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RESEARCH ARTICLE

Assessing the Economic Effects of Ketosis on Dairy Farm

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Abstract

Milk represents one of the most critical sources of animal protein for human nutrition, with dairy cows serving as the primary contributors to global milk production. Metabolic diseases pose significant challenges in dairy farming, with ketosis (K) being one of the most common and impactful conditions. This study aims to evaluate the economic cost of a K case on a dairy farm. Ketosis was diagnosed based on a case history, clinical examination, and measurement of ketone body concentrations, with a defined β-hydroxybutyrate (BHBA) level of ≥ 1.4 mmol/L. Economic losses associated with ketosis were calculated using treatment costs and potential losses attributable to reductions in milk yield. In our study, the treatment cost for a ketosis case was determined to be 39.5 dollars per animal, while the treatment of other diseases associated with ketosis amounted to 593.09 dollars. The total cost of medicines used for all treatments reached 1 022.30 dollars. Milk production loss was not observed during the study period. Treatment costs were reported to depend on herd size, productivity level, and the parity of the animals. K also predisposes dairy cows to other metabolic and reproductive disorders. In this study, the incidence rates of hypocalcemia, metritis, and retentio secundinarum associated with ketosis were found to be 29%, 25%, and 13%, respectively. These findings emphasize the importance of implementing effective preventive strategies against ketosis to minimize economic losses and improve herd health.

Key Words: Dairy cows, economic effects, lactation, milk yield, subclinical ketosis

Bir Süt Sığırı İşletmesinde Ketozisin Ekonomik Etkilerinin Değerlendirilmesi

Öz

Süt, insan beslenmesinde önemli bir hayvansal protein kaynağıdır ve dünya genelindeki süt üretiminin büyük kısmı süt sığırlarından elde edilmektedir. Metabolik hastalıklar, süt sığırı işletmelerinde önemli sorunlar arasında yer almakta olup, ketozis (K) en yaygın ve etkili hastalıklardan biridir. Bu çalışma, bir süt sığırı işletmesinde K vakasının ekonomik maliyetini değerlendirmeyi amaçlamaktadır. Ketozis tanısı; vaka öyküsü, klinik muayene ve keton cisimciklerinin ölçümüne dayanmakta olup; K, β-hidroksibütirat (BHBA) düzeyinin≥1.4 mmol/L olması şeklinde tanımlanmaktadır. Ketozise bağlı ekonomik kayıplar, tedavi giderleri ve olası süt verimi düşüşleri üzerinden hesaplanmıştır. Bu çalışmada, bir ketozis vakasının tedavi maliyeti hayvan başına 39.5 dolar olarak belirlenmiştir. Ketozisle ilişkili diğer hastalıkların tedavi maliyeti 593.09 dolar olarak hesaplanmıştır. Tüm hastalıkların tedavisinde kullanılan ilaçların toplam maliyeti ise 1 022.30 dolara ulaşmıştır. Çalışma süresince süt verimine ilişkin herhangi bir ekonomik kayıp tespit edilmemiştir. Ayrıca tedavi maliyetlerinin işletme büyüklüğüne, verimlilik düzeyine ve hayvanların yaşına göre değiştiği belirtilmiştir. K, süt sığırlarında diğer metabolik hastalıklara ve fertilite bozukluklarına predispozisyon oluşturmaktadır. Çalışmada, ketozisle ilişkili hipokalsemi, metritis ve retentio sekundinarum insidans oranları sırasıyla %29, %25 ve %13 olarak bulunmuştur. Bu bulgular, ketozise karşı etkili koruyucu önlemlerin uygulanmasının ekonomik kayıpların azaltılması ve sürü sağlığının iyileştirilmesi açısından büyük önem taşıdığını göstermektedir.

