inseminated at proper time, the number of services required for conception gives a quantitative measure of the fertility rate of the cow.
- **Non return rate:** This measure is based on the assumption that if a cow after an initial insemination is not brought again for another insemination within 60 to 90 days the cow is pregnant.
- **Calving interval:** The frequency of calving or the interval between calvings is regulated by the management decision on how soon after calving a cow is rebred as well as the success of the first or subsequent services. A calving interval of 12 months for cows and 13 months for first calf heifers have been found to be optimum.
- **Breeding efficiency /reproductive efficiency**: It is the ratio between actual calving to ideal calving interval of 365 days and expressed as a percentage.

Wilcox formula: $$BE = \frac{365\,(N-1)}{D} \times 100$$

Where, N – No. of calvings
D – Days between first and last calving

365 – Ideal calving interval

Tomar formula: $$\text{BE Cattle} = \frac{N(365) + 1020}{A + C} \times 100$$

$$\text{BE Buffaloes} = \frac{N(365) + 1040}{A + C} \times 100$$

Where,
N – No. of calving intervals
A – Age at 1st calving
C – No. of days between 1st and last calving

- 365 days – Ideal calving interval
- 1020 and 1040 days – ideal age of 1st calving in cows and buffaloes, respectively
- In adverse environmental conditions, the poor milk producing animals may not be much affected compared to high milk yielders.
- *In buffaloes* low reproductive efficiency due to long gestation period, long calving interval, silent heat and low conception rate.

Chapter-8

PREPARATION OF ON FIELD BALANCED FEED WITH AVAILABLE RESOURCES

N. Nalini Kumari
Professor, Dept of Animal Nutrition
College of Veterinary Science, PVNR Telangana Veterinary University
Rajendranagar, Hyderabad-500030, Telangana
Email: nalini_reddy123@yahoo.co.in

Introduction

Feeding is the largest input for any livestock production system accounting for 60-70% of the cost of production. Growing demand for livestock products, shortage of feed resources and animals with improved production potential are some of the major factors responsible for greater interest in the improved feeding management of livestock. The major factor responsible for low livestock productivity is imbalanced nutrition. The balanced nutrition improves the animal output as well as reduces the cost of production and the emission of greenhouse gases per unit of animal product. The feed formulation using locally available feed resources in scientific manner will improve the feed efficiency in animals. This involves simple methods as well computer programming. Ration balancing is providing a dairy animal with calculated amount all the required quantity of nutrient at specific time for period of 24 hours. The feed is formulated after calculation of nutrient requirement of an animal. The feed may be formulated based on the least cost feed formulation techniques. Feed formulation is a very important of animal production. The success of any animal production enterprise depends to a large extent on appropriate nutrition and feeding based on economic rations. The animal production practitioner should have a good knowledge of nutrition, feeding, physical and chemical characteristics of the feedstuffs, feedstuff interactions and limitations as well as economics of production. Low productivity of animals with higher genetic potential can be primarily attributed to the imbalanced and inadequate feeding. According to Cunningham (2005), “genetics has created the potential, nutrition has failed to deliver that potential,” irrespective of the type of system practiced.

Ration formulation is a task that meets the nutrient requirements of the animal with combinations of various feed ingredients. Rations must be properly balanced for livestock to use feeds most efficiently. The efficient producer can use ration balancing as another management tool to maximize the profits. Feeding of imbalanced ration leads to deficient of some nutrients as well excess feeding. This will reduce the milk production and increase the cost of production, but also affect the various physiological functions including fertility, productivity and long term animal health.

Rations can be formulated using mathematical models and sophisticated electronic computers. However, satisfactory rations can be formulated using simple calculations. The first priority is to select locally grown feeds among the available on a per unit cost basis. Roughages and forages are the least expensive feeds and they therefore, should compose as large a percentage of the diet as is feasible. Concentrates, minerals and vitamins are supplemented to ensure that all the essential nutrients are included in the diet.

Principles of ration formulation

A **ration** is the amount of feed an animal receives in a 24-hour period.

A **balanced ration** is the amount of feed that will supply the appropriate amount and optimum proportions of nutrients needed for an animal to perform a specific purpose such as growth, maintenance, lactation or gestation.

Nutrient requirements are the amount of nutrients the animal needs for a specific purpose. They are influenced by many factors, like body weight of animal, sex, growth rate, milk yield, lactation stage, environment and others.

The **nutrient composition** of a feed is the amount of specific nutrients contained in the feed. They are expressed as a percentage of the dry matter. The nutrient composition of a feed can be provided from laboratory analysis or a composition table, which will include dry matter, crude protein, energy and minerals.

Dry matter (DM) is the portion of the feed left after all moisture is removed which contains all the nutrients. The dry matter intake shown in feeding standards or nutrient requirement tables are represent of an amount that can be consumed under normal circumstances. Different feeds contain different levels of dry matter; therefore, it is desirable to balance the ration on a dry matter basis and then convert the various feeds back to an as-fed basis.

Crude protein (CP) may also be called total protein. It is determined by measuring the nitrogen content of feed and multiplying by the factor 6.25 since on average proteins typically contain 16% nitrogen. All the nitrogen-containing compounds are not true proteins. These are called non protein nitrogen (NPN) sources. Many of these NPN compounds are utilized by the rumen microbes in the rumen and can synthesis into microbial protein under optimum conditions. Generally, NPN sources are not used well as protein animals have high protein requirements, such as young cattle with high rates of growth and dairy cattle with high milk yield. True protein sources should be included in the rations.

Energy is not actually a nutrient. It is contained in nutrients such as carbohydrates, fats, etc. There are several methods of measuring the energy values of feedstuffs. Some of these are total digestible nutrients, starch equivalent, digestible energy, metabolizable energy, net energy for maintenance and production. Total digestible nutrients (TDN) are the values most commonly used in simple ration balancing.

Minerals are compounds needed to regulate many metabolic functions in the body. They may be classed as macro or trace minerals depending on the amounts needed. Examples of macro minerals are calcium and phosphorus. Iron, zinc and copper are examples of trace minerals. Other important nutrients are vitamins and water. These nutrients must be provided in adequate amounts for desired production. Water is particularly important because feed intake decreases when water intake is not adequate.

Roughages are feeds that are relatively high in crude fiber and low in energy and protein. Green forages (legumes and cereal and non-cereal), hay, straw, bagasse, cobs, cottonseed hulls and corn stalks are examples of roughages.

Concentrates are feeds or mixtures of feeds that are relatively low in crude fiber and provide energy/protein as the primary nutrient. Usually concentrate mixture contains

Ingredient	**Range (%)**
Cereal grains (Maize/jowar/bajra/wheat/broken rice)	20-30
Oil cakes (Groundnut cake / soybean / cottonseed meal)	15-35
Grain by-products (Rice bran, wheat bran/rice polish)	0-35
Molasses / jaggery	0-10
Common salt	0.5-1
Calcite powder	0.5-2
Mineral mixture and other supplements	1-2 .5

Characteristics of a balanced ration:

- The ration should be properly balanced and more purposeful and beneficial
- The ration must be palatable
- The ration should have variety of feeds which make it more palatable
- The ration should contain enough of mineral matter
- The ration should be fairly laxative
- The ration should be fairly bulky
- The ration should contain sufficient green fodder
- Avoid sudden changes in the ration
- Maintain regularity in feeding
- The ration should be economical

Impact of feeding balanced ration:

- Increases the milk production and net daily income
- Increases the milk production efficiency
- Increases the rumen microbial protein synthesis
- Increases the immune status of animals
- Decreases the parasitic infestations in animals
- Decreases the enteric methane emission
- Increases the efficiency of feed nitrogen use in milk

Prerequisites of formulating a ration:

- Determine the nutrient requirements of the animals
- List the locally available feed resources
- Mention the nutrient composition of the feed resources
- List the inclusion levels of the feedstuffs
- List the cost of the feed resources

Methods of formulation especially for concentrate mixture or grain mixture:

Mechanics of feed formulation:

Ration formulation is matching of the nutrient requirements of the animal with the nutrients present in the feedstuffs of the ration. When rations are formulated by hand, generally they are first formulated for one nutrient.

Then the other nutrients are checked to determine whether the feedstuffs used will meet the requirements or whether alternative feed resources need to be included in the diet. One method is to balance for protein first and then to check energy levels to see if they are met. Next, the ration can be checked for the other nutrients such as calcium and phosphorus.

When the number of nutrients specified is small, diet formulation can be adequately carried out through simple calculations. The calculations involved in this type of formulation are simple and few. However, as the number of nutrient specifications and the number of feedstuffs available increases, the mathematics get quite involved and confusing. In such cases, it is appropriate to use computer spread sheets or specialized programs.

1. **Trial& Error method:**

   This is the most commonly used method of formulating ration. It is a type of feed formulation followed in many developing nations of the world. As the name implies, the formulation is manipulated until the nutrient requirements of the animal are matched. When using the trial and error method, one starts with a primary feed ingredient and modifies the fundamental ration formula step by step to compensate for any nutrient deficiencies found in the primary feed.

   This method makes possible the formulation of a ration that meets all the nutrient requirements of the animal. Greater control can be had on implementing restrictions and judging inclusion levels. It is a time consuming method involving a lot of calculations and meeting out specifications may not be very precise.

Step 1: Make a list of the ingredients with their nutrient compositions Available for possible inclusion in the ration to be formulated

Step 2: Fix the requirements of the ration to be composed

Step 3: Proceed to balance the ration as follows:

Step 3.1: Reserve 2% for minerals / vitamins.

Step 3.2: Include ingredients a certain minimum percentage of which needs to be incorporated for various reasons.

Step 3.3: Include ingredients with an energy value higher than that required in the ration to constitute 30%. The priority should be given to those ingredients with the lowest price per unit of energy. It should be careful not to exceed the safe maximum levels for the ingredients.

Step 3.4: Include ingredients with protein contents higher than the required level in the ration you want to prepare. To start with, limit the level of inclusion of such ingredients to 18%. Again, priority should be given to those ingredients with the lowest price per unit of protein without exceeding the safe maximum levels.

- Step 3.5: Now, add the percentage and quantities of the various nutrients and compare the nutrient quantities with requirements of the target class of animal.
- Step 3.6: Select an ingredient that is a good source of the nutrient (energy, protein) missing the most. The selected ingredient is included to constitute 10% of the final ration. Continue to do the same until you reach 100% by repeating step 3.5 after every addition.
- Step 3.7: It may be necessary to substitute some ingredients by others in order to obtain proper levels and ratios of the required nutrients. This is usually done when proceeding from 90 to 100%.

2. **Pearson square method**

1. Draw a pearson's square for determining the proportions (or) ratio of feeds to be mixed.

2. Partition the feeds as high protein and low protein feeds.
3. Place the percentage of crude protein desired in the center of the pearson's square.
4. Place the average percentage of crude protein present in high protein feeds on the left side upper corner of this square.
5. Place the average percentage of the crude protein present in low protein feeds on the left side lower corner of this square.
6. Take about the diagonal lines in the square.
7. Draw the difference between the figures on the left hand sides and the center figure and place these on the right hand corners of the square, in the direction of diagonal lines.
8. The figures obtained on the right hand side corners are the parts or proportions in which ratio the given feeds should be mixed to obtain the mixture of desired CP percentage.
9. Pass the feeds to be mixed through grinder and then mix the ground feeds in horizontal / vertical mixer.
10. Fill the gunny bags using the shovel (or) directly fill it from the mixer.
11. Label the feed mixture along with the weight neatly, clearly and legibly.

Note: Minerals consisting of bone meal and common salt may also be added in required quantity before grinding and mixing.

Example

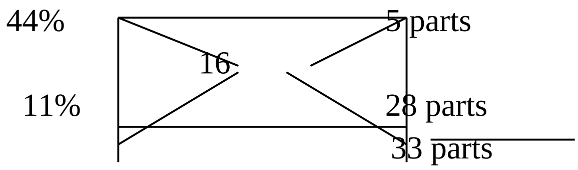
Prepare 100 kg concentrate mixture containing 16 % CP using maize grain, ricebran and ground nut cake consisting of 10, 12 and 44% CP, respectively.

Solution

Average CP of low protein feeds = Maize + rice bran / 2

= 10 +12 / 2 = 11%.

CP content of high protein feed (ground nut cake) = 44%



ie. 33 kg of mixture will contain 5 parts of ground nut cake

100 kg should contain ? parts of ground nut cake

= 100 x 5 / 33 = 15.15 kg or 15 kg

Therefore,

Amount of low protein feeds = 100 – 15 = 85 kg.

maize= 85 x 10/22= 38.6 parts

rice bran= 85 x 12/22= 46.36 parts

Verification:

Feedstuff	**Parts**	**% CP supplied**
Groundnut cake	15.1	15.1 x 44 /100 = 6.6
Maize	38.6	38.6 x 10 /100 = 3.86
Rice bran	46.3	46.3 x 12 / 100 = 5.55
Total	100	16.031 %

3. Algebraic method:

1. Divide the ingredients into two groups ie. Low protein group and high protein group depending on their protein content.
2. Calculate the average protein content of each group, if there is more than one feed ingredient.
3. Assume that 'X' represents the amount of low protein feeds and 'Y' represents the amount of high protein feeds present in 100 kg of concentrate mixture. That means,

X + Y = 100 ---------- (1)

Note: In case, the amount of mineral mixture and salt to be included in the ration are fixed say 2 and 1% respectively, then this fixed proportion of 3% should be subtracted from the total quantity of conc. Mixture. In such case

X + Y = 97 -----------(1)

4. For example, assume that Average CP content of low protein group is 8 %

This means, 100 kg of feed will contain 8 kg CP

Therefore, the amount of CP supplied through 'X' kg will be

= X * 8 / 100 = 0.08 X kg.

b. Average CP content of high protein group is 40 %

This means, 100 kg of feed will contain 40 kg CP

Therefore, the amount of CP supplied through 'Y' kg will be

= Y * 40 / 100 = 0.40Y kg.

c. However, the amount of CP/DCP being supplied through low and high protein feeds should be equal to the desired protein level (say 18%). So,

0.08 X + 0.40 Y = 18 --------------- (2)

5. Calculate the value of 'X' and 'Y' from the above two equations.
6. Now, 'X' and 'Y' representing the amount of low and high protein feeds should be divided equally, depending on the number of ingredients in each group.
7. Check whether the calculated proportion of each ingredient when mixed together is supplying the desired CP content or not.

Example:

Prepare 100 kg concentrate mixture containing 18 % CP using maize grain, wheat bran and linseed cake consisting of 10, 12 and 30 % CP respectively.

Solution:

Let maize and wheat bran represent low protein group and linseed cake represent high protein group.

Average CP content of low protein group = 10 + 12 / 2 = 11 %

Average DCP content of high protein group = 30 %

Assume that 'X' represents the amount of low protein feeds and 'Y' represents the amount of high protein feeds present in 100 kg of concentrate mixture. That means,

X + Y = 100 ---------- (1)

Average DCP content of low protein group is 11 %

This means, 100 kg of feed will contain 11 kg DCP

Therefore, the amount of DCP supplied through 'X' kg will be

= X * 11 / 100 = 0.11X.

Average DCP content of high protein group is 30%

This means, 100 kg of feed will contain 30 kg DCP

Therefore, the amount of DCP supplied through 'Y' kg will be

= Y * 30 / 100 = 0.30Y.

c. However, the amount of DCP being supplied through low and high protein feeds should be equal to the desired protein level (say 18 %).

So,

0.11X + 0.30Y = 18 ---------------(2)

Multiplying equation (1) by 0.3 we get

0.3X + 0.3Y = 30 ----------(3)

Subtracting equation (3) from (2)

0.11X + 0.30Y = 18---------------(2)

0.3X + 0.3Y = 30 --------------(3)

0.19X = 12

or X = 12 / 0.19 = 63.16 or 63 parts

and Y = 100 – 63 = 37 parts.

Therefore,

No. of parts of maize = 63 / 2 = 31.5

No. of parts of wheat bran = 63 – 31.5 = 31.5

No. of parts of linseed cake = 37

Verification:

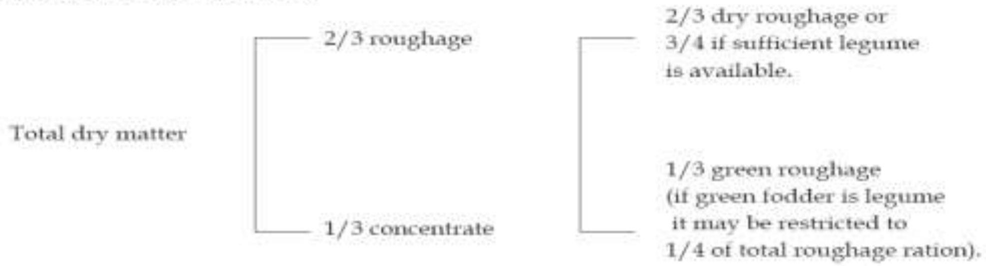
Feedstuff	Parts	% CP supplied
Linseed cake	37.0	37 x 30 /100 = 11.10
Maize	31.5	31.5 x 10 /100 = 3.15
Wheat bran	31.5	31.5 x 12 / 100 = 3.78
Total	100	18.03 %

Formulation of Ration containing roughages and concentrates:

1. Find out the total requirements of the animal in terms of DM, CP and TDN depending upon the physiological status (pregnancy, lactation, growth, work *etc*.) from the feeding standards.

DM requirement: The total quantity of dry matter the animal can consume per day should be known, so that we can compute the ration in a manner that the entire quantity of the nutrients required is present in the dry matter, the animal is able to consume. Cattle will generally consume 2.0 to 2.5 kg of dry matter per 100 kg body weight. Buffaloes, crossbred animals and heavy yielder consume 2.5 to 3.0 kg dry matter per 100 kg body weight. In mid lactation (10-29 weeks) DM intake has to be increased by 1.7 kg/day. In late lactation (30 weeks onwards) DM intake has to be increased by 4.1 kg / day. In early lactation, the probable DMI may be up to 18 % less than mid lactation.

PARTITIONING OF DRY MATTER



If a cow is weighing 4000kg body weight, the DM requirement will be calculated as follows

$$\text{Dry matter requirement} = \frac{400 \times 2.5}{100} = 10\text{kg or } \frac{400 \times 3}{100} = 12 \text{ kgs.}$$

The dry matter requirement = 10 to 12 kg.

Partitioning of dry matter:
1/3 of DM from concentrate
10 X 1/3 = 3.3 kg   or 12 X 1/3 = 4.0 kg}3 to 4 kg Dry matter from concentrate
7 to 8 kg from Roughages----- 1/3 from green roughage = 2 to 3 kg.
2/3 from dry roughage = 4 to 5 kg.

2. By trial and error method, find out the amount of green and dry fodder that should be offered to meet the nutrient requirements of the animal taking into consideration their availability.
3. Calculate the amount of DM, CP and TDN supplied through green and dry fodder.
4. Now, subtract the amount of nutrients supplied through green and dry fodder from the total requirements of the animal to find out the balance of nutrients to be supplied through concentrates.
5. Finally, calculate the amount of concentrate mixture to be offered to the animal to meet the balance of nutrients.

Note: Generally, rations are first formulated for one nutrient (say CP) and then, the other nutrients (say TDN) are checked to see whether the feedstuffs used will meet the requirement or whether alternative feeds need to be included in the ration.

Example: Formulate a ration for a cow weighing 400 kg yielding 10 kg of milk/day with 5 % butterfat and in **1st** lactation using the following feedstuffs.

Feedstuff	**DM%**	**CP%**	**TDN%**
Hybrid Napier	13.5	10.5	55
Paddy straw	90	5.13	40
Concentrate mixture	90	16	70

* Values of feeds and fodders on DM basis

Solution:

1. Calculation of nutrient requirements of the animal (to be taken from the nutrient requirements tables)

Requirements	**DM (kg)**	**CP (kg)**	**TDN (kg)**
For maintenance	8.64	0.436	3.27
For production (10kg with 5 % fat)	5.7	0.96	3.70

Growth allowance (20 % - 1st lactation)	1.72	0.087	0.65
Total requirements	16	1.48	7.62

2. Finding out the amount of nutrients supplied by green and dry fodder

Feedstuff	Amount on Fresh basis (kg)	Dry basis (kg)	CP (kg)	TDN (kg)
Hybrid Napier	25	3.3	0.34	1.81
Paddy straw	8	7.2	0.36	2.88
Total quantity	33	10.5	0.7	4.69

3. Balance of nutrients to be supplied thru concentrate mixture supplied thru

	DM (kg)	**CP (kg)**	**TDN (kg)**
Total requirement	16	1.48	7.62
Green & dry fodder	10.5	0.7	4.69
To be supplied thru conc.	5.56	0.78	3.44

4. Amount of concentrate mixture required to meet the CP requirement

Amount of CP to be supplied thru concentrates = 0.78 kg

Amount of CP present in the concentrate mix = 16 %

Amount of DM to be supplied through concentrate to meet the CP requirement is

$$= \frac{0.78}{16} \times 100 = 4.87 \text{ kg.}$$

5. Amount of TDN supplied through concentrate mixture

Amount of TDN present in the concentrate mix = 70 %

$$\text{Amount of TDN supplied thru conc. mix} = \frac{4.87}{100} \times 70 = 3.40 \text{ kg}$$

Amount of concentrate mixture required on fresh basis = 5.41 kg

Verification:

Nutrients supplied through	**DM (kg)**	**CP (kg)**	**TDN (kg)**
Hybrid Napier	3.3	0.34	1.81
Paddy straw	7.2	0.36	2.88
Concentrate mixture	4.87	0.78	3.40
Total	**15.37**	**1.48**	**8.0**
Actual requirement	16.0	1.48	7.62

Note: The short fall in the TDN requirement can be met by increasing the quantity of paddy straw in the ration.

