IJAS Iranian Journal of Applied Animal Science

Protein Profile and IgG Content of Colostrum from Three Goat Breeds Raised in the Foothills of Bulgaria

Research Article

S. Stoycheva[1*], S. Dyankova[2], N. Solakov[2], L. Mondeshka[1] and K. Loginovska[2]

[1] Research Institute of Mountain Stockbreeding and Agriculture, 281 Vasil Levski Str., 5600, Troyan, Agricultural Academy, Sofia, 1373, Bulgaria
[2] Institute of Cryobiology and Food Technologies, 53 Cherni Vrah blvd., 1407 Sofia, Agricultural Academy, Sofia, 1373, Bulgaria

Received on: 11 Jun 2024
Revised on: 6 Jan 2025
Accepted on: 31 Jan 2025
Online Published on: Mar 2025

*Correspondence E-mail: s.e.stoycheva@abv.bg

Online version is available on: www.ijas.ir
https://doi.org/10.71798/ijas.2025.1202964

ABSTRACT

Colostrum is the first food the newborn takes immediately postpartum. The study aimed to identify the protein fractions and determine the IgG content in lyophilized colostrum samples from three breeds of goats, such as Bulgarian White Dairy (BWD), Toggenburg (TG), and Anglo-Nubian (AN), and their change within 24 h postpartum assessing its potential as a source of high-quality proteins. Using lyophilization methods and protein analysis, differences in the concentration of key proteins between breeds and the effect of the lyophilization process on colostrum composition were examined. This will fill the knowledge gap related to colostrum composition in these breeds. No significant difference in protein profile was observed between breeds. Differences in the time of receipt were found. From a practical point of view, only colostrum collected in the first hours after kidding was of special interest. At the 24th hour, a decrease in the number and intensity of the fraction with Mw of 56.5 - 59.2 kDa (IgG heavy chain) and to a lesser extent IgG light chain (22.5-23.0 kDa) was reported. The content of IgG in the colostrum of goats was strongly influenced by the breed, as in Anglo-Nubian, Bulgarian White Dairy, and Toggenburg goats it varies within very wide limits.

KEY WORDS colostrum, goats, IgG, immunity, protein fractions.

INTRODUCTION

In recent years, interest in goat milk (Selvaggi *et al.* 2014) and products with added goat colostrum has increased worldwide. Proteins in goat milk consist mainly of caseins (70%), whey proteins (25%), and 5% membrane protein in milk fat globules (Chen *et al.* 2019). According to Salem *et al.* (2009), milk proteins play an important role, not only in the nutrition and growth of the offspring but also in various technological aspects, such as heat treatment, coagulation, and digestion rate. Colostrum, and goat colostrum in particular, is increasingly popular both as a nutritional supplement and in health and beauty products. Colostrum is the first food the newborn takes immediately postpartum. It is characterized by a high protein and antibody content, and a low carbohydrate and fat content (Linzell, 1959; Linzell and Peaker, 1971a; Linzell and Peaker, 1971b; Menatian *et al.* 2016; Koushki *et al.* 2019). When consuming colostrum, the newborn receives passive immunity from its mother. According to Zazharska and Samoylenko, (2016), the quality of colostrum depends mostly on the concentration of IgG. Goat colostrum contains twice as much immunoglobulin G as bovine colostrum. Again, according to them, the concentration of immunoglobulin G in colostrum depends on the goat breed, as local (autochthonous) breeds have a higher concentration than dairy goats.

The study of the interconnection between the immune response and nutrition is one of the most current problems, as

it allows for determining the possible causes of the development of immunodeficiency conditions in humans (Lych *et al.* 2017) and animal organisms. Constant *et al.* (1994) found that kids had no serum Ig G concentrations at parturition, that is, they were agammaglobulinemic at parturition (Arguello *et al.* 2004; Arguello *et al.* 2006).

Colostrum consists of two fractions – milked colostrum and residual colostrum, which remain in the udder after the first milking. This residual colostrum will be a part of the colostrum milked 2 days postpartum (Moreno-Indias *et al.* 2012). The authors found in Majorera goats that within 10 h postpartum, the amount of IGH in the colostrum dropped dramatically, and in the residual colostrum it was lower than in the first milking. In the first hours postpartum, the intestinal epithelium of the newborns is permeable to protein formations, including immunoglobulins. Fetal enterocytes can pass immunoglobulins only within 48-72 h postpartum (Baintner, 2007; Hurley and Theil, 2011; Nordi *et al.* 2012; Moretti *et al.* 2013).

In a study of how different feeding systems can affect the occurrence of cryptosporidial infections, Goyena *et al.* (1997) demonstrated that low immunoglobulin content in colostrum was associated with high morbidity and mortality in newborn kids. The only way to acquire immunoglobulin remains the timely administration of colostrum immediately postpartum so that they acquire passive immunity to protect them from infections during the neonatal period (Halliday and Williams, 1979; Arguello *et al.* 2004; Kessler *et al.* 2019).

In the available literature, many studies of colostrum are available in different breeds of goats in several countries, such as Anglo-Nubian, Appenzell, Boer, Bunte Deutsche Edelziege, Chamois-colored, Grisons Striped, Peacock, Saanen, Toggenburg, and Valais Blackneck in Germany and Switzerland (Kessler *et al.* 2019), Black Bengal, Saanen in Thailand (Buranakarl *et al.* 2021), Honamli and hair goat in Turkey (Altintas and Kankavi, 2020). Hyrslova *et al.* (2016) investigated the idea of using goat and bovine colostrum for the production of functional foods with different additives. They found that goat colostrum has a more similar immunomodulatory effect to human milk than bovine colostrum. In their study, Salem *et al.* (2009) found that goat's milk proteins have a unique electrophoretic pattern compared to that of cow's milk. The molecular weights of the casein fractions in goat's milk are smaller than those of cow's milk.

