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DRIVING DAIRY FORWARD

INNOVATION • NUTRITION
SUSTAINABILITY.

FUTURE OF DAIRY FARMING
TRENDS SHAPING TOMORROW

NUTRITION THAT PERFORMS
BALANCED FEED, HEALTHY HERD

SMART FARMS STRONGER FUTURE
TECHNOLOGY MEETS TRADITION

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HEALTH
Benefits of A2 Milk

Strong Teeth
Milk is the best source for calcium and that's exactly what your teeth need. In addition, milk helps prevent cavities and tooth decay.

Healthy Bones
It's true that kids need to drink milk to increase bone health, in order to improve proper growth.

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Sit down and drink a warm glass of milk. This helps to relieve muscle tension and soothe your nerves.

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When you're struggling to get through the day and you need a little pick-me-up, reach for an ice cold glass of milk. You will feel revitalized in no time.

BENEFITS OF DRINKING MILK

Calcium for strong bones

Protein for muscles

Vitamin D for absorption

Phosphorus for growth

Hydrates with nutrients

Potassium for heart health

From the Pen of Chief Editor

2026 Market Outlook: Shared Pressures Across Livestock Production

The livestock industry is expected to face several common challenges in 2026, despite continued growth in demand for animal-based protein products. Rising production costs, disease threats, climate variability, and market uncertainties are putting pressure on producers across poultry, dairy, swine, and beef sectors.

Feed remains the largest expense for livestock farmers, and fluctuations in grain and oilseed prices continue to impact profitability. At the same time, outbreaks of diseases such as Avian Influenza and African Swine Fever highlight the importance of strong biosecurity measures and effective farm management practices.

Climate change is another major concern. Heat stress, droughts, and irregular weather patterns are affecting animal productivity, feed availability, and overall farm performance. Producers are increasingly investing in climate-resilient practices, improved genetics, and efficient resource management to minimize risks.

Labor shortages and rising wages are encouraging the adoption of automation, precision farming, and digital monitoring technologies. These innovations help improve productivity while reducing operational costs.

Although market demand for meat, milk, and eggs remains strong, global trade uncertainties and supply chain disruptions may continue to influence prices and profitability. In this evolving environment, livestock producers who focus on efficiency, sustainability, and technological advancement will be better positioned to overcome challenges and achieve long-term growth in 2026.

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MARKET OUTLOOK

ARTICLE

Estrus Behaviour in Dairy Animals: Behavioural Signs for Better Heat Detection

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Introduction

Efficient reproduction is the backbone of profitable dairy farming. In dairy cows and buffaloes, timely detection of estrus, commonly known as heat, is very important for successful breeding and artificial insemination. If heat is missed, the animal may remain open for another cycle, which increases calving interval, reduces lifetime milk production, and increases the cost of maintenance.

Estrus is the period of sexual receptivity in a female animal when she is ready to accept mating. In cattle, the estrous cycle is generally around 21 days, although it may vary from animal to animal. During estrus, the level of estrogen increases, which produces specific behavioural and physical signs. Correct identification of these signs helps the farmer inseminate the animal at the proper time and improve conception rate. Standing to be mounted is considered the most reliable sign of estrus in cattle.

Meaning of Estrus Behaviour

Estrus behaviour refers to the changes in normal behaviour shown by a female animal during the heat period. These changes are mainly controlled by ovarian hormones, especially estrogen. During this period, the animal becomes restless, more active, shows interest in other animals, may mount other females, and finally stands still when mounted by another animal.

In simple words, estrus behaviour is the natural way by which a female animal shows that she is ready for breeding.

Importance of Heat Detection in Dairy Farming

Heat detection is important because artificial insemination can be successful only when it is done near the time of ovulation. Poor heat detection leads to missed breeding opportunities, repeat breeding, increased days open, longer calving interval, and economic loss to the dairy farmer.In high-producing dairy cows, heat signs may be weaker and shorter due to high milk production, intensive management, slippery floors, heat stress, lameness, and poor body condition. In buffaloes, the problem is even more serious because many buffaloes show **silent heat** or weak external signs, especially during hot weather. Heat stress can reduce standing and mounting behaviour in dairy cows, making visual heat detection more difficult.

Primary Sign of Estrus: Standing Heat

The most reliable sign of estrus is **standing heat**. In this condition, the cow or buffalo stands still and allows another animal to mount her. This sign indicates that the animal is in true heat and is close to the proper time for insemination.

Standing heat is more dependable than other signs because many animals may show restlessness, bellowing, or

mounting before or after true heat, but the animal that **stands firmly to be mounted** is usually in the most fertile phase. Extension sources describe standing to be mounted as the surest sign of heat.

However, in practical farm conditions, standing heat may not always be observed. A study on Holstein-Friesian cows reported that standing heat was highly reliable, but it was observed only in a portion of ovulatory estrus events, indicating that farmers should also observe secondary signs carefully.

Secondary Behavioural Signs of Estrus

Secondary signs are useful indicators that the animal is either coming into heat, is in heat, or is going out of heat. These signs should not be ignored, especially in buffaloes and high-yielding cows.

1. Mounting Other Animals

A cow or buffalo in heat may try to mount other females. This is one of the important behavioural signs. However, mounting alone does not always confirm true heat because some animals mount before they enter standing heat or after the peak heat has passed.

2. Restlessness and Increased Activity

The animal becomes restless, walks more than usual, frequently changes position, and may not remain calm in the shed. Activity monitors used in modern dairy farms are based on this principle because animals in estrus often show increased movement.

3. Bellowing

Some animals show repeated bellowing during heat. This is more visible in cattle than in buffaloes. Bellowing occurs due to hormonal stimulation and sexual excitement.

4. Sniffing and Licking Other Animals

The animal may sniff the vulva of other animals, lick them, or show interest in their urine. This is a social and sexual behaviour associated with estrus.

5. Chin Resting

A cow in heat may rest her chin on the back or rump of another animal before mounting. This is a useful pre-mounting sign and should alert the farmer to observe the animal closely.

6. Following Other Animals

The animal may continuously follow other cows or buffaloes in the group. This is often seen before standing heat.

7. Reduced Feed Intake and Milk Yield

Some animals eat less during heat due to restlessness and hormonal changes. A temporary slight drop in milk yield may also be noticed in some dairy animals.

8. Frequent Urination

Frequent urination is commonly observed during heat. The urine may attract other animals and helps in sexual communication.

Observable signs of heat in cattle include mounting or attempting to mount, smelling or trailing other females, bellowing, nervousness, reduced appetite, clear mucus discharge, and roughed-up hair over the tail head.

Physical Signs Associated with Estrus

Along with behavioural changes, some physical changes are also observed.

1. Clear Mucus Discharge

A clear, transparent, string-like mucus discharge from the vulva is one of the common signs of heat. This mucus may be seen hanging from the vulva or sticking to the tail, thighs, or perineal region.

2. Swollen and Moist Vulva

The vulva may appear slightly swollen, moist, and reddish due to increased blood flow under the influence of estrogen.

3. Ruffled Hair on Tail Head

Due to repeated mounting by other animals, the hair over the tail head may become rough, broken, or rubbed.

4. Mud or Scratch Marks on Hindquarters

Animals that have been mounted may show mud marks, hoof marks, or scratches on the back, flank, or hindquarters.

5. Raised Tail

Some animals hold the tail slightly raised or move it frequently during estrus.

Estrus Behaviour in Dairy Cows

In dairy cows, estrus signs are generally more visible than in buffaloes. The common signs include standing to be mounted, mounting others, restlessness, bellowing, clear mucus discharge, chin resting, sniffing, and increased activity.

In high-producing dairy cows, estrus duration may be short and

signs may be less intense. Therefore, a farmer should not depend only on one observation per day. Observation should be done several times daily, especially early morning and late evening.

Research and extension recommendations suggest that frequent observation improves heat detection. Checking animals at different times of day can improve the chance of detecting standing estrus, because many cows show heat activity during evening, night, and early morning hours.

Estrus Behaviour in Buffaloes

Heat detection in buffaloes is more difficult than in cows. Buffaloes often show weak, silent, or less obvious estrus signs. In many buffaloes, estrus occurs during late evening or night, so farmers may miss the signs if animals are observed only during daytime.

Common estrus signs in buffaloes include restlessness, frequent urination, swelling of vulva, clear mucus discharge, bellowing, reduced feed intake, raised tail, and sometimes mounting behaviour. Standing heat may not be very prominent in many buffaloes. A review on heat detection in cattle and buffalo reported that buffaloes show variable intensity of signs such as vulvar swelling, clear mucus discharge, spontaneous milk letdown, bellowing, restlessness, frequent urination, and raised tail.

In buffaloes, farmers should give special attention to:

- Clear mucus discharge
- Frequent urination
- Restlessness during evening and night
- Reduced feed intake
- Bellowing
- Swollen vulva
- Interest in other animals
- History of previous heat cycle

Silent heat is more common in buffaloes, especially during summer. Therefore, regular observation, proper nutrition, cooling management, and use of teaser bulls or heat detection aids can improve breeding efficiency.

Silent Heat: A Major Challenge

Silent heat means the animal undergoes ovarian cyclicity and ovulation, but external signs of heat are weak or not clearly visible. This is common in buffaloes and may also occur in high-yielding dairy cows.

Silent heat may occur due to poor nutrition, mineral deficiency, heat stress, postpartum weakness, uterine infection, lameness, poor body condition, or improper management. In such cases, the animal may not show standing heat, but may show mild mucus discharge or slight restlessness.

Farmers often say, “animal heat mein nahi aa rahi,” but actually the animal may be cycling silently. Veterinary examination, rectal palpation, ultrasonography, progesterone testing, or synchronization protocols may be needed in such cases.

