

HEALTH STATUS AND ITS EFFECTS ON DAILY MILK PRODUCTION IN SIMMENTAL COWS CONSIDERING KEY ANIMAL-RELATED FACTORS*

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Abstract

This study analyzed the effect of mastitis on daily milk production parameters in Simmental cows, considering factors such as lactation stage, parity, and production level. After applying quality control measures, the final dataset consisted of 2,835,101 test-day records of dairy Simmental cows. The results showed that both subclinical and clinical mastitis negatively impacted milk yield and milk composition. Cows with subclinical mastitis had lower milk production compared to healthy cows, while those with clinical mastitis experienced even more significant losses. Mastitis also influenced milk quality, with increased fat and protein content and decreased lactose levels. The effects were more pronounced in cows in later stages of lactation and those with higher production levels. Early detection and intervention are critical to minimize milk production losses and maintain milk quality. Improving farm management practices, such as monitoring somatic cell counts and ensuring proper hygiene and nutrition, is essential for optimizing milk production and reducing economic losses.

Key words: *mastitis, dairy Simmental, milk production, somatic cell count*

INTRODUCTION

Production diseases in dairy cows are primarily caused by management practices, especially poor feeding and handling. These diseases encompass metabolic disorders, infertility, mastitis, and laminitis, with nutritional and managerial factors being pivotal (Nir, 2003). Although infectious diseases often garner more public attention, production diseases have a far greater economic impact, which surpasses that of epidemic outbreaks (Hogeveen *et al.*, 2019). Addressing these concerns through better management practices not only improves animal health but also enhances the economic efficiency of dairy production. Mastitis, the most common production disease in dairy cattle (Seegers *et al.*, 2003), is primarily caused by intramammary infections (IMI) from bacterial

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pathogens. It results in physical, chemical, and bacteriological changes in milk, as well as pathological alterations in glandular tissue. Mastitis can be classified into clinical and subclinical forms. Clinical mastitis presents with visible symptoms, such as abnormal milk, gland inflammation, and systemic illness, whereas subclinical mastitis is asymptomatic and is identified by elevated somatic cell counts (SCC) (Adkins & Middleton, 2018). Clinical mastitis is further classified based on severity: mild (milk abnormalities), moderate (gland inflammation), and severe (systemic symptoms) (Narváez-Semanate *et al.*, 2022). Mild cases are the most common, while severe cases are relatively rare. Additionally, mastitis has a significant impact on milk production, quality, and farm economics, underscoring the importance of early detection and intervention. Mastitis diagnosis is based on clinical observations and measurements of the inflammatory response, with the identification of the causative agent being essential for diagnosing intramammary infections (IMI). Subclinical mastitis, which is more common than clinical forms, is responsible for up to 80% of milk production losses and represents a significant long-term risk (Halasa *et al.*, 2007). If left untreated, affected udder quarters may become nonfunctional, leading to culling or even death. Despite its economic impact, preventive measures are often delayed until a decrease in milk yield is observed. Early detection is crucial, as changes in udder tissue occur before visible symptoms (Argaw, 2016). Prompt diagnosis can help reduce antibiotic use, maintain milk production, and prevent the spread of infection (Kamal *et al.*, 2014). Additionally, mastitis contributes to greenhouse gas emissions, highlighting the importance of prevention for both sustainability and profitability (Özkan Gülzari *et al.*, 2018). Effective management not only minimizes losses and optimizes culling rates but also reduces emissions per kilogram of milk produced.

