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REVIEW

Body Condition Score as a Key Indicator of Milk Production in Dairy Cows in Tropical and Subtropical Regions

Body Condition Score sebagai Indikator Utama Produksi Susu pada Sapi Perah di Wilayah Tropis dan Subtropis

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ABSTRAK

Body Condition Score (BCS) merupakan indikator penting yang mencerminkan status cadangan energi tubuh sapi perah dan berhubungan erat dengan kinerja produksi susu, kesehatan, serta efisiensi reproduksi. Perbedaan kondisi lingkungan antara wilayah tropis dan subtropis, khususnya suhu, kelembaban, dan kualitas pakan, menyebabkan respon fisiologis sapi perah terhadap BCS dan produksi susu menjadi berbeda. Artikel ini bertujuan untuk melihat hasil-hasil penelitian terkait hubungan BCS dengan produksi susu pada sapi perah di wilayah tropis dan subtropis. Metode yang digunakan adalah studi literatur terhadap jurnal nasional dan internasional yang relevan dalam 15 tahun terakhir (2010-2025). Hasil review menunjukkan bahwa BCS optimal pada awal laktasi berhubungan positif dengan produksi susu yang tinggi dan stabil. Namun, di wilayah tropis, stres panas dan keterbatasan kualitas pakan sering menyebabkan penurunan BCS yang lebih parah sehingga berdampak negatif pada produksi susu. Sebaliknya, di wilayah subtropis, manajemen pakan dan lingkungan yang lebih baik memungkinkan pengendalian BCS yang lebih optimal. Hasil review dapat disimpulkan bahwa pengelolaan BCS yang tepat dan spesifik wilayah sangat penting untuk memaksimal produksi dari seekor sapi perah.

Kata Kunci: *BCS, Produksi Susu Sapi, Tropis, Subtropis.*

ABSTRACT

Body Condition Score (BCS) is a crucial indicator that reflects the body energy reserves of dairy cows and is closely linked to milk production performance, health, and reproductive efficiency. Environmental differences between tropical and subtropical regions, specifically

temperature, humidity, and feed quality result in varying physiological responses regarding BCS and milk yield. This article aims to examine research findings related to the relationship between BCS and milk production in dairy cows across tropical and subtropical regions. The method used is a literature study of relevant national and international journals published within the last 15 years (2010–2025). The review results show that an optimal BCS at the start of lactation is positively correlated with high and stable milk production. However, in tropical regions, heat stress and limited feed quality often lead to a more severe decline in BCS, which negatively impacts milk production. Conversely, in subtropical regions, better feed and environmental management allow for more optimal BCS control. It is concluded that appropriate and region-specific BCS management is essential to maximize the production of a dairy cow.
Keywords: *BCS, Milk Production, Tropical, Subtropical.*

INTRODUCTION

Meeting the global nutritional requirements for protein relies, among other sources, on milk. Cow's milk is the most widely produced dairy product worldwide compared with milk from other dairy animals (Kim & Lee, 2021). Milk demand remains high in many countries, not only for direct consumption but also for processed dairy products such as cheese, yogurt, butter, and sweetened condensed milk. The management of dairy cows, particularly their physiological status, plays a crucial role in determining animal performance, including reproductive efficiency, milk yield, milk composition, and overall health (Bednarski & Kupczyński, 2024). One of the most appropriate methods for assessing the physiological condition of dairy cows is the Body Condition Score (BCS). Body Condition Score is a visual and tactile assessment of dairy cattle conducted by trained professionals, focusing on key anatomical areas such as the ribs, hip bones, tail head, and backbone (Rodriguez *et al*., 2021). Globally, BCS has been recognized and used for a long time; however, its practical application at the farm level remains limited in some regions. This subjective assessment aims to evaluate body fat reserves in order to determine the animal's energy balance, which is closely associated with productive performance in dairy cows (Rearte *et al*., 2023).

The conditions in tropical regions differ from those in subtropical areas, particularly regarding environmental factors that influence feed availability and nutrient quality. Throughout the life cycle of a dairy cow, energy requirements must be carefully managed, especially during early lactation (Drackley *et al*., 2014). During this period, dairy cows typically experience a state of negative energy

balance. However, attention should not be focused solely on early lactation. But the period preceding breeding also requires careful nutritional management. Achieving high milk production in dairy cows depends on maintaining an adequate energy balance between intake and physiological demands (Martens, 2023). Body fat reserves are mobilized to compensate for energy deficits, but inadequate control of this process can negatively affect productive performance. There is a well-established relationship between BCS at calving and milk production throughout the lactation period, which is reflected by changes in the lactation curve (Montiel-Olguín *et al.,* 2019).