Best Time for Heat Observation

Heat observation should be done when animals are calm and not disturbed by feeding, milking, or cleaning. The best time for visual observation is:

Fig.1 Standing to be mounted

Fig. 2 sniffing of the vulva

Early morning: before feeding and milking
Late evening: after daily farm activities
Night observation: especially useful in buffaloes
Midday observation: useful as an additional check

Observation should ideally be done for **20–30 minutes at a time**, two to three times daily. More frequent observation increases heat detection efficiency. A review on heat detection techniques suggested that visual observation three times a day for at least 30 minutes each time improves detection, and detection aids can further improve results when used in combination

Timing of Artificial Insemination

Proper timing of artificial insemination is essential. Traditionally, the **AM-PM rule** is used:

If the animal is first seen in heat in the morning, inseminate in the evening.
If the animal is first seen in heat in the evening, inseminate the next morning.

This rule is based on the relationship between standing heat, ovulation, and sperm survival. Ovulation generally occurs after the onset of standing heat, so insemination should be timed in such a way that viable sperm are present in the reproductive tract when ovulation occurs.

Factors Affecting Estrus Expression

1. Heat Stress

High temperature and humidity reduce feed intake, increase body temperature, and suppress normal reproductive behaviour. During summer, animals may show weak heat signs, especially buffaloes.

2. Flooring

Slippery concrete floors reduce mounting activity because animals fear slipping and injury. Non-slippery flooring improves expression of mounting and standing behaviour.

3. Group Size

Animals kept alone or tied continuously may not express mounting behaviour properly. Loose housing and group observation improve heat detection.

4. Lameness

Lame animals may not mount or stand to be mounted due to pain. This leads to missed heat detection.

5. Nutrition

Energy deficiency, mineral deficiency, and poor body condition reduce estrus intensity. Dairy animals need balanced ration, mineral mixture, and proper postpartum care.

6. Postpartum Health

Animals with retained placenta, metritis, endometritis, ketosis, or poor uterine involution may show delayed or weak estrus.

7. Milk Production Level

High-producing cows may show shorter and less intense estrus due to increased metabolism of reproductive hormones.

Modern Heat Detection Aids

Visual observation is the basic method, but heat detection aids are very useful in modern dairy farming.

1. Tail Paint or Tail Chalk

Paint or chalk is applied near the tail head. When the animal is mounted, the paint gets rubbed off, indicating mounting activity.

Fig. 3 Swollen and congested vulva

Fig. 4 Transparent mucus discharge From vulva

2. Heat Mount Detectors

These are pressure-sensitive devices pasted on the rump. When another animal mounts, the device changes colour or becomes activated.

3. Teaser Bull

A vasectomized or apron-fitted bull can help identify females in heat, especially in buffalo herds.

4. Pedometers and Activity Monitors

These devices detect increased walking activity during heat.

5. Milk Progesterone Test

Low progesterone indicates that the animal may be near estrus. This is useful in problem breeders or silent heat cases.

6. Ultrasonography

Ultrasound can help assess ovarian structures such as follicles and corpus luteum, especially in animals with silent heat or irregular cycles.

Heat detection aids such as tail paint, chalk, heat mount detectors, detector animals, and electronic devices are commonly used to support visual observation.

Practical Tips for Farmers

Farmers should maintain a heat detection register and note the date of heat, insemination, mucus discharge, standing behaviour, and expected next heat date. Since the average cycle length is about 21 days, animals should be watched carefully around 18–24 days after the previous heat. Animals should be observed quietly without disturbing them. Observation during feeding or milking is not ideal because animals are focused on other activities. Buffaloes should be watched especially during evening, night, and early morning.

Good nutrition, clean housing, cooling arrangements, mineral supplementation, regular deworming, proper postpartum care, and lameness control are essential for good estrus expression.

Common Mistakes in Heat Detection

Many farmers make the mistake of inseminating only on the basis of mucus discharge without observing behaviour. Some inseminate too early when the animal is only restless, while others inseminate too late after standing heat is over. In buffaloes, many farmers miss heat because they observe animals only during the daytime.

Another common mistake is not keeping records. Without records, it becomes difficult to predict the next heat date. Regular recording is one of the simplest and cheapest tools for improving reproductive performance.

Conclusion

Estrus behaviour is a natural and valuable signal of reproductive readiness in dairy animals. The most reliable sign of heat is **standing to be mounted**, but secondary signs such as mounting, restlessness, bellowing, frequent urination, chin resting, mucus discharge, swollen vulva, and increased activity are also very important.

In cows, heat signs are usually more visible, while in buffaloes they are often weak, silent, or expressed during night hours. Therefore, careful observation, good management, proper nutrition, cooling during summer, and use of heat detection aids can greatly improve breeding success.

Better heat detection means timely insemination, better conception rate, shorter calving interval, more calves, and higher lifetime productivity of dairy animals.

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Murrah Buffalo Breed: Origin, Characteristics and Management Practices

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Introduction

Murrah breed is also known as "Delhi", "Kundi" and "Kali". Buffalo milk is highly valued for the production of high-fat and solids-not-fat (SNF) dairy products. It is widely used in the preparation of traditional and commercial products such as butter, ghee, milk powder, khoa, curd, yogurt, shrikhand, dried ice cream mixes, dairy whiteners, and particularly Mozzarella cheese, which is a key ingredient in pizza production. In India, restrictions on cow slaughter have further enhanced the significance of buffaloes as an important source of meat. Murrah buffaloes are also recognized for their strength and endurance, and their males are extensively utilized for draught purposes in addition to meat production. Moreover, buffaloes possess a remarkable ability to efficiently utilize low-quality roughages and agricultural by-products, enabling them to perform well even under suboptimal management and harsh environmental conditions. Owing to their multifaceted contributions to milk, meat, and draft power, Murrah buffaloes are often referred to as the "Black Gold" of India.

Origin and Breeding tract

The breeding tract of "Murrah" includes Hisar, Rohtak, Gurgaon and Jind district of Haryana and Delhi. However, Murrah buffaloes are also found in Punjab and Western Uttar Pradesh. The breed is used for grading-up non-descript buffaloes almost in all parts of world and has even formed an important place in the livestock industry of many developing countries like Bulgaria, Philippines, Malaysia, Vietnam, Brazil and Sri Lanka.

Physical Characteristics

The breed has a massive body, long head and neck, short and tightly coiled horn, well developed udder and broad hips. Usually the buffaloes of this breed are jet black in colour with occasional white marking on switch of tail. The eyes of Murrah buffaloes are generally bright, lively and more prominent in females, whereas they appear comparatively less prominent and slightly sunken in males. The ears are small, thin, and highly responsive. Females possess a long and slender neck, while males exhibit a thicker and more muscular neck. The hip region is broad and well developed. Both the forequarters and hindquarters show a gentle downward slope. The tail is characteristically long, extending below the hock joint up to the fetlock and terminating in a white switch. The udder is large and well developed, extending from the hind limbs to the area just behind the navel flap, with clearly visible and prominent milk veins. The teats are elongated and evenly spaced, with the hind teats usually being longer than the fore teats.

Performance Characteristics of Murrah Buffaloes:

Trait	Value
Body Measurements (Adult Males)	
Body length	150 cm
Height at withers	142 cm
Heart girth	220 cm
Body Measurements (Adult Females)	
Body length	148 cm
Height at withers	133 cm
Heart girth	202 cm
Birth Weight	
Male calf	31.7 kg
Female calf	30.0 kg
Adult Body Weight	
Male	450–800 kg (Average: 567 kg)
Female	350–700 kg (Average: 516 kg)
Reproductive Traits	
Average age at first service	943.4 days
Average age at first calving	1,319 days
Service period (First parity)	177.1 days
Service period (Overall)	136.3 days
First calving interval	455–632 days (Average: 488.1 days)
Overall calving interval	430–604 days (Average: 452.9 days)
Number of services per conception	1.75–2.15 (Average: 1.93)
Production Traits (First Lactation)	
Total lactation milk yield	1,678.4 kg
305-day milk yield	1,675.1 kg
Lactation length	307.0 days
Dry period	187.6 days
Production Traits (Overall Lactations)	
Total lactation milk yield	1,751.8 kg
305-day milk yield	1,660.1 kg
Lactation length	298.7 days
Dry period	154.8 days
Milk Composition	
Average fat content	7.3%

Production and Reproduction Traits of Murrah Buffaloes

Lactation milk yield

Milk production in Murrah buffaloes varies across production systems due to differences in management practices, nutrition, and environmental conditions. In large, well-managed herds, the average milk yield is approximately 1,800 kg per lactation.

Service period

Murrah buffaloes are usually allowed a postpartum rest period of 60 days; however, their average service period often extends to 5–6 months.

Lactation length

Buffaloes with extended lactation lengths are generally associated with higher milk production, provided they receive an adequate dry period before the next calving to facilitate physiological recovery and support optimal performance in the subsequent lactation.

Dry period

Murrah buffaloes generally exhibit an average dry period of approximately six months, which provides sufficient time for mammary gland regeneration and physiological recovery before the subsequent lactation.

Calving interval

Calving interval is an important reproductive trait that directly affects both reproductive performance and overall production efficiency in dairy buffaloes.

Peak yield

Similar to other traits, there is variation in peak yield as well, but the minimum peak yield of herds is more than 7 kg.

Life time milk yield

The estimation of total lifetime milk production is challenging because buffaloes are generally culled before reaching their natural lifespan. As a result, several approaches have been developed to evaluate lifetime milk yield. Murrah buffaloes are characterized by exceptional longevity and the capacity to maintain satisfactory milk production in later lactations.

