Acta fytotechn zootechn, 28, 2025(2): 106–114
http://www.acta.fapz.uniag.sk

Original Paper

Changes in the Physicochemical and Microbiological Quality of Crossbred Goats Colostrum During four Days Postpartum

Loubna Djouza*[1, 2], Alla Eddine Mahamedi[3, 4]

[1]*University of Ghardaia, Faculty of Natural Sciences, Life and Earth Sciences, Department of Agronomic Sciences, Ghardaïa, Algeria*
[2]*Université Kasdi Merbah Ouargla, Faculté des Sciences de la Nature et de la Vie, Laboratoire de Bio Ressources Sahariennes: Préservation et Valorisation, Ouargla, Algeria*
[3]*University of Ghardaia, Faculty of Natural Sciences, Life and Earth Sciences, Department of biology, Ghardaïa, Algeria*
[4]*Ecole Normale Supérieure de Kouba Cheikh Mohamed Elbachir Elibrahimi, Laboratoire de Biologie des Systèmes Microbiens (LBSM), Alger, Algeria*

Article Details: Received: 2024-09-26 | Accepted: 2025-04-15 | Available online: 2025-06-30

https://doi.org/10.15414/afz.2025.28.02.106-114

The colostrum consumed by newborn ruminants immediately after birth plays a crucial role in ensuring their long and healthy lives. It is their first nutrition, supporting growth, development, and immunity against diseases. The study envolved eight goats crossbreeds of Saanen × Makatia and Saanen × Alpine goats, raised in the Ghardaia region, known for its arid climate. Colostrum samples were collected during four days after kidding. Each sample was subjected to the evaluation of the microbiological quality and the key physicochemical properties, including fat and protein content, pH, titratable acidity, density, conductivity, appearance and colour. The results showed a decrease in fat and protein content from day one to day four in both goat populations, although the differences in the four-day averages were not significant. Acidity and density also followed a decreasing trend, with the difference in four-day averages being significant in the Saanen × Makatia group. In terms of pH, variation over the four days was not significant. Conductivity values increased consistently in both populations. Microbiological analysis revealed the absence of sulphite-reducing *Clostridium*, *Salmonella* and yeasts in all samples. The counts of *Staphylococcus aureus*, total aerobic mesophilic flora, and total and faecal coliforms remained within acceptable limits for raw milk, indicating that the colostrum was of satisfactory microbiological quality.

Keywords: colostrum, Alpine goat, Makatia goat, microbiological quality, physicochemical analysis, Saanen goat

1 Introduction

Milk is a natural and essential source of nutrition for mammals, serving as a vital source of protein and providing most of the elements required by both animal and human bodies. It is rich in minerals, particularly calcium and phosphorus, as well as vitamins such as B2 and B12. Through the consumption of milk, many benefits have been found. Its protein content supports bone strength, tissue growth, and brain development. Additionally, the présence of vitamins A and D contributes to maintaining normal vision and enhansing calcium absorption (Zulkifli et al., 2023). Goat milk is typically produced in small, tradionnal farms, where the fresh milk is collected from healthy, well-fed goats raised in hygienic conditions. This ensures that the milk is free of unwanted flavours and odours. Several factors can affect goat milk composition. According to Park et al. (2007), these include environmental conditions, geographical location, diet, individual variation, breed, udder health, parity, season, management, and lactation phase. Some of these factors can affect taste of milk as well.

Colostrum, the newborn's first food, is produced in the periods immediately before and after parturition. It serves as a vital source of passive immunity due to its high immunoglobulin content; these do not enter the embryo's bloodstream in cattle, small ruminants, and horses (Hernández-Castellano et al., 2015). Colostrum also improves the metabolism of young mammals,

***Corresponding Author:** Loubna Djouza, University of Ghardaia, Scientific area, PB 455, 47000, Ghardaia, Algeria
loubna_djouza@yahoo.fr https://orcid.org/0000-0002-2570-5416

stimulates the digestive system, and reduces the risk of infection (Nowak et al., 2012). For goat kids, the neonatal stage is critical and marked by a high death rate. The only effective way to boost a newborn's immune system and increase survival chances is by providing them high-quality colostrum as early as possible (Lotito et al., 2023). However, the microbiological quality and composition of colostrum are a critical factors influencing the health and disease resistance of the offspring. Bacterial contamination can reduce the intestinal absorption of immunoglobulin G (IgG), increasing the risk of pathogen transmission (Lorenz et al., 2011). Microbial contamination from various sources can lead to acute or chronic illnesses in newborn (Godden et al., 2012). Despite the significant nutritional value of goat milk in Algeria and its widespread consumption, goats are often considered a secondary species associated with sheep and have largely neglected in research and agricultural development (Ouchene-Khelifi et al., 2021). Moreover, studies on the physicochimical and bacteriological quality of goat colostrum in Algeria remain very limited. In this context, the aim of the present work is to asses the day-to-day changes in the physicochemical and microbiological composition of colostrum over a four-day period following parturition in two crossbred goat populations raised in Ghardaia region.

