Innovations in Dairy Management

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Edited by

Girish Kumar V, Sagar S Deshmukh, V. Jagadeeswary

National Institute of Agricultural Extension Management
(MANAGE), Hyderabad, Telangana &
Karnataka Veterinary, Animal and Fisheries Sciences University
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PREFACE

Our Nation being the largest producer of milk in the world is a key player in the dairy industry and the opportunity for growth is immense. As one of the fastest growing beverage segments in the Indian market, dairy is predicted to become a billion-dollar market leading down the way. In recent years there have been significant technological advancements in the Indian dairy industry and Indian companies including Amul, KMF, and start-ups are taking milk marketing to millennials, not just as a health drink, but as a functional drink. As a key player in the global dairy market, India is positioned to be industry leaders. Although operational challenges still account for major loses, modern farming innovations and technological solutions are playing a key role in the development of new age Indian farms and dairies and over the last few decades, such innovative advancements in dairy farming have allowed dairy farmers to improve the everyday quality of life of their herds as well. Present deliberation is an attempt to throw an insight on various innovations existing in Dairy farming and the feasibility of the Innovations at the farmers' level. The topics have been meticulously identified to offer possible direction for the Veterinarians to transfer the same for enhancing production and income of the farmers. This book was made possible by the committed efforts of the scientists and we duly acknowledge the authors.

This e-book is an outcome of collaborative online training program on "INNOVATIONS IN DAIRY MANAGEMENT" conducted from 28 June – 30 June, 2022. This book will be highly useful to Veterinary Professionals across the country and Extension workers who are working at the grassroots level. A docket of topics from Smart Dairying: Practical Applications of Information Communication Technologies, Advances in Dairy Healthcare Diagnostics and Therapy, Advanced Feeding Technologies to Optimize Milk Production in Dairy Animals, Scientific Breeding Technologies in Dairy Farming - New Age innovations, Climate Resilient Innovations for Smart Dairying, Reproductive biotechnologies: Practical applications for Reproductive Management In Dairy Cattle, Innovations in Value Addition of Dairy Products, Mobile Applications for Technology Transfer of Dairy Innovations – Experience sharing and Innovations in Dairy Farming - A Perspective of a Private Entrepreneur has been covered for the benefit of the Veterinarians.

The editors express sincere thanks to Prof. K.C. Veeranna, Hon'ble Vice Chancellor, Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, Karnataka, for inspiration and motivation in publishing this e-book. The financial aid provided by MANAGE, Hyderabad for this training program is duly acknowledged. We hope and trust that the valuable inputs provided through this e-book will help to improve the ability of all the stakeholders in Dairy sector to enhance dairy production for welfare of the farming community.

JUNE, 2022

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CONTENTS

1. SMART DAIRYING: PRACTICAL APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES

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'Smart dairying' or 'Precision dairy farming' refers to the use of Information and Communications Technologies (ICTs) to measure and utilize physiological, behavioural and production indicators of individual animals for taking management decisions that achieve profitable and sustainable production of high-quality milk. The primary objectives of smart dairying are maximizing animal performance, early detection of ill-health in individual animals, early detection of herd-level health and production problems, enhancing farm efficiency and minimizing use of resources at the farm.

The term'Information and Communications Technology (ICT)' is commonly used synonymously with Information Technology (IT), but is particularly preferred in the fields of education and governance. In common usage, it is often assumed that ICT is synonymous with IT. ICT in fact encompasses any medium to record information, technology for broadcasting information, and technology for communicating through data, voice, imagesand/or videos. It includes the wide variety of computing hardware (PCs, servers, mainframes, networked storage, cloud storage), the rapidly developing personal hardware market (mobile phones, tablets, smart watches), application software (from the smallest home-developed spreadsheet to online software services); and the hardware and software needed to operate networks for transmission of information. Thus, ICT makes more explicit that technologies such as broadcasting and wireless mobile telecommunications are included.

ICT has the potential to change the economy of livestock, agriculture, and rural artisans in India. The livestock sector should come up with need based, location specific and local language content in the form of computer software and other electronic material in regards to livestock disease control, dairy herd management, livestock production, and marketing of livestock and livestock produce. ICT-based information delivery to livestock sector can significantly improve the quality of decision-making in livestock farming system. With intensification of crop/livestock production systems and increased market demand of animal based products, the importance of information is growing in many developing countries. In this process of structural change and potential growth in high value products, ICT based

livestock advisory services for knowledge dissemination to the farming communities for better and informed decision-making at the farm level, have become essential. Some of the ICT-enabled applications which enhance the efficiency of dairy farms and aid in precision farming are given below:

1. **Identification**: Development and commercialization of animal identification systems has reached a very advanced state. A variety of systems based on Radio Frequency Identification (RFID) are available, some of which work reasonably well and have been adopted at the country level. These systems greatly facilitate the traceability and certification of products, particularly of beef, and therefore are crucial tools to minimize the losses and market disruptions caused by "mad-cow" disease and foot-and-mouth disease.
2. **Instrumentation***:* This involves acontrol system that consists of sensors that measure variables related to the system's state and actuators that provide input of mass, momentum or information to the system towards directional modification of the state. Animal state is estimated by the history up to a recent time, position, activity, temperature, live weight and other physiological variables of all individuals in the herd. This is especially observed in farms located in adverse environmental conditions where sensor-based automatic micro-climate manipulations in the form of misters are activated to ensure that the animals are kept comfortable.
3. **GPS**: The use of GPS "collars" for livestock and wildlife has become widespread in the last ten years. This opened the possibility of recording detailed position information for long periods of time, thus allowing a more complete understanding of the habits and causes of spatial distribution of ruminants. Current GPS technology can determine position of individual animals with a precision of 10 m or better. The position information can be stored on small flash cards together with large amounts of behaviour and physiological data and it can be transmitted to a management centre in real time or in periodical sessions. Commercial GPS collars usually include three sensors: temperature, fore-aft movement, and left-right movement.
4. **Animal behaviour sensors**: The data recorded by these sensors is somewhat ambiguous, but models can be developed to infer activity. Various types of sensors are necessary for a detailed record of behaviour. Mercury switches have been useful to document not only head movements but also walking and lying behaviour. Sensors have been tested for

measuring head angle, head acceleration, leg acceleration, steps (pedometers), swallowing, jaw movements, biting and chewing sounds, ruminal pH, weight, heart rate, core temperature etc.

5. **Health monitoring**: Sensors and techniques for heath monitoring are well developed for dairy production under confined conditions. Behaviour and changes in behaviour can be used to detect health problems before disease affects animal productivity. Sensors have been able to detect 80% of health problems related to ketosis, locomotion and lameness at least one day sooner than the farm staff by analysis of short-term feeding. Use of the pedometer and advanced time series analysis to detect oestrus in dairy cows has been quite successful.

6. **Herd management software:** The ability to digitally store herd information is a valuable tool for all farms, and a necessity for those desiring to utilize RFID to aid in farm management. Herd management software provides mechanisms for farmers to store individual cow data into a database. Data can be entered into this software application manually or automatically through the use of other digital devices (such as milk meters, cow weight scales) linked to this database. Many capabilities of herd management software are virtually impossible to achieve utilizing traditional paper-based techniques. For example, utilizing such an application allows a farmer to easily view, analyze, manipulate and sort data with a few taps or keystrokes. Subsequently, farmers are able to easily and immediately view information on individual cattle, view an entire cow's history (calving date, artificial insemination dates, treatments etc.), produce reports on individual cows, selected cows or the herd as a whole etc. Additionally, the data, and results from any analysis/reports can then be viewed via a digital display or in hard copy documents. Such information storage and manipulation capabilities provide farmers with an extremely valuable resource to aid them in their farm management activities and decisions.

7. **Automated feed-dropping control units:** Feed bins that have the ability to automatically drop a designated amount of feed into the feed trough of each individual cow have been demonstrated to be highly effective in dairy farms. Combining the operation of their feed bins with the RFID tags of their cows and the herd management software is more effective. This subsequently enables automated feed calculation and delivery in the dairy. Automated feed units provide a variety of benefits to farms, including reduced labour, cost savings, removal of possibility for human error, and of course the ability to automatically calculate

and provide the required amount of feed for cows to sustain or increase their milk production.

8. **Feed troughs with measuring capability:** The capability to provide a specific amount of feed to each cow to meet their requirements is one of the most valuable capabilities for a dairy farm. Utilizing this approach will not only allow farmers to ensure that their cows are eating their required amount of feed, but will also aid to detect any cows that may be having a problem, such as illness. For example, if a cow is eating less than 70% of their allotted feed, there may be a need for the farmer to examine this cow and investigate possible reasons why this may be happening.

9. **Milk meters:** In a business where milk is the primary product, it is important to know how much milk each cow is producing, and likewise, to have a source of feedback to establish what factors enable your cows to produce the maximum amount of milk. Milk meters provide this valuable ability, measuring the amount of milk each cow provides at every milking session. To be useful, this information should be automatically recorded in the herd management database. Other pieces of information, such as the time at which the reading took place, the cow's number, and duration of milking can also be derived from milk meters, and should be stored in the database. These pieces of information serve as solid records of each cow's milking session, and may provide grounds to various analysis activities for the farmer.

10. **Milking machines:** The milking controller is an essential piece of equipment for all modern dairy operations. This is the device that controls the suction and suckling motion of the milking cups attached to the teats of each cow. Utilizing this system in combination with RFID technology can generate a cow's complete milking history and milking style. When combined with a flow meter, it is possible to record quarter-wise milk yield of each cow. Recent advances in the use of automatic milking systems totally obviate the need for human presence at the milking point.

11. **Automatic drafting gates:** The use of drafting gates has been demonstrated to provide large savings of both time and labour for the farmers in extracting individual cows from the main herd. These cows may be extracted for a wide variety of reasons, including the need for veterinary treatment, artificial insemination etc. The most useful location for these drafting gates is believed to be on the exit to the dairy, as this is where all lactating cows

must pass at least twice a day. Operating in conjunction with herd management software, these gates would be a valuable asset to almost any dairy farm.

12. **Digital device network:** A form of digital network is required to enable the communication of devices between one another, with RFID readers and the central herd management software. There are essentially three methods of establishing such a network – wired, wireless or hybrid. Each has its own advantages and disadvantages, and the eventual selection of the implementation type will depend upon the characteristics and preferences of individual dairy farms. A completely wired network involves connecting all devices with a network cable, with no ability to cater for wireless connections or wireless devices. This will enable an array of devices, whether fixed or portable, to be linked directly to real-time data in the herd management database. Such devices include the mainstream computer network devices such as laptops, desktop personal computers, printers and smartphones. These also provide the vital links to dairy farm devices, such as RFID readers, milking controller units, feed management units, drafting gates, and a vast array of other devices that could be configured to operate under computer control, or require access to herd information for operation. Alternatively to a completely wired or wireless network, a hybrid of the two can also be formed.

Conclusions

Livestock production is in a period of rapid adjustment and development, both regionally and globally. There are intense pressures and concurrent opportunities associated with the need to produce safe and environmentally friendly livestock products. This has created the need and opportunity to use Information Technologies at the national level in many countries. Simultaneously, advances in electronic communications and GPS technologies fuelled by consumers of information has driven major declines in the prices and improvements in performance, opening a window of opportunity to create cost-effective systems for large scale precision livestock production. ICT based information delivery can also help the livestock farmers to make significantly better quality decisions on various livestock practices.

2. ADVANCED FEEDING TECHNOLOGIES TO OPTIMIZE MILK PRODUCTION IN DAIRY ANIMALS

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Dairy farming plays a vital role in livelihood of rural farmers. In particular safeguards food security and regular income generating through selling of surplus milk. The animals raised at rural area were usually characterized by low milk productivity as the farmers adopted low input low yield production system. In this system they feed grasses and crop residues as roughage source and cheap grains which is available locally to support production. Feeding animal with available feed resources to minimize cost of the production would be the prime priority to increase profit to the livestock farmers. Livestock productivity is influenced by the genetics and the environment. In order to exploit the genetic potentials of the animal, good nutrition and management are necessary so that the animals feel comfortable with minimum stress. Optimizing rumen fermentation is the key to maximize production and good health. Several feeding technologies can improve productivity in dairy animals but still failed to adopt several feeding technologies by livestock farmers. Hence, in this chapter it is intended to discuss on feed technologies and phase feeding in cattle to optimize milk production. Some of the technology recommendations to improve dry matter intake and productivity as follows:

Silage making technologies

Silage is a type of fodder made from green foliage crops which have been preserved by fermentation under anaerobic condition to the point of acidification. Hay making is practically impossible during wet and cold environment. Silage making provide opportunity to store surplus green fodder produced even during wet season, which can be utilized during scarcity of green fodder. The cereal crops like maize and sorghum preferred for silage making. It can be done using plastic drums, earth pits, and nylon bags as silo. Addition of locally soluble fermentable carbohydrates and protein such as maize bran (5-10%) or molasses (3-5%) and legume leaves to the material to be ensiled is recommended for quality silage production. this technology adopted by few commercial farms but not adopted by small livestock farmers

The reasons for low adaptability of this technology might be due to

- High labour demand in silage preparation
- Absence of forage choppers and unsuitable storage facility
- Improper storage and damage by rodents are common

Hay making technologies

Hay making is the process of turning green perishable forage into a dry product under sunlight while keeping nutrient loss to a minimum and moisture content preferably less than 15 percent that can be safely stored and easily transported. This technology helpful to store excess produced green fodder into dry form and can be used during scarcity of green fodder as animals prefer to consume hay better than dry fodder and hay feeding reduce the amount of concentrate feeding. The time of hay making should be done after rainy season. The crops with thin stems and more leaves are better suited for hay making as they dry faster than crop with thick stems. Suitable crops for hay making are oats, Desmodium, Lucerne, Maize, Sorghum, Napier grass, Rhodes grass, Cowpea.

The reasons for low adaptability of this technology might be due to

- Unaware about the hay making
- Usually farmers are not exposed to the advantages of the technology
- Improper hay making results in mould growth which may be extremely toxic to animals
- Inability to afford sophisticated and expensive machines such as tractor powered hay balers
- High labour demand and limited storage facility

Urea ammoniation of poor quality crop residues

In our country most of the ruminants fed on crop residue based roughage source, crop residues have inherently low acceptability, palatability and digestibility due to high fibre content (>18%). Thus, processing of fibrous crop residues for better animal performance is essential. 4% urea and 40% water can be used for urea ammoniation of crop residues. Urea treatment improves the nutritive value of cereal straws by increasing crude protein content, palatability and digestibility. Straws and stovers are rich in lignin, which holds cellulose and therefore cellulose unavailable for microbial digestion. Urea ammoniation shall dissolve the ligno-cellulose bond and hence cellulose will be free to utilize by rumen microbes. This technology is considered as a proven technology to improve the nutritive value of roughages. Urea treatment of straw increases its nutritive value by raising the protein content from 4 to 8 per cent. Feeding urea treated straw may reduce the cattle feed requirement up to 30 per cent.

The reasons for low adaptability of this technology might be due to

- Unorganised and sporadic extension efforts to promote this technology.
- Usually farmers are not exposed to the advantages of the technology as they do not get to see other farmers practising urea treatment successfully.
- Farmers do not feel comfortable feeding urea to the animals as it is considered toxic by many farmers
- The availability of straws is limited in most places which also limits the use of this technology.

Total mixed ration/complete diets

Grinding (hammer mill using 8mm sieve) and blending (horizontal mixer) roughage and concentrate at certain proportion are called TMR or complete diets. The purpose of feeding a TMR diet is that each cow can consume the required level of nutrients in each bite. The cows ration should include good quality roughages, a balance of grains with protein, vitamins and minerals. These improve feed efficiency, resulting in more suitable an ideal environment for the rumen microbes and provide adequate nitrogen and carbohydrate source that vary in their ability and rate of rumen breakdown. 4% increase in feed utilization and 5% increase in milk production can be expected by feeding TMR compared to a conventional ration of forage and grains fed separately. In general the mixing time should not be more than 5 minutes in the horizontal mixer for uniform distribution of concentrates/grains in TMR after adding additives. Poor quality unpalatable roughage sources can also be used as sole roughage source by using this TMR technology. To improve palatability preheated (70^0C) molasses can be used upto 10% in complete diets and care should be taken to add sodium bicarbonate 1-2 % of concentrate in preparation of TMR to prevent acidosis since less chewing activity in TMR fed animals might result in less saliva secretion which require for buffering the rumen contents.

