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Milk Traits of Damascus Goats at Different Lactation Stages: 1. Somatic Cell Counts and Milk Quality Parameters*

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Summary: In this study, milk of healthy 20 goats in the 3rd - 4th lactation periods was analyzed in different lactation stages. While milk pH, fat, fat-free dry matter, protein, lactose and freezing point were similar between groups in all lactation stages, electrical conductivity and Somatic Cell Count (SCC) increased with the continuation of lactation (P<0.05; P<0.001). Nonspecific relations were found between SCC and electrical conductivity in mastitis-free goats. Also, correlations were found between milk quality parameters and different lactation stages at the significant levels (P<0.05, P<0.01). There was a positive correlation between SCC and milk fat in early lactation (r=0.619; P<0.05). On the other hand, a negative correlation was found between freezing point and electrical conductivity in the late lactation (r=-0.474; P<0.05). It was understood that milk composition and especially SCC values were different in different stages of lactation in Damascus goats.The relationship between the components of milk was found to be related to the lactation period. As a result, while the chemical composition of milk did not change during the lactation, it was concluded that the milk produced in the early lactation had lower SCC and electrical conductivity values than in the other lactation stages, and the milk produced in early lactation stage was higher quality.
Key words: Damascus goat, lactation period, milk quality

Farklı Laktasyon Dönemlerindeki Damascus Keçilerinde Süt Özellikleri: 1. Somatik Hücre Sayısı ve Süt Kalite Parametreleri

Özet: Bu çalışmada 3.-4. laktasyon dönemlerindeki sağlıklı 20 keçinin sütü farklı laktasyon aşamalarında analiz edilmiştir. Süt pH'sı, yağ, yağsız kuru madde, protein, laktoz ve donma noktası tüm laktasyon aşamalarında gruplar arasında benzerken, laktasyonun devamında elektriksel iletkenlik ve Somatik hücre sayısı (SHS) artmıştır (P<0.05; P<0.001). Mastitis olmayan keçilerde SHS ile elektrik iletkenliği arasında spesifik olmayan ilişkilerin olduğu belirlenmiştir. Ayrıca, farklı laktasyon aşamaları ile süt kalite parametreleri arasında önemli seviyelerde korelasyonlar bulunmuştur (P<0.05, P<0.01). Erken laktasyonda SHS ile süt yağı arasında pozitif bir ilişki bulunmuştur (r=0.619; P<0.05). Diğer taraftan, geç laktasyonda donma noktası ile elektriksel iletkenlik arasında negatif bir korelasyon bulunmuştur (r=-0.474; P<0.05). Damascus keçilerinde laktasyonun farklı dönemlerinde süt kompozisyonu ve özellikle SHS değerlerinin farklı olduğu anlaşılmıştır. Diğer taraftan sütün kimyasal kompozisyonunu oluşturan unsurlar arasındaki ilişkinin de laktasyon dönemi ile ilişkili olduğu görülmüştür. Sonuç olarak, laktasyon boyunca sütün kimyasal komposizyonu değişmezken laktasyonun erken dönemlerinde üretilen sütün SHS ve elektriksel iletkenlik değerlerinin diğer laktasyon dönemlerinden düşük olması bu sütlerin daha kaliteli olduğu kanaatini oluşturmuştur.
Anahtar kelimeler: Damascus keçisi, laktasyon periyodu, süt kalitesi

Introduction

Small ruminant breeding has great importance because of product quality and profitability. Goats, were domesticated about 10 thousand years ago, and have been breeding with increasing supply and demand (Yakan et al., 2019). Today, it is estimated that there are more than 1000 goat breeds in the world (Crisa et al., 2016). The importance of goat breeding is increasing day by day with the awareness of healthy nutrition (Yurchenkoo et al., 2018). While the number of goats around the world was around 750 million heads in the early 2000s, this number increased gradually and reached 1 billion heads as of 2018 (FAOSTAT, 2020).