2 Material and Methods

2.1 Animal Material and Sampling

During this study, a total of 32 colostrum samples were collected from eight clinically healthy crossbred goats, consisting of Saanen × Makatia (n = 4) and Saanen × Alpine (n = 4) raised in Ghardaia region (southern Algeria). The animals were approximately 3.5 years old. The animals were fed with 35–40% per day concentrate and 60–65% fodder with mineral and vitamin supplements, without access to grazing. Colostrum samples were aseptically collected by hand milking for each goat once daily during 4 days after parturition. The samples were stored in an icebox and transferred to the laboratory for subsequent analyses.

2.2 Physicochemical Analysis

The collected raw colostrum samples were analysed for physico-chemical characteristics, including pH, density, conductivity, titratable acidity, colour, appearance, fat content, and protein content.

Colostrum appearance and colour were assessed visually. The pH was measured using a pH meter (ADWA AD1030) at a temperature of 20 °C. Titratable acidity, which measures the amount of lactic acid in the sample, was determined by titrating by sodium hydroxide (0.11 N) in the presence of phenolphthalein as an indicator. Acidity is expressed in grams of lactic acid per liter of colostrum. Density was measured by pycnometer (IsoLab, Germany), at a sample temperature of 20 °C, and reported in $g \cdot L^{-1}$. Electrical conductivity was measured using a conductivity meter (ADWA AD330, EC/TDS/Meter), and results were expressed in millisiemens per centimeter ($mS \cdot cm^{-1}$). Protein content were determined using a milk analyzer (Lactostar Funke Gerber 3510). Colostrum fat content was determined by Gerber acid-butyrometric method.

2.3 Microbiological Analysis

2.3.1 Decimal Dilutions

Physiological water is a saline solution containing 9 g of $NaCl \cdot l^{-1}$ of distilled water. For the preparation of decimal dilutions, 1 ml of the colostrum is added to 9 ml of sterile physiological water. Before transferring the inoculum from one tube to the next, the solution must be thoroughly homogenized (Joffin and Leyral, 2006). This process is repeated by the successively transferring 1 ml from the previous dilution into 9 ml of fesh sterile physiological water, continuing until the desired series of dilutions is obtained. All dilutions are prepared in duplicate.

2.3.2 Search and Enumeration of Bacterial Groups

2.3.2.1 Staphylococcus aureus

Enumeration of *Staphylococcus aureus* (positive coagulase) was carried out on Baird Parker agar (Liofilchem, Italy) following the method described by Guiraud (1998). A volume of 0.1 ml from both the raw colostrum and 10^{-1} dilution was spread onto the agar surface. Typical black colonies with a clear halo around the colony are counted after 24 to 48 h of incubation at 37 ° C. Confirmation of typical colonies of *Staphylococcus aureus* was carried out by microscopic characterization, Gram staining, catalase, and DNase production tests.

2.3.2.2 Escherichia coli

Detection of *E. coli* is performed using Chromocult Chromogenic Agar (Merck, Germany), with incubation at 37 °C for 48 h.

2.3.2.3 Salmonella

For the detection of *Salmonella*, a multi-step procedure was followed as described by Guiraud (1998). Samples were first subjected to pre-enrichment in the buffered peptone water (Liofilchem, Italy), followed by selective enrichment in Rappaport broth (Biokar, France). Isolation was then carried out on Hektoen agar (Tm Media, India), with incubation at 37 °C for 24 hours.

2.3.2.4 Total Mesophilic Aerobic Flora (FAMT)

Enumeration of total aerobic mesophilic flora was performed on Plate Count Agar medium (PCA; Liofilchem, Italy) using dilutions from 10^{-1} to 10^{-3}. For each dilution, 1 ml was introduced into a sterile Petri dish, followed by the addition of approximately 20 ml of PCA cooled to 45 ±1 °C. Plates were then incubated at 30 °C for 72 hours, with colony counts recorded every 24 hours (Guiraud, 1998).

2.3.2.5 Total and Faecal Coliforms

Coliforms were enumerated using Violet Red Bile Lactose (VRBL) medium (Merck, Germany) following the Most Probable Number (MPN) method. Incubation was carried out at 30 °C for total coliforms and at 44 °C for faecal coliforms, both for 24 hours.

2.3.2.6 Faecal Streptococci

A volume of 1 ml from decimal dilutions was inoculated into Rothe broth (Liofilchem, Italy) and incubated at 37 °C for 24 to 48 h, using the most probable number (MPN) method. Positve tubes were confirmed using Eva Litsky medium (Liofilchem, Italy), with incubation at 37 °C for 24 hours. Mac Grady MPN table was used for counting.

