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Investigation of the changes in physical and chemical parameters of Damascus goat milk in the early postpartum

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ABSTRACT

The aim of this study was to reveal the milk components and the changes in their characteristics in Damascus goats during the early postpartum period. For this purpose, 50 Damascus goats (aged 2 to 8 years) were selected for this study. A total of 291 milk samples were collected under sterile conditions during the mornings of the 10th, 20th and 30th days postpartum. Results were statistically analysed using the Mann-Whitney U Test and repeated measures ANOVA. All collected samples were analysed for milk composition (lactose (L), protein (P), casein (C), fat (F), total solid (TS), solid not fat (SNF), freezing point (FP), acidity (A), density (D), free fatty acid (FFA), and citric acid (CA)). A significant decrease was detected in P, C, F, TS and SNF values between the 10th and 30th days postpartum (pp) ($P < 0.01$). Similar results were also observed in FP, A, D and CA values between the same days ($P < 0.05$; $P < 0.01$). A significant positive correlation was detected between FP, A, P, C, F and TS (0.812 and 0.980; $P<0.05$ and $P<0.01$). Additionally, a correlation was detected between C and P (0.983; $P < 0.01$). These results reveal that these parameters decreased significantly in the early puerperal period compared to the first 10 days, and these decreases were not associated with an increase during milk yield in the early period of lactation (up to the 30th-day pp).

Key words: Damascus; goat; milk; milk composition; postpartum

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Introduction

Goat's milk is an important nutritional source due to its low fat, low lactose and calcium content, together with its antioxidant and antibacterial properties (MAYER and FIECHTER, 2012). The importance of milk protein, casein and amino acid profile for human nutrition is well known (RAFIQ et al., 2016). Cheese made from goat's milk from a variety of family businesses leads to deviations in milk quality and the manufactured cheese (PAVIĆ et al., 2002). Goat milk proteins, forming a softer curd, are specific when compared with cow milk proteins. Moreover, milk fat in goat's and sheep's milk or cheese has significantly higher levels of short chain, medium chain, mono- and polyunsaturated fatty acids than are found in cow's milk or cheese (BOYAZOGLU and MORAND-FEHR, 2001).

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Goat's milk is also used as a substitute for cow's milk for those who are allergic to cow's milk (PARK, 1994; TAITZ AND ARMITAGE, 1984). Goat's milk contains more potassium and chloride but less orotic acid, N-acetyl neuraminic acid, folate, vitamin B6, and vitamin B12 than cow's milk (JENNESS, 1980).

However, the variety in the chemical composition of goat's milk can be seasonal. The main constituents of goat's milk are high in early lactation, and then decline rapidly and remain low for a variable period, before increasing again during the latter stages of lactation (GUO et al., 2001). The lactose content of goat's milk is independent of the lactation stage (JUAREZ AND RAMOS, 1984). The gross composition of goat's milk, lower lactose, is higher than in bovine milk (HAENLEIN and CACCESE, 1984; JENNESS, 1980). There are significant differences between the physico-chemical properties of the casein micelles of caprine milk and bovine milk (RICHARDSON and CREAMER, 1976).

The Damascus or Shami goat is a native breed of Syria and other Near East countries (Lebanon, Cyprus, Israel etc.), and is known for its high milk yield and prolificacy in Near and Middle Eastern countries (MAVROGENIS et al., 2006). Total milk production ranges between 350 kg and 650 kg per goat per lactation (LOUCA et al., 1975). The composition of Damascus goat's milk consists of 3.8% to 4.5% fat and 4.0% to 4.8% protein (MAVROGENIS et al., 2006).

Goat raising and breeding is an important source of livelihood in Cyprus, with farmers mainly producing milk, traditional cheese (Halloumi), and yoghurt. Goat's milk differs from cow's milk in the way it is 'naturally homogenised' and can be more easily digested by humans. Traditional products, especially Halloumi cheese, are produced from milk of native breeds such as the hair goat and the Damascus goat (AGRICULTURE AND NATURAL RESOURCES MINISTRY, 2007).

