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ANALYSIS OF COLOSTRUM AND MILK FROM CROSSBRED GOATS – PHYSICOCHEMICAL PROFILE

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Abstract

This study examines the changes in the physicochemical composition of goat colostrum during the first five days postpartum, as well as the composition of goat milk on the 40th day of lactation. A total of 69 colostrum samples and 16 milk samples were analyzed, collected according to a schedule from 16 crossbred goats (Murciana Granadina × Bulgarian White Dairy - MG×BWD). The fat content decreased significantly from 7.13% on the first day to 4.74% on the fifth day and remained relatively stable (4,57%) up to the 40th day. The solid-non-fat content also declined, from 13,08% to 8,51%, with a notable drop during the first five days. Protein content decreased from 8,26% to 3%, and the salts also showed a significant reduction. The total solids decreased from 20,22% on the first day to 13,33% on the 40th day, reflecting an overall decline in other components. The freezing point rose (-0,796°C to -0,528°C), correlating with the reduced concentration of soluble substances. These changes indicate the gradual transformation of colostrum in to milk.

Key words*: colostrum, dairy goats, milk, physicochemical parameters.*

INTRODUCTION

The access to more and more information through social networks and the World Wide Web is increasing farmers' interest in adopting new practices and importing new breeds of animals. In Bulgaria, this is manifested by the import and breeding of new breeds of goats offering certain productive characteristics. It is not possible to give a definitive answer as to whether this trend is good or not. The impact of these breeds on traditional goat breeding remains poorly understood, especially as regards the composition and quality of milk and colostrum.

One of the breeds that is attracting attention is the Mursiana-Granadina. This breed originates from the semi-arid regions of Spain - Murcia, Granada and Alicante and is known for its exceptional milk production and high quality milk composition, containing 5.7% fat and 3.7% protein (Todorov & Borislavov, 2019). Although its population in Bulgaria is still very limited, sporadic imports are observed, often associated with crossbreeding with traditionally bred breeds, such as the Bulgarian White Dairy breed. This crossbreeding aims to combine the productive traits of the imported breeds with the adaptability and sustainability of the local breeds.

The composition of colostrum varies between goat breeds (Arguello et al., 2006). The scientific literature provides a considerable amount of data on the composition of colostrum and milk of the Murciana-Granadina breed. For example, Segura et al. (2024) studied the dynamics of colostrum chemistry, lactoferrin and immunoglobulin G levels within 96 hours of parturition, analysing the influence of season and parity. Caja et al. (2006) also focus on the composition of colostrum and milk, while the studies by Martín-Ortiz et al. (2019) and Ruiz et al. (2014) deepen the understanding of the specific characteristics of these raw materials.

At the same time, there is limited data on the composition of colostrum from the Bulgarian White Dairy goat, which is one of the most common breeds in the country. Although Stoycheva & Mondeshka (2024) investigated the composition of colostrum, more research is needed on this topic. Dimitrova et al. (2020, 2021) and others provide information on the chemical composition of milk.

The lack of comparative analysis of the composition of colostrum and milk from crosses between these breeds represents a significant scientific gap that opens up opportunities for future research and further knowledge in this area. Such research is key to understanding the potential benefits of crossbreeding and the quality of the resulting production. The present study focuses on the physicochemical profile of colostrum from crossbred goats during the first five days after parturition, as well as the composition of milk at day 40 of lactation, in order to provide valuable data for their application in breeding practice and selection in Bulgaria.

MATERIALS AND METHODS

The study was carried out at the goat farm of the Research Institute of Mountain Stockbreeding and Agriculture - Troyan.

The colostrum analysed in this study was obtained from 16 clinically healthy goats, a cross between the breeds Mursiana Granadina × Bulgarian White Dairy (MG×BWD).

A total of 69 samples were milked daily on a schedule from the first to the fifth day after parturition, and milk analysis was performed on the fortieth day of lactation. Each sample was placed in an individual container of 200 ml and transported to the meat and milk laboratory of the laboratory complex of the Research Institute of Mountain Stockbreeding and Agriculture - Troyan. The samples were analysed immediately upon receipt without freezing.

A total of nine parameters were analysed using a Lactoscan LW milk analyser, including lactose, fat, protein, non-fat dry matter, solids, salts - expressed as a percentage, freezing point in °C, density in g/cm³ and pH.

Titratable acidity and calcium content of colostrum were determined by standard titration methods.

JMP v7 software package was used for statistical processing of the results.