Zunev *et al.* (2004) observed the changes in the physicochemical parameters of colostrum in goats of the Bulgarian White Dairy (BWD) and Toggenburg (TG) breeds. They found that protein content (total, casein, and non-casein) was higher on day 1 in TG, as, whey proteins being about 40% of total protein in both breeds. The variation of total protein in colostrum on the first day was from 4.34 to 10.49% in BWD and from 5.43 to 11.29% in TG. For whey protein, the deviation was 1.46 to 4.37% in BWD and 1.67 to 4.57% in TG. The same authors noted that whey proteins in colostrum decreased by 40% at 48 h compared to 24 h postpartum.

To date, no studies have been conducted on the immunoglobulins and protein profile in the colostrum of the goat breeds raised in Bulgaria. This study is the first to analyze Ig-G content and protein fractions in the Bulgarian White Dairy (BWD), Toggenburg (TG) and Anglo-Nubian (AN) breeds, with an emphasis on dynamic changes in the first 24 hours after birth. While other studies focus on general indicators of colostrum, the present study examines changes in the protein profile and Ig-G over time, which may provide new data on the role of time in colostrum quality.

The study provides detailed information on the differences in protein concentration in colostrum from different goat breeds. The comparison of BWD, TG and AN breeds provides a unique insight into the differences between local and dairy breeds, which may have applications in both goat kids feeding and functional food development. This is one of the first studies to look at the effect of breed on the protein composition of lyophilized colostrum, showing how differences in genetic makeup can alter colostrum quality. The results will highlight the potential of lyophilized colostrum for use in nutritional supplements and cosmetic products.

The study aimed to identify the protein fractions and determine the Ig-G content in lyophilized colostrum samples from three breeds of goats, such as Bulgarian White Dairy (BWD), Toggenburg (TG), and Anglo-Nubian (AN) and their change within 24 h postpartum.

MATERIALS AND METHODS

The study was conducted in the goat farm of the Experimental Base of RIMSA, Troyan, during the kidding period (February-March). It included 30 clinically healthy goats. Accordingly, 10 goats of the following breeds: Bulgarian White Dairy (BWD), Toggenburg (TG) and Anglo-Nubian (AN). All goats were reared under the same conditions. During the winter period, the animals were kept in a barn and fed with a ration containing 2 kg of hay and 0.8 kg of concentrated feed per head. They had free access to water and salt. During the spring and summer months (May-November) the goats were pasture-raised. Kidding was in February and March. Before the parturition, the goats were separated into individual boxes, where colostrum was also sampled. Samples were obtained in sterile 200 ml containers, immediately 1 h postpartum (1-30) and at 24 h (1' - 30') postpartum. The description of the obtained colostrum

samples is presented in Table 1. The samples were frozen and stored at -25 °C until the end of the kidding campaign.

Table 1 Legend of received samples

Breed[1]	1 h-total number of samples, coding	24 h-total number of samples, coding
BWD	10 (from 1 to 10)	10 (from 1' to 10')
TG	10 (from 11 to 20)	10 (from 11' to 20')
AN	10 (from 21 to 30)	10 (from 21' to 30')

BWD: Bulgarian White Dairy; TG: Toggenburg and AN: Anglo-Nubian.

Lyophilization of colostrum

The frozen colostrum samples were distributed in individual containers from the lyophilizer kit and placed in the sublimation chamber of a Hochvakuum-TG 16.50 vacuum-sublimation installation (Germany). Lyophilization was conducted under the following regime parameters: primary drying temperature – (-40) °C, temperature of the desublimator – (-65 °C), maximal working vacuum – 2.101 Pa; secondary drying temperature + 28 °C. Duration of the process – 24 ± 1 h. Lyophilized colostrum samples were packed in three-layer aluminum foil bags and stored at a temperature (-25 °C) until the beginning of the analyses. Determination of residual moisture after lyophilization: The moisture content of the lyophilized samples was measured with Sartorius Thermo Control YTC 01L balances with infrared heating of the sample.

Colour of lyophilisates

The colour parameters of the lyophilized colostrum samples were determined with an NR200 Portable Digital Colorimeter (Huanyu), according to the CIE Lab scale. Measurements were made on 5 samples from each experimental group. Measurements were performed on a white standard background (L*=94.98, a*=0.29, and b*=-1.67). The total colour difference (ΔE) was calculated using the formula:

$$\Delta E = \sqrt{(L^* - L)^2 + (a^* - a)^2 + (b^* - b)^2}$$

SDS – Polyacrylamide gel electrophoresis

The protein profile of the lyophilized colostrum samples was determined by SDS-PAGE under reducing conditions according to Laemmli (1970) at concentrations of stacking gel 6% and running gel – 10%, 3 samples were analyzed from each group. An accurately weighed amount of 0.1750 g of the lyophilisate was dissolved in 10 ml of distilled water for 1 hour under continuous stirring. 250 µL of the resulting solution was mixed with 750 µL of sample dissolution buffer (0.2 M Tris-HCl, pH 6.80, containing 2% SDS, 16% glycerol, and 10 mM DDT). 20 µL of all gel samples were applied. α–lactalbumin, β-lactoglobulin, α-casein, β-casein (Sigma-Aldrich), and Protein Test Mixture for SDS PAGE (SERVA Electrophoresis) were applied as standard proteins. A protein electrophoresis system was used - a Pharmacia LCB MultiDrive XL equipped with an Omni-PAGE WAVE Electrophoresis System (Cleaver Scientifics). Electrophoresis was conducted at a constant current of 30 mA. The gel was stained using 0.1% Coomassie Brilliant Blue (30-40 min).

Densitometry

Analyses of protein fractions of goat colostrum were performed using GelDoc Go Imaging System (Bio-Rad) with Image Lab 6.1 software.

Determination of IgG content in colostrum samples

IgG content in colostrum was assessed using the goat IgG ELISA kit (Abbkine Scientific Co., Ltd.). Lyophilized colostrum samples were rehydrated with distilled water at a ratio of 1:4 and homogenized on a VORTEX MX-S (DLAB Scientific) for 5 min. Then reconstituted colostrum samples were diluted with sample buffer and IgG determination was conducted under the manufacturer's instructions. Finally, the absorbance was measured at 450 nm using a microplate Reader (RT-2100C, Rayto).