The ideal body condition of a dairy cow is typically achieved from the onset of milk production through the peak of lactation, during which higher milk yields are observed. Assessment of BCS in dairy cows is influenced not only by internal physiological factors but also by external factors, particularly environmental differences that affect temperature, humidity, and wind speed in subtropical and tropical regions (Rodriguez *et al*., 2021). Stable climatic conditions combined with abundant availability of high-quality feed strongly support the establishment and sustainability of the dairy industry in a given region. In recent decades, dairy producers worldwide have employed various strategies to identify and develop superior dairy cows primarily based on milk production performance. Genetic improvement programs in dairy cattle have been implemented from the past to the present, and the Friesian Holstein breed has been widely recognized as a superior dairy breed (Hussein *et al*., 2025). The advantages of this breed include its adaptability to new environments, efficient metabolic capacity, and high milk quality. The cool climate of subtropical regions allows dairy cows to remain within the thermoneutral zone, enabling energy derived from body fat reserves to be efficiently redirected toward milk biosynthesis without the presence of heat stress. In contrast, dairy farming in tropical regions faces different challenges, characterized by a combination of high ambient temperatures and extreme humidity (Goodluck *et al*., 2025). Such conditions induce excessive body heat accumulation, which can alter energy reserves and metabolic priorities. Under tropical conditions, the metabolism of dairy cows is not exclusively directed toward milk production but is also required to support survival and thermoregulation.

Tropical environments lead to an imbalance in the interaction between BCS and milk production, differing markedly from conditions in subtropical regions (Martens, 2023). Dairy cows in tropical areas are often observed to have relatively high BCS values due to increased susceptibility to stress and adaptive physiological responses, resulting in greater body fat accumulation. Feed-related factors may further contribute to the failure of

cows to recover body condition after peak lactation. In contrast, subtropical dairy systems generally provide high-energy diets, allowing better control of BCS fluctuations throughout lactation (Knob *et al*., 2021). Therefore, a comprehensive understanding is required regarding whether BCS standards developed in subtropical regions can be directly applied to tropical conditions. Researchers and practitioners in tropical regions often continue to follow guidelines established in developed countries without considering necessary modifications related to environmental factors. Inappropriate BCS management can lead to increased reproductive disorders and reduced feed intake, particularly in dairy cows raised in tropical climates. This review aims to evaluate the relationship between BCS and milk production in both tropical and subtropical regions. Proper BCS management is essential for improving dairy cow productivity in tropical environments without compromising animal welfare, particularly with respect to minimizing heat stress. Through this comparative approach, more region-specific and applicable body condition management strategies are expected to be formulated for dairy farmers worldwide.

RELATIONSHIP BODY CONDITION SCORE (BCS) AGAINST MILK PRODUCTION

The performance of a dairy cow can be assessed qualitatively in various ways, one of which is the Body Condition Score (BCS) assessment. (Rearte *et al*., 2023). Body Conditional Score is an assessment based on the body parts of dairy cows, using existing methods, including observing and palpating specific areas. Commonly used BCS assessments are based on a scale of 1-5 from the Wisconsin Dairy Extension and Agriculture and Horticulture Development (UK) (Poczynek *et al*., 2023). The period of a dairy cow's life that requires more attention is the transition period, namely the transition from the end of pregnancy to the beginning of lactation. A crucial point during this period is the significant changes in body metabolism and the vulnerability to negative energy balance (Martens, 2023). After giving birth until dairy cows enter the beginning of lactation, the need for nutrients is high, especially energy sources, which will be converted into body fat reserves if excessive, and a decrease in BCS occurs (Młynek *et al*., 2021). A dairy cow's milk production is highly dependent on its BCS value. The desired and required BCS is ideal (neither too fat nor too thin). This condition is not always positive and can even be negative (Rearte *et al*., 2023). Dairy cows that are too thin or fat will negatively impact milk production and even milk quality. Cows that are too thin will cause problems due to a lack of energy reserves, which directly impacts optimal milk production (Montiel-Olguín *et al.,* 2019). In contrast, overweight cows will have an impact on their eating patterns due to a lack of appetite and metabolic disturbances, which will also impact milk production. This pattern

illustrates that as BCS increases, milk production will also increase until it reaches an optimal point (Antanaitis *et al*., 2022). However, it will decrease as BCS increases. The importance of this study for dairy farmers or nutritionists in a dairy company is that it has a direct impact on feed management, so it is necessary to find the best method to achieve optimal dairy cow performance (Rearte et al., 2023). The following table 1 shows the differences in BCS assessments in dairy cattle in tropical and subtropical regions.