A number of factors, including the breed, individual differences, diet, season, stage of lactation, and environment, affect milk quality and quantity. The chemical composition of goat's milk, especially cheese yield and its preparation, depend on milk quality and its major constituents (fat, lactose, crude protein, casein etc.) (GUO et al., 2004). In particular, fermented milk products are influenced by the physicochemical features and microbiological quality of the milk (STULOVA et al., 2010).

The aim of this study was to reveal the milk components, changes in milk characteristics and the relationships between them in milk from Damascus goats during the early postpartum period.

Materials and methods

This study was approved by the Animal Ethics Committee of Near East University, No: 206/4; 24.20.2016. All samples were taken according to local ethical rules.

Animals. A total of 50 Damascus dairy goats aged between 2 and 8 years were randomly selected from a private farm situated in Nicosia. The herd size of the farm was 600 head, and Damascus goats that had a new kid or at least one kid were chosen. These goats exhibited no health problems and were fed a similar diet (corn silage, barley hay, vetch-barley hay, and pasture feeding). The goat farm used a semi-intensive machine-milking system for milk production. Milk samples were collected by hand-milking between March and April 2017.

Milk Sampling. A total of 291 milk samples were collected from each of the udder halves belonging to the goats under sterile conditions on the mornings of the 10th, 20th and 30th days postpartum. Before the morning milking, each udder half was wiped using sterile cotton pledgets soaked in 70% ethyl alcohol, and the foremilk was discarded. Then, at least 10 ml of milk was extracted into a sterile test tube for milk composition analysis. On the same day, milk samples were delivered in a cold chain to the Laboratory of the Milk Industry Corporation (Nicosia). No milk could be obtained from 3 udder halves, which represented 9 samples. Daily milk yield was 1.7 kg/day per goat, and milk was produced until weaning, with an average of 450 kg per goat per lactation.

Milk Composition Analysis. For regular milk control, all collected samples were analysed for total bacterial count (TBC) by BactoScan FC, and somatic cell count (SCC) by Fossomatic FC 5000, in compliance with the manufacturer's instructions. The milk samples were collected from goats whose SCC values were determined to be between 30,000 and <1 million/ml^{-1} and the total bacterial count was between 5-370 (*1000 cfu/ml) (GOCMEN et al., 2019).

All collected samples were analysed for milk composition analysis. The milk composition, including the chemical parameters and physical properties (lactose, total protein, casein, fat, total solid, solid not fat, freezing point, acidity, density, free fatty acid, citric acid) of the Damascus goats' milk was analysed using Foss MilkoScan FT 120 equipment, in compliance with the manufacturer's instructions.

Statistical Analysis. The statistical analyses were conducted in the IBM SPSS Statistics 21 program. The mean value and standard deviations in the homogenous data were obtained by applying descriptive statistics (x ± s). The Shapiro-Wilk test was used to determine the normality of distribution. The Mann-Whitney U was used as the nonparametric test in the case of non-homogeneous distribution of the values and repeated measures ANOVA (General Linear Model) for normal data distribution was applied. The Pearson Correlation Coefficient Test was used for measuring the statistical relationship.

Results

Changes in the components of milk from Damascus goats were examined according to the postpartum (pp) period, and it was determined that there was a statistically significant difference between all the postpartum days in terms of protein, SNF and TS values (P<0.001). Between the 10th and 30th pp days, there was a significant decrease in the values of the parameters apart from the lactose values (P<0.001). A statistically significant decrease was observed in the fat values on the 20th and 30th days compared to the 10th day (P<0.001; Table 1).