Statistical processing

The analyses were performed with 3 or 5 replicates. Statistical evaluation of the results was performed with the Excel 2016 software package and data were presented as mean ± standard deviation (SD). A one-way ANOVA was performed to determine the differences.

RESULTS AND DISCUSSION

Figures 1 and 2 present photographs of lyophilized colostrum samples from the three goat breeds taken immediately postpartum (1 h) and at 24 h, respectively.

The lowest yield of lyophilisate from 100 mL of colostrum taken immediately postpartum was found in TG (24.43 g) and reached 27.64g in BWD and 27.73g in AN, but the differences were not statistically significant (Table 2). In samples taken 24 h postpartum, the amount of lyophilisate obtained from 100 mL of colostrum decreased significantly to 19.03 g in BWD, 19.89 g in TG, and 23.33 g in AN.

The high yield of colostrum lyophilisate in the Bulgarian White Milk (BWD) and Anglo-Nubian (AN) breeds in the first hour after birth can be explained by the higher dry matter content compared to the Toggenburg (TG) breed. These differences probably reflect genetic variation in milk and colostrum secretion between the goat breeds studied. The decrease in lyophilisate yield at 24 hours is related to the natural decrease in colostrum nutrient concentration with time, which is a physiological mechanism supporting the transition to mature milk.

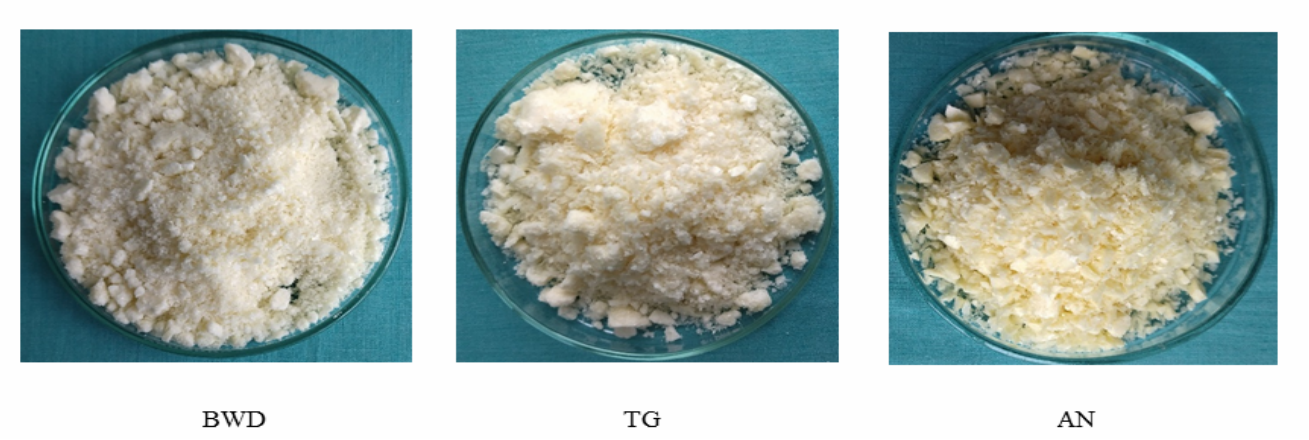

Figure 1 Photographs of lyophilized colostrum from three goat breeds taken immediately postpartum (1h)

Figure 2 Photographs of lyophilized colostrum from three goat breeds taken 24 h postpartum

Table 2 Lyophilizate yield (g) from 100 mL of colostrum

Goat breed	1 h	24 h	Significance
BWD	27.64±5.81	19.03±5.59	**
TG	24.43±6.09	19.89±6.00	*
AN	27.73±6.08	23.33±2.93	**

BWD: Bulgarian White Dairy; TG: Toggenburg and AN: Anglo-Nubian.
* (P≤0.05) and ** (P<0.01).

Lyophilized colostrum was a dry, porous mass that was easily sifted. The colour in the different groups varied from white to pale yellow, which is in agreement with the instrumentally determined colour parameters (Table 3). The results for lightness (*L*) are the highest for the lyophilized colostrum from BWD and the lowest for AN. The samples from AN have the highest values for *b* (yellowness), which was also confirmed by visual observation (Figures 1 and 2). There was an increase in *L* and a decrease in *b* in the colostrum of all three breeds taken at 24 hours compared to that at 1 hour. The values for the total colour difference (*ΔE*) between the two groups of samples were respectively: 4.1 (BWD), 8.1 (TG), and 6.8 (AN).

All samples of the lyophilized colostrum had a low moisture content (from 1.76% to 3.04%) and there was no significant difference between the different experimental groups.

It is known that milk proteins are divided into two large groups - caseins and whey proteins (Data of the Committee on Milk Protein Nomenclature and Methodology of the American Dairy Science Association) (Korhonen, 2009; Lych *et al.* 2017). The serum fraction contains β-lactoglobulins and α-lactoalbumins, whose molecular weight is about 18 kDa and 14 kDa, respectively, also lactoferrin (80 kDa), lysozyme (15 kDa) and immunoglobulins (Lych *et al.* 2017).

Table 3 Colour and moisture content (MC) of frozen dried colostrum samples

Goat breed	1 h				24 h			
	Color[1]			MC[3] (%)	Color			MC (%)
	L	*a*	*b*		*L*	*a*	*b*	
BWD	90.1±1.3	-1.5±0.4	14.4±3.7	2.54±0.49	91.6±1.9	-1.1±0.3	11.2±1.4	3.04±0.10
TG	88.0±1.4	-0.9±0.5	25.4±4.8	2.03±0.41	89.2±1.7	-0.8±0.2	17.6±1.1	2.82±0.16
AN	86.4±0.8	-1.6±0.3	26.8±3.8	1.76±0.30	87.6±1.0	-1.5±0.3	19.9±1.5	3.00±0.42

BWD: Bulgarian White Dairy; TG: Toggenburg and AN: Anglo-Nubian.
L: lightness; *a*: redness and *b*: yellowness.