Most of the crop residues (straws and stovers) available in our country can be incorporated upto 50% in complete diets, whereas the tree fodders can be incorporated upto 20%. For maintenance ration the good quality crop residues can be incorporate from 50-70% whereas, for lactating animals the proportion is 30-50%. The recommended Roughage: concentrate ratio for dairy animals is 60:40 to 40:60 based on growth/lactating stage of the animals.

The reasons for low adaptability of this technology might be due to

- High labour demand
- Mixing and blending require small to moderate expenditures for equipment and maintenance
- Over mixing may result in less effective feed utilization by the cows
- It is not economical for small scale livestock holders

Urea molasses mineral blocks

It is made up of urea, molasses, mineral mixture and brans or other ingredients in a suitable proportion. It is a source of energy, nitrogen and minerals for dairy animals. Feeding of urea molasses mineral blocks improve feed intake, digestibility and production. NDDB has developed "cold process" of manufacturing UMMB licks and this technology is being provided to dairy cooperative and other private organizations. UMMB are useful for milk producers in green fodder deficit areas.

Precautions while feeding UMMB

- Should not be given to monogastric animals and ruminants younger than 6 months
- should not be fed alone, minimum quantity of roughage intake require before UMMB licking to avoid urea poisoning
- UMMB moisture content should not be more than 10% and stored at dry place

Bypass protein/fat

The dietary protein contains both RDP and UDP. RDP is the portion of protein degraded in rumen whereas the UDP is the portion of protein bypass rumen fermentation and degraded upon action of enzymes at duodenum. If suitable treatment is given to dietary protein, degradation in the rumen can be minimized to 25-30%. This process of protecting protein known as bypass protein technology. True protein can be bypassed rumen fermentation. Therefore the quality protein will utilized efficiently at lower gut. Bypass protein feed is recommended for the lactating animals yielding more than 10 litre milk per day.

Similarly, fat is good source of energy and feeding fat as such affect rumen fermentation, therefore, fats are protected from rumen fermentation. Generally high milk yielders suffer from energy deficiency in early lactation and utilize body reserves to meet the demand. This leads to delayed conception and such animals produce less milk during this period. Thus decrease lactation yield. Hence, at this stage feeding bypass fat minimize energy deficit. It can be supplemented in the ration of dairy animals@15-20g/kg milk production or 100-150 g per animal per day.

Hydrophonic fodder

Hydrophonic fodder is the green feed grown from seeds without soil, and with little water. A week after the seeds have sprouted the nutritious seedlings will be upto 30 cms tall. It can be produced every day of the year. It is observed that 1kg of maize seed can produce 5 kg of fodder. Loss of 15-20% dry matter during sprouting is inevitable when compared to grains.

Hydrophonic fodder can be used as a supplementary feed**.** We don't have recommended hydrophonic fodder for large and small ruminants as these fodders have high water content. This fodder is against our aim of promoting higher dry matter intake to achieve better body condition, better reproduction and productivity. Feeding maize grain along with dry fodder is better and economical than feeding germinated seeds with dry fodder. Several works were going on to replace concentrate feed with hydrophonic fodder showing positive results. However, it is considered to be new feed resource and need more research work to have feeding recommendations.

Phase feeding in cattle during lactating cycle

Lactating cow requires lot of water; therefore always provide clean and fresh water. Good quality *Adlibitum* roughage should be supplemented (both green and dry fodder) to optimize dry matter intake and recommended to increase frequency of feeding to enhance dry matter intake. Required quantity of balanced concentrates should be supplemented at least three to four times a day for efficient utilization of nutrients. Continually provide mineral blocks or mineral licks to prevent mineral deficiency and to maximize milk production and introduce new feeds gradually to prevent digestion disturbances. A simple index to judge the nutritional status of animals is to look at the Body Condition Score (BCS). Recommended BCS for drying off 3.5, for calving 3.75-4.0, one month postpartum 2.5-3.5 and for mid lactation 2.75-3.75. The lactation length in dairy cattle is 305 days, followed by a dry period of about 60 days. Nutritional requirements vary with the stage of lactation. For feeding practices in dairy cattle define 5 distinct phases during this 365-day period as follows:

- ***Phase 1. Early lactation (0 to 70 DIM)*** (peak milk production)

During Phase 1 milk production increases rapidly and reaches peak milk production at around 6 to 8 weeks after calving. The feed intake does not meet the energy requirements of cow. Therefore, cow uses its body reserves to meet the requirements. Hence, the cow loses its body weight gradually. The total nutrient consumed and also the body reserves both used for milk production. The protein level of concentrated diet should be around 17.5 -19.5% of DM,

whereas, the forage ration level should be maintained more than 45 per cent. In this phase, increasing dry matter intake is most important. Therefore feed top quality palatable forage such as Maize fodder, Guinea grass, hedge Lucerne, Alfalfa hay etc., and allow constant access to feed. Increasing balanced concentrate gradually 0.5 kg per day from day 10 to day 20. It is advised not to give more than 60% of dry matter as concentrate, because it will reduce rumen pH due to alteration in volatile fatty acid production in the rumen leads to acidosis. Rumen bypass fat from 100-150g /cow/day to diets can be fed to meet energy requirement. Always provide mineral lick blocks to prevent mineral deficiencies.

- ***Phase 2. Mid lactation (70-200 DIM)*** (peak DM feed intake)

If the cow is not inseminated yet, it should be done in the beginning of this period. Preferably before 85 days in milk (DIM), but certainly before 140 DIM. Good feeding management in this period will results in successful inseminations prolonged high milk production and increasing body weight. At this phase milk production has passed its peak and starts to decrease gradually whereas the feed intake reaches its peak and there will be increase in body weight gain. The nutrients consumed used for both milk production and body weight gain. The protein level of concentrated diet should be around 15-17% of DM, whereas, the forage ration level should be maintained more than 50 per cent. In this phase, increasing feed intake, hence provide adequate high quality forages and concentrates several times a day and supplement mineral blocks and continue to minimize stress conditions.

- ***Phase 3. Late lactation (200 to 305 DIM)*** (restoration phase)

This phase will be the easiest to manage. It is important to make sure the cows are in good condition to be dried off. At this phase milk production is declining (8-10% drop per month), nutrients consumed used for both body condition and milk production. Cow is pregnant and nutrient intake will easily meet or exceed requirements. Therefore the increase in body weight notice at this period, to avoid making the cows too fat. The Crude protein levels should be maintained between 14 - 15% of DM and increase the forage ration level to more than 55 per cent. At this phase aim is to having the cows in good condition for the dry period. Therefore, maximize forage intake, feeding high quality forages or total mixed rations increases voluntary feed intake. Feeding high concentrates at this phase will not increase milk production but will increase the cost and make cows too fat. The animal should be maintained in stress free conditions.

- ***Phase 4. Dry period—60 to 14 days before parturition***

The dry period is a critical phase of the lactation cycle. A good dry cow program can increase milk yield during the following lactation and minimize metabolic problems. At this phase there is no milk production, the body weight gain increasing, whereas markable reduction in feed intake noticed. The nutrients consumed used for both foetus growth and body condition. Therefore 12 per cent crude protein on Dry matter basis maintained at this phase. Whereas forage ration level in the total ration should be more than 60 per cent. The supplementation of calcium and phosphorus should be 60-80 and 30-40 g/day respectively.

The main aim at this phase is to adjust feeding to have a correct body condition score for calving. Therefore separate from lactating cows, observe body condition of dry cows and adjust energy feeding as necessary. Care should be taken that cow don't become too fat. The forage levels in the ration should be atleast 60 per cent. In this phase low quality forages such as maize or sorghum stover, ragi or paddy straw can be fed. Provide correct amounts of Ca and P but avoid excess calcium and phosphorus intakes to dry cows. This will increase problems of milk fever. Provide adequate amounts of vitamin A, D, and E in rations to improve calf survival and lower retained placenta and milk fever problems. Limit salt to 28g per day and limit other sodium-based minerals in the dry cow ration to reduce udder edema problems. Introduce transition ration starting 2 weeks before calving. Never supplement mineral lick block in this period.

- ***Phase 5. Transition period—14 days before calving***

The transition or close-up dry cow feeding program is critical to adjusting dry cows and springing heifers to the lactation ration and preventing metabolic problems. At this phase there is no milk production but body weight increasing whereas feed intake decreases. The crude protein level should be around 14.5 to 15% of DM and forage ration level should be more than 55 per cent. The calcium and phosphorus levels should be 60-80g/day and 30-40 g/day respectively. The main aim at this phase is to prepare the rumen for the lactating period. Therefore continue with same forages as in previous dry cow stage and increase concentrate gradually to 2.5 to 3 kg to adapt rumen bacteria. Remove salt from ration if edema is a problem. If niacin (to control ketosis) and/or anionic salts (to help prevent milk fever) are going to be used, they should be included in the ration during this period.

Dietary Cation - Anion difference (DCAD)

Higher or positive DCAD tend to cause milk fever, whereas, Low or negative DCAD tends to prevent milk fever in dairy cattle, as acidic diets promote calcium mobilization from bone since bone along with kidney acts as a buffer against excessive systemic acidity. To calculate DCAD in milli-equivalents in a diet, the following formula is used:

{(%Sodium/0.023)+(%potassium/0.039)}-{(%chloride/0.0355)+(%sulphur/0.016)}=
mEq/100g dry matter

or

{(Sodium x 435)+(Potassium x 256)}- {(Chloride x 282) + (Sulphur x 624)} = mEq/kg DM

The recommended DCAD level for dry cow in late gestation ranges from -100 to -150 mEq per kg dry matter. Adding anionic salts like magnesium chloride, magnesium sulphate, calcium chloride, calcium sulphate, ammonium chloride, ammonium sulphate etc., to the diet lowers DCAD and reduces incidence of milk fever. Addition of anionic salts can reduce palatability of feed. Therefore start with magnesium sulphate as it is most palatable; hence add until total magnesium is 0.4% of dry matter. Next, add calcium sulphate and /or ammonium sulphate until sulphur is 0.4 to 0.5% of dry matter. Lastly add calcium chloride and/or ammonium chloride until DCAD is -5 to -15 m Eq per 100g dry matter or 50 to 150 m Eq per kg dry matter. Low sodium, potassium and more chloride in the diet is a key to achieve negative DCAD. Urine pH ranging from 6 to 6.5 is a good indicator of anionic status in blood. Recommended composition of anionic mineral supplement for late gestation is: 40.7% calcium chloride, 33.3% magnesium sulphate, 19.3% Sodium chloride and 6.7% di-calcium phosphate.

To conclude the key factors to optimize rumen fermentation and milk production

Optimizing rumen fermentation is the fundamental principle in feeding ruminants. If the rumen fermentation is optimized, the production performance and production economics are optimized. In order to keep the rumen optimally functional, the most important things are as follows:

- Maintain rumen pH in the range of 6 to 6.5
- Continuous input of substrates for the microbes
- Removal of end products of microbial metabolism.

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3. ADVANCES IN DAIRY HEALTHCARE DIAGNOSIS ANDDIAGNOSTICS

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When we talk of dairy animals in India, it includes some of the most important domesticated species that contributes economically to agriculture and includes cattle, sheep, goat, buffalo and yak. All these animals are ruminants having the common factor of chewing their cud and all have pregastric fermentation that occurs in the rumen and all these animals are herbivores. Study and practice of ruminant medicine is called as BUIATRICS. The ruminant practitioner is referred to as a BUIATRICIAN. In this paper I will concentrate on diseases of dairy cattle and buffalo as this is the major group in the dairy sector.

India, as per the 20th livestock census, has total bovine population of 302.79 million as of in 2019, which has increased by 1 per cent from that of previous census i.e., 2012. The population of the total exotic or crossbred cattle has increased by 26.9% in 2019 as compared to previous census. This dairy sector which constitutes a major part of the livestock with special reference to bovine population, is crippled by various diseases/disorders, namely ruminant disorders, metabolic diseases, systemic diseases and the infectious diseases.

The disease pattern in ruminants is very different as compared to other species and also oral medication is quite complex as the fermentation and digestion process of the foregut interfere with oral medication. The ruminant system is more efficient in extracting dietary energy because of selective retention and all of the microbial products must pass through gastric digestion. Compared to non – ruminant herbivores, ruminant herbivores can exist on smaller intakes of food through digestive extraction. The rumen probably evolved as part, is a detoxification system for secondary compounds and thus allows the animal to access wider range of plant products.

The advantages of the anatomic (four chambered stomach) and physiologic adaptation (pregastric fermentation) to some extent are offset by making the ruminants susceptible to diseases unique to this group. These diseases include specifically ruminant disorders and metabolic diseases.

Ruminant disorders:

1. Inactivity of ruminal flora
2. Enlargement of rumen
3. Acidosis/Lactic acidosis
4. Traumatic Reticulitis/TRP
5. Ruminaltympany/Bloat complex
6. Alkalosis
7. Abomasal displacement
8. Vagal indigestion

Metabolic disorders:

1. Milk fever
2. Ketosis
3. Downer cow syndrome
4. Grass Tetany
5. Acidosis

Ruminants and Health:

Consequent to the control f epidemic diseases, endemic diseases have emerged as the main health problem. These diseases conditions include mastitis, metritis, foot infections, pneumonia, enteritis and non-infectious metabolic conditions. Infectious endemic diseases are caused by agents normally found in the environment and host population. For eg: Environmental mastitis and shipping fever. Host environment pathogen interactions influence disease incidence. The presence of the agent alone is not sufficient to cause disease. Disease occurs when multiple factors upset the balance in animal resistance and organism pathogenicity. Environmental factors contribute to upset this balance. Factors that influence endemic disease include seasonal conditions, nutrition, ventilation, hygiene, pathogen buildup, milking practices and general husbandry practices. Subclinical forms of endemic and metabolic conditions may not be apparent, but they reduce production reproduction. Eg: subclinical mastitis, subclinical ketosis, subclinical hypocalcemia etc. Total eradication of endemic disease conditions is unlikely because control is complicated by host, management and environment interactions. Health programs have to expand and consider farm health, environment health, food safety and animal welfare in order to reduce the diseases and increase production.

Production/Metabolic Diseases:

Though these two conditions are little different, many a times these words are used synonyms. Metabolic conditions constitute a significant proportion of endemic health problems in ruminants, especially in dairy cattle. These conditions are associated with parturition. Risk factors that contribute to metabolic conditions include body condition, nutrition in both the non-lactating and lactating periods, and age of the cow and stage of lactation.

The modern dairy cow is a marvel of nutrient metabolism and metabolic efficiency. Due to combination of genetic selection, advances in nutrition and improved management practices, these cows have the potential to produce large quantities of milk (upto 90 kg of milk per day). Metabolic diseases or disorders result from an imbalance between dietary supply of specific nutrients (INPUT) and the high demand of the nutrients for productive purposes (OUTPUT). Production may proceed using body stores (THROUGHPUT), however an imbalance occurs when there is an inability of tissues to adapt to the increased requirement in conjunction with either a decreased or limited intake. Increased production has been linked to the increased susceptibility of dairy cattle to milk fever and mastitis.

Infectious diseases:

It is important to diagnose the infectious diseases for identifying the causative agent or the disease, to aid in treatment, to undertake prevention and control strategies and predict the prognosis of the disease. The most common infectious diseases are parasitic both internal and external, bacterial, viral, rickettsial and protozoan (hemoprotozoan and enteric) in nature.

Various methods for diagnosis of systemic and specific diseases in Dairy animals are

1. History
2. Clinical examination: Recording of temperature, heart rate, respiration and pulse and use of techniques like palpation, percussion, tactile percussion/ballotment, auscultation, combined percussion and auscultation, per-rectal examination and by special examination method like William's method of auscultation and palpation.
3. Blood tests: Haematology, Smear examination and blood biochemistry
4. Fecal examination: For parasitic ova, worms, larvae, Protozoa and protozoan cysts
5. Urine analysis:
6. Rumen fluid examination: routine as well as for detection of poisoning

7. Body fluid examination: abdominal fluid, pleural fluid, transtracheal fluid, bronchoalveolar lavage, joint fluid etc.,
8. Milk tests: Somatic cell count, electrical conductivity tests, culture and molecular diagnostic tests.
9. Imaging techniques: Radiography, Ultrasonography, Endoscopy etc.
10. ECG
11. Metal detection tests
12. Skin tests: Skin scrapings examination, culture, cytology, allergy tests etc.
13. Lymph node biopsy, fine needle aspirate examination and tissue biopsy
14. Conjunctival cytology
15. Otoscopic and Ophthalmoscopic examination

Diagnosis of infectious diseases can be made by employing diagnostics that should be Accessible, Accurate and Affordable. Plethora of modern molecular diagnostics are available commercially for diagnosis of bacterial, viral, mycotic and parasitic diseases affecting the dairy animals apart from the routine tests employed. Some of the commonly employed molecular diagnostic tests are: ELISA (Indirest, Sandwich, Competitive and Avidin biotin), PCR (Broad range PCR, Multiplex PCR, Nested/semi nested PCR, RT-PCR, Real time PCR), Blotting (Southern, Northern and Western) etc. Most of them are for diagnosis of diseases like Foot and Mouth, Infectious Bovine rhinotracheitis, Bovine Viral Diarrhea, Rabies, Bovine leukosis, Bovine Respiratory Syncytial Virus, Lumpy Skin Disease, bovine coronavirus, rotaviral infection, Brucellosis, Leptospirosis, Tuberculosis, Paratuberculosis, Mycoplasmosis, Campylobacter infections, Chlamydophila infections, Leptospirosis, Salmonellosis, Q fever, Anaplasmosis, Cryptosporidiosis and Babesiosis. These diagnostics include rapid antigen /antibody detecting Lateral Flow Assay (LFA), Plate or strip based Enzyme Linked Immunosorbent Assay (ELISA), Polymerase Chain Reaction (either conventional or RealTime), Immunofluoresence tests, Agglutination tests, immune diffusion or Intra dermal tests using variety of clinical samples such as Blood, Serum, Plasma, milk, Swabs of clinical materials. The details will be discussed.

