



Periodic Feeding in Dairy Cattle

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Abstract. This study examines the lactation stages of dairy cattle and their specific nutritional requirements, particularly in terms of vitamin requirements. The lactation process is divided into four main stages: early lactation (0–70 days postpartum), mid-lactation (70–140 days), late lactation (140–305 days), and the dry period (pre-partum ~60 days). Energy, protein, vitamin, and mineral requirements increase significantly due to increased milk production in early lactation. B vitamins, in particular, vitamins A, C, D, and E, play a critical role in energy metabolism, immune function, and reproductive health. Milk yield gradually decreases in mid- and late lactation, and nutrient and vitamin requirements change accordingly. During the dry period, adequate intake of vitamins A, D, E, and B vitamins is crucial for preventing metabolic diseases, supporting immunity, and optimizing calf development during parturition and subsequent lactation. In the study, the effects of balanced nutrition on milk yield, animal health and farm efficiency were emphasized by detailing the vitamin requirements specific to each lactation stage.

Keywords: Milk, Vitamin, Energy, Protein

1 Introduction

Lactation in dairy cattle is a crucial period during which milk production occurs following calving, and cows' nutritional and metabolic changes occur. This is the period when milk production capacity is most clearly demonstrated in dairy cattle. Lactation in dairy cattle is divided into various stages, each with its own unique requirements. The interactions between these stages and feeding strategies are crucial for both milk productivity and the overall health of the cows. These stages are divided into four main stages: early lactation (0-70 days postpartum), mid-lactation (70-140 days), late lactation (140-305 days), and dry period (pre-partum ~60 days). These stages vary in terms of the physical and physiological health of the animals, milk yield, milk composition, and general nutritional needs. However, among the lactation stages, early lactation and dry period nutrition are the periods that require special attention to ensure and maintain pregnancy, healthy calf development, and high milk production.

1.1 Early Lactation Feeding

In parallel with the increased milk production in early lactation, cattle's need for energy and other nutrients increases significantly. It has been stated that appropriate feeding practices during this period can significantly increase milk production in subsequent periods stated that metabolic diseases can occur in cows if their high energy requirements are not met during lactation [1]. If energy balance is not achieved during this period, milk yield may decrease. If the required energy is not supplied through the diet, a negative energy balance occurs, and fat is mobilized by drawing on body reserves. Depending on the severity of the negative energy balance, the levels of ketones (acetoacetic acid, beta-hydroxybutyric acid, acetone) in the blood also increase. These ketones are utilized in the liver for energy metabolism. However, if liver capacity is exceeded, these substances accumulate, causing fatty liver syndrome, and the liver becomes unable to perform its functions. Studies indicate that cattle require 0.74 Mcal of net energy to produce 1 kg of 4% fat milk [2]. Protein synthesis, one of the basic components of milk, requires 85-95 g of crude protein per kilogram of milk in the ration [3]. The increased energy requirement for milk production also increases the need for vitamins. The need for B vitamins, which are directly effective in energy metabolism, and vitamins A, C, and E, which have indirect effects, tends to increase during this period. B vitamins play a role in energy synthesis through their roles in the structure of enzymes such as pyruvate dehydrogenase and α -ketoglutarate dehydrogenase (thiamine), acetyl Co-A formation (pantothenic acid), carboxylation (biotin), trans and decarboxylation (pyridoxine) (Figure 1).

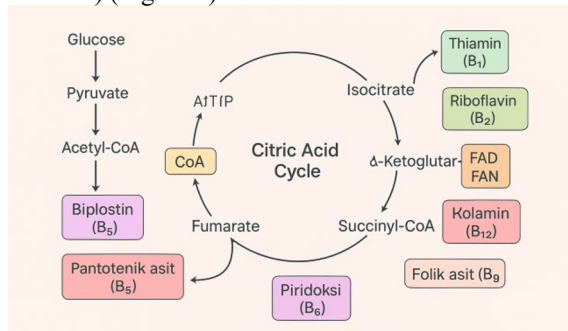


Fig. 1. Vitamins in Energy Metabolism

Meeting the vitamin B requirements of dairy cattle in a balanced diet is crucial [4,5]. Vitamins A, C, and E are involved in this process by supporting ATP production and oxidative phosphorylation by protecting mitochondrial enzymes and membranes. Vitamin A, which is crucial for vision, reproduction, and immune function, has a positive effect on milk productivity when adequately included in dairy cattle diets [6]. Beta carotene, the precursor of vitamin A, supports skeletal and reproductive health in ruminants and also improves milk quality [7]. Vitamin C, which functions as a powerful antioxidant and plays an important role in immune system support, is generally not necessary in the diet because cattle can synthesize it in their bodies [8]. Vitamin D

supports bone health by playing an important role in calcium and phosphorus metabolism. Vitamin D deficiency in dairy cattle has been shown to negatively impact milk production by reducing calcium absorption [9,10]. It has been observed that low serum vitamin E levels may increase the risk of infections such as mastitis in early lactation [11].