Management practices to reduce feed cost

- Individual feeding based on body weight, milk production and pregnancy.
- High level of green grass based feeding and low concentrate feeing i.e., High green diet based total mixed ration.
- Every 5kg of legume green fodder is almost equivalent to one kg concentrate mixture

- Green fodder should be chapped at least one inch thickness and fed to the animal.
- Feeding of total mixed ration instead of separate feeding of concentrate, greens and fodder.
- Increasing the frequency of feeding at least 4 times in a day.
- Providing clean fresh drinking water available for 24h.
- Energy is more deficient in cattle feeding. Hence energy deficiency has to be taken care.
- Sufficient quantity of mineral mixture feeing is necessary.
- Avoid metabolic disorder viz. milk fever, ketosis etc.
- High grain feeding should be accompanied with sodium bicarbonate.
-

Table 1. Composition of Commonly Used Feeds (dry matter basis) NRC 1984

Feedstuff	Dry Matter, %	TDN, %	CP, %	Ca, %	P, %
Alfalfa hay, midbloom	90	58	17.0	1.41	.24
Alfalfa hay, late bloom	90	52	14.0	1.43	.25
Barley grain	88	84	13.5	.05	.38
Bluegrass hay	89	56	13.0	.33	.16
Crimson clover hay	87	57	18.4	1.40	.22
Ladino clover hay	90	60	22.0	1.35	.31
Red clover hay	89	55	16.0	1.53	.25
Corn, yellow	88	90	10.1	.02	.35
Corn, yellow, high-moisture	72	93	10.7	.02	.32
Corn stover	85	50	6.6	.57	.10
Ground ear corn	87	83	9.0	.07	.27
Corn silage (few ears)	29	62	8.4	.34	.19
Corn silage (well-earred)	33	70	8.1	.23	.22
Corn, distillers grain (dehydrated)	94	86	23.0	.11	.43
Fescue hay, early veg.	91	61	12.4	.51	.36
Fescue hay, early bloom	92	48	9.5	.30	.26
Lespedeza hay, midbloom	93	50	14.5	1.20	.25
Molasses (syrup)	78	79	8.5	.17	.03
Oats	89	77	13.3	.07	.38
Orchardgrass hay, early bloom	89	65	15.0	.27	.34
Orchardgrass hay, late bloom	91	54	8.4	.26	.30
Sorghum stover	88	54	5.2	.52	.13
Sorghum grain (milo), 8-10 CP	87	84	10.1	.04	.34
Sorghum silage	30	60	7.5	.35	.21
Sorghum sudangrass hay	91	56	8.0	.55	.30

Sorghum johnsongrass hay	89	53	9.5	.84	.28
Soybean meal (44%)	89	84	49.9	.33	.71
Timothy hay, midbloom	89	57	9.1	.48	.22
Urea (45% nitrogen)	99	0	281.0	0	0
Wheat	89	88	16.0	.04	.42
Wheat hay	88	58	8.5	.15	.20
Wheat silage, full bloom	25	59	8.1	.15	.20
Wheat straw	89	41	3.6	.18	.05
Mineral Sources					
Dicalcium phosphate	97	---	---	22.0	19.3
Ground limestone	100	---	---	39.4	---
Magnesium Oxide (56% Mg)	98	---	---	3.1	---
Steamed bone meal	97	8.4	15	31.5	14.2
Sodium tripolyphosphate	96	---	---	---	25.0

Table 2. Daily Nutrient Requirements of Small Breed Cows (live weight _ 454 kg) in Early Lactation (intake estimated at 11 days in milk). Values are Appropriate for the Diet Below With 78% TDNa (NRC,2001)

Milk (kg)	Fat (%)	True Protein (%)	DMI (kg)	LW change (kg)	NE_L (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
15	4.0	3.0	9.4	−0.3	19.0	1060	500	11.3	5.3	16.6
15	4.0	3.5	9.4	−0.3	19.4	1060	630	11.3	6.7	18.0
15	4.0	4.0	9.4	−0.4	19.8	1060	760	11.3	8.1	19.4
15	4.5	3.0	9.7	−0.3	19.7	1090	490	11.2	5.1	16.3
15	4.5	3.5	9.7	−0.4	20.1	1090	620	11.2	6.4	17.6
15	4.5	4.0	9.7	−0.5	20.5	1090	750	11.2	7.7	18.9
15	5.0	3.0	9.9	−0.4	20.4	1110	480	11.2	4.8	16.0
15	5.0	3.5	9.9	−0.5	20.8	1110	610	11.2	6.2	17.4
15	5.0	4.0	9.9	−0.5	21.2	1110	740	11.2	7.5	18.7
30	4.0	3.0	12.9	−1.4	30.1	1410	1170	10.9	9.1	20.0
30	4.0	3.5	12.9	−1.6	30.9	1410	1430	10.9	11.1	22.0
30	4.0	4.0	12.9	−1.7	31.8	1410	1690	10.9	13.1	24.0
30	4.5	3.0	13.5	−1.5	31.5	1460	1150	10.8	8.5	19.3
30	4.5	3.5	13.5	−1.7	32.3	1460	1410	10.8	10.4	21.2
30	4.5	4.0	13.5	−1.9	33.2	1460	1670	10.8	12.4	23.2
30	5.0	3.0	14.0	−1.6	32.8	1510	1140	10.8	8.1	18.9
30	5.0	3.5	14.0	−1.8	33.7	1510	1400	10.8	10.0	20.8
30	5.0	4.0	14.0	−2.0	34.6	1510	1660	10.8	11.9	22.7

[a]Diet used for this table consisted of 15% immature legume silage, 33% normal corn silage, 34% ground high moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% menhaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NE_L intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

Table. 3: Daily Nutrient Requirements of Small Breed Cows (live weight _ 454 kg) in Mid lactation (intake estimated at 90 days in milk). Values Are Appropriate for the Diet Below with 78% TDN*a* (NRC, 2001)

Milk (kg)	Fat (%)	True Protein (%)	DMI (kg)	LW change (kg)	NE_L (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
20	4.0	3.0	16.0	1.0	22.7	1680	560	10.5	3.5	14.0
20	4.0	3.5	16.0	0.8	23.2	1680	740	10.5	4.6	15.1
20	4.0	4.0	16.0	0.7	23.8	1680	910	10.5	5.7	16.2
20	4.5	3.0	16.5	0.9	23.6	1730	550	10.5	3.3	13.8
20	4.5	3.5	16.5	0.8	24.2	1730	720	10.5	4.4	14.9
20	4.5	4.0	16.5	0.7	24.8	1730	900	10.5	5.5	16.0
20	5.0	3.0	17.0	0.9	24.5	1770	540	10.4	3.2	13.6
20	5.0	3.5	17.0	0.8	25.1	1770	710	10.4	4.2	14.6
20	5.0	4.0	17.0	0.6	25.7	1770	880	10.4	5.2	15.6
30	4.0	3.0	19.5	0.4	30.1	1980	1010	10.2	5.2	15.4
30	4.0	3.5	19.5	0.2	30.9	1980	1270	10.2	6.5	16.7
30	4.0	4.0	19.5	0	31.8	1980	1530	10.2	7.8	18.0
30	4.5	3.0	20.3	0.3	31.5	2040	990	10.0	4.9	14.9
30	4.5	3.5	20.3	0.1	32.3	2040	1250	10.0	6.2	16.2
30	4.5	4.0	20.3	−0.1	33.2	2040	1510	10.0	7.4	17.4
30	5.0	3.0	21.1	0.2	32.8	2100	980	10.0	4.6	14.6
30	5.0	3.5	21.1	0	33.7	2100	1240	10.0	5.9	15.9
30	5.0	4.0	21.1	−0.2	34.6	2100	1500	10.0	7.1	17.1
40	4.0	3.0	23.1	−0.3	37.5	2240	1470	9.7	6.4	16.1
40	4.0	3.5	23.1	−0.6	38.6	2240	1820	9.7	7.9	17.6
40	4.0	4.0	23.1	−0.8	39.8	2240	2160	9.7	9.4	19.1
40	4.5	3.0	24.2	−0.5	39.3	2310	1460	9.5	6.0	15.5
40	4.5	3.5	24.2	−0.7	40.5	2310	1800	9.5	7.4	16.9
40	4.5	4.0	24.2	−1.0	41.7	2310	2150	9.5	8.9	18.4
40	5.0	3.0	25.2	−0.7	41.2	2390	1450	9.5	5.8	15.3
40	5.0	3.5	25.2	−0.9	42.3	2390	1790	9.5	7.1	16.6
40	5.0	4.0	25.2	−1.1	43.5	2390	2140	9.5	8.5	18.0

[a]Diet used for this table consisted of 15% immature legume silage, 33% normal corn silage, 34% ground high moisture shelled corn, 12% soybean meal (48% crude protein), 2.5% tallow, 1.5% menhaden fish meal, and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NE_L intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

Table 4 Daily Nutrient Requirements of Small Breed Cows (live weight _ 454 kg) in Mid lactation (intake estimated at 90 days in milk). Values are Appropriate for the Diet Below with 68% TDN*a* NRC, 2001)

Milk (kg)	Fat (%)	True Protein (%)	DMI (kg)	LW change (kg)	NE_L (Mcal)	RDP (g)	RUP (g)	RDP (%)	RUP (%)	CP (%)
10	4.0	3.0	12.4	0.9	15.3	1240	230	10.0	1.9	11.9
10	4.0	3.5	12.4	0.8	15.6	1240	320	10.0	2.6	12.6
10	4.0	4.0	12.4	0.8	15.9	1240	420	10.0	3.4	13.4
10	4.5	3.0	12.7	0.9	15.7	1270	230	10.0	1.8	11.8
10	4.5	3.5	12.7	0.8	16.0	1270	320	10.0	2.5	12.5
10	4.5	4.0	12.7	0.8	16.3	1270	410	10.0	3.2	13.2
10	5.0	3.0	12.9	0.9	16.2	1290	220	10.0	1.7	11.7
10	5.0	3.5	12.9	0.8	16.5	1290	310	10.0	2.4	12.4
10	5.0	4.0	12.9	0.8	16.8	1290	400	10.0	3.1	13.1
20	4.0	3.0	16.0	0.4	22.7	1560	680	9.8	4.3	14.1
20	4.0	3.5	16.0	0.3	23.2	1560	860	9.8	5.4	15.2
20	4.0	4.0	16.0	0.2	23.8	1560	1040	9.8	6.5	16.3
20	4.5	3.0	16.5	0.4	23.6	1610	660	9.8	4.0	13.8
20	4.5	3.5	16.5	0.3	24.2	1610	840	9.8	5.1	14.9
20	4.5	4.0	16.5	0.2	24.8	1610	1030	9.8	6.2	16.0
20	5.0	3.0	17.0	0.4	24.5	1660	650	9.8	3.8	13.6
20	5.0	3.5	17.0	0.2	25.1	1660	830	9.8	4.9	14.7
20	5.0	4.0	17.0	0.1	25.7	1660	1010	9.8	5.9	15.7
30	4.0	3.0	19.5	−0.1	30.1	1870	1130	9.6	5.8	15.4
30	4.0	3.5	19.5	−0.3	30.9	1870	1400	9.6	7.2	16.8
30	4.0	4.0	19.5	−0.4	31.8	1870	1670	9.6	8.6	18.2
30	4.5	3.0	20.3	−0.2	31.5	1940	1110	9.6	5.5	15.1
30	4.5	3.5	20.3	−0.3	32.3	1940	1380	9.6	6.8	16.4
30	4.5	4.0	20.3	−0.5	33.2	1940	1650	9.6	8.1	17.7
30	5.0	3.0	21.1	−0.2	32.8	2000	1090	9.5	5.2	14.7
30	5.0	3.5	21.1	−0.4	33.7	2000	1360	9.5	6.4	15.9
30	5.0	4.0	21.1	−0.6	34.6	2000	1630	9.5	7.7	17.2

[a]Diet used for this table consisted of 40% mid-maturity legume hay, 27% normal corn silage, 23% cracked dry shelled corn, 8% soybean meal (48% crude protein), and 2% mineral and vitamin mix. Requirements are dependent upon the diet fed. Requirements shown do not include nutrients needed for live weight change. Live weight change is based on assumed NE_L intake minus requirements. Requirements for RUP do not include protein provided by loss in body reserves or required for gain in body reserves. Requirement for total CP assumes RDP and RUP are met. Requirement for total CP will increase if RDP requirement is not met.

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Chapter-09

PREVENTIVE HEALTH CARE MANAGEMENT FOR DAIRY COW

K. Lakshmi
Associate Professor
Department of Veterinary Medicine,
College of Veterinary Science, Rajendranagar, Hyderabad, Telangana.
Email: drklakshmi1@gmail.com

Introduction

The single biggest advance in dairy health in the last few years has been the paradigm shift from treatment of clinical illness to disease prevention. Shifts in philosophy, key assumptions, and priorities underlie the specific advances in science and technology. A fundamental advancement has been recognition of the multifactorial nature of almost all diseases of importance in dairy cattle. Epidemiology has been a critical new influence and tool to describe and quantify the interconnected risk factors that produce disease. In turn, health management or production medicine is characterized by an integrated, holistic, proactive, data-based, and economically framed approach to prevention of disease and enhancement of performance. Health management has been defined as the promotion of health, improvement of productivity, and prevention of disease in animals within the economic framework of the owner and industry, while recognizing animal welfare, food safety, public health, and environmental sustainability. Accordingly, disease prevention, considered broadly, is no longer the sole domain. Conversely, to deliver health management and effective disease prevention, consideration of nutrition, housing, and whole farm management systems are the recommendations of best practices. Major advance in applying new knowledge and effecting disease prevention has been a shift in focus from individual animals to groups and herds. Although dramatic increases in herd sizes have of themselves required this shift, the power of this approach is applicable to small or large herds. It is important to know about the interaction between management and health of dairy cows, with a focus on major factors that influence health outcomes and the management practices that promote overall animal health and prevent the development of disease. Both preventive and responsive herd health management programs are critical to promoting animal health and minimizing the risk of major adverse health events at the individual or herd levels.

Disease Screening, Treatment, and Surveillance

Disease screening, treatment, and surveillance are critically important components of herd health programs. These practices require regular observation of the herd, whole herd surveillance testing for certain diseases, and timely necropsies for animals who have died or been euthanized. A key to management of disease is fast and accurate diagnosis, followed by effective treatment. This requires a good surveillance system—the ability to identify, examine, and treat sick animals. Early identification of sick animals is critical to treatment success, and therefore it is essential that distinguishing between sick and healthy cattle should be done. Characteristics of sick cattle include Lack of appetite, Listlessness, Lameness or abnormal gait, Stiff movement, Coughing, Nasal and occular discharges, Increased breathing rate, Crusted muzzle, Sunken eyes, Drooping ears, Rough hair coat, Loose or very firm faeces, Abnormal abdominal fill, Straining, Spending an abnormal amount of time at the water source or segregated from pen mates. Cattle with these or other clinical signs of illness, or that just look "off," should be examined more closely and, if necessary, treated.

The herd health management plan should include the steps to take after an animal is treated and also specific plans for re-evaluation and relocation. Animals identified as chronically ill with little to no chance of recovery should be marketed for salvage value (only if there is no violative residue) or should be euthanized to minimize pain and discomfort. Pens, pastures, or groups of animals from which individual sick animals are identified should be closely observed to quickly identify other sick animals, as well as to avoid an epidemic or disease outbreak. Despite its importance, group surveillance remains a challenge, and it is often difficult to distinguish sick from recently received animals, particularly for calves that were recently weaned. In addition to visual observation, operations should also consider technologies such as monitoring and/or evaluation systems that use objective measurements to identify sick animals. Similarly, protocols should be developed for the prevention and control of disease. Protocols should be followed strictly by all personnel so that the success or failure of treatment can be evaluated accurately and the risk of human food safety hazards is minimized.

The effectiveness of the treatment protocol should be evaluated regularly by determination of the response rates for the various treatment regimens. Failure to develop and implement appropriate treatment protocols often leads to the use of many different drugs indiscriminately, which then leads to excessive treatment costs, diminished treatment success, and increased risk of development of drug resistance. The severity of the illness should also be assessed and recorded to adequately evaluate response to treatment. This information can be used to generate a report for each animal that was treated and decide whether an animal should be culled or to determine treatment efficacy. Castration and dehorning should be performed before weaning. In addition, calves should be vaccinated with at least one round of clostridial and viral bovine respiratory disease (BRD) vaccines before weaning. Completion of vaccination, deworming, implant placement, and any other necessary management procedures before weaning allows calves to be weaned without handling and decreases the amount of stress they will be subjected to throughout the process.

Nutritional management

Nutritional management of cattle is critical to ensure that nutrition does not limit immune function. Gestational nutrition of the dam has lasting implications for calf health through its impact on both the quantity and quality of colostrum available to the newborn calf. Nutrient-restricted cows are expected to provide less and lower-quality colostrum to their calves. Because colostrum is the means through which the newborn calf's immune system is populated with antibodies, gestational nutrition of the dam can have a major impact on calf health. Undernutrition of gestating females can lead to an increased incidence of dystocia because of lack of weight and size, weakness at the time of parturition, insufficient colostrum weak calves at birth, high incidence of prolonged postpartum anestrus, which leads to a high percentage of non-pregnant animals that will need to be culled. For growing cattle, nutritional deficiencies or disorders are more common. Stress associated with cattle handling and human-cattle interactions can impact cattle health. Operations that effectively implement low-stress handling practices typically observe decreases in cattle morbidity and mortality.

Vaccination

Vaccines are pharmaceutical products that are intended to be administered to healthy animals to better prepare the animal's immune system to combat bacterial, viral, or protozoal health challenges. More simply stated, vaccines are intended to be used to prevent disease. Vaccination against Brucella, Leptospira, Vibrio, Trichomonas, Campylobacter, Anthrax IBR and BVD. Calfhood vaccination programmes should include vaccination against various clostridial and viral respiratory diseases. The herd veterinarian should specify procedures for the treatment of sick and injured cattle by providing one or more standard protocols that outline the treatments for individual diseases, injuries, or conditions.

Parasite Control Measures

Both internal and external parasites represent health and production risks to the cattle. Each may impact the operation through decreased performance or productivity as well as increased susceptibility to disease and increased risk of mortality. Many of the performance or productivity losses often go unrecognized. Generally speaking, internal and external parasite control programs should be a component of all beef operation herd health plans.

Internal parasites generally impact cattle health and productivity through chronic blood loss. Depending upon the region and environmental conditions, common internal parasites of cattle include stomach worms such as *Ostertagia*, *Haemonchus*, and *Trichostrongylus*; intestinal worms such as *Cooperia* spp; and protozoa such as *Coccidia*, liver flukes, lungworms, and tapeworms.

External parasites negatively impact cattle health not only by declining required nutrients, but also by increasing stress to the animals, because they act as vectors for other diseases, such as anaplasmosis, theileriosis, and tickborne fever. Depending upon the region and environmental conditions, under certain conditions, cattle may become hosts to a number of internal parasites. A comprehensive internal parasite control program includes environmental management strategies that minimize exposure to the parasite, along with strategic administration of anthelmintics when necessary. Selective grazing management practices, such as rotational grazing, can be effective and important components of internal parasite control programs. In addition, intermittently rotating the species that grazes a pasture, or resting pastures if possible, can help to break the life cycle of many internal parasites through removing the host that is necessary for their propagation. Anthelmintic administration should be based upon target parasite load, parasite susceptibility to treatment, and potential impact that removing or decreasing the parasite load will have on the animal(s). In addition, the focus should be placed on breaking the parasite's life cycle and avoiding pasture reinfestation. Faecal egg counts along with egg, cyst, and oocyst identification conducted before and after anthelmintic administration can be incredibly valuable to developing a treatment plan with a high likelihood of success.

Similar to internal parasite control, components of a comprehensive external parasite control program include physical management strategies that minimize exposure to the parasite, as well as administration of products that deter, kill, or otherwise alter the normal life cycle of the parasite. Removing unnecessary accumulations of faeces, old feed, and water are the major physical means through which the life cycle of many external parasites can be disrupted. Nonetheless, it is practically impossible to remove all of these materials, and therefore additional methods of external parasite control are almost always necessary. External parasite control methods include:

- Insecticide-impregnated ear tags
- Pour-on or otherwise topically applied insecticides (such as back rubs, for example)

- Premise sprays
- Feed-through insecticides, such as an insect growth regulator (IGR) for control or a larvacide for control of multiple fly species
- Parasitic wasps
- Physical trap

On-Farm Biosecurity Programmes

To minimize disease transmission, breeding should be done by artificial insemination (AI). Semen should be purchased from a reputable AI center with a documented high-quality health status monitored on a monthly basis. Other biosecurity measures include a minimum of 48 hours free of animal contact and shower facilities for all personnel before entry into the sow and boar centers. Fumigation rooms are an excellent way to disinfect inanimate objects, such as tools and feed bags, before their entry into the animal airspace. For personnel movement between on-site facilities, personnel should change boots and coveralls and wash their hands before entering each facility. All openings to facilities should be bird-proofed, using bird screen, particularly over the sidewall openings to naturally ventilated finishing facilities. Other important components of a sound biosecurity program include incineration of carcasses, washing and disinfecting transport vehicles when marketing animals, and perimeter fencing.

Because faecal-oral transmission is the most common route of infection for the gastrointestinal diseases, manure systems must be designed to provide minimal opportunity for faecal contamination of feed and water sources. Regardless of the system in place, manure should be removed regularly and in the direction away from the most susceptible animals (i.e., calves, youngstock, maternity pens). Equipment (e.g., buckets) used to handle manure should not be used to deliver or push up feed to animals. Adult cow manure not to be spread on pastures where youngstock are allowed to graze. Careful consideration should be given to the types of feeds provided, as well as systems for feed storage, feed delivery, feed bunk design, and feeding management. One feed-related concern is that many wet byproduct and commodity feeds are often contaminated with *Salmonella*. Practices such as pelleting, steam flaking, and roasting can reduce bacterial numbers. *Salmonella* bacteria are killed by heat processing at temperatures of 55°C (131°F) for 1 hour or 60°C (140°F) for 15 to 20 minutes.

Disposal of Carcass

Proper disposal of carcasses of animals died of infectious disease is of utmost importance in preventing the spread of diseases to other animals and humans. Carcasses should never be disposed off by depositing them in or near a stream of flowing water, because this will carry infections to points downstream. An animal died of an infectious disease should not be allowed to remain longer in sheds as biting insects, rodents, etc. can reach it. Unless approved by a veterinarian (even then, only in a disinfected place) it is not safe to open carcasses of animals that have died of a disease. All carcasses should be disposed of properly either by burying or by burning. Deep burial is necessary to prevent worms carrying bacterial spores to the surface as well as to prevent carnivorous animals from digging up the carcass.

Summary

- Isolation of new arrivals of the animals for at least 30 days and they must be dewormed.

- Isolation of sick animals from the herd and treatment must be initiated to prevent economic losses to the farmers. Attendants and equipment's for sick animals should be ideally separate
- Prevention of infectious diseases can be achieved by effective Vaccination methods. Regular annual vaccination of animals in endemic areas will prevent the disease from occurring.
- Heavy milch animals and exotic breeds of cattle bred for milk should be protected regularly.
- Disinfection of animal sheds with bleaching powder or phenol. The equipment's should be thoroughly sanitized and proper disposal of left over feed by the animal.
- Proper disposal of carcasses.
- Housing of young animals should be separate from adults as they are more susceptible to parasites.
- Feed and water should not be contaminated by the faeces and they must be kept clean and free of contaminants.
- White washing of water troughs and regular cleaning of feed troughs should be practiced. Water logging areas should be levelled to prevent multiplication of snails, flies and insects. Reduce snail population by treating infected pastures, ponds with copper sulphate.
- To reduce infection from the pasture, Rotational grazing for the livestock species should be followed.
- Proper disposal of manure and other contaminants from the premises will prevent the spread of infections to the animals.

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Chapter-10

RECENT ADAVANCES IN ANIMAL NUTRITION (SPROUTS, HYDROPONICS, AZOLLA)

Arumbaka Sudheer Babu[1], Ch. Rama Krishna[2] and Badavath Rajender[3]

[1]Assistant Professor, Department of AN, College Of Veterinary Science, Hyderabad-500030, Telanagana, India
[2]Assistant Professor (Agronomy), Department of LFC, College Of Veterinary Science, Hyderabad-500030, Telanagana, India
[3]PG Scholar, Department of AN, College Of Veterinary Science, Hyderabad-500030, Telanagana, India

Introduction

Due to the scarcity of green fodder, concentrate feed and its high prices in animal feeding, the quest for readily available and inexpensive alternative sources has become critical for dairy industry seeking to minimize the cost of animal production. Livestock production is growing faster than any other sector with in entire agriculture sector and its contribution is expected to increase manifold in terms of number and value in coming years owing to rapid urbanization, growth of disposable income coupled with growing consumer awareness. In view of the above facts, Indian livestock production throws an open challenge to the animal nutrition researchers for finding the solution in order to sustain the productivity of animals along with livelihood security of small and marginal farmers. Under the above perspectives, alternate feed resources show the ray of hope to partially mitigate the scarcity of livestock feed and fodder in India. Numerous more recent feed options have been examined and proved to be beneficial for feeding cattle. These technologies must be upgraded for more widespread use. Farmers have recently begun incorporating some of the local feed resources, such as azolla, maize and sorghum *kadbi*, hydroponics grass, sprouts, brewery residues, and oil residues, in the ration with the proper processing methods. A cost-effective strategy for sustainable livestock production is to use these alternative feed resources in place of some of the traditional feed ingredients. Among these potential feed ingredients are spoken about in this chapter.

Nutrition could be a serious limitation to livestock production especially when feed resources are inadequate in both quality and quantity. Global livestock production over the years has increased consistently and brought about increase in animal numbers. (1) Feed quality and quantity combined with low producer prices have often forced farmers and feed producers to remain at low levels of animal feed production, compensated by large numbers of animals. Feed is the most important input in all livestock production systems in terms of cost, and the availability easily available and high-quality feeds is critical if livestock production is to remain competitive and continue to grow to meet demand for animal protein. Earlier conventional methods of livestock improvements (genetics and breeding, livestock nutrition and livestock disease management) have been used for increasing livestock productivity. However, these options can no longer sustain higher production; consequently, new intensive techniques are now required to augment productivity. Ruminants have distinct advantage over monogastrics in being able to convert organic materials that are not suitable for human consumption into products that are of high nutritional value such as meat, milk, and by-products [13, 14, and 15]. They also provide fertilizer from the faecal and undigested residues. The aim in the feeding of ruminants thus should be to feed as much forage as possible that could satisfy most of the nutrient requirements of the animal. The quantity and quality of roughage made available to the ruminant will then determine the extra amount and type of supplement or concentrate to be fed. Several advances to improve productivity in dairy animals are being formulated but are failing to be adopted in field by the livestock farmers. Hence, in this chapter it is intended to discuss on recent advances available in animal nutrition to optimize milk production by improving the nutritive value of feed and also to produce the feed or fodder within a short duration specifically to improve dry matter intake and productivity.

Azolla:

Azolla is an aquatic floating fern, found in temperate climate suitable for paddy cultivation. The fern appears as a green mat over water. The Blue Green Algae cyanobacteria (Anabaena azollae) present as a symbiont with this fern in the lower cavities actually fixes atmospheric nitrogen. The rate of nitrogen fixed is around 25 kg/ha. As green manure, Azolla is grown alone for two to three weeks in flooded fields. Afterwards, water is drained out and Azolla fern is incorporated in the field before transplanting of paddy. Otherwise, 4-5 q of fresh Azolla is applied in standing water one week after planting of paddy. Dry Azolla flakes can be used as poultry feed and green Azolla is also a good feed for fish. It can be used as a bio-fertilizer, a mosquito repellent, in the preparation of salads and above all as a bio-scavenger as it takes away all heavy metals.

Azolla is rich in protein, essential amino acids, vitamins, and minerals. Azolla is very rich in protein (25-35%), Calcium (67 mg/100g) and Iron (7.3 mg/100g). Azolla can be supplemented with regular feed of the animal @ 2-2.5 kg of azolla per animal. Azolla, if grown for fodder is essentially required to be grown in hygienic environment and there should be regular supply throughout the year. The fodder plots should preferably be near the home or dairy shed for easy nurturing and maintenance.

Table.1 Comparison of bio-mass and protein content of Azolla with different fodders

Sl. No	Item	Annual production of biomass (MT/ha)	Dry matter content (MT/ha)	Protein content (%)
1	Hybrid Napier	250	50	4
2	Kolakattao grass	40	8	0.8
3	Lucerne	80	16	3.2
4	Cowpea	35	7	1.4
5	Subaboo	80	16	3.2
6	Sorghum	40	3.2	0.6
7	Azolla	1000	80	24

Source: Dr P Kamalasanan *et al*. 2004 “Azolla -A sustainable feed substitute for livestock”, Spice India.