Health care/Dairy Health Care

Traditionally health care programs are based on the veterinarian providing services to diagnose and treat diseases in individual animals or animals in a farm, recommend vaccination and anthelmintic programs, perform basic surgeries, test for reportable diseases and perform rectal examination for pregnancy and examination of breeding animals.

Modern concepts in dairy health have expanded .and perhaps the single biggest advance in dairy health in the last 25 years has been the paradigm shift from treatment of clinical illness to disease prevention. A fundamental advancement has been recognition of the multifactorial nature of almost all diseases of importance in dairy cattle. Health management or production medicine is characterized by an integrated, holistic, proactive, databased 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 is no longer considered as the sole domain of veterinarians. Conversely, to deliver health management and effective disease prevention veterinarians must integrate consideration of nutrition, housing and whole farm management systems into recommendations of best practices. Thus veterinarians are therefore evolving from task-oriented providers of therapy to advice-oriented consultants. Another major advance in dairy health has been redefining disease more broadly, to include subclinical conditions (e.g., subclinical mastitis, ketosis, rumen acidosis, endometritis and milk fever).

Improvement of dairy health can be achieved by following certain of the basic practices and this includes:

1. Scheduled farm visits
2. Individual dairy cow health care and emergency services
3. Scheduled analytic and training activities in health management of dairy cows.
4. Quality control programme.
5. Nutritional management
6. Milking management
7. Sick animal disease diagnosis
8. Animal welfare
9. Record keeping

4. SCIENTIFIC BREEDING TECHNOLOGIES IN DAIRY FARMING - NEW AGE INNOVATIONS

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The increase in the overall performance of the dairy cattle through genetic improvement is well established and has been done all these years since the period of Robert Bakewell. However, human desire to further increase or sustain the production, inspite of changes in climate, environment, fodder and feed availability, emergence of newer diseases have made breeders to innovate and exploit new generation technologies as biotechnology and bioinformatics in the field of animal breeding. Most of the developing countries, inspite of having rich animal biodiversity and conducive environment for animal husbandry, are far behind in dairying compared to several developed countries. Here, a brief view of the new age technologies revolutionising the animal breeding as per the need of the day are being discussed.

The modern scientific animal breeding technique involves Animal identification, recording and analysis of various types of data i.e., phenotpic, genomic and epigenomic data for selection of breeding stock using bioinformatic tools and finally manipulation and dissemination of germ plasma using biotechnology tools.

1. Selection of the breed:

In dairy farming, selection of the breed is a very important. The selected animal should be a milch breed capable of performing optimally in the given environment and available resources inputs. Holstein Friesian is the most popular, milk breed in the world followed by Jersey. These two breeds are extensively used for Dairy farming in India as well. India is the world's largest producer of milk, producing 198.40 ×× 10^9 kg milk per annum, and increasing at 5.68% per annum. Some 49% of milk is produced by buffaloes and 49% by cattle, of which 57% come from crossbreds. In India, HF and Jersey constitutes 43.3 % and 54.9 % of exotic and crossbred population with an average yield of just 8.09 kg/day which is very low compared to breed standards. Major reasons for lower yield is imbalance of exotic inheritance of the animal and production environment; and culling being not practiced. Recent studies have indicate strong potential for genomic selection to improve milk production of smallholder

crossbred cows in India. Further, Gir is the world famous milch breed of Indian origin with an average lactation yield of 1600 kg. Brazil, have imported and genetically improved the breed for milk production, where the average lactation yield is 3500kg. The dairy breed improvement plans should involve short term strategy of importing genetically proven germplasm and long term goal of genetic improvement of dairy animals for our environment. The frozen semen and embryo technology have made exchange of superior genetic material across the countries easier compared to transit of live animals. In India, import or export of Bovine germplasm is as per 2018 guidelines of Department of AHDF, Government of India.

2. Animal identification

International Committee on Animal Recording (ICAR) is an International Non-Governmental Organisation (INGO) which strives to stimulate animal production across the globe that is more sustainable and efficient. It provides network for cooperating, sharing and enabling among members and stake holders in developing and implementation of global standards in animal production. The aim of ICAR is to promote the development and improvement of the activities of identification, performance recording and the genetic evaluation of farm livestock. ICAR prescribes global standards for animal identification systems and approves certifies them for use.

National Dairy Development Board (NDDB) in India is the member of ICAR and is the nodal agency approved by Government of India for providing Unique Animal Identification numbers to all the cattle population of the country. Unique I.D. is a 12 digit number, first 11 digits are running serial numbers and 12th as check digit. This can be used for any form of tagging system viz. Plastic, barcoded, RFID etc. Government of India have made it mandatory for cattle to have ear tagged with Unique I.D for implementing its schemes. The tags recommended and supplied by government of India is yellow colour plastic tags with Unique I.D number and Barcode.

Radio frequency identification (RFID) of animals is becoming popular system of animal identification especially in the dairy farms with complete electronic system of data recording. International Organisation for Standards (ISO) have authorised the International Committee for Animal Recording (ICAR), for registering and providing certification to the manufacturer of RFID system of animals in accordance with ISO 117842 and ISO 11785. Most widely used RFID tag is with Alien H3 chip as it provides read range of up to 8-10 mt which is much required for a full proof RFID Animal Tracking Solution. In India, only few Private

farms who wish to implement completely electronic system of data recording are using RFID tagging system with Unique I.D.number provided by NDDB.

3. Computerised Animal Data Recording:

In majority of the Dairy developed countries, the dairy herds are large in size. In UK the average herd size is 148, where computerised animal data recording is followed. In India, an average herd size is less than 2 and performance recording is almost not done. In view of this, NDDB in collaboration with INFOSYS an Indian software company have developed Information Network for Animal Productivity and Health (INAPH), an application database for dairy cattle data recording in India. INAPH also covers the CMU recognized semen stations with registered bulls by the application called INSPRM. INAPH helps to record activities of Animal Breeding, Progeny Testing, Nutrition and Health programs in the field and also helps to evaluate & estimate Breeding Values of bulls & bull mothers on the basis of their daughters' performance thru field based progeny testing program. INAPH application can run on different devices we can deployment them on desktop, PDA, windows Mobile, Note book. Popularising INAPH mobile application usage among dairy farmers of India, is the need of the hour for Indian Dairy Industry.

4. Existing and new traits for dairy cattle breeding

The profitability of dairy not just depends on milk production traits, several other traits as milk quality, udder health, hoof score, etc. needs to be considered which is seldom done during animal selection in developing countries. Further, the consumers in the near future are likely to demand more diverse breeding goals which include traits such as animal welfare, animal disease, product quality and environmental footprint.

a. Milk data recording standards

ICAR Guidelines section 2 elaborates an updated guidelines for Dairy cattle milk recording accepted globally. ICAR also gives updated information about milk production traits which are very important for managing and breeding dairy herds. The milk recording process starts with the collection of animal identification, a calving date of milking cows, the amount of milk given and the date with time or time frame of a day. A milk sample may be taken. The obtained milk sample is analysed for milk constituents. The results of the analysis plus the data about milk yield and time of milking are stored in a database. Subsequently a number of parameters, cumulative yields and indices are calculated and stored in the database. Estimation of lactation yields based on test day records is one such contribution of ICAR.

b. International standards for Conformation and Bovine Functional traits

Body conformation and condition score, Bovine functional traits as Dairy Cattle Health traits, female fertility traits, Udder health traits, Claw health and Lameness scores are the traits that needs to be emphasised during the selection of breeding stock. ICAR in section 5 and section 7 of its Guidelines is regularly updating the list of such traits, methods of recording and decision support system for evaluation of the animals for such traits. This list of traits should be scored by all organisations in the same way to improve further harmonisation on international level.

c. Behaviour, welfare and other traits under evaluation

Milking temperament, oestrous behaviour, mid-infrared spectroscopy of milk, reproductive tract ultrasound, video image analysis, transcriptomics (i.e., expression profile for genes at a given time period), experimental – extensive phenotyping (e.g., immunological challenge) of a smaller number of animals divergent for a characteristic under investigation are being studied for their inclusion in Animal data recording system. Using technology certain data can be automatically captured, and translated to useful information for herd management and animal breeding. The MIR spectrum can also be used for other performance traits such as energy balance and methane emissions. Milk electro-conductivity to asses udder health, Progesterone profiling for detection of ovulation and pregnancy, Pedometers used to assess oestrus and possible health. In grazing animals, algorithms based on information generated by pedometers can be used to predict duration of grazing and therefore feed intake. Many other possible technological advances exist such as monitoring of rumen conditions by using sensor and communication technology in rumen boluses or monitoring of congregation of cows though the use of GPS technology.

The collation of all data sources into a useable format that can be relayed back to the user via a decision support tool, will require a concerted, multi-disciplinary, and multi-national effort.

5. Phenotypic and genomic selection

Earlier, selection of breeding stock was based on their own performance records, which were influenced by local environmental conditions and herd-specific management practices. Daughter– dam comparisons were used for more than 30 yr which resulted in better genetic progress compared to earlier methods. Contemporary (herdmate) comparison methods allowed more accurate accounting for environmental factors and genetic progress began to accelerate

the genetic progress, later the information of pedigree along with progeny testing program was the proven method for selection of breeding stock especially breeding bulls. Advances in computing and robust statistical methods facilitated the implementation of mixed linear models, Maximum likelihood and Best Linear Unbiased Prediction methods that used pedigree and performance data optimally and enabled accurate selection decisions.

Bovine whole genome sequencing technology have revolutionised dairy cattle breeding and genetic progress accelerated rapidly. Pedigree-based models have given way to whole-genome prediction and combined models with robust data analysis methods G-BLUP and SNP-BLUP, and Bayesian regression models (BayesA and BayesR) and machine learning algorithms. Future developments will likely include elucidation of the mechanisms of genetic inheritance and epigenetic modification in key biological pathways, and genomic data will be used with data from on-farm sensors to facilitate precision management on modern dairy farms.

Genomic Selection

Marker-Assisted Selection: Molecular genetics technologies for assessing variation at the genome level, such as RFLP or microsatellite markers, allowed geneticists to pursue underlying functional mutations or QTL with large effects. From 1980s to 2000s, various methodologies were developed for marker-assisted selection. Information about QTL that were identified by various methods was incorporated into linear models for selection. However, the expected genetic progress over and above the conventional method was not achieved. The effects of significant markers were often overestimated and many QTL with small effects were missed due to stringent significance thresholds.

Whole-Genome Selection: Development of Next generation sequencing methods and inexpensive high-throughput genotyping platforms for SNP markers revolutionized dairy cattle breeding. Dozens of methods and algorithms were developed for whole genome selection in dairy cattle. The statistical analysis of large data of SNP effects and their association with phenotypes was initial hurdle in Genomic selection. However, advancement in bioinformatics, increased computational power of computers and development of suitable robust statistical techniques eased the process.

BLUP Mixed linear models have been used to estimate SNP effects that can be summed over to obtain genomic EBV of new selection candidates and is termed as SNP-BLUP. Equivalently, a genomic relationship matrix (G) can be constructed from SNP genotypes, and

this replaces the pedigree based relationship matrix (A) in BLUP when computing genomic EBV. GBLUP is appealing due to its familiarity and ease of implementation among animal breeders who have been using BLUP for decades. The rapid growth in genotyped animals is due to the availability of inexpensive, low-density SNP panels, which typically feature 5,000 to 25,000 SNP dispersed evenly across the genome. These low-density genotypes can be matched with medium-density (50,000 to 100,000 SNP) or high-density (500,000 to 800,000 SNP) genotypes of ancestors, and missing SNP on the low-density panel are filled in with 95 to 99 % accuracy using genotype imputation algorithms. Single-Step GBLUP solved the perplexing challenge of analysing phenotypes from genotyped and non-genotyped animals simultaneously when computing genomic predictions.

Bayesian Regression Models:

Another set of models for genomic prediction was developed using Bayesian regression. Ordinary least squares regression cannot accommodate a situation in which the number of explanatory variables (SNP) exceeds the number of data points but in Bayesian regression models, the SNP effects are treated as random samples from an underlying distribution. Bayesian regression methods tend to outperform GBLUP if QTL with moderate or large effects exist, whereas GBLUP performs very well in situations where inheritance approaches the infinitesimal model.

Machine Learning Methods:

Machine learning a branch of artificial intelligence, is utilised in animals science for prediction of breeding value of unobserved individuals by applying highly flexible algorithms to the known outcomes of observed individuals. In animal breeding older animals with known genotypes and phenotypes constitutes the reference population or training set based on which the validation of population or testing set of selection candidates with known genotypes will be done. Countless machine learning algorithms exist, and no single method provides universally superior predictions—the optimal method and its parameters vary from one application to the next. Machine learning, such as deep learning algorithms and multi-layer artificial neural networks, has great potential for enhancing genomic selection and dairy herd management. Several powerful algorithms are available both commercially as well as open source in public domain. The flexibility of machine learning algorithms is very much needed when dealing with massive quantities of genomic and phenotypic data, for predicting the breeding values of selection candidates.

Genomic selection of Bovines in India

National Dairy Development Board, during 2014 initiated implement Genomic selection for the Cattle and Buffaloes in India with the objective to establish suitable methodologies for selection of animals on the basis of more reliable Genomic Breeding Values (GBV) under small holder dairy system of the country. Efficiency of the genomic selection depends on the reference population from the region and population in which genomic selection is done. NDDB, utilised repository of milk records and DNA of animals of various Cattle and Buffalo breeds which was covered under various progeny testing and pedigree selection schemes were utilised to create huge reference population to facilitate implementation of genomic selection. NDDB developed a customized SNP chip named as "INDUSCHIP" for genotyping the indicine breeds of cattle and their crosses which is replaced by 53K SNP - INDUSCHIP2. The Genomic breeding values of HF crossbred and Gir cattle using INDUSCHIP was estimated and published in 2018 and 2019, respectively. Subsequently, in 2020, a medium density (59K) custom genotyping chip named as BUFFCHIP was designed with technical assistance from USDA and initiated genotyping in Buffaloes. At present Genomic selected bulls for crossbreds, Gir and Murrah breeds are now supplied to semen stations for faster genetic progress in various cattle and buffalo breeds.

INTERBULL- is a permanent subcommittee of the ICAR with the objective to international genetic evaluation of bulls of member nations. It gives the details of the protocols and standards to be followed in genetic evaluation of bulls. INTERBULL Publishes the Genomic breeding values for various traits and ranks them across the world. It helps several countries to import best germ plasm and involve in genetic improvement of their dairy cattle. India is not the member of INTERBULL.

Germplasm manipulation and dissemination

For effective exploitation of the germplasm of genetically selected bulls needs to be manipulated and disseminated in the population. Artificial Insemination using frozen semen is one such technology which have revolutionised the genetic progress of dairy animals by efficient use of bulls. As it is mostly more of female calves which are required in dairy industry and culling of male calves is costly as well as animal welfare issue, the sexed semen technology is becoming increasingly popular. Further, several advanced techniques as Ovum pick up, Multiple ovulation, Invitro fertilization, embryo transfer are being used for propagation of elite female germ plasm.