Table 1. The differences in BCS assessments in dairy cattle in tropical and subtropical regions.

Parameters Assessed	**Tropical**	**Subtropical**
BCS during calving	2.75-3.25	3.25-3.50
Peak Lactation	Hampered by decreased feed consumption	Maximum achieved
High BCS (3.5)	Metabolism is disrupted due to high stress, loss of appetite, and death.	Dystocia, ketosis and fatty liver
Low BCS (2.5)	Decreased immunity, poor reproduction, marital failure (high conception rate)	Milk production decreases, estrus does not appear
Fat Mobilization Efficiency	Flexible to divide for other needs such as thermoregulation	High focus on the biosynthesis of milk production in the udder
BCS Repair	Slow	Fast

NEGATIVE ENERGY BALANCE (NEB) EFFICIENCY AGAINST BCS

Dairy cattle farming relies heavily on the performance of individual dairy cows. During pregnancy, the feed provided to a dairy cow must be carefully considered, from the composition of the ingredients, nutrient content, to its basic living needs (Churakov *et al.,* 2021). If feed management is inadequate or inadequate, it will impact the energy content of the cow's body, resulting in suboptimal milk production and impacting BCS (Rearte *et al.,* 2023). Different regional climatic conditions will significantly impact the condition of a dairy cow, such as negative energy balance. Negative Energy Balance (NEB) is a metabolic condition that commonly affects dairy cows after calving, characterized by metabolic health, suboptimal milk production, and poor reproductive performance (Martens, 2023).

Utamy *et al.* (2025) reported that dairy cows experiencing NEB after being given supplemental feed significantly improved metabolic performance. Harder *et al.* (2019) explained that cows emerge from NEB and regain positive energy balance and metabolic stabilization between 80-140 days. Nutritional strategies aimed at preventing or reducing NEB focus on providing a diet rich in protein and energy to meet the increased metabolic needs in early lactation (Gibson *et al.,* 2019). Dairy cows with severe NEB have higher IGF-1 levels than those with mild NEB (Bailes *et al.,* 2021).

In some tropical countries, dairy cows lose more body fat because the energy derived from fat is used for thermoregulation. This causes a derease in BCS, which leads to a slight increase in milk production. Meanwhile, in subtropical countries, high metabolic rates facilitate the conversion of fatty acids into lactose and milk fat (Gibson et al., 2019).

FEED QUALITY AS A LIMITING FACTOR ON BCS

Feed is an important indicator for determining the basic living needs of individual livestock (Krpálková *et al.,* 2021). Dairy cattle require complete nutrition as a source of carbohydrates, protein, fat, vitamins, and minerals. From the moment the fetus is born, attention is paid to the proportion of colostrum provided. The quality of colostrum directly impacts the growth of the fetus or calf as it approaches adulthood (Zhuang *et al.,* 2025). Calves that continue to develop and grow will be given green fodder as a source of fiber and concentrate as a source of energy. The needs of each period of dairy cattle are different, including calves after weaning, heifers approaching mating, and the lactation period (Khan *et al.,* 2016). Many things must be considered in feeding, namely that green fodder must be more abundant when compared to concentrate. Concentrate is a feed mixture containing grains with a fairly high protein content for each ingredient along with high energy. Feeding must be accompanied by a percentage of requirements because it impacts the BCS (Naderi *et al*., 2022). The world's climate varies from region to region, impacting feed quality and individual livestock performance, particularly in milk production. In tropical climates, dairy cows are generally fed high-fiber forage, which impacts the condition of the rumen system (Shi *et al.,* 2023). Rumen microorganisms will be able to digest fiber well because they also produce the final product, namely VFA (Volatile Fatty Acids) as precursors of milk biosynthesis in udder cells (Mammi *et al*., 2022). Therefore, cows fed a high-crude-fiber diet can provide optimal BCS values. Conversely, if fed low-quality forage, milk production will decrease (Shi *et al.,* 2023). In subtropical regions, the use of fermented products is the main choice, such as corn silage and concentrates containing high protein, allowing cows with low BCS to maintain high production (Gandra *et al.,* 2025). The graph of the relationship between BCS and milk production accompanied by dry matter consumption shown in Figure 2.