RESULTS AND DISCUSSIONS

One of the key physiological mechanisms that ensures the survival and optimal development of goat kids is the ingestion of colostrum in the first hours after birth. Colostrum is the primary secretion of the mammary gland produced by the mother immediately after birth. This biologically active food provides essential nutrients that support the immune system, modulate the immune response, influence the composition of the gut microbiota and play an essential role in the processes of tissue growth and regeneration (Uruakpa et al., 2002; Mann et al., 2020a; Mann et al., 2020b; Agradi et al., 2023).

Goat colostrum is characterised by a high dry matter content and a variable but significant proportion of lipids, consisting mainly of short-chain fatty acids, which are absorbed with high efficiency by newborns. In addition, it contains a significant amount of protein of high biological value and a relatively low proportion of lactose (Dimov et al., 1975; Kaskous & Pfaffl, 2025).

In addition to being an important source of energy for the newborn, colostrum is rich in bioactive molecules that play a critical role in passive immune transfer (Soloshenko et al., 2020). The anatomical characteristics of the goat placenta do not allow efficient transplacental transfer of immune factors, particularly immunoglobulins, from the mother to the fetus. As a result, goat kids are born with agammaglobulinemia and are susceptible to infection (Agradi et al, 2023; Zhou et al, 2023).

Assessment of colostrum quality can provide valuable information on the nutritional composition and immunological status of the mother, which in turn has a direct impact on the health, growth and development of the newborn (Yang et al., 2015; Agradi et al., 2023).

Table 1 presents the dynamics of the physicochemical profile of colostrum and milk during the study period.

Fats

The fat content of colostrum decreased significantly ($P<0.01$) from day one to day five and remained stable until day forty of lactation. The fat content was highest at the beginning of the period, with similar values on days one and two, followed by a decrease on days three and four, which continued in samples from day forty onwards. The standard deviation is highest at the beginning, gradually decreasing to the lowest value at the end of the period, which may indicate a reduction in individual variability. The confidence intervals confirm this trend, being wider at the beginning, reflecting greater dispersion, but narrowing towards the end of the period, indicating a consolidation of the indicator around lower values.

Data similar to ours on the fat content of goat colostrum have been published by Sánchez-Macías, et al. (2014), who studied the first ninety days of lactation in Majorera goats and reported values of 7.70% for the fat content of colostrum immediately after birth and 3.88% in mature milk thirty days later.

Knight & Peaker (1982) found a correlation between the number of goat kids born and the fat content of the milk produced. They reported that colostrum from goats that gave birth to one goat kid contained less fat than that from goats that gave birth to two or more goat kids.

Table 1. Physicochemical composition of colostrum and milk from crossbred goats

Indicators	Day	1	2	3	4	5	40	Sig.
		n=11	n=13	n=14	n=15	n=16	n=16	
Fats (%)	**Mean**	**7.13**^{a}	**7.17**^{a,b}	**5.63**^{b,c}	**4.75**^{c}	**4.74**^{c}	**4.57**^{c}	**
	SD	2.84	2.23	1.40	1.51	1.70	1.25	
	Lower	5.96	6.09	4.59	3.91	3.77	3.90	
	Upper	8.30	8.24	6.67	5.58	5.71	5.24	
SNF (%)	**Mean**	**13.08**^{a}	**11.28**^{b}	**10.76**^{b}	**10.64**^{b}	**10.39**^{b}	**8.51**^{c}	***
	SD	3.03	1.53	0.94	0.89	0.82	0.00	
	Lower	11.05	10.36	10.22	10.15	9.95	7.97	
	Upper	15.12	12.20	11.30	11.13	10.82	9.04	
Lactose (%)	**Mean**	**2.47**^{a}	**3.61**^{a}	**4.11**^{a,b}	**4.52**^{b}	**4.65**^{c}	**4.72**^{d}	***
	SD	0.43	0.43	0.07	0.47	0.33	0.44	
	Lower	2.19	3.34	3.96	4.26	4.47	4.48	
	Upper	2.76	3.89	4.26	4.78	4.83	4.95	
Salts (%)	**Mean**	**1.06**^{a}	**0.91**^{b}	**0.87**^{b}	**0.86**^{b}	**0.83**^{b}	**0.67**^{c}	***
	SD	0.25	0.13	0.08	0.07	0.05	0.09	
	Lower	0.90	0.84	0.83	0.82	0.81	0.62	
	Upper	1.23	0.99	0.91	0.90	0.86	0.71	
Protein (%)	**Mean**	**8.26**^{a}	**4.11**^{b}	**3.93**^{b}	**3.89**^{b}	**3.75**^{b}	**3.00**^{c}	***
	SD	0.85	0.57	0.35	0.33	0.23	0.39	
	Lower	7.69	3.77	3.73	3.71	3.62	2.79	
	Upper	8.83	4.45	4.13	4.08	3.87	3.21	
TS (%)	**Mean**	**20.22**^{a}	**18.45**^{a,b}	**16.39**^{b,c}	**15.39**^{c,d}	**14.99**^{c,d}	**13.33**^{d}	***
	SD	5.43	2.55	1.81	1.39	1.70	2.44	
	Lower	16.57	16.91	15.35	14.62	14.08	12.03	
	Upper	23.86	19.99	17.43	16.16	15.89	14.63	
Freezing point (°C)	**Mean**	**-0.80**^{a}	**-0.74**^{b}	**-0.71**^{b}	**-0.70**^{b}	**-0.68**^{b,c}	**-0.53**^{c}	**
	SD	0.06	0.08	0.06	0.05	0.04	0.09	
	Lower	-0.84	-0.79	-0.74	-0.73	-0.70	-0.58	
	Upper	-0.76	-0.7	-0.68	-0.67	-0.65	-0.48	