In colostrum, the electrophoretic profile is much different compared to milk. According to Rahmatalla *et al.* (2022) the vast variations in casein proteins are crucial for the production of milk and milk products with different properties for human health and nutrition.

SDS-PAGE results of lyophilized goat colostrum (1 h) showed a rich protein composition (Figure 3). When compared with the results of the electrophoresis of skimmed goat milk (Figure 4), significant differences in the protein fractions and their intensity were reported. Whereas casein fractions mainly prevail in milk, in colostrum, a significant presence of high molecular weight fractions with a molecular mass above 60 kDa was observed.

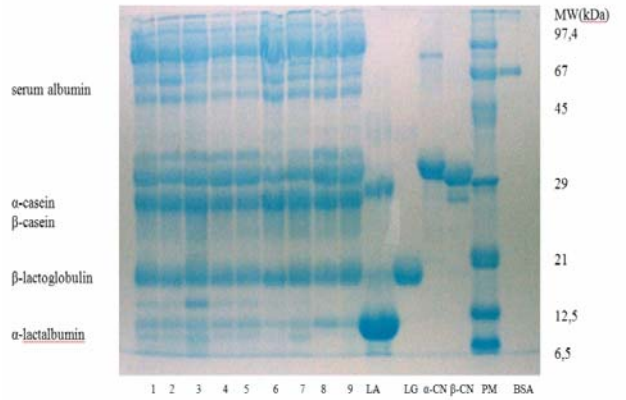

Figure 3 SDS-PAGE of colostrum proteins taken at 1 h: 1, 2, and 3 - individual samples of BWD breed; 4, 5 and 6 - individual samples of the TG breed; 7, 8, and 9 - individual samples of the AN breed; LA: lactalbumin; LG: lactoglobulin; α-CN: α-casein; β-CN: β-casein; PM: protein marker (Protein Test Mixture 6-Serva) and BSA: bovine serum albumin

The determination of the Rf value of the expressed protein fractions and the calculation of the molecular masses were performed using Image Lab 6.1 software, using the molecular mass data of a standard protein mixture - Protein Test Mixture 6 for SDS PAGE (SERVA Electrophoresis). The results of the calculations for the molecular masses of the colostrum proteins are presented in Table 4.

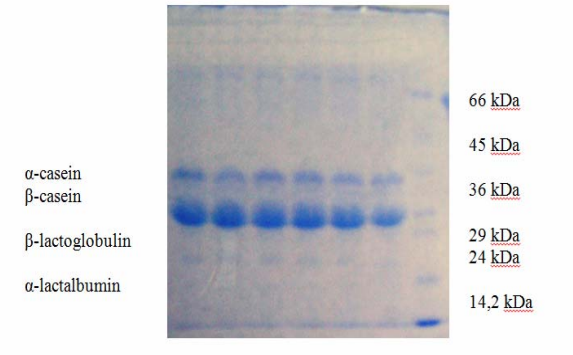

Figure 4 SDS PAGE of goat milk proteins

In all groups, 12 to 13 protein fractions with different electrophoretic mobility were observed from the colostrum taken at 1 h. In the BWD breed, 2 high-molecular fractions with average Rf values - 0.024, 0.068 and molecular masses - 127.5 kDa and 109.0 kDa were reported. Similar results were obtained for the other groups, with slight variations in the calculated mean Mw, respectively: 131.5 kDa and 112.4 kDa (TG breed) and 133.6 kDa and 114.9 kDa (AN breed). The intense protein fraction with Rf 0.140 and Mw 84.0 kDa was identified as lactoferrin. According to Rachman *et al.* (2015), the molecular mass of lactoferrin in colostrum from different breeds and crossings of goats ranged from 83.5 to 86 kDa. Segura *et al.* (2024) analyzed changes in lactoferrin content in colostrum from Murciano-Granadina goats during the first 96 hours after birth. From our results for the TG breed, the average molecular mass of lactoferrin was 86 kDa, and for the AH breed was 88.5 kDa. The strip with a molecular mass of 67.7 kDa corresponds to serum albumin. In the other breeds, the albumin variation was 68.7 and 69.6 kDa. According to literature data, serum albumin in goats has a molecular mass of approximately 69 kDa.

The next protein fraction has a Mw from 56.5 to 59.2 kDa (respectively, in BWD breed-56.5 kDa; TG breed - 58.8 kDa; AN breed-59.2 kDa). Most likely, it corresponds to immunoglobulin G - heavy chain (IgG heavy chain).

Table 4 Rf values and molecular masses of protein fractions after electrophoresis of goat colostrum samples (1 h postpartum)

BWD breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 1	0.03	128467	Sample 2	0.023	126691	Sample 3	0.02	128006
	0.078	104275		0.065	109168		0.061	110571
	0.143	83131		0.142	83546		0.136	85230
	0.206	67274		0.205	67601		0.203	67931
	0.262	55932		0.259	56598		0.256	57137
	0.372	39591		0.431	31252		0.43	31321
	0.455	31047		0.499	27518		0.508	26880
	0.506	26985		0.575	22585		0.582	22224
	0.573	22707		0.795	18270		0.787	19468
	0.79	18413		0.865	16780		0.862	16835
	0.866	16767		0.923	14817		0.924	14795
	0.923	14817		0.961	11288		0.965	11232
	0.959	11307		-	-		-	-
TG breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 4	0,014	130679	Sample 5	0.008	133412	Sample 6	0.015	130005
	0,058	111994		0.055	113146		0.058	111994
	0,129	87388		0.125	87711		0.138	84806
	0,198	69099		0.197	69268		0.204	67766
	0,248	58512		0.243	59639		0.25	58234
	0,433	30043		0.433	30043		0.365	40476
	0,509	25775		0.506	26985		0.437	31699
	0,579	22383		0.576	22544		0.497	26681
	0,789	18431		0.789	18431		0.572	22789
	0,863	16821		0.857	16932		0.79	18000
	0,924	14095		0.929	14731		0.922	14628
	0,956	11346		0.957	11336		-	-
AN breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 7	0.004	135501	Sample 8	0.007	133757	Sample 9	0.008	131490
	0.042	113000		0.049	115488		0.051	116490
	0.122	88606		0.127	88047		0.12	88057
	0.196	69606		0.195	69077		0.184	70385
	0.247	58791		0.248	58512		0.238	60500
	0.361	41019		0.35	42416		0.353	41944
	0.425	31888		0.425	31888		0.428	31603
	0.489	27291		0.495	26791		0.497	27627
	0.569	22954		0.566	23121		0.564	23205
	0.784	19541		0.644	21228		0.644	21228
	0.922	14628		0.784	19541		0.782	19615
	0.962	11269		0.92	14561		0.918	14883