Advantages of Azolla

- It easily grows in wild and can grow under controlled condition having dual roles of feed and also as crop yield enhancer.
  It can easily be produced in large quantity required as green manure in both the seasons – Kharif and Rabi.
- It can fix atmospheric CO_2 and nitrogen to form carbohydrates and ammonia respectively and after decomposition it adds available nitrogen for crop uptake and organic carbon content to the soil.
  The oxygen released due to oxygenic photosynthesis, helps the respiration of root system of the crops as well as other soil microorganisms.
- It solubulises Zn, Fe and Mn and make them available to the rice and suppresses tender weeds such as Chara and Nitella in a paddy field.
- Azolla releases plant growth regulators and vitamins which enhance the growth of the rice plant.
- Azolla can be a substitute for chemical nitrogenous fertilizers to a certain extent (20 kg/ha) and it increases the crop yield and quality.
- It increases the utilization efficiency of chemical fertilizers and reduces evaporation rate from the irrigated rice field.
- Azolla is fed to livestock (cow, buffalo, sheep, goat and rabbit) as it is easily digestible (because to its high protein and low lignin content), increases feed efficiency, average daily gain of animals, and milk production by 15–20%

Fig.1: Azolla farming at Department of LFC, CVSc, Hyderabad

Cultivation of azolla

The soil in the area is first cleared of weeds and leveled Bricks are lined horizontally in a rectangular fashion. A UV stabilized silpauline sheet of 2mX2m size is uniformly spread over the bricks in such a way as to cover the margin of the rectangle made by the bricks 10-15 kg of sieved soil is uniformly spread over the silpauline pit. Slurry made of 2 kg cow dung and 30 g of Super Phosphate mixed in 10 liters of water, is poured onto the sheet. More water is poured on to raise the water level to about 10 cm. About 0.5-1kg of pure mother azolla culture seed material is spread uniformly over the water, after mild stirring of soil and water in the azolla bed. Fresh water should be sprinkled over the azolla immediately after inoculation to make the azolla plants upright. In a week's time, the azolla spreads all over the bed and develops a thick mat like appearance. A mixture of 20 g of Super Phosphate and about 1 kg of cow dung should be added once in 5 days in order to maintain rapid multiplication of the azolla and to maintain the daily yield of 500 g. A micronutrient mix containing magnesium, iron, copper, sulphur etc., can also be added at weekly intervals to enhance the mineral content of azolla. About 5 kg of bed soil should be replaced with fresh soil, once in 30 days, to avoid nitrogen build up and prevent micro-nutrient deficiency 25 to 30 percent of the water also needs to be replaced with fresh water, once every 10 days, to prevent nitrogen build up in the bed. The bed should be cleaned, the water and soil replaced and new azolla inoculated once every six months. A fresh bed has to be prepared and inoculated with pure culture of azolla, when contaminated by pest and diseases

Harvesting

Azolla grows rapidly and fills the pit within 10 - 15 days. From then on, 500-600 g of azolla can be harvested daily which is done every day from the 15th day onwards with the help of a plastic sieve or tray with holes at the bottom. The harvested azolla should be washed in fresh water to get rid of the cow dung smell

Precaution to be adopted

- Maintenance of pure culture free from contamination is essential for good yield.
- Azolla should be harvested regularly to avoid overcrowding.
  Temperature is an important factor for good growth. It should be around 35 degrees Celsius and the fodder plot is to be covered with a plastic sheet in cold regions so as to reduce the impact of weather.
- Places with direct and adequate sunlight should be preferred. A shady place yields less.
- pH of the medium should be between 5.5 to 7.
  Suitable nutrients such as cow dung slurry, micronutrients should be supplemented as and when required.

Costing of fodder plot

The cost involved in setting up fodder plot varies between Rs 1500 to Rs 2000. The primary cost is in the form of manual labour, which can be contributed by the family labour. While estimating the cost of fodder plot, two units of fodder beds have been considered to maintain regular yield of azolla fodder. Number of units can be increased depending upon the number of cattle and fodder requirements.

Hydroponics Technology:

It is a science of growing plants in nutrients rich solutions instead of soil and can be efficiently used to take pressure off the land to grow green feed for the livestock. Plants require three things to flourish, water, nutrients, and sunlight. Hydroponics is a straight forward way of providing all these nutrients without the need of soil under controlled environment conditions to optimize the growth of plants.

Technology has been tested on various crops such as Maize, Sorghum, Barley, and Oats for producing high quality of nutritious green fodder for dairy animals. Beside this hydroponics can be used for growing wheat grass, paddy saplings etc in seven days of time for optimum growth. Fodder obtained from hydroponics consists of grass with grains, roots, stem and leaves as compared to only stem and leaves part in conventionally grown fodder.

Hydroponic innovative technology for dairy business

- To grow green fodder at wider temperature (15º - 32 ºC) and humidity (70 -80 %) range without fungal growth.
- Environmental friendly.
- Contamination free fodder.
- Saves water and labor
- Fodder grown is highly palatable and nutritious
- Fodder improves animal health and reproductive efficiency.

Advantages of Hyrdoponics

- Conservation of water
- Land
- Reduced labor requirement.
- Reduction in growth time of green fodder.
- Green fodder round the year.
- Increasing of nutritive value of fodder
- Natural feed
- Enhancement of milk production
- Minimizing loss of fodder


Sprouts:

Sprouting is the next step of germination. It results after grains, legumes, or nuts are soaked in water for a period of time. Water removes certain metabolic inhibitors that protect the seed from bacterial invasion and preserve the seed during its dormant stage. During germination and sprouting the seed springs into life, increasing its nutritional value and digestibility. Inherent enzyme inhibitors, phytates, oxalate, etc. that act as protective shields in every seed, get removed and pre-digestion occurs. At this stage of pre-digestion, all the nutrients are converted into a simple and ready-to-absorb form.

Nutritional value of sprouted food:

By a process of natural transmutation, sprouted food acquires vastly improved digestibility and nutritional qualities. During sprouting, the vitamins, minerals, carbohydrates, trace elements, and protein content of food increase substantially. Amino acids are present in their finest form in sprouted foods; enzymes and hormones are also present in ample quantity. The acid/alkali balance of the body is maintained, proven to be powerful antioxidant, increase oxygen content of the body. On other hand processed food has reduced nutrient availability as it destroys enzymes, hormones, and oxygen and promotes acid accumulation in the body; it also interferes with digestion and weakens the immune system.

The components required for sprouted fodder include:

- A temperature- and humidity-controlled space
- Trays on which to sprout the grains
- Buckets to soak the grain
- Buckets with slits to drain water if you use this system8
- Enough light for the sprouts to green up
- A water source and way for the sprouts to be moistened and drained three times per day

Steps involved in production of sprouts:

- Acquire grain. Barley is very commonly used for sprouting, but you can use any number of grains: oats, milo, sunflower seeds, and more.
- Wash and Soak the grains. As a first step wash the grains with a one percent bleach solution or hydrogen peroxide to cleanse the grain. Place the grain in a 15 liter bucket about halfway full with a bit of sea salt and cover with water until the water is a couple of inches above the grain. Let this soak for six to twelve hours.
- Drain and let sprout. Pour the soaked grain into another bucket with slits in the bottom to allow water to drain but the grain to remain in the bucket.
- Rinse and drain. Every day, rinse the sprouts two to three times and allow the water to drain from the trays and don't allow water to remain inside or between the grains. Keep grains moist but drained. Temperature should be between 15 to 21 degrees Celsius and 70 percent humidity is ideal.
- Harvesting of feed is at day six or seven with green mat of sprouted grain having a wheatgrass look. Feeding of this mat to the animals is as a whole, using a knife to slice it into portions. Rotate the growth so that we have some trays on day one and some on day seven all the time keeping the supply of fresh fodder every day to livestock.

Feeding sprouts to the livestock provides multiple benefits which include:

- Improvement in milk quality and quantity by about 20%
- Improvement in milk fat level
- Decrease in feed cost
- Improvement in body coat condition
- Improved fertility rate
- Improved lactation rate
- Increase in the taste of milk (Sweetness)
- Increased disease resistance power
- Fast recovery from disease

Conclusion

Strategies for expanding the supply of feed and fodder should concentrate on the suitability and accessibility of local resources. The dependence on conventional components is reduced by the use of some non-traditional feed items. Proper processing techniques that are efficient at neutralizing the toxins and affordable and easy enough has a significant impact on optimizing the dairy production chain. Perception of end users about the technology and benefits validation can also play a key role for successful adoption of above methods.

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Chapter-11

VALUE ADDITION AT FARM LEVEL

M. SahityaRani
Assistant Professor, Department of LPT, PVNRTVU, Hyderabad

Introduction

India is currently self-sufficient and the largest producer of milk in the world. About one-fifth of the milk produced is collected and processed by the organized dairy sector. There is an increasing demand for new products and processes. Value addition can be a great tool for doubling the farmer's income, and making more profit out of liquid milk with the use of certain techniques. With increasing consumer awareness in recent times, people are more aware regarding healthy nutrition and diet which has increased the market scope of value added functional dairy foods.

Reason for value addition of milk

There are various reasons to process milk into functional dairy products, such as the following:

- Dairy products have longer shelf life as compared to fresh milk.
- Problem of storage of fresh milk is resolved, as fresh milk is more perishable in nature and bulky to store.
- The demand of raw milk for sale is limited.
- Preserved value added functional food products can be transported to longer distances without spoilage as compare to fresh milk.
- Greater economic gain could be achieved.

Cream

Cream may be defined as that portion of milk which is rich in milk fat or that portion of milk into which fat has been gathered. According to the FSSR Rules (2011), cream excluding sterilized cream is the product of cow or buffalo milk or a combination there of which conations not less than 25 per cent milk fat. Cream is rich in energy giving fat and fat-soluble vitamins A, D, E, and K, the contents of which depends on the fat level in cream.

Classification

Cream may be broadly classified into Market cream, which is used for direct consumption,and Manufacturing cream, which is used for the manufacture of dairyproducts.The three different types of cream are

- Table cream/Lightcream contains 20-25% milkfat.
- Coffee cream/ Whipping cream Contains 30-40 % milk fat,and
- Heavy cream/Plastic cream contains 65-85 % milk fat.

Composition of cream

The average chemical composition of cream is as follows:

- Water 45.45-68.2%
- Fat 25-60 %
- Protein 1.69-2.54 %
- Lactose 2.47-3.71. %

- Ash 0.37-0.56 %
- Total solids 31.8-54.55 %
- Solids not fat 4.55-6.80 %.

Method of cream production

I. Gravity method

When the milk is allowed to stand undisturbed for some time, there is a tendency for the fat to rise is given by the following equation, which is known as Stokes Law:

$$V = 2G (ds - df) r^2 / ù$$

where,

V = velocity or rate at which a single fat globule rises

G = acceleration due to gravity.

ds = density of skim milk

df = density of fat.

r = radius of fat globules.

ù = viscosity of skim milk.

Applying the stokes law it can be observed that theoretically, velocity is increased by increase in radius of fat globules: Increase indifference in densities of skim milk and fat, Decrease in viscosity of skim milk.

The rate of rise of fat globules in gravity methods is affected by

- Size of fat globules: as the size of fat globules increases, the rate at which cream rises also increases.
- Temperature: As temperature increase, viscosity decreases and hence the velocity increases.
- A clump or cluster acts like a single globule in so far as movement through skim milk is concerned.
- Gravity methods being very slow, are no, longer used commercially for cream separation.

II. Centrifugal method

Centrifugal cream separators are similar to clarifiers in that they consist of a stack of conical discs housed in a separator bowl and rotated at high speed by an electric motor.

The Separator

- The separator is a unit, which removes most of the milk fat from milk by centrifugal force. Its principal components are power source, a separator bowl, a set of gears and shafts, a product inlet and a product outlet for cream and skim milk.
- The separator bowl consists of an outer shell within which are a large number of cone shaped discs constructed so that between each pair is a very small space of not more than 0.5mm. As the milk enters the bowl,it is distributed into these spaces between the discs; it is immediately subjected to a tremendous force. While both the fat and skim milk subjected to the centrifugal force, the difference in density affects the heavier portion (skim milk) more intensely than the lighter portion (i.e. Cream) thereby the skim milk is forced to the periphery while the fat portion moves towards the centre. The skim milk and cream both form vertical walls within the bowl and are separated by being led trough separate outlets.

- Any insoluble particles in the milk, such as bits of curd or dirt etc., collects as 'separator slime' and is thrown outward as the bowl operates. These pass along with the skim milk into the space between the outer edge of the discs and the inner face of the bowl shell. Such material is deposited on this face of the bowl shell, which is removed latter. Separator bowl operate at speeds as great as 20,000 rpm. The separator is a precision instrument and hence has to be in good condition and operated properly to get maximum skimming efficiency.

Centrifugal force (F) = K .W. R . N^2

Where

W= mass of the revolving body,

R= radius of the circle in which body revolves.,

N= R.P.M of the revolving body.

K= constant.

Stokes's law applied to centrifugal separation is as follows

((ds-df) / n) X V = r^2 N^2.R.K.

Where

V = velocity

n = viscosity of skim milk

r = radius of fat globule,

ds = density of skim milk

df density of fat,

N= speed of the bowl

R= distance of fat globule from the axis of rotation.

K = constant

Factors influencing the fat percentage of cream

The important factors that influence the fat percentage of cream by centrifugal cream separation methods are

Position of the cream screw

The cream screw /outlet consists of a small threaded, hollow screw pierced by a circular orifice thorough which the cream emerges. This screw can be driven IN and OUT thus bringing it nearer to and away from, the centre of rotation. Similarly, the skim milk screw /outlet for the removal of skim milk, once the cream screw or skim milk screw has been adjusted, the cream separator delivers, under normal conditions, a definite ratio of skim milk and cream, which is usually90:10 (or 85:15) by volume. By altering the position of the cream screw or skim milk screw the ratio of skim milk to cream changes. Thus when the cream screw is IN towards the axis of rotation, a higher fat percentage in cream is obtained and vice versa. This is because the force tending to discharge cream through the orifice is decreased while that tending to discharge skim milk remains unaltered. Smaller proportions o cream is therefore discharged, which, containing the same quantity of fat, shows a higher fat percentage. Screwing OUT the cream screw produces thinner cream. Similarly, the skim milk screw OUT results in richer cream and vice versa.

Fat percentage in milk

The higher the fat percentage in milk, the higher the percent fat in cream. And vice versa. Since practically all the fat in milk is contained in the cream.

Speed of bowls

Higher the speed of the bowl, the higher the fat percentage on cream, and vice versa.

Rate of milk in-flow

The higher the rate of milk inflow, lower the fat percentage in cream and vice versa.

Temperature of milk

The lower the temperature of milk during separation, the higher the fat percentage of the cream and vice versa.

Amount of water or skim milk added to flush the bowl.

The greater the quantity of water added to flush the bowl, the lower the fat percentage in cream, and vice versa.

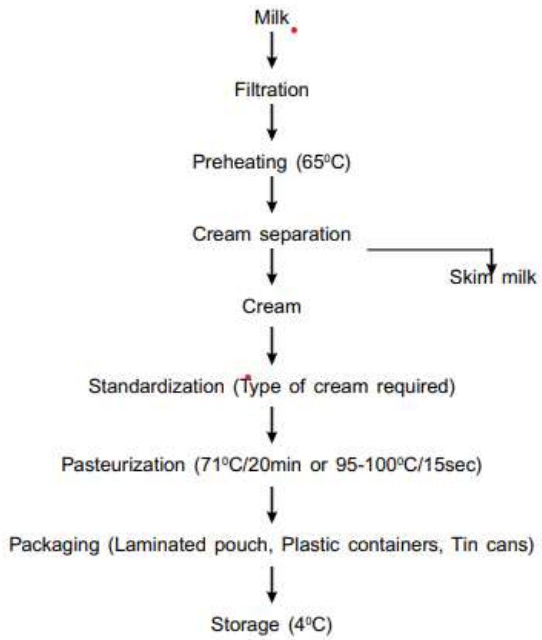
Factors affecting fat loss in skim milk during separation

The 'skimming efficiency (SE) of a cream separator refers to the 'percentage total fat from milk recovered in the cream. The higher the fat percentage in milk and/or the greater the fat loss in skim milk, the lower the skimming efficiency and vice versa.

The factors affecting the fat loss in skim milk are

- Temperature of milk
- Speed of the bowl
- Rate of milk inflow
- Position of cream screw
- Mechanical condition of the machine
- Size of the fat globule
- Degree and temperature at which milk is agitated before separation
- Presence of air in milk
- Acidity of acidity

Method of Manufacture of cream



Butter

Butter is a fat rich dairy product, generally made from cream by churning and working. It contains 80% fat, which is partly crystallized. Butter making is one of the oldest forms of preserving the fat component of milk. As per FSSR, 2011 Butter can be defined as the fatty product derived exclusively from milk of cow and/or buffalo or its products principally in the form of an emulsion of the type water-in-oil. The product may be with or without added common salt and starter cultures of harmless lactic acid and / or flavour producing bacteria. Table butter shall be obtained from pasteurised milk and/ or other milk products which have undergone adequate heat treatment to ensure microbial safety. It should be free from other animal fats, wax, and mineral oils, vegetable oils and fats. No preservatives except common salt and no colouring matter except annatto and carotene may be added. It must contain not less than 80% by weight of milk fat, not more than 1.5 % by weight of curd, and, not more than 3% by weight of common salt. Diacetyl may be added as a flavoring agent but, if so used the total diacetyl content must not exceed 4 ppm. calcium hydroxide, sodium carbonate, sodium polyphosphate may be added, but must not exceed the weight of butter as whole by more than 0.2 %.

Types of butter are found in the market.

Pasteurized cream butter

Made usually from pasteurized sweet cream. Such butter usually has a milder flavour than that made from similar cream not pasteurized.

- **Ripened cream butter**
  Butter made from the cream in which butter culture is added and incubated till the desired acidity and flavour are produced. Properly made ripened cream butter has a delicate flavour which is referred to as 'real butter flavour'.
- **Unripened cream butter**
  Made from unripened cream.
- **Salted butter**
  Butter towhich salt has been added
- **Unsalted butter**
  Contains no added salt.
- **Sweet cream butter**
  Butter produced from cream in which the acidity does not exceed 0.2% in the churned cream.
- **Sour cream butter**
  Made from cream in which the acidity exceeds 0.2%.
- **Fresh butter**
  Butter that does not undergo cold storage.
- **Cold storage butter**
  Butter stored at a temperature of about -18 ° C for some time.
- **Dairy butter (USA)**
  Made on farm. It is usually made from unpasteurised sour cream, which has not been standardized for acidity. This butter generally has a sour flavour due to the high acid content of cream.

- **Creamery butter**
  Made in a creamery or dairy factory. It is more uniform in quality than dairy butter.
- **Cream Processing**

Aging

Cream is held at cool temperatures to crystallize the butterfat globules, ensuring proper churning and texture of the butter. In the aging tank, the cream is subjected to a program of controlled cooling designed to give the fat the required crystalline structure. As a rule, aging takes 12 - 15 hours. From the aging tank, the cream is pumped to the churn or continuous butter making machine via a plate heat exchanger which brings it to the requisite temperature.

Churning

Cream is agitated, and eventually butter granules form, grow larger, and coalesce. In the end, there are two phases left: a semisolid mass of butter, and the liquid left over, which is the buttermilk.

Draining and washing

In traditional churning, the machine stops when the grains have reached a certain size, whereupon the buttermilk is drained off. With the continuous butter maker the draining of the buttermilk is also continuous. After draining, the butter is worked to a continuous fat phase containing a finely dispersed water phase. It used to be common practice to wash the butter after churning to remove any residual buttermilk and milk solids but this is rarely done today. This washing process would ensure that all the butter milk is washed out of the butter. Otherwise the butter would not have good shelf life and go rancid.

Salting

Salt is used to improve the flavor and the shelf-life, as it acts as a preservative. Further, the butter is worked to improve its consistency. Salt used should be 99.5 to 99.8% sodium chloride and microbial count should be less than 10/g. Salt is added at the rate of 2 to 2.5%.

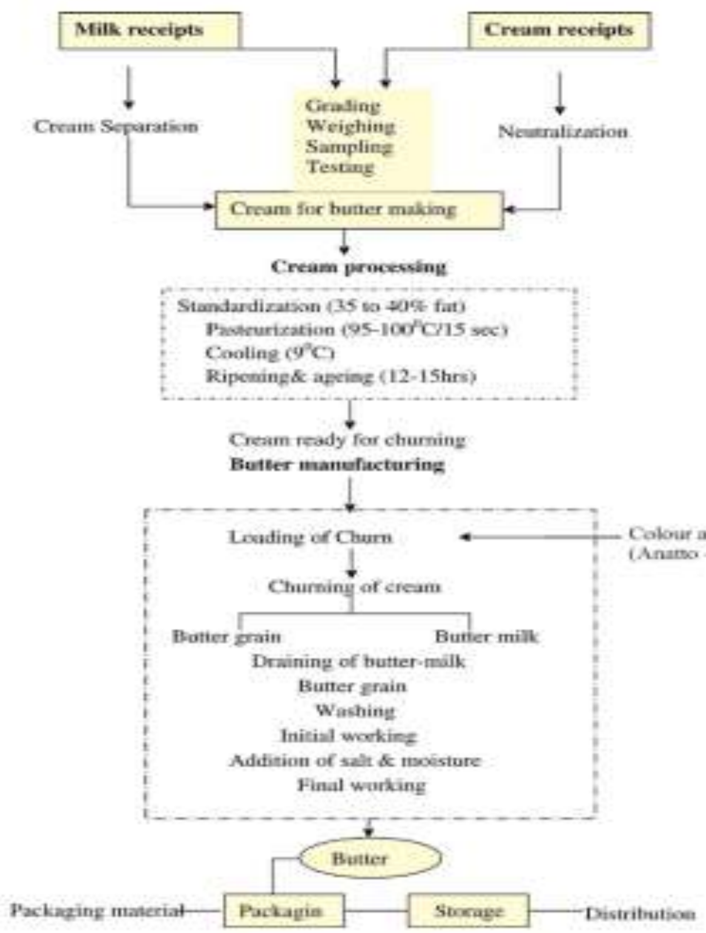
Working

The objective of working butter is to incorporate moisture and uniformly distribute added moisture and salt in butter. During this process remaining fat globules also break up and form a continuous phase, and moisture is finally distributed to retard bacterial growth in butter. It is safer to slightly over-work butter than to under-work. Under-worked butter may be leaky in body with large visible water droplets and may develop ‘mottles’ on standing.

Packing and storage

The butter is finally patted into shape and then wrapped in waxed paper and then stored in a cool place. As it cools, the butterfat crystallizes and the butter becomes firm. Whipped butter, made by whipping air or nitrogen gas into soft butter, is intended to spread more easily at refrigeration temperatures. Normally butter is stored at -23^0 C to -29^0 C.

Method of manufacture of Butter



Ghee

Since time immemorial, ghee has been used in Indian diet as the most important source of fat. Ghee, the Indian name for clarified butterfat, is obtained by heat clarification and desiccation of sour cream, cream or butter. Because of its characteristics flavor and pleasant aroma, besides being a source of fat-soluble vitamins, ghee occupies predominant position amongst milk products in India. Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added. Ghee essentially consists of 99 to 99.5% milk fat.

Characteristics	**Requirements**	
	Cow	**Buffalo**
Milk fat	99 to 99.5 per cent	
Moisture	Not more than 0.5 per cent	
Unsaponifiable matter		
Carotene (m g/g.)	3.2-7.4	-
Vit.A (I.U./g)	19-34	17-38

Tocopherol (m g/g.)	26-48	18-37
Free fatty acids (% oleic)	Max. 2.8 (agmark)	
Charred casein, salts of copper and iron, etc.,	Traces	

Methods of Preparation:

The principle involved in ghee preparation includes concentration of milk fat in the form of cream or butter, followed by heat clarification of fat rich milk portion and thus reducing the amount of water to less than 0.5%. The brown colored residue (curd) is then removed as ghee residue from clarified fat.

There are five methods of ghee making:

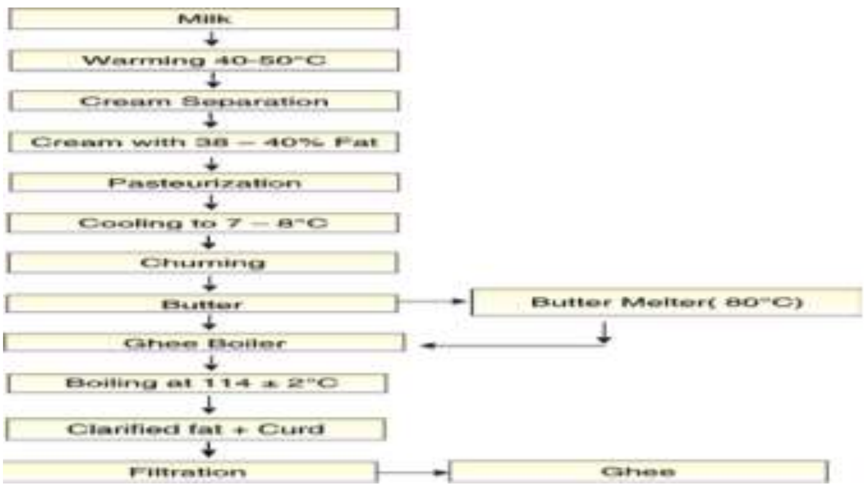
- Desi or Indigenous Method
- Direct Cream Method
- Creamery Butter Method
- Pre-stratification Method
- Continuous Method

Desi method

This was the practice from age-old days in rural areas where excessive milk will be cultured and kept for overnight for fermentation. The resultant curd was churned using hand driven wooden beaters to separate the milk fat in the form of desi butter. Some follow slightly different method wherein milk is heated continuously to about 800 C, the malai (creamy layer) that forms over the surface was collected manually. This malai is then churned to get the desi butter. After collection of desi butter over a period of time, this butter is melted in a metal pan or earthenware vessel on an open fire. Extent of frothing is an index to judge when to terminate heating. Heating must be stopped when sudden foaming appears and leave the contents undisturbed after heating. Curd particles starts settling down over a period of time and decant the clear fat carefully. In this method it is possible to achieve only 75 – 85% fat recovery.