Management Practices

In their native breeding tract, Murrah buffaloes are generally maintained under a mixed housing system. Animals are often tethered to trees or poles in open areas, while suitable

shelters are provided to protect them from harsh climatic conditions. The housing structures are usually well ventilated, consisting of permanent (pucca) walls and earthen (kutcha) flooring. Buffaloes are predominantly reared under a stall-feeding system. During the Rabi season, green fodders such as berseem, oats, and mustard are commonly offered, whereas pearl millet, sorghum, and cluster bean constitute the major fodders during the Kharif season. In periods of fodder scarcity, the animals are sustained on wheat and pulse straws supplemented with oil cakes and concentrate feeds. Women play a major role in buffalo husbandry, carrying out nearly 80% of the management activities, including feeding, milking, cleaning, and general animal care. Calves are usually allowed to remain with their dams and are not commonly weaned. Only a limited number of farmers maintain breeding bulls exclusively for reproductive purposes; otherwise, male buffaloes are utilized both for breeding and draught work. Under field conditions, natural mating remains the most widely practiced breeding method.

Diet and Nutrition

Proper nutrition plays a crucial role in maintaining the health, productivity, and milk quality of buffaloes. A balanced feeding regimen significantly influences both milk yield and milk fat content. Animals are mostly stall fed with available seasonal green fodder.

Green Fodder: Lactating buffaloes should be provided with approximately 20–30 kg of green fodder per day, such as Napier grass, berseem, maize, or other nutritious forage crops.

Dry Fodder: About 5–8 kg of dry roughages, including wheat straw or paddy straw, should be included in the daily ration to ensure adequate fiber intake and proper rumen function.

Concentrate Mixture: Depending on the animal's production level, 4–6 kg of a balanced concentrate feed should be supplied daily to meet energy and protein requirements.

Mineral Supplementation: Supplementing the diet with around 50 g of mineral mixture along with common salt each day helps prevent mineral deficiencies and supports reproductive efficiency.

Water Requirement: Adequate access to clean and fresh drinking water is essential, with lactating buffaloes generally requiring about 30–40 liters of water per day, depending on environmental conditions and milk production.

Points to keep in mind while rearing Murrah buffalo

Successful rearing of Murrah buffaloes and the achievement of optimum milk yield depend on several key management practices, including the selection of superior breeding stock, provision of a balanced and nutritious diet, effective heat stress management through adequate cooling and wallowing facilities, and maintenance of proper hygiene and sanitation. As Murrah buffaloes are recognized as a high-yielding dairy breed, efficient day-to-day management is essential to ensure better productivity and economic returns.

Conclusion

Murrah buffalo is one of the most important dairy buffalo breeds of India and has earned global recognition due to its superior milk production potential, high milk fat content, adaptability, and multifaceted utility. The breed plays a significant role in enhancing rural livelihoods by contributing to milk, meat, and draught power, thereby justifying its designation as the “Black Gold” of India. Its ability to efficiently utilize low-quality feed resources and perform under diverse agro-climatic conditions further increases its economic importance.

Use of Total Mix Ration in Dairy Production

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Introduction

A Total Mixed Ration is a balanced blend of all feed ingredients required by dairy animals. The ingredients are mixed using a TMR mixer wagon or feed mixer to prevent selective feeding and ensure uniform nutrient intake.

Roughages, concentrates, minerals, vitamins, and feed additives are all completely combined and fed to dairy animals as a single ration under the Total Mixed Ration (TMR) feeding system. By ensuring that animals eat a balanced meal in every mouthful, this approach improves their health and productivity.

The fundamental idea behind TMR is to give animals a nutritionally balanced diet while preventing selective feeding. The animal consumes the desired amount of nutrients throughout the day when all feed ingredients are mixed evenly.

Components of TMR- Typical TMRs include-Green fodder, such as berseem, sorghum, and maize,Hay, wheat straw, and paddy straw are examples of dry roughages.blend of concentrated ingredients (grains, oil cakes, bran)
Combination of minerals- Typical salt
Feed additives- (yeast culture, probiotics, and buffers)

Objective of TMR Feeding-

-To give each mouthful a balanced diet.
-To enhance nutrient utilisation and feed intake.
-To improve the quality and quantity of milk produced.
-To cut down on feed waste.
-To preserve the health of the rumen and the effectiveness of digestion.

Benefits of TMR in Dairy Production-
1.Better Nutrient Utilisation- Guarantees a balanced nutrient intake.
2.Increased Milk Production- This improves the composition and yield of milk.
3.Improved Rumen Health- Encourages microbial activity and keeps the pH of the rumen steady.
4.Decreased Feed Wastage- Selective feeding and feed sorting are minimised.
5.Enhanced Feed Efficiency- Produces milk more effectively.
6.Labour Saving- Cuts down on the amount of time and effort needed to feed.Consistent Animal Performance-Offers a consistent diet every day.

7.Reduced Feed Wastage- Mixing all ingredients together minimizes sorting and feed losses, resulting in better feed efficiency.

Preparation of TMR-
Determine the nutrient needs based on milk production and body weight.
-Choose appropriate concentrations and roughages.
-Accurately weigh the ingredients.
-Roughages should be mixed first, then concentrates and supplements.
-Make sure the mixture is even.
-After preparation, feed right away.

Role of TMR in sustainable Dairy Farming- TMR improves feed conversion efficiency, reduces nutrient losses, and enhances animal productivity. It helps dairy farmers utilize locally available feed resources efficiently while lowering production costs. Better nutrient utilization also reduces environmental pollution from animal waste. Total Mixed Ration is an advanced feeding strategy that improves nutrient utilization, milk production, animal health, and farm profitability. By providing a balanced diet in every bite, TMR ensures optimal performance of dairy animals. Although it requires proper equipment and management, the benefits of TMR make it an essential tool for modern and sustainable dairy production.

Types of TMR- 1. **Traditional TMR**-Every day, all ingredients are combined and fed fresh.

2**. PMR, or partial mixed ration**-Animals are fed a diverse diet in addition to extra concentrates, which are frequently provided by milking parlours.

3. **FTMR, or fermented TMR-** Before feeding, the mixed ration is fermented to increase its shelf life and palatability.

Economic Benifits of TMR-

Advantages for Dairy Cattle and Buffaloes-

According to research, Dairy animals given TMR frequently display-
-Increased consumption of Dry Matter
-Increased production of milk
-A higher amount of milk Fat
-Improved physical Health
-Improved reproductive Efficiency

Restrictions
Equipment for mixing may require a large initial expenditure,calls for appropriate conceptualisation and consistent observation,Maintaining feed quality requires appropriate storage facilities.

Future Prospects and

Conclusion- The use of TMR is growing because of its contribution to sustainable dairy production and precision feeding. The profitability of dairy farms can be further increased by integrating TMR with contemporary technologies like automated feeding systems and computerised ration preparation. For buffaloes and dairy cattle, the Total Mixed Ration is a successful feeding method. TMR increases feed efficiency, milk production, animal health, and overall farm profitability by offering a consistent and balanced diet. As a result, TMR is becoming a crucial instrument for sustainable animal production and contemporary dairy farming. utilising artificial intelligence to balance rations.TMR formulation applications for mobile devices.Agro-industrial residues and by-products are included.Feeding with precision to increase sustainability.integration with dairy farming methods that are climate-smart.

Recent Innovations in TMR- Probiotic and prebiotic use in TMR,supplementing with nanominerals,use of bypass proteins and protective lipids.,robotic feeding systems that are automated.,TMR technology with fermentation.

Parameter	Conventional Feeding	TMR Feeding
Feed Wastage	Higher	Lower
Labor Requirement	More	Less
Milk Production	Moderate	Higher
Feed Efficiency	Lower	Better
Profitability	Moderate	Higher

Advances in Bovine Artificial Insemination: Present Practices and Future Prospects

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Introduction

Artificial insemination (AI) has emerged as a cornerstone of modern bovine reproductive management. It enables the widespread use of genetically superior sires, facilitating rapid genetic improvement in dairy and beef cattle populations. Through precise selection and controlled breeding, AI significantly enhances production traits, disease resistance, and overall herd fertility. With ongoing advances in semen processing, cryopreservation techniques, estrus synchronization, and the introduction of sex-sorted semen, AI has become more efficient and widely accessible. These innovations have improved conception rates, enabled targeted production of female calves, and reduced the need for natural service, thereby minimizing the spread of reproductive diseases.

Although AI is very common in cattle (75% of all inseminations) and swine (85% of all inseminations), it is also popular among livestock breeders for improving their herds using semen from males with desirable traits. The adoption of artificial insemination considerably reduces the spread of both genital and non-genital diseases in livestock.

History of Artificial Insemination

Artificial insemination (AI) began in 1780 when LazzaroSpallanzani successfully inseminated a dog. The first use of AI in horses followed in 1887. Major progress occurred in 1949 with the development of semen freezing, and by 1960, PVC straws were being used for semen storage. Cattle AI began in 1963 and became commercially available in 1965. In 1996, Dolly, the first cloned sheep, was born. By 2000, sexed semen had become available, allowing farmers to select the sex of their calves and revolutionizing cattle breeding.

Steps of Artificial Insemination of cattle

a) Proper Positioning of the Cattle

The success rate of artificial insemination greatly increases when the cow is standing calmly on a **level, non-slippery surface**. The cow should **not be mixed with unfamiliar groups**, as this may cause stress. Insemination should be done in a **familiar environment**, ideally where the cow is comfortable and has access to **food and water**. A relaxed and calm animal improves the chances of successful conception.

b) Softening of the Straw

The semen straw should be thawed at a **temperature of 37°C**. Using forceps remove the straw from the liquid nitrogen container and **immerse it in warm water**. Thaw for **20–30 seconds for a 0.25 ml straw** and **around 40 seconds for a**

0.5 ml straw. Meanwhile, **pre-warm the AI gun** by rubbing it between your hands. After thawing, insert the straw into the AI gun, hold the gun vertically, and **gently press the plunger until semen just reaches the top** of the sheath, ensuring there's no air space.

c) Insertion of the Palpating Arm

Form your fingers and thumb into a point and **gently insert your gloved palpating hand into the rectum** to locate and stabilize the cervix. With your free hand, **clean the vulva** using a paper towel to remove any manure and reduce the risk of introducing infection. Apply **slight downward pressure** with your rectal hand to slightly open the vulva, which helps allow clean and smooth insertion of the AI catheter.

d) Insertion of the AI Catheter

Insert the AI catheter **gently into the vulva at a 30-degree upward angle**. This helps avoid mistakenly entering the urethra and depositing semen into the bladder. Move carefully to ensure proper direction toward the cervix.

e) Insertion into the Cervix

Once the catheter reaches the area near the cervix, guide its tip into the **cervical opening**. Be careful not to insert it into the **fornix vagina**-a blind pocket surrounding the cervix. This mistake is common, so use your palpating hand to feel and guide the tip of the catheter correctly into the cervical canal.

f) Depositing the Semen

Proper semen deposition is critical for success. The semen should be deposited in the **uterine body**, just past the cervix. If it is released inside the cervix, most sperm cells may flow back into the vagina, significantly lowering conception chances. Use your fingers to **feel the position of the catheter tip**, ensuring it's correctly placed before slowly pressing the plunger to deposit the semen.