a, b, c, d - the differences between the values obtained for the individual indicators bearing different letters on one line are significant; **P < 0.01; ***P ≤ 0.001.

The solid-not-fat (SNF)

The dry fat-free residue content is influenced by the lactose, protein and mineral content of the milk and is a relatively more stable quantity than dry matter (Dimov et al., 1975; Kaskous & Pfaffl, 2025). In our study, the dry solids content decreased (Table 1) with the transition from colostrum to milk. It was highest at the beginning, decreased on the second day and then stabilised between the third and fifth day. On the fortieth day, the values were lowest and statistically significant compared to the initial period ($p < 0.05$). The variation was most pronounced at the beginning. The confidence intervals support this dynamic, being wider at the beginning and narrowing significantly towards the end, highlighting the robustness of the parameter.

Consistent with what was found in this study, in our previous study on the physicochemical profile of colostrum from Togenburg goats milked immediately after parturition and twenty-four hours later, we reported DFR values of 14.96 and 11.81%, respectively (Stoycheva & Mondeshka, 2024). The decrease in DFR is physiological and due to various biochemical and physicochemical changes in the composition of colostrum as it is converted to mature milk

Lactose

The data in Table 1 show an increase in lactose content as lactation progresses, with statistically significant differences between groups supporting the reliability of this trend. Confidence intervals are relatively narrow, especially at higher lactose levels, suggesting greater precision of measurements in these groups. The highest values for this parameter were recorded on the fortieth day of lactation, and the results obtained are within the norm for mature goat's milk according to literature data. The increase in lactose content observed is in agreement with that reported by Romero, et al., (2013), who described dynamic changes in the lactose content of colostrum from Murciano-Granadina goats, with a concentration of 2.9% in colostrum milked immediately after birth and 4.68% on day 5.

Argüello et al. (2006) conducted a study aimed at evaluating the influence of lactation order and number of newborn goat kids on the physicochemical composition of colostrum. The analysis results showed a statistically significant increase in lactose concentration as the lactation period progressed. The authors also found that the number of goat kids born had a significant effect on the lactose content of colostrum.

Salts

The salts content decreases as colostrum passes into milk. On the first day, the concentration is highest, then decreases, and between the third and fifth day, the values do not fluctuate sharply. On the fortieth day, the content reaches the lowest values, the difference concerning the initial period being statistically significant ($p < 0.05$).

Protein

The protein content decreases, with the decrease logically being most pronounced in the first days. A significant decrease was observed on the second day ($p < 0.05$). In the following days, the decrease continued at a slower rate, with stable values between the third and fifth day.

The decrease in protein content may be due to biochemical changes during the transition from colostrum to milk. This trend is in line with the changes observed in the other parameters analysed, highlighting the complex nature of the dynamics of the composition of the samples studied.

Ruminant colostrum is particularly rich in immunoglobulins (Ig), which account for about one third of the total protein content. In goat colostrum, the major immunoglobulin is IgG, which makes up about 90% of the total immunoglobulin content, followed by IgM (6.0%) and IgA (3.7%) (Rudovsky et al., 2008; Farooq et al., 2024). The concentration of IgG shows a sharp decline after birth, reaching a minimum at 36 hours (Morales-delaNuez et al., 2011). This explains the decrease in this indicator in the first days after birth.