Creamery Butter Method

Method of manufacture of Ghee by creamery butter method



This is the standard method adopted in most of the organized dairies. Unsalted or white butter is used as raw material. Butter mass or butter blocks are melted at 60°C to 80°C in butter melter.

Molten butter is pumped into the ghee boiler, where final heating will be done using steam as heating medium. Increase the steam pressure to raise the temperature. Scum which is forming on the top of the surface of the product is removed from time to time with the help of perforated ladle. At the moment of disappearance of effervescence and appearance of finer air bubbles on the surface of the fat along with browning of the curd particles indicates the end point. At this stage typical ghee aroma is produced. Final heating temperature is adjusted to about 114±2°C. To get the cooked flavour, heating beyond this temperature is also being in practice. Ghee is filtered via oil filter into the settling tank.

Pre-stratification method

The two above mentioned practices of ghee making has the disadvantage of poor quality of the finished product characterized by an over-heated and smoky flavour, along with high acidity, making it greasy and with reduced shelf life.Hence research work has led to the evolving of a newer method/technique, which yields a higher grade product at lower cost, known as the pre-stratification process.

The basic principle of this method is that, when butter is left undisturbed 80-85ºCfor 15 to 30 minutes, it stratifies, i.e., separates into 3 distinct layers, viz., a top layer of floating denatured particles of curd, a middle layer of fat, and a bottom layer of buttermilk. This separation is called pre-stratification. The bottom layer of buttermilk contains 60-70 percent of solids-not-fat and also over 80 per cent of the moisture originally present in butter. The buttermilk is removed mechanically without disturbing the top and middle layers. After wards, the temperature of the remaining two upper layers (of denatured curd and fat) is raised to the usual clarifying temperature of 110-120ºC.

Physico-chemical constants

Ghee is characterized by certain physico-chemical properties, which show some natural variations depending on such factors as, method of manufacture, age and condition of the sample, species, breed, individuality and animals stage of lactation, season of the year, region of the country, feed of the animal etc.,Some of the important analytical constants or standards of mixed ghee produced under standard conditions are given below:

Melting and solidifying points

The melting point varies from 28ºC to 44ºC, while the solidifying point varies from28ºC to 15ºC. (As ghee fat is of a mixtureof glycerides, it does not have a sharp melting or solidifying point).

Specific gravity

This varies from 0.93 – 0.94.

Refractive index

The Butyro-Refractometer (B.R), reading (at40ºC) varies from 40-45.

Reichert-Meissel (RM) Value

This is also known as Reichert value, and this should be normally not less than 28. However, ghee from cottonseed feeding areas, the limit is 20.

Polenske value (P.V)

This should be normally not more than 2 (except for cotton-seed feeding areas, where the limit is 1.5)

Saponification value

This should be normally not less than 220.

Iodine value

This should normally vary from 26 to 38.

(Cotton tract refers to the areas in the states where cottonseeds are extensively fed to the cattle and so notified by the state government concerned.)

Tests	All India Regional	
	Winter	Summer
Baudouin	Negative	Negative
Phytosterol acetate	Negative	Negative
B.R.reading (40°c) [40.0-43.0]	41.5-44.0	42.5 - 45
R.M.Value [28.0]	Not less than 23.0	Not less than 21.0
P. Value [1.0-2.0]	0.5-1.20	0.5-1.0
Moisture (%)	not more than 0.3	not more than 0.3
FFA (% oleic)	Special-grade Agmark Red label not more than 1.4 General-Grade Agmark Green label not more than 2.	

Ghee Residue

This refers to the charred light to dark brown residue which is obtained on the cloth strainer after the ghee, prepared by different methods, is filtered. It is by-product of the ghee industry. Essentially it contains heat-denatured milk-proteins, caramelized lactose and varying proportions of entrapped fat, besides some minerals and water.

Type of Residue	Chemical composition					Ave.Yield (kg) (per 100 Kg) Butter / Cream (kg)
	Water	Fat	Protein	Lactose	Ash	
From Desi Butter						
Cow	14.4	32.4	36	12	5.2	1.6
Buffalo	13.4	33.4	32.8	15.4	5.2	1.6

Ghee residue is a rich source of milk fat, proteins and minerals. Methods of recovery of ghee-residue includes, centrifugal and pressure techniques.

Uses

- For direct consumption.
- For preparation of ghee-toffees
- For preparation of sandwich paste and
- For preparation of burfi sweets

Khoa

- Among the indigenous milk products, khoa occupies first position as it form a base for number of sweet delicacies. Khoa is a popular product throughout India and is called by different names in different regions like Khoya, Mawa, Kova, Palghova etc.
- According to Food Safety and Standard regulations 2011, khoa means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination thereof by rapid drying. The milk fat content shall not be less than 30% on dry weight basis of finished product. It may contain citric acid not more than 0.1 per cent by weight. It shall be free from added starch, added sugar and added colouring matter.
- Khoa has been prepared for centuries in India as a base material for manufacturing sweets. It is prepared by the traditional method by milk traders and halwais. A five times concentration of milk is normally required.
- The three main varieties are "**pindi**" for burfi, "**dhap"** for gulabjamun, pantooa etc., and "**danedar**" used for kalakand. Khoa making has been the easiest way of preserving rurally produced milk in the flush season.

Preparation of Khoa

Khoa is prepared by different methods depending on the location, quantity etc. Khoa is manufactured by the following four basic methods viz. traditional method, improved batch method, mechanized method and use of membrane technology.

Traditional Method

Generally, buffalo milk is preferred for manufacture of khoa as it results in higher yield, smooth texture and soft body with sweet taste. Where buffalo milk is not available, cow milk is used for khoa making but it results in pasty body and slightly saltish taste in the product. Filtered milk is taken in a thick wide mouth iron pan (karahi) and boiled on a brisk non – smoky fire. An iron scraper (kunti) is used for stirring the milk during boiling and also to scrape the milk films forming on the surface during boiling. A rapid stirring and scrapping is carried out throughout boiling to facilitate quick and rapid evaporation of water from milk and also to prevent scorching of milk film on surface. Due to continuous evaporation of water, the milk progressively thickens. Some researchers observed that at 2.8-fold concentration of cow milk and 2.5-fold concentration of buffalo milk, heat denaturation of milk proteins take place and the proteins will not go into solution again. As the concentration is progressing the product slowly tends to leave the sides of the pan and starts accumulating at the bottom and at this stage the pan has to be removed from the fire. The contents are worked up and allowed to cool and the residual heat in the product helps in further evaporation of moisture. At this stage, stirring and scraping is increased to obtain good quality product. If the milk is subjected to high heat treatment with less stirring and scraping at this stage results in dark colored khoa that does not fetch good market value as that of white or cream colored khoa which is more preferred for sweets making.

Improved method

This is followed in organized firms, where, the equipment, conditions of dehydration, and the quality of the milk used are given importance. The karahi and open fire substituted with stainless steel jacketed-pan or kettle, which is heated by water or steam. Milk is boiled till it assumes pasty consistency and then held at 85ºC and stirring at 100 rpm. Regarding the quality of the milk used, buffalo milk is preferred over cow milk as the latter produces soft, loose body and gives smooth a granular texture which is not relished. The milk should contain 4% and 5% fat respectively for cow and buffalo milk. Neutralization of acid milk improves the texture but does not improve the flavour of khoa. Starch adulterated milk gives hard khoa. Homogenization of milk produces softer body and fat leakage.

Continuous Khoa Making Machine

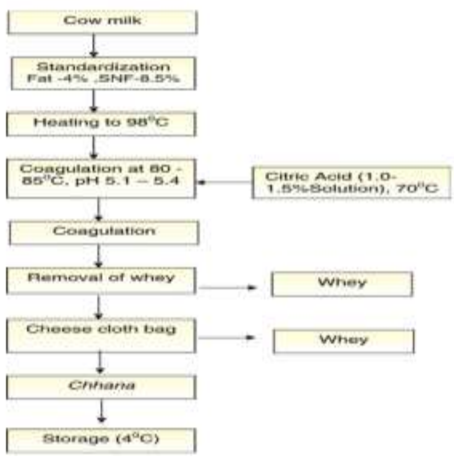
A continuous khoa making machine was developed which consists of a preheating cylinder and two cascading pans. The preheater is a steam jacketed cylinder containing rotary scrapers which rotate at 120 rpm. The cascading pans are open steam jacketed pans provided with spring loaded reciprocating type scrapper knives operating at 30 strokes per minute. The milk is taken into the preheater and heated by steam at 3 kg/cm2 pressure. Here the milk is concentrated to about 30 to 35 per cent of total solids within 10 to 12 minutes time. From the preheater, the milk enters the first cascading pan. Here the milk is further concentrated to about 50 to 55 per cent total solids within 7 to 8 minutes. The product then moves to the second cascading pan where its concentration is raised to the desired level i.e., 70-75 per cent in 6 to 7 minutes. The steam pressures maintained in the two pans are 2 kg/cm2 and 1.5 kg/cm2 respectively. 50 liters of milk can be converted into khoa within an hour time in this machine. The steam requirement is 50 kg per hour and electric power requirement is 4 KW per hour.

CHHANA

Chhana is an acid coagulated product obtained when milk coagulated with the permitted acids at nearly boiling temperature. Solid curd obtained after filtration of coagulum is called chhana. It looks off-white, tastes mildly acidic, and has characteristic spongy texture. Chhana is mainly prepared from cow milk and used for preparation of verities of Bengali sweets. Production of chhana is confined to mostly in Eastern region of the country notably West Bengal, Bihar, Orrisa. About 4 to 4.5% of the total milk produced in India is used for chhana making. Chhana is used as a base for the preparation of a variety of sweets like Sandesh, rasogolla, chamcham, rasmalai, pantoa etc.

According to Food Safety and Standards Regulation, 2011 definition Chhana as a product obtained from cow or buffalo milk or combination thereof by precipitation with sour milk, lactic acid or citric acid. It should not contain more than 70% moisture, and its milk fat content should not be less than 50% on the dry matter basis. If skim milk is used, moisture should not exceed 70% milk fat should not exceed 13% of dry matter.

Method of manufacture of Chhana



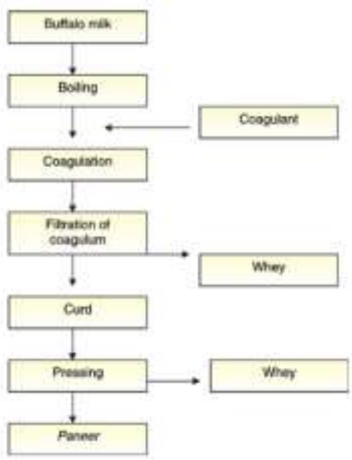
Channa is usually prepared by mixing old channa whey with boiling hot milk. The dilution with whey also contributes to make a smooth coagulum, which is considered desirable for making many Bengali sweets. For channa production, cow milk is preferred since it yields a soft bodied and smooth textured product. Both these characteristics are suitable for production of high-grade channa sweets. Channa from buffalo milk has a slightly hard body, a greasy and coarse texture, and does not produce good quality channa sweets. In order to obtain a desirable body and texture in channa the pH of coagulation should be around 5.4, the temperature of coagulation is above 80ºC and the time in which coagulation is effected should be less than a minute. The satisfactory strength of the coagulating acid solution is 1-2 per cent. The acids commonly used for coagulation are lactic and citric acids. Lactic acid group consists of chemical lactic acid or sour whey whereas the citric acid group consists of chemical citric acid or limejuice. While lactic acid tends to produce a granular product, citric acid produces a pasty one. Commercial manufacturers generally use sour whey for economic reasons.

Weigh the empty container. Milk is taken in container and weighed again. The difference in weights furnishes weight of milk taken. Milk is brought to boiling point and 5% citric acid solution is added with simultaneous agitation. Curdling should be effected in 1-2 minutes and sufficient amount of acid should be added to precipitate all proteins. Contents of vessel emptied over a piece of muslin cloth fixed on to a funnel. Whey is then collected is a pre weighed container. No pressure is applied and Channa is transferred to butter paper, weighed and cold stored. Yield of channa from cow milk is 16-18% and buffalo milk is 22-24%.

Paneer

Paneer is an acid coagulated product obtained when standardized milk coagulated with the permitted acids at specified temperature, resultant coagulum is filtered and pressed to get the solid curd mass. FSSR, 2011 Standards Paneer means the product obtained from the cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid, or citric acid. It shall not contain more than 70% moisture and milk fat content shall not be less than 50% of the dry matter.

Method of manufacture of Paneer



Dahi

Dahi is a fermented dairy product, produced by fermentation process by deliberately adding live, harmless, lactic acid producing bacteria in the form of bacterial culture to milk. Lactic acid bacteria added in the form of starter culture multiply and grow, produces lactic acid, acetic acid and carbon dioxide by utilizing lactose present in the milk. Some bacteria use the citric acid of milk to produce certain volatile organic compounds mainly diacetyl, which is mainly responsible for flavor of dahi. Judicious combination of acid producing and flavour producing microorganisms in the starter helps in the production of Dahi with a firm body and good flavour.

Food safety and standards regulation (FSSR, 2011) defines: Dahi or curd means the product obtained from pasteurised or boiled milk by souring, natural or otherwise, by a harmless lactic acid culture or other harmless bacterial culture may also be used in conjunction with lactic acid bacteria cultures for souring. Dahi may contain added cane sugar. Dahi shall have the same minimum percentage of milk fat and milk solids-not-fat as the milk from which it is prepared.

Method of Preparation: Traditional Method

In traditional method of dahi preparation, milk is heated intensively to boil for 5 to 10 min and then it is cooled to room temperature. Thus boiled and cooled milk is added with previous day's curd or buttermilk, stirred and allowed undisturbed, to set, usually for overnight. At halwai's shop the milk is considerably concentrated before being inoculated with starter culture. So that the total solid content of milk is increased, particularly increase in the protein content of milk results in custard like consistency of the dahi and keep the product from wheying off.

Starter required

Good quality milk, starter culture which includes *Streptococcus diacetylactis* , *Streptococcus cremoris*, ith an aroma producing bacteria mainly *Leuconostoc citrovorum* or *Leuconostoc dextranicum.*

Dairy Byproducts

A byproduct may be defined as a product of commercial value produced during the manufacture of a main product. During the processing and conversion of milk into various milk products some byproducts are also generated. Skim milk, buttermilk, ghee residue and whey are the main dairy byproducts. Separation of milk for obtaining cream results in skim milk, separation of butter from cream results in buttermilk, ghee residue is that fraction of cream or butter that is left out when they are converted into ghee. Whey is the watery portion obtained during the manufacture of cheese, casein, paneer, chhana, and shrikhand. Sometimes these dairy byproducts are also called as dairy co-products. It has always been realized that effective utilization of byproducts is an essential prerequisite to profitable dairying. Utilization of dairy byproducts improves plant economy, makes valuable nutrients available for humans and reduces environmental pollution originating from dairy waste.

S.No	Main Product	By Product	Processing method	Products Made
1	cream	Skim milk	Pasteurization	Flavoured milk
			Sterilization	Sterilized flavoured milk

			Fermentation	Cultured Buttermilk
			Fermentation and Concentration	Concentrated sour skim milk
			Concentration	Plain and Sweetened Condensed skim milk
			Drying	Dried skim milk or Skim milk powder or Non Fat Dry Milk (NFDM)
			Coagulation	Cottage cheese, Quarg, edible casein
2	Butter	Buttermilk	Fermentation and Concentration	Condensed buttermilk
			Concentration and drying	Dried buttermilk
			Coagulation	Soft cheese
3	Cheese, Casein, Channa, Paneer	Whey	Fermentation	Whey beverage, Yeast whey
			Concentration	Plain and sweetened condensed whey, whey protein concentrate, whey paste, lactose
			Drying	Dried whey
			Coagulation	Ricotta cheese
4	Ghee	Ghee residue	Processing	Sweetmeat, Toffee, Sweet paste

Chapter-12

MEASURES TO INCREASE CONCEPTION RATE THROUGH ARTIFICIAL INSEMINATION

Ch Siva Naga Pavani
Assistant Professor
Department of Veterinary Gynaecology and Obstetrics
College of Veterinary Science, Rajendranagar
suresh.pavani.arja@gmail.com

Introduction

During the 20th century the most commonly used assisted reproductive technologies (ART) in livestock is Artificial Insemination with cryopreserved semen. AI revolutionized the animal breeding industry because of its unequivocal and important role in genetic improvement, genetic resource conservation and productivity in animal husbandry. The impact of this technology on economic developments of developed nations is very much evident. However, the potential of this technology has not been fully harnessed in several countries, including India. It is an established fact that the technology of artificial insemination using cryo-preserved semen can address major problems being faced by farmers in managing a bull for breeding of their animals. The overall AI coverage in cattle and buffaloes in India is only 29.7 % with an overall meagre conception rate of 35%. There are several reasons for failure to exploit full potential if AI. Few of these limitations that need immediate redressal include difficulties in timely delivery of AI, absence of mechanisms to ensure use of semen from certified semen stations, non-adherence to state breeding policy, absence of a mandatory system of animal identification and data retrieval, and poor control over AI technicians. Addressing these needs and following certain measures will help to increase conception rate through Artificial Insemination.

Artificial insemination is a technique in which semen is collected from the male, processed, stored and artificially introduced into the female reproductive tract at proper time for purpose of conception. Artificial insemination is one of the most important reproductive technologies in the dairy industry that not only increases the use of genetically superior sires to improve performance of the herd but also reduces the incidence of sexually transmitted diseases. AI technology is a part of reproductive technologies besides multiple ovulation and embryo transfer and In vitro embryo production which has role in genetic resource conservation and productivity in animal husbandry. Hafez (1980) pointed out that artificial insemination is the most important single technique ever devised for the genetic improvement of animals. However, the potential of artificial insemination has not been fully exploited in India. Despite having one of the largest networks for livestock breeding, the overall AI coverage in cattle and buffaloes in India is only 29.7 % with an overall meagre conception rate of 35%. The reasons behind the failure to exploit full potential of AI are many. Difficulties in timely delivery of AI, absence of mechanisms to ensure use of semen from certified semen stations, non-adherence to state breeding policy, absence of a mandatory system of animal identification and data retrieval, and poor control over AI technicians are few limitations that need immediate redressal.

Few important milestones in the history of Artificial Insemination

E I Ivanoff, a leading Russian investigator and a pioneer in artificial insemination, was the first man to successfully undertake the Artificial Insemination of cattle and sheep. The first rectovaginal or cervical fixation method of artificial insemination was developed by Danish veterinarians in 1937. In India, AI was first done by Sampat Kumara in 1939 at 'Palace Dairy Farm Mysore'. Salisbury et al developed egg yolk citrate diluter in 1941. The first buffalo calf through Artificial Insemination was born at the Allahabad Agriculture Institute. cryoprotective effect of glycerol in frozen semen technology was discovered by Polge, Smith and Parkes. Cassou (1964) developed French medium and mini straws for packing frozen semen.

Advantages of AI:

1. Increased efficiency: Semen collected from genetically proven sires can be diluted and extended to create hundreds of doses from a single ejaculate.
2. Increased potential for genetic selection: Using AI few males are needed to produce more offspring.
3. Increased safety for animals and farmers: When there is disparity between the size of male and female use of AI will reduce accidents and injury to either the cow or the bull.
4. Reduced disease transmission: Bulls selected for semen collection are free from diseases which will control the diseases which spread through sexual contact.
5. Improving animals' productivity: AI plays an important role in enhancing animal productivity especially milk wield as the sires of such daughter bulls are genetically proven.
6. In case of abnormalities due to physical, physiological or behavioral breeding can occur.
7. Semen collected during AI can be linked to other reproductive biotechnologies such as sperm cryopreservation, sperm sexing.
8. AI can be used in conservation of rare breeds germplasm.
9. Use of antibiotics during semen preservation prevent the transmission of bacterial diseases.

Disadvantages of AI:

1. Cost of AI is more than compared to natural service.
2. Inappropriate or unplanned use can lead to inbreeding.
3. Use of costly equipment and skilled persons.
4. There is focus on certain individuals which may lead to loss of genetic variation.
5. Rapid spread of diseases if sires or bulls are not screened properly.

Poor conception rates with AI: In India, the fertility rate from AI is comparatively lower than in other major milk producing countries, where the fertility rates through AI range from 60-72% with an average non-return rate of 60 days (Vishwanath, 2003). Against this, the average conception rate in India still hovers around 35%. Poor conception rate may be one of the major reasons for poor adoption of AI by farmers. Studies have shown that the acceptance level of AI is lower in areas where the farmers complain about poor conception rate through AI relative to natural insemination. Further, detection of estrus (heat) in animals is another challenge to farmers. Inseminating the animals without proper heat confirmation is a major factor for reduced conception rate under field conditions. It has been reported that the percentage of cattle and buffaloes wrongly detected as in oestrus by visual observations were 11.05 and 20.75 per cent, respectively (Kumaresan et al, 2001). About 19% of the inseminations were performed when the plasma level of progesterone was high and the cows were pregnant. Such an insemination of pregnant cows led to an estimated 17% induced embryonic death and/or abortion (Sturman et al., 2000). The present system of AI delivery, cannot ensure the service at right time due to (i) stationery nature of most AI centers with fixed working hours, (ii) lack of effective communication between farmers and AI service providers, (iii) limited number of AI service providers and (iv) poor training of inseminators

Important factors affecting conception rate through AI can be broadly classified under

- Cow fertility
- Heat detection
- Time of Artificial Insemination
- Fertility of males
- Processing of semen
- Storage and handling of semen
- AI technique
- Role of inseminator

1. **Cow fertility**
   a) **Post partum breeding**:
   Time required for complete uterine involution in cow is 45-60 days. Therefore cow should be bred after 60 days postpartum.
   b) **General Management of female**:
   For successful reproduction, cow has to be fed well with balanced diet containing energy, protein, vitamins and minerals. Deficiency or excess of any of these components affect reproduction along with other physiological functions.
   c) Functional disorders in females:
   This may be due to physiological anoestrum (stress, nutrition, season) or pathological due to inflammatory conditions atypical estrus like short estrus, prolonged estrus, silent estrus, etc. or ovulatory failure.
2. **Heat Detection:**
   In India, most animals brought for insemination are inseminated based on farmers' observation on visual signs of heat. This may lead to poor estrus detection by farmer/herds due to ignorance of true signs of estrus, large head size, relatively short duration of oestrus in some animals and crowded sheds. So identification of cows in estrus is very important as it facilitates the breeder to preform AI at appropriate time. Heat detection can be improved at farm level by the use of estrus detection aids such as tail paint, heat mount detectors, teasers, or use of crystoscope etc. to identify the "fern pattern" of cervical mucous to detect correct time of ovulation.

3. **Time of Artificial Insemination:**
Cows ovulate at about 12 hrs after the end of oestrus. The ideal time for insemination is therefore 6-24 hrs prior to ovulation (Roberts 1986). The best conception rates occur if insemination is made in the middle to the end of standing estrus.
Trimberger (1948) established “am-pm” recommendation which says that cows in estrus during am hours should be inseminated during the pm hours and cows in estrus in the pm should be bred the following am.
However, research with large numbers of cows indicates that maximum conception rates may not be achieved using the am-pm rule. Better do AI before am-pm rule.
4. **Fertility of males:**
Methods of selection should be based on clear breeding goals, aimed at increased milk and/or beef, and improved productivity. This will allow for the selection of sires used in Artificial Insemination based on Estimated Breeding Values (EBVs) of the sire’s parents or in the case of beef breeds, his own EBMs for different traits.
5. **Processing of the semen / Evaluation of semen:**
Commonly used method for semen collection in bulls is by using Recto-vaginal method. Immediately after collection semen should be transferred to water bath maintained at 35 ^{0}C. Semen is evaluated macroscopically and microscopically before further processing and dilution. With the developments in science and semen technology, it is now possible to assess all the fine characteristic of spermatozoa. Even today, traditional method of semen analysis is being followed that gives only an idea about few pre-requisite characteristics of spermatozoa to fertilize an oocyte. These tests do not indicate about other important sperm functional requirements. The sperm motility, viability, acrosomal and membrane integrity are mostly assessed to certify the suitability of frozen semen; however the results of such tests do not always correlate with field outcomes (Rodriguez Martinez, 2013). Further, to maintain the frozen semen quality, adequate quantity of liquid nitrogen at required interval is essential, which is also a major problem at gross root level. It is time to shift from traditional semen analysis to technology-based semen quality control tests. These tests can be adopted by the semen stations to ensure the fertility of frozen semen doses by the use of fluorescent microscopy or flow cytometry.
6. **Storage and handling of semen**
Continuous cold chain has to be maintained in the cryocan during storage of frozen semen straws using liquid nitrogen. Frozen semen should be well immersed into liquid nitrogen at all times for optimum fertility. One of the major causes of low fertility associated with the use of Artificial Insemination is mishandling of semen leading to thermal variation at various level. Some factors which influence frozen semen quality are atmospheric temperature, wind and solar radiation, height to which the canister is lifted, duration of exposure to higher temperature, packaging of semen doses, level of Liquid Nitrogen, etc. Failure to follow (MSP) Minimum standard protocol for retrieving, thawing and protecting straws until AI results in damaged sperm membranes, cold-and-heat-shocked or impaired sperm motility.