Advantages of Artificial insemination

Artificial insemination (AI) significantly boosts animal productivity, particularly milk yields, in developing countries when supported by a well-defined breeding strategy and a strong technical foundation tailored to their needs (Mohammed, 2018).

AI also contributes to genetic improvement by facilitating routine semen evaluation and monitoring, overcoming geographical limitations, allowing for long-term storage, reducing injury risk, supporting natural service, encouraging regular examination of the female reproductive tract, enhancing the reproductive potential of sub-fertile males, enabling fixed-time AI, controlling venereal diseases within herds, and permitting the use of frozen semen long after the donor or sire has died (Valergakis et al., 2007).

During natural breeding, a male typically deposits more semen than necessary to achieve pregnancy, and the process is physically stressful, which limits the number of matings a male can perform. In contrast, collected semen can be diluted and extended to produce hundreds of doses from a single ejaculate. Additionally, semen can be easily transported, allowing multiple females in different locations to be inseminated simultaneously, and can be stored for extended periods, enabling males to produce offspring long after their natural reproductive lifespan has ended (Valergakis et al., 2007).

Artificial insemination allows fewer males to produce more offspring, reducing the need for numerous sires and enabling the selection of only the top males as parents, thereby increasing selection intensity. Additionally, the increased number of offspring per male enables more accurate evaluation of their genetic value through progeny testing. Finally, individual farmers can use artificial insemination to broaden the genetic pool available for mating their animals, potentially reducing the effects of inbreeding (Mulu et al., 2018).

Another significant advantage of artificial insemination is the elimination of the costs and risks associated with maintaining a bull on the farm (Mohammed, 2018). Male animals are generally larger than females, consume more feed, and are often stronger, more powerful, and potentially more aggressive, requiring special housing and handling equipment (Mulu et al., 2018).

Male animals can become large and aggressive, making the maintenance of a bull on a farm potentially dangerous. Furthermore, due to the larger size of adult males compared to

females, natural mating presents a higher risk of accidents and injuries to both the cow and the bull compared to artificial insemination (Mulu et al., 2018).

The use of artificial insemination on dairy farms also reduces the risk of spreading sexually transmitted diseases or genetic defects. Natural mating can transmit venereally transmitted diseases such as brucellosis, listeriosis, leptospirosis, and trichomoniasis between males and females (Mohammed, 2018).

Additionally, collected semen is routinely tested for quality, which helps prevent issues related to male infertility (Mulu et al., 2018). Artificial insemination ideally enables the use of fixed-time insemination, a system designed to manipulate the timing of female estrus, ovulation, and insemination (Mulu et al., 2018).

Disadvantages of AI

Despite the well-known advantages of artificial insemination (AI), many dairy farmers worldwide continue to use natural service bulls to breed their cows. The main reasons for this preference include the higher costs associated with AI compared to maintaining herd bulls and additional expenses due to extended calving intervals caused by low heat detection rates with AI. The costs of AI encompass labor, equipment, liquid nitrogen, semen, and multiple "services per conception" (Valergakis et al., 2007). Additionally, the availability of economically priced liquid nitrogen for semen cryopreservation is a significant constraint on the widespread use of AI (Mohammed, 2018).

AI requires precise timing to maximize conception rates, and its success heavily depends on the skills of inseminators, leaving room for human error. Effective and efficient AI is a trained skill that demands significant time and practice, necessitating a qualified veterinarian or animal technician, which can be costly (Mohammed, 2018).

Other disadvantages of AI include poor conception rates due to inadequate heat detection, low efficiency of AI technicians, and the potential for spreading reproductive diseases (Mohammed, 2018).

Furthermore, high costs associated with semen collection, processing, storage, and transport, as well as budgetary and administrative challenges, contribute to the drawbacks of AI (Mohammed, 2018). When receiving semen from another state or country, timing becomes even more critical, as it must arrive within the appropriate time frame for thawing and insemination. AI can be labor-intensive, requiring precise alignment of the cow for insemination and frequent veterinary checks, which adds to the cost. Additionally, AI may reduce the value of stock and increase the risk of inbreeding (Shehu B M et al., 2010). The process is also limiting, if necessary, resources are unavailable, requiring specialized knowledge, trained personnel, and significantly more time to execute effectively compared to natural service, often leading to increased expenses (Mohammed, 2018).

1. Specialized equipment is needed. An artificial vagina (AV), thermometers, warmed containers and equipment non-spermicidal gel and equipment to measure motility (warmed stage microscope) and sperm concentration are all necessary for AI to be practised properly. This is expensive and a well-equipped laboratory may cost in vicinity of $40 000 just for the equipment (without the building and fittings).
2. Technical expertise is needed. Personnel need to know how to make the AV so that it is right for the stallion and then how to collect and process the semen properly.
3. Improper artificial insemination practices can adversely affect reproductive outcomes. For example, the use of an inappropriate lubricating gel in the artificial vagina (AV) may go unnoticed for several weeks, resulting in markedly reduced pregnancy rates.

Nutrition : A Critical Lever To Sustain Milk Production Under Heat Stress

As dairy experts start paying more attention to cow lifetime productivity, they understand how cow longevity and milk production are affected by reproduction performance, animal health, and stress mitigation. In this regard, heat stress is one of the most important factors which negatively impacts cow lifetime productivity because it may reduce milk production, fertility and compromise the immune system.

Heat stress commonly costs ~5–20% of daily milk yield during hot/humid periods and can exceed 25–30% reduction during severe heat waves—but the exact loss depends heavily on Temperature-Humidity Index (THI) level, duration (cumulative heat load), night cooling, lactation stage, parity, and cooling infrastructure.

Heat Stress : A Systemic Challenge

Producers often see reduced feed intake as the main driver of lost milk. But we now know heat stress is more complex. Elevated temperatures can trigger a cascade of physiological responses. For example, in the gastrointestinal tract, heat stress leads to a decrease in rumen pH and thus alters microbial fermentation, but it also negatively impacts gut integrity, resulting in dehydration and inflammatory responses. On the fertility side, heat stress reduces cow pregnancy rates by decreasing oestrogens in blood, suppressing follicular dominance and reducing embryo quality. All contribute to losses that cannot be recovered over a lifetime of production. The good news is dairy cow diets can be tailored to reduce internal heat, while key micronutrients help relieve heat stress and support normal body functions.

Modern dairy cows are metabolically more demanding than ever before. Nutrition is one of the most effective tools we must master to help cows maintain productivity and resilience when environmental conditions become challenging.

The Role Of Nutrition

When looking at nutrition for mitigating heat stress, mineral and electrolyte balance is the first critical challenge. Water, potassium, and bicarbonate losses increase significantly under heat stress due to sweating and panting, which are important mechanisms for heat dissipation. The rise in environmental temperature from 21°C to 32°C increases water loss from panting by 55% and from sweating by 177%. Furthermore, dehydration makes heat dissipation more difficult.

Electrolytes are substances that help the animal absorb water across tissues, including the intestinal wall. Electrolytes make up part of the dietary cation-anion difference (DCAD). A positive DCAD diet can be fed on an as-needed basis to lactating cows while helping to get water into the animal's system.

Electrolyte management, particularly potassium, sodium, and magnesium, plays a central role in maintaining cellular hydration and acid-base balance during heat stress. The goal is to support a more favourable dietary cation-anion difference while avoiding unintended rumen disruption. However, feeding potassium for long periods of time can lead to kidney failure among other issues and increasing DCAD balance of dry cow diets can lead to metabolic diseases. Therefore, other nutritional solutions can be used in dairy cow diets for mitigating heat stress , including osmolytes, compounds that work at the cellular level to maintain cell volume and hydration. Osmolytes prevent cells from becoming dehydrated and help maintain the expression of heat shock proteins. Osmolytes also help with absorption and have been shown to prevent leaky gut syndrome. To achieve optimum responses, osmolytes should be added to diets at least 10 to 14 days before the onset of heat stress.

Another important challenge is to counteract the decline in feed intake with diets more concentrated in nutrients and rumen buffers, without exacerbating metabolic heat production.

General Recommendations Are :

1. Feeding high-quality rumen-bypass proteins to avoid energy losses due to urea metabolism.
2. Feeding higher-quality forages to increase the energy content of the diet and decrease the heat of fermentation while supplying effective fibre to maintain rumination and pH.
3. Increasing bypass starch because rapidly fermentable starch during heat stress can

increase the risk of acidosis at a time when saliva production, a key rumen buffer, is already reduced.

4. Including strategic fat to help raise energy density without increasing rumen heat load. When used carefully, fats allow producers to meet energy requirements while keeping starch at controlled levels.

Beyond macronutrients, micronutrition has emerged as a valuable tool in heat stress nutrition programs.

Vasodilators are a group of compounds that work to dilate blood vessels, increasing blood flow in the skin and allowing heat to escape. Skin vasodilation naturally occurs in the animal during heat stress and can be easily enhanced with ingredients. However, vasodilators should be used carefully due to their tendency to decrease blood flow to the gastrointestinal tract, which may lead to leaky gut syndrome.