Somatic cell count (SCC) is a vital indicator of intramammary infections and milk quality, monitored at the individual, herd, and population levels (Schukken *et al.*, 2003). Monitoring SCC offers valuable insights into udder health, as elevated counts usually signal inflammation caused by pathogen invasion, which triggers an immune response and leads to an increase in somatic cells in the milk (Ivanov *et al.*, 2016; Alhussien & Dang, 2018). An increase in SCC across successive lactations is mainly associated with polymorphonuclear leukocytes (PMN), while fluctuations in SCC within a lactation involve both PMN and other immune cells (Blackburn, 1966). Various factors influence SCC variability, including lactation stage, parity, season, management practices, and environmental conditions. SCC tends to rise with lactation number due to cumulative udder stress and immune system changes (Mikó *et al.*, 2016). Cows in late lactation often show higher SCC levels due to prolonged milk stasis and diminished immune function. Heat stress further aggravates SCC fluctuations, as demonstrated in studies on Holstein cows, where SCC levels varied according to temperature-humidity index, milk yield, breed, and parity (Gantner *et al.*, 2011, 2017). Moreover, herd management plays a critical role in controlling SCC, as poor milking hygiene, improper equipment maintenance, and inadequate housing conditions contribute to bacterial infections and increased SCC (Hadrich *et al.*, 2018). Healthy udder function is typically indicated by SCC levels below 100,000 cells/ml, with optimal milk quality falling within the range

of 20,000 to 100,000 SCC/ml (Mikó *et al.*, 2016). Elevated SCC is associated with considerable production losses, with cows exhibiting SCC levels between 50,000 and 100,000 cells/ml experiencing a loss of more than 8%, and those with SCC levels ranging from 100,000 to 250,000 cells/ml suffering losses of 15–18% (Pfützner & Ózsvári, 2016). The overall impact on milk yield is influenced by the distribution of SCC across cows and the parity within the herd (Chen *et al.*, 2021). Therefore, managing SCC through improved hygiene, nutrition, and environmental control is crucial for maintaining milk production efficiency and minimizing economic losses.

Given the significance of mastitis analysis on dairy cattle farms, this study aimed to examine the effect of animal health status (normal, subclinical, or clinical mastitis) on daily milk production parameters in Simmental cattle, taking into account key animal-related factors such as lactation stage, parity, and production level.

MATERIALS AND METHODS

The statistical analysis in this study was based on test-day records from Simmental cows, collected over a 10-year period (January 2013–December 2022) as part of routine milk recording. The milk recording process followed the standards set by the International Committee for Animal Recording (ICAR, 2017) for alternative milk recording methods (AT4/BT4). Under this system, milk yield measurements and sample collection were performed every four weeks, with samples taken from each cow during either morning or evening milking. Data collection for the AT4 method was conducted by trained officers from the Croatian Agency for Agriculture and Food (HAPIH), while farm employees trained in milk recording were responsible for the BT4 method. After collection, milk samples were transported to the accredited Central Laboratory for Milk Quality Control (SLKM) of HAPIH for analysis, in full compliance with ICAR (2017) protocols.

Milk composition analysis included parameters such as fat, protein, lactose, total solids, solids-not-fat, urea, casein, free fatty acids, pH, ketone bodies, and freezing point. These parameters were determined using infrared spectrophotometry on MilkoScan analyzers. Somatic cell counts were measured using Fossomatic analyzers, utilizing the fluoro-opto-electronic method.

Materials and Methods

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Before implementing logical data control procedures, the dataset obtained from HAPIH contained over 4 million test-day records. During the validation process, entries that did not meet the standards set by ICAR (2017) were excluded. Additionally, records with missing or inaccurate information regarding breed, farm identification, breeding region, lactation stage, parity, age at first calving, calving date, and milk recording date were

removed to ensure data integrity and consistency. After applying these quality control measures, the final dataset consisted of 2,835,101 test-day records from Simental cows. Somatic cell count (SCC) served as the primary indicator for identifying subclinical and clinical mastitis. Based on SCC levels, cows were categorized into three groups: healthy ($< 200,000$ cells/ml), subclinical mastitis ($200,000\text{--}400,000$ cells/ml), and clinical mastitis ($> 400,000$ cells/ml). To account for the effect of lactation stage, cows were divided into four days-in-milk (DIM) classes: < 100 days, $100\text{--}200$ days, $200\text{--}300$ days, and > 300 days. Additionally, cows were grouped according to parity into four categories: first (I), second (II), third (III), and fourth or higher ($\geq$ IV). Cows were also categorized by their daily milk yield (DMY) into four production groups: I. DMY < 20 kg, II. DMY between 20 and 30 kg, III. DMY between 30 and 40 kg, and IV. DMY > 40 kg.