7. **Role of inseminator:**
The present conception rate for Artificial Insemination with frozen semen at the field level is reported to be low. The main reason is improper handling and /or deposition of semen. Moreover, thawing and insemination are the two important phases to be handled by the inseminator with utmost care. Inseminator may be a veterinarian, a livestock inspector, an Artificial Insemination worker or Gopal Mitra / Maitri. Inseminator is a key person who is responsible for the success or failure of Artificial Insemination program. There is a technological gap between scientific AI i.e., Minimum Standard Procedure (MSP) and adopted process of AI by inseminators. Hence, skill and knowledge level of inseminators has to be improved by continuous education programme.

a) Licensing of AI technicians:
In India major proportion of Artificial Insemination is carried out by AI technicians who are not well trained. Skill of inseminator is very important to achieve high Conception Rate. Rigorous training of Artificial Insemination technicians under a nationally recognized training center - then registered, ensure timely services at farmers doorsteps. Presently, the policies and protocols related to AI under field conditions are completely ignored and sometimes decided by inseminators only. As such, for enforcing the breeding policies, the licensing system of AI technicians is expected to help implementation of the SOPs

b) Continuous education programme for AI technicians:
In India, most animals brought for insemination are inseminated based on farmers' observation on visual signs of heat. Inseminators have to be trained to detect cows in heat which appears to be of great significance in achieving the optimum conception rates and getting dependable field data for accurate breeding value estimation and selection of future bulls. Further, an online feedback system from farmers regarding adherence to Standard Operating Procedures by technicians while performing AI will not only help in assessment of their efficiency but also in identification of desired area of training for skill improvement.

c) Procedure for loading the Artificial Insemination gun:
Inseminator should identify the canister from which semen is to be taken, remove the lid of the container and lift the proper canister upto the level of the frost line. Never lift the canister above the neck level. With the help of long forceps grasp an individual straw, remove it and at the same time lower the canister immediately back into the container. Then thaw the semen straw.

d) Thawing of semen:
The most convenient method is to plunge the straw in warm water at 35^0 C for a minimum of 20-30 seconds for optimal survival of spermatozoa. During thawing care to be taken to completely submerge the straw in water bath.

Thawing semen in warm-water (35-38 °C) for 40 seconds is the most commonly used thawing procedure reported by inseminators (80%). A significant increase in the conception rate (27%) was reported when thawing occurred in warmwater (33-35°C) as opposed to air (Dejarnette and Marshall, 2005)6. Kaproth et al. (2005) [7]

also reported a significant increase (62.4%) in the fertility rate when thawing is done in warm-water at 35 °C for 30 seconds compared to pocket-thaw.

e) **Precautions while inseminating a cow:**
Following thawing straw to be wiped dry, properly load the gun with its laboratory seal towards the upper side, cut straw at right angles insert sheath over it and lock the AI gun. After loading the gun, semen has to be deposited in the female within 15 minutes. Minimum Standard Procedure (MSP) has to be followed for insemination. Semen and AI equipment has to be handled hygienically. The gun is unwrapped and then inserted at a 30°- 40° angle into the cow's vulva. The left hand is inserted into the rectum to check for the location of the end of the AI gun. The cervix is grasped with the hand in the rectum of the cow and is held steadily while the AI gun is thread into the cervix of the cow. When the AI gun is all the way through the cervix, the location is checked with index finger. The AI gun should be placed just into the base of the uterus. Slowly the plunger is depressed at the end where the right hand is so that half of the straw's contents is deposited. Recheck and deposit the remaining semen. The service of skilled inseminator is essential in maintaining optimum fertility in the field.

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Chapter-13

LIVESTOCK EXTENSION SYSTEM IN INDIA – LESSONS TO BE LEARNT

CH. Satayanarayana

Professor & Head, Dept. of Veterinary & A.H. Extension Education,
College of Veterinary Science, P.V. Narsimha Rao Telangana Veterinary University,
Rajendranagar, Hyderabad, Telangana, India

Introduction

Livestock extension system meant to bridge the gap between research labs to a farmer's field. Livestock research, education and extension are the most important arears for promoting livestock productivity and enhancing farmer's income. The public sector is major extension service provider and the reach of the public extension is limited in India and in addition it is burdened with non-extension responsibilities such as the implementation of Government schemes, fodder and fodder seeds distribution, grounding of animals and other rural development activities consuming more time and a little time left to attend to core livestock extension activities (Nandi and Nedumaran 2019). Amongst various types of government spending, Agricultural Research and Education (R&E) is found to be one of the most critical for promoting farm yields, which contributes towards augmenting incomes of peasantry and thus reducing rural poverty. The objective of the article is to review the livestock extension system in India to learn about the barriers to livestock extension and pave ways for better livestock extension system in India. The public extension services are highly skewed towards crop husbandry ignoring allied sectors in India. Over the years the understaffed extension departments are burdened with non-extension works. Extension services for livestock sector is marginalized. Further, extension personal are less than the recommended ratio of 1:750 at a national level. Hiring and training sufficient number of extension professionals in the sector can significantly contribute to the farmer's income. India spent just 0.7 per cent of Agriculture GDP on agriculture research and education which includes extension and training, of which 0.54 percent goes for Research and Education alone while 0.16 percent is allocated to Extension and Training. Within the expenditure incurred on extension and training, almost two-thirds goes to crop husbandry and 10 percent to livestock, despite the fact that livestock sector contributed 26 percent of value of output of agriculture and allied activities in TE 2013-14 even the allocation was par below the recommended 2 per cent by the World Bank. The Government vision of achieving doubling of farmer's income by 2022 without the successful delivery of extension services to rural small and marginal livestock holders is a daunting task if the issues not addressed timely(Gulati et al, 2018). Reviewing of the early extension systems during pre & post-independence era would help us to learn the focused areas of human living and their transition into latest Extension systems viz; Information Communication Technologies and Artificial Intelligence.

The livestock sector plays a crucial role in the economy of rural India. The importance of livestock in Indian agricultural economy has been well recognized and next to land and irrigation, livestock is the single largest asset in rural India. Given India's agro climatic diversity, a large variety of livestock are available for draught power, milk, meat, eggs, wool etc and thus ensuring additional income to the livestock farmers. About 75 percent of the Indian rural households are keeping the livestock out of which the resource poor farmers own nearly 80 percent of the livestock. Therefore, livestock and livelihood have an intimate relationship particularly in arid and semi arid areas. Further, livestock production in India is largely an output of small holders and more than 70 million rural households depend either directly or indirectly on livestock for their livelihoods. Even more importantly, livestock provides a major source of supplementary income for a large majority of rural households and this sector is therefore, highly livelihood intensive and more importantly provides sustenance during drought and other natural calamities to rural families. Improvement in livestock production is, therefore, an important pathway for increasing the income of marginal and small farmers and landless labourers, given the uncertainties of crop production. The livestock extension education plays an important role in this context to empower the farmers with appropriate technological knowledge and skills through various extension education and training programmes. This chapter briefs about livestock extension services with special reference to Indian livestock farming situations with a focus on, development process and goals, livelihood, communication and adoption of technologies and latest extension systems are discussed briefly for providing a holistic understanding of livestock extension systems. (https://icarzcu3.gov.in/book_publications/Livestock_Extn_Educn/Livestock%20Extension%20Education.pdf).

In India, Extension work had its beginning with a few outstanding individuals of philosophic and philanthropic bent of mind. For the most part they worked in isolation from one another and without government assistance. In some cases these men were government servants whose interest had been aroused through their official areas.

Shrinikethan Project (1921)

One of the pioneers of rural welfare work in India was the famous poet and thinker, Rabindranath Tagore. He in collaboration with Elmhirst started this project in 1921 in Bengal. Tagore believed in both self-help and mutual help and was one of the first to recognize the need for a change in the outlook as a pre-condition for any improvement. The aim of project was to assist them in solving the most pressing problems and to develop the people's resources and their credit and to teach them better methods of growing crops, vegetables and keeping livestock. It also aimed to encourage the villagers to learn and practice arts and crafts and bring home to them the benefits of associated life, mutual aid and common endeavour. The project could not make much headway due to lack of funds to finance the expanded activities. Comparatively less educative work was planned for women in villages. There was a tendency towards gradual urbanisation and centralisation. The project was idealistic and the practical aspects of the project were rather neglected.

Marthandam Project (1921)

This project was started by Spencer Hatch, an American Agriculture Expert in Travancore (Kerala) in 1921 under the auspices of YMCA. The objective of the project was to bring about a complete upward development towards a more abundant life for rural people in spiritual, mental physical, social and economic fields. The working principles of the project were self help with expert guidance, training persons to improve their skill, making people conscious of their wants and needs and organizing reconstruction programmes to include the poorest. The project emphasized on education, local workers, self help and faith in god. The activities were mainly organized at Marthandam and the village workers did not stay in villages.

Sevagram Project (1921)

It was started under the guidance of Mahatma Gandhi in 1921. He considered the village to be the very essence of Indian life. He started his micro laboratory at Sevagram in the district of Wardha, M.P. for conducting his experiments on social, economic and spiritual renaissance of the villages. He established Intensive Agriculture and animal husbandry including cattle breeding in Ashram. The fullest use was made of local manure resources including human and animal waste as a demonstration. The basic system of schools was introduced for the education of children and adults, called it 'Nai Talim'. He desired radical changes in the administration. The main activities of the project was organization of training centres for cottage industries, prohibition, removal of un-touchability and preaching and practising communal harmony. The set very high personal standards in the project was difficult for the common man to reach and therefore the project couldn't provide the expected results.

Gurgaon Experiment (1921)

The Government official, Mr F.L.Brayne started a fairly extensive experiment in rural reconstruction in the Gurgaon district of Punjab and succeeded in arousing considerable enthusiasm among the people. He introduced such improvements into the villages as the construction of manure pits and ventilators and the use of improved agricultural implements. He also encouraged the education of women. For the purpose of disseminating new knowledge among the villagers, he introduced the ideas, having a **village guide** in each village, which served as channels for information outside. Mr. Brayne did not succeed in making his experiment self sustaining. The experiment remained dependent upon the initiative of a single person and when he was transfered to another district, the people reverted to their traditional way of life.

Rural Reconstruction Programme (1946)

Rural Reconstruction Programme was conducted by V.T. Krishnamachary in Baroda state in 1946. His programme aimed at developing a will to live better and develop capacity for self-help and self-reliance. The programme included the items like improvement of communication, digging of drinking water wells, distribution of seeds and establishment of panchayats, cooperatives etc.

Etwah Project (1948)

The project was launched in Etwah district of UP during September 1948 under the guidance of Lt. Col. Albert Mayer, an American who had come to India with American armed forces. The aim was to make maximum progress both in improving the physical productivity and in developing the peoples own capacities and initiative, to give the people better land and better implements and at the same time to prepare the people for the future. It received financial assistance from US Point 4 programme. This project was started in 64 villages and the number was later increased. It encouraged development of panchayat, educational facilities, the spread of improved farming, methods and the construction of roads and soak pits. It was clearly established that the villagers should be educated rather than commanded and that education should proceed through demonstration and persuasion rather than by force and compulsion. The concept of a multi-purpose VLW was started.

The summation of above programmes brought out the following limitations to consider for future development of extension systems in the 1st five year plan to promote holistic development;

1. Involvement of various departments in rural work confused the villager

2. Various programmes forced on the villagers and as such they failed to create any enthusiasm or spirit of cooperation in them
3. The approach was top down and lacked initiation from the people
4. The scheme depended too much on government finances which were quiet meager
5. Theoretical advice needed to be supplemented by inputs and demonstrations
6. The programmes lacked intensive action
7. Respecting the experiences of the villagers was neglected
8. Lack of definite, inspiring and attractive goal for villagers

Community Development (CD)

The new programme CD, as successor of several prior experiments, was designed to be a synthesis of all the available experiences accruing from the early attempts. The new project was launched on October 2, 1952 starting 55 community projects comprising 27,388 villages and a population of 16.4 millions. Each of 55 community projects covered about 300 villages with an area of 450 to 500 square miles, a population of about 2 lakhs. Each project area was divided into three development blocks. Each block in turn was divided into groups of 5-10 villages manned by VLW, now known as “Gram Sevak”. A project was to be completed within a period of 3 years. It covered all aspects of village life; agriculture, animal husbandry, minor irrigation, communications, public health and medicine, education, social education, village industries, women and children programmes, special programme for the tribal people and depressed. Village institutions such as Panchayat and co-operatives were also due to receive attention.

National Extension Service (NES)

After launching of these pilot projects within a few months, it was prominently expressed that the people were ready even keen, for the programme. The people in all the projects areas responded enthusiastically and indeed much beyond the expectations of the government. This fact emphasized the need for a rapid extension of programme to other parts of the country. But country’s resources were not sufficient to sustain a comprehensive plan of same magnitude as contemplated in the first 55 projects. The government decided to launch alongside the CD another programme, which was somewhat less intensive in nature called NES. It was started on October 2, 1953 i.e. one year after CD. The idea behind the NES was to cover the entire country within a period of about 10 years i.e. 1960-61.

It is necessary to explain the inter relation between the CD and NES. The both programmes had identical aims. The NES was a permanent organization and had to cover the whole country. It provided the basic organization, official, non-official and a minimum financial provision of development. NES blocks in which successful results had been achieved with the maximum cooperation were selected for intensive development for a period of 3 years. These are called Community Projects. NES and CD had uniform unit of operation i.e. development block. It represented on an average of 100 villages with a population of 60,000 to 70,000 spread over an area of 150-170 square miles. With effect from 1st April, 1958, there was no distinction between NES and CD and there was no phase like post intensive phase (Dahama OP & Bhatnagar OP, 1985, Mathialagan P, 2020 and Sharma GRK, 2023).

In the contemporary India, Information Communication Technologies appeared to overcome the limitations of extension systems in terms of lack of extension staff and budget and provide desired expected results, further ICT's advanced into Artificial Intelligence tools usage in livestock production. The following ICT initiatives left daunting effect on livestock production;

i) Akashganga

Akashganga (meaning ‘The Milky Way’) is being used at the Dairy Cooperative Society (DCS), which is a farmer-owned, grass-root level unit in the cooperative structure. It is playing a crucial role in improving quality of milk produced by the members of Dairy Cooperatives by introducing innovative, low cost analyzer. Basic milk collection transaction done by AKASHGANGA comprises of

a) Measuring weight of milk with electronic weighing scale

b) Fat testing using milk tester

c) Capture of unique member ID by the Personal Computer software and

d) Multilingual printing of payment slip.

(*http://www.unhabitat.org/bestpractices/2006/mainview.as p?BPID=357*)

ii) Dairy Information Service Kiosk (DISK)

Speedier collection of milk and timely disbursement of payment. Maintenance of Dairy Co-operative Society (DCS) accounts. Dairy information service kiosk (DISK) initiatives of National Dairy Development Board (NDDB), out of 70,000 dairy cooperative societies in the country, around 26000 are using Electronic Milk-Testers (EMT) and around 2500 are using the Personal Computer connected electronic milk-tester machines (known as Automatic Milk Collection Systems - AMCS). These systems introduced very satisfactory milk collection methods and facilitated immediate payments to farmers based on the quality and quantity of milk delivered. The scheme initiated in 1996 by National Dairy Development Board, Anand.

iii) Online integrated computerized systems (OICS)

SUMUL, Surat District Co-operative Milk Union Limited (SUMUL) award winning Online Integrated Computerized Systems (OICS) in Surat-Gujrat started in 1999, has helped the dairy use data generated at 1004 village level dairy cooperatives collecting milk from 2,14,415 members. The OICS acts as a network for procuring and providing all crucial information like weigh bridge data, all production/ stock data and cash collection details. Automatic Milk Collection System (AMCS) and Bulk Chilling Unit (BCU) modules are also integrated into the OICS at village cooperative societies. These are used by SUMUL members to procure information like receipt for milk sold, society credit/debit note, society ledger/pass book, information on pending loans etc. In terms of ICT innovations, plans are afoot to further the reach of the OICS to ensure that milk producers receive all critical information at their fingertips and ensure that every single animal and milk producer is recorded and monitored.

iv) ICT for Livestock Productivity -Nandini

Enhance livestock productivity and ready to help the livestock farmers with timely information on reproductive life cycle of crossbred cows. It gives timely information on oestrous, artificial insemination, pregnancy diagnosis, parturition, milk yield, vaccination, de-worming and drying off of crossbred cows and areas of delayed sexual maturity, repeat breeding etc. The project has been done by Orissa e-Governance Services Limited (OeSL) in-house. The UNDP funded Project Nandini received the e-India Jury award-2010 as a unique project in the country in helping the livestock farmers by providing better advisory and monitoring services (*http://www.eindia.net.in/2010/awards/details/eGov-G Details.asp?PNo=54*).

v) The Livestock Guru:

Livestock Guru in Orissa by Livestock development group, University of Reading (UK) in 2005 is multimedia learning programme for poor livestock keepers implemented in Cuttack, Khurda, Puri and Gangam districts in Orissa state in India to meet the unique needs of the poor livestock keepers in Orissa state based on the priorities of the poor as expressed by them. (Lin and Heffernan, 2010).

vi) Information Village Centers of MSSRF - Village Linkage

The M.S. Swami Nathan Research Foundation (MSSRF) is a non-profit organization founded by the noted Indian Food and Agricultural scientist, Dr. M.S. Swaminathan. Village knowledge

Center (VKC) Project, conceived, developed and implemented by the M. S. Swaminathan Research Foundation (MSSRF), a Non-Governmental Organization (NGO) located in Chennai, India. The state level hub, located at MSSRF is the knowledge resource that creates and maintains websites and databases for the local hubs – in close collaboration with national and international agencies. "All the centers regularly hold video conferences between the rural communities and experts, between farmers, between Self Help Groups (SHG) and between farmers and manufacturers. An information system establishes lab-to-lab, lab-to-land, land-to-lab and land-to land linkages (*ZipAgExtension1/ag_extension1/Materials/May6Session 2/ITapplications-Agriwatch.pdf*).

vii) IKISAN

iKisan is an agricultural website developed by the Nagarjuna Group which provides online information on knowledge and business requirements to workers and traders in the agricultural sector. iKisan is being developed as a comprehensive agri-portal in Andhra Pradesh and Tamil Nadu in 2000, to address the information, knowledge and business requirements of various players in the agri arena including farmers, trade channel partners and agri input/output companies. The portal is also an e-market place where trade activities can take place online. This portal provides all kinds of agri-information, crop diagnostics, local information at the sub-district level and other related information for the use of farmers. Farmers are able to become members by paying Rs. 100 per year or Rs. 20 per month. They are there to provide both on- and off-line information services and able to diagnose, analyse and advise about diseases and pests (http://info.worldbank.org/etools/docs/library/51025/).

viii) ICT'S for Comprehensive Development:

Sustainable access in rural India (SARI) project aimed at rural social, economic, and political development by providing comprehensive information and communication services through computer and internet kiosks in rural communities. By June 2004, it had established 78 such kiosks in rural communities in Melur Taluka, an administrative subunit of Madurai district in Tamil Nadu. It has also developed partnerships with the Tamil Nadu Agricultural and Veterinary University for providing remote agricultural and veterinary services.

ix) Soochana se Samadhan

It is an initiative to use the power of voice as the primary means of information dissemination. It facilitates exchange of information among the marginalized communities such that it helps in improving their quality of life in Haryana, Himachal Pradesh, Madhya Pradesh and Uttar Pradesh states in 2005. It aims to provide connectivity, content and capability via a phone-based service. Life Line is an agri information service leverages a mix of internet and telephone technologies - to provide essential and demand-based information, advice and guidance to remote and rural communities in India through the medium of "voice, in the local language and within 24 hours. The information is available on more than 50 different fields of agriculture and animal husbandry allied activities covering a complete chain of information from production to consumption. The service is being implemented on the ground in partnership with Indian Society of Agri-Business Professionals (ISAP), TARAhaat, Datamation Foundation (Heffernan C, 2006).

x) ASHA

ASHA initiative has taken by Assam Small Farmers' Agribusiness Consortium (ASFAC)is extending the benefits of the agro-information through two prongs, internet ASFAC's online agri-portal (assamagribusiness.nic.in), and a state-wide kiosk network providing information to over 6,000 farmers in the state through community information centres (CIC). Services related to agriculture, animal husbandry and veterinary, fishery and sericulture are available to farmers in various packages (Hosman and Fife, 2008).

xi) Agriculture Technology Information Center (ATICS)

The Agricultural Technology Information Center (ATIC) is a "single window" support system that connects various departments of research institutions with intermediate users and end users (farmers) to make decisions and solve problems initiated by Indian Council of Agriculture Research (ICAR) in ICAR Research Complex for NEH Region, Umiam (Meghalaya) in 2001 to Building confidence and strengthening of linkages between institute and the farmers, Provide diagnostic and advisory services such as soil testing, plant health clinic, and disease identification and veterinary services etc., Sale and distribution of improved products emerging as a result of research being done at the institute like seed, plants, livestock, breeds, fish seeds, poultry strains and processed products etc., providing an overview of improved technology through published literatures and other communication materials and overcoming of technology dissemination loss and to provide direct access to farmers to improve expertise as well as products of technology.

xii) IFFCO Kisan Sanchar limited (IKSL)

IFFCO Kisan Sanchar Limited is joint venture initiative of corporate sector of Indian Farmers Fertiliser Cooperative Limited (IFFCO), together with Telecom Giant Bharti Airtel and Star Mobitel, has promoted IKSL has been formed with the objective of bringing cost effective communication and other add on informational Value Added Services (VAS) to rural communities. Each voice message is of one-minute duration and cover diverse areas including weather forecast, real time mandi prices, farming tips etc. to farmers. These information help farmers in taking their farming decisions resulting in crop yield. (*http://www.iffco.nic.in/iksl/ikslweb.nsf/ef05d07df0ecee65652575040037b375/cba18de8cdc6 6cf8 652577 a600389765?OpenDocument iKisan*).

xiii) Kisan Call Center

Kisan Call Centre (KCC) has been launched in January 21, 2004 by Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, functioning across the country to provide an easy access point to the farmers, all over the country, and in their 22 local languages. They have been set up by the Telecommunications Consultants India Ltd. (TCIL), a Government of India enterprise. All KCC locations are accessible for answering farmers' queries in from 6 A.M. to 10 P.M. on all 7 days a week in 365 days nationwide by dialling single toll free number1551 and 1800- 180-1551 (from 13th Feb. 2009). The farmers call enquire about the various queries/ problems related to the crops, seeds, fertilizers, agriculture commodity prices, pesticides, horticulture, veterinary etc. at free of cost (*http://agricoop.nic.in/PolicyIncentives/kisanCallfirst.htm*).

xiv) Mobile Extension Advisory Services (MEAS)

Evaluation of re-dressal of constraints in sheep rearing through Mobile Extension Advisory Services' (MEAS) in treatment group was found to be effective above 90 per cent amongst new beneficiaries of Sheep Rearing Development Programme (Anil, 2019).

xv) Mobile App On Dairy Business

The respondents were allowed to use the Mobile App for one month to ascertain its utility in terms of knowledge and awareness acquired by the respondents in the aspects of technical, managerial, financial information of dairy entrepreneurship and the utility of the developed mobile app. Majority (96.67%) respondents acquired knowledge, majority (91.66%) acquired awareness regarding technical aspects, among the respondents, majority (93.33%) acquired knowledge, (96.67%) acquired awareness regarding managerial aspects, a majority (96.67%) of respondents acquired knowledge, (95.00%) acquired awareness regarding financial aspects of dairy entrepreneurship Prasad (2017).

Majority, 90.00 per cent acquired awareness and 91.66 per cent of the respondents acquired knowledge on technical information needs, 90.00 per cent acquired awareness and 95.00 per cent acquired knowledge on managerial information needs, a majority, 86.66 per cent acquired awareness and 93.34 per cent of respondents acquired knowledge on financial information needs on sheep entrepreneurship and majority, 90.00 per cent of the respondents felt that the Mobile App is more useful (Sammaiah, 2019).

In recent years, information and communication technology has become increasingly important in India. Currently, both the central and state government policies support the use of ICT as a tool for agricultural extension activities. The spread of information centers based on information and communication technologies and the quality of rural connectivity are improving. There is a huge gap between the ICT tools developed by various institutions and the needs of the agricultural community, as well as factors such as the shortage of quality and quantity content in agriculture, which are also obstacles to large-scale production expansion. If the above limitations are resolved, the potential of ICT can be used to provide extended services (Ibrahimkhail, 2017).

Attitude of Farmers towards Use of ICT's

Most livestock farmers (73.33%) had a favourable and positive attitude toward the distribution of information using various ICT methods in the livestock sector, followed by 15.83% with more favourable and 10.83% with less favourable attitudes (Rajoria et al., 2022). The advantages of ICT's belittled their limitations and channeled human wisdom to develop technologies which could substitute human involvement which is intensive in livestock production.

Without Human beings, Livestock Production?