Anahtar Kelimeler: Ekonomik etki, Holstein, laktasyon, subklinik ketozis, süt verimi

INTRODUCTION

Dairy farms play a critical role in increasing the supply of high-quality animal protein for human nutrition and contributing to national economies. For dairy enterprises to remain profitable, it is essential to optimize both milk production levels and herd health. A well-established positive correlation exists between high productivity and profitability in dairy cattle breeding. However, higher milk yields often come at the cost of increased susceptibility to metabolic and reproductive disorders, especially during the early lactation period (1). Ketosis (K) is one of the most significant metabolic disorders affecting high-yielding dairy cows. K commonly arises during the early weeks of lactation as a consequence of the substantially increased energy demand associated with milk production. This increased demand, paired with limited glucose availability, results in disrupted carbohydrate metabolism, excessive mobilization of body fat, and elevated concentrations of ketone bodies such as β-hydroxybutyrate (BHBA) (2). Subclinical ketosis (SCK) often progresses without clinical signs, allowing it to quietly undermine herd productivity and health. For this reason, many studies have evaluated and reported the wide-ranging negative effects on milk yield, fertility, and cow health from an economic perspective (3). The negative impacts of ketosis on milk production and quality are widely acknowledged in the literature and field studies. Numerous studies have reported reductions in daily milk yield, in some cases occurring even before the clinical signs or diagnosis of the disease (3-4). Ketosis may also impact milk composition, particularly fat and protein levels, further affecting economic returns (5) with increased treatment costs and decreased milk production. From an economic perspective, both clinical ketosis (CK) and SCK impose considerable economic costs on dairy farms. A systematic review reported that the cost per ketosis case ranged broadly from 19 euros to 812 euros, depending on herd structure, management, and disease severity. In another study, a single CK case cost approximately 709 euros, while an SCK case cost around 150 euros (6). A study conducted in Canada estimated SCK losses at 203 dollars (7), while another study reported costs of approximately 78 dollars per case (8). An investigation conducted in the Netherlands reported annual losses of approximately 130 euros per cow attributable to SCK (5). Given the physiological, productive, and economic implications of ketosis, particularly in high-yielding dairy cows, this study aims to assess the economic impact of ketosis on a dairy farm. By evaluating the financial implications of treatment, the secondary diseases associated with K, and the potential production-related losses, this study aims to provide a data-driven evaluation to inform more effective prevention and management strategies for dairy herds.

MATERIAL AND METHODS

Animals and Housing

The research was conducted at the Bursa Uludağ University Faculty of Veterinary Medicine, Animal Health, Animal Production Research and Application Farm (BUF) (Figure 1). The study included 37 Holstein dairy cows, followed from one month before calving until the end of the fresh period. The lactating cows are housed in the free-stall barn (A and B), which features a 33 m long feed line. There are 44 headstalls, each 75 cm in length, located on the right and left sides, as well as 44 beds. The flooring in the pens was made of polyurethane foam mattresses, and the alleys were cleaned with automatic scrapers. A total mixed ration for lactating dairy cows was offered ad libitum and delivered twice to feed. All animals had ad libitum access to water from a self-filling trough. The milking parlor has been used to milking three times a day for lactating cows.

Figure 1. Plan of (BUF) (image from Google Maps, © Google Maps 2025). A-B: Free-stall barn of the Holstein dairy cows evaluated in the study, C: Open barn of heifers, 1: Milking parlour, 2: Cows' barn building, 3: Feed warehouse, 4: Barn of bulls, 5: Individual calving pens building, 6: Individual calf pens

Sample Collection and Ketosis Classification

Cows with a β-hydroxybutyrate (BHBA) level ≥ 1.4 mmol/dL were classified as having ketosis, while cows below this reference value were considered healthy. BHBA concentrations were measured using a β-hydroxybutyrate meter operating based on reflectance photometry, in accordance with the manufacturer's instructions for the Vet-TD-4235 β-ketone monitoring system (Taiwan). BHBA testing was performed on the 7th and 15th days postpartum. Animals diagnosed with ketosis were provided with appropriate veterinary treatment, and the active ingredients of all medicines were recorded. Treatment costs for ketosis (K), hypocalcemia (HC), metritis (M), and retentio secundinarum (RS) were also included in the research. Economic losses for metabolic diseases aside from ketosis were estimated considering the indications of medications within the treatment protocols. This stems from the fact that these conditions generally occur following the ketosis process. Throughout the study, individual data for each cow were recorded as 'ketosis' and 'associated co-occurring diseases' and were subsequently included in the economic evaluations.