The analysis of the effect of animal health status (normal, subclinical, or clinical mastitis) on daily milk production parameters in Simental cattle was conducted separately for the classes of lactation stage, parity, and animal production level. The statistical model used for the analysis is as follows:

$$y_{ijklmn} = \mu + b_1 \left(\frac{d_i}{305} \right) + b_2 \left(\frac{d_i}{305} \right)^2 + b_3 \ln \left(\frac{305}{d_i} \right) + b_4 \ln^2 \left(\frac{305}{d_i} \right) \\ + A_j + R_k + H_l + S_m + M_n + e_{ijklmn}$$

where:

y_{ijklmn} = estimated milk production trait (daily milk yield, daily fat, protein, lactose and urea content, log value of somatic cell count);

μ = intercept;

b_1, b_2, b_3, b_4 = regression coefficients;

d_i = stage of lactation ($i = 6$ to 400 day);

A_j = fixed effect of age at first calving ($j = 21$ to 36 month) * only for first parity;

R_k = fixed effect of region k ($k = \text{Central, Eastern, Mediterranean}$);

H_l = fixed effect of herd size ($l = \text{I, II, III, IV, V, VI}$);

S_m = fixed effect of season ($m = \text{spring, summer, autumn, winter}$);

M_n = fixed effect of animal health status M ($n = \text{healthy, subclinical mastitis, and clinical mastitis}$);

e_{ijklmn} = residual.

The significance of the differences between the estimated LSMeans was tested by Scheffe's method of multiple comparisons using the MIXED procedure of SAS (SAS Institute Inc., 2019)

RESULTS AND DISCUSSION

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Table 1. LsMeans of daily milk production parameters regarding the Simmentals health status and considering lactation stage classes (< 100 days, 100 – 200 days, 200 – 300 days, > 300 days)

Lactation stage class	Health status	DMY	DFC	DPC	DLC	SCClog	UREA
< 100 days	Normal	17,98 ^A	3,92 ^A	3,20 ^A	4,56 ^A	5,51 ^A	19,45 ^A
	Subclinical	17,68 ^B	4,01 ^B	3,27 ^B	4,48 ^B	8,10 ^B	18,97 ^B
	Clinical	17,53 ^C	4,06 ^C	3,30 ^C	4,38 ^C	10,03 ^C	18,84 ^C
100 – 200 days	Normal	17,10 ^A	4,02 ^A	3,41 ^A	4,52 ^A	5,70 ^A	20,95 ^A
	Subclinical	16,94 ^B	4,10 ^B	3,45 ^B	4,44 ^B	8,05 ^B	20,41 ^B
	Clinical	16,88 ^C	4,13 ^C	3,48 ^C	4,35 ^C	9,93 ^C	20,34 ^C
200 – 300 days	Normal	16,38 ^A	4,27 ^A	3,64 ^A	4,49 ^A	5,98 ^A	21,62 ^A
	Subclinical	16,26 ^B	4,33 ^B	3,69 ^B	4,41 ^B	8,05 ^B	21,23 ^B
	Clinical	16,21 ^C	4,35 ^C	3,71 ^C	4,32 ^C	9,86 ^C	21,22 ^C
> 300 days	Normal	16,13 ^A	4,41 ^A	3,79 ^A	4,47 ^A	6,13 ^A	21,77 ^A
	Subclinical	16,00 ^B	4,47 ^B	3,84 ^B	4,38 ^B	8,05 ^B	21,53 ^B
	Clinical	15,94 ^C	4,49 ^C	3,86 ^C	4,28 ^C	9,83 ^C	21,54 ^C

*LsMeans marked with different letter (capital or small), differ statistically highly ($p < 0.001$) significant or statistically ($p < 0.01$) significant

DMY – daily milk yield (kg), DFC – daily fat content (%), DPC – daily protein content (%), DLC – daily lactose content (%), SCClog – log value of somatic cell count, UREA – concentration of urea in milk (mg/dl)