Table 1. Changes in Components of Damascus Goat's Milk in the Lactation Period (Between 10th and 30th Days)

Day	Lactose (%)	Protein (%)	Casein (%)	Fat (%)	Solid Not Fat (SNF) (%)	Total Solids (TS) (%)
10	4.45±0.04	3.37±0.05^{a}	3.05±0.03^{a}	6.23±0.15^{a}	9.08±0.05^{a}	15.36±0.17^{a}
20	4.53±0.02	2.75±0.02^{b}	2.51±0.02^{b}	4.57±0.10^{b}	8.43±0.04^{b}	13.01±0.10^{b}
30	4.48±0.02	2.51±0.02^{c}	2.29±0.02^{c}	4.42±0.10^{c,b}	8.05±0.03^{c}	12.56±0.10^{c}
P	P>0.05	a:b ;b:c; a:c P<0.001	a:b; b:c;a:c P<0.001	a:b; a:c P<0.001	a:b ;b:c; a:c P<0.001	a:b ;b:c; a:c P<0.001

a,b,c: Different letters indicate statistically differences between days for each parameter.

When the change in the different parameters determining the characteristics of the milk in the pp period was examined (Table 2), it was found that the freezing point and acidity of the milk decreased significantly until the 30th day (P<0.001). It was demonstrated that there was a significant decrease in viscosity and citric acid between the early days and 30 days pp (P<0.001 and P<0.05).

There was a positive correlation between freezing point and acidity, protein, casein, fat and total solid at different rates (0.812 ~ 0,980) (P<0.05 and P<0.01). Likewise, there was a significant correlation between acidity and protein, casein, solid not fat and total solid (0.918; P <0.05 and 0.847; P <0.001). In other correlations, a high level of positive correlation was determined between protein and casein (0.983; P <0.01). In addition, protein was highly correlated with both solid not fat and total solid (0.915 and 0.912; P<0.05), while casein was positively correlated only with solid not fat (0.918; P<0.05), where the significance of the correlation was at the level of P<0.05. There was a significant negative correlation between milk yield and protein (-0.980; P<0.05). However, a significant positive correlation (0.963; P<0.05) was determined between milk yield and total solid, but no significant correlation was found between other parameters and milk yield (Table 3).

Table 2. The changes in the physical properties and components of milk in the lactation period (between the 10th and 30th days) according to days

Day	Freezing point (FP) (-^{0}C)	Acidity (A) (^{0} SH)	Density (D) (g/ml)	Free fatty acid (FFA) (mmol/L)	Citric acid (CA)
10	-0.58±0.003^{a}	6.88±0.30^{a}	1028±0.30^{a}	1.26±0.08	0.10±0.005^{a}
20	-0.53±0.003^{b,c}	5.16±0.10^{b}	1028±0.24^{a,c}	1.24±0.04	0.09±0.005^{a,c}
30	-0.52±0.003^{c}	4.45±0.10^{c}	1027±0.22^{b}	1.23±0.03	0.09±0.004^{b}
P	a:b; a:c P<0.001	a:b; a:c; b:c P<0.001	a:b; c:b P<0.001	P>0.05 n.s	P<0.05

a,b,c: Different letters indicate statistically differences between days for each parameter.

Table 3. Correlations between milk components and milk yield in Damascus goats

Parameters/ Correlations	Freezing point (FP)	Acidity (A)	Protein (P)	Casein (C)	Fat (F)	Solid not fat (SNF)	Total solid (TS)
FP	-	0.832* (P<0.05)	0.812* (P<0.05)	0.980* (P<0.05)	0.837* (P<0.05)	0.832 (P>0.05)	0.923** (P<0.01)
A		-			0.987 (P>0.05)	0.980* (P<0.05)	0.832* (P<0.05)
P		0.847** (P<0.01)	-	0.983** (P<0.01)	0.897 (P>0.05)	0.915* (P<0.05)	0.912* (P<0.05)
C		0.947** (P<0.01)		-	0,976 (P>0.05)	0.918* (P<0.05)	0,734 (P>0.05)
F					-	0.977 (P>0.05)	0.997* (P<0.05)
SNF						-	0.678 (P>0.05)
Milk Yield	0.345 (P>0.05)	0,500 (P>0.05)	-0,980* (P<0.05)	0,379 (P>0.05)	0,505 (P>0.05)	0,476 (P>0.05)	0.963* (P<0.05)