Milk Production Data

Fresh cows were milked three times daily. Weekly average milk yields during the study period, alongside milk yield records from previous lactations (DeLaval Alpro, Sweden), were recorded.

Economic Analyses

The costs for a single case of ketosis were calculated in two stages: first, by dividing the aggregate milk production losses and treatment expenses by the total number of ketosis cases. Subsequently, the economic costs for individual cases of K, HC, M, and RS were evaluated. Economic losses associated with ketosis were determined by incorporating treatment costs, the farm's total mixed ration (TMR) costs, and national milk and feed prices as stipulated by the Turkish National Dairy Council.

Data Analyses

Statistical analysis was performed using SPSS 28.0.0 statistical software (IBM, Chicago, IL, USA) and one-way ANOVA. Significant variances were further analyzed using Bonferroni post hoc comparison tests. Weekly mean milk yields were assessed using the independent samples t-test. Data are presented as mean ± standard error. Statistical significance was determined at P<0.05.

A polar heat map was generated to visualize the distribution of milk yield data across animal groups and lactation. The dataset included milk yield records from healthy cows and cows diagnosed with ketosis (K), categorized as previous or current lactation. All data preprocessing, normalization, and categorization steps were performed prior to visualization. The polar heat map was created using OriginPro 2025b (OriginLab Corporation, Northampton, MA, USA). The Polar Heatmap plotting module was used, and each lactation category was assigned a separate concentric ring. Color scaling was based on a continuous gradient ranging from low to high milk yield (0-9350 kg). The plot settings were standardized for all groups to enable direct visual comparison.

RESULTS

Table 1 lists the active ingredients and pricing for the medicines included in the ketosis treatment protocols.

Table 1. Pharmacological profile and unit costs of medicines used in ketosis treatment cost calculations

Composition	Price (dollars)	Composition	Price (dollars)
0,01 izotonic solution (%0,01-0,09)	39.82	Benzatin cephapirin	188.78
Clavulanic acid	20.62	Vitamin (B_1,B_6)	0.90
%5-20 dekstroz	61.85	Oksitosin	1.92
Amoxillin+Clavulanic Acid	19.57	Primamycin 100 ml	0.27
Enrofloxacin	20.04	PGS- 10 ml	0.77
Cloxacillin benzathine	0.64	Propylene glycol	86.30
Buserelin	0.93	Vaccine (E.coli)	67.12
Calcium Treatment	29.75	Deksametazone+sodium phospate	2.31
Sodium selenite	21.89	Vitamin+ mineral	3.60
Liquid Treatment	20.00	Wound care and treatment-vulva	27.57
Tetracycline- Neomycin	7.49	Metamizole	0.56
Cephaleksin sodium	39.57	Chlortetracycline	17.81
Ceftiofur hydrochloride	1.44	Furosemide	11.43
Treatment cost of laminitis	186.14	Ceftiofur	252.57
Flunixin meglumine	6.59		

The study investigated the occurrence rates of ketosis (K) and diseases secondary to ketosis. Ketosis (K) showed the highest occurrence rate at 33%. The occurrence of HC due to K was recorded at 29%. M due to K was observed in 25% of cases. The lowest occurrence rates were for RS due to K and death/culling, both of which were recorded at 13%. Statistically, the occurrence rate of K is significantly different from the rates of metritis and RS/death (P<0.05). The HC occurrence rate, although higher than M (25%) but lower than K (33%), is significantly higher than the RS/death rates (P<0.05). Furthermore, the occurrence rate of metritis is significantly different from the rates of RS and death/culling (P<0.05) (Table 2).