BWD: Bulgarian White Dairy; TG: Toggenburg and AN: Anglo-Nubian.
Lane: lane number; Rf values: relative mobility and MW: molecular weight.

Immunoglobulin G is a glycoprotein with a mol mass of approximately 160 kDa, which consists of 2 heavy and 2 light polypeptide chains. Under the reducing conditions of SDS-PAGE, individual subunits are revealed, and according to literature, the IgG heavy chain has a molecular mass of 55-59 kDa, and the IgG light chain - 22-27 kDa (Ounis, 2010). The picture in Figure 3 shows an intense band with Mw 22.5 -23.0 kDa, which coincides with the data for the IgG light chain.

In our studies, the casein fractions appeared as two bands with Mw respectively: 30.0-31.5 kDa (α-casein) and 26.0-27.8 kDa (β-casein). These values largely overlap with those reported by Salem *et al.* (2009). The band intensity of β-casein was significantly higher than α-casein, which also agrees with literature data on the composition and distribution of casein fractions in goat's milk.

Of the fractions with a molecular mass below 20.0 kDa, the band of β-lactoglobulin (18.5–19.5 kDa) was the most

intense. The other main whey protein - α-lactalbumin (14.5 kDa) was also detected but with a lower intensity. No significant differences were observed in the protein profile of β-lactoglobulin and α-lactalbumin between breeds. Similar results were reported by Da Costa *et al.* (2014) when investigating the protein composition of milk from Saanen and Alpine goat breeds raised in northern Brazil. Two additional low molecular weight fractions with Mw of approximately 17.0 and 12.0 kDa were observed in some of the samples. The intensity of the stripes was weak, especially in TG and AN breeds.

The obtained results of SDS-PAGE of colostrum samples taken 24 h postpartum are presented in Figure 5 and Table 5.

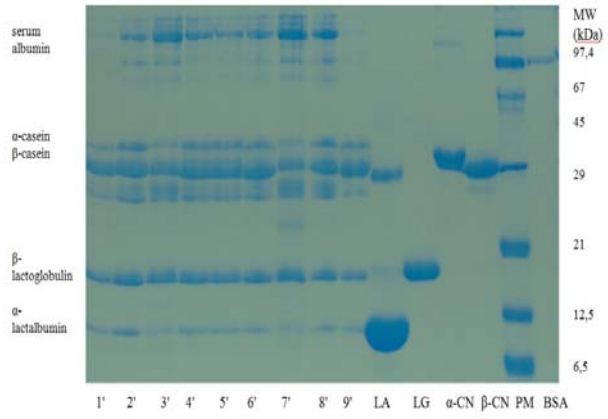

Figure 5 SDS-PAGE of colostrum proteins (24 h): 1', 2' and 3'- individual samples of BWD breed; 4', 5' and 7' - individual samples of the TG breed; 7', 8' and 9' – individual samples of the AN breed; LA: lactalbumin; LG: lactoglobulin; α-CN: α-casein; β-CN: β-casein; PM: protein marker (Protein Test Mixture 6-Serva) and BSA: bovine serum albumin

Significant differences were observed compared to the first-hour samples. The number of bands decreased to 8-10 and all samples lacked the protein with Mw around 130 kDa. The intensity of the fraction with Mw goes from 56.5 to 59.2 kDa (IgG heavy chain). In the samples of the TG breed, this fraction is absent. The band corresponding to IgG light chain (Mw 22.5-23.0 kDa) was detected in all samples but with a weaker intensity than at the zero hour.

In general, only the main casein proteins, β-lactoglobulin, α-lactalbumin, and also lactoferrin remain unchanged in the 24-hour lyophilized colostrum.

According to Chen *et al.* (1998), the amount of immunoglobulins in the colostrum decreases dramatically at 24 h postpartum, which was also confirmed by our studies. The authors also reported a significant decrease in total protein. A comparison of the protein profile between the colostrum of the three breed groups showed no significant differences. A difference was observed between the protein profiles of colostrum taken at 1 h and 24 h. From a practical point of view, only colostrum collected in the first hours after kidding was of special interest, because after some time the level of proteins, and in particular immunoglobulins, rapidly decreases in it.

The results obtained in the analysis of total IgG content in the reconstituted colostrum samples by ELISA method are presented graphically in Figure 6.

In small ruminants, the placenta prevents the transfer of immunoglobulins from mother to fetus during pregnancy (Moreno-Indias *et al.* 2022). Immunoglobulins in the colostrum of different breeds of sheep and goats are known to vary widely (Kessler *et al.* 2019). In our study, we observed very wide variations in the amount of immunoglobulins, both interbreeding and depending on the time of sample collection. Anglo-Nubian goats showed the highest average IgG concentrations both at 1 h (105.15±14.29 mg/mL) and at 24 h (63.89±11.16 mg/mL) of sample collection. In this breed, the decrease in the amount of IgG was 41.26 mg/mL during the first 24 h postpartum.