* Correlation is significant at P<0.05; Correlation is not significant at P>0.05
** Correlation is significant at P<0.01

Discussion

The milk of Damascus goats is used in the production of cheese, butter and yoghurt (MAVROGENIS et al., 2006; WILSON, 2017) and is an important source of income. Some studies have focused on the structures determining the components and compositions of milk in goats and sheep in breeds such as Saanen, Alpine, Epirus, Masri, and Sardinian goats (RAYNAL-LJUTOVAC et al., 2007; SIMOS et al., 1996; ZENG and ESCOBAR, 1995). However, no comprehensive study has been conducted or published in this area on Damascus goats. Previous studies have shown that lactation levels peak in weeks 5- 6 in Damascus goats (GOCMEN et al., 2019; LOUCA et al., 1975). Therefore, the aim of this study was to determine the parameters related to milk composition and characteristics until the postpartum 30th day of high milk yield of Damascus goats. It has been demonstrated that factors such as total solid, fat, protein and casein affect cheese production capacity (GUO et al., 2004).

The chemical composition of goat's milk and its products is affected by factors such as breed, stage of lactation, udder health, and nutrition. The udder health condition and milk quality depend on SCC and TBC (CONTRERAS et al., 2007; PAAPE et al., 2001). Goat's milk contains a naturally higher SCC than cow's milk due to the apocrine secretory process (HAENLEIN, 2002; TELEB et al., 2014) and the allowable SCC for goat's milk have been reduced to 750,000/ml^{-1} from 1.5 million/ml. However, it is currently 1 million/ml^{-1} in the USA but 400,000 ml^{-1} in many European countries (GOCMEN et al., 2019; HAENLEIN, 2002; HINCKLEY, 1990). The EU directives bacterial count limit for the production of raw sheep's and goat's milk is based on non-thermically treated milk is ≤ 500,000 cfu/ml (EUROPEAN COUNCIL, 2003; PIRISI et al., 2000). In this study, SCC values were determined to be between 30,000 and <1 million/ml^{-1} and the total bacterial count was between 5 and 370 (*1000 cfu/ml).

The results obtained in this study showed that the values for protein, casein, fat, solid not fat and total solid milk components decreased significantly on the 30th day postpartum (pp) compared to the 10th day pp. Also, these parameters were significantly higher on the 10th day pp. compared to the 30th day pp. ($P<0.001$). The only parameter in which there was no significant change between the 10th and 30th days postpartum was lactose. In a study conducted on the 60th, 90th and 120th days in the late postpartum period, it was revealed that the average value of protein increased, while the fat value decreased on the 120th day (STRZALKOWSKA et al., 2009). In this study, the milk yield of goats was controlled between the 10th and 30th days, and it was determined that there were significant changes in these parameters during this period. In Bedouin goats, where milk reached its highest level on the 35th day, it was shown that significant decreases in fat, protein and SNF values occurred between the 5th-8th weeks compared to the 1st-4th weeks (KOURI et al., 2019).

Similarly, MAROUNEK et al., 2012 observed that the fat ratios decreased from 5.67% to 3.48%, and SNF rates from 16.6% to 11.20% in the first 30 days postpartum. In a later study, a significant decrease in protein and SNF values was reported during the 5th-8th weeks compared to the 1st-4th weeks and the lactation curve increased in week 5, reaching a peak in week 6 (KOURI et al., 2019). PAVIĆ et al. (2002) determined that the lactose values were highest at the beginning of lactation, but decreased to their lowest levels in the following days of lactation. Evidently, there is a temporary decrease in milk components in the early postpartum period. In our study, a relative decrease was obtained on the 30th day of lactation compared to the beginning of lactation.