Other speciality ingredients present in the market are gut-protective compounds, antioxidants, anti-inflammatory and post-biotics. During heat stress, intestinal integrity is often compromised, increasing the risk of inflammation and toxin translocation.

Supporting gut health is essential if we want cows to recover more quickly from thermal challenges and sustain lifetime production.

These nutritional strategies are not quick fixes. Many require 10 to 21 days to reach full physiological effect, underscoring the importance of proactive planning rather than reactive formulation changes once temperatures spike.

The Role Of Thermal Management

Effective heat stress mitigation is also addressed with management. There are several strategies used to combat the effects of heat stress, including:

Air movement: Ensure proper air movement, fan placement and cleanliness when barn temperatures exceed 18°C.

Water availability: Access to fresh, clean and abundant drinking water remains non-negotiable; intake and milk output can decline rapidly with even minor water restrictions. A cow milking 35L/day at 21°C drinks 114L of water. The same cow at 32°C drinks 136L of water or more. Finally, timed sprinkler systems over alleyways are crucial to combating heat stress.

Timely feedings: To maximise intake, make sure fresh feed is available every evening during cooler nighttime temperatures. Increasing the proportion of daily ration delivered during early morning and late evening encourages cows to eat when thermal load is lower. Cows can consume 2/3 of their diet during cooler nighttime temperatures.

Total mixed rations (TMR) Savers: Calcium propionate or other propionic acid-based products can help reduce the potential for yeast and mould growth, preserve feed, and enhance bunk life.

Integrated Solutions To Combat Heat Stress

Progressive dairy nutritionists build high-performing diets by adapting to changing ingredient quality and animal needs. Cargill Animal Nutrition & Health offers the MAX System for Dairy, a rationing tool that leverages nutrition expertise and global research to help develop nutritional solutions tailored to every herd, focusing on the precise nutrients that support health and productivity.

Dairy MAX is fully integrated with Cargill laboratories and feed manufacturing plants to guarantee a consistent nutrient supply in real-time. The system runs its calculations within CNS, the Cargill Nutrition System, enabling dynamic closed-loop feedback incorporating herd management and environmental conditions, such as assessing the impact of heat stress on nutrient requirements and identifying the right "summer nutrients" to optimise diets.

Dairy MAX includes an additive evaluation tool that demonstrates the value of including solutions like Diamond V ICE Plus in summer diets. Diamond V ICE Plus is a unique, synergistic blend of micronutrients that helps lessen the heat's impact on milk production and reproductive health by supporting cow cooling at the cellular level.

Diamond V supports this solution with proven data backed by two decades of use in rations, field trials, and controlled studies to support cows during heat stress.

For a fully integrated solution, Cargill nutritionists can also support farms with Dairy Enteligen, a digital platform developed to optimise the management of dairy farms. Combining automatic data collection, visual management, and financial projection tools, the platform offers a comprehensive view of daily operations, allowing producers to monitor their herd's health and productivity in real time.

Through personalised graphs, reports, and alerts, Dairy Enteligen helps identify opportunities for improvement, correct inefficiencies, and implement strategies that maximise lifetime production and farm profitability. In addition, the platform integrates different systems and devices, connecting all aspects of production into a single intuitive interface, facilitating informed and assertive decision-making, as is required for heat stress management.

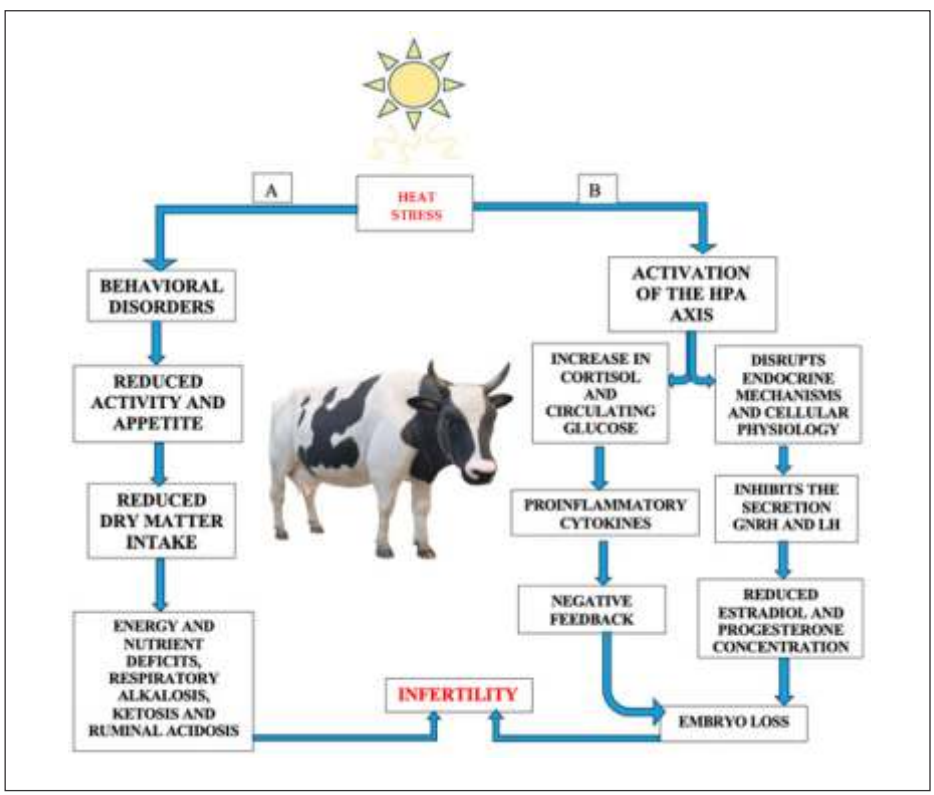
Conclusion

Heat stress is no longer a seasonal inconvenience—it is a systemic and recurring challenge that threatens both immediate performance and long-term herd productivity. As environmental pressures intensify and cows become increasingly metabolically demanding, the industry must shift from reactive responses to proactive, integrated strategies.

Nutrition stands out as one of the most precise and powerful levers available. By balancing electrolytes, optimising nutrient density, supporting gut integrity, and leveraging targeted micronutrients, producers, supported by expertise and integrated solutions from partners like Cargill Animal Nutrition & Health, can help cows maintain hydration, metabolic stability, and resilience under thermal stress.

However, success depends on early planning, consistency, and a holistic approach that aligns feeding programs with sound management practices.

Ultimately, mitigating heat stress is about preserving lifetime performance—not just surviving the summer. Producers who adopt forward-looking nutritional and management strategies will be better positioned to protect animal welfare, sustain milk production, and drive long-term profitability in an increasingly challenging climate.



Metabolic Pathways of Lactation In Dairy Cattle

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INTRODUCTION

Mammals invest considerable energy and nutrient resources to establish and sustain gravidity to full term. Consequently, a high probability of offspring survival requires further maternal care after birth in the form of lactation. The availability of mammary gland secretion during lactation supports the development of the offspring in many ways, such as providing immunization and nutrition and strengthening mother–offspring bonding. The domestication of ruminants and breeding for milk production in dairy cows to levels far beyond the needs of their own offspring are essential for the maintenance of human food security in terms of meat and milk production. The driving forces pushing dairy cow selection toward higher performance resulted in a continuous increase in milk production in recent decades.However, milk production challenges the metabolism and health of dairy cows. Although complex adaptation processes take place to enable the maintenance of the animals' energy and nutrient homeostasis, many individuals fail to successfully cope with the genetically imposed burden of meeting the requirements for the metabolically prioritized mammary gland in early lactation. Consequently, metabolic stress arises with various effects on the immune system, reproductive performance, milk yield, product quality, and the overall well-being of the dairy cow. In particular, public perception of industrialized dairy cow farming, the controversial discussion about ruminant-derived greenhouse gas emissions, the high dependency on feed sources suitable for human nutrition, and the apparently abundant use of antibiotics do not support the reputation of modern dairy farming. Public concerns must be taken seriously,keeping in mind that the agricultural industry depends on the consumers who purchase the products. Awareness of ethical and animal welfare issues has increased, and customer concerns and perceptions have considerably shaped the way of agriculture (e.g., organic farming, banning of hormones and growth-promoting agents in livestock production in many countries. The market demand for dairy products depends on consumer acceptance, which generates income for dairy farmers. An efficient and sustainable dairy business requires a serious and continuous rethinking of management practices.However, cows adapt more or less successfully to metabolic challenges.Production diseases are not necessarily related to performance level, although the risk increases with higher performance. Our recent research aimed at identifying more robust and resilient dairy cows revealed that adaptation response patterns are flexible at

later lactational stages. This metabolic plasticity implies the extent to which a cow tolerates catabolic stages without developing health disorders.

CLASSICAL BREEDING STRATEGIES, ASSOCIATED RISKS FOR ANIMAL HEALTH, AND IMPORTANCE OF METABOLIC PLASTICITY

The onset of lactation in dairy cows is characterized by a high priority in directing nutrients to the mammary gland Despite the presence of a negative energy balance (NEB), milk production is maintained and further increases until peak lactation. Thus, the survival of the milk-fed offspring is ensured. Recent studies showed that overall lifetime performance and longevity must be improved to achieve more efficiency and sustainability in milk production. Losses up to 15% due to culling occur during the rearing phase of animals before they actually start to produce milk. The classical approach and aim of feeding animals according to their energy and nutrient requirements throughout all stages of the gestation–lactation cycle is not always possible. Owing to the limited feed intake capacity and restrictions from the cow's side (e.g., limited capacity for glucose and lipid absorption, maintenance of rumen function), the actual requirements cannot be met by feeding and must be covered by a tremendous mobilization of body reserves.