Goat breeding is a source of quality animal products, especially for people with food allergies to milk and dairy products such as cheese and yoghurt, those with digestive system disorders and also for children (Albenzio et al., 2012;Yakan et al., 2019). Goat milk fat is more beneficial because of nutritional and dietetic parameters (Anghel et al., 2017). In ruminants, milk production depends on genetic and environmental factors such as nutrition. However, in general, goat's milk is richer in carbohydrate, fat and protein

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values than cow's milk. In addition, the proportion of short and medium-length fatty acids in goat's milk is higher than in milk of other species (Zhu et al., 2014).

Physiology of animals changes during lactation period. Therefore, there are significant differences in milk composition at different lactation stages (Yakan et al., 2019). It is also reported that milk composition could be influenced by the energy balance in lactation goats (Zailan and Yaakub, 2018). On the other hand, it is known that somatic cell count (SCC) of milk is an important marker for mammary health and physiology. Goat milk has more SCC than cow milk, in general. However, SCC levels may change without infectious factors during the lactation period (Kuchtik et al., 2015; Raynal-Ljutovac et al., 2005).

Thanks to numerous studies, cow milk production and secretion process are well known (Sandolhm et al., 1995; William and Edmondson, 2010). There is also abundant information about milk production physiology of goat (Haenlein, 2004). On the other hand, it is estimated that there are important differences related to production and composition of milk in different goat species (Yakan et al., 2019). It is known that milk composition change in different lactation stage and this is an important factor for human nutrition consuming milk and dairy products. Due to its high milk and reproductive characteristics, especially in the last 20 years, Damascus goat breeding has increased in some countries such as Turkey, Syria, Lebanon, and other Mediterranean countries (Keskin et al., 2004; Yakan et al., 2019).

Production and secretion of milk in goats have some differences. In goats, milk secretion type is apocrine. This physiological difference cause wide range of SCC even without mastitis. It is known that molecular activity in somatic cells may change the composition of milk (Zecconi et al., 2020). The aim of this study was to evaluate the variation of somatic cell count and chemical composition of milk according to the lactation stages in Damascus goats.

Materials and Methods

Animal materials

This study was done with 20 Damascus goats in the 3rd– 4th lactation periods. Animals were randomly selected from 200 heads flock. One week after parturition, goats were in pasture for grazing (06:00-18:00, in a day). After grazing, goats were housed in pen. Besides grazing, goats consumed 300 g/head/day concentrate feed (Table 1). All management and feeding procedures were practiced according to routine breeding procedure. Following births, 50 ml of milk was taken from each goat in the morning milking during the early [10-20 days after parturition, Early Lactation Stage (ELS)], mid [100-110 days after parturition, Mid Lactation Stage (MLS)] and late [200-210 days after parturition, Late Lactation Stage (LLS)] stages of lactation.

Table 1. Chemical and physical composition of concentrate feeds

Items contents	Proportions (%)
Wheat grain	18.50
Maize grain	21.60
Corngrain	17.00
Sunflower meal (crude protein 28-29%)	16.00
Cottonseed meal (crude protein 31-32%)	11.00
Barley grain	7.80
Wheat bran	2.00
Molasses	4.70
Marble powdered (38% Ca^{++})	0.50
NaCl	0.75
Vitamin mineral premix*	0.15
Total	100.00
Calculated nutrition value of concentrated feed	
Dry matter	89.81
Crude ash	5.97
Ether extract	2.54
Crude protein	16.75
Total Metabolic Energy (kcal/kg)	2767.16

*: Per 1.5 kg vitamin mineral premix contains 15 000 000 IU Vit A, 3 000 000 IU Vit D3, 50 000 IU Vit E, 50 g manganese, 50 g ferrous, 50 g zinc, 10 g copper, 0.8 g iodine, 0.2 g cobalt, 0.3 g selenium.

Milk sampling and measured parameters

After bringing the samples to the laboratory in the cold chain, SCC (Lactoscan SCC 6010) and pH (Hanna pH meter, HI83141) were determined. In addition, fat, fat-free dry matter (FFDM), protein, lactose, freezing point and electrical conductivity of milk samples were investigated (Milkotester Master Classic LM2 P1). Measurements were made within 2 hours of milking in two replicates and mean values were recorded.