The colostrum of Bulgarian White Dairy goats showed the presence of IgG from 94.42 ± 12.04 mg/mL at 1 h to 59.77 ± 6.15 mg/mL at 24 h. The decrease for the 24 hours was 34.65 mg/mL. The colostrum of the Toggenburg breed had the lowest IgG content at 1 h (74.21±19.63 g/L) and 24 h (59.80±24.11 g/L), respectively. For the studied breed, the decrease was 14.41 g/L for 24 h. According to Kessler *et al.* (2019), the colostrum of sheep and goats from dairy breeds contains a lower amount of IgG compared to meat breeds such as the Boer breed for example. The Anglo-Nubian goat breed is a milk and meat breed (combined type), and this could explain the significantly higher amount of immunoglobulins in their colostrum. Differences between breeds probably reflect the genetic characteristics and physiological needs of newborn animals in analyzing the effect of various factors on goat IgG concentration in China, Xiaoqing *et al.* (2021) found a reliable decrease in IgG with a difference between day one and day two of 20 mg/mL. Similar to the results of our study, Sharma *et al.* (2023) and Segura *et al.* (2024) reported a decrease in immunoglobulins in the colostrum of goats in the first 24 h after parturition, and the decrease found varied according to the breed and genetic characteristics of the animals. According to Sharma *et al.* (2023) the concentration of IgG in goat colostrum significantly decreased with time, with the same authors emphasizing that breeds with a combined dairy and meat purpose, such as the Anglo-Nubian breed, showed higher levels of IgG in colostrum compared to breeds specialized for milk.

From a practical point of view, our results emphasize the importance of obtaining colostrum in the first hours after birth. This is essential for the health and survival of newborn kids.

Table 5 Rf values and molecular masses of protein fractions after electrophoresis of goat colostrum samples (24 h postpartum)

BWD breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 1'	0.039	112834	Sample 4'	0.036	114338	Sample 9'	0.036	114591
	0.079	94746		0.085	91927		0.085	91927
	0.375	30158		0.152	69155		0.151	69584
	0.437	25003		0.378	29828		0.192	58682
	0.5	21185		0.448	24254		0.371	30590
	0.728	18324		0.518	20277		0.442	24692
	0.866	14569		0.737	18242		0.495	21471
	-	-		0.873	14361		0.732	18290
	-	-		0.917	12002		0.864	14698
TG breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 12'	0.035	114755	Sample 13'	0.024	120494	Sample 15'	0.032	116269
	0.08	93970		0.07	98319		0.051	107113
	0.377	29980		0.373	30356		0.08	94330
	0.458	23589		0.449	24194		0.15	69879
	0.516	20391		0.508	20792		0.378	29879
	0.735	18255		0.728	18326		0.459	23514
	0.871	14432		0.863	14708		0.517	20331
	-	-		-	-		0.739	18216
	-	-		-	-		0.873	14361
AN breed								
Lane	Rf	MW	Lane	Rf	MW	Lane	Rf	MW
Sample 23'	0.032	116435	Sample 26'	0.031	117208	Sample 29'	0.027	118962
	0.049	108057		0.049	107821		0.065	100418
	0.082	93440		0.081	93842		0.37	30682
	0.109	82919		0.147	70602		0.447	24309
	0.148	70456		0.194	58257		0.5	21172
	0.189	59427		0.371	30570		0.722	18383
	0.363	31309		0.44	24798		0.861	14930
	0.431	25429		0.485	21994		-	-
	0.485	21967		0.727	18339		-	-
	0.578	20838		0.861	14930		-	-
	0.729	18319		-	-		-	-
	0.861	14930		-	-		-	-

BWD: Bulgarian White Dairy; TG: Toggenburg and AN: Anglo-Nubian.
Lane: lane number; Rf values: relative mobility and MW: molecular weight.

The findings of the present study are in line with the claims of Kessler *et al.* (2019) for the presence of IgG in goat colostrum, where the Anglo-Nubian breed had the highest amount, followed by Saanen and Toggenburg, which had the least. The values commented on by the authors are significantly lower than what we found.

Agradi *et al.* (2023) investigated the quality of colostrum obtained within the first 6 h postpartum of several goat breeds reared in Northern Italy. According to them, the presence of a different amount of IgG in colostrum can distinguish autochthonous goat breeds from cosmopolitan ones.

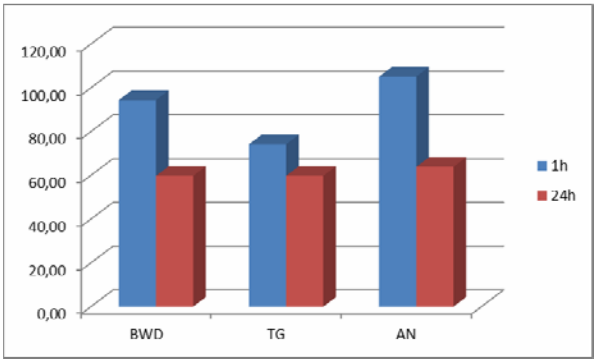

Figure 6 Concentration of IgG in the colostrum of goats of the breeds BWD, TG and AN obtained at 1 h and 24 h postpartum (mg/mL)

Although the values for the amount of IgG in the scientific literature vary widely, our findings are closest to the results of Agradi *et al.* (2023). These values are in the upper limits of those reported by most researchers. Moreno-Indias *et al.* (2012) reported the highest concentration of IgG in colostrum immediately postpartum and a rapid decline thereafter. If the quality of the colostrum is not good enough, the newborn kid will not be able to receive enough immunoglobulins and provide passive immunity to protect it from morbidity and mortality (Gilbert *et al.* 1988; O'Brien and Sherman, 1993). It is recommended that the minimum amount of colostrum that a kid should ingest in the first 24 hours of its postnatal life should be at least 10% of its birth weight Kumar *et al.* (2016). Administration of 4g IgG per kg live weight during the first 24 h postpartum provides adequate passive immunity in 80% of kids (Castro *et al.* 2007; Kessler *et al.* 2019).