As with other nutrients, vitamin requirements vary depending on factors such as the animal's physiological stage, milk composition, disease and other stress factors, diet, and agonist/antagonist substances in feed. However, in general, vitamin requirements for dairy cattle are as shown in Table 1 below.

Table 1. Vitamin requirement levels in dairy cattle (/L milk)

Vitamin	Approximate Amount	Description
Vitamin A	400-700 IU	It is important for milk fat and milk structure.
Vitamin D	40-60 IU	Plays a role in calcium and phosphorus metabolism, critical for milk calcium.
Vitamin E	5-10 mg	It protects cells as an antioxidant and is important for milk quality.
Vitamin K	0.5-1 mg	
Vitamin B1 (Tiamin)	0.05-0.1 mg	Important in energy metabolism, nervous system and blood production.
Vitamin B2 (Riboflavin)	0.15-0.25 mg	
Vitamin B3 (Niasin)	0.5-1 mg	
Vitamin B5 (Pantotenic acid)	0.1-0.2 mg	
Vitamin B6 (Piridoksin)	0.05-0.1 mg	
Vitamin B12 (Kobalamin)	0.00005-0.0001 mg	

Adequate mineral consumption is also important during early lactation. Adequate mineral intake has been found to play a critical role in increasing milk production [1,12].

1.2 Mid and Late Lactation Feeding

During the mid-lactation period, which covers the period of 70-140 days after calving, milk yields in cattle remain stable. However, studies can be conducted to increase milk yield by modifying the ration. Previous researchers have reported a positive correlation between lactation number and milk yield in the current period [13,14]. During the mid-lactation period, energy consumption is crucial; supporting cows' metabolic status with optimal feeding conditions can prevent potential metabolic disorders [15]. Because this period is the beginning of pregnancy, meeting the nutrient requirements for survival

and productivity in adult animals will be sufficient. The nutrient requirements of animals should be reassessed during the late lactation period, when milk yield begins to decline during the 140-305 days after calving. Energy balance is a particularly important factor during this period, prior to the transition to the dry period. While inadequate feeding conditions can lead to metabolic disorders [16], it has also been reported that appropriate feeding strategies during this period can help maintain cow health [17]. Since calf development has not yet accelerated during an existing pregnancy, the ration should be designed to accommodate decreasing milk yield. Otherwise, excess energy intake will lead to increased body condition scores and narrowed birth passages. This will also increase the risk of difficult or stillbirths. The reduction in energy required for milk production will also reduce the need for vitamins used in energy production. Therefore, reviewing the levels of other nutrients in ration manipulations will be beneficial for animal health and farm economics.

1.3 Dry Period Nutrition

The dry period is a crucial period, marking the end of lactation and approximately 60 days before parturition. During this period, when calf development peaks, parents are expected to utilize the nutrients they receive in their diets entirely for calf development, thus halting the declining milk production through external intervention. Furthermore, the animal is allowed time for mammary tissue regeneration and colostrum production. Adjustments to the ration during this period directly impact calf development and postpartum milk yield [1,18]. As with late lactation, excess energy intake during this period can lead to labor difficulties and calf losses. It has been observed that the risk of fat accumulation in dry dairy cattle fed low-energy rations is reduced, and this prevents metabolic disorders that may occur after parturition [19].

Considering vitamin requirements during the dry period is important to prevent metabolic disorders and prepare animals for a healthy lactation process. Adequate vitamin A intake during the dry period helps dairy cattle transition quickly into lactation after parturition. The daily vitamin A requirement of dairy cattle during the dry period generally ranges between 20,000-30,000 IU. Researchers report that vitamin A deficiency can lead to a weakened immune system [20]. Maintaining adequate vitamin A levels in the ration through proper feeding positively impacts cows' health and reduces the risk of postpartum complications such as mastitis [21,22].

