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Effect of Feeding Bypass Nutrients on Reproductive Performance of Dairy Animals

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Introduction

India ranks first in milk production, accounting for 24.64 % of global production. The average yield per animal per day for exotic/crossbred is 8.55 kg/day/animal and for indigenous/non-descript is 3.44 kg/day/animal. In recent decades, significant improvements in milk production capacity in dairy cows have coincided with decreased fertility. The energy required to maintain body tissues and milk production often exceeds the amount of energy available from the diet, leading to a negative energy balance. This deficit forces the cows to mobilize body fat reserves to meet their energy needs, resulting in increased utilization of adipose tissue. This increased demand is most pronounced in high-producing cows, prompting a compensatory response involving processes like increased breakdown of fats, production of glucose from non-carbohydrate sources (gluconeogenesis), release of stored glycogen, and mobilization of protein and minerals. Negative energy balance (NEB) is a common occurrence among dairy cattle in the early periparturient period, typically starting around one week before calving due to reduced feed intake. This imbalance becomes evident in early lactation with a decline in body condition, reaching its lowest point approximately two months after calving as cows continue to utilize their reserves of fat and protein.

Due to reduced feed intake towards the end of gestation, the period of negative energy balance often begins before calving. During initial lactation, to meet the high energy demands of crossbred animals producing at high levels, they should either be fed higher levels of cereal grains or given a diet enriched with bypass nutrients. However, increasing the level of concentrates in the diet of high-producing dairy animals to boost energy density reduces fiber intake and can lead to issues such as acidosis and decline in milk fat production. For early lactating or highly productive dairy animals, incorporating fat into their diet helps increase

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energy density significantly, as fat provides 2.25 times more energy than carbohydrates. Supplementing fat in the diet of these animals helps mitigate negative energy balance during early lactation, prevents conditions like acidosis and laminitis, reduces heat production, and supports the incorporation of fatty acids into milk fat.

Nutritional strategies focus on enhancing the nutrient density of diet of periparturient cow to mitigate the negative impacts of reduced dry matter intake. Key energy yielding nutrients include fatty acids, glucose, and amino acids, which serve as fuel or provide essential components for synthesizing fats, proteins, and carbohydrates in the body or milk. Moreover, extensive breakdown of high-quality nutrients in the rumen often reduces their availability to the animal, resulting in nutrient wastage. A promising solution to this challenge is protected nutrient technology, which involves shielding dietary nutrients like fats and proteins from rumen degradation. This allows these nutrients to bypass the rumen and be digested and absorbed in the lower digestive tract more effectively.

Various methods such as heat treatment, chemical treatment, encapsulation, selective manipulation of rumen metabolic pathways have been employed to protect or decrease degradation of nutrients in the rumen. These methods help the nutrients to bypass the rumen and increases the outflow of nutrients from rumen to intestine.

The development of rumen-protected products (RPP) involves encapsulating or coating fats to deliver essential nutrients after the rumen, where absorption occurs without degradation by rumen microbes. This approach offers a solution to reduce methane and waste production resulting from overfeeding nutrients in the diet. Rumen-protected nutrients such as fatty acids, amino acids, and vitamins can address nutritional deficiencies in diets and feed ingredients by targeting specific nutrients rather than relying on whole groups that may provide excess of some and deficiency of others. The objective of bypassing rumen is to save the beneficial unsaturated fatty acids from microbial bio-hydrogenation. It has been shown that supplementation of concentrate and bypass fat with fresh grasses significantly improves feed intake and livestock performance. The supplementation increases energy, proteins, minerals, and vitamins intake, and a good quality forage, helps to overcome the problem of low palatability, leading to better production. However, recently the nutrients like fat, vitamins, amino acids and probiotics are also given to the animals in rumen protected form to obtain maximum productivity.

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Role of bypass nutrients in pre-pubertal heifers

In heifers, maturity is determined by body weight rather than age. Underfeeding or an unbalanced diet slows down growth rates. Providing heifers with low-energy and low-protein diets can reduce their overall productive and reproductive performance, particularly delaying puberty and sexual maturity. Factors such as insufficient energy intake, poor body condition, and reproductive diseases can prolong the time before cyclic reproductive activity resumes. Negative energy balance (NEB) results in inadequate release of reproductive hormones, contributing to delayed postpartum estrus and ovulation. Cows experiencing these conditions are at higher risk of being culled by dairy producers to improve economic returns. In a study, supplementation with an experimental diet containing bypass protein, bypass fat, rumen-protected choline, rumen-protected niacin, and probiotics was found to significantly reduce the age at first estrus by 2 months.