In addition to immunoglobulins, goat colostrum contains a number of biologically active components, including vitamins, hormones, growth factors, cytokines, enzymes, bioactive peptides, and immunocompetent cells, which aid in the development of the newborn's immune system (Filipescu et al., 2018; Xu et al., 2021; Zhou et al., 2023; Övet, 2024).

Of particular importance is lactoferrin, an iron-binding glycoprotein that is one of the most important immunostimulatory factors in colostrum (Rachman et al., 2015; Menchetti et al., 2020).

Solids

The solids content decreased steadily, without sharp drops, reaching its lowest value in goat milk at 40 days ($p < 0.05$). This suggests continuous biochemical and physical changes in composition.

The decrease in solids content is probably related to complex physicochemical and microbiological processes. These observations highlight the dynamic nature of changes in colostrum composition.

Our results, correspond with those of Hodulová et al. (2014), in Czech White Shorthaired goats, who reported a decrease in dry matter content within the first 24 hours. A similar trend was confirmed by Elmaz et al. (2022) in the Honamli breed, and by Romero et al. (2013) in Murciano-Granadina goats, which recorded the highest dry matter values in colostrum during the first followed by a decrease in the following days of lactation. Similar observations were made by Hadjipanayiotou (1995) and Keskin et al. (2007), who found that the dry matter content of colostrum of Damascus goats was highest on the first day and gradually decreased until the third day after parturition.

Freezing point

The freezing point increases with time, reflecting changes in the composition of the water and dry fractions in the colostrum. On the first day the value is lowest, but on the second day there is a significant increase. On the following days, the trend continued at a steady rate, with the freezing point reaching its highest value on the fortieth day, which was statistically significant with respect to the previous periods ($p < 0.05$).

The increase in freezing point may be the result of a decrease in the content of salts, lactose and other solutes that lower the freezing point and is a logical explanation for the observed changes. In addition, possible water diffusion and phase transitions may also contribute to the shift in this parameter (Linzell & Peaker, 1974). The present results emphasise the importance of monitoring freezing point as an indicator of changes in chemical composition, particularly in the context of storage and process flows. A clear downward trend was observed in the acidity indicator (Fig. 1), with the highest value recorded on the first day after birth, after which the indicator progressively decreased. Our findings correspond with the studies of Romero et al. (2013) in Murciano-Granadina goats and Torres Vilar et al. (2008) in Saanen goats.

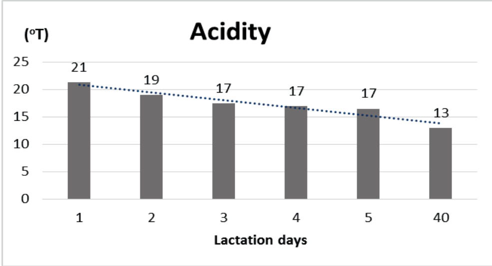

Figure 1. Acidity of colostrum and milk

Our results are lower, but the tendency to lower acidity is identical, with differences probably due to interbreed differences (Figure 1). Primary acidity can be influenced by the health status of the animal, its diet and the lactation period. At the beginning of lactation, colostrum has a very high acidity, which gradually decreases and falls below 15°T towards the end of the lactation period (Dimov et al., 1975). Torres Vilar et al. (2008), reported a high correlation between colostrum protein content and titratable acidity, proving the statement of Mariani et al. (1981), that lower protein content leads to lower titratable acidity. The downward trend in acidity may be explained by changes in milk composition associated with the progression of the lactation period, including reduction of organic acids and changes in the buffering system. The observed decrease is an indication of the physiological adaptations in milk composition occurring with the transition from colostrum to mature milk (Dimov et al., 1975).

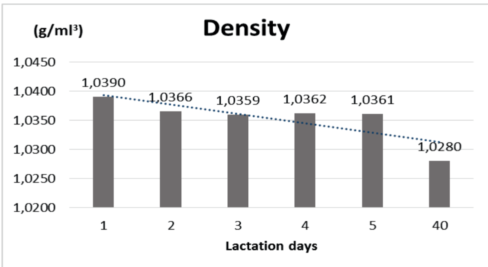

Figure 2. Density of colostrum and milk

Figure 2 shows the density dynamics during the first five days after birth and on the fortieth day of lactation. There is a marked tendency for this parameter to decrease during the transition from colostrum to milk.