Vitamin D, which plays a crucial role in calcium and phosphorus metabolism, is recommended as 20,000-40,000 IU during the dry period. In dairy cattle, vitamin D deficiency during the dry period increases the risk of hypocalcemia. Therefore, supplementing the diet with vitamin D during the dry period is crucial [23]. Inadequate vitamin D intake can lead to a decrease in milk yield after calving [24,25]. Increasing vitamin D intake supports cows' bone health and helps maintain calcium balance after calving, preventing potential metabolic problems.

Vitamin E, which is effective in muscle tissue synthesis, reproductive activities, preventing cellular damage, and strengthening the immune system, has a recommended daily intake of 1,000-2,000 IU during the dry period. Adequate vitamin E intake is vital

for maintaining the overall health of dairy cattle. Vitamin E is effective in milk production and reducing the risk of conditions such as postpartum mastitis [26].

It has been determined that B vitamins taken during the dry period can help maintain energy balance in cows and prevent metabolic problems that may occur in the postpartum period [27,28]. During this period, the recommended daily intake is 3-4 mg/day for B1 (Thiamin), 2-3 mg/day for B2 (Riboflavin), 2-4 mg/day for B6 (Pyridoxine), and 3-6 mg/day for B12 (Cobalamin). It has been reported that the intake of these vitamins may be beneficial in increasing milk yield because they provide energy regulation [29,30].

During the early dry period (prepartum 60-21 days), rations based on high-quality roughage supplemented with some concentrate should be offered. A 32-38% NDF level will be sufficient to stimulate physical satiety. However, calcium nutrition is of paramount importance during the dry period. Phosphorus-rich feeds should be provided to stimulate parathyroid hormone activity to minimize the risk of birth paralysis. In the late dry period (prepartum 21 days), energy density should be slightly increased because rumen volume is suppressed due to calf development and dry matter consumption decreases. Increasing colostrum quality and raw protein intake is also necessary for milk production following birth. Anion-cation balance is another important consideration during the late dry period. Maintaining anion-cation balance at -100 to -150 mEq/kg DM minimizes the risk of milk fever. To prevent difficult calving and postpartum complications such as mastitis and retained placenta, the diet should be supplemented with vitamins A, D and E and the elements selenium, zinc, copper and manganese.

In general, the importance of vitamin requirements during the dry period in dairy cattle should not be overlooked. The intake of these vitamins plays a critical role in improving cow health, preventing potential problems that may occur during and after calving, and enhancing lactation performance. Optimizing vitamin intake during the dry period ensures sustainable productivity for dairy cattle. Adequate and balanced vitamin intake enhances the farm's overall productivity and establishes a sustainable feeding strategy.

2 Result

Lactation periods in dairy cattle are highly dynamic and critical stages, where the animals' physiological needs and feeding strategies vary. Early lactation and the dry period, in particular, are the most sensitive periods in terms of both milk yield and animal health, and correctly meeting vitamin requirements is crucial. In early lactation, in parallel with the increased energy and protein needs, adequate provision of vitamins A, D, E, and B vitamins reduces the risk of metabolic diseases and increases milk yield. While vitamin requirements decrease in mid- and late lactation, balanced nutrition is essential for supporting pregnancy and maintaining metabolic balance. During the dry period, vitamin supplementation plays a critical role in preventing postpartum complications, strengthening the immune system, and ensuring a healthy lactation. Consequently,

providing vitamin supplements appropriate to physiological needs at each stage of lactation is a cornerstone of sustainable productivity and health management in dairy cattle.

3 Conclusions

In conclusion, lactation in dairy cattle represents a highly dynamic physiological process in which nutrient and vitamin requirements vary substantially according to production stage. Early lactation and the dry period emerge as the most critical phases, where inadequate nutritional management may predispose animals to metabolic disorders, impaired immune function, and reduced milk performance. Ensuring optimal intake of energy, protein, and particularly vitamins A, D, E, and B-complex vitamins play a pivotal role in maintaining metabolic balance, enhancing reproductive efficiency, and preventing postpartum complications. While nutrient demands moderate during mid- and late lactation, strategic ration adjustments remain essential to sustain productivity and body condition. Overall, stage-specific vitamin supplementation constitutes a cornerstone of sustainable dairy management, contributing not only to improved milk yield and animal health but also to long-term farm efficiency and economic viability.

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