We should mention that this study, despite its significant results, has several major limitations. The sample size, which only included certain breeds of goats, limits the generalizability of the results to all breeds. Expanding the sample to include a larger number of breeds in different geographic settings would allow a better understanding of the diversity in the protein composition of lyophilized colostrum. It is possible that the methodology associated with lyophilization resulted in minor changes in colostrum composition that were not accounted for in detail in the present study. Despite the limitations, our study offers a significant contribution to the scientific literature. The systematic approach in comparing lyophilized colostrum from different goat breeds provides new data on protein composition that may be useful in future studies on the application of colostrum in animal husbandry and the food industry.

The research methodology, including high-quality laboratory equipment and accurate measurement of proteins, provides a high degree of accuracy and reliability of the results. This is particularly important for the creation of comparative data that can be used to improve production processes and the standardization of colostrum from different breeds. Last but not least, the use of lyophilization to preserve colostrum ensures the stability of samples over a long period, which is essential for research on its composition under different storage conditions.

CONCLUSION

In the present study, the protein profile of lyophilized colostrum from different goat breeds was analyzed in order to provide a new perspective on the quality and potential utility of this valuable product. The results showed significant variation in the concentration of key proteins depending on the breed, confirming the importance of genetic factors for colostrum composition. The electrophoretic protein profile of colostrum is specific and differs greatly from that of goat's milk. A significant presence of high molecular weight fractions and less of casein proteins was observed. SDS-PAGE can be used as a fast and reliable method to identify and prove the authenticity of products and nutritional supplements containing lyophilized colostrum. Our research shows that lyophilized colostrum is a stable and reliable source of valuable proteins that can be used in various fields such as animal husbandry, healthcare and the food industry. To increase the understanding of the influence of different factors on colostrum composition, further research is needed that includes more breeds and looks at other important colostrum components. Based on the results of this study, we can conclude that lyophilized colostrum represents a valuable resource that can be improved and adapted for different applications, while further studies are required to optimize the storage and production processes.

ACKNOWLEDGEMENT

We express our gratitude to the Research Institute of Mountain Stockbreeding and Agriculture in Troyan, Bulgaria for their support.

REFERENCES

Agradi S., Gonzalez-Cabrera M., Arguello A., Hernandez-Castellano L.E., Castro N., Menchetti L., Brecchia G., Vigo D., Tuccia E. and Curone G. (2023). Colostrum quality in different goat breeds reared in Northern Italy. *Animals*. **13,** 3146-3155.

Altintas R. and Kankavi O. (2020). Research on the colostrum interferon-gamma and immunoglobulin G content of honamli and hair goat breeds. *Fres. Env. Bul.* **29(7),** 6213-6218.

Arguello A., Castro N. and Capote J. (2004). Growth of milk replacer kids fed under three different managements. *J. Appl. Anini.* Res. **25,** 37-40.

Arguello A., Castro N., Alvarez S. and Capote J. (2006). Effects of the number of lactations and litter size on chemical compo-

sition and physical characteristics of goat colostrum. *Small Rumin. Res*. **64,** 53-59.

Baintner K. (2007). Transmission of antibodies from mother to young: evolutionary strategies in a proteolytic environment. *Vet. Immunol. Immunopathol*. **117,** 153-161.

Buranakarl C., Thammacharoen S., Semsirmboon S., Sutayatram S., Nuntapaitoon M., Dissayabutra T. and Katoh K. (2021). Effects of litter size and parity number on mammary secretions including, insulin-like growth factor-1, immunoglobulin G and vitamin A of Black Bengal, Saanen and their crossbred goats in Thailand. *Vet. Sci.* **8(6),** 95-107.

Castro N., Capote J., Quesada E., Briggs H. and Argüello A. (2007). Short Communication: Addition of milk replacer to colostrum whey: Effect on immunoglobulin G passive transfer in Majorera Kids. *J. Dairy Sci.* **90(5),** 2347-2349.

Chen J.C., Chang C.J., Peha H.C. and Chen S.Y. (1998). Total protein and γ-globulin contents of mammary secretion during the early post-partum period of Nubian goats in the Taiwan area. *Small Rumin. Res*. **31,** 67-73.

Chen D., Li X., Zhao X., Qin Y., Wang J. and Wang C. (2019). Comparative proteomics of goat milk during heated processing. *Food Chem*. **275,** 504-514.

Constant S.B., Leblanc M.M., Klapstein E.F., Beebe D.E., Leneau H.M. and Nunier C.J. (1994). Serum immunoglobulin G concentration in goats kids fed colostrum or a colostrum substitute. *J. Am. Vet. Med. Assoc.* **205,** 1759-1762.

Da Costa W.K.A., Souza E.L., Beltrão-Filho E.M., Vasconcelos G.K.V., Santi-Gadelha T., de Almeida Gadelha C.A., Franco O.L., Queiroga R.C.R.E. and Magnani M. (2014). Comparative protein composition analysis of goat milk produced by the Alpine and Saanen breeds in Northeastern Brazil and related antibacterial activities. *PLoS One.* **9(3),** e93361.

Gilbert R.P., Gaskins C.T., Hillers J.K., Parker C.F. and McGuire T.C. (1988). Genetic and environmental factors affecting immunoglobulin G1 concentrations in ewe colostrum and lamb serum. *J. Anim. Sci.* **66,** 855-863.

Goyena M., Ortiz J.M. and Alonso F.D. (1997). Influence of different systems of feeding in the appearance of cryptosporidiosis in goat kids. *J. Parasitol.* **83(6),** 1182-1185.

Halliday R. and Williams M.R. (1979). The absorption of immunoglobulin from colostrum by bottle-fed lambs. *Ann. Rech. Vet.* **10,** 549-556.

Hurley W.L. and Theil P.K. (2011). Perspectives on immunoglobulins in colostrum and milk. *Nutrients.* **3,** 442-474.