The table presents the least squares means (LsMeans) of daily milk production parameters (DMY, DFC, DPC, DLC, SCClog, and UREA) in Simmental cows, classified according to their health status (Normal, Subclinical, or Clinical Mastitis) and lactation stage classes (< 100 days, 100–200 days, 200–300 days, > 300 days). The results show how mastitis severity affects various milk production parameters and highlight the importance of managing animal health to optimize milk yield and quality. The general trend observed in the table is a decrease in daily milk yield as lactation progresses. Cows in the <100 days lactation stage have the highest DMY, while cows in the >300 days lactation stage produce the least milk. Health status significantly affects milk yield: normal cows consistently have the highest DMY across all lactation stages, followed by cows with subclinical mastitis, and finally, clinical mastitis cows, which exhibit the lowest milk yield. These differences are statistically significant ($p < 0.001$), suggesting that mastitis, particularly clinical mastitis, severely impacts milk production. Daily fat

content follows a similar pattern to milk yield, with values decreasing slightly as lactation advances. For each lactation stage, clinical mastitis cows show the highest fat content, followed by subclinical mastitis cows, and normal cows, though the differences are small. These differences are statistically significant ($p < 0.01$). The higher fat content in mastitis-affected cows could be a compensatory mechanism, as the body attempts to adjust to the infection by altering the composition of milk. Daily protein content remains relatively stable across different lactation stages, with slight decreases observed in later lactation stages. For each lactation class, normal cows have the highest protein content, followed by subclinical mastitis cows, and clinical mastitis cows, which have the lowest protein content. These differences are statistically significant ($p < 0.01$), suggesting that mastitis affects the nutritional quality of milk, leading to lower protein levels, which can ultimately affect dairy product quality.

Lactose content in milk decreases slightly as lactation progresses. For each lactation stage, normal cows exhibit the highest lactose content, followed by subclinical mastitis cows, and then clinical mastitis cows. These differences are statistically significant ($p < 0.01$), indicating that mastitis impairs lactose production, a key component of milk. The log value of somatic cell count increases as lactation advances, with cows in the >300 days lactation stage showing the highest values. SCC is significantly higher in mastitis-affected cows. Clinical mastitis cows consistently have the highest SCClog values across all lactation stages, followed by subclinical mastitis cows, and normal cows, which have the lowest values. These differences are highly significant ($p < 0.001$), as somatic cell count is directly related to udder health and mastitis severity. Urea concentration in milk increases as lactation progresses, with the highest levels in the >300 days lactation stage. In terms of health status, cows with clinical mastitis show slightly higher urea concentrations than subclinical or normal cows, although the differences are less pronounced than for other parameters.

These differences are statistically significant ($p < 0.01$), and the elevated urea levels could reflect alterations in nitrogen metabolism due to the inflammatory response associated with mastitis. The results of this analysis demonstrate the significant negative impact of mastitis on milk production and quality. Cows with clinical mastitis have the lowest milk yield and milk quality, particularly in terms of protein and lactose content, and exhibit the highest somatic cell counts. Subclinical mastitis, although less severe, still results in decreased milk yield and quality. These findings underscore the importance of early detection and effective management of mastitis to prevent economic losses on dairy farms. The analysis also reveals that lactation stage plays a key role in milk production. As cows progress through lactation, there is a natural decline in milk yield and quality. This decline is further exacerbated by the presence of mastitis, particularly clinical mastitis, which highlights the need for appropriate management strategies to mitigate the effects of mastitis and maintain optimal milk production.

Table 2. LsMeans of daily milk production parameters regarding the Simmentals health status and considering parity classes (I., II., III., and VI.+)