Table 2. Occurrence rates of K, HC, M, and RS in the study

Occurrence Rates	Value	Reference
Occurrence of ketosis (%)	33^{a}	BUF
HC due to ketosis (%)	29^{ab}	BUF
M due to ketosis (%)	25^{b}	BUF
RS due to ketosis (%)	13^{c}	BUF
Death and culling due to clinical ketosis (%)	13^{c}	BUF

^{a,b,c} Different lowercase letters within a column indicate significant differences among groups (P<0.05)

The scatter plot illustrates the weekly milk yield patterns of Healthy and K cows over a 16-week period (Figure 2). During the early lactation weeks (Weeks 1-4), the K group generally exhibited higher milk yields compared with the Healthy group. However, from approximately Week 6, Healthy cows began to show a more consistent production pattern with lower variability. While K cows reached their highest yields around Weeks 8-10, their values displayed pronounced fluctuations, indicating unstable production dynamics. In contrast, Healthy cows maintained a more stable curve, with yields remaining clustered between 27 and 31 L after mid-lactation. Overall, the graph demonstrates a shift in performance, where the initial advantage of K cows diminished over time, eventually favoring the Healthy group. Peak milk yield in lactating dairy cows occurs during the first 8 weeks postpartum; therefore, average milk yields for this period were evaluated, and the results for both groups are presented in Table 3. The mean values of weekly average milk yield are almost the same, but this confirms that ketosis is observed in high-yielding dairy cows.

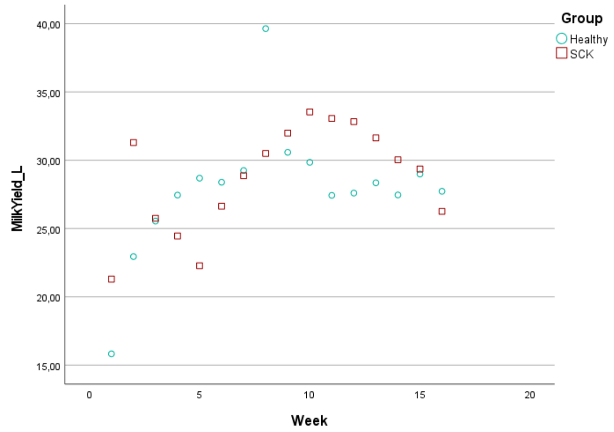

Figure 2. Scatter plot of average weekly milk yield in the SCK and healthy groups.

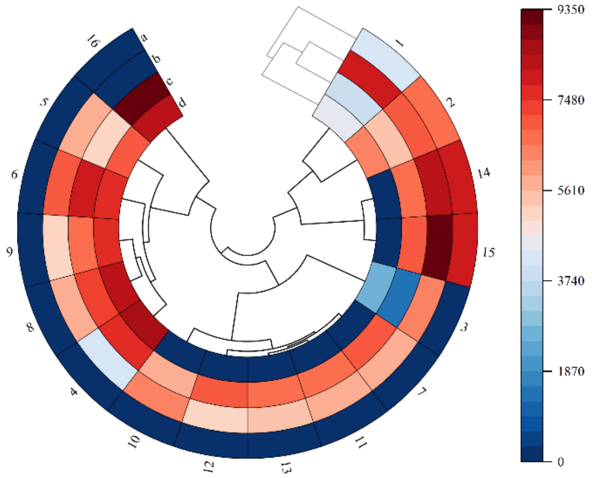

Figure 3. Previous and current lactation milk yield records (L) a: Healthy group- current lactation milk yield, b: healthy group- previous lactation milk yield, c: ketosis group- previous lactation, d: ketosis group- current lactatition milk yield

Table 3. Weekly milk production (L; Mean ± SEM) of the healthy and K groups

Week	Healthy (L; Mean±SEM)	K (L; Mean±SEM)
1	42.64±15.33[a]	22.22±1.37[a]
2	69.17±22.67[a]	27.43±1.6[b]
3	49.15±22.60[a]	29.82±1.89[a]
4	69.36±28.25[a]	31.34±1.78[a]
5	48.86±18.3[a]	32.38±1.90[a]
6	29.70±0.94[a]	32.46±1.93[a]
7	29.47±1.25[a]	33.10±1.92[a]
8	27.35±1.05[a]	32.74±2.35[a]