Statistical analysis

Descriptive statistics were described as "Mean ± Standard error of mean". Pearson correlation coefficient was performed to determine the relationships between the quality parameters of goat milk. MIXED procedure of SPSS (V22.0; SPSS Inc., Chicago, IL, USA) was used to analyze the effect of the period of lactation as early, mid and late term on the quality parameters of goat milk by using the following model with repeated measures:

$Y_{ijk}= \mu+ P_i+ e_{ijk}$

Where, Y_{ijk}, dependent variable; μ, overall mean; P_i, effect of period of lactation (i = early, mid and late term); and e_{ijk}, residual error. Animals within group were assessed as a random effect, while period of assessed as a fixed effect. P<0.05 was considered as significant in all analyses.

Results

In the study, SCC of animals were lower than 1000 $x10^3$/mL during all lactation stages (ELS, MLS,LLS). With the continuation of lactation, however, SCC in ELS, MLS and LLS groups were 183.07±40.36, 482.11±108.43 and 517.41±107.60, respectively (P<0.05). SCC of ELS group was lower than MLS and LLS groups (P<0.05). On the other hand, there was no significant difference in terms of SCC between the MLS and LLS groups (Table2). While milk pH, fat (%), fat-free dry matter (%), protein (%), lactose (%) and freezing point were similar between groups, it was determined that electrical conductivity increased with the continuation of lactation (P<0.001) (Table 2).

According to lactation periods, it was found that there was a positive and statistically significant correlation between SCC and fat in ELS group (r=0.619; P<0.05). In ELS group there was also negative correlation between fat with protein (r=-0.545; P<0.05) and fat with lactose (r=-0.545; P<0.05).In addition, while there was a high positive correlation between FFDM and protein (r=0.985; P<0.01) and lactose (r=0.996; P<0.01), it was found that there was a high negative and statistically significant correlation between FFDM and freezing point (r=-0.986; P<0.01).Moreover, statistically important and highly positive correlation was found between protein and lactose (r=0.982; P<0.01). Finally, negative correlations were found between freezing point and protein (r=-0.970; P<0.01) and lactose (r=-0.978; P<0.01) in ELS group samples (Table 3).

MLS group was the group with the highest correlation among parameters. While negative correlations were found between pH with fat (r=-0.511; P<0.05) and pH with freezing point (r=-0.666; P<0.01), positive correlations were determined between pH and most of the other evaluated parameters with variable significances in MLS group (Table 3). Meanwhile, there were a negative and important correlations between milk fat and FFDM (r=-0.591; P<0.01), protein (r=-0.551; P<0.05), lactose (r=-0.581; P<0.01) and electrical conductivity (r=-0.746; P<0.01). Positive correlation was found between milk fat and freezing point (r=0.513; P<0.05). Three of the determined parameters (protein, lactose, and electrical conductivity) in MLS group were positively correlated with FFDM (P<0.05).

On the other hand, a negative and a significant correlation was found between FFDM and freezing point (r=-0.993; P<0.01) in MLS group. As the amount of FFDM in milk increases, a decrease will occur in the freezing point for the mineral load in it. This confirms the negative correlation detected between the two parameters. While positive correlations were found between protein and lactose (r=0.994; P<0.01) and electrical conductivity (0.483; P<0.05), a negative correlation was determined with freezing point (r=-0.992; P<0.01). In addition, a negative correlation was determined between the freezing point and electrical conductivity (r=-0.474; P <0.05).

Table 2. Parameters of milk in different lactation periods (Mean±SE)

Parameters	Groups			P
	ELS	MLS	LLS	
SCC (x1000)	183.07±40.36[b]	482.11±108.43[a]	517.41±107.60[a]	<0.05
pH	6.70±0.07	6.73±0.03	6.67±0.02	-
Fat (%)	4.05±0.31	4.45±0.23	3.69±0.20	-
FFDM (%)	8.62±0.13	8.79±0.18	8.77±0.07	-
Protein (%)	3.12±0.04	3.18±0.07	3.17±0.03	-
Lactose (%)	4.69±0.07	4.81±0.10	4.78±0.04	-
Freezing point	-0.58±0.01	-0.30±0.01	-0.60±0.01	-
E. Conductivity	4.65±0.02[c]	4.73±0.03[b]	4.85±0.02[a]	<0.001