Agriculture is the mainstay occupation in many countries worldwide and with rising population, which as per UN projections will increase from 7.5 billion to 9.7 billion in 2050, there will be more pressure on land as there will be only an extra 4% of land, which will come under cultivation by 2050. This means that farmers will have to do more with less. According to the same survey, the food production will have to increase by 60% to feed an additional two billion people. However, traditional methods are not enough to handle this huge demand. This is driving farmers and agro companies to find newer ways to increase production and reduce waste. As a result, Artificial Intelligence (AI) is steadily emerging a part of the agriculture industry's technological evolution. The challenge is to increase the global food production by 50% by 2050 to feed an additional two billion people.AI-powered solutions will not only enable farmers to improve efficiencies but they will also improve quantity, quality and ensure faster go-to-market for crops and livestock products. There is a school of thought that associates AI with a dystopian future, where machines will take over or completely replace humans because Animal farming is becoming a data-centric business. Researchers believe that the answer lies in sensors, robots and artificial intelligence.

Artificial Intelligence in Automated Milking:

- **Precision livestock farming**
  Today, there are numerous sensors available that can help farmers track alterations in animal movements, food intake, sleep cycles and even air quality in animal shelters. When paired with artificial intelligence software, this sensor provides users with early, proactive solutions to problems. Along with the capability to record information about reproduction, health and nutrition, the sensor also provides farmers with solutions for each individual cow.
- **Artificial Intelligence for health monitoring**
  By using advanced AI and machine learning algorithms to predict deviations or abnormalities, farmers can now identify, predict and prevent disease outbreaks, even before a large-scale outbreak
- **Artificial Intelligence for Detection of Oestrus**
  The collar (with motion sensors) tied to on the cow neck for collects all types of data related to cow 24 hours a day.
- **Robotic System to Deliver Vaccines**
  The robotic injection system reads the RFID tags attached to the cow's ear and gets health-related information and vaccination record for the cow. If the cow needs an injection, it is directed to the injection site and the injection mechanism position itself to deliver the medication in the cow's neck.
- **Improving animal health using facial recognition systems:** Several useful applications, such as helping us learn more about the animal's emotional and attentional state. For example, by studying the ear and eye movements of an animal, we can now understand its mood and excitement level with reasonable accuracy.
- **Gains in optimizing feed efficiency & energy intake:** RGB-D camera can help farmers measure feed intake for individual cows and optimize feed expenses according to their animal needs. Their energy expenditure during lactation can be assessed based on parity, milk yield and body condition score. The day is not far when a drone will knock your door step to deliver milk with the desired fat and SNF percentage. The milk composition will exactly match as per your health requirement. Cisco developed an Agricultural Digital Infrastructure (ADI) solution in August 2019 that enhances farming and knowledge sharing. This ADI is likely to play a vital role in the data pool that will be created by the Department of Agriculture under the National Agri Stack. The pilot project for this initiative will take place at Kaithal (Haryana) and Morena (Madhya Pradesh).
- The Jio Agri (JioKrishi) platform launched in February 2020, digitizes the agricultural ecosystem along the entire value chain to empower farmers. The core function of the platform uses stand-alone application data to provide advisory, the advanced functions use data from various sources, feed the data into AI/ML algorithms and provide accurate

personalized advice. The pilot project for this initiative will take place at Jalna and Nashik (Maharashtra).

- In June 2021, The Ministry of Agriculture and Farmers Welfare signed an MoU with Microsoft to run a pilot programme for 100 villages in 6 states. Under the MoU, Microsoft will create a 'Unified Farmer Services Interface' through its cloud computing services. This is a major part of the ministry's future plan to create 'AgriStack' – a unified platform to provide end-to-end services across the agriculture food value chain to farmers. For this the government is planning to create unique farmer IDs for farmers across the country to integrate it with various government schemes and create digital agricultural ecosystems (Tripathy, 2021).
- TCS's solution brings information and communication technology (ICT) to livestock through their **mKRISHI** platform for systematic breed improvement through selective artificial insemination-based cross-breeding (indigenous/exotic cattle breeds). Using ICT, TCS helps increase milk yield by identifying the best bull for insemination using 'Artificial Intelligence on Artificial Insemination'.

Impact / Implementation:

TCS provides palmtop awareness on cattle care management practices, monitoring anomalies, retraining requirements, and generation of observations in real-time and an easy-to-use manner. This helps improve progeny milking performance from 2-3 litres per day to 14-16 litres per day in just five to six years. The solution contributes to increased profits and reduced hunger owing to the surplus of 12-13 litres per day ***(https://indiaai.gov.in/case-study/ai-for-livestock-management)***.

Disease outbreak data were aligned with generated risk variables to the respective latitude and longitude, which were subjected to climate disease modelling. Preview of NADRES home page, Discriminant Analysis (FDA) and Classification Tree Analysis (CTA) were employed for disease modelling. Different modelling methods return different types of 'model object' and all these model objects could be used for the predict function to make predictions for any combinations of values of independent variables. Response plots were created to explore and understand model predictions. Anthrax outbreak on livestock is forecasted for the month of April 2019 in Karnataka. The fitted models were assessed for their discriminating power using Receiving Operating Characteristic (ROC) curve, Cohen's Kappa (Heildke Skill Score) and True Skill Statistics (TSS). These measures were used to evaluate the quality of predictions based on presence-absence data. Raster Stack was used to combine the results of individual predictions by different model methods. All the models were assessed for overfitting because it can cause misleading of estimated co-efficient, p values and R-Squares values. Overfitting is suspect when the model accuracy is high with respect to the data used in training the model but drops significantly with new data. In this study, the cross-validation procedure was adopted to assess the overfitting of models by keeping 30% data on hold while, the rest was used for training. The accuracy of held out data was used to compare the accuracy derived from data used in the training and the significant variance in these two flags overfitting. The outcome of best fitted model/ s were in probability of disease occurrence and was categorised into 6 risk levels-No risk (NR), Very low risk (VLR), Low risk (LR), Moderate risk (MR), High risk (HR) and Very high risk (VHR) (Suresh, 2019).

MoooFarm is testing video and picture machine learning (ML) analysis to predict which livestock to purchase and which to avoid. Kochi-based Brainwired has created a cattle health tracking and monitoring mechanism that employs IoT technologies ear labels to monitor livestock vitals and the reproductive cycle. The data is then processed by a Learning algorithm, which detects and alerts farmers to ailments and pregnancy. Hydrogreens Agri Solutions, Bengaluru employs IoT sensors to check the temperature and humidity levels in the warehouses, & regulate water and airflow to provide high-quality fodder for the farmers (Madhukar, 2022).

Conclusion

As the Indian Agriculture and Allied sectors evolved from traditional livestock extension systems to modern extension systems. Presently the livestock extension systems is on the verge of adopting modern technologies, such as IoT, AI/ML and agri-drones for unmanned aerial surveying, Indian and foreign agritech players can play a vital role in supplying these advanced technologies to farmers. Currently, there are few players in the market, but catering to ~267 million farmers in a country exhibits a huge opportunity for private and foreign entities to expand their footprint in the country. However, influential factors that will define the success of digital agriculture in India are technology affordability, ease of access and operations, easy maintenance of systems and supportive government policies. Major challenge is to stream line the small and marginal livestock farmers to exploit latest livestock extension systems to make the livestock production profitable and sustainable. Overall, livestock extension systems in India play a critical role in enhancing the productivity, profitability, and sustainability of livestock farming. By providing valuable knowledge, training, and support, these systems contribute to the growth of the livestock sector and the overall rural economy.

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Chapter-14

ECO-FRIENDLY METHODS OF LIVESTOCK WASTE MANAGEMENT FOR ENHANCING FARM PROFIT

K.Vijay

Assistant Professor, Department of LPM, College of Veterinary Science, Hyderabad-30, Telangana, India

Introduction

Livestock excrement and waste is a major source of toxic, global warming gases, dangerous germs, and odour. To reduce the creation of harmful pollutants and safeguard the environment, livestock manure must be appropriately managed. Crop yield and sustainability can both be improved by the proper use of livestock manure. In the production of biogas, compost, and vermicompost. Proper utilization of livestock excrement and waste into bio-fertilisers, biogas, compost and vermicompost can be very useful to increase crop yield, sustainable production and safeguard our environment. In this chapter, the work carried out regarding livestock waste management and value addition in some developed and some developing countries have been reviewed. The two leading Asian nations utilising biogas technology are India and China. The biogas can be successfully processed, and can be used as compressed natural gas (CNG) in vehicles and for cooking saving hard-earned money of the livestock farmers. The integration of composting and vermicomposting is preferable compared to either composting or vermicomposting alone, because it takes less time to complete the cycle and the substrates produced have better physical and chemical qualities which can support crops. Recent research revealed that growing of algae from livestock waste can provide bio-oil and many other important goods. Fish aquaculture that incorporates waste from cattle or other sources has a decent chance of making money. The livestock keeping practises were transformed throughout the previous decade from mixed farming systems to specialised dairy farming with animal confinement and zero grazing. This system of livestock keeping is termed as Confined Animal Feeding Operations (CAFOs). According to Gerber et al. (2005), the trends in livestock management that have been modified to increase profitability have polluted the air, water, and land. A significant source of greenhouse gases, pollution, diseases, and stink comes from livestock manure. Agriculture and animal byproducts contribute 40% of the world's methane, and 18% of the global waste disposed (EPA 1998). Livestock manure and waste has a wealth of nutrients and energy that can be recovered and used to improve organic agriculture. Traditionally, in India the dung cakes are utilized for cooking the food in rural areas so is the case in some other developing countries. The increasing pressure on the petroleum products forced us to utilize the ability of livestock waste for various possible energy products, among them biogas is most popular product in majority of countries of the world. Its daily production per adult unit normally ranges from 0.8 to 1.6 m^3. One tonne of manure with a 20% solid content can yield 20 to 25 cubic metres of biogas with a total energy value of 100 to 125 kWh, as well as 35 to 40 kWh of electricity and 55 to 75 kWh of heat energy (Burton and Turner 2003). The agriculture and allied sectors has the chance to lessen its dependency on chemical fertiliser, by utilising the high-quality organic fertiliser made from animal manure this will improve the soil fertility and sustainability. Farmers may be able to benefit from new markets for waste products by using animal waste as an input for bioenergy conversion processes. In addition to creating millions of jobs in rural areas, the proper use of cow dung and cow urine can produce manure, insecticides, medicines, and other dairy products, protect the land from fertilisers and chemicals, and increase soil fertility (Vijay 2011). In the past ten years, practically every European country has seen a rapid development in bio-waste management. In the future, composting or anaerobic digestion will be able to handle around 40% of all garbage in Europe (Barth 2006). Therefore, there is a need for novel waste management systems that make animal operations economically viable and environmentally friendly, ensuring higher profits for livestock owners by effectively recycling the nutrient's energy, mitigating the effects on the environment and achieving the sustainable development goals 7, 13, 14 and 15 of United Nations.

Biogas production technology

Anaerobic biomass digestion is a well-known method for producing gas. Worldwide, there are currently billions of biogas installations. In order to preserve energy in rural areas, particularly in developing nations in Asia and Africa, biogas can be utilised as a substitute for other non-renewable fuels. Biogas is a clean, effective, and renewable source of energy. The total amount of biogas produced throughout European nations was 62 billion kWh, with Germany producing the most with 4,300 plants producing 1,600 MW of power (Fachagentur für Nachwachsende Rohstoffe e.V. (FNR) 2009). The two leading Asian nations utilising biogas technology are India and China. The majority of developing nations in Asia and Africa use biogas primarily for domestic use. Biogas is a gaseous fuel generated from biological decomposition via anaerobic digestion of organic manure. The gas can be used in a biogas burner for cooking. The slurry of bio gas plant can be used as organic fertilizer. Biogas comprises of the fallowing gases carbon dioxide (35%), Methane (58%), nitrogen (5%), hydrogen sulphide (1%). Cattle dung contains about 20% solids, in buffalo dung it is 15-18%, in sheep and goat droppings it is 30-35%, depending on the season, moisture content of fodders and level of water consumption. The dung/droppings are put in the mixing tank and mixed with water to reduce the solids content to 10%. This is better done by mixing 1/3rd quantity of urine in 2/3rd quantity of dung in the slurry-mixing tank. In this way, care has to be taken by increasing or decreasing the quantity of urine added to see that the dung and urine slurry contains Carbon and Nitrogen in the ration of 25:30. By adding up to 20% of the bio-digested slurry coming out of the plant back into the input tank production of biogas can be increased. Also adding 5% of Azolla (a green algae that is grown as feed) to the dung and urine mix also increases biogas production. After mixing the material in the input-mixing tank well, removing any undesirable foreign matter from it at this stage, the mixture is either pumped or let in using the gravitation into the fermentation tank of the plant. From the fermentation tank, the partially fermented material is let into the digester via pipes, where it is left for 30-40 days. During this period, due to biochemical changes, methane or the biogas is produced, which gets collected in the gas holder and is ready for usage.It is quite expensive to distribute biogas through the pipeline to final consumers. IIT New Delhi recently developed a unique biogas purification and bottling technology (Vijay 2011). Because pure biogas in cylinders is a sellable product, they can be utilised anywhere at any time like LPG cylinders. Because the technology for compressed natural gas (CNG) is now widely available, bio-methane (or enriched biogas), which is identical to CNG, can be utilised in all the same applications as CNG. In India's Maharashtra and Punjab states, the first biogas bottling plants were able to effectively create pure biogas with a 98% methane content that was compressed to 150 bar pressure and used to fill cylinders.

Table 1 shows the preliminary research findings from the aforementioned biogas bottling factory in India and Pakistan, which are highly positive and confirm that biogas can be cleaned to have a 98% methane concentration and be stored in CNG cylinders. According to Kapdi *et al.* (2006) and Ilyas (2006), stored biogas was used to power diesel and petrol auto rickshaws. Over 18,000 school pupils in India received midday meals prepared with the cleaned gas (Bamboriya, 2012). By selling slurry to farmers in nearby areas as organic fertiliser, a 600 m3 plant in Punjab, India was able to earn an extra $111 per day. It was expected that the project in question could recoup its entire investment in 4-5 years. In light of this, preliminary research on biogas bottling in India and Pakistan has been determined to be promising, particularly for developing nations, and to have a bright future, particularly for usage in automotive applications, particularly in developing countries that depend on the import of petroleum. However, the initial, enormous capital demand requires assistance from the government in the form of loans and subsidies. Since it replaces crude oil, most nations already have laws in place to encourage investment in projects of this nature. The usage of bottled biogas can partially replace the dependency on the imports of crude oil. The imports of crude oil have increased from 184.80 MTs during 2012-13 to 226.95 MTs during 2019-20. But during 2020-21 the same has been reduced to 196.46 MTs, a reduction of 13% over the financial year 2019-20. The same may be due to COVID-19 pandemic. However, during 2021-22 the fuel import has again experienced a growth of 7.9% and reached at 211.98 MTs (Energy statistics India 2023). Burden of crude oil imports has the same impact on other nations' economies as well (Ilyas 2006). Therefore, a number of countries offer loans and subsidies to support these kinds of facilities.

Table. 1 Potential of newer biogas purification and bottling technology

Country	Plant capacity (m^3)	Pure biogas produced (Kg/day)	No. of gas cylinders filled	Use of gas	Savings	Reference
India	600	231	27 cylinders of 8 kg	Cooking	Replaced LPG of $240/d	Kapdi et al. (2006)
Pakistan	60	21.6	4 cylinders of 3.5 kg	To run engines	Diesel of $147/d	Ilyas (2006)

Power generators based on biogas can be utilised to produce electricity. When a 10 kVA generator is run for 8 hours, it may produce 80–90 units, and around 0.75–0.8 m3 of biogas can produce 1 unit (1 kWA) of power. The Ministry of New and Renewable Energy (MNRE) reports that the Biogas-based Power Generation Programme (BPGP) is the primary strategy in India for promoting biogas power. Although several nations have already begun using biogas for power generation, the literature examined in this respect revealed that there is still much work to be done in this area in the upcoming years.

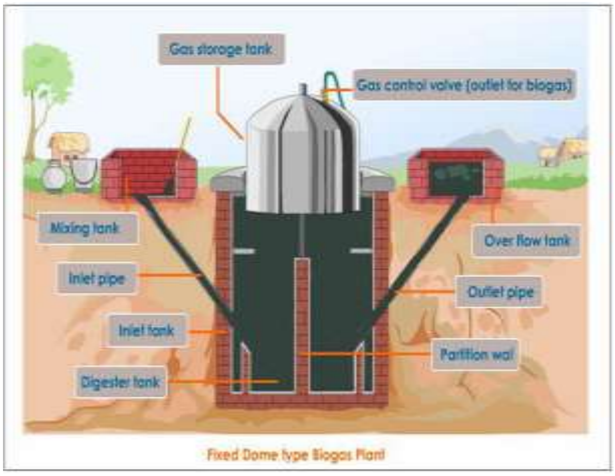

Figure 1. Fixed dome type Biogas plant

Figure 2. Feeding the slurry

Composting

It is common knowledge that fertilisers must be added to soil to boost crop yield. In particular, the chemical fertiliser (NPK) has significantly enhanced crop productivity. However, prolonged NPK use is detrimental to the viability of crop production. The quality and productivity of soil are dramatically impacted by long-term usage of chemical and organic fertilisers, primarily through increasing the availability of vital nutrients to soil microorganisms and plant roots (Acton and Gregorich 1995). Both have the ability to maintain or boost crop output, and their application alters the chemical, physical, and biological characteristics of the soil (Belay *et al.* 2002). One lengthy experiment carried out in China (Li *et al.* 2012) is highly instructive in this regard. In that experiment have applied the different combinations of NPK and composted pig manure (CPM) in soil used to grow corn (Zea maize) continuously for 21 years. At the beginning of the trial and again after 21 years, they conducted analyses on the soil samples for significant soil property metrics. The findings are shown in Table 2, which demonstrates that after 21 years, soil that had only received chemical fertilizers had a considerably lower soil pH than the group that had not received any fertilizer (CK). The application of only CPM and NPK + CPM increased the soil pH significantly. These findings suggest that CPM treatment is crucial for preserving soil pH. CPM use might lessen the detrimental effects of N application on pH, while application of NPK + CPM preserved the soil pH at its initial level. In order to prevent the acidification of Mollisol farmlands, CPM treatment is a crucial practice in preserving soil pH.

Table. 2 Effect of long-time application of compost and chemical fertilizer on soil properties Li *et al.* (2012)

Soil properties	**Initial**	**After 21 years**			
		No fertilizer	**Only NPK**	**Only CPM**	**NPK + CPM**
pH (Soil:water, 1:2.5)	6.20	6.15^{b}	5.91^{c}	6.21^{a}	6.21^{a}
Total N (g kg^{-1})	3.0	2.1^{c}	2.7^{ab}	2.5^{b}	3.1^{a}
Total P (g kg^{-1})	0.7	0.6^{b}	0.9^{a}	0.7^{b}	1.0^{a}
Total K (g kg^{-1})	21.9	21.8^{c}	22.4^{b}	21.9^{c}	23.5^{a}
Available N (mg kg^{-1})	213	163^{d}	241^{a}	178^{c}	261^{b}
Available P (mg kg^{-1})	17.9	19.2^{c}	29.1^{b}	18.7^{c}	32.7^{a}
Available K (mg kg^{-1})	191	183	192	184	199

1. CPM Composted pig manure alone, NPK Nitrogen, Phosphorus and Potassium (K)
2. ^{a,b,c,d} Values followed by different letters in the same row are significantly different ($P < 0.05$)

Composting is a natural aerobic process that stabilizes a variety of organic matter and livestock manure. A well-composted manure smells like humus. Well-managed composting eliminates pathogens and weed seeds due to the heat produced during the composting process. The composting process can be used to successfully recycle the dead animals, but feathers, teeth, and bone fragments may resist composting, hence they may be removed mechanically if necessary. Within 24 hours of death, animal corpses can be placed in a compost pile and covered with a thick layer of solid manure or soil. Composting is not recommended for dead animals with a history of neurological disease, anthrax, or other diseases and conditions held in a quarantine (Belay et al. 2002). Composting is the bio-oxidation of organic waste that occurs more quickly, going through a stage that is thermophilic (45 to 65 degrees Celsius) and in which microorganisms, primarily bacteria, fungus, and actinomycetes, release heat, carbon dioxide, and water. Through turning or aeration, the heterogeneous organic material is converted into a homogeneous and stabilised humus-like product. A stable material is often reached through the relatively quick biodegradation process of composting, which normally takes 4-6 weeks. The compost shall be turned after three months manually or mechanically and then allowed to stand for 3 more months (Fulhage 1993). Composted material with a low moisture content and fine texture can be utilised as organic fertiliser. Composting is done in such a way that it will control odours, flies, rodents and other vermin (Morrow 2001).

In India, pile composting is the most used method. The NADEP method of composting is another one utilised in India and has been shown to yield better nutrients than traditional composting (Yadav 2012). The NADEP method of organic composting was developed by a Gandhian worker of Maharashtra named Narayan Deotao Pandharipande. The method, has become quite popular among the farmers in Western India, now bears his name. This compost uses a wide range of organic materials such as crop residues, weeds, forest litter and kitchen waste with an end-product of a fertilizer that serves as a good alternative to farmyard manure. The construction is a simple rectangular brick tank with enough spaces maintained between the bricks for necessary aeration. The recommended size of the tank is 10 ft (length) x 5 ft (breadth) x 3 ft (height). All the four walls of NADEP tank are provided with 6 vents by removing every alternate brick after the height of 1ft. from bottom for aeration. Tank can be constructed in mud mortar or cement mortar. The Nadep method of making compost is unique not because it is successful in making good compost, which other methods can also lay claim to its real secret lies in the large quantities of compost the process can deliver with a minimum of human effort within a specific period of 90 to120 day decomposition time. The process basically involves placing select layers of different types of compostable materials in a simple, mud-sealed structure designed with brick and mud water. The most important procedure in making NADEP compost is to fill the tank completely all at once, within 24 hours, and no later than 48 hours to avoid compromising the compost's quality. To encourage bacterial activity from all four sides, the tank is coated with diluted cattle dung slurry prior to filling. A thatched roof is designed to stop excessive moisture evaporation. With the help of the device, 40 kg of rich compost can be made from about 1 kg of animal faeces, which can then be spread directly on the ground. Approximately 2.5 tonnes of compost can be produced from each NADEP tank.

Fig.3 NADEP compost tank

Windrow composting: In windrow composting, the mixture of raw materials are arranged in long, narrow piles or windrows that are periodically mechanically moved to aerate the piles. Turing by itself frequently cannot guarantee constant oxygenation. Within an hour of turning, oxygen levels in a pile frequently plummet significantly, which in turn lowers microbial activity. The pile must be turned frequently for this reason. Additionally, pile size must be taken into account because it becomes challenging to aerate piles taller than 3 meters. A blower aerates the composting mass in forced aerated static piles.

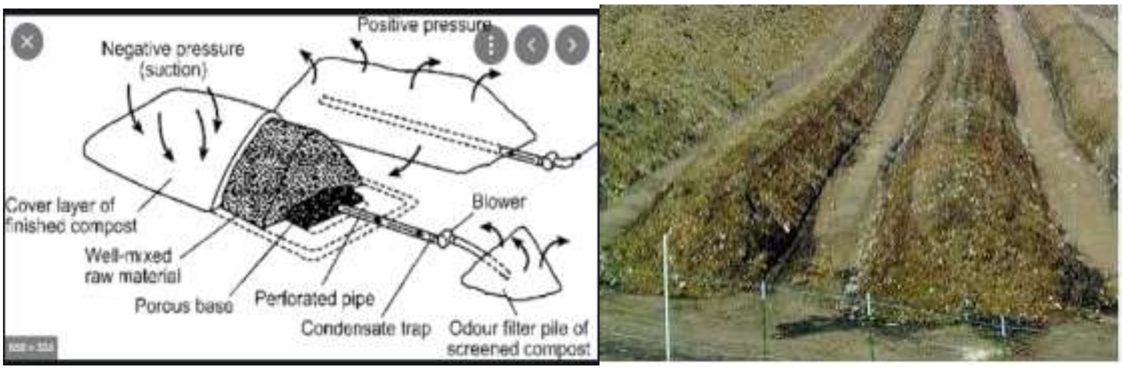

Fig. 4 Windrow composting

The four major factors that affect the composting are aeration, nutrient balance, moisture content and temperature. If these four factors are properly controlled, composting will take place at a very rapid pace. Timely mixing and turning for proper aeration, maintaining ideal ratio of carbon to nitrogen (C:N) nutrients in the compost pile i.e. 20 to 40 parts of carbon per part of nitrogen or 25:1 to 30:1. If the ratio is too low, excess nitrogen is converted to ammonia and escapes into the atmosphere, causing undesirable odours. If the ratio is too high, the rate composting decreases. Compost moisture content should be between 40% to 60%. If the moisture content exceeds 60%, oxygen movement is inhibited and the process becomes more anaerobic. Below 40% moisture, the rate of decomposition decreases rapidly. Due to the breakdown of organic material by microorganisms the pile will reach 150°F in less than 2 days. The maximum composting rate occurs when the temperature is between 110°F and 150°F. It has been shown that a temperature of 131°F for 3 days will kill all parasites, weed seeds, and disease-causing organisms. It is important to turn the piles frequently to ensure that all parts of the pile are exposed to these temperatures.

In Japan, composting is primarily used for livestock waste. There are five primary types of composting systems utilised in Japan: pile, box, rotary kiln, enclosed vertical type, and open elongated type with turning gear. The pile type and the open elongated form are primarily used for large ruminants. For swine and poultry wastes, the open elongated form and the enclosed vertical type are common compost types. In affluent nations, the pig dung is collected with a lot of water, making composting a challenging procedure. Manure's composting qualities will be improved via solids separation. Successful composting of separated pig manure solids with up to 79% moisture has been documented (Liao et al. 1993). It was suggested to use low-moisture bulking agents such as straw, sawdust, peat, peanut shells, rice hull, etc. for composting high-moisture manure (Georgacakis et al. 1996).