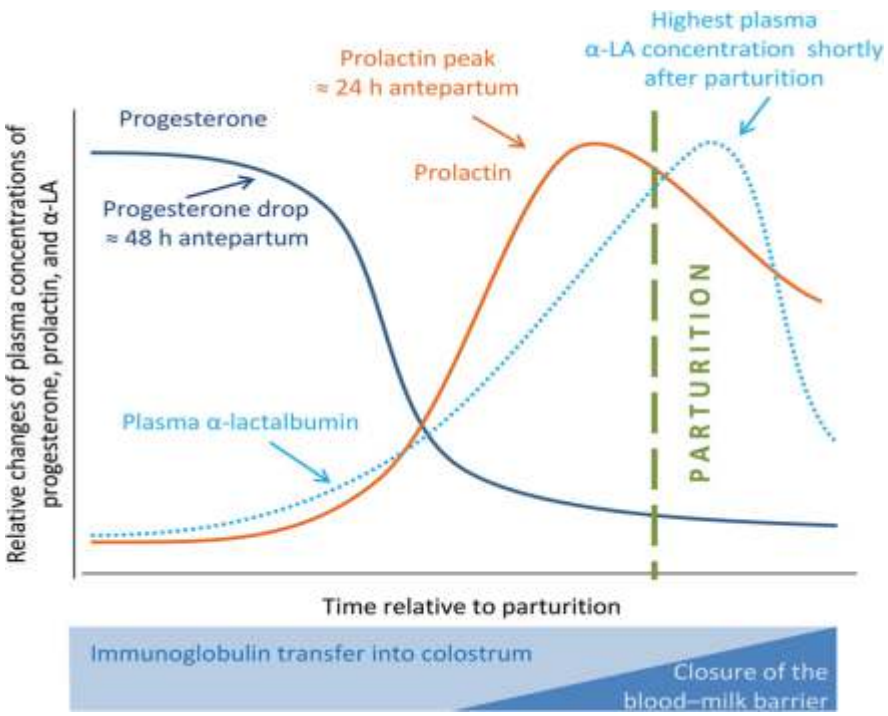
CONSEQUENCES OF FEEDING INTENSITY AND MANAGEMENT FOR MAMMARY GLAND DEVELOPMENT AND REMODELING

Recently, ad libitum feeding of milk and milk replacer to calves in early life was recommended to stimulate mammary gland development and to achieve a better lifetime performance. However, epigenetic effects caused by feeding level are assumed to be effective only in early life. Still, restricted prepubertal feeding is recommended to achieve a high degree of development of parenchymal structures and a low portion of adipocytes in the mammary gland, with direct effect on later lactational performance. Excessive prepubertal heifer growth allows early breeding on one hand but also results in a high accumulation of fat in the mammary fat pad and only a poorly developed functional parenchyma.

During lactation, no further mammogenesis that might modulate milk production occurs in bovine species. Although rearing in early life significantly affects growth and later performance, adult cows may adapt differentially to successive lactations, with a clear effect of the dry period between Drying off dairy cows initiates the process of mammary gland involution and redevelopment.

NECESSITY FOR IMMEDIATE COLOSTRUM AVAILABILITY AND CONSEQUENCES FOR ENDOCRINE AND METABOLIC ADAPTATION AROUND PARTURITION

Newborn calves depend on the timely supply of IgG via colostrum in their first hours of life (Furthermore, precocial animals such as bovines require milk that is rapidly digestible and frequently available immediately after birth . Compared with other species, endocrine changes in dairy cows, in particular the decrease in progesterone and peaking concentrations of prolactin and glucocorticoids, occur before the



end of term and enable the onset of copious milk production directly at parturition. Thus, milk is immediately available for the newborn calf. Furthermore, significant amounts of colostrum could already be obtained during the few hours before parturition Within a very narrow time frame in the periparturient period, quality and volume of mammary secretions could be replenished after milking once prepartum. This could ensure the neonatal supply of sufficient IgG in cases of dystocia and milk leakage before calving. However, with the second milk removal (suckling or machine milking), concentrations of IgG rapidly decline as the blood–milk barrier closes. Concomitantly, digestive tract activity on calves increases and intact maternal antibodies can no longer be transferred across the intestinal barrier.

ADAPTATION MECHANISMS ASSOCIATED WITH CHANGING METABOLIC REQUIREMENTS OF THE MAMMARY GLAND DURING THE COURSE OF LACTATION

The transition from late gestation to lactation is considered the most striking and challenging period in the lactation cycle of dairy cows. The evolutionarily anchored maternal care behavior established lactation to provide a customized, complete food for the offspring over a long period . The constant availability and composition of milk widely independent of the dam's nutritional and health status ensure growth and survival of the neonate .The gradual development of the calf to a ruminant is indirectly reflected by the shape of the lactation curve: the sharp increase of milk production until peak lactation mirrors the growing and initially exclusive demand from the calf, whereas the declining phase of the lactation curve coincides with the decreasing importance of milk as the sole feed source. Corresponding with the lactation curve, metabolic priority and requirements of the mammary gland change distinctly, thereby draining nutrients from circulation toward milk synthesis with changing tenacity. Knowledge about physiological adaptation responses of the mammary gland to available nutrients at various stages of lactation is essential for making management decisions (e.g., selection for breeding, formulation of diets, time of insemination, and so on).

High milk production in the first days of lactation concomitantly implies elevated energy and nutrient requirements; however, the decline in periparturient DMI and the already low feed intake level do not cover the needs. Due to the selection toward greater lactation performance, particularly during the early lactation period, initial milk yields above 30 or 40 kg/d in the first days of lactation are common and not exceptional. Thus, the prevailing NEB triggering lipolysis already exposes high-producing cows to metabolic stress at the time of calving. Consequently, predisposition to metabolic and infectious diseases is initiated at the very beginning of lactation. Additional factors such as inadequate feeding and overconditioning during the dry period may further aggravate metabolic adaptation and favor hypocalcemia, endometritis, and so on.

CONCLUSIONS AND OUTLOOK

The question of whether breeding aggravated metabolic priority of the lactating mammary gland to achieve today's performance level in dairy cows cannot be answered completely. The evolutionarily conserved direction of nutrients to the mammary gland immediately after calving certainly provided the basis for successful selection toward higher milk yields. Endocrine and metabolic adaptations differ distinctly among developing, remodeling, and lactational stages of the mammary gland. Any changes in management practices create new challenges. Early metabolic programming and rearing strategies of calves determine the later lactational performance of cows. Additionally, failures in adult cow management between successive calvings affect metabolic adaptation mechanisms in the following lactation period. Although high milk production imposes challenges on animal health, feeding, and management, the considerable variation in adaptation mechanisms creates perspectives for more efficient and sustainable dairy farming. Metabolic plasticity describes the adaptation capacity of the whole organism, particularly the mammary gland, depending on available energy and nutrients. Approaches toward more sustainable dairy production must take the different functional stages and the associated adaptation mechanisms of the mammary gland into account. Individual variation in metabolic plasticity in early-lactating dairy cows might be a target for future dairy cow breeding.

2026 Market Outlook : Shared Pressures Across Livestock Production

Hamlet Protein CEO Erik Visser shares his outlook on the key topics that will shape our markets in the coming year and their impact on animal protein and animal nutrition supply chains.

Animal protein production will continue to grow in 2026, but not for all species. Poultry and aquaculture will keep momentum, while swine and ruminant production will decline. Geopolitics will continue to influence trade flows across the globe, and disruptions impacting the entire supply chain can flare up anytime. The most important bilateral relationship to watch for will be the one between China and the US.

Feed costs are expected to remain stable, allowing producers to invest in speciality ingredients and additives. Soybean meal (SBM) cost levels are forecast to remain stable. Nutritional strategies will become increasingly important in reaching the animal's genetic potential. African Swine Fever (ASF) and Avian Influenza (HPAI) continue to be a threat to producers worldwide, who will increase their focus on farm management, biosecurity measures, and nutrition to minimise risks.

Regulation in the EU and USA has the potential to have a strong impact on feed, feed ingredients, and feed additive producers alike, and EU regulation specifically may affect the competitive positioning of European producers versus their global peers. Sustainability efforts of the industry will move beyond a focus on compliance towards integral risk management strategies that not only mitigate for climate-related risks but also seek to adapt business models.

Geopolitics : Risks Remain

After the initial shock of the 2025 US trade policies, the markets seem to have stabilised. Do not be fooled by that, as geopolitical risks will remain significant and disruptions can flare up anytime.

The question is no longer whether the US will use tariffs as a political tool, but to what extent, and what the knock-on effects of those tariffs will be

A challenge to the so-called "reciprocal" tariffs on goods from individual countries and for levies imposed on China, Canada, and Mexico tied to the flow of fentanyl into the U.S. was argued before the U.S. Supreme Court in late 2025, and a decision is expected in early 2026. Watch especially for the impact of the US-China trade relationship on soy- and pork exports from the US, and its implications for global markets. The current trade agreement will expire in the second half of 2026, and, combined with the US midterm elections coming up in November, this may be enough motivation for the current US administration to reach a deal with China.

The free trade deal with the two largest U.S. trading partners, Canada and Mexico, is up for review in 2026 amid uncertainty over whether the US will let the pact expire or try to renegotiate key provisions.

The European Union will assess its trading relationship with China, and tariffs or other measures will be considered as options to address the growing imbalance in their trading ties.

Global Economy : Watch AI, China and US

Current projections will see 2026 deliver stronger economic growth than expected earlier: +3%, mostly driven by China (+5%) and the US (+2.5%). Growth in the Eurozone will be more sluggish at +1.2%. Watch out for the large stock that was built by US companies in 2025, to avoid the impact of increasing import rates, which reduced the inflationary effect of the US trade policies. If we see a delayed effect in 2026, and that effect is strong enough, then this could impact growth rates.

Artificial Intelligence (AI) may not impact the real economy to the same extent, but it is already playing a role in the financial markets. Large investments and strong valuations will be affected in a possible market correction. At the same time, advancing technology will impact labour markets and productivity and, as such, affect economic growth. While China has grown to become a dominant player on the global political and economic stage, the less predictable US trade and

foreign policies create an opportunity for the European Union – and the EURO – to grow its global influence.