Different letters on the same line indicate the statistical difference between the groups; **FFDM:** Fat-free Dry Matter; **E. Conductivity:** Electrical Conductivity[a, b, c]:Means with different letters in rows differ significantly

Table 3. Correlations of measured parameters in different lactation stages

Groups	Parameters	pH	Fat (%)	FFDM (%)	Protein (%)	Lactose	Freezing point	E. Conductivity
ELS	SCC	0.161	0.619*	-0.286	-0.266	-0.331	0.223	-0.078
	pH		0.029	0.177	0.145	0.169	-0.231	-0.354
	Fat (%)			-0.513	-0.545*	-0.545*	0.394	-0.126
	FFDM (%)				0.985**	0.996**	-0.986**	-0.386
	Protein					0.982**	-0.970**	-0.341
	Lactose (%)						-0.978**	-0.364
	Freezing point							0.393
MLS	SCC	0.346	-0.181	0.161	0.177	0.133	-0.186	0.325
	pH		-0.511*	0.685**	0.692**	0.661**	-0.666**	0.551*
	Fat (%)			-0.591**	-0.551*	-0.581**	0.513*	-0.746**
	FFDM (%)				0.995**	0.997**	-0.993**	0.515*
	Protein					0.994**	-0.992**	0.483*
	Lactose (%)						-0.992**	0.504*
	Freezing point							-0.474*
LLS	SCC	0.170	0.358	0.060	0.026	0.124	0.080	0.305
	pH		0.013	0.300	0.328	0.397	-0.050	0.241
	Fat (%)			0.277	0.137	0.311	-0.322	-0.471
	FFDM (%)				0.951**	0.978**	-0.569*	-0.446
	Protein					0.949**	-0.585*	-0.335
	Lactose (%)						-0.546*	-0.362
	Freezing point							0.279

*:P<0.05; **: P<0.01; **E. Conductivity:** Electrical Conductivity

In the LLS group, another group in which correlations between parameters were examined, positive correlations were determined between FFDM and protein (r=0.951; P<0.01) and lactose (r=0.978; P<0.01). Also, there was a negative correlation found between FFDM and freezing point (r=-0.569; P<0.05). Similarly, MLS negative correlations were determined between freezing point and protein (r=-0.585; P<0.05) and lactose (r=-0.546; P<0.05) in this group. Beside all these results, a highly positive correlation was found between lactose and protein (r=0.949; P<0.01). In addition to the changes in milk composition, the relationship between the parameters that make up the milk composition changed according to the lactation period.

Discussion and Conclusion

Somatic cell count is in a wide range in healthy goats because of secretion type (Souza et al., 2012). Physiological changes occur in the mammary gland following the start of lactation in the postpartum period. Although there are different reports of transition from colostrum to normal milk, the secretion passes to normal milk after the approximately 10^{th} day of lactation (Lu et al., 2016; Marounek et al., 2012; Sanchez-Maciaz et al., 2014). Also, it is reported that milk somatic cell counts are influenced by lactation stage in small ruminants and accuration of mastitis by California Mastitis test are better in ewes than goats (Souza et al., 2012).

Leitner et al. (2004) are stated that healthy goat's milk SCC is approximately 450 $x10^3$/mL in in their study. It is reported that SCC averages are under 575 $x10^3$/mL in Saanen goats, while Muricano-Granadina breeds averages are more than 1000 $x10^3$/mL (Sanchez et al., 2005; Granado et al., 2014). In our study, milk SCC of Damascus goats were under the 1000 $x10^3$/mL in all lactation periods. It is also reported that milk SCC might be between 270 - 2000 $x10^3$/mL in healthy goats and it is not possible to obtain reliable information about health of mammary gland and milk quality by determining only SCC, regardless of lactation period in goats (Moroni et al., 2005; Souza et al., 2012). Unlike cattle, it is reported that breed and lactation period (especially end of the lactation) are one of the most important parameters for SCC in goats (Granado et al., 2014; Kuchtik et al., 2015). Similar to the findings of this study, Yakan et al. (2019) reported that milk SCC increased in the late lactation stages in the same breed of goats. This is considered to be the lactation characteristic of Damascus goats. While it is reported that SCC does not change even if daily milking frequency increases in

Murciano-Granadine breed goats (Salama et al., 2003), in another study, it is reported that SCC decreases as daily milking frequency increases in Alpine breed goats (Komara et al., 2009). Granado et al. (2014) reports that this is due to the dilution effect of milk. Unlike other ruminants, the lactation characteristic of goats in terms of SCC depends on breed type along with other factors.