On the 120th day, in the final stage lactation, a decrease in protein values was detected in this period, when the milk yield also decreased (STRZALKOWSKA et al., 2009). In the late lactation period (final stage), an increase was observed in milk fat, casein, solid not fat and total solid values (STRZALKOWSKA et al., 2009). While only 30-40% of body fat is lipolized during the early lactation period, fat lipolysis occurs more in the final stage of lactation (COLLINS et al., 2003; GAJDUSEK et al., 1993). Since these authors examined these changes until the end of lactation, they obtained a statistically significant difference. In other studies consistent with our study, when these parameters were examined in the postpartum period when the milk yield reached its highest level, a significant decrease was obtained in the values on the 30th day pp. Differently, these components were affected according to the lactation period of the milk. Our study revealed that the mean values of protein, casein, fat, solid not fat and total solid significantly decreased on the 30th day postpartum. There was a significant decrease in freezing point, acidity and density values in the following days of lactation compared to the 10th day. KUCHTIK et al. (2008) revealed that milk components such as total solid, SNF, fat, protein and casein, were closely related to the lactation period, including the 33th, 67th and until the 191st day, and these components showed an increase in the following lactation period compared to the beginning of the lactation period. However, these researchers saw an increase in these components over a longer period of lactation. The decreasing values in the early postpartum period that we obtained turn into an increase in the later lactation periods, as revealed by KUCHTIK et al. (2008). In a study on Norwegian goats, casein values were low in the early lactation period, and only reached high values in the middle lactation period. In the same study, total solid values were also low during early lactation and decreased to a minimum in the pasture period. Naturally, different factors also play a role in determining whether these values are high or low; it has been stated that fat and protein values decrease during the lactation period in summer, depending on the animals' nutritional status (LOEWENSTEIN and SPECK, 1984). Likewise, in a study on Baladi goats, it was demonstrated that protein, fat, TS and SNF values remained at low values until the 80th day of the early lactation period (EL-TARABANY et al., 2018). For example, fats become more lipolized, with the effect of enzymes in the progressive and final stages of lactation, and thus an increase in fat values occurs (COLLINS et al., 2003). In fact, the increase in lipolysis during the early lactation period indicates a negative energy balance. A negative effect on the palatability traits of milk develops (STRZALKOWSKA et al., 2009).

In this study, it was observed that this decrease was not directly related to the increase in the milk yield of goats. Although the milk yield increased between the 10th and 30th postpartum days, this increase was detected to be highly negatively correlated with protein, and positively correlated with total solid values. Alternatively, there was no significant correlation between milk yield and other measured parameters. However, it was determined that there was a significant positive correlation between casein and SNF (0.918; $P<0.05$) as well as between fat and TS (0.997; $P<0.05$), and there was a significant correlation between protein, casein, SNF and TS. Although there was a high correlation between protein with fat (0.897) and casein with fat (0.976), this correlation was not significant ($P>0.05$). Likewise, although there was a high level of correlation between fat and solid not fat (0.977; $P>0.05$), this correlation was not significant.

These findings reveal that there was a relationship between milk components during lactation. Another point is that the contents of total solids, fat, protein, and pH increased towards the middle and end of lactation (PAVIĆ et al., 2002); therefore, a important decrease in the studied parameters in the early postpartum period (until 30th days) was non-significantly correlated with milk yield. Similar results were also reported from KRACMAR et al. (2002) and MAROUNEK et al. (2012).