Sexed Semen

Sexed semen contains an enriched proportion of either X or Y chromosome-bearing sperm cells. However, it is usually X chromosome enriched for Dairy cattle as more females are desired to be produced. The bovine X chromosome contains approximately 3.8% more total DNA content than the Y-chromosome thus differentially stained and sorted using flow cytometry. There are two commercially patented process of sex sorting of semen. SexedULTRA 4M is the sexed semen produced using a USDA-developed, patented and licensed to Sexing Technologies. The "4M" refers to 4 million sperm cells per unit. Sexcel is another sexing technology produced by ABS Global (Genus plc) using their proprietary IntelliGen technology. This sexing process also involves staining of sperm cells and differentiation of X and Y chromosome-bearing sperm based on DNA content, however, a laser ablation process is used to selectively destroy sperm cells carrying the undesired chromosome.

Due to the sexing procedure and subsequent cryopreservation, sexed semen can result in reduced pregnancy rates compared with conventional semen. Sexed sperm cells appear to have a shorter fertile lifespan after insemination. Therefore, in order to achieve optimal pregnancy rates with sexed semen, a female that expresses standing heat should receive AI approximately 18 to 24 hours after the start of that female's standing heat behaviour. Brahma Genetics Facility is the first and only bovine semen sexing lab in India. ABS India, in 2017, deployed Genus IntelliGenTM technology at Brahma, near Pune in Maharashtra and is producing and providing sexed semen for Holstein, Jersey, Sahiwal, Gir, Red Sindhi, Crossbreeds and Murrah and Mehsana buffaloes for the first time in India under the brand SEXCELTM.

5. CLIMATE RESILIENT STRATEGIES FOR SMART DAIRYING

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Introduction

Though the climate change is a global phenomenon, its intense negative impacts are felt mostly in developing countries. Adding to this phenomenon, animal agriculture is amongst the most climate-sensitive economic sectors in India. Across the globe, the dairy farming is providing employment, sustainable income and social security to a large population. The adverse impact of climatic extremes and seasonal fluctuations on herbage quality and quantity are the crucial factors which influence the well-being of livestock in extensive production systems and thereby result in impairing reproduction and production efficiency of grazing animals. The extreme heat throughout summer months negatively impacts grazing animals and ends up in nutritional imbalances. Consequently inadequate and low quality feed causes under-production in animals in arid and semi-arid tropical regions. Further, under-nutrition in livestock can occur in late spring and summer due to increased energy output for thermoregulation and concurrent reduction in energy intake. This section is an attempt to assemble information on different strategies to improve dairy production under the changing climate scenario.

Impact of Climate change on livestock production

In no doubt, the climate change has influenced dairy and livestock industries including all aspects of livestock production, reproduction, animal health, input costs, product prices and natural resources management.

The climatic factors such as ambient temperature, relative humidity, solar radiation and wind speed directly influences dairy cattle. The direct effect of climate change on cattle is thermal stress while the indirect effect being the low pasture availability and water scarcity and the increased incidence of pest and diseases. The reproductive performances of dairy cattle are severely affected due to heat stress and nutritional stress. Heat stress due to increased ambient temperature and decline in fodder and pasture availability due to increased temperature and decreased rainfall pose unfavourable effect on reproduction in dairy cattle.

The direct effect of heat stress includes reduced dry matter intake, increased water intake, increased sweating and panting to maintain core body temperature, decreased milk production, increased mortality and morbidity, increased rectal temperature and respiratory rate.

The indirect effects of climate change has the potential to impact the quantity and reliability of forage production, quality of forage, water demand for cultivation of forage crops as well as large-scale rangeland vegetation patterns, of which the primary productivity of forage crops and rangelands shows most visible effects. The grasslands are effects with elevated atmospheric carbon dioxide, higher temperatures, changes in precipitation regime and increasing concentrations of ground level ozone. These changes adversely affect productivity, species composition and quality, with potential impacts not only on forage production but also on other ecological roles of grasslands. In conclusion, climate change impacts livestock production by affecting feed crops production, grasslands and grazing systems.

Significance of climate resilience in animal husbandry

The mitigation of climate change requires effective global action with major structural change in the agriculture, forestry and other land use sectors. The rising carbon price has tainted the cost of land management practices and commodities depending on their emissions profiles. The domestic food production in many developing countries is at immediate risk of reductions in agricultural productivity due to crop failure, livestock loss, severe weather events and new patterns of pests and diseases (FAO 2006). Likewise, farmers in developing countries are equipped with lesser options to adapt to and effectively manage these risks due to their higher proportion of small-scale and subsistence farms, poorly developed infrastructure and lesser access to capital and technology. Adding to these impacts, the rapid increases in population and food demand in developing countries further leads to increase in global food prices. So, at this crucial juncture of climate change and need of sustainable farming, the dairy / livestock farming including agriculture sector has to resort to the smart climate resilient strategies.

Sustainable strategies to improve livestock production under changing climate scenario

The adaptive strategies for managing the climate change directly or indirectly involve technology. The capacity of local communities to adapt and mitigate climate change depends on their socio-economic, available resources and environmental conditions. Though livestock producers have traditionally adapted to various environmental and climatic changes based on their in-depth knowledge of the environment, the expanding human population, urbanization, environmental degradation and increased consumption of animal source foods have rendered

most of those coping mechanisms ineffective. Adding to this, rapid and fast changes brought about by global warming exceed the capacity of spontaneous adaptation of both human communities and animal species. The various adaptation strategies in place to counter changing climate scenario are given in Table 1

Table 1: Sustainable Interventions for dairying under climate change scenario

Sl.No.	Sector of Dairy adaptation	Adaptation strategies
1.	Dairy animal breeding	i) Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources ii) Improving local genetics through cross-breeding with heat and disease-tolerant breeds
2	Dairy animal management	i) Provision of shade and water to reduce heat stress from increased temperature ii) Reduction of livestock numbers in some cases iii) Changes in livestock/herd composition iv) Improved management of water resources v) Pasture and Grazing management vi) Feeding strategies
3.	GHG emissions	i) Mitigation strategies
4	Diseases	ii) Monitoring and Surveillance of disease outbreaks
5.	Annual rainfall pattern	i) Crop production adjustments
6.	Livestock Markets	i) Promotion of interregional trade and credit schemes
7	Capacity building for livestock owners	i) Understanding and awareness of climate change ii) Training in agro-ecological technologies and practices iii) Extension services
8	Institutional policies	i) Removing or introducing subsidies, insurances ii) Income diversification practices iii) Livestock early warning systems

Universal smart options for sustainable dairying

- Development and promotion of drought-tolerant and early-maturing crop species
- Good shelter, pasture, feeding and management practices
- Adaption of annual production cycle matching with feed production
- Farming improved animal breeds and grass/legume seed stock with increased resilience to projected climate conditions
- In-situ Integrated Disease Surveillance Response systems and emergency preparedness to tackle, prevent, mitigate and respond to epidemic outbreaks.

- Strengthening of local meteorological services to provide timely weather and climate forecast/information early-warning systems.
- Encouragement and strengthening aquaculture, poultry etc as alternative livelihoods
- Use of cost effective herbal and alternative medicine
- Intensifying agriculture extension activities for wide dissemination of knowledge about climate resilient options

Technological interventions in dairy animal breeding

- Selections for heat tolerance based on temperature-humidity index (THI) in genetic evaluation models. Inclusion of molecular markers and marker assisted selection in breeding programs for developing appropriate breed to specific agro-ecological zone.
- *In situ* and *ex situ* conservation of genetic resources with better characterization of dairy breeds, production and associated knowledge.

Shelter management for dairy animals

1. Comfort Animal shelter design: Physical modification of the shelter to decrease heat gain by radiation interception.
2. Proper ventilation: Remove heat, moisture, and odours created by livestock, and replenish the oxygen supply by bringing in drier, cooler outside air. Adequate air exchange also removes gases such as ammonia (NH4), hydrogen sulphide (H2S), and methane (CH4) which can be harmful to both animal and operator health.
3. Using shades: For tropical climate condition loose housing system is considered most appropriate. The longer side of the animal shelter should have an east-west orientation. This reduces the amount of direct sunlight shining on side walls or entering the house. In addition to this roof can be extended with shading material, and the vertical shading moved to the outside of the roof. Such devices give much better protection from the direct solar radiation and sun. The west side of the shed can also be protected similarly and fitted with side covers and gunny bags or curtains. The height of the shed structure should be greater then 2.4 meters tall to allow sufficient air movement under shade. However, tall structures (more than 305meters high) are not economically viable.
4. Increasing air flow: To increase air flow two main approaches may be used. One is to install large fans so that air movement is increased and the second is to open the side of the shed. The netting can be raised to increase air flow during the summer and lowered

during the winter. Increasing the roof venting is yet another option that may be used for animal sheds. Double wall approach is an effective and proven technology in structural design for increasing or reducing temperature.

5. Using Sprinklers: High pressure irrigation-type sprinklers can improve inexpensive wetting of animals, especially when coupled with fans, to increase air movement.. Altering the microclimate of the sprinkled area helps in improving the wellbeing of feedlot cattle under extreme environment condition by reducing body temperature.
6. Forced ventilation using fans: The role of fans is to increase heat loss by convection. Fans can reduce the body temperature by 0.3 to 0.4 º C, provided that the temperature of the provided air is lower than the surface temperature of the animal.
7. Simple Management Tools includes wetting the body by wet gunny bags, bathing the animal frequently, growing trees around, green grass in the paddocks, hanging wet gunny bags against the direction of wind, iincreasing the number of feedings, placement of feed and water so that they are always in the shade, artificial lighting increase consumption at night and avoiding the handling of cows during the hottest part of the day, micro-climate management

Pasture management

The climate change seriously hampers the pasture availability especially during the period of frequent draught in summer. Both the quantity and quality of the available pastures are affected during extreme environmental conditions. Further, with changing climate, animals have to walk a long distances in search of pastures. Emphasis on more drought resistant crops in drought-prone areas could help in reducing vulnerability to climate change. Climate change adversely affects crop production through long-term alterations in rainfall resulting in changes in cropping pattern and calendar of operations. The advantages of mixing crops with varying attributes are in terms of maturity period (e.g. maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes) and end users of the product. A specific and viable system has to be put in place for developing feed and fodder banks at strategic places. Production of forage on-site and without the use of energy-intensive inputs.

Grazing management

- Livestock stocking rate in allay with the grazing capacity of the pastures.

- Strategic and rotational grazing system.
- Supplementing feed in addition to fodder grazing.
- Grazing in association with daily activities
- Mixed livestock farming systems: A lower number of more productive animals lead to more efficient production and lower greenhouse gas emissions from livestock production.
- Plantation of fodder trees in grazing area – integrated farming provides feed as well as shade duing summer.
- Formulation of proper range policy and establishment of competent authority for management of range lands

Dietary Management: The following are the common nutritional tips for dairy animals during heat stress-

- Feed total mixed rations
- Increase the number of feedings
- Feed during cooler times of the day
- Keep feed fresh.
- Use high-quality forage
- Mineral balance with sodium and potassium
- Avoid secondary fermentation in feed bunk.
- Improve forage quality
- Palatable feeds
- High nutrient density
- Antioxidant Supplementation
- Adequate fiber feeding promote chewing and rumination to maintain ruminal pH
- Feeding Fats and Concentrates- rumen protected fats
- Seasonal Specific Feeding - ensiling and feed blocks (FB) methods, local non-conventional feeds according to their availability.
- Body condition scoring as a simple tool to optimize livestock production
- Water balance and water requirements - increase both the accessibility and the amount of cool water, Cleaning out water troughs daily and keeping the water and the feed in a cooled area will help to increase H2O consumption.

Mitigation strategies to reduce GHGs from dairy sector

1. The enteric methane emission reduction strategies are grouped under managemental, nutritional and other molecular strategies.
2. Reduce enteric methane through nutritional interventions- propionate enhancers, oil supplementation, Ionophore supplementation etc.
3. Reducing enteric methane emission using plant secondary metabolites
4. Managing crop rotations that sequester carbon, conserve water and maintain soil fertility.
5. Improving feed resources that reduce greenhouse gas emissions.
6. Sustainable management of grazing in combination with fallowing and/ or rehabilitation of degraded lands
7. Development of vaccines for methane reduction in ruminant livestock
8. Pastured livestock efficiently close the loop between harvesting forage and returning nutrients to the soil with less energy. Distributing manure and urine on the pasture also reduces methane emissions from manure slurry.
9. Proper soil and pasture management mitigate the release of emissions. Rotating animals through pastures and moving feeding, watering and shade areas, spread the manure and urine out more uniformly and help decrease N_2O emissions from pasture soils

Strategies to minimize disease occurrences

The prevention, monitoring and control of livestock diseases require good data exchange mechanism at both state and national level including distribution of animal diseases, ecological conditions including climate, and associated drugs and chemo-therapeutants. The epidemiological surveillance serves as critical component with early identification of emerging diseases and trends for resource planning and measuring the impact of control strategies. A global approach to epidemiological surveillance involving collaboration between professionals involved in human, animal and environmental health is needed. The geographic information system (GIS) is of much helpful in this aspect. Furthermore, laboratory and field research will also help in illuminating how climate changes influence pathogen characteristics, and models will help researchers and producers predict and plan for pathogen threats. The strategies involves –

- Public awareness and health education programs
- Appraisal of public health and socioeconomic impacts of zoonosis
- Strengthening of surveillance and disease investigation capacities
- Networking of epidemiological and laboratory units under public health and animal health sectors
- Prevention and control of livestock diseases under national programs
- Harmonization of appropriate cross-border disease surveillance
- Vaccinations (e.g., FMD vaccines) as a control measure in endemic areas
- Modification of veterinary and medical curricula with respect to epidemiology and public health aspects of zoonosis
- Involvement of medical and veterinary institutions NGOs, international professional associations and animal welfare organizations in zoonoses control activities.

Extension services to augment dairy / livestock production

1. Strengthening existing extension systems to counter the climate changes
2. Establishing appropriate links between different stakeholders for climate change research through participatory approach
3. Fostering community-based development plans to increase local capacity and co-manage natural resources.
4. Conducting livelihood analyses for the strategies to cope with unpredictable ecosystems and climate variability and change.
5. Establishing policy and institutional options to promote the uptake of technologies that enhance the capacity of communities to adapt to climate change
6. Enhance participatory research into the role of women in the livestock sector

Conclusions

Climate change and food security are faced by people all over the world. While livestock's role in contributing to food security is very well acknowledged, its negative impacts by way of contributing to GHG in the atmosphere raise criticism. Being the facts that the livestock production system including dairying is sensitive to climate change and at the same time itself a contributor to the phenomenon, climate change has the potential to be an increasingly formidable challenge to the development of the dairy sector in India. Responding to the challenge of climate change requires appropriate adaptation and mitigation options.

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6. REPRODUCTIVE BIOTECHNOLOGIES: ADAPTATION FOR REPRODUCTIVE EFFICIENCY IN DAIRY CATTLE

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Human population growth, increasing urbanization and rising incomes are fuelling a massive increase in demand for food of animal origin (milk, meat, eggs) in developing countries. Globally, livestock production is growing faster than any other sector, and by 2050 the livestock sector is predicted to become the most important agricultural sector in terms of added value.

Most food of animal origin consumed is currently supplied by small-scale, often mixed crop-livestock family farms or by pastoral livestock keepers. The on-going major expansion of the demand for livestock products for food is expected to have significant technological and structural impacts on the livestock sector. The productivity from livestock needs to be substantially increased in order to meet the increasing consumer demand and efficiently utilize scarce resources. The biotechnologies are necessary to enhance the animal production and health.

Biotechnology is not new. It has been applied since the time of domestication of animals and the beginning of animal husbandry around 12000 years ago. The technologies were invented or discovered to obtain traits dictated by social, nutritional and environmental needs with little understanding of the molecular processes involved. FAO back ground documents describe Biotechnology As “any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use”. Since the world war II a wide range of biotechnologies have been used in animal reproduction, genetics and breeding, animal nutrition and production and animal health. These technologies have produced large economic benefits induced primarily by adoption of artificial insemination.

Reproduction is the backbone of animal production and productivity is the key to development. Reproductive inefficiency is one of the most important causes of economic losses in animal industries and it is realized throughout the world. Infertility due to low conception rate and high embryonic mortality rate remains a major problem.

Reproductive biotechnologies are used to shorten generational intervals and to propagate genetic material among breeding animal populations. To achieve this goal, reproductive technologies have been developed in generations over the years, namely artificial insemination (AI), embryo transfer (ET), manipulation of fertilization *in vitro* (IVF), cloning and transgenesis. These, together with sperm sexing, embryo sexing, transcriptomics, embryo genomics, and stem cell technology have the potential to play a huge role in improving the livestock productivity. Some of the technologies like artificial insemination have a long history of successful use, others like embryo transfer, invitro fertilization, have been used with varied success, and many more like cloning, and transgenics are at different stages of development and commercialization.

