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Effect of somatic cell count on milk composition and some chemical properties of milk

[*Investigação do efeito da contagem de células somáticas na composição e algumas propriedades químicas do leite*]

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ABSTRACT

Subclinical mastitis is a very important disease for dairy cattle farms. As a result of the deterioration of milk quality, it causes economic losses in enterprises. Milk samples of 180 cows were divided into five groups according to the somatic cell count. Some chemical properties and composition were measured in milk samples. The ratio of solid-non-fat, mineral matter, lactose, and protein decreased as the somatic cell count of the milk increased ($P<0.05$). No statistical difference was observed between the fat content of milk and the level of somatic cell count ($P>0.05$). Although specific gravity decreases ($P<0.05$), the electrical conductivity increases ($P<0.001$) in milk with high levels of somatic cell count. The milk quality of dairy cattle deteriorates due to the high somatic cell count. Therefore, regular monitoring of somatic cell count is recommended in dairy farms to monitor changes in fat, protein, solid-non-fat, lactose, and mineral matter ratios as well as some chemical properties that make up the milk composition.

Keywords: cow, milk composition, somatic cell count, subclinical mastitis

RESUMO

A mastite subclínica é uma doença muito importante para as fazendas de gado leiteiro. Como resultado da deterioração da qualidade do leite, ela causa perdas econômicas nas empresas. Amostras de leite de 180 vacas foram divididas em cinco grupos de acordo com o nível de contagem de células somáticas (SCC). Algumas propriedades químicas e composição foram medidas em amostras de leite. A proporção de sólido sem gordura, matéria mineral, lactose e proteína diminuiu à medida que a SCC do leite aumentava ($P<0,05$). Nenhuma diferença estatística foi observada entre o conteúdo de gordura do leite e o nível de contagem de células somáticas ($P>0,05$). Embora a gravidade específica diminua ($P<0,05$), a condutividade elétrica aumenta ($P<0,001$) no leite com altos níveis de contagem de células somáticas. A qualidade do leite do gado leiteiro se deteriora devido à alta contagem de células somáticas. Portanto, o monitoramento regular da SCC é recomendado nas fazendas de leite para monitorar mudanças nas proporções de gordura, proteína, sólidos não gordurosos, lactose e matéria mineral, bem como algumas propriedades químicas que compõem a composição do leite.

Palavras-chave: vaca, composição do leite, contagem de células somáticas, mastite subclínica

INTRODUCTION

Subclinical mastitis is defined as inflammatory changes in the mammary gland that cause decreased milk production. It causes an increase in somatic cell count (SCC) in milk associated with the presence of microorganisms. Excessive passage of neutrophils from blood to milk causes an increase in SCC in milk (Zhao and Lacasse, 2008; Sharma *et al*., 2011).

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Since there is no clinical finding in subclinical mastitis, reliable diagnostic methods are needed to detect the disease. Microbiological examination of milk is used as the gold standard in the diagnosis of bovine mastitis. However, the costs and the time needed for culturing are restrictive. Thus, indirect diagnosis methods are needed for mastitis. Microscope counting and automated cell counting devices are used to detect bovine mastitis as an indirect method. Also, the California Mastitis Test is used for this purpose. One of the methods used to detect subclinical mastitis is SCC follow-up. Somatic cell count is also used to determine the quality of milk and even the price per liter of milk (Adkins and Middleton, 2018).

Subclinical mastitis is a very costly disease that negatively affects dairy farms, affecting milk production and quality. It is also reported that approximately 70–80% of milk losses are caused by subclinical mastitis (Awale *et al*., 2012). Increased SCC in milk (i.e. subclinical mastitis) has been associated with changes in milk protein, mineral matter, fat, lactose, and electrical conductivity. The high SCC has been shown to impair milk yield and quality traits, technological properties (Costa *et al*., 2019), and cheese yield and quality (Barbano *et al*., 1991). Hence low-quality milk and milk products are obtained. Other factors that affect SCC in milk include breed, number and stage of lactation, udder anatomy, milking frequency, season, appropriate milking hygiene, education of employees in dairy farms, and the training they have received on these subjects (Uzmay *et al*., 2003; Lindmark-Mansson *et al*., 2006; Kasikci *et al*., 2012; Koseman *et al*., 2016).

In this study, we aimed to determine how milk composition and some chemical properties of milk change according to the levels of SCC, which affects milk and milk products.