Parity class	Mastitis class	DMY	DFC	DPC	DLC	SCClog	UREA
I.	Normal	16,66 ^A	4,13 ^A	3,44 ^A	4,58 ^A	5,61 ^A	20,88 ^A
	Subclinical	16,56 ^B	4,21 ^B	3,50 ^B	4,50 ^B	8,04 ^B	20,28 ^B
	Clinical	16,52 ^C	4,25 ^C	3,52 ^C	4,42 ^C	9,89 ^C	20,10 ^C
II.	Normal	17,23 ^A	4,16 ^A	3,50 ^A	4,52 ^A	5,73 ^A	20,76 ^A
	Subclinical	17,01 ^B	4,24 ^B	3,55 ^B	4,44 ^B	8,07 ^B	20,27 ^B
	Clinical	16,94 ^C	4,26 ^C	3,57 ^C	4,36 ^C	9,91 ^C	20,09 ^C
III.	Normal	17,46 ^A	4,11 ^A	3,46 ^A	4,50 ^A	5,79 ^A	20,58 ^A
	Subclinical	17,22 ^B	4,18 ^B	3,52 ^B	4,42 ^B	8,04 ^B	20,13 ^B
	Clinical	17,13 ^C	4,22 ^C	3,54 ^C	4,34 ^C	9,90 ^C	20,10 ^C
VI.+	Normal	17,12 ^A	4,06 ^A	3,43 ^A	4,48 ^A	5,91 ^A	20,66 ^A
	Subclinical	16,93 ^B	4,13 ^B	3,48 ^B	4,39 ^B	8,08 ^B	20,32 ^B
	Clinical	16,83 ^C	4,16 ^C	3,51 ^C	4,29 ^C	9,98 ^C	20,32 ^C

*LsMeans marked with different letter (capital or small), differ statistically highly ($p < 0.001$) significant or statistically ($p < 0.01$) significant;

DMY – daily milk yield (kg), DFC – daily fat content (%), DPC – daily protein content (%), DLC – daily lactose content (%), SCClog – log value of somatic cell count, UREA – concentration of urea in milk (mg/dl)

Table 2 presents the least-squares means (LsMeans) for various daily milk production parameters in Simmental cows, considering both health status (normal, subclinical, and clinical mastitis) and parity classes (I, II, III, and VI+). These parameters include daily milk yield (DMY), daily fat content (DFC), daily protein content (DPC), daily lactose content (DLC), log-transformed somatic cell count (SCClog), and urea concentration in milk (UREA). The results show that both health status and parity significantly influence milk production and composition, with clear patterns emerging from the data. Milk yield tends to decrease as parity increases, with the highest yields observed in first-lactation cows (I. parity) and the lowest in cows with higher parities (VI+). Within each parity group, normal cows produce the most milk, followed by subclinical, and then clinical mastitis cows. These differences are statistically significant ($p < 0.001$), highlighting that mastitis negatively affects milk production in all parity classes, with clinical mastitis having the most detrimental effect. For instance, in the I. parity group, normal cows yield 16.66 kg of milk per day, while subclinical and clinical mastitis cows yield slightly lower amounts (16.56 kg and 16.52 kg, respectively). As parity increases, milk yields remain higher for normal cows compared to those affected by mastitis, but the differences between health status groups narrow, particularly in the VI+ group, where the yield difference is minimal (16.83 kg for clinical mastitis cows vs. 17.12 kg for normal cows). Fat content (DFC) also shows a slight decrease as parity increases. Normal cows consistently show the highest fat content across all parity groups. However, the differences between health statuses are statistically significant ($p < 0.01$), with clinical mastitis cows consistently having the highest fat content, followed by