Before adopting any reproductive biotechnologies in India some fundamental questions have to be asked

- To what extent are they being used?
- What are the reasons for their success or failure
- What emerging challenges can be addressed through their application?
- What options do we have to make a informed decision on the use of appropriate technologies to enhance foods security

Reproductive biotechnologies

AI and complimentary technology like estrous synchronization are reproductive management tools that have been available for over 50-years.Embryo transfer started in 1975 next to artificial insemination and estrous synchronization..

Artificial insemination (AI): AI has been the most widely applied biotechnology, particularly in combination with cryogenetics. AI has been used in cattle breeding to the extent of 80% in Europe and North America and 100 percent in Turkey, where as in India it is a meager 29.7 percent with the conception rate of 35 percent. Even with this coverage it has led to significant genetic improvement for productivity especially milk yield and dissemination of male germplasm. Complimentary technologies like estrus synchronization, monitoring of hormones and sexed semen have improved the efficiency of AI globally.

In India AI is usually used for cross breeding with imported germplasm or imported animals rather than for breeding males of local breeds, due to lack of animal identification and recording and evaluation programs. Although AI has been extensively use to transfer superior

germplasm, In India natural mating is still the common practice for breeding buffaloes and indigenous breeds. The potential of Artificial Insemination is not completely exploited in India, the reasons being difficulties in timely delivery of AI, absence of mechanism to ensure use of semen from certified semen stations, disregard for state breeding policy, absence of system for identification of animals and poor control over AI technicians and poor data collection and retrieval. .

With the policy of GOI in 1964 being increasing milk production, It brought in the cross breeding of Indigenous/nondescript cattle with European breeds as an option to increase milk production. . Visibly it can be seen that the AI has effectively enhanced the genetic potential of animals for high milk production and has direct positive effect on milk production placing India in the number one position in milk production. In 2000-01 the total number of AI performed in India was 19.77 million which increased to 75.6 million in 2017-18, currently in 2021it is 78 million. Despite the positive developments in AI, the coverage is yet to reach the desired level. Where there are some states with 60 percent coverage others have a meagre 10 percent with an average of 30 percent coverage for the entire country.

The constraints that India faces for the desired genetic improvement in cattle are many. Some of them being low coverage of AI, poor conception rate with AI, limited availability of bulls with high genetic merit and high fertility, quality and quantity of Frozen semen. The policy paper 96 on AI recommends the following strategies to harness the complete potential of AI for genetic improvement as follows Implementation of bovine breeding act, Regulation of AI delivery agencies, licensing of AI technicians, continuing education program for AI technicians, timely treatment of infertile/sub fertile animals and repeat breeders., use of semen from bulls of high genetic merit, induction of technology based semen analysis in semen stations, standard operating procedure for sexed semen usage.

Also for effective implementation AI should be complemented with improvements in animal nutrition and veterinary services. It should provide adequate economic incentives to farmers by giving them access to markets and making sure that they get the right price for their products. Equally important are meeting sound managerial and operational requirements which include: the presence of a flexible and independent management structure; the consistent availability of funds and trained staff; the presence of adequate expertise and the strong commitment of all stakeholders, including public awareness and education initiative

Sexed Semen

Depending on the species the X chromosome bearing sperm cell has 2-5 percent more DNA than the Y bearing sperm. This difference is exploited to separate the X and Y bearing sperms using flow cytometry.

The global veterinary artificial insemination market size was valued at USD 4.2 billion in 2021 and is estimated to expand at a compound annual growth rate (CAGR) of 6.5% from 2022 to 2030. Growing demand for improved animal efficiency and productivity, demand for animal protein, supportive initiatives by industry stakeholders, need for sustainable food production, and adoption of sexed semen in developing markets are some of the key drivers of this market. The' sexed semen technology had been develop for Red Sindhi, Gir, Jersey, Holstein, Sahiwal Crossbreeds, and Mehsana and Murrah buffaloes, under the 'Sexcel' brand in India.

In Asia Pacific, the market for veterinary artificial insemination is estimated to witness the fastest CAGR of over 7.0% during the forecast period. Large cattle inventory, a thriving dairy industry, supportive government initiatives, and growing awareness about the benefits of artificially inseminating livestock are propelling market growth. For instance, in August 2019 Department of Veterinary, Gynaecology, and Obstetrics of Madras Veterinary College started artificial insemination in cattle using sexed semen. In 2020, the government allowed Milk Producer Companies to establish multipurpose AI technicians in rural areas following necessary approval to boost AI coverage in the country. Many milk-producing companies in India have also initiated doorstep AI delivery to support market growth.

The sexed semen segment is expected to show the fastest growth in the market for veterinary artificial insemination over the forecast period. This is due to increasing adoption to promote the rate of herd expansion and supportive government policies. In June 2021, the Indian government subsidized the price of sexed semen straws. This partnership between the government and Genus ABS would help dairy farmers in the Indian state of Maharashtra by bringing down the price of sex-sorted semen from USD 17.50 to USD 1. The normal semen segment dominated the market for veterinary artificial insemination and accounted for the revenue share of 79.5% in 2021. 78.1% in 2021. The animal husbandry segment dominated the market for veterinary artificial insemination and accounted for the largest revenue share of around 78.1% in 2021. . The growth can be attributed to the majority of the semen collection and AI procedures being performed on-site in breeding farms. Moreover, increasing

government initiatives, technological advancements, and demand for milk and protein are further increasing the adoption of AI technology. For instance, in June 2020 Indian government approved around USD 2.06 billion for Animal Husbandry Infrastructure Development Fund (AHIDF). The revenue is attributed to the low price of normal semen as compared to sexed semen and high fertility rates. For instance, according to a study published by the Italian Journal of Animal Science in May 2017, the conception rate of sexed semen as a percentage of normal semen ranged from 71.8% to 78.5%, which was indicative that normal semen had a higher fertility rate than sexed semen.

Embryo Transfer Technology

ET in the mammalian species, enhanced by multiple ovulation and oestrus synchronization (MOET), allows acceleration of genetic progress through increased selection intensity of females, and freezing of embryos enables low cost transport of genetic material across continents, and also conservation of diploid genomes. MOET may also be used to produce crossbred replacement females whilst only maintaining a small number of the straightbreds. In 1998, worldwide 440,000 ETs have been recorded in cattle, 17,000 in sheep, 1,200 in goats, and 2,500 in horses. About 80 % of the bulls used in AI in the developed world are derived from ET. Despite the potential benefits of ET, its application is largely limited to developed countries. What are the required technical and/or policy elements that will enable developing countries to make use of these technologies on a greater scale ?

ET is also one of the basic technologies for the application of more advanced reproductive biotechnologies such as ovum pick-up (OPU) and in vitro maturation and fertilization (IVM/IVF), sexing of embryos, cloning, and of transgenics.

The lack of systems to identify superior animals together with weak technical capacity restricts the use of more advanced technologies like embryo transfer or MAS (marker assisted selection) in developing countries.

As per IETS report 2020 1518150 embryo were collected for cattle is 7 percent more than that of 2019. It also stated that more of invitro produced embryos were transferred in comparison to invivo derived embryos. Viewing the world moving towards IVP embryos GOI has launch the Accelerated Breed Improvement Program, through which it hopes to transfer the embryos to farmers. Under the initiative, a target of two lakh embryos has been set up for the next three years. The animal husbandry and fisheries department had sanctioned 31 laboratories to clone

cows in 2019, 17 of them are functional as of now. Around 10 of the labs are producing embryos through IVF technology and the rest are still using the earlier Multiple Ovulation and Embryo Transfer (MOET) technology. Right now, the average cost of IVF technology is Rs. 30,000 per calf, but with private players in the market and the government's added incentive, the average cost would be Rs 20,000."

Although The GOI has taken measures to promote ET in cattle , it is still largely confines to research stations. For the farmers to adopt this technology on their own without the institutional support is not profitable. The cost of preparing the donors, recipient, embryo recovery and transfer to get pregnancy is high.

Along with increasing the milk production conservation of indigenous breeds is also a priority of this nation using the potential of AI and ET for cryo-conservation purposes. . Due to changes induced by global warming it is reasonable that the need for indigenous genetic resources will increase.

Progesterone measurement

The estimation of hormones like progesterone using RIA provides information both on the problems in breeding management of farmers and the deficiencies in AI services provided by the government. RIA of progesterone has been the corner stone for the services provided for improving productivity of livestock and the capacity to use this technique at field level.

Oestrus synchronization

Oestrus synchronization was generally limited to either intensively managed farms that are under the supervision of the government or farmers who are linked to farmers association or cooperatives where AI is routinely used. Protocols used for oestrus synchronization includes use of hormones like progesterone, prostaglandin, GnRH and its analogues, oestrogen. These protocol help to alleviate the infertility and repeat breed problem and result in better conception rate with AI.

OPU and IVM/IVF:

OPU in mammals allows the repeated pick-up of immature ova directly from the ovary without any major impact on the donor female and the use of these ova in IVM/IVF programs. Making much greater use of genetically valuable females at a very early age may substantially increase genetic progress. What potential uses of these technologies are feasible in developing countries

? What are the required technical and/or policy elements that will enable developing countries to make practical use of these technologies?

Cloning:

IVM/IVF are a source of large numbers of low cost embryos required for biotechnologies such as cloning and transgenesis. Three different types of clones are distinguished, as a result of: (1) limited splitting of an embryo (clones are genetically identical); (2) introducing an embryonic cell into an enucleated Zona (clones may differ in their cytoplasmic inheritance); (3) introducing the nucleus of a somatic cell (milk, blood, dermal cells), after having reversed the DNA quiescence, into an enucleated Zona (clones may differ in their cytoplasmic inheritance and there is likely to already exist substantial knowledge of the phenotype of the parent providing the somatic cell). Cloning will be used to multiply transgenic founder animals. Cloning technologies offer potential as research tools and in areas of very high potential return. The sampling of somatic tissue may assist collection and transfer of breed samples from remote areas

The extent of success and failure of a biotechnology, its transfer, its adaptation is affected by the following factors (FAO, 2017)

- Lack of clear livestock development policy conducive to the introduction of new proven technology
- Lack of necessary technology adaptation to suit local/regional conditions
- Insufficient information flow from and to decision makers
- Accessibility of technologies as determined by price, intellectual property rights, the presence or absence of support or backstopping after their introduction;
- Insufficient understanding of the decision process of the livestock owner/producer with regard to investment in animal production and health;
- Weak expression of technology demand
- Public acceptance or rejection of biotechnology and ethical questions.

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7. INNOVATIONS IN VALUE ADDITION OF MILK AND MILK PRODUCTS

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Introduction

'Value addition' is changing or transforming a product from its original state to a more valuable state. Creating Value is a different strategy that involves developing products in one or the other way. The product difference may be real or perceived.

India being "The Livestock Giant" possess the largest livestock population (535.82 million) in the world, with the highest cattle (192.52 million), buffalo (109.85 million), and bovine population (302 million) which in turn make the country highest milk producer of the world (BAHS, 2019). India is the world's largest producer and consumer of milk and dairy products. The market for dairy products in India has grown rapidly over the last few decades and anticipated to be growing at a faster rate when compared to the global dairy products market. The global dairy product market is expected to witness significant growth over the forecast period (Knips, 2005). Growing world population base, rise in per capita income, and increase in consumer awareness level regarding nutritional values of dairy products and, change in consumer dietary patterns are the key drivers regulating the market growth. In addition, technological advancements and innovations for obtaining more milk from dairy animals are also estimated to boost market growth. Demand for milk and milk products such as cheese and butter is increasing daily with increase in world population. High-end technology is required to meet these needs by increasing the milk processing capacity and maintaining the quality of the product. The dairy industry is highly localized owing to perishable nature of milk products. The market is segmented on the basis of type of product. It includes milk, butter, cheese, ice cream and yoghurt. Among these products, milk, cheese and lactose are estimated to hold major share of the market owing to their rising demand and increased usage rates in all levels of population. Rising consumption levels of foods such as ice creams and milk shakes are also anticipated to drive market growth over the forecast period (Granato*et al*., 2018). Over

the next five years, changing lifestyles of urban population and rising demand for healthy and convenient dairy products is anticipated to play an instrumental role in the growth of India dairy products market.

Milk Processing In India

India is currently self-sufficient and the largest producer of milk in the world, a status it has maintained since the late nineties. This has been largely achieved through a combination of favourable policies and an institutional network that has helped support millions of rural households in pursuing their livelihoods through small scale dairy farming. About one-fifth of the milk produced is collected and processed by the organized dairy sector (Bhatt, 2019). Cooperatives now link more than twelve million small scale dairy producers to urban markets and provide them a stable source of income. The dairy industry in India is going through major changes with the liberalization policies of the Government and the restructuring of the economy. This has brought greater participation of the private sector. This is also consistent with global trends, which could hopefully lead to greater integration of Indian dairying with the world market for milk and milk products (Warrier&Aparna, 2021). India today is the world's largest and fastest growing market for milk and milk products with an annual growth rate of about 4.5 per cent. India is witnessing winds of change because of improved milk availability, a change-over to market economy, globalization, and the entry of the private sector in the dairy industry. Value addition and variety in the availability of milk products is on everybody's agenda. There is an increasing demand for new products and processes. The main reasons are an increase in disposable incomes; changes in consumer concerns and perceptions on nutritional quality and safety; arrival of foreign brands; increasing popularity of satellite/cable media; and availability of new technologies and functional ingredients. From conventional milk products like paneer and cheese, the market has evolved over time and now caters to the wellness market as well with its sugar free and probiotic milk products (Kumar*et al*., 2019).

Value Addition of Milk

Milk being a perfect vehicle and a source of various valued macronutrients like fat, protein, & milk sugar -lactose, vitamins and micronutrients; available in the form of minerals, and is considered a complete food, a balanced or a 'nutritious food' as it contains all the vital nutrients required by the body for its proper functioning but it lack certain essential components such as micronutrients (iron, copper etc.) and fiber and milk in itself has certain

limiting factors such as it is a cause of allergenicity for many, inability of lactose digestion for lactose intolerance population, presence of cholesterol and saturated fat content, etc (Yusuf Bekere, 2019). To combat the voids of the milk, with the help of advancements in expertise and tools available, numerous components obtained through milk are being used in combination with other non -milk components for preparing versatile range of food products with enhanced nutritional output in the form of 'value-added' products with better assimilability and superior functionality along with the benefits of wholesomeness. In this context, milk in its desiccated form is an epitome where the nutritional profile is at par along with the desired sensory appeal. Desiccation where at one point removes unwanted moisture from the milk, also roots to the concentration of valuable nutrients of the milk. Herein it is worth to mention that the lacking components of the milk can be excellently compensated if different sources can be included at this point. This particular brainstorm idea gave birth to a newer dominating category of Indian dairy products – i.e. Composite dairy foods. Such combinations always create nutritionally far superior category which otherwise single ingredient cannot serve at all. For population with milk allergenicity or lactose intolerance problems, various other additives can be added to the milk so that a complete food in real sense can be prepared out of it, and therefore supplementation and complementation of various micronutrients derived and obtained from adding various cereals, millets, fruits, vegetables and legumes is now in practice (Kaur *et al*., 2021).

Traditional Milk Products

Indian dairy products or Indian Indigenous milk products can be defined as all milk products which are native of India and which were evolved over ages utilizing locally available fuels and cooking ware, whereas the Codex standards (1999) define composite dairy product is a food product from milk and/or its constituents, milk products, with or without addition of milk processing by-products and non-dairy components (expect non-dairy fats) included in as individual ingredients, added for purposes other than substitution of milk constituents (Kumar and Staal, 2010). The classification of traditional milk products is depicted in Figure 1.