MATERIALS AND METHODS

Before morning milking, the first three squirts were taken from each quarter, then milk samples were taken. Milk samples were obtained from clinically healthy, 180 mid-lactation, multiparous cattle (Holstein and Simmental) from seven commercial dairy farms in Elazig (Türkiye), 3–5 years old (between parities two and three), milked at 12-hour intervals.

Somatic cell count was measured in raw milk samples using a DeLaval Cell Counter® (Cellcounter DCC; DeLaval, Sweden) device and in accordance with the manufacturer's manual and methods in the literature (Safak *et al*., 2022). As stated in the previous study (Safak and Risvanli, 2022), the raw milk samples with different SCC (< 150,000, 151,000–400,000, 401,000–600,000, 601,000–1,000,000, and >1,000,000 cells⁄mL) were determined.

Fat, solid-non-fat, protein, lactose, mineral matter, specific gravity, and electrical conductivity in the milk samples were measured using a Lactoscan Milk Analyser (Milkotronic/Europe) device. It was applied according to the manufacturer's criteria and as stated in the literature (Safak and Risvanli, 2021).

In a Kolmogorov-Smirnov/Shapiro-Wilk test, there was no normal distribution for within-group values. Thus, the Kruskal-Wallis test was used to compare these characteristics for five groups. Mann-Whitney-U test with Bonferroni correction was used for post-hoc analysis (P<0.01). Statistical analyses were performed using SPSS software (Statistical Package for the Social Sciences for Windows SPSS 22.0 Edition, Chicago, USA).

RESULTS

The level of SCC and related changes in milk composition are presented in Table 1. The ratio of solid-non-fat, protein, lactose, and mineral matter decreased as the SCC of the milk increased (P<0.05). Also, it was statistically determined that the fat content of milk did not change according to the SCC level (P>0.05).

It was observed that the specific gravity of the milk samples decreased as the SCC level increased (P<0.05). However, electrical conductivity in milk increases with increasing SCC (P<0.001) (Table 2).

Table 1. Composition of milk by the level of somatic cell count (Mean ± Standard error of the mean)

SCC (×10^3) (cells⁄mL)		Item				
		Fat (%)	Solid-non-fat (%)	Protein (%)	Lactose (%)	Mineral matter (%)
<150 (n=56)	$\bar{x}\pm s_{\bar{x}}$	3.85±0.35	10.14±0.08^b	3.68±0.02^b	5.54±0.04^b	0.79±0.007^b
	Median	2.90	10.15	3.70	5.60	0.80
151-400 (n=51)	$\bar{x}\pm s_{\bar{x}}$	4.97±0.33	10.12±0.09^b	3.67±0.03^b	5.53±0.05^b	0.79±0.008^b
	Median	4.60	10,10	3.70	5.50	0.80
401-600 (n=20)	$\bar{x}\pm s_{\bar{x}}$	5.01±0.46	9.96±0.15^{ab}	3.61±0.05^{ab}	5.44±0.08^{ab}	0.77±0.012^{ab}
	Median	4.90	10.00	3.65	5.45	0.80
601-1000 (n=17)	$\bar{x}\pm s_{\bar{x}}$	4.87±0.66	9.90±0.18^{ab}	3.61±0.06^{ab}	5.40±0.10^{ab}	0.77±0.020^{ab}
	Median	4.40	9.80	3.60	6.40	0.80
>1000 (n=36)	$\bar{x}\pm s_{\bar{x}}$	4.54±0.36	9.74±0.16^a	3.52±0.05^a	5.31±0.08^a	0.75±0.014^a
	Median	4.15	9.65	3.50	5.25	0.75
P		-	*	*	*	*

-: P>0.05, *: P<0.05

^{a,b}: The difference between groups with different superscripts in the same column is statistically significant, (P <0.01)

Table 2. Specific gravity and electrical conductivity of milk (Mean ± Standard error of the mean)

SCC (×10^3) (cells⁄mL)		Specific gravity (kg/m^3)	Electrical conductivity (mS/cm)
<150 (n=56)	$\bar{x}\pm s_{\bar{x}}$	1,034.46±0.54^b	4.25±0.02^a
	Median	1,035.00	4.30
151-400 (n=51)	$\bar{x}\pm s_{\bar{x}}$	1,033.49±0.56^{ab}	4.38±0.02^b
	Median	1,033.00	4.50
401-600 (n=20)	$\bar{x}\pm s_{\bar{x}}$	1,032.85±0.71^{ab}	4.52±0.04^{bc}
	Median	1,033.50	4.50
601-1000 (n=17)	$\bar{x}\pm s_{\bar{x}}$	1,032.76±0.97^{ab}	4.55±0.04^c
	Median	1,032.00	4.60
>1000 (n=36)	$\bar{x}\pm s_{\bar{x}}$	1,032.36±0.72^a	4.74±0.02^d
	Median	1,032.50	4.70
P		*	***