[a,b] Different letters within the same row indicate statistically significant differences (P<0.05)

The previous lactation milk yields of the animals in the ketosis and healthy groups were 6332 kg and 6407 kg, respectively, while the current lactation milk yields are 6773 kg and 6724 kg. The polar heat map illustrates clear differences in milk yield patterns between healthy cows and cows diagnosed with ketosis (K) across both current and previous lactations (Figure 3). Overall, healthy cows exhibited consistently higher milk yields, represented by the predominance of darker red tones, particularly in the current lactation layer. In contrast, cows with K showed markedly lower milk production, reflected by more frequent blue and light-colored segments. In the current lactation, K cows demonstrated substantial reductions in yield at multiple time points, with several segments approaching the lower end of the scale. The previous lactation yields followed a similar pattern, confirming that reduced milk production was not limited to the present lactational cycle. Healthy cows showed more stable and elevated yields across time, with only a few isolated decreases. The distribution pattern visible in the radial structure indicates that the difference between healthy and K cows is consistent rather than episodic. The heat intensity gradients suggest a systematic impact of subclinical ketosis on milk yield rather than random variation.

Inputs used to calculate the cost of a case of subclinical ketosis are listed in Table 4. In this research, the dairy efficiency and cost of 1 kg of dry matter basis to produce 1 lt of milk were found to be 1.55 and 0.33 dollars, respectively. An economic analysis of K incidence utilizes several key parameters sourced from the BUF and the Turkish National Dairy Council. The data confirms that CK is associated with a milk production decrease of 2.07 kg per affected animal, which is valued at a loss of approximately 0.89 dollars per day when calculated against the average Turkish milk price of 0.43 dollars/L (derived from 18.35 TL at the 42 5500 exchange rate). Furthermore, the study identifies the substantial capital risk posed by K, noting that 13% of cases result in culling or death. The economic loss associated with culling is quantified at 96.75 dollars per animal , reflecting the difference between the average herd cow value (1.543 dollars) and the cow's salvage meat value (2.16 dollars/kg). These metrics, alongside the cost of producing 1 L of milk (0.33 dollars, TMR basis) and a dairy efficiency of 1.55, collectively underline that K constitutes a systematic and significant financial burden on high-yielding dairy operations, extending beyond simple milk loss to include substantial capital depreciation through culling.

Table 4. Inputs Used to Calculate the Cost of a Case of Ketosis (K is defined as elevated blood BHBA ≥1.4 mmol/dl on either the 7th or 15th day after calving

Milk production change (kg) due to clinical ketosis	2.07	BUF
Average milk price in Türkiye (dollars/L)	18.35 TL – 0.43 dollars (Exchange Rate=42 5500)	Turkish National Dairy Council
Dairy efficiency	1,55	BUF
Cost (dollars) of 1 kg of TMR (dry matter basis) to produce 1 L of milk	0.33 dollars	BUF
The average value of a cow in a herd(dollars)	1 543 dollars	BUF
The average value of cow meat per kg(dollars)	2.16 dollars	BUF
Economic loss per animal related to culling	96.75 dollars	BUF