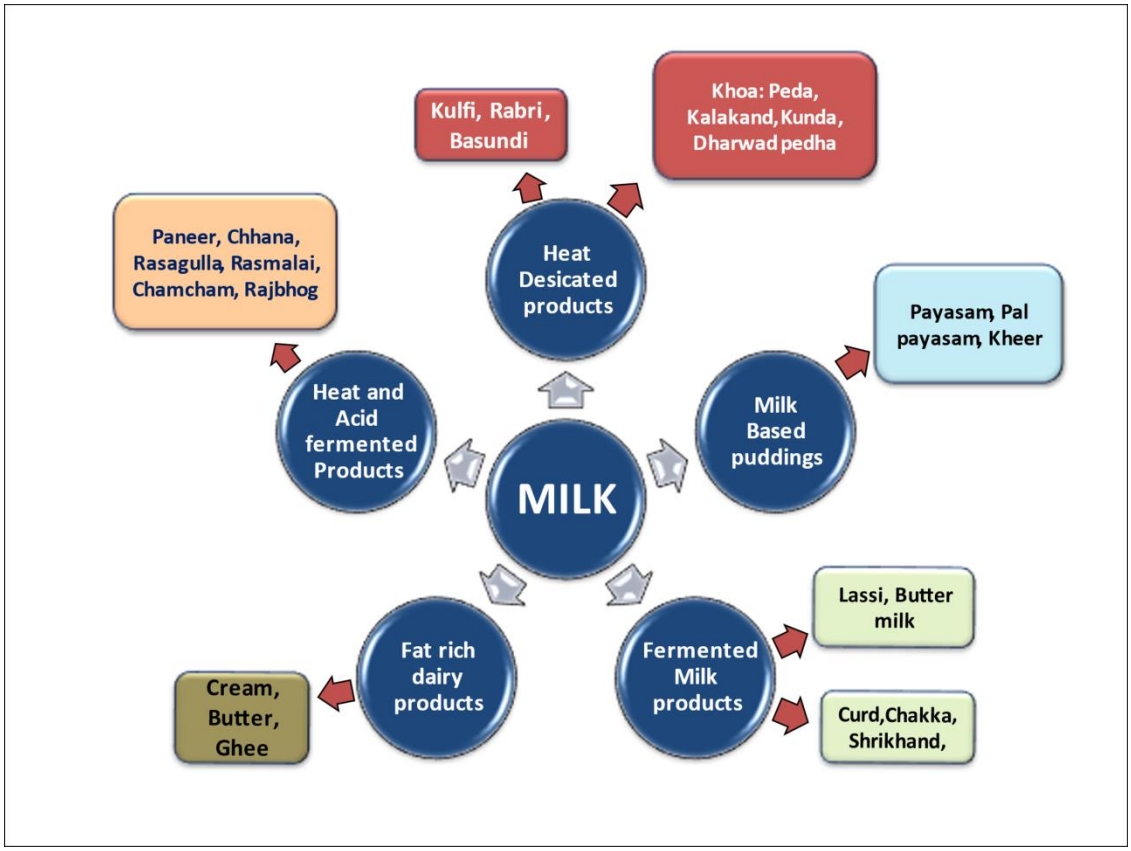
Reasons for value addition

Fast pace life*:* Lives are getting faster and busier; peoples are more opting for readymade dairy foods which can be easily purchased from supermarket. Peoples are not having much time for common activities of making homemade butter or ghee or even setting of curd and Lassi.

***Healthier Lifestyle**:* People are becoming more and more health-conscious and opting for healthier diet options. Value added dairy products being a healthier diet option led to an increase in demand for value added products as compared to the raw product i.e., liquid milk. Products like Probiotic drinks which resolve digestive issues and improves intestinal health is a quite popular drink nowadays, which make a lot of impact on the overall growth of the value-added functional food industry.

***Growing financial trends**:* Due to rise in buyer's disposable income, tendency to buy more priced value-added products than liquid milk has been increased in recent times. People are developing a habit of eating out more often in cafe and restaurant's which use more of value added products like paneer, cheese etc.

Figure 1: Classification of Traditional milk products of India



Need of Value Addition In India

Increased urbanization has given a boost to demand for health products. Moreover, with rise in disposable income and educational level, the awareness for nutrition and health improves which in turn raises the demand for health and nutritional products (Tariq*et al.*, 2008). Market studies indicate that consumers are looking for healthier alternatives. Keeping this in mind, companies have introduced a range of functional products. After introducing India's first

sports and energy drink Stamina, Pro-biotic Icecreams, Pro-biotic Lassi and Curd, and High Calcium Milk, Amul has also introduced Reduced Salt Butter in order to give the consumers a wide choice of health products. Another example is Nestle which introduced Nesvita Pro-Heart Milk with Omega 3 that helps manage Cholesterol. Presently India produces 125 million tonnes milk per year. India's milk production today accounts for more than 15 percent of the total world output and 40 percent of Asia's total production. It continues to grow at about 4 percent per annum far exceeding the global average of 1.2 percent in recent years. Out of the total milk production, 77 percent is sold as liquid milk, with the balance of 23 percent converted into products (Bhandari and Ravishankar, 2020).

Value Addition of Milk And Milk Products

Milk & Milk Products are an integral part of human food consumption around the World. Since ages, human beings have relied on milk as their primary source of wholesome nutrition. However, with higher cost of milk production, many people at the lower or middle income around the World are still unable to embrace it as a part of their daily diet. With increasing milk production at one hand and increasing incomes and thereby affordability of consumers at other hand, a gradual shift from basic food products like coarse grains to value-added food like milk & milk products is evident.In case of India, it has always been hailed as a land of milk right from the times of Indus Valley Civilization and milk consumption has remained high (Kennedy*et al*., 2018). Further, Indians have evolved their platter with a wide variety of milk products right from Paneer, Ghee, Lassi, Buttermilk to delicacies like Shrikhand, Phirni, Kheer, Paisam, etc.

In countries where domestic prices for dairy products are supported well above world market prices, as a consequence, the domestic market has to be protected against foreign competition in order to ensure the market outlet for domestic farmers who would otherwise have difficulties to sell their overpriced products. The major policies countries put in place to limit imports are tariffs and tariff rate quotas (TRQs) and other non-tariff barriers. Globally dairy products are among the agricultural commodities with the highest tariff protection with an average protection level of over 80 percent. The most important measure promoting exports are export subsidies. Under the WTO Agreement on Agriculture, countries that used export subsidies on agricultural products were required to set commitment levels on the volume and value of export subsidies that could be provided. As far as India is concerned, demand for food is growing faster as funds flow in our economy and increase in our GDP. On one hand, Government is under pressure to remove or reduce food subsidy forcing food prices

up on other hand it is also passing bill on right for food (Shah, 2021). Reading all these together you would appreciate that food demand is likely to grow faster than local production and may result in imports. Compulsion to keep inflation under check will also compel government to reduce import duties to zero as has happened in recent past, in case of milk powder, sugar, edible oil, onion, etc. This pushes domestic producer prices down and may further slow-down production and increase demand-supply gap. As the demand grows and local production lags behind, international business will expand and provide markets to developed countries' agriculture and that too at better prices.

Importance of milk components w.r.t. commercial value addition

Compounds	**Properties**	**Uses**
α-lactoglobulin	Nutrition, carrier of retinol and its fatty acid	Infant formula, Humanized milk
ß-lactoglobulin	Gelling, solubility and nutrition	Restructured meat and fish
Immunoglobulins and bovine serum albumin	Anticancer, Enhanced immunity	Cancer prevention and treatment, diet for person who are HIV Positive, have AIDS
Lactoferrin	Antibacterial	Infant Formula, health foods
Lactoperoxidase	Anticaries, important component of LP system, antimicrobial	Tooth paste, Tumor therapy, Cosmetics
Whole protein coprecipitate	Balanced amino acid profile	Nutritional beverage
Whey protein isolates	Functional performance	Egg substitute in bakery industry, Fat replacer in ice cream and frozen dessert
Protease-peptones	Immunomodulatory	Prebiotic foods
Immunoglobulin	Provide passive immunity	Cancer prevention
Casein (acid)	Functional properties	Glue, paints, leather, rubber, textile, plastic industries
Casein (rennet)	Stretch properties	Analogue cheese preparation
When protein concentrate (WPC)	Special performance, solubility, gelling, emulsifying, foaming agent	Value added products, health beverages and egg substitute in bakery products

When protein hydrolysates	Nutritionally rich, reduce allergenicity, solubility over a wide range of pH	Infant health foods, geriatric foods, Athletic drinks
Lactulose	Bifidobacteria enhancement, laxative, oxygen uptake, ammonia reduction in blood	Infant formula, laxative, diet for athletes
Lactitol	Bifidobacteria enhancement, noncaloric sweetener	Infant formula, chewing gum
Lactobionic acid	Bifidobacteria enhancement and other health related uses	Various food applications
Oligosaccharides	Bifidobacteria enhancement	Infant formula, baby foods, yoghurt, fermented dairy products
Mixture of salts recovered from when UF permeate	Flavor, nutrition, low sodium content	Table salt substitute, health drink

(Parekh *et al*., 2014 and Rajesh Singh, 2020)

Methods of Value Addition

- Enrichment with milk fractions
- Use of probiotics
- Enriching milk products with plant products
- Addition of additives to milk products
- Modification in processing conditions
- Utilization of recombinant dairy enzymes
- Intelligent packaging for value addition of milk products
- Improvement in sensory quality
- Value added functional milk product (Sanyal, *et al*., 2020)

The focus is being given to value-added products such as cheese, paneer, yogurt, probiotic drinks, etc. They are also introducing innovative products keeping in mind the specific requirements of the Indian consumers.

Probiotics

Probiotic are gut friendly microorganism/yeast preparation intended to provide health benefits to the person by improving the indigenous microflora in GI tract. Probiotics mainly contains Lactobacillus and *Bifidobacterium*. Group bacteria and may contains yeasts such as *Saccharomyces boulardii*, predominantly contain lactobacilli group because of their tendency to grow rapidly and tolerate acidic environment. Probiotics have variety of health benefits in the body including, various gastrointestinal conditions like antibiotic assisted diarrhoea, constipation, irritable bowel syndrome (IBS), inflammatory bowel diseases, and diverticular disease. It prevents colic, and necrotizing enterocolitis, and sepsis in infants. Probiotics bacteria by colony formation on the intestinal wall and production of H_2O_2 andbacteriocins, prevent colonization of pathogenic bacteria, i.e. put ecologic barrier to the pathogenic bacterial proliferation (Dinesh and Rajender, 2022)

Dairy Probiotic Foods

Dairy functional foods beyond its basic nutritional value have physiological benefits. In fermentation process, acids such as lactic acid, acetic acid and citric acid are naturally produced. These acids enhance organoleptic qualities as well as safety of food products. Lactic acid bacteria are found to be more tolerant to acidity and organic acids than most of the pathogens and spoilage microorganisms. Some fermented dairy products with detailed consideration are discussed as follows.

Probiotic ice cream

Probiotic ice cream is produced by incorporation of probiotic bacteria in both of fermented and unfermented mix. *Lactobacillus* and *Bifidobacterium* are the most common species of lactic acid bacteria used as probiotics for fermented dairy products. The pH of non-fermented ice cream is near to seven which is providing to survive probiotic bacteria. The high total solids level in ice-cream including the fat and milk solids provides protection for the probiotic bacteria. Because the efficiency of added probiotic bacteria depends on dose level, type of dairy foods, presence of air and low temperature, their viability must be maintained throughout the product's shelf-life and they must survive the gut environment. The therapeutic value of live probiotic bacteria is more than unviable cells; therefore, International Dairy Federation (IDF) recommends that a minimum of 10^7 probiotic bacterial cells should be alive at consumption time per gram per mililiter of product. Studies indicate, the bacteria may not survive in high enough numbers when incorporated into frozen dairy products unless a suitable

method is used against freeze injury and oxygen toxicity. The physical protection of probiotics by microencapsulation is a new method for increasing the survival of probiotics. *Lactobacillus casei*(Lc01) and *Bifidobacterium lactis* (Bb12) have the highest resistance to simulated acidic, alkaline and ice cream conditions in comparison with other probiotic strains, making them suitable probiotic strains for use in probiotic ice cream.

Probiotic cheese

There are two ways for development of probiotic cheese: in the first step, the manufacture processes of cheese products have to be modified and adapted to the requirements of probiotics and in second step, appropriate probiotic strains to be applied or new cheese products have to be developed. The proteolytic and lipolytic properties of the probiotic bacterial cells have important effects on taste and flavour of the probiotic cheese. Antagonism between bacteria is often based on the production of metabolites that inhibit or inactivate more or less specifically other related starter organisms or even unrelated bacteria. Cheese provides a valuable vehicle for probiotic delivery, due to creation of a buffer against the high acidic environment in the gastrointestinal tract, and thus creates a more favourable environment for probiotic survival throughout the gastric transit, ought to higher pH. The presence of the prebiotics inulin and oligofructose can promote growth rates of *bifidobacteria* and lactobacilli, besides increased lactate and short chain fatty acids production in petit-suisse cheese.

Probiotic yoghurt

The conventional yoghurt starter bacteria, *L. bulgaricus*and *Streptococcus thermophilus*, do not have ability to survive passage through intestinal tract and consequently so, they are notconsidered as probiotics. But the addition of *L. acidophilus* and *B. bifidum*into yoghurt can add extra nutritional and physiological values. Heat treated homogenized milk with an increased protein content (3.6–3.8%) is inoculated with the conventional starter culture at 45°C or 37°C and incubated for 3.5 and 9 h, respectively. The probiotic culture is added prior to fermentation simultaneously with the conventional yoghurt cultures or after fermentation to cooled (4°C) product before packaging. The survival of probiotic bacteria in fermented dairy products depends on the chemical composition of the fermentation medium (e.g. carbohydrate source), final acidity, milk solids content, availability of nutrients, growth promoters and inhibitors, strains used, interaction between species present, culture conditions, concentration of sugars (osmoticpressure), dissolved oxygen (especially for *Bifidobacterium spp*.), level of inoculation, incubation temperature, fermentation time and storage temperature.

The ‘over acidification’ is prevented to a limited extent by applying ‘good manufacturing practice’ and by using cultures with reduced ‘over acidification’ behaviour. The inhibition of bifido-bacteria in probiotic yoghurt is due to antagonism effects among starter bacteria rather than hydrogen peroxide or organic acids. The ideal procedure for probiotic yoghurt manufacturing is growing the *Bifidobacterium* spp. Separately, followed by washing out of free metabolites and the transfer of the cells to the probiotic yoghurt. Oxygen toxicity is a critical problem for *Bifidobacterium* spp. because they are strictly anaerobic. Low initial oxygen content in milk provides the low redox potential required in the early phase of incubation to guarantee Bifidobacteria growth. Oxygen easily dissolves in milk during yoghurt production and also permeates through packages during storage. It has been suggested to inoculate *S. thermophilus*and *Bifidobacterium* simultaneously during fermentation to avoid the oxygen toxicity problem. *S. thermophilus*has a high oxygen utilization ability, which results in reduction of dissolved oxygen in probiotic yoghurt and an enhancement in viability of bifidobacteria.

Probiotic milk

Acidophilus milk production, the milk is heated at 95°C for 1 h or at 125°C for 15 min. Such a high heat treatment stimulates the growth of *Lactobacillus acidophilus* by providing denatured proteins and released peptides. High-heat-treated milk is cooled to 37°C and kept at this temperature for a period of 3-4 h to allow any spores present to germinate. Then, milk is re-sterilized to destroy almost all vegetative cells. Unless skim milk is used, the heat-treated milk is homogenized and cooled down to inoculation temperature (37°C). *Lactobacillus acidophilus* is added as active bulk culture. The level of inoculation is usually 2-5% and the inoculated milk is left to ferment until pH 5.5-6.0 or ~1.0% lactic acid is obtained, with no alcohol. The fermentation takes about 18-24 h under inactive conditions. After the fermentation, the number of viable *Lactobacillus acidophilus* colonies is about $2\text{-}3\times10^{9}$ cfu mL^{-1}, but this number decreases up to consumption time. Following fermentation, the warm product is rapidly cooled to <7°C before agitation and pumped to a filler where it is
filled into bottles or cartons. Acidophilus milk has higher free amino acids than milk. As the milk lactose is hydrolyzed by β-galactosidase of Lactobacillus acidophilus, acidophilus milk is more suitable for individuals suffering from lactose intolerance. Acidophilus milk is enriched with calcium, iron and vitamins. Technology of bifidus milk and acidophilus-bifidus milk manufacturing is similar to acidophilus milk. **(**Pandey *et al*., 2014)

Probiotic Shrikhand

Fermentation of milk product is one of the best methods of preserving nutrients and exerts added good therapeutic value when added with the probiotic cultures. Probiotic *Shrikhand* prepared using heat treated whole milk (control), whole milk with carrot juice (7.5:1) and whole milk with carrot pomace (9:1) showed 27.8%, 29.3%; 30.0% yield of chakka respectively. The carrot juice enriched probiotic *Shrikhand* was very good followed by the carrot pomace enriched *Shrikhand* (Mahesh *et al*., 2016).

Designer paneer

Value added paneer was prepared to improve the fibre content in the otherwise fibre deficient paneer. Cereals like wheat and finger millet at 1% level was included in the preparation of paneer. Inclusion level of more than 1% caused pasty consistency. Sensory analysis was also carried out on the designed paneer. It was found that there was no significant difference in the flavour and overall acceptability between the designer paneer and control samples. Texture analysis was carried out for various attributes. It was found that wheat based paneer was equal to control samples in terms of adhesiveness which may be due to the pasty nature of the wheat flour. However, this designed paneer had an overall acceptability and could be used as a value added product (Narayanan *et al*., 2014).