Animal Protein : Slowing Growth

Growth in animal production will slow down in 2026 to less than 0.5%. While poultry and aquaculture will continue to grow, swine and ruminant production will stabilise or show a slight decline. Producers will face tighter margins due to disease, higher trade costs, and trading down by price-sensitive consumers.

Efficiency will be the name of the game, and nutrition will play a key role in reaching the animal's genetic potential

Markets : Mixed Picture

The global demand for animal protein is being supplied through local production and imports. Disease outbreaks, regulation, and trade policies are key factors in determining where production will take place. Whenever a market disruption takes place, one of the competing export blocks will quickly step up production volumes to benefit from the emerging opportunity.

Europe will see pork and poultry production grow, but political pressure on agriculture may cause volumes to shift from NWE to CEE. North America will see modest growth in swine, while poultry will accelerate. Southeast Asia is set to deliver increased pork production, but African Swine Fever remains a challenge. Poultry production will see strong growth.

Following government-mandated herd contraction at the end of 2025, China will see its swine production decrease. South America will see growth across all species, primarily driven by Brazil. The EU-Mercosur interim trade agreement may create growth opportunities for beef and poultry exporters. Multinational companies that offer a diversified product portfolio, serve a broad range of species, and have market share in all regions are best positioned to deal with changing market conditions and shifting consumer preferences.

Feed Costs: Stable

Feed costs can account for up to 70% of total production costs, which is why it is such an important KPI to track. An intensification of the La Niña phenomenon could reduce crop yields in South America – particularly soy and maize – and impact anchovy fishing in Peru, which is essential for producing fishmeal and fish oil.

Feed costs are expected to remain stable, or trend moderately lower, in 2026, allowing producers to invest in speciality ingredients and feed additives inclusion to drive the health and performance of their animals

A potential risk could come from deteriorating trade relations between the EU or the US on one side and China on the other. As China produces more than 70% of the world's vitamins and many critical amino acids, including more than 75% of the world's lysine and more than 25% of methionine, access to Chinese suppliers is critically important for feed producers.

SBM : Stable

Soybean Meal (SBM) has evolved from a traditional agricultural crop into a global strategic instrument. Although production reached record levels in 2025, pricing not only relates to available quantity, but also to politics, sustainability, and traceability are becoming ever more important.

China is by far the biggest importer of soybeans and has a large crushing capacity. The trade relation with the US will determine whether their volume will be sourced from the US or Brazil. After China, Europe is the largest importer of soybeans and SBM, predominantly from South America. The EU's own soybean harvest, all of it non-GM, is insufficient to serve the demands from the industry. The implementation of the EUDR, the strategic restructuring of U.S.–China trade relations, US and Brazilian biofuel policies, US farm subsidies, and logistical pressures in South America will define the soybean meal markets in 2026.

Our current view is for price levels to remain stable in 2026

Ocean Freight : Low Predictability

After years of unprecedented supply chain disruption – from the Covid-era chaos to the Red Sea crisis distortion – stability is not yet in sight. 2026 will see a strong influx of new vessels, increasing the global fleet capacity by as much as 5%. At the same time, the potential reopening of the Suez Canal will lead to short-term disruption. Couple that with the unpredictable nature of tariffs and volatility in pricing and availability, and it is going to be the only certainty in the new year.

Energy Costs: Downward Trend Oil & Gas

Gas and electricity are important cost factors in the production of fertilisers, resulting in an indirect impact on feed costs, and in the production of animal nutrition and feed specialities. Oil is an important driver for transportation costs and for producing certain feed commodities. 2026 will see pressure on oil and gas prices due to expected oversupply. Oil because of OPEC ending its voluntary production cuts, and gas due to new liquefied gas (LNG) capacity being brought on stream. Electricity pricing is expected to see an upward trend, following increased demand.

The ongoing war in Ukraine, an unstable ceasefire in the Middle East, and the potential for further escalation in Venezuela will keep supply chains and energy security exposed to sudden disruptions. On the other hand, we could see Europe benefit from a cessation of hostilities in Ukraine and normalisation of energy supply from Russia. While the energy transition advances, it does so at a slower pace following recent policy changes and a lack of storage capacity in major markets. Still, wind and solar energy are set to become ever more important in the energy mix.

Labour Market : Risk of Shortage of Skilled Workers

In 2026, the industry's workforce will continue to shrink. A rising number of retirements, a slowdown in attracting new talent, and restrictive migration policies will put pressure on animal protein and animal nutrition producers alike. Automation may be part of the answer, but the industry will need to focus on highlighting the importance of producing safe feed for food and how young professionals can contribute to feeding a growing global demand. Feed mills, farms, and integrators alike should have a strategy in place to cover their future workforce, invest in hiring, training, and retaining skilled workers, and offer compensation packages that allow them to compete with other industries.

Disease outbreaks: Impact Continues

Where, and to what extent, diseases will affect markets is impossible to predict. That we will experience disease outbreaks in 2026, and that this will affect animal protein supply chains, should be considered a certainty.

Outbreaks in local markets will disrupt export flows, drive up costs for producers, and impact price levels

African Swine Fever (ASF) and Avian Influenza (AI) will be the most widespread diseases that will impact local and export markets. Combined with emerging diseases like New World Screwworm, Foot and Mouth Disease, and Bluetongue, the risk of these outbreaks will drive increased biosecurity measures.

Regulation : Major Policies Under Review

The implementation of the European Deforestation Regulation (EUDR) was delayed by another twelve months in December 2025. The legislation targets seven key commodities, amongst which cattle and soy are directly related to animal protein and animal nutrition. On 30th April, the EU will review reporting demands under the EUDR, and during the year, a clearer timeline for its implementation is expected to be confirmed.

An important adjustment that has been announced already is that the responsibility for EUDR-compliant sourcing will be limited to the company that introduces SBM on the European market.

In the US, the Innovative Feed Enhancement and Economic Development (FEED) Act is pending in Congress with bipartisan support. The legislation aims to modernise the current FDA's regulatory framework to allow approval of feed ingredients offering benefits beyond basic nutrition. This will mean a huge step forward for both US manufacturers and importers to communicate more effectively on the health and performance impact of feed additives.

The use of medication in feed formulations in general, and antibiotic growth promoters (AGP) in particular, will be subject to ever-increasing regulation. As there is no single product that can replace antibiotics, a multi-faceted nutritional approach will be needed to drive animal health and performance.

Regulatory frameworks will provide growth opportunities for feed additives and speciality ingredients producers

Sustainability: A Strategic Pillar

Sustainability is no longer a nice-to-have, but a must-have throughout the supply chain. That does not mean all sustainability efforts can be

monetised. Customers will select suppliers based on sustainable practices, without necessarily paying a premium. Animal protein producers will increasingly focus on optimising feed for better efficiency, reducing their environmental impact, using alternative ingredients, and improving animal health and welfare. At the same time, risk management is becoming a more important element in sustainability practices, as future investments will increasingly consider climate change. Finally, regulatory demands will force producers to integrate sustainability policies into their strategic planning.

Mergers & Acquisitions : Increased Deal making

Expect an increased M&A activity in 2026, after several years of limited deal-making in animal nutrition and animal protein markets. Multinational companies and private equity (PE) seeking scale and efficiency will focus on sustainability, technological integration, and strategic consolidation.

Large, integrated companies are looking to streamline their portfolios, divesting non-core animal nutrition assets to focus on areas where they have a stronger, more competitive position. Private equity firms are actively deploying capital and consolidating mid-sized suppliers of speciality additives, attracted by the sector's resilience and consistent growth. And inorganic growth by current midsize players to expand geographically, add technology, or drive portfolio diversification will further boost M&A activity. Large transactions, like the planned sale of DSM-Firmenich's animal nutrition division, may accelerate further consolidation in the industry.

Artificial Intelligence (AI) : Evolution Not Revolution

Artificial intelligence (AI) in animal protein and animal nutrition production will be a matter of evolution, not revolution, as implementing it in a conservative business environment like ours is likely to be challenged by farm managers and nutritionists alike. We do expect an increased focus on using data from multiple sources to create tailored and optimised diets for different animal species and monitoring of individual animal feeding behaviours for early detection of health or nutrition challenges. At the same time, AI will be applied to support sustainability initiatives, like optimisation of water and energy usage, reduction of waste, carbon footprint tracking, and improved manure management, for example.

Effective August 11, 2026 Milk prices across Maharashtra have increased by ₹2 per litre for both cow and buffalo milk.

The Milk Producers and Processors Welfare Association (MPPWAM) approved this state-wide price revision due to an escalation in operational expenditures. Under the new pricing structure, the retail cost of cow milk has risen from ₹60 to **₹62 per litre**, while buffalo milk has increased from ₹76 to **₹78 per litre**

The price revision has sent immediate ripples through household budgets, retail supply chains, and festive food planning across major metropolitan areas such as Mumbai and Pune. This extensive report explores the economic drivers, stakeholder positions, regional market dynamics, and downstream impacts of the dairy sector overhaul.

Overview of the Price Hike

The price structure adjustment is uniform across all private and cooperative dairy federations operating in Maharashtra. This baseline shift ensures regional pricing parity but forces consumers to modify their monthly grocery forecasts.

Core Economic Drivers of the Hike

A combination of macro-economic constraints and agricultural resource inflation caused the price adjustment. Dairy processors argued that operational absorption limits had been breached, making a retail price pass-through unavoidable.

1. Surging Logistics and Diesel Costs

Logistics remain the single largest variable component in daily milk procurement and urban supply networks. The association highlighted that **diesel prices surged by ₹10 per litre**. Because milk collections require thousands of daily routes from rural collection kiosks to cold-chain processing plants, transportation costs grew exponentially.