subclinical and normal cows. For example, in the I. parity group, normal cows have a DFC of 4.13%, while clinical mastitis cows have 4.25%. This trend is consistent across all parity groups, indicating that mastitis may influence milk fat content, potentially as a compensatory response to the infection. Protein content (DPC) follows a similar pattern to fat content, with normal cows having the highest protein levels, followed by subclinical and clinical mastitis cows. These differences are statistically significant ($p < 0.01$). For example, in the I. parity group, normal cows produce milk with 3.44% protein, while clinical mastitis cows have 3.52% protein. As parity increases, protein content in milk generally decreases, but the relative differences between health status groups remain consistent. This suggests that mastitis, regardless of its form, slightly reduces milk protein levels, which could negatively affect milk quality. Lactose content (DLC) decreases with increasing parity, similar to protein and fat content. Normal cows again show the highest lactose content, while clinical mastitis cows exhibit the lowest levels. These differences are statistically significant ($p < 0.01$). In the I. parity group, normal cows produce milk with 4.58% lactose, while clinical mastitis cows have 4.42%. This pattern holds across all parity groups, suggesting that mastitis has a negative impact on lactose synthesis, which may reduce the nutritional value of the milk. Somatic cell count (SCC), a key indicator of udder health, is significantly higher in mastitis-affected cows across all parity groups. Clinical mastitis cows show the highest SCC levels, followed by subclinical cows, with normal cows having the lowest SCC values. These differences are highly statistically significant ($p < 0.001$). For instance, in the I. parity group, normal cows have a log-transformed SCC value of 5.61, subclinical cows have 8.04, and clinical mastitis cows have 9.89. As parity increases, SCC values also increase, reflecting the general decline in udder health as cows age, especially for those with mastitis. Elevated SCC levels in mastitis-affected cows indicate an ongoing immune response to infection, which impacts milk quality and yield. Urea concentration in milk tends to increase with increasing parity, and it is also higher in mastitis-affected cows compared to normal cows, although the differences are less pronounced than in other parameters. Statistically significant differences are observed ($p < 0.01$). For example, in the I. parity group, normal cows have a urea concentration of 20.88 mg/dl, while clinical mastitis cows have 20.10 mg/dl. While the differences in urea concentration are relatively small, they indicate changes in protein metabolism, which could be due to the metabolic stress associated with mastitis. This analysis reveals the significant impact of both health status and parity on daily milk production parameters in Simmental cows. Mastitis, whether subclinical or clinical, consistently reduces milk yield, protein, and lactose content, while increasing fat content and somatic cell count. The detrimental effects of mastitis are more pronounced in cows with higher parities, although even first-lactation cows with clinical mastitis show a marked reduction in milk production and quality. Therefore, early detection and management of mastitis are critical for maintaining milk yield and quality, particularly in older cows. Regular monitoring of somatic cell count and milk composition is essential for managing udder health and ensuring optimal milk production in dairy herds.

Table 3. LsMeans of daily milk production parameters regarding the Simentals health status and considering animal production level (I., II., III., and VI.+)

Production class	Mastitis class	DMY	DFC	DPC	DLC	SCClog	UREA
I. DMY < 20 kg	Normal	9,43 ^A	4,27 ^A	3,60 ^A	4,45 ^A	6,06 ^A	20,31 ^A
	Subclinical	9,25 ^B	4,36 ^B	3,67 ^B	4,34 ^B	8,10 ^B	20,11 ^B
	Clinical	9,13 ^C	4,41 ^C	3,72 ^C	4,23 ^C	10,00 ^C	20,18 ^C
II. DMY in 20 – 30 kg	Normal	13,98 ^A	4,18 ^A	3,50 ^A	4,51 ^A	5,89 ^A	20,06 ^A
	Subclinical	13,94 ^B	4,25 ^B	3,56 ^B	4,43 ^B	8,08 ^B	19,70 ^B
	Clinical	13,91 ^C	4,27 ^C	3,58 ^C	4,33 ^C	9,96 ^C	19,67 ^C
III. DMY in 30 – 40 kg	Normal	17,96 ^A	4,09 ^A	3,44 ^A	4,54 ^A	5,74 ^A	20,76 ^A
	Subclinical	17,91 ^B	4,16 ^B	3,48 ^B	4,46 ^B	8,05 ^B	20,30 ^B
	Clinical	17,89 ^C	4,19 ^C	3,50 ^C	4,37 ^C	9,92 ^C	20,25 ^C
VI. DMY > 40 kg	Normal	26,14 ^A	3,98 ^A	3,34 ^A	4,57 ^A	5,47 ^A	21,91 ^A
	Subclinical	25,72 ^B	4,05 ^B	3,38 ^B	4,50 ^B	8,00 ^B	21,28 ^B
	Clinical	25,56 ^C	4,07 ^C	3,39 ^C	4,42 ^C	9,83 ^C	20,94 ^C

*LsMeans marked with different letter (capital or small), differ statistically highly ($p < 0.001$) significant or statistically ($p < 0.01$) significant;

DMY – daily milk yield (kg), DFC – daily fat content (%), DPC – daily protein content (%), DLC – daily lactose content (%), SCClog – log value of somatic cell count, UREA – concentration of urea in milk (mg/dl)