Innovations in processing technology for value addition

1. **Aseptic processing and packaging**

Considered as the single most important innovation for food products in the last half-century, it involves producing shelf-stable products by sterilizing product and the packaging material or container separately and filling in a sterile environment. It was popularized in India with the success of fruit juices drinks & milk such as Frooti and Amul Taaza (Sanjana*et al*., 2019).

2. **Membrane processing**

Recently, membrane processing has gained importance over conventional processes in food industry for its advantages that are well known and established. Membrane processing has presented new possibilities for the production of newer intermediate dairy products that can be used in different foods based on their functional properties (Liu *et al*., 2021).

a. *Reverse Osmosis*: The Reverse Osmosis membranes are characterized by a molecular weight cut off of nearly 100 daltons and the pressures involved are 5-10 times greater than those used in UF (Deshwal*et al*., 2021).

b. *Nanofiltration*: Nanofiltration allows divalent ions to pass through while retaining the organic molecules, It separates particles with molecular weights in the range of 300-1000 daltons. Operating pressures required are nearly 300 psig. Nano-filtration applications in the dairy industry are related to the capability of the process to selectively remove ionic particles. NF is used for demineralization of whey UF permeate prior to manufacture of lactose. It is also used for de-acidification of sour whey and for removal of sodium chloride from salty cheddar cheese whey (Yadav *et al*., 2021).

c. *Ultrafiltration*: UF membranes allows separation of smaller molecular weight substances ranging from 10,000 to 75000 daltons with operating pressures ranging between 10 to 200 psig. The ultrafiltration technology can be used for Deproteinization of whey, Fractionation of proteins, Milk protein standardization, Preparation of Biological peptides, Cheese making, Manufacture of rasogolla mix powder, Manufacture of milk protein concentrate, Manufacture of low lactose powder (Gavazzi-April*et al*., 2018).

d. *Microfiltration*: In microfiltration, membranes with pore sizes ranging from 0.1 to 10 micron and the operating pressures in the range of 1 to 25 psig are used. MF is essentially employed as a clarifying operation to remove macro materials and suspended solids, milk fat globules, bacteria and colloidal particles (France *et al*., 2021). Of these, the most significant application of MF is for selective separation of bacteria from milk. The MF system is capable of removing 99.5% of all the bacteria in skim milk, and when used in combination with pasteurizer or UHT processing can substantively improve the thermal efficiency and shelf life of resultant products (Hartinger*et al*., 2021). MF system can also be used for separation of native casein from whey proteins and for isolating peptides for Pharmaceutical applications.

3. **Mechanization**

Mechanization is the one of the most reliable and advocated tool by many researchers and scientists in the growth of food processing sector. This not only enables continuous production but also offers advantages such as uniformity and reproducibility. Such an innovation in the field of TDP with special reference to composite foods can be seen as SSHE or ISSHE wherein continuous khoa production can be seen. The machine has numerous advantages like continuous khoa dispensing system, uniformity in granular size and reproducible process for larger systems (Khamrui, 2020).

4. **3DPrinting**

3D food printing is the process of manufacturing variety of food products using a variety of additive manufacturing techniques. With this method, various customized shapes, colors, texture, flavor or nutrition, can be sought off and is not only limited to foods products but is also having applications in space exploration and healthcare. Classically, it is "The process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" (ASTM F42 Committee).

5. **Developments in preservation**

Inclusion ofsynthetic and natural preservative system is been a practice since older times in traditional Indian dairy products. Though the desiccation process itself requires no preservation system owing to the lowering of water activity. However, to further extend the life, various synthetic additives like sorbates, ortho- phosphates or other organic acid like citrates can be added to the product matrix to extend its shelf life (Meng*et al*., 2021). With an unprecedented surge in natural preservatives, the synthetic preservation system is currently overhauled by natural preservative systems like use of bacteriocins naming a few as: microgard, nisin and natamysin (Ibarra-Sánchez*et al*., 2020). Their promising results are another factor for its wider publicity and popularity amongst consumers.

6. **Developments in packaging**

Packaging has surpassed the simple role of containing and carrying the goods to a level beyond a stage wherein it serves as a vehicle for extending the produce's life. Now, the concept of conventional and traditional packaging is getting obsolete, and a new era of smart and intelligent packaging is heading to the market. A flood of terms like edible packaging, edible antimicrobial packaging, active and passive packaging, smart or intelligent packaging, and terms of the same origin have captured the market and the articles thereon. The increasing occupancy of such products in the market can be due to the consumer's expanding knowledge and interest towards shelf-stable products, choice and demand of nutritious products with supplemented safety.

In response to the growing demand for sustainability and ecological safety, recently, many investigations have been focused on the development of effortlessly degradable and biocompatible food packaging materials commonly referred as edible packaging. These biopolymer-based packaging materials can be simply disposed of after use in bio-waste decomposition centers for further degradation, releasing organic byproducts like carbon dioxide (CO2) and water (H2O). However, the application of biodegradable polymers in food

packaging systems is often restricted due to various shortcomings like poor mechanical, barrier, and thermal characteristics compared to the conventional non-biodegradable petroleum-based plastics (Mangaraj*et al*., 2019).

7. **Other advanced technologies**

a. *Spinning Cone Column Technology (SCC)*: For Flavour Management Flavoaurtech's Spinning Cone Column is the world's fastest, most efficient and cost-effective method for the capture and preservation of volatile flavour components, from all kinds of liquid or slurry substances (SaffarionpourandOttens, 2018). This unit handles a wide range of products, such as Dairy products like milk, cream, hot beverages like tea, coffee, malt drinks.

b. *Bactofugation*: The process involves subjecting milk to high speed centrifuging at around 50-600C to remove bacteria of milk. The process can be adopted selectively before or after pasteurization depending on the equipment. The process is reported to remove 70-80% of bacterial cells from milk depending on the initial load (Júnior*et al*., 2019).

c. *Super-Heated water spray sterilizer*: A new method of sterilization has been developed called "Super-Heated Water Spray Sterilizer" for heat sensate products. This is suitable for delicate containers like plastic bottles. This system is suitable for rapid heating and rapid cooling for heat liable products (Linke*et al*., 2019).

Conclusions:

Milk is a nutrient rich liquid comprises of variety of nutritional components, many of which possess excellent functional and nutritional qualities and can be used to develop value-added functional dairy products. Value addition of milk will provide various health benefit to the society and boost the economy of the farmer and dairy industry simultaneously. Value addition can result in foreign exchange for the country if planned, processed and marketed judiciously following scientific principles. The prevailing image of value-added Livestock products as domestic upmarket or foreign market products needs to be changed. This calls for production and marketing of products as per the needs, expectations and acceptance of as large population as possible at affordable price. Apart from developing sophisticated technologies for specialty products for niche market, concerted efforts should also be made to develop cost-effective, intermediate technology for promoting poultry processing as a cottage industry in rural areas, where huge market potential exists, as a vehicle of rural employment and income

generation. To achieve this, there is need for promoting rural livestock production and processing by provision of adequate credit support and other technical inputs viz., training, orientation for development of processing skills and entrepreneurship and location –specific technology. A link with fast food vendors, restaurants, hotels and retail outlets in nearby town or city could be a profitable proposition in promoting rural products manufacturing units, which in turn will give a fillip to livestock production activities in rural areas.

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8. MOBILE APPLICATIONS FOR TECHNOLOGY TRANSFER OF DAIRY INNOVATIONS: EXPERIENCE SHARING

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The sector of Agriculture in India has been growing tremendously with the introduction of the green revolution, white revolution, blue revolution and horticulture revolutions. Use of Information and Communication Technologies (ICT) to support the transmission of localized information and services for making farming socially, economically and environmentally sustainable, comprises the 'Digital Agriculture'. This digital change is acting as a tipping point for Indian agricultural system (KrishiJagran, 2019; Panda *et al*., 2019).

Livestock is symbolic to wealth and power, across civilizations for centuries. Nearly two thirds of farm families in India are associated with one or the other form of livestock to sustain their livelihood. The main objective of scientific livestock rearing is to create sustainable livelihood by reducing the cost of production, improving the productivity of the animal and ultimately bringing out quality production. In this line, lots of activities are adopted by many universities and research institutions to penetrate the knowledge of scientific rearing of livestock. One such attempt to transfer the technologies and disseminate information at the fastest mode among the ICT tools is mobile applications.

Mobile phones are widely being used and have facilitated in addressing the day to day issues of the livestock farmers. Internet and its application are highly involved in planning, weather forecast, post-harvest management, marketing, disaster management, extension management and thus a very powerful source to disseminate knowledge to the livestock farmers. It provides a gamut of information through online sources of information regarding different crops and thus in turn will shape the future of veterinary and animal husbandry development in the State (Pavan *et al*., 2017).As India is the second largest smart phone user country, it has a wide scope and potential in using it as technology transfer tool. Although, smart phone penetration is increasing in rural areas, internet penetration is still a long way to go and hence to cope-up with this barrier along with other bottlenecks like illiteracy and large population, an android mobile application with local language touch, which works offline will play a great role in overcoming information asymmetry existing among the group of farmers.

Mobile phones were the success story of bridging the rural digitals divide, bringing the tangible economic benefits and acting as agents of social mobilization through improved communication. It is interesting to know that the number of telephone subscribers in India is 1201.20 million. The shares of urban and rural subscribers are 55.90 per cent and 44.10 per cent, respectively. The wireless Tele-density in India is 88.17 per cent, out of which urban and rural share is 141.03 per cent and 60.27 per cent, respectively (TRAI, 2021). Mobiles have become affordable and ever increasing connectivity among more and more people. The value added services of the mobile like Short Message Service (SMS), voice SMS, videos etc. have been contributing to the extension. So, mobile phone in today's era is the most likely accessed device for information dissemination and providing lot of hope to improve extension services. By using this technology, extension has succeeded in reaching out to greater audience especially the disadvantaged groups (Mittal *et al.*, 2010). The main advantages of mobile apps for farmers are that they give timely information in response to the farmer's specific needs.

Government of India has launched a number of web and mobile based applications for dissemination of information on agriculture related activities, free of cost, for the benefit of farmers and other stakeholders. These apps can be downloaded from the official website mkisan.gov.in or from the Google play store. There are apps also developed by agricultural institutions, private sector, NGOs, ICAR institutes etc. These mobile applications are disseminating information from agricultural research and extension to farmers and other stakeholders and facilitating exchange of information among stakeholders. The information on mobile apps developed by various institutions provide access to agricultural and allied information along the agricultural value chain. (www.manage.gov.in)

Knowledge on scientific rearing practices and existing animal husbandry technology is the need of the hour for the farmers. Livestock are sustained on only crop residues obtained from Agriculture activities and as well as high cost inputs like concentrates. Cost of production can be brought down as well as production levels can be increased by reducing the concentrate cost and feeding the animals with good quality green fodders, which can be grown exclusively to feed them. In this line, lot of activities are adopted by many Universities and research institutions to penetrate this knowledge of growing of green fodder for feeding animals as well as updating the livestock farmers on latest technologies in farming. Focusing on wider reachability, quick penetration of knowledge into the social system, in turn to improve knowledge and create awareness and to increase adoption of better practices to improve their

livelihoods, the new generation smart technology of Android Applications were planned as they play a great role in overcoming information asymmetry existing among the group of farmers. With this concept in mind, in order to make awareness and adoption of better practices to improve their livelihoods, the new generation smart technology of Android Fodder App and Dairy App were designed, developed, launched and evaluated by the Department of Veterinary & Animal Husbandry Extension Education, Veterinary College, Bengaluru, Karnataka Veterinary, Animal and Fisheries Sciences University, KVAFSU (Bidar) in collaboration with Jayalaxmi Agrotech Limited Company. This article shares the experiences of developing and evaluating the fodder and dairy mobile Applications.

Development of Android Fodder Mobile Application:

- Consultation with experts and subject matter specialists of Veterinary and Agriculture colleges, a technical repository for sixteen selected fodders suitable to Karnataka was prepared, which included two, Fodder Sorghum and Fodder Maize varieties from annual monocotyledons, seven, Hybrid Napier, Green Panic grass, Para grass, Rhodes grass, Anjan grass, Signal grass and Guinea grass from perennial monocotyledons, two, Fodder Cowpea and Fodder Horsegram from annual dicotyledons, three, Lucerne, Hedge lucerne and Stylosanthes from perennial dicotyledons and two, Sesbania and Moringa from tree fodders. The detailed information regarding each fodder variety's specific features, soil, weather, nutritional content, cultivation requirements, cultivation practices and finally harvesting and yield was prepared and suitable pictures were taken from various institutes of India.
- The first of this kind of mobile app was developed in Kannada language under android platform using all essential elements of multimedia like text, images, audio, animation and graphics. The mobile app had recognizable imaged icons so that even illiterate farmers could also easily access the information on fodder production.
- Personal and Socio-economic characteristics of the respondents were studied. Assessment of perception among the livestock farmers about the developed Android Mobile Fodder App revealed that majority of the respondents of study area had perceived the relevance of contents as more relevant (56.66%), preciseness of content as very precise (72.50%), very simple (61.66%) in understanding of information, very good video (70.00%) and audio quality(48.34%), more credible information (71.66%), very effective in arousal of curiosity and interest (56.66%), very easy to use (55.83%),

high perceived utility (54.16%), information covered as highly educational (53.34%), highly satisfied with the logical presentation of information (61.66%) and very effective in improving self confidence (50.83%) resulting in the overall perception as favorable by good number of respondents (47.50%).

- Effectiveness of android mobile fodder app among livestock farmers in terms of knowledge gain revealed that majority of total respondents had low (60.00%) and medium (38.34%) levels of pre-exposure knowledge on fodders, whereas the distribution of respondents upon exposure to fodder mobile app showed the knowledge gain among the respondents. Majority were under high (50.00%) and medium (37.50%) levels of knowledge categories at post exposure stage. Study showed the overall knowledge gain among all respondents from the study area, wherein mean knowledge score at pre and post exposure stages were 8.80 and 21.17 with difference of knowledge gain showing 12.37 (41.23%). The 't' value of overall respondents was found to be statistically highly significant.

Development of Android Dairy Application:

- The Project was carried out in three broad steps (a) Repository preparation for dairy App (b) Development of "Android dairy App" and (c) Effectiveness of Android Dairy App among the dairy farmers. With experts consultation, Content was prepared and required pictures were collected. The technical repository was evaluated by the subject matter specialists.
- According to the repository, the relevant pictures were taken from various dairy farms, institutes, and Veterinary colleges. Further the contents were sequenced with the corresponding images. Audio recording of all documented information was done using recording software in appropriate speed flow so that the farmers can easily understand the information and necessary editions like noise reduction and amplification was made using software to have fine and clear audible quality. Relevant images selected were edited using various softwares like Paint, PPT (Power Point Presentation) and Free image converter. To draw clear picture to livestock farmers, the appropriate edited images were sequenced to audio flow. "Android Eclipse software" including others like Java and Xml was used to design Dairy App showing appropriate recognisable main and sub icons, which farmers can easily recognise and operate it.