Our results show that significant correlations were found between freezing point with acidity, protein, casein, fat and total solid, and acidity with casein, solid not fat, total solid. In addition, a high level of correlation was demonstrated between casein and protein. Various studies revealed a correlation between casein and protein (RAFIQ et al., 2016), total solid with fat and protein, as well as fat with protein and solid not fat (DRAČKOVÁ et al., 2008). The same interaction has been revealed between casein and protein (AGANGA et al., 2002; SORYAL et al., 2005). It has been demonstrated that the cause of the change in protein also occurs in casein (STRZALKOWSKA et al., 2009). It is discussed that protein and casein fractions have a significant effect on the acidity change in milk (STRZALKOWSKA et al., 2009). Our study shows that a statistically significant decrease in protein and casein values between the postpartum 10th and 30th days was also highly correlated with acidity values (r=1.0; P<0.001). These components affect both each other and acidity.

We observed that the freezing point value (-0.609 °C, - 0.596°C and - 0.625 °C) decreased while passing from the 1st stage (D60) to the second stage (D120) and then increased in the 3rd stage (D200). PARK et al. (2007) revealed that the freezing point of goat's milk ranges between -0.540 °C and - 0.570 °C. It has been stated that these values are between – 0.596 °C and – 0.609 °C and even decrease to – 0.625 °C and are related to the increase in the milk component values in the later periods of lactation (STRZALKOWSKA et al., 2009). The freezing point values of Damascus goat's milk in this study were detected to between - 0.580 °C (pp D10) and - 0.520 °C (pp D30). The average acidity and freezing point values of the milk are high at the beginning of lactation and decrease significantly as the lactation period progresses (PAVIĆ et al., 2002). This supports the downward trend in components until the 35th day of lactation. In fact, this gradual decrease in acidity shows that the milking is hygienic. The sudden changes in acidity show that the milk is either affected by the environment and environmental temperature, or that milking is not hygienic (PAVIĆ et al., 2002).

Conclusions

In conclusion, this study showed that the parameters significantly decreased in the early puerperal period, that is the first 10th days, as well as that this decrease was not related to the increase in milk yield in the early period of lactation (until the 30th-day pp), and that these factors affect each other. On the basis of these normal values, deviations from these values can be a significant reference point for researchers. In addition, these values can be used as normal values, especially in products such as cheese and yoghurt.

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SAŽETAK

Cilj rada bio je prikazati sastojke mlijeka i njihove promjene tijekom ranog postpartalnog razdoblja u koza pasmine damask. Istraživanjem je obuhvaćeno 50 koza u dobi od 2 do 8 godina. Ukupno 291 uzorak mlijeka prikupljen je pod sterilnim uvjetima, tijekom jutra 10., 20. i 30. dana postpartalnog razdoblja. Rezultati su statistički analizirani Mann-Whitney U testom i ANOVA metodom s ponovljenim mjerenjima. Svi prikupljeni uzorci mlijeka analizirani su s obzirom na sastojke odnosno pokazatelje: laktoza (L), protein (P), kazein (C), mast (F), ukupna suha tvar (TS), bezmasna suha tvar (SNF), točka smrzavanja (FP), kiselost (A), gustoća (D), slobodne masne kiseline (FFA) i limunska kiselina (CA). Znakovito sniženje ($P<0,01$) između 10. i 30. postpartalnog razdoblja uočeno je u vrijednostima P, C, F, TS i SNF. Slični rezultati ($P<0,05$; $P<0,01$), između istih dana, utvrđeni su i za FP, A, D te CA. Statistički znakovita pozitivna korelacija ($P<0,05$ i $P<0,01$; 0,812 i 0,980;) uočena između FP, A, P, C, F i TS. Osim toga, potvrđena je korelacija između C i P (0,983; $P<0,01$). Rezultati pokazuju da su se razine istraženih sastojaka/pokazatelja tijekom ranog puerperija znakovito snižavale u odnosu na razdoblje prvih 10 dana. Navedeno snižavanje nije povezano s povećanjem koje se javlja tijekom proizvodnje mlijeka u ranom razdoblju laktacije (do 30. dana postpartalnog razdoblja).

Ključne riječi: pasmina damask; koza; mlijeko; sastav mlijeka; postpartalno razdoblje

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