DISCUSSION AND CONCLUSION

Ketosis-related financial losses comprise treatment and culling-associated costs, an increased rate of secondary diseases. The cost of subclinical ketosis (SCK) may differ per farm due to farm-specific conditions (6-9). Generally, research on ketosis (K) and SCK takes the form of estimation or modeling. However, this study utilized existing farm data, and our objective was to evaluate the economic impact of SCK in terms of treatment cost and milk yield. The average prevalence of SCK in dairy cows ranges from 11% to 49% in European countries, including Italy, Croatia, Hungary, Portugal, Spain, Germany, and Türkiye (10,11). In the present study, the incidence of clinical ketosis was determined to be 33%, and the total economic cost associated with subclinical ketosis (SCK) amounted to 593.09 dollars. These findings are partially consistent with those reported by Steeneveld et al. (6), who documented annual treatment costs of ketosis of 1.051 euros. Previous estimates of SCK-related costs vary considerably in the literature. Mostert et al. (9) reported an average cost of 130 euros per case per year (ranging from 39 to 348 euros), whereas Esslemont et al. (12) estimated costs as high as 735 euros per case. Similarly, Gohary et al. (7) calculated the cost of a single SCK case to be approximately 203 dollars using a modeling approach. In contrast, a Canadian study (8) reported substantially lower losses, estimating the cost of SCK at 78 dollars per case. Raboisson et al. (13) further reported average costs of 257 euros per cow per calving. Such discrepancies among studies likely reflect differences in herd management practices, cost components included in the analyses, and the relative contribution of culling to total economic loss. Steeneveld et al. (6) also indicated that variations in average herd milk production had only a minor effect on the overall cost of ketosis, and that herd size primarily influenced the variability of annual costs rather than the average cost per case. In line with these findings, no direct economic loss attributable to reduced milk yield was identified in the present study. Nevertheless, the lack of a detectable production loss should be interpreted with caution, and further investigations incorporating subsequent lactations are warranted. Notably, the visual comparison of weekly milk yield patterns suggests that SCK primarily affects production stability rather than total milk output. Cows with SCK exhibited higher milk yields during the early weeks of lactation, likely due to increased mobilization of body reserves, a phenomenon commonly observed in metabolically stressed cows (14). However, this initial advantage was not maintained, as reflected by greater variability and a less uniform distribution of weekly milk yields after mid-lactation. In contrast, healthy cows displayed a more consistent and stable production pattern, indicative of better metabolic regulation and a more typical lactation curve. Collectively, these findings suggest that ketosis compromises the cow's ability to sustain stable milk production over time, underscoring the importance of early metabolic management to prevent long-term production instability and associated economic losses. The polar heat map provides a visual confirmation that subclinical ketosis exerts a significant negative influence on milk yield across consecutive lactations. The consistently lower production values observed in K cows support previous findings indicating that metabolic disorders impair both immediate and long-term lactational performance. However, in a related study, although SCK was present in 26.3% of cows, no significant reduction in milk yield or pregnancy rates was observed among the affected animals (15,16). The clustering of low-yield regions in K cows suggests that the effects of subclinical ketosis are not confined to a specific stage of lactation but persist throughout the production cycle. This pattern may reflect compromised energy balance and reduced feed intake commonly associated with K, which in turn diminishes milk synthesis capacity. Furthermore, the similarity of the patterns between the current and previous lactations implies that cows experiencing K are at higher risk of recurring production losses across multiple lactations. In contrast, healthy cows demonstrated stable and consistently high yields, indicating robust metabolic status and efficient nutrient utilization. The visual separation between healthy and SCK groups reinforces the importance of early detection and management of subclinical ketosis to mitigate cumulative productivity losses. Overall, the heat map indicates that metabolic health is a crucial determinant of sustained milk production and that K has both immediate and long-lasting effects, necessitating close monitoring and intervention in dairy herd management. Crucially, the heat map analysis revealed that the economic consequences of ketosis extend beyond mere calculated costs, as the initial yield advantage of affected cows is not sustained, leading to unstable production dynamics and a persistent long-term performance disparity in favor of healthy animals.

In conclusion, the 33% incidence of ketosis and its association with hypocalcemia and mastitis underscore the metabolic challenges in high-yielding dairy herds. While quantifying precise milk yield losses remains complex, these findings highlight that ketosis poses a chronic, systemic threat to sustained profitability. Effective prevention can be achieved through early diagnosis and specific nutritional strategies, such as diet balancing and controlled supplementation of calcium and energy (17). Furthermore, it is acknowledged that treatment costs vary significantly with farm size, productivity level, and animal age, necessitating robust management strategies to mitigate cumulative economic losses across multiple lactations.

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CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

TNS and HU took part in the study planning, TNS sample collection, TNS and HU the writing of the study and final check.

ETHICAL STATEMENT

All procedures involving animals were conducted in accordance with the ethical guidelines outlined in the Turkish National Animal Protection Law.

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