Role of bypass nutrients during transition period

During the transition phase, dairy animals require high energy supplements to mitigate the negative effects of reduced dietary intake and weight loss. To ensure optimal nutrition during periods of high nutrient demand, utilizing protected or bypass dietary nutrients is a promising strategy to improve both the quality and quantity of animal production. Several hypotheses propose the role of fatty acids in enhancing reproductive performance in dairy animals. These hypotheses suggest that improving energy balance can lead to earlier resumption of post-partum ovarian cycling, increased linoleic acid levels may boost $PGF2\alpha$ production, promote ovarian cycling and follicular recruitment, and higher progesterone secretion, influenced by improved energy balance or impact of dietary fat on lipoprotein composition, can enhance fertility. Furthermore, bypass fats, which serve as precursors for progesterone through cholesterol and prostaglandins, are considered beneficial as energy supplements during the transition period, potentially improving reproductive performance.

Role of bypass fat in anestrus animals

The reproductive physiology and secretion of reproductive hormones are directly influenced by the energy status of animals. Studies indicate that cows with low body fat reserves are less likely to respond to hormonal therapy. Various authors have reported estrus response rates of 66% (Ovsynch) and 71% (Mineral Mixture + BPF supplementation), respectively. In one study, a significant increase in estrus signs was observed in groups supplemented with Mineral Mixture+BPF. This supplementation is likely to have a beneficial effect on restoring ovarian cyclicity in anestrus animals. Minerals are well-known for their role as co-factors in steroidogenesis, crucial for resuming ovarian activity. Additionally, feeding fat positively affects ovarian functions by promoting the synthesis of steroidal hormones.

Role of bypass fat on post-partum reproductive efficiency

Feeding bypass fat reduced the average time to conception after calving from 118 to 92 days in cows. When bypass fat was added to the diet of crossbred cows, the number of artificial inseminations needed per conception decreased from 1.4 to 1.2, indicating improved reproductive performance of the animals. Supplementing bypass fat to advanced pregnant cows during the pre-partum period increased calf weight (24.94 kg to 27.95 kg) and calving percentage (88.88% to 100%), while decreasing the incidences of stillbirths (1 to 0), premature births (1 to 0), and retention of fetal membranes (4 to 1) in high-yielding crossbred cows.

Some researchers have also documented improved reproductive outcomes in cows fed locally prepared bypass fat. In Murrah buffaloes, along with enhanced and sustainable milk production, reproductive performance improved with supplementation of protected fats and proteins during early lactation. Introducing Ca-LCFA into the diet positively influenced the reproductive performance of dairy cows, with outcomes influenced by the specific fatty acid profile of the calcium salt. Feeding Ca-LCFA was associated with increased pregnancy rates and reduced days open.

Milk production

Supplementing protected nutrients significantly boosted milk yield and milk fat in lactating Murrah buffaloes, resulting in increased profitability. Numerous studies have shown a notable increase of 5.5% to 24.0% in milk yield when dairy animals were fed with supplemented bypass fat. The stage of lactation affects the effectiveness of bypass fat supplementation on both milk yield and fat-corrected milk (FCM) yield, with greater effects typically seen in early and peak lactation stages. This enhancement is likely due to higher energy intake, improved fat utilization by the mammary gland, and increased tissue mobilization before peak production.

Conclusion

Nutrition is crucial throughout the lifespan of dairy animals, particularly during times of negative energy balance and peak milk production. These periods result from reduced feed intake due to the stresses of calving and lactation. Sustaining milk production in dairy cows depends significantly on well-balanced nutrition postpartum. A modern approach to ensure adequate nutrition is the use of protected nutrient technology, which prevents degradation during ruminal digestion. Feeding bypass nutrients to dairy animals has the potential to revolutionize the dairy industry, and thus maximizing profitability.