Vermicomposting

It is a bio-oxidation and stabilisation process of organic material that, in contrast to composting, involves the joint action of earthworms and micro-organisms and does not involve a thermophilic stage. Earthworms are the agents of turning, fragmentation and aeration. It also contains worms at various stages of development and other micro-organisms associated with the composting processing. Earthworm's castings in the home garden often contain 5 to 11 times more nitrogen, phosphorous, and potassium in the soil. Finished vermicompost should have rich, earthly smell, if properly processed by worms. Important plant nutrients like N, P, K, and Ca that are contained in organic waste are released during vermicomposting and changed into forms that are more soluble and useful to plants. Additionally, vermicompost has biologically active ingredients like plant growth regulators. In addition, the worms themselves serve as a source of protein for animal feed. Table 3 shows the average nutrient contents (Nitrogen, Phosphorus and Potassium) of various types of vermicompost reported by different authors, which show that vermicompost is a rich source of nitrogen, phosphorus and potassium but there is high fluctuation in compositions reported by different workers.

Table 3 Average nutrient content of some common composts of animal and plant origin

Sl. no.	Manures/composts	C:N ratio	Nutrient content (%)			Reference
			N	P_2O_5	K_2O	
1	Farm yard manure	1: 25–40	0.80	0.41	0.74	Palaniappan (2010)
2	Poultry manure	1: 25–40	2.87	2.93	2.35	
3	Vermicompost	–	1.60	2.20	0.67	
4	Vermicompost	1:16.8	1.20	0.004	0.37	Jambhekar (1992)
5	Cattle waste Vermicompost	1: 8.32–19.20	0.51–1.61	0.19–1.02	0.15–0.73	Nagavallemma *et al.* (2004)
6	Palm oil waste-based Vermicompost	1: 13.23–32.72	1.29–2.53	–	7.79–11.97	Rupani et al. (2013)

At the Navsari Agricultural University in Navsari, India, the efficiency of vermicompost on an elephant foot yam crop has been assessed (Anonymous 2008). According to the findings of a three-year trial, vermicompost applied at a rate of 5 tonnes per hectare outperformed poultry manure or FYM in terms of production (Table 4). Additionally, the crop under study had a BCR (2.3) and lower cultivation costs because to the usage of vermicompost. In a different experiment, vermicompost was shown to be a suitable replacement for 100% of the FYM and roughly 70% of the chemical fertiliser used for mulberry production (Sinha et al., 2005). Vermicompost may replace 50% of artificial fertiliser (NPK) and still maintain the output of potato, mustard, mulberry, and marigold (Gopakumar et al. 2000).

Table. 4 Effect of different composts treatments on tuber yield in elephant foot yam crop Anonymous (2008)

Treatments		**Tuber yield (t ha^{-1})**				**Economics**			
		2009–10	**2010–11**	**2011–12**	**Pooled**	**Cost of cultivation (Rs ha^{-1})**	**Gross income (Rs ha^{-1})**	**Net income (Rs ha^{-1})**	**BCR**
T_1	VC @ 5 t ha^{-1}	18.0	18.0	15.2	17.1	1,52,000	3,42,000	1,90,000	2.3
T_2	FYM @ 10 t ha^{-1}	15.7	16.0	15.6	15.8	1,56,900	3,16,000	1,59,100	2.0
T_3	PM @ 5 t ha^{-1}	14.6	15.7	14.0	14.8	1,58,000	3,96,000	1,38,000	1.9

1. *VC* Vermicompost, *PM* poultry manure, *FYM* farm yard manure

Hence, it can be said that vermicomposting is not only capable to replace chemical fertilizer but also may serve as business opportunity for rural poor.

Integrating composting and vermicomposting

The major problems associated with traditional thermophilic composting are the long duration of the process, the frequency of turning of the material, loss of nutrients during the prolonged composting process, and the heterogeneous nature of the product. The major drawback in the vermicomposting process is that it must be maintained at temperatures below 35 °C which does not remove all the pathogens. Thus, an integrated system approach that harvests advantages from both processes would be necessary to provide a product free of pathogens, and a product with desirable characteristics at a faster rate than either of the individual processes. If vermicomposting is used in combination with the traditional composting, the required temperature for ensuring adequate pathogen kill would be achieved. Above said approach was tried at Spain using vermicomposting process for 30 and composting for 28 days in sequences (Ndegwa and Thompson 2001). Combining the two systems resulted in a superior product with more stability and homogeneity. Another trial of this combination of both processes has been successfully conducted at Spain (Lazcano et al. 2008) and India (Kaushik and Garg 2004).

Integration of waste treatment with algal cultivation

The carbon dioxide is a major component in the product gases from anaerobic digestion (Vijay 2011) and thermo-chemical conversion processes from livestock waste (Cantrell *et al.* 2008) which can be used for production of algal biomass. Algae can utilize carbon dioxide ten times more efficiently than terrestrial plants and can generate algal biomass and intracellular oil (Miao and Wu 2006). The algae cultivation has several benefits, i.e., rapid generation rates with biomass harvesting up to 50 metric tons acre−1 year−1 (Demirbas 2001), the accumulation of large amounts of fatty acids and hydrocarbons, as well as the ability to play a role in waste treatment. These algal products can be processed into many value-added products including bio-oil. So, it is a most promising non-crop-based raw material for bio-fuel production. The algal biomass productivity of 6.83 g m−2 d−1 was observed in pond fed with biogas slurry contained 200 g m−3 of total nitrogen and 2.5 g m−3 of total dissolved phosphorus (Chen *et al.* 2012).

Profitable manure management by livestock fish integration

Slurry mixed water is very hazardous if not handled properly. However, simultaneously it is source of nutrients that can be recycled through integrating farming. Traditional practices of recycling effluent through agriculture, horticulture and aquaculture have been in use in several countries (Ghosh *et al.* 1999). Integration of fish with livestock farming is the best method for recycling of organic wastes. Cattle manure has been used extensively in India as a source of manure in carp polyculture (Sinha *et al.* 2005). Manure is normally applied at 5,000–10,000 kg ha−1 year−1, in low productive ponds but can be used as high as 25 tons ha−1 year−1 (Lazcano *et al.* 2008). Livestock Research Station, Navsari (Gujarat) is utilizing the wallowing pond made for buffaloes for fresh water aquaculture with fish yield of 5 t ha−1 without any supplementary feeding (Anonymous 1998). The said pond was manured by dung and urine of buffaloes excreted during wallowing in summer months where as in winter months the slurry produced during washing of livestock sheds was directly drained into the said pond. This is very useful recommendation made available to farmers during 1998 from the said university (Anonymous 1998). The pond water is periodically pumped to irrigate the fodder farm with good result. The fish–pig integration is practiced in China, Taiwan, Vietnam, Thailand, Hong Kong, Malaysia, Hungary and some other European countries (Kumar and Sierp 2003). The N and P loadings of 4 kg ha−1 d−1 and 2 kg ha−1 d−1, respectively, were defined as optimal for Tilapia monocultures in a series of experiment using both organic and inorganic fertilizers at the Asian Institute of Technology and other research stations. The yield up to 4–5 tonnes ha−1 of 200–250 g fish yield in around 6 months is possible if 1 fish m−2 is stocked. Higher stocking densities (up to 5 fish m−2) can increase net fish yields further. If smaller fish are acceptable and multiple stocking and harvest are practiced, net extrapolated yields of 12 tonnes ha−1 year−1 are possible (Knud Hansen 1998). The various poultry waste-fed aquaculture were tried at Japan with good fish yield (Little and Satapornvanit 1996). They got highest dry matter yield with highest feed conversion efficiency in egg laying duck-based aquaculture (Table 6).

Eco friendly methods of animal waste management is a promising area of research in India and other countries. Researchers like Dr. John Abraham, from Keral had patented (Patent No.371344) his “Biodiesel Production from Chicken Slaughter Waste” invention.

Fig. 5 Biodiesel production plant and usage of the so produced biodiesel in vehicles

Conclusion

In order to offset growing energy costs, promote sustainable agriculture, and lessen the environmental risks posed by conventional animal waste management practises, livestock manure can be recycled in a variety of novel methods. India, China, Germany, Malaysia, and Brazil are some of the top nations utilising biogas technology worldwide. Initial tests at biogas bottling facilities in India showed that the biogas might contain up to 98% pure methane. It is possible to successfully fill CNG cylinders with pure biogas for use as vehicle fuel. The future of biogas is bright since it can replace crude oil. The growing of algae in waste water is a useful way to recycle carbon dioxide, a potent greenhouse gas. In addition, algal biomass can be turned into a variety of products with additional value, such as bio-oil. It is possible to compost dead animals and birds to create nutrient-rich compost. Using low-moisture bulking materials like straw, sawdust, peat, peanut shells, rice hulls, etc., high-moisture organic waste can be composted. Vermicomposting is not only an effective way to recycle organic waste; it also has the potential to create jobs, particularly in rural regions. However, combining the composting and vermicomposting processes yields better substrate in a shorter amount of time. Aquaculture that is fed by poultry or duck waste or integrated fish farming is a very promising business that can boost farmers' revenue. Eco friendly methods of animal waste management is a promising area of research in India and other countries to protect the environment and increase the farmers income sustainably.

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Chapter-15

ENTREPRENEURSHIP OPPORTUNITIES IN THE MILK PROCESSING INDUSTRY IN INDIA

Sagar Deshmukh[1*] and Kashmiri Jadhav[2]

[1*] Assistant Director, National Institute of Agricultural Extension Management (MAANGE), Hyderabad – 500030. India.
[2] Consultant, National Institute of Agricultural Extension Management (MAANGE),
*Corresponding Author: sagdeshmukh@gmail.com

Introduction

The milk processing industry, a backbone of agricultural economies around the world, holds an especially venerable position in India – often hailed as the world's largest milk producer. The entrepreneurial landscape in this sector, seasoned by traditional practices yet eagerly embracing modernity, offers numerous avenues for innovation and investment. Understanding the intricacies of the Indian dairy milieu can unlock numerous collaborative and business opportunities. With a burgeoning middle class, changing dietary habits, and an emphasis on value-added dairy products, the canvas is ripe for entrepreneurial endeavours.

Background

India's tryst with milk processing traces back centuries, grounded in traditional methods of producing ghee, curd, and indigenous sweets. However, the modern chapter of this journey can be credited to the establishment of co-operatives like Amul in the mid-20th century. These co-operatives revolutionized the industry, streamlining procurement and enhancing the quality of products. Today, India's milk processing industry stands at a confluence of traditional practices and modern technologies. Co-operatives, though dominant, now share the stage with formidable private players, each vying for their piece of the vast Indian consumer pie.

Opportunities

a) **Expansion of the Consumer Base:** India's projected population by 2025 is nearly 1.4 billion. A recent study by the National Dairy Development Board (NDDB) indicated that urban centers would see a 4% rise in milk demand annually, while rural areas are expected to see a 2% increment. This sheer volume, combined with higher disposable incomes and exposure to international dairy trends, implies a vast consumer base ready for innovative products. Furthermore, the Indian dairy exports market has been growing, with a CAGR of 7% over the last five years, suggesting an untapped potential for dairy entrepreneurs eyeing international markets.

b) **Diverse Product Range:** According to a report by the Food Safety and Standards Authority of India (FSSAI), there's a 20% annual increase in demand for cheese products in urban India. Probiotic drinks and yogurt, once considered niche, have seen a 15% growth rate annually. Entrepreneurs tapping into these specialized products can cater to an ever-evolving urban palate.

c) **Technological Advancements:** The Confederation of Indian Industry (CII) emphasizes that adopting modern technologies can reduce processing costs by up to 20%. Startups like Stellapps have introduced IoT in dairy farming, ensuring real-time monitoring and enhancing yield quality. With smartphone penetration expected to reach 85% by 2025 in India, app-based solutions connecting producers and consumers directly have a significant potential market.

d) **Organic and Specialized Dairy Products:** An ASSOCHAM report indicates that the organic food market in India is growing at 25% annually, with dairy products taking a substantial share. The global trend towards health consciousness and sustainable produce is mirrored in India, opening avenues for specialized dairy products.

Challenges

a) **Supply Chain Issues:** A study by the Indian Institute of Management (IIM) highlighted that nearly 30% of India's total dairy produce doesn't reach the consumer due to supply chain inefficiencies. Cold chain maintenance remains a hurdle, with over 60% of rural areas still struggling with consistent electricity supply.

b) **Quality Standards:** India ranks 44th out of 113 countries in the Food Safety Index. While the nation has made substantial progress, gaps remain, especially when juxtaposed against global benchmarks. Entrepreneurs must bridge this gap, particularly if they aim to tap into export markets.

c) **Intense Competition:** The Indian dairy market, valued at around $140 billion in 2020, sees fierce competition. Local dairies, national giants, and international brands vie for market share. Strategic differentiation, robust branding, and quality assurance become vital in this crowded arena.

d) **Environmental Concerns:** The World Wildlife Fund (WWF) indicates that the dairy sector contributes to 4% of global greenhouse gas emissions. In India, with its vast livestock base, sustainable farming, ethical livestock treatment, and waste management become non-negotiable for any entrepreneur.

Cases in the Diary Sector

a) **Amul:** Beginning with a modest start in Anand, Gujarat, Amul now boasts a turnover exceeding $5 billion as of 2020. Its model focused on farmer empowerment and ensuring consistent product quality, turning it into a case study for dairy cooperatives worldwide.

b) **Mother Dairy:** From its inception to cater to Delhi's milk demands, Mother Dairy's turnover was around $1 billion in 2020. Its thrust on product diversification and adaptability to changing market dynamics makes it an inspiration for dairy startups.

c) **Private Players and Start-ups:** New players like Licious and Country Delight focus on niche offerings and direct sourcing. Licious, which began as a meat delivery platform, ventured into dairy, capitalizing on its robust supply chain to ensure quality. A list of a few startups with their brief details is given below in the table.

Table.1 List of a few Dairy Startups in India

Sl. No.	Name of Startup (Website)	Name of Founders	Idea in Brief	Geographical Coverage	Turnover
1	Stellapps (stellapps.com)	Ranjith Mukundan, Venkatesh Seshasayee	IoT solutions for dairy farms. SmartMoo IoT router helps in optimizing milk production and distribution.	Pan-India	Not Publicly Disclosed

Sl. No.	Name of Startup (Website)	Name of Founders	Idea in Brief	Geographical Coverage	Turnover
2	Country Delight (countrydelight.in)	Chakradhar Gade, Nitin Kaushal	Direct to home delivery of fresh cow and buffalo milk. Uses a tech-enabled supply chain for ensuring freshness.	Delhi-NCR, Pune, Mumbai, Bangalore	Estimated $15-20M
3	Licious (Dairy Segment) (licious.in)	Abhay Hanjura, Vivek Gupta	Expansion into dairy segment, focusing on high-quality, direct sourced products.	Major Metropolitan areas	Total (including meats): Estimated $100M
4	Milk Mantra (milkmantra.com)	Srikumar Misra	Ethical milk sourcing and innovative products like MooShake. Uses technology for efficient supply chain management.	Odisha and nearby states	Estimated $10M
5	Osam Dairy (osamdairy.com)	Abhinav Shah, Ravi Kumar	Focuses on a range of dairy products, leveraging technology for farm-to-table distribution.	Jharkhand, Bihar	Estimated $8-10M
6	Mr. Milkman (mrmilkman.co)	Samarth Setia	SaaS platform for dairy businesses, optimizing procurement, processing, and delivery.	Pan-India (B2B)	Not Publicly Disclosed
7	Doodhwala (doodhwala.net) (Acquired by FreshToHome)	Ebrahim Akbari, Aakash Agarwal	Subscription-based morning delivery of fresh milk & essentials. Used an app-based platform for operations.	Bangalore, Pune	Not Publicly Disclosed (Before Acquisition)

Sl. No.	Name of Startup (Website)	Name of Founders	Idea in Brief	Geographical Coverage	Turnover
8	Gowardhan (Parag Milk Foods) (paragmilkfoods.com)	Devendra Shah	Wide range of dairy products, focus on modern processing tech & value addition.	Pan-India	Estimated $200M
9	Happy Milk (happymilk.in)	Mehal Kejriwal	Offers organic milk and dairy products. Emphasis on tech-enabled, sustainable farming methods.	Bangalore	Estimated $2-3M
10	Akshayakalpa (akshayakalpa.org)	Shashi Kumar	Organic milk production using technology to automate farming operations, ensuring organic standards.	Karnataka	Estimated $4-5M

Innovative Technologies in the Milk Processing Industry

A few innovative technologies in the milk processing industry are discussed below

a) **A2 Milk:**
A2 milk is a variant of cow's milk that contains only the A2 type of beta-casein protein rather than the conventional A1 and A2 mix. It is believed to be more digestible for some people and might reduce discomforts related to regular dairy.

b) **Ultrafiltration Technology:**
Ultrafiltration is a membrane filtration process used in the dairy industry to separate components such as water, minerals, and lactose from the milk, resulting in a concentrated product. This technology is crucial for cheese manufacturing and whey protein extraction.

c) **High Pressure Processing (HPP):**
A cold pasteurization technique where milk is subjected to very high pressures, killing microorganisms while maintaining the nutritional and sensory qualities of the milk. HPP extends shelf life without using heat, which can degrade milk quality.

d) **Microencapsulation:**
This involves coating bioactive ingredients or probiotics with a protective layer, allowing them to survive harsh processing conditions and enhance their storage stability. For dairy, this can mean added health benefits in products like yogurts and cheeses.

e) **Milk Protein Concentrates (MPCs):**
MPCs are produced by removing the lactose from the milk and concentrating the proteins. They have diverse applications in cheese manufacturing, yogurt, and nutritional beverages due to their high protein content and functional properties.

f) **Infrared Milk Analysis:**
Used to assess the composition (fat, protein, lactose, etc.) of milk rapidly. By passing infrared light through milk, specific waveforms can be detected which correspond to

various components. This ensures consistent quality and assists in price determination for milk suppliers.

g) **Flash Pasteurization:**
This involves heating milk to a high temperature for a very short period. It eliminates harmful bacteria while ensuring minimal loss of nutritional quality. The method is faster and often considered more efficient than traditional batch pasteurization.

h) **3D Printing for Dairy Products:**
Emerging technology where ingredients like milk powder are used in 3D printers to create complex structures. This could revolutionize aspects of food design and customization, particularly in cheese and dessert sectors.

i) **Cold Brew Coffee Milk:**
Combining the trend of cold brew coffee with milk to create a beverage that's both creamy and offers the caffeine kick. It involves steeping coffee beans in cold milk for an extended period, then filtering out the beans to leave a naturally sweetened coffee-infused milk.

j) **Lactose-Free Dairy Products:**
Through the use of lactase enzymes, lactose (a sugar in milk) is broken down into simpler sugars, glucose, and galactose, which are more digestible. This allows people who are lactose intolerant to enjoy dairy products without digestive discomfort.
These innovations continue to shape the milk processing industry, catering to evolving consumer demands, health concerns, and sustainability imperatives. As always, the success of these technologies and products depends on market reception, scalability, and their integration into the broader food system.

Innovative milk-based products

Innovative milk-based products that have made their mark or are emerging in the dairy industry are discussed below

a) **Probiotic Milk Drinks:**
These are fermented milk products that contain beneficial bacteria known as probiotics. They support gut health and boost immunity.
Example: "Yakult" by Yakult Honsha Co. and "Lifeway Kefir" by Lifeway Foods.

b) **Milk-Based Sparkling Beverages:**
A fusion of milk with carbonation creates a unique, bubbly beverage. These are refreshing and provide an alternative to traditional sodas, combining the goodness of milk with a sparkling twist.
Example: "Viomilk" by Vio Foods (Coca-Cola's venture in India).

c) **Milk-Based Protein Bars and Snacks:**
Leveraging the high protein content of milk, manufacturers have started producing protein bars and snacks using milk concentrates and isolates, offering a healthy, on-the-go nutrition option.
Example: "Think! High Protein Bars" by Think Products.

d) **Lactose-Free Ice Cream:**
For lactose-intolerant consumers, this product uses lactase enzymes to break down lactose, allowing them to enjoy ice cream without digestive issues.
Example: "Lactaid Ice Cream" by Lactaid (a Johnson & Johnson company).

e) **High Protein Yogurts:**
These yogurts, often known as "Greek" or "Icelandic" (Skyr), are strained more than traditional yogurts, resulting in a thicker texture and higher protein content. They cater to health-conscious consumers looking for protein-rich diets.

Example: "Chobani Greek Yogurt" by Chobani and "Siggi's Icelandic Yogurt" by Siggi's Dairy.

f) **Milk-Based Meal Replacements:**
Drinks or powders that combine milk proteins, essential nutrients, and vitamins to act as a meal substitute. They're popular among those with busy lifestyles or those looking for controlled nutritional intake.
Example: "Ensure" by Abbott Laboratories.

g) **Oat Milk Yogurt and Cheese:**
While oat milk itself isn't dairy, when combined with dairy elements, it can be used to produce unique yogurt and cheese products, merging the popularity of oat milk with traditional dairy.
Example: "Oatgurt" by Oatly.

h) **Milk with Functional Additives:**
Regular milk fortified with functional ingredients like omega-3s, vitamins, or minerals. This enhanced milk caters to specific health needs, such as bone health, brain development,

or immunity boost. *Example:* "Horizon Organic DHA Omega-3 Milk" by Horizon Organic (a Danone company).

i) **Dairy-Based Coffee Creamers:**
These are not just regular creamers but come with added flavors, and some even offer additional benefits like MCT oil for energy, catering to the evolving coffee culture.
Example: "Coffee mate" by Nestlé.

j) **Dessert Hummus with Dairy:**
A blend of chickpeas with dairy ingredients and sweet flavors, creating a creamy dessert that's a healthier alternative to traditional sweet spreads or dips.
Example: "Delighted By Dessert Hummus" by Delighted By Desserts.

These innovative products cater to a wide range of consumer preferences, dietary needs, and lifestyle choices. They reflect the dairy industry's adaptability in integrating modern nutritional science, consumer trends, and traditional dairy goodness.

Conclusion

The milk processing industry, with its deep historical roots and traditional methods, has witnessed an exciting phase of innovation and transformation, especially in the last few decades. With the advent of technology, changing consumer preferences, and an emphasis on health and wellness, the sector has evolved to meet new challenges and tap into fresh opportunities. India, as one of the world's largest milk producers, stands at the forefront of this change. The country's unique amalgamation of age-old dairy practices with emerging technological advancements makes it a vibrant hub for the milk processing industry. From the rise of A2 milk to the adoption of cutting-edge processing technologies, India exemplifies the adaptability of the dairy sector. Furthermore, the emergence of startups in the milk processing domain has added a fresh dynamism to the industry. These startups, driven by young entrepreneurs and innovative thinkers, are not just addressing the demands of the Indian market but are also making their mark on the global stage. Their endeavors underscore the vast potential and the myriad opportunities that lie ahead for those willing to innovate and adapt. However, like any other industry, the milk processing sector is not without its challenges. From ensuring sustainable practices to addressing concerns related to animal welfare and environmental impact, the industry needs to remain vigilant. It's crucial for stakeholders to collaborate, sharing knowledge and best practices to overcome these challenges. The influx of innovative milk-based products, from high-protein yogurts to probiotic drinks, underlines a broader trend: consumers today are looking for products that cater to their specific needs, be it health, taste, or convenience. The industry's response to these demands is a testament to its resilience and its commitment to delivering value to its consumers.

In conclusion, the future of the milk processing industry in India is teeming with possibilities. As it rides the waves of change, the sector promises growth, innovation, and an enhanced focus on sustainability and quality. Stakeholders, whether they are established industry giants or budding entrepreneurs, have the opportunity to shape this future, ensuring that the legacy of the dairy industry is carried forward with vigor and vision. As the industry moves ahead, it will undoubtedly continue to be a cornerstone of India's agricultural and economic landscape, nourishing millions and fostering entrepreneurial spirit.

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Chapter-16

UDDER HEALTH MANAGEMENT IN MILCH ANIMALS

M. Gopalakrishna

Assistant Professor, Department of VGO,
College of Veterinary Science,
PVNRTVU, Rajendranagar, Hyderabad-30, Telangana, India

Introduction

The dairy farmer and the dairy processing industry must constantly strive for products that are excellent in quality and flavour. Udder health of the dairy cow plays an important role in achieving this goal. Maintaining minimal standards of cleanliness on the dairy farm is essential for producing milk of good quality. If the dairy herd and the surrounding environment are clean, you are more likely to have healthier cows producing high-quality milk. Milk is regarded as an excellent source of proteins, milk sugars, and minerals, in particular when milk is produced by healthy cows. Farmers are paid for the composition (milk fat and protein) and quality of the milk produced. Milk of a lesser quality may be refused by the dairy-processing industry as public health standards are high. Milk from healthy udders contains a mini- mum of bacteria and somatic cells. It should be noted that cows producing milk of abnormal composition due to udder health problems will cost the dairy farmer more because of lower milk production, a lower milk price, extra labour and higher veterinary costs. So cows with healthy udders will produce milk of excellent quality and thereby will contribute substantially to the dairy farmer's income.