Density is highest on the first day, which is to be expected given the high content of solids and biologically active components in colostrum. During the following days, a gradual decrease is observed, with values fluctuating within a relatively narrow range. On the fifth day, the density decreased slightly, indicating a stabilisation of the parameter at this stage. The lowest value was recorded on the fortieth day, which is a significant decrease compared to the initial measurements.

Our observations on the density of colostrum from crossbred goats are consistent with the results reported by other researchers. For example, in goats of the Murciano-Granadina breed, Romero et al. (2013) found a decrease in density from 1.0528 to 1.0318 g/cm³ over a period of 156 hours. In the colostrum of Majorera goats, analysed immediately after birth, the density was 1.0480 g/cm³ and five days later it decreased to 1.0330 g/cm³; on the thirtieth day of lactation, the value reported for this parameter remained at approximately similar values of 1.0290 g/cm³ (Sánchez-Macías et al., 2014). The decrease in density is proportional to the decrease in other colostrum components, including protein, fat and dry matter. This confirms the adaptive changes in colostrum composition associated with the reduction of macromolecular components, such as proteins and immunoglobulins, characteristic of the colostral period, and the shift towards mature milk with lower density.

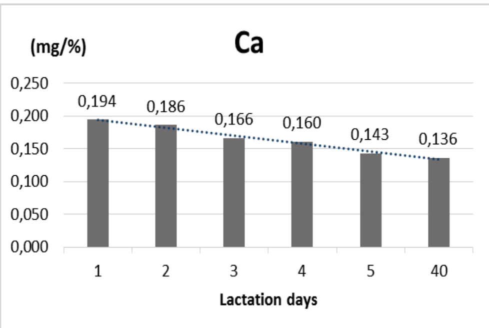

Figure 3. Calcium content in colostrum and milk

Figure 3 shows the changes in colostrum calcium concentration on different days of the colostral period and on day 40 of lactation. There is a clear downward trend, consistent with physiological changes in milk composition as lactation progresses.

On the first day, the calcium content is highest, on the following days the concentration gradually decreases until the fifth day. On the fortieth day it reaches the lowest value, which is significant compared to the initial period.

This decrease in Ca content during the study period is probably related to the transition from colostrum to mature milk, in which the mineral content decreases in accordance with the changing physiological needs of newborns. Calcium salts are present in colostrum and fresh goat's milk in ionic, molecular and colloidal dispersions. Their concentration is relatively constant and deviations from the permissible limits may indicate certain diseases in animals (Dimov et al., 1975; Kaskous & Pfaffl, 2025).

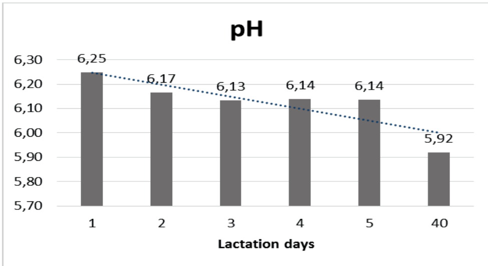

Figure 4. pH of colostrum and milk

There is a tendency for a gradual decrease in pH (Figure 4) as lactation progresses. Initially, the pH is highest, then a slight decrease is observed between the second and fifth day, with values fluctuating within a narrow range. The lowest value for this indicator was recorded on day 40, with significant differences from the results obtained during the colostrum period. The active acidity or pH of the milk changes much more slowly than the titratable acidity, due to the buffering properties of the milk, resulting from the content of proteins and salts (Dimov et al., 1975). The presence of a decreasing trend in our study, represented by the trend line, highlights the importance of monitoring pH as an indicator of qualitative and biochemical changes in milk. Anifantakis & Kandarakis (1980) considered that the freshness of goat's milk can best be determined by the indicators pH and acidity.

CONCLUSIONS

In conclusion, our study followed the dynamics of the physicochemical profile of colostrum and milk at day 40 in crossbred goats (BWD×MG). The composition of colostrum undergoes significant changes during the first days of lactation. The levels of fat, protein, salts and solids-non-fat decreased sharply in the early period ($p < 0.05$) and stabilised after day 5. Density also followed this trend and reached its lowest values on day 40.

Lactose and freezing point increased as lactation progressed. The calcium content decreased gradually, with significantly lower values on day forty compared to the initial period.

The results of this study are a starting point for new extended studies and can be used by farmers in connection with the introduction of the MG breed and by breeding organisations in the development of technologies and breeding programs.

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