Table 3 provides the least-squares means (LsMeans) of daily milk production parameters in Simmental cows, categorized by health status (normal, subclinical, and clinical mastitis) and animal production level. The production levels are classified based on daily milk yield (DMY) into four groups: less than 20 kg (I), 20–30 kg (II), 30–40 kg (III), and greater than 40 kg (VI+). The parameters analyzed include daily milk yield (DMY), daily fat content (DFC), daily protein content (DPC), daily lactose content (DLC), log-transformed somatic cell count (SCClog), and urea concentration in milk (UREA). The table demonstrates how mastitis and production levels influence milk composition and yield. As expected, cows in higher production classes (VI+) consistently produce more milk than those in lower production classes. For example, cows in class VI+ (DMY > 40 kg) yield 26.14 kg of milk per day when healthy, whereas cows in the I. class (DMY < 20 kg) yield only 9.43 kg per day. Additionally, mastitis (both subclinical and clinical) reduces milk yield within each production class, with clinical mastitis resulting in the most significant decrease in yield. For instance, in the I. production class, normal cows produce 9.43 kg of milk, while clinical mastitis cows produce 9.13 kg, a drop of approximately 0.30 kg. This trend is observed across all production levels, with clinical mastitis cows yielding less milk than those with subclinical or no mastitis. The differences in milk yield between health statuses are statistically significant ($p < 0.001$), emphasizing the negative impact of mastitis on milk production. Fat content in milk shows a similar trend to milk yield, with normal cows consistently exhibiting the highest fat content across all production levels. For example, in the I. production class, normal cows have 4.27% fat, while clinical mastitis cows have

4.41%. Although fat content increases slightly in mastitis-affected cows, the differences in fat content between health statuses are statistically significant ($p < 0.01$), with clinical mastitis cows showing the highest fat content. This may be due to metabolic changes associated with mastitis, potentially as a compensatory response. In higher production classes, this trend continues, with clinical mastitis cows generally showing the highest fat content compared to subclinical and normal cows. Protein content in milk follows a similar pattern, with normal cows consistently having the highest protein levels in all production classes. For instance, in the I. production class, normal cows have 3.60% protein, while clinical mastitis cows have 3.72%. The differences in protein content are statistically significant ($p < 0.01$), and clinical mastitis cows generally have higher protein content compared to subclinical cows, despite the negative effect of mastitis on overall milk yield. As with fat content, protein content tends to be slightly higher in clinical mastitis cows across all production classes, indicating that mastitis might lead to changes in milk composition. Lactose content shows a general decline with increasing severity of mastitis. Normal cows exhibit the highest lactose content, while clinical mastitis cows show the lowest levels. For example, in the I. production class, normal cows have 4.45% lactose, while clinical mastitis cows have 4.23%. These differences are statistically significant ($p < 0.01$). As mastitis severity increases, lactose synthesis appears to decrease, which could contribute to the reduced nutritional value of milk. The same trend is observed across higher production levels, with clinical mastitis cows having the lowest lactose content. Somatic cell count (SCC), which is a key indicator of udder health, shows a clear increase with the severity of mastitis. Clinical mastitis cows have the highest SCC, followed by subclinical cows, and normal cows show the lowest SCC. The differences in SCC are highly significant ($p < 0.001$). For instance, in the I. production class, normal cows have a log-transformed SCC of 6.06, while clinical mastitis cows have 10.00. As production level increases, SCC also increases, especially for mastitis-affected cows. This indicates that udder health declines as milk production rises, which is expected as higher-yielding cows often experience more udder stress. Urea concentration in milk generally increases with production level, with higher-yielding cows having higher urea concentrations. For example, in the VI+ production class, normal cows have 21.91 mg/dl of urea, while clinical mastitis cows have 20.94 mg/dl. The differences in urea concentration are statistically significant ($p < 0.01$), though the differences between health statuses are relatively small compared to other parameters. This suggests that mastitis has a moderate effect on milk protein metabolism, reflected in the urea concentration in milk. The analysis of Table 3 highlights the substantial impact of both mastitis and production level on milk production parameters in Simental cows. Mastitis, whether subclinical or clinical, consistently reduces milk yield, protein content, and lactose content, while increasing fat content and somatic cell count. Higher production levels are associated with higher milk yields but also with higher somatic cell counts and slightly higher urea concentrations in milk. Clinical mastitis has the most significant negative effect on milk yield and quality, and this impact is evident across all production classes. Effective management and early detection of mastitis are crucial for maintaining optimal milk

production and quality, especially in high-producing cows. Regular monitoring of somatic cell count and milk composition is essential for ensuring udder health and maximizing dairy farm profitability.