I. Bovine Mastitis

Bovine mastitis is the most costly disease affecting dairy cows worldwide. It is estimated that almost half of all cows in any herd have some form of udder inflammation and mastitis free herds are extremely rare. In fact, the real cost of mastitis is surprising, since many mastitis cases are difficult to notice and therefore its effect on milk production cannot be quantified. In order to prevent production losses due to mastitis, it is imperative to control the disease. The dairyman's effort can greatly contribute to protecting the dairy cows from mastitis by introducing objectives to prevent new cases or to eliminate existing ones. It is important to emphasize that several on farm management and environmental factors must interact together to reduce the exposure of cows to mastitis organisms. Therefore, a strategy of mastitis control should involve the total dairy herd management and should not only be limited to the milking parlour itself. You will find that the cost of active control of mastitis is far lower than the cost of simply reacting to it.

1. Mastitis Occurrence

The occurrence of mastitis can widely vary, depending on the cause and the susceptibility of the dairy cow. Mastitis is an inflammation of the udder and is caused by bacteria in nearly all cases. Pathogenic microorganisms have to invade the teat orifice and canal to infect the mammary tissue, causing inflammation of a quarter. It will immediately result in the transfer of white blood cells (leukocytes) into the milk to combat the pathogens. This will lead to higher somatic cell counts in the milk produced and consequently, to reduced milk production. The cow's natural defence against the penetration of bacteria is the muscle around the teat end (the teat sphincter). When this muscle closes tightly it is more difficult for bacteria to enter.

However, to permit milk to flow, the muscle around the teat orifice must be flexible. It is just during and after milking that cows are most susceptible to new infections. By using a teat dip or spray, the risk of teat canal infections becoming intramammary infections can be reduced significantly. On average, the sphincter is not fully closed for about 1 to 2 hours after milking. Any bacterium that comes in contact with the teat end during or directly after milking has little difficulty gaining access to the mammary tissue.

2. Different forms of Mastitis

Mastitis can be subdivided into subclinical and clinical mastitis. Subclinical mastitis cannot be noticed by the dairy farmer because there are no perceptible signs of the disease. About 90% of all cases of mastitis are subclinical. In contrast, clinical mastitis is easily detected; for example, the udder tissue is warmer and less soft to the touch. Examination of at least two squirts of foremilk from each teat for abnormalities, greatly assists the milker in detecting mastitis at an early stage. Cows with mastitis should be milked last in order to avoid spreading of the infection to other cows. It goes without saying that it is important to know that subclinical and clinical mastitis are not necessarily corelated with each other. For example, it is known that dairy farms with a low somatic cell count may experience sudden out- breaks of clinical mastitis.

2.1 Subclinical mastitis

Subclinical mastitis usually goes unnoticed (hidden) at farm level, because the milk and udder appear normal. This form of mastitis is much more important than clinical mastitis, because it is more prevalent, and results in the greatest loss of milk. However, symptoms of infection are present in the udder, resulting in, amongst others, increased somatic cell count and reduced milk production. It can be detected through individual cell count recording and laboratory diagnostic tests. In most cases, subclinical mastitis indicates the presence of an infection that has not been effectively treated. The presence of subclinical mastitis may be an important cause of the occurrence of clinical mastitis. Dry cow treatment of all quarters of all cows is the best way to cure subclinical mastitis. Eventually, culling of problem cows may be the only way to remove the infection source from the herd.

2.2. Clinical mastitis

Clinical mastitis can easily be recognized since flakes are formed by the white blood cells that have moved into the milk in large numbers. In addition, the udder or a specific quarter often shows signs of an inflammation, such as a higher temperature, an abnormal swelling and/or over- sensitivity of the infected quarter. The milk from seriously affected quarters can be watery, clotted or a thick purulent dis- charge with a foul smell may be produced. In most cases, the cow has an increased body temperature. Each case should be treated immediately to maximize chances of curing the infection. Clinical mastitis may be frequent even though the bulk milk somatic cell count is low.

3. Pathogens

The majority of infections are caused by the following types of pathogens:

- Streptococcus agalactiae, Streptococcus dysgalactiae and Streptococcus uberis;
- Staphylococcus aureus;
- Escherichia coli;
- Klebsiella pneumoniae and Pseudomonas aeruginosa;

- Actinomyces (Corynebacterium) pyogenes;
- Mycoplasmas (fungus).

These bacteria can be divided into three categories of pathogens:

3.1 Udder-related bacteria

The so-called udder related bacteria, which are spread from infected quarters to other quarters can easily survive within the udder. The transmission takes place typically during milking, since the hands of the milker, udder cleaning cloths and the milking machine come in direct contact with the various udders and teats. Streptococcus agalactiae, Streptococcus dysgalactiae, and Staphylococcus aureus are typical examples of udder related bacteria. Hygiene during milking must have top priority in controlling these pathogens. Follow a strict programme of teat dipping; milking of infected cows last; culturing milk samples; treating of infected quarters; dry cow treatment; and culling of chronically effected cows. Optimal milking machine functioning is essential to control these infections.

3.2 Environmental bacteria

These bacteria are specifically found in the cow's environment. They are: Streptococcus uberis, Escherichia coli, Klebsiella pneumonia and Pseudomonas aeruginosa. S. uberis and E. coli are causes of udder inflammation during lactation as well as during the dry period. The infection is principally caused by dirty bedding in free stalls (cubicles). Klebsiella species are found in bedding materials, particularly in sawdust. Pseudomonas bacteria are mainly inhabitants of water pipelines and water reservoirs. Hygienic measurements are important for control, such as maintaining a neat environment, clean and dry bedding and culling of non-responsive cows. The response of the cow's immune system is also important. Nutrition, stress and other factors have shown to affect this.

3.3 Other pathogens

These groups of pathogens are not dependent on the cow for survival. They can survive and multiply within other organisms, whereby the cow acts as an intermediary. These pathogens may initially cause another illness, with mastitis occurring as an additional affliction. Actinomyces pyogenes and Mycoplasmas belong to this group of pathogens. Actinomyces pyogenes is the causative agent of summer mastitis. Overall hygiene and effective fly control are a prerequisite to control these pathogens. In addition, teat dipping should be carried out and infected cows should be isolated. It is recommended to cull infected cows where feasible.

4. Monitoring and Diagnosis

For the detection of subclinical mastitis, it is important to take regular bulk milk samples for somatic cell counts. Furthermore, it is essential to keep an up-to-date administration of clinical mastitis on a 'mastitis chart'. This chart should be fixed in a place easily accessible to the milkers. It will greatly assist in monitoring the udder health status of the dairy cows.

4.1. Monitoring subclinical mastitis at herd level

To evaluate the udder health status of a dairy herd, samples of bulk tank milk should be taken for investigation. Through regular monitoring of the somatic cell count and the number and types of pathogens, a proper insight can be gained into the herd's udder health status. The milk is graded according to the number of somatic cells per milliliter. A high number of cell counts from bulk tank milk indicates a higher incidence of (sub) clinical mastitis. In general, it can be said that a somatic cell count above 200,000 cells per milliliter (ml) of milk suggests a significant prevalence of subclinical mastitis in the dairy herd. A high somatic cell count is associated with a substantial loss of milk production. To evaluate the udder health status of a dairy herd, samples of bulk tank milk should be taken for investigation. Through regular monitoring of the somatic cell count and the number and types of pathogens, a proper insight can be gained into the herd's udder health status. The milk is graded according to the number of somatic cells per milliliter. A high number of cell counts from bulk tank milk indicates a higher incidence of (sub) clinical mastitis. In general, it can be said that a somatic cell count above 200,000 cells per milliliter (ml) of milk suggests a significant prevalence of subclinical mastitis in the dairy herd. A high somatic cell count is associated with a substantial loss of milk production.

4.2. Monitoring subclinical mastitis at cow level

For detection of subclinical mastitis in cows, identify individual cows with a high somatic cell count with the California Mastitis Test (CMT). This cow-side paddle test in combination with a T-pol reagent and the use of a strip cup is of great help in detecting abnormal milk. For reliable results, the CMT test should be used after discarding of the foremilk. In the Netherlands, the results of somatic cell count of individual cows can be sent on request to the dairy farmer together with each milk-recording report. Individual somatic cell counts above 200,000 cells per ml of milk suggest the presence of an important pathogen, in particular, if somatic cell counts at herd level are higher than desirable or are increasing within a certain period of time. The somatic cell count recording of individual quarters is essential to detect the cows responsible for this level.

4.3. Recording of clinical mastitis

One of the most useful tools in mastitis control is good record keeping. A good system is the so-called "clinical mastitis chart". All data relating to cows with a case of clinical mastitis should be re- corded, i.e. the dates of mastitis occurrence, the number of cases of mastitis per individual cow, the quarters infected, the results of the laboratory analyses and the antibiotic used for that specific treatment. With the help of the mastitis chart, the effectiveness of the treatment applied and the cows with severe mastitis problems can easily be identified. Cows who regularly have serious mastitis problems, can be the source of infection to other cows and should therefore be culled. Through good record keeping the dairy farmer can take effective action to improve the herd's udder health status.

4.4. Laboratory analysis

Through laboratory analyses of cow milk samples with increased somatic cell counts and for clinical mastitis, a proper indication can be found of the type of pathogens causing the (sub) clinical mastitis. Moreover, after determination of the susceptibility of the mastitis microorganisms to different antibiotics, very effective treatment of (sub) clinical mastitis can be carried out. Each pathogen needs a specific antibiotic to treat the infection effectively. It is good practice to treat the subclinical cases during the dry period with a specific dry cow antibiotic to achieve the best results possible. Consult your vet for further assistance.

III. Important Factors Influencing Udder Health

Milk obtained from clean and healthy cows is quality milk. The cows should be free of mud, manure and dust. It is recommended to clip the udders and flanks to prevent dirt from sticking to long hairs. Filthy udders and teats are the main source of milk contamination. Visible dirt should be kept out of the milk by thoroughly cleaning the udder and teats before milking. Under all circumstances avoid dirt contamination of the milk during milking. Although filtration is a recommended practice, it will not remove bacteria and dissolved dirt. A milk filter should be regarded only as a safeguard against the accidental presence of dirt and as a monitor of hygiene.

Prevention of mastitis is much better than cure and, for this reason, preventive measures are essential. Many environmental factors influence the yield and the cleanliness of milk produced. In general, the health of the dairy cow and its udder are affected by:

- water
- milker
- environment
- milking machine
- milking
- nutrition
- herd replacement management
- herd health management programme.

Water

Clean potable water is the backbone of the entire dairy farm hygiene programme. In most developed countries, the dairy farms are connected to the main municipality water supply systems using treated water. It is important that the dairy farmer is assured of water that is safe for human and animal consumption. The potable water may look and taste good, but to be sure of its quality, a complete water analysis is recommended. The water may contain impurities which may hamper effective cleaning. Similarly, bacteria in the water could affect overall herd health. It is also important to be aware of dissolved solids which may reduce milk production and affect the taste of the milk.

In the Middle East, for example, water supplied by wells is often high in mineral content. Trials comparing untreated water with treated water (that is, water of lower mineral content) have demonstrated that cows receiving treated water were healthier, drank more water, and produced significantly more milk than cows given normal (untreated) well water. Water with a high calcium content reduces the effectiveness of cleaning and causes the formation of milk stone on inner surfaces. This can cause serious problems with cleaning and therefore milk quality. So it is necessary to confirm that the water supply is free of harmful organisms, is of a well-balanced composition, of minimal hardness and without any taste.

Milker

The milking herd together with the milking machine system in use, can only be as good as the milker handling them. Even if a perfect functioning milking machine system exists, the milker still must have the necessary knowledge to operate the milking machine. The milker should not only know how the milking system works but should also be aware of necessary regular maintenance to keep the installation in top working order. A professional approach is always important with cow milking. Since milking is considered by many as the most important task on the dairy farm, it should be performed by the most capable person(s) on the farm.

Improved milking equipment has not subsided the importance of the milker. Although modern milking equipment has made it easier to do a better job, the operator is as important as ever. The first priority is that the milker has empathy with cows, a disciplined attitude and a high degree of personal hygiene. Some milkers do not like cows and this will affect their milking ability. It is sensible to assign these workers to other tasks at the farm. Filthy clothes and dirty hands during milking are unacceptable. The hands of the milker may transfer udder pathogens amongst cows. A cow is a creature of habit and breaking her routine is probably one of the worst things one can do. Routine practices, treatment and schedules used in the first few weeks after calving will affect production for the entire lactation. Good training and motivation of the milker are essential for clean milk production. Appropriate training in dairy husbandry will give the milker a clear understanding of the role he or she is expected to play in the whole dairy setup. Good communication with your milkers is a must. Introduce bulletin boards in your dairy to relay information regarding milk production and milk quality. Up-to-date record keeping is an absolute **must** within the dairy business. In addition, a bonus system based on quality premiums or other fringe benefits for general herd performance contribute to the involvement of the employee.

Environment

The dairy cow lives in a very vulnerable environment in which specific and non- specific udder infection causing microbes can survive and, in many cases, proliferate. The dairy cow is very susceptible to udder health problems at the time of drying-off, and during and after calving. In the dry period it is essential to check the udder regularly. The housing of dairy cows, the calving pattern throughout the year, and the seasonal climatical conditions, such as temperature and humidity, all have a considerable influence on cow health. It should be emphasized that farm cleanliness is of utmost importance in maintaining a low incidence of udder contamination.

Housing

The housing of dairy cows has a great influence on the cow's udder health. Of importance are the climate, the size of the resting place and the bedding mate- rial used. If the cows are restricted in their freedom of movement in free stalls, then it will increase the incidence of teat injury. Cows often injure their teats, when the resting place is too small. The climate in the housing should always be fresh and cool with average humidity. Draught and direct contact with too cold air must be avoided at all cost as this adversely affects udder health.

Bedding materials can be an important source of pathogens, owing to prolonged contact with the teats. Dry dust-free (without mould) and clean bedding material should be regularly provided. Regular removal of manure and drainage of muddy areas helps to eliminate significantly the occurrence of flies in its breeding areas. The floors in barns should be properly sloped to maintain a dry surface area. Other environmental causes of increased exposure to pathogens are over- crowding, poor maintenance of housing facilities and general lack of cleanliness.

Heat stress

Under hot weather conditions, factors such as high humidity, mud, manure, and bedding become even more important as they influence the numbers of pathogens present on udders and teats. In general, high temperatures in combination with high humidity increase the occurrence of udder infections and consequently reduce milk production. The construction of shade structures on elevated areas in open-air corral systems contributes greatly to heat stress reduction. Under (sub)tropical conditions proper cooling can increase the well-being of dairy animals above that in more moderate areas. New developments in evaporative cooling have been very successful. Nowadays, corral coolers are available for dairy operations in dry, hot and humid climates which helps to reduce heat stress problems. The system is based on distinctive air-water mixing and evaporative convection cooling.

Flies and Other Insects

Flies and other insects area nuisance in the milk parlour, calf pens, dairy barns and holding areas. Each fly lays about 100 eggs for a number of days. That is, a few flies can develop into a hoard of flies in a short time. The method of manure handling and storage has a great effect on overall hygiene. If manure is allowed to build up or is handled improperly there will be serious problems with hygiene and fly control. The first step towards effective fly control is the removal of manure and thorough cleaning of all areas where fly eggs and maggots are found. The emphasis must be on eradicating the breeding places of flies. Regular cleaning and disposal of all manure accumulations is an absolute must. Biting flies and insects reduce milk production by causing stress. However, more importantly, they may transfer harmful organisms among cows, leading to various diseases (e.g. mastitis, pinkeye and scours). Therefore, fly control is essential during hot and humid weather when conditions are optimal for multiplication. The application of special eartags, spraying or fly-traps can be of assistance.

Milking machine

In the Proper Milking Management manual the operation of the milking machine and the milking-related equipment is thoroughly described. Many actions and interactions during the milking process may contribute to increased somatic cell counts and udder infections. The milking machine may effect the development of mastitis in the following ways:

1) Teat cup liners

The teat cup liners should not be worn or be too wide. Tiny cracks in liners are an ideal niche for the growth of bacteria. Usually, liners should be renewed after about 2,500 milkings depending on the type of liner. The same applies to the milking tubes. All rubber parts that are in contact with milk should be replaced in time when showing signs of wear. Consult your supplier for further advice.

2) Instable or insufficient vacuum level

Improper use of the milking machine may predispose the cow to a mastitis infection through a teat-end injury. It may carry pathogens from one cow to another during milking. During milking, the udder pathogens can easily be transferred from an infected quarter to an uninfected quarter of the same cow within the claw piece, for instance in case of an abrupt reduction in milking vacuum. The main cause is sudden air admission through slipping of liners, which creates the formation of milk columns in the milk tube. It happens as well if milk pipes become completely flooded with milk and consequently the vacuum supply to the cluster unit is restricted. Low-level milk pipes of the correct diameter in milk parlours and with the desired slope to the milk receiver assist in maintaining a constant vacuum and better milk flow.

3) Milking speed

The milking speed is related to the ease of milking of the cows and the vacuum level in the milking system. The milk flow will speed up with an increased vacuum level. However, an increased vacuum level will result in higher strip yields (the amount of milk left behind in the udder after the milking unit has been removed). The adjustment of the vacuum level is a compromise among the milking speed, pulsation ratio, the strip yield and physical load on the teats. Do not use working vacuum levels above 50 kPa.

4) Other sources

Pulsators should be clean and operating properly. It has been shown that cows milked with irregular pulsations and consequently causing vacuum fluctuations have a higher incidence of mastitis than cows milked at regular vacuum. The recommended pulsation rate for dairy cow is 50 to 60 cycles/minute.These vacuum fluctuations may cause liner slip at the end of milking and may lead to a blast of air and milk droplets ("impacts") towards the teat end. Exactly the same will happen if the cluster is removed while under vacuum. These "impacts" may penetrate the teat orifice and may cause high infection rates.

Excessive over-milking and machine stripping will damage the tissue lining of the udder, teats, and teat orifice and must be avoided under all circumstances.

It is good practice to regularly inspect the milking machine equipment and to perform testing on a twice-yearly basis to keep the installation in good working order. Never forget that the most important parts of the milking machine are the people who operate, maintain and service the installation.

Milking

Good milking practice is thoroughly described in the Proper Milking Management manual. Furthermore, it is emphasized that the 5-point plan described in the chapter on mastitis control in this manual is routinely followed.

Nutrition

Nutrition may sometimes have an effect on the cow's udder health. Rations deficient in vitamin A or E and the selenium (Se) trace element may cause an in- creased incidence of mastitis, owing to reduction of the natural defenses of the udder. Sometimes this will happen when the cow's diet depends heavily on stored forages, especially silage. Selenium is an essential tissue nutrient required by all body tissues including the udder. Selenium as well as vitamin E are needed for a proper udder immune function. In practice, selenium and vitamin E deficiencies are quite common during the dry period when often less attention is paid to good nutrition. Therefore, enough care should be taken to ensure that the rations are properly supplemented with minerals, especially selenium, and vitamins. Fresh, green forages are the major sources of vitamins A and E.

Rations with an in balanced roughage/ concentrates ratio may lead to a reduced fiber intake and consequently play a part in causing metabolic disorders, such as milk fever, ketosis and rumen acidosis. The stress caused by these in balanced rations, especially during the beginning of lactation when milk production is at its highest level, make cows more susceptible to udder health problems. Consult Feeding Management, Volumes 1 and 2. Just after milking, the teat orifice (teat end) is most susceptible to bacterial invasion. For this reason, it is good practice to encourage cows to remain standing for at least one hour after milking. It is recommended that fresh and palatable feeds are provided after the cows have left the milking parlour. This keeps the cows standing and gives the teat dip or spray enough time to act, thus reducing the exposure of the teat orifice to environmental pathogens.

Herd replacement management

Utmost attention should be paid to the purchase of in-milk dairy replacement stock from unknown sources. It is advisable to send milk samples of these cows for culture to animal health clinics, prior to admitting these cows to your milking herd. If culture facilities are unavailable, then check with a cow-side paddle test, for quarters with an increased somatic cell count. Sometimes these animals were culled by the previous owner for having an udder health history. If these animals are carriers of subclinical mastitis, they may easily transfer udder pathogens to healthy cows. Not checking purchased cows for the presence of udder infections is tantamount to asking for trouble. Heifers are less likely to be infected with udder pathogens, but occasionally heifers get udder infections before calving. Always check the mammary system of heifers during their pregnancy. Hygienic conditions are important, just before calving as well as during and after calving.

From practical experience we know that, it is important to rear young heifer calves in individual calf pens to prevent suckling. Besides this, weaners and bulling heifers should be kept in separate groups in a clean and dry environment, and not be mixed with the dry cows. Furthermore, practice fly control to prevent udder infections in heifers, especially during grazing.

Herd health management programme

A good method for controlling mastitis in dairy herds is to use a herd animal health and management software programme. These comprehensive management programmes can assist in daily animal management, herd performance monitoring and problem analysis. Animal data are entered via a menu-based system and the animal events can be organised around many parameters, such as reproduction, milk yields, health records, inventories for drugs, feeds, semen, etc. These programmes provide access to a large amount of data required to help in daily management with action lists, allow for performance monitoring and analyze problems.

The use of these software packages in conjunction with regular visits of the field officer responsible for milk quality control, after-sales services of the milking machine agent and the vet greatly assist in improving udder health and overall milk production efficiency.

IV. Mastitis Control

The primary objective of controlling mastitis is to reduce the number of new udder infections. For this reason, it is essential to introduce management practices for dairy managers and their milkers to reduce the rate of new infections and to shorten the duration of existing infections. It involves the conscientious application of only a few basic practices and may be described as the 5-point plan for mastitis control. This plan is successfully in operation worldwide.

5-point plan for mastitis control:

1. Proper milking hygiene, good milking technique and desired milking machine function;
2. Dipping of teats after milking;
3. Treatment of all quarters of all cows at drying off;
4. Prompt treatment of clinical udder infections during lactation;
5. Culling of chronically infected animals.

1. Proper milking hygiene, good milking technique, and adequate milking machines

The primary objectives of proper milking hygiene, good milking techniques and desired milking machine function are thoroughly described in the Proper Milking Management manual. Of utmost importance is that teats are dry and clean before milking starts. Furthermore, provide a relatively stable vacuum level, avoid slipping of teat cup liners during milking and shut off vacuum to the claw piece before removing the teat cups. Milk only as many cows as you can handle efficiently.

2. Dipping of teats after milking

The transfer of mastitis pathogens is in- evitable during milking time. Therefore, it is necessary to dip teats at the end of milking to destroy remaining pathogens. It is recommended that each teat be fully covered by dipping or spraying with a suitable teat dip shortly after the clusters have been removed.

3. Treatment of all quarters of all cows at drying off

Treatment of all quarters of all cows with long-lasting antibiotics for dry cow treatment is recommended, if there is a high incidence of mastitis. This treatment should take place following the final milking of the lactation.

4. Prompt treatment of all clinical udder infections during lactation

In daily practice the observant milker will soon detect cases of clinical mastitis. These cases require immediate action with appropriate therapy in close cooperation with the vet. Keeping an up-to-date administration of individual quarter mastitis cases on a ‘mastitis chart’ will assist in controlling udder health. Treated cows should be clearly marked to help prevent accidental contamination of bulk milk.

5. Culling of chronically infected animals

Cows with repeated flaring-up of clinical and/or subclinical mastitis and not responding favourably to treatment should be culled. These cows can be the main source of infection for other animals.

The general guidelines for good udder health are:

1) Constantly monitoring udder health;
2) Using a strip cup to be sure that milk is normal;
3) Using the CMT paddle test for detecting abnormal milk or subscribing to an individual somatic cell count programme;
4) Recording mastitis cases on a ‘mastitis chart’ for monitoring udder health;
5) Practicing the 5-point programme for mastitis control;
6) Keeping your cows and their environment clean at all times;

7) Clean and disciplined milkers;
8) Allowing time for feeding after milking to allow teat dip to act and dry;
9) Checking-up your milking machine every 6 months;
10) Consulting your vet about setting up an effective mastitis control programme.

Conclusion

It is imperative that in order to maintain good udder health and clean milk production, initial bacterial contamination of milk should be avoided as much as possible. Herd health management, with the emphasis on udder health and its surrounding environment, is an essential condition for the production of quality milk from healthy udders. A sound mastitis control programme will definitely assist in reducing the level of mastitis cases. The benefits will be an increased milk production, reduced veterinary expenses and fewer dairy cows culled. Accurate identification of the pathogen causing subclinical mastitis is essential for effective treatment. Furthermore, good recording of data relating to cows with clinical mastitis will assist the dairy farmer in taking the requisite action.

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About the Editors

Dr. Shahaji Phand, Deputy Director and Centre Head of Centre for Extension in Agri-allied Sector and also Principal Coordinator, Agri-Clinics and Agribusiness Scheme (AC&ABC), National Institute of Agricultural Extension Management (MANAGE), Hyderabad. With Specialization in Animal Husbandry/Veterinary Extension, presently shouldering the responsibilities of strengthening allied sector extension management

Dr. Sushrirekha Das presently working in Centre for Extension in Agri-allied Sector, National Institute of Agricultural Extension Management (MANAGE), Hyderabad. She is a core extension officer in the field of allied sector. She has contributed more than 8 years in allied extension service for betterment of farmers.

Dr. K. Sai Maheshwari Presently working as Assistant Director in Agri-allied Sector, MANAGE, Hyderabad. She has served more than 25 years in allied extension. She has actively involved in planning, development and implementation of watersheds at the field level officers and the farmers and other developmental schemes / programmes.

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