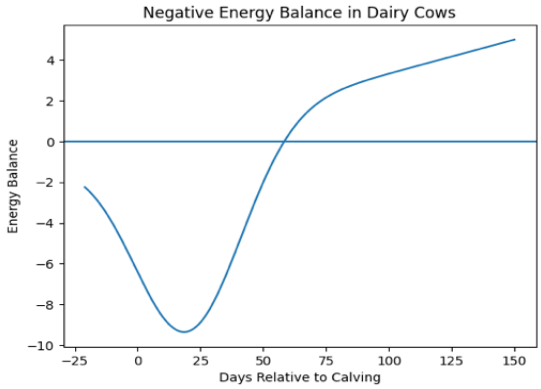

Figure 1. Negative Energi Balance In Dairy Cows (Source: Martens, 2023)

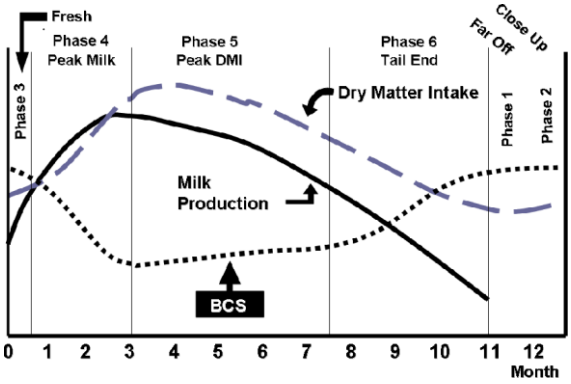

Figure 2. The relationship between BCS and milk production accompanied by dry matter consumption (Source: Truman *et al*., 2022)

DIFFERENCES BETWEEN INTERNAL AND EXTERNAL FACTORS ON BCS

Many factors influence the individual cow to BCS value. Causes can be categorized into two types including internal and external. Genetic is inheritance properties that can lowered from his elders to his son through the gene system. Genetics explain how much big the similarities are passed down as well as analyzes a little the difference. As a result, genetics to BCS value gives influence difference among others that can determine the change energy into milk or body fat. Weller and Ezra (2025) reported that Genetic correlation between BCS results in lower genetic gains for milk, fat, and protein production, as well as little economic gain for ewe fertility, SCS, and herd age. According to Bastin *et al.* (2010) that the genetic relationship between birth traits and BCS during the next lactation period is moderate and favorable and during lactation will have a greater chance of producing calves that survive and pass on better genes to support milk production. Parity describes the number of births that a female dairy cow has experienced. For young cows, the effect of parity still tends to be thinner because they continue to grow. Paul *et al.* (2022) that increased BCS at calving is associated with greater milk production in first and second parity cows, and decreased milk production in third or higher parity cows. The smooth functioning of the body's metabolic system is important for mobilizing nutrients throughout the body, especially for milk biosynthesis.

The feed consumed by dairy cows is expressed by conversion, which indicates how efficiently the feed can become adipose tissue reserves. Na and Guan (2022) stated that the cow's metabolic system controls the flow of feed so that it can be converted into adipose reserves. Ojo *et al.* (2024) stated that cattle maintenance requires attention to feed efficiency, which will impact growth, production performance, and reproductive performance. External factors also have a significant influence on BCS in dairy cows. Temperature and humidity can affect their feeding patterns; this is because high temperatures cause a decrease in BCS and thus a decrease in appetite. Reported by Demir and Yazgan (2022) explained that extreme temperatures and humidity in Turkey can cause a decrease in milk production in dairy cattle, affecting appetite, which impacts BCS values. Tropical areas rich in forage with high crude fiber quality can complicate BCS recovery.

Cheng *et al.* (2021) stated that nutritional intake significantly influences BCS values in dairy cows. It was also reported by Liu *et al.* (2023) that the provision of starch in dairy cattle rations affects the performance of dairy cattle, which can be measured using BCS. Management factors or the way the dairy cattle business is run also influence dairy cattle performance, including the behavior of staff in the barn and the barn facilities in maintaining cow comfort. Ebinghaus *et al.* (2018) that positive behavior of humans or barn staff towards dairy cows provides comfort for livestock so that it does not cause stress that impacts their performance such as BCS, reproductive performance and milk production.

CONCLUSION

The Body Condition Score (BCS) is a crucial indicator for maximizing milk production, health, and reproduction in dairy cows in tropical and subtropical regions. By understanding the relationship between BCS and milk production and implementing appropriate management strategies, farmers can improve the efficiency and profitability of their operations. Routine BCS monitoring, good feed management, heat stress management, and disease control are key to achieving optimal BCS, especially in dairy cows.

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