The results of this study show a significant impact of mastitis on daily milk production and milk quality in Simmental cows. In all lactation stages and production classes, cows with clinical mastitis had lower daily milk yields compared to healthy cows, while cows with subclinical mastitis also showed a decrease in production, but to a lesser extent. These results confirm previous studies indicating significant milk production losses due to mastitis, especially subclinical mastitis, which is responsible for long-term losses (Halasa *et al.*, 2007). Furthermore, the data suggest that older cows and cows in later stages of lactation have lower daily milk yields, which is linked to cumulative udder stress. Higher SCC in these groups confirms the negative effect of stress on the udder (Schukken *et al.*, 2003). Changes in milk composition, such as increased fat and protein content, along with decreased lactose levels, were also observed in cows with mastitis, which can negatively affect milk quality (Nir, 2003; Seegers *et al.*, 2003). In conclusion, mastitis, whether clinical or subclinical, has a significant impact on milk production and quality. Preventive management of mastitis, including SCC monitoring, better hygiene practices, and nutritional support, is essential for reducing production losses and maintaining milk quality (Argaw, 2016; Kamal *et al.*, 2014; Özkan Gülzari *et al.*, 2018).

CONCLUSIONS

Based on the results of this study, it can be concluded that mastitis, both clinical and subclinical, has a significant impact on daily milk production and milk quality in Simmental cows. Cows with subclinical mastitis also showed a reduction in milk production compared to healthy cows, although this reduction was less pronounced than in those with clinical mastitis. Data from different stages of lactation and production levels clearly indicate a negative effect of mastitis on daily milk yield, especially in older cows and those in the later stages of lactation, which is associated with cumulative udder stress.

Additionally, changes in milk composition, including increased fat and protein content and reduced lactose levels, further confirm the negative impact of mastitis on milk quality, which can have long-term consequences on farm economics. Therefore, early detection and effective management of mastitis, including monitoring SCC, improving hygiene practices, and proper nutrition, are crucial for reducing milk production losses and preserving milk quality.

With proper prevention and control of mastitis, it is possible to reduce economic losses and optimize milk production, thereby enhancing the sustainability and profitability of dairy farms.

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ZDRAVSTVENO STANJE I NJEGOVI UČINCI NA DNEVNU PROIZVODNJU MLJEKA U SIMENTALSKIH KRAVA UZIMAJUĆI U OBZIR KLJUČNE FAKTORE VEZANE UZ ŽIVOTINJE

Sažetak

Ova studija analizirala je utjecaj mastitisa na dnevne parametre proizvodnje mlijeka u Simmental krava, uzimajući u obzir faktore poput faze laktacije, pariteta i razine proizvodnje. Nakon primjene mjera kontrole kvalitete, konačni skup podataka sastojao se od 2,835,101 zapisa o testnim danima Simmental krava. Rezultati su pokazali da su i subklinički i klinički mastitis negativno utjecali na prinos mlijeka i kvalitetu mlijeka. Krave sa subkliničkim mastitisom imale su manji prinos mlijeka u usporedbi s zdravim kravama, dok su one s kliničkim mastitisom pretrpjele još veće gubitke. Mastitis je također utjecao na kvalitetu mlijeka, s povećanjem sadržaja masti i proteina, te smanjenjem razine laktoze. Učinci su bili izraženiji kod krava u kasnijim fazama laktacije i onih s višim razinama proizvodnje. Rana detekcija i intervencija ključni su za minimiziranje gubitaka u proizvodnji mlijeka i očuvanje kvalitete mlijeka. Poboljšanje praksi u upravljanju farmom, kao što je praćenje somatskih stanica i osiguranje odgovarajuće higijene i prehrane, ključno je za optimizaciju proizvodnje mlijeka i smanjenje ekonomskih gubitaka.

Ključne riječi: *mastitis, mliječna goveda, Simentalac, proizvodnja mlijeka, somatske stanice*