2. Escalation in Packaging Materials

The cost of food-grade low-density polyethylene (LDPE) pouches and secondary crates saw a **30% spike in packaging expenses**. Supply chain constraints on plastics and printing inks intensified production-level overheads for processed pouch milk

3. Fodder and Milch Animal Inflation

Dairy farming overheads at the grassroots level expanded significantly. According to spokespersons from the dairy collective, the prices of high-protein cattle-feed, dry grass, and straw inflated by **15% to 25%**. The capital cost required to purchase healthy milch cows and buffaloes followed a matching upward curve, raising entry and maintenance barriers for rural dairy producers

4. Competitive Procurement Pressures

To secure stable daily yields from rural areas, cooperative networks like Gokul and Katraj had to elevate their base procurement prices paid directly to farmers. Failing to raise these prices would risk losing milk supplies to private dairies or cross-border processors in neighbouring states like Andhra Pradesh and Karnataka

Downstream Impact on Dairy By-Products

Liquid milk serves as the raw base ingredient for an extensive consumer market segment. Because processors now encounter higher base input rates, the prices of secondary and tertiary dairy items are projected to climb by **up to 10%**.

Fresh Curd & Yogurt: Expect standard retail cup and pouch pricing to scale upward shortly.

Paneer (Cottage Cheese): Expected to see direct packaging premium additions.

Ghee & Butter: Bulk fats will require greater input volumes, forcing a tiered price hike across top commercial brands.

Confectioneries & Sweets: Traditional sweet shops (Mithaiwalas) anticipate a direct rise in production costs for milk-heavy treats like *Mawa*, *Pedha*, and *Barfi* ahead of major regional festivals

Policy, Administration, and Governance Frameworks

The administrative landscape surrounding dairy pricing remains a delicate balance between free-market mechanics and state-level intervention policies

The Minimum Support Price (MSP) Stance

The union governance structure has explicitly stated that **there is no active proposal to introduce a Minimum Support Price (MSP) for milk**. The Ministry of Fisheries, Animal Husbandry, and Dairying reconfirmed that dairy pricing remains fully deregulated. Prices will continue to adapt dynamically according to market supply, consumer demand, and seasonal fluctuations

Balancing Rural vs. Urban Welfare

The state administration faces a dual challenge

Farmer Remuneration: Securing higher cash flows for farmers to shield them from agricultural inflation. For instance, regions like Sangli expect a collective injection of **₹17 lakh additional daily**

income directly into the local agrarian economy.

Consumer Affordability: Guarding the budgets of low-income urban families who depend heavily on milk as a foundational source of dietary protein

National Production Context

While regional prices reflect immediate local inflationary pressures, India's aggregate dairy production capabilities continue to expand National milk yields climbed steadily from **146 million metric tonnes (MMT) in 2014-15 to 248 million metric tonnes (MMT) in 2024-25**. This structural volume expansion protects the country from relying on international dairy imports, though it does not fully insulate urban consumers from localized logistical and fuel price shocks

If you would like to analyze how this adjustment changes your household outlays, tell me your **average daily consumption volume** or your **preferred milk brand**. I can map out your exact monthly budget variance

The National Dairy Development Board (NDDB) has mobilized ₹1,500 crore to establish 25 Milk Producer Organisations (MPOs) across India, with women members contributing ₹326 crore.

India is the world's largest milk producer, contributing nearly 25% of global output, with women forming the backbone of the sector by accounting for around 70% of the dairy workforce. Despite their central role in rearing cattle, milking, and managing day-to-day dairy operations, women historically had limited control over income, assets, and decision-making within the value chain.

Over the past 12 years, NDDB Dairy Services has played a transformative role in reshaping this imbalance through the development of farmer-centric Milk Producer Organisations (MPOs). Supported by global and national partners such as the World Bank, JICA, Tata Trusts, and the National Rural Livelihood Mission, NDDB has mobilized ₹1,500 crore to establish 25 MPOs across India, creating structured, professionally managed yet farmer-owned institutions.

A defining feature of this transformation is the rise of women in leadership roles. Out of 25 MPOs, 18 are fully women-owned enterprises. Women now hold 23 chairperson positions and occupy 217 of 256 board seats, reflecting a significant shift toward gender-inclusive governance. In addition, women dairy farmers have collectively contributed ₹326 crore in member capital, underscoring their growing financial stake and confidence in institutional ownership.

The MPO model blends cooperative principles with corporate efficiency, enabling better price realization, improved market access, and transparent income distribution. Across the network, more than ₹60,000 crore has been transferred directly to rural households, with approximately ₹8,000 crore disbursed directly into farmers' bank accounts in the last year alone. As a result, women participants currently earn an average of ₹13,000–₹14,000 per month after expenses, providing a stable and predictable income stream.

Beyond income generation, the initiative emphasizes sustainability and livelihood diversification. Around 75,000 household biogas units have been installed, reducing dependence on LPG while producing clean energy and organic fertilizer. Women are also being trained in allied activities such as food processing, handlooms, and handicrafts, expanding their economic opportunities. NDDB is further working toward launching a dedicated women-owned consumer brand to enhance value capture and market presence.

Looking ahead, NDDB envisions a significant scale-up in productivity and income, aiming to raise average monthly earnings of women dairy farmers to ₹1 lakh within the next decade through advanced breeding technologies, improved cold-chain infrastructure, and stronger governance systems.

Collectively, women-led MPOs are redefining India's dairy sector by fostering economic empowerment, leadership, and sustainable rural development.

Editorial Calendar 2026

Publishing Month: **January** Article Deadline : **18th, Dec. 2025** Advertising Deadline : **20th, Dec. 2025** Focus : **Opportunities and Challenges**	Publishing Month: **February** Article Deadline : **18th, Jan. 2026** Advertising Deadline : **20th, Jan. 2026** Focus : **Budget**	Publishing Month: **March** Article Deadline : **18th, Feb. 2026** Advertising Deadline : **20th, Feb. 2026** Focus : **Summer Stress Management**	Publishing Month: **April** Article Deadline : **18th, March 2026** Advertising Deadline : **20th, March 2026** Focus : **Cold Chain**
Publishing Month: **May** Article Deadline : **18th, April 2026** Advertising Deadline : **20th, April 2026** Focus : **Nutrition**	Publishing Month: **June** Article Deadline : **18th, May 2026** Advertising Deadline : **20th, May 2026** Focus : **Milk - Production & Preservation**	Publishing Month: **July** Article Deadline : **18th, June 2026** Advertising Deadline : **20th, June 2026** Focus : **Monsoon Management**	Publishing Month: **August** Article Deadline : **18th, July 2026** Advertising Deadline : **20th, July 2026** Focus : **Sustainability**
Publishing Month: **September** Article Deadline : **18th, August 2026** Advertising Deadline : **20th, August 2026** Focus : **Processing & Packaging**	Publishing Month: **October** Article Deadline : **18th, September 2026** Advertising Deadline : **20th, September 2026** Focus : **Disease Prevention**	Publishing Month: **November** Article Deadline : **18th, October 2026** Advertising Deadline : **20th, October 2026** Focus : **Biosecurity**	Publishing Month: **December** Article Deadline : **18th, November 2026** Advertising Deadline : **20th, November 2026** Focus : **Winter Stress**

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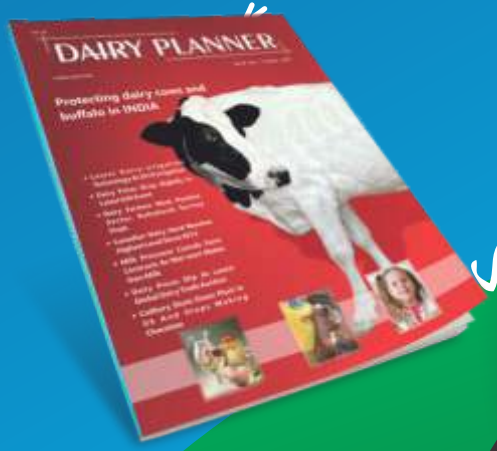

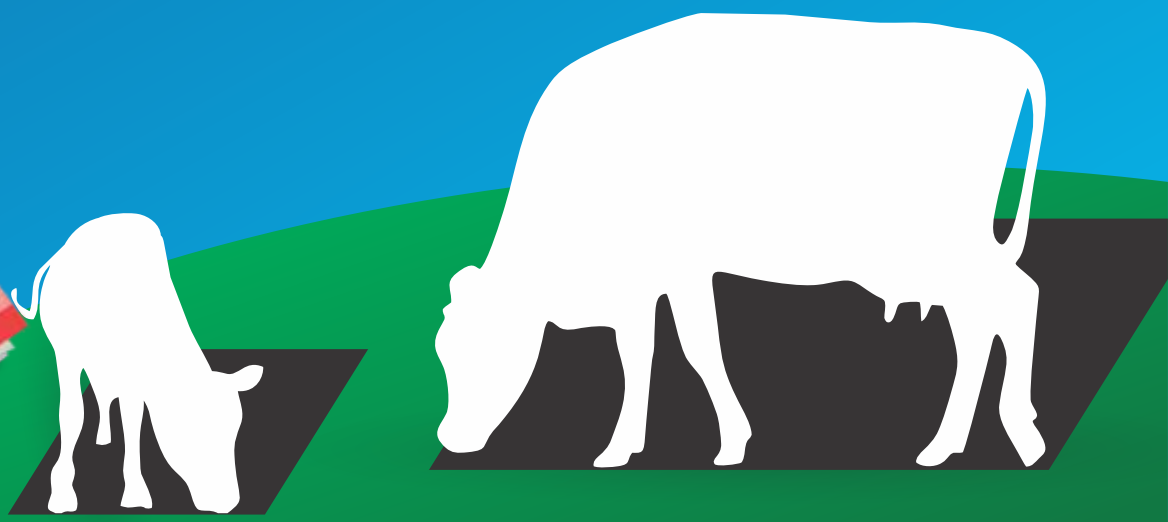

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