Hyrslova I., Krausova G., Bartova J., Kolesar L. and Curda L. (2016). Goat and bovine colostrum as a basis for new probiotic functional foods and dietary supplements. *J. Microb. Biochem .Technol*. **8,** 56-59.

Kessler E.C., Bruckmaier R.M. and Gross, J.J. (2019). Immunoglobulin G content and colostrum composition of different goat and sheep breeds in Switzerland and Germany. *J. Dairy Sci.* **102,** 5542-5547.

Korhonen H. (2009). Bioactive components in bovine milk. Pp. 15-42 in Bioactive Components in Milk and Dairy Products Y.W. Park, Ed., Wiley-Blackwell, Iowa, USA.

Koushki R., Mansoori Yarahmadi H., Khaldari M., Fakhraei J. and Karkoodi K. (2019). Milk yield and blood metabolite profile in late pregnancy in Lori ewes receiving diets containing undegradable protein sources. *Iranian J. Appl. Anim. Sci.* **9(4),** 643-650.

Kumar M., Dutta T.K. and Chaturvedi I. (2016). Nutritional importance of colostrum in different farm animals- A Critical Review. *J. Sci*. **2(1),** 16-29.

Laemmli U. (1970). Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature.* **227,** 680-685.

Linzell J.L. (1959). Physiology of the mammary glands. *Physiol. Rev.* **39,** 534-576.

Linzell J.L. and Peaker M. (1971a). Mechanism of milk secretion. *Physiol. Rev*. **51,** 564-597.

Linzell J.L. and Peaker M. (1971b). Intracellular concentrations of sodium, potassium, and chloride in the lactating mammary gland and their relation to the secretory mechanism. *J. Physiol*. **216,** 683-700.

Lych I., Veriovka S. and Zayarnyuk A. (2017). Determination of molecular weights of biologically active fragments of colostrum by electrophoresis method. *Ukr. J. Food Sci*. **5(2),** 197-206.

Menatian S., Mirzaei Alamouti H.R., Fatahnia F. and Masoumi R. (2016). Effects of pre-pubertal plane of nutrition on skeletal growth, lamb mortality, IGF-1 concentrations, quantity and quality of colostrum production in Kurdish female lambs. *Iranian J. Appl. Anim. Sci.* **6(4),** 841-847.

Moreno-Indias I., Sanchez-Macias D., Castro N., Morales-de la Nuez A., Hernandez-Castellano L.E, Capote J. and Arguello A. (2012). Chemical composition and immune status of dairy goat colostrum fractions during the first 10 h after partum. *Small Rumin. Res.* **103,** 220-224.

Moreno-Indias I., Morales-dela-Nuez A., Sánchez-Macías D., Hernández-Castellano A., Argüello A. and Castro N. (2022). Immunoglobulin concentration in goat colostrum and its influence on neonatal immunity. *Small Rumin. Res*. **212,** 103549-103555.

Moretti D.B., Wiolene M.N., Anali L.L., Pauletti P. and Machado-Neto R. (2013). Enterocyte IgG uptake in the small intestine of goat kids during the period of passive immunity acquisition. *Small Rumin. Res*. **114,** 182-187.

Nordi W.M., Moretti D.B., Lima A.L., Pauletti P., Susin I. and Machado-Neto R. (2012). Intestinal IgG uptake by small intestine of goat kid fed goat or lyophilized bovine colostrums. *Livest. Sci.* **144,** 205-210.

O'Brien J.P. and Sherman D.M. (1993). Serum immunoglobulin concentrations of newborn goat kids and subsequent kid survival through weaning. *Small Rumin. Res*. **11,** 71-77.

Ounis W.B. (2010). Evaluation du potentiel des interactions proteine polysaccharide pour l'extraction du TGF-P2 a partire de substrats laitiers. MS Thesis. Université Laval, Québec, Canada.

Rachman A.B., Maheswari R.A. and Bachroem M.S. (2015). Composition and isolation of lactoferrin from colostrum and milk of various goat breeds. *Proc. Sci.* **3,** 200-210.

Rahmatalla S.A., Arends D. and Brockmann G.A. (2022). Review: Genetic and protein variants of milk caseins in goats. *Front. Genet.* **13,** 995349-995355.

Salem S.A., EL-Agamy I., Salama F.A. and Abo-Soliman N. (2009). Isolation, molecular and biochemical characterization

of goat milk casein and its fractions. *Trop. Subtrop. Agroecosyst*. **11,** 29-35.

Segura M.M., Martínez-Miró S., López M.J., Madrid J., González V. and Hernández F. (2024). The Effect of the season on the time dependent changes in colostrum Lactoferrin level in Murciano–Granadina Goats in intensive system farming. *Animals*. **14,** 2580-2587.

Selvaggi M., Laudadio V., Dario C. and Tufarelli V. (2014). Major proteins in goat milk: an updated overview on genetic variability. *Mol. Boil. Rep*. **41(2),** 1035-1048.

Sharma A., Sharma R., Kumar R., Giri R., Kumar A., Jha R., Verma A., Shukla R., Soni S. and Choudhary R. (2023). Effects of breed and time post-partum on immunoglobulin concentrations in goat colostrum. *J. Dairy Sci.* **106(5),** 3340-3348.

Xiaoqing S., Cheng M., Zhang X., Wang C. and Jiang H. (2021). Analysis on the effect of the various factors on immunoglobulin G in goat colostrum. *E3S Web Conf*. **233,** 2042-2050

Zazharska N.M. and Samoylenko Y.V. (2016). Chemical and immunological parameters of goat colostrum and milk depending on lactation period. *Visnyk Dnipropetrovskoho Derzhavnoho Ahrarno-Ekonom. Univ.* **2(40),** 70-75.

Zunev P., Myhailova G. and Iliev T. (2004). Changes in some physicochemical indicators of colostrum and milk of goats raised in the Central Balkan Mountain. *Bulgarian J. Anim. Hus.* **21(1),** 26-30.