Electrical conductivity is a marker for early detection of mastitis in cattle farms (Cavero et al., 2006). There are contradictions in the literature about the relationship between electrical conductivity and mastitis due to breed factor in goats (Diaz et al., 2011). In a study, it is reported that lactation stage is an important factor for electrical conductivity of milk in goats (Diaz et al., 2011). In that study, it is reported that the significant and gradual increase of electrical conductivity was detected with the continuation of lactation.

Chemical composition of goat milk and cow milk are similar (Kuchtik et al., 2015). However, goat milk has more alkaline pH values. Hence, goat milk is more suitable than cow milk for those suffering from stomach acid imbalance (Kuchtik et al., 2015). On the other hand, pH is one of the most important factors in goats for dairy products like cheese (Yakan et al., 2019). In a study comparing different breeds, the pH of the milk is reported to be around 6.53-6.64 in the early period of lactation (Agnihotri and Rajkumar, 2007), while in this study, it is determined that the Damascus breed's pH value is around 6.67-6.70 during lactation stages. Considering the effect of lactation period on milk quality, it is determined that there are no significant differences in terms of measured pH according to lactation stage. In a study similar to this study, pH is reported to be similar during the early lactation period and other periods of lactation in Sahel, Sokoto Red, WAD and Damascus goat breeds (Addass et al., 2013; Yakan et al., 2019).

In a study investigating the effect of lactation period on milk composition in Baladi goats in Egypt, it is reported that lactose, which was around 4.00% in the early period, was similar in the mid-lactation period and decreased in the late period. However, it has been determined that there is no significant change in milk fat and protein (El-Tarabany et al., 2018). In another study conducted in Saanen X Kilis crossbreed goats, it is reported that milk fat, protein and lactose contents were 3.45, 4.00 and 4.00%, respectively (Güzeler et al., 2010). The Damascus goat's milk composition has some differences than other breeds at different lactation stages. It is thought that the possible reason of these differences are breed type and different environmental features.

ELS covers the period when the lactation curve is highest in Damascus goats, therefore, milk yield in this stage constitutes the peak of lactation (Yakan et al., 2019). In the lactation periods with high lactation yield, the decrease of milk fat is normal physiological and biological property in ruminants. However, the milk protein ratio is generally stable in lactation. It is expected to be a pathological condition for this ratio to change. Therefore, a negative correlation between milk fat and milk protein in ELS confirms the relevant mechanisms.

Fat-free dry matter consists of a very large amount of lactose and protein and a very small amount of minerals and vitamins. Therefore, a very high positive correlation between lactose and protein is to be expected. On the other hand, as the amount of solids forming FFDM in milk increases, freezing point decreases, therefore the negative correlation between these two parameters confirms the relevant mechanisms.

It is known that protein, lactose, and electrical conductivity are significantly affected by lactation stages (Ceballos et al., 2009; Prasad et al., 2005; Yakan et al., 2019). Prasad et al. (2005) was reported that fat, protein and lactose parameters were strongly correlated in all lactation. It is understood with this study that MLS reflects the typical goat milk characteristics.

In a study, it was reported that positive and significant correlations were found between electrical conductivity and SCC (<1000 x10^3/mL and >2000 x10^3/mL) in mastitis-free goats (Diaz et al., 2011). It was believed that it might also be related with mineral contents of milk. With our results and other studies (Bruckmaier et al., 2005; Diaz et al., 2011) it was understood that nonspecific relations were found between SCC and electrical conductivity in mastitis-free goats.

The results of this study showed that there were significant differences in milk composition during lactation periods. Beside the secretion type of goats, breed should be considered the most important factor. On the other hand, depending on the lactation period, it is understood that more than one parameter in milk is directly related to each other. For understanding the differences and relations, more studies on the molecular level are needed on about milk composition in Damascus goats.

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