*: P < 0.05, ***: P < 0.001

^{a,b,c,d}: The difference between groups with different superscripts in the same column is significant, (P < 0.01)

DISCUSSION

Inflammation of the mammary gland is associated with higher SCC in milk. It is manifested by changes in protein, fat, solid-non-fat, mineral matter, and lactose in milk with subclinical mastitis, where the SCC is high. Due to these changes, it is claimed that the quality of milk and milk products has decreased (Lindmark-Mansson *et al*., 2006; Li *et al*., 2014; Franzoi *et al*., 2019).

In the studies of some researchers, it has been suggested that the milk-fat ratio decreases with increasing SCC (Kul *et al*., 2019; Najafi *et al*., 2009). Millogo *et al*. (2009) stated that with the increase in SCC level, the ratio of fat in milk increased, while Moslehis *et al*. (2010) and in the current study, it was found that there was no relationship between SCC changes and fat ratio. It was determined that while the fat content increased in the milk with mastitis caused by *Escherichia coli* (*E. coli*), the non-solid fat, protein, and lactose ratios decreased. While there was no change in milk components in the *Staphylococcus aureus* (*S. aureus*) group compared to healthy milk, only an increase in fat ratio was observed in mastitis caused by

Streptococcus agalactiae (*S. agalactiae*) (Safak *et al*., 2021).

In the presented study, the lowest solid-non-fat, protein, lactose, and mineral matter were detected in milk samples with high SCC. This is consistent with previous studies (Jaeggi *et al*., 2003; Sekmen *et al*., 2020). On the other hand, Ozlem and Kul (2020) stated that the values of solid-non-fat, protein, and lactose did not significantly change with the increase in SCC. There are also studies reporting that lactose decreases with the increased SCC in milk (Sobczuk-Szul *et al*., 2015; Garcia *et al*., 2015). Also, the milk fat and milk protein ratio decrease as the milk SCC level increases (Sert *et al.*, 2016). Another study reported that there was no difference in protein and lactose content between healthy and subclinical mastitis milk (Panda *et al*., 2019). Jia-zhong *et al.* (2010) stated that milk SCC levels and milk fat levels were positively correlated in Holstein cows. Also, It has been reported that the milk protein ratio increases with the increase in SCC level. In this study, the increase in SCC did not significantly change the fat content (P>0.05). Contrary to Jia-zhong *et al.* (2010), the level of milk protein decreased with increasing SCC, with values of 3.68, 3.67, 3.61, 3.61, 3.52% at SCC < 150,000, 151,000–400,000, 401,000–600,000, 601,000–1,000,000, and >1,000,000 cells/mL, respectively.

Due to these changes in vascular permeability, the ions in the structure of the milk also change. As a result of the change in the ion value of the milk, there is a change in the electrical conductivity and the specific gravity of the milk (Alhussien and Dang, 2018; Norberg *et al*., 2004). In the presented study, there was a positive correlation between the electrical conductivity of milk and the increase of SCC in milk, while a negative correlation was found between the specific gravity and the increase of SCC in milk. This knowledge supports previous studies (Kasikci *et al*., 2012; Boas *et al*., 2017; Sekmen *et al*., 2020) to determine the relationship between the SCC change of milk and its electrical conductivity. However, in another study, it was reported that in the case of subclinical mastitis, the specific gravity did not change compared to healthy milk samples (Panda *et al*., 2019).

CONCLUSION

We detected changes in milk composition and some chemical properties of milk due to changes in SCC in milk. There were changes in these parameters according to levels of SCC, but it was concluded that the changes could not be standardized. Therefore, regular monitoring of SCC is recommended in dairy farms to monitor changes in fat, solid-non-fat, protein, lactose, and mineral matter ratios as well as some chemical properties that make up the milk composition.

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AUTHOR'S CONTRIBUTION

Safak T. and Risvanli A.: Research planning, clinical activity, and laboratory activities, Safak T.: Writing-Manuscript draft, Risvanli A.: Review and editing. All authors read and approved the final manuscript.

ETHICS COMMITTEE APPROVAL

This study was approved by the Fırat University Local Ethics Committee on Animal Experimentation (FU-2018/98).

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