- The main icon consists of 'General Information', 'Important cattle and Buffaloes breeds', 'Breeding Management', 'Selection of dairy animal', 'Housing Management', 'Feeding Management', 'General care and management of calves, milch animal' varieties', 'Diseases', 'Clean milk production', 'Economic dairying', 'Vaccination', 'Feed calculator' and 'Record Keeping'. By selecting any of icons, farmers can access information in audio format with visual background
- The developed information module was named as "Dairy Kannada" and "Dairy English" and was tested among dairy farmers and extension professionals for refinement in the content and quality of the App. The mobile app was shared to other android mobiles through Shareit and Bluetooth applications and also made available in play store for downloads.
- Effectiveness was assessed among a total of 320 dairy farmers who were selected randomly for the present study, from four divisions of Karnataka viz., Mysuru, Bengaluru, Kalburgi and Belagavi. A pretested interview schedule was developed to study the knowledge and adoption of dairy farmers (pre and post app exposure).
- Using pre-tested interview schedule, data was collected from the respondents at two stages (pre and post exposure of dairy app) by leaving a gap of 25 to 35 days. Percentage knowledge level regarding breeding management, feeding management, housing management, disease management and general care and management among selected dairy farmers at pre and post app exposure were collected and the difference between these two stages is represented as change in percentage of knowledge level. The effectiveness of dairy app in terms of knowledge gain was found to be satisfactory. Highest knowledge gain was found in feeding management (59.7%) as the app provides information on balanced ration and proportion of green fodder, dry fodder and concentrate needed as per milk yield. This was followed by, knowledge gain regarding general care & management (56.5%), housing management (51.05%), breeding management (47.36%) and Disease management (44.52%). Overall knowledge gain was found to be 54.57 per cent and could be understood that developed dairy app was effective in terms of knowledge gain.
- After the dissemination of the APP, more number of livestock farmers started adopting different scientific dairy practices. Within a short period of 25-35 days exposure towards the APP, 16.88 per cent had already adopted scientific breeding practices. The most common breeding management practices adopted were identification of heat symptoms, artificial insemination in time and pregnancy diagnosis

at appropriate time. Among the other dairy practices, adoption level increased more in disease management (19.38%) and general care and management (19.38%). With respect to feeding practices, 17.50 per cent have changed their feeding pattern. Some started practicing silage making to combat inadequate fodder availability in lean season and dry fodder enrichment using urea. Among all, improvement in adoption of practices on housing management was found to be low (6.25%) and this can be attributed to fact that, most farmers had already established sheds for their animals and not easy to alter due to space shortage. The most common housing management practices adopted were regular cleaning and usage of disinfectants. Overall it could be concluded that the dairy app improves the adoption of various scientific dairy practices among the dairy farmers to a considerable extent in future (Satyanarayan *et al*.,2018)

Up scaling the Technologies:

Upscaling and dissemination to a larger population was carried out by translation of the application to other languages like Telugu, Marati and Hindi. Posters during meals, TV and Radio programmes and Training programmes were used as a platform for technology dissemination.

Challenges of mobile applications in farming

- Lack of mobile friendly and locally relevant digital content in local languages
- Rural mobile infrastructure limitations like network/signal connectivity problem, internet problem, High cost of internet, electricity problem
- Digital Illiteracy and lack of awareness among the rural people.
- Large number of local languages which made difficult for preparing content repository.
- Greater customization and frequent updating of information is required Frequent criticism is that the information provided is old and routine.
- Mobile has added personal touch through voice calls, made understanding easier through pictures and videos and instant communication with experts anytime and anywhere, a reality obtained through mobile communications.
- To leverage the full potential of information dissemination enabled by mobile telephony along with supporting infrastructure and capacity building amongst farmers it is essential to ensure the quality of information, its timeliness and trustworthiness.

- By analyzing trends of mobile application in dissemination of agricultural information, we can say there is paradigm shift from mobile texting and calling option to multimedia format.
- Mobile phone which helps in improving awareness, education among farmers will act as a catalyst for rural development and country's economic growth.
- A true revolution in farm sector to happen the farmers must be able to get information which is need based, location specific and individual oriented which is made possible by mobile As of mobile, which are "Accessibility, Affordability, Applications" will make mobile as an omnipresent tool in future extension.
- Research Institutes, agricultural and allied universities need to develop appropriate repository regarding farming need to develop in local languages
- Public Private Partnerships should be initiated for digitalization of content which could be in voice, image, audio, graphic and text integrated format for dissemination of useful information among the millions of farm families.

Conclusion:

Extension is to bring about planned changes in behavioural complex of farmers i.e. creating awareness, improving knowledge and finally making them to adopt scientific practices for a profitable venture. To a considerable extent, fodder app and dairy app has reached out to more than 30,000 farmers each and has made the farmers to know, remember and to recollect the things learnt & experienced and finally adopt the practices. These mobile applications are important tools in diffusing the scientific developments in the field of dairy production and fodder production and also acts as a ready handy reckoner to refer through the information at any time.

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9. INNOVATIONS IN DAIRY FARMING - A PERSPECTIVE OF A PRIVATE ENTREPRENEUR

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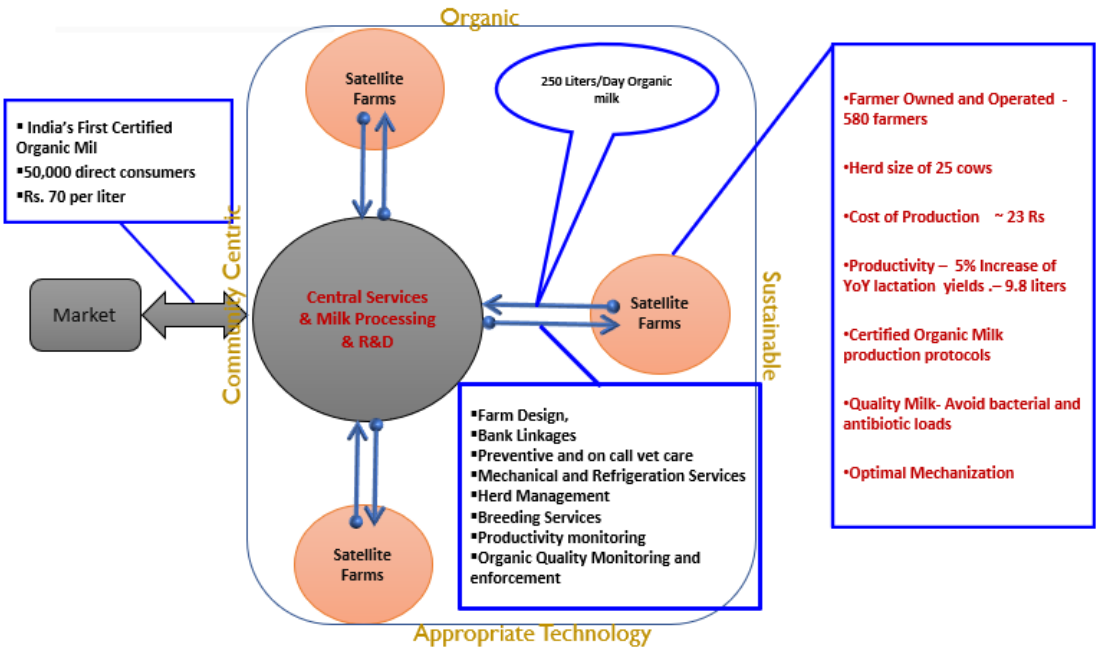
The Akshayakalpa Farms and Foods Private Limited based at Tiptur, Karnataka works closely with young farmers who have discontinued farming operations due to economic non-viability and are groomed as entrepreneurs by providing bank linkages, extension outreach, technical services, and market access. Maintains symbiotic relationship between human beings and natural resources and follow organic production processes that integrate better soil management and build farm biodiversity. Furthermore, using technology interventions to evaluate and improve closed-loop farming ecosystems objectively.



Productivity Focused Operations Model

The farm was established eleven years back with the aim of transforming smallholder farmers (< than 3 acres of holding) livelihood-based farming operations into wealth creation opportunity through Organic Dairy Farming.

Development Approach to Organic Farming by Akshayakalpa involves:

- Linking Value Creator/Farmer to Market/Consumer
- Technology intervention – Data Driven Approach for Farming & Removal of Drudgery
- Dairy and Bio Diverse Farms Provides Multiple market facing interventions
- Organic Dairy
- Organic Coconut
- Organic Fruits, Greens & Vegetables
- Organic Mushrooms
- Pollination management through Bee Keeping
- Organic Eggs – Through Backyard Poultry
- Organic Millets – Impetus on Rainfed Crops

The Organic Dairy Approach by Akshayakalpa involves:

a. Production Hubs in and around Markets – Local Market Creation
b. Market Facing Milk & Soil Facing Dung – Daily Cash flows and Closed loop Soil Management Leading to Regenerative Farming
c. Localisation of Feed and Fodder – Reduce external dependencies and work with local resource constraints
d. Productivity of Dairy Operations – Better Management of Feed and Fodder, extensive data based decision making
e. Delinking market risks by Moving away from lean and flush seasons
f. Allied Crop Productivity – By better Soil Management
g. Sensitive to land holding patterns and working with constraints, leveraging the Fallow Lands – 50% of the famers are landless
h. Women Farmers - 25% Lady farmers
i. Methane - Energy utilization at Farms for heating and power production.

Farmer Revenue – Means of Verification

BHAG Parameter	Parameter Descriptions	Objectively verifiable indicators	Means of Verifications
Farmer Revenue	Low Feed Conversion Ratio (FCR) affects revenue. Ideally, Akshayakalpa shall focus on 1:1.8 FCR. That is, every 1 KG dry matter intake expected to take about 1.8 kg of Milk Herd composition of 80:20 ratio with Adult and Young stock respectively, Herd lactation curve should have a Dolphin curve to ensure revenue throughout the year, and average days in milking should be around 150 to 180 days in the herd. Work on fodder security through silage and hay and reduce external dependency. 70% of the feed composition should be silage Focus on breeding services based on genomic selection and breeding value, focusing on disease resistance, ease of maintenance, and composition of milk solids Focus on quality and productivity through standardization of dairy practices/Protocols Focus on providing adlib access to feed, fodder, and water	As per the United States Department of Agriculture (USDA), the average dairy farmers income is ₹ 2,29,116/- per month National Sample Survey Office (NSSO) during its 70th round (January 2013-December 2013), the average monthly revenue per agricultural household from all sources is estimated to be Rs. 6,426. As per Committee on Doubling Farmers' Income (DFI), is ₹ 20,250/- per month on or before 2022-2023 ₹ 1,00,000/- per month, within two years of joining the Akshayakalpa program	Farm MIS

SCC – Means of Verification

BHAG Parameter	Parameter Descriptions	Objectively verifiable indicators	Means of Verifications
Somatic cell count (SCC) in the milk and milk products	Somatic cells are the inflammatory indicators appearing in the Milk during the pathogenesis of the mammary gland The somatic cells are mainly milk-secreting epithelial cells and white blood cells like neutrophils, monocytes, and macrophages SCC is the most significant component in assessment aspects of quality, hygiene, and Mastitis control. It is a single reliable indicator of udder health and useful predictor of Intra Mammary Infections In healthy cows, the SCC would be less than one lakh cells per ml, CMT score ZERO means less than two lakh cells per ml CMT score ONE means 2-5 lakh cells per ml CMT score TWO means 5-8 lakh cells per ml CMT score THREE means more than 8 lakh cells per ml High somatic cell counts in the milk cause deterioration of milk quality. For instance, the use of such Milk in the production of cheese resulting in reduced curd firmness decreased cheese yield, increased fat and casein loss in	As per US FDA[5] standard, the regulatory limit is 7,50,000 cells/ml of Milk As per European standard[6], the regulatory limit is 4,00,000 cells/ml of Milk No legal, regulatory standard for domestic use in India, but for Export, Express Industry Council of India (EICI) is 4,00,000 cells per ml of Milk Akshayakalpa standard limit would be	Farm-level California Mastitis Test every month Bulk tank Somatic cell count with a digital somatic cell counter Bulk tank Somatic cell count with microscopic slides

	whey, and compromised sensory quality, adversely affect the milk protein concentrates Due to clinical and sub-clinical Mastitis affected cow milk escalates somatic cell count, whey protein, bovine serum albumin, protease peptone, lactate, Sodium and chloride level, an enzymatic activity like lipase, lysozyme, Nagase and Beta Glucuronidase in Milk Due to clinical and sub-clinical Mastitis affected cow milk decreases Lactose, Fat, Total casein, Calcium, Magnesium, Phosphorus, Zinc, and Potassium level Public health hazards due to consumption of Milk with high SCC:Ingestion of a large number of bovine neutrophils in Milk may be objectionable as per National Mastitis Council Report-2005. Contamination of Milk by somatic cells may result in problems like allergy, Ear and tonsillar infections, Bedwetting, Asthma, Intestinal bleeding, colic, and childhood diabetes in children, but in adults, high SCC causes arthritis, heart disease, sinusitis, leukemia, lymphoma and cancer	2,00,000 cells/ml within two years of joining the Akshayakalpa program	

SPC – Means of Verification

BHAG Parameter	Parameter Descriptions	Objectively verifiable indicators	Means of Verifications
Bacterial load count (SPC) in the milk and milk products	• Indication of Aerobic bacteria's present in the Milk at the time of procurement • Un-hygienic milking machines, Housing management, Poor milking practices, Soiled and Mastitis cows are the probable drivers for the higher total count • Failure of rapid chilling of Milk at the farm level • Standard plate count (SPC) in healthy cows would be range between 1000 – 10,000 CFU/ml • The acidity of Milk will increase drastically due to overload of the total count and will reduce the MBRT of Milk • Due to the overload of total count in the Milk, it will affect the public health ranging from mild diarrhea to potential fatal Hemolytic Uremic Syndrome(HUS), Hemorrhagic colitis, mycobacterium tuberculosis, Q fever, Typhoid fever, and salmonella induced diarrhea • The total count clause is not there in the NPOP standard. One of the	• SPC count • 100000 CFU/ml as per US FDA standard, • Less than 200000 CFU/ml as per (BIS)[10]Bureau of Indian Standard, • 100000 CFU/ml as per Express Industry Council of India for Export, • 10000 CFU/ml as per Akshayakalpa standard at farm level, within two years of joining the Akshayakalpa program	Farm-level raw milk AGAR plating BMC level chilled milk AGAR plating at Plant

	critical parametersthat need to be included in the NPOP standards. • Coliform Bacteria Count (CPC) is always associated with manure and environmental contamination. It's a fecal contamination indicator of Milk.		

Free of Aflatoxins – Means of Verification

BHAG Parameter	Parameter Descriptions	Objectively verifiable indicators	Means of Verifications
Aflatoxin in the milk and milk products	• Indication of mycotoxins produced by fungus/molds like Aspergillus flavus, A. parasiticus, and A. nomius are found in dairy feeds/concentrates and human food products, • Mycotoxins are prevalent in warm and humid conditions as exist in India and many Asian countries, • The primary form of aflatoxins in dairy feeds/concentrates are B1,B2,G1, and G2, • In Milk M1 and M2 are the major aflatoxins,	Aflatoxin B1 in dairy feeds/concentrates As per US FDA 20 PPB/20 µg per Kg of feed As per European union for milking animals, 5 PPB/5 µg per Kg of feed As per BIS[13] 20 PPB/20 µg per Kg of feed As per Akshayakalpa[14,] 20 PPB/20 µg per Kg of feed (following BIS standard) Aflatoxin M1 in milk and dairy products As per US FDA 0.5 PPB/0.5 µg per Kg of milk/dairy products	1. Farm-level feed sample testing with Total Aflatoxin Rapid test kit 2. Farm-level milk sample testing with Aflatoxin M1 Rapid test kit 3. BMC level milk sample testing with Aflatoxin M1 Rapid test kit at the plant facility

	• Aflatoxins B1 is converted into M1 in the Bovine Liver with the help of cytochrome P450 enzyme. This M1 is considered a potential carcinogen, • Visual symptoms in dairy animals are Feed refusal, Reduced Growth, Decreased Food Conversion Ratio, Rough Hair Coat, Mild Diarrhea, Abnormal Estrus Cycle, and Abortions • Ensure less than 13% moisture level in all feeds/concentrates, store the materials on wooden pallets, and avoid wall surfaces • Usage of ideal aflatoxin binders like mineral clays and herbal molds inhibitors like Neem leaves and biological toxin binders like saccharomyces cerevisiae while feeding	As per European[13] 0.05 PPB/0.05 µg per Kg of milk/dairy products As per FSSAI, 0.5 PPB/0.5 µg per Kg of milk/dairy products As per Akshayakalpa standard is the Milk is Aflatoxin free	

Free of Antibiotics – Means of Verification

BHAG Parameter	Parameter Descriptions	Objectively verifiable indicators	Means of Verifications
Antibiotic in the milk and milk products	The presence of antibiotic residues in the milk and milk products due to indiscriminate use of Antibiotics for Clinical Mastitis, Bacterial and Viral infections Antibiotics or their metabolites become deposited in the animal tissue and matrix intended to use for human consumption, where concentration is beyond the permitted level for a certain period are known as Antibiotic residues Due to the indiscriminate use of Antibiotic for treatment and growth purpose, the animal gets resistantto Antibiotics, Quite tricky to treat animals with various infections. If an animal gets Antibiotic-resistant, this will lead to an increase in the production cost and need to go for higher antibiotics, The time needed after drug administration of any milking cow was below a determined Maximum Residue Limit found in the milk and milk products In public health concern, the antibiotic residue will lead to Antibiotic resistance, allergic reactions, carcinogenicity, mutagenicity, teratogenicity, and disturbances in the normal gut micro-flora	Maximum Residue Limit as per US FDA is 100 PPB per Liter of milk/dairy products Maximum Residue Limit as per FSSAI standard is 100 PPB per Liter of Milk/dairy products, As per Akshayakalpa standard, the Milk is Antibiotic-free	Farm-level Antibiotic test results Antibiotic test at the plant

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