2.3.2.7 Sulphite-reducing Clostridia

In order to isolate sporulated forms, tubes containing 10^{-1} to 10^{-2} dilutions were first heated to 80 °C for 10 minutes and then rapidly cooled to eliminate bacterial vegetative forms. A volume of 1 ml from each treated dilution was aseptically transferred into sterile screw tubes (16 mm in diameter). Approximately 15 ml of Liver Meat agar (Institut Pasteur, Algeria), previously melted, cooled to 45 ±1 °C, and supplemented with iron alum and sodium sulphite, was then added to each tube. Incubation was carried out at 46 °C for 16 to 48 hours (Marshall et al., 1965).

2.3.2.8 Yeasts and Moulds

Yeasts and moulds enumeration was carried out on Yeast Glucose Chloramphenicol agar (Liofilchem, Italy) and incubated at 25–30 °C during 5 days (Guiraud, 1998).

2.4 Statistical Analysis

Statistical analyses were carried out using analysis of variance (one-way ANOVA) followed by post-hoc comparisons with Honestly Significant Difference (HSD) Tukey's. All statistical analyses were performed using R version 4.0.3 (R Core Team, 2020).

3 Results and Discussion

This study reports, for the first time, the physicochemical and microbiological composition of colostrum from Saanen × Makatia and Saanen × Alpine goats, crossbred goats raised in southern Algeria, particularly in the Ghardaia region.

3.1 Physicochemical Analysis

Colostrum physicochemical parameters from Saanen × Makatia and Saanen × Alpine goats are presented in Table 1, showing the day-to-day changes. Physicochemical characteristics during the first four days postpartum showed that all samples were liquid and of milk-white colour. Progressive changes (decrease) in lipid and protein components in the colostrum of the two populations were found. Acidity and density also followed a decreasing curve; the difference between the 4-day averages was significant in the Saanen × Makatia population. For pH, no significant difference was found between the daily

Table 1 Physicochemical characteristics of colostrum from the two populations during the first four days postpartum

Populations	Days post_ partum	Parameter					
		pH at 20 °C	acidity (lactic acid) ($g \cdot L^{-1}$)	density at 20 °C ($g \cdot L^{-1}$)	conductivity	protein (%)	fat (%)
Saanen × Makatia	1	6.49^{a} ±0.12	2.97^{a} ±0.68	1.038^{a} ±0.01	4.19^{a} ±0.56	6.00^{a} ±2.02	10.40^{a} ±4.68
	2	6.62^{a} ±0.13	2.27^{ab} ±0.56	1.030^{a} ±0.008	4.96^{a} ±0.70	4.68^{a} ±0.63	8.63^{a} ±4.65
	3	6.59^{a} ±0.08	1.81^{b} ±0.12	1.030^{a} ±0.006	5.12^{a} ±0.11	4.79^{a} ±0.65	6.83^{a} ±3.52
	4	6.61^{a} ±0.12	1.85^{ab} ±0.15	1.027^{a} ±0.01	5.31^{a} ±0.21	4.62^{a} ±0.24	5.11^{a} ±2.27
Saanen × Alpine	1	6.39^{a} ±0.09	2.8^{a} ±0.61	1.035^{a} ±0.003	5.38^{a} ±0.78	5.46^{a} ±0.74	8.11^{a} ±1.53
	2	6.61^{a} ±0.12	2.08^{a} ±0.68	1.031^{a} ±0.005	6.40^{a} ±0.43	4.24^{a} ±0.30	6.31^{a} ±1.61
	3	6.45^{a} ±0.18	2.16^{a} ±0.74	1.032^{a} ±0.002	6.11^{a} ±0.65	4.76^{a} ±1.003	7.14^{a} ±3.96
	4	6.64^{a} ±0.10	1.63^{a} ±0.51	1.028^{a} ±0.005	6.63^{a} ±0.32	4.17^{a}	6.43^{a} ±2.15

a, b – values in the same column with different superscripts are statistically different (P <0.05)

averages. Increasing conductivity values were observed for both populations.

For both populations, all samples were liquid in appearance and milk-white in colour, except on the first day when the colour was pale yellow. El Hatmi et al. (2023) confirmed the relationship between the colour characteristics, particularly redness (a*) and yellowness (b*), and the content of camel colostrum. The colostrum colour is considered an indicator of its quality. In terms of its overall composition, a colostrum value that is lower is linked to a paler colour. As reported by Jrad et al. (2014), camel colostrum, particularly in the first hours following parturition, has a higher lactoferrin content than mature milk, which may be responsible for the colostrum's increased redness. In bovine species, particularly, colostrum's reddish-yellow colour is largely caused by the presence of carotenoids; in contrast, goat and ewe colostrum only contains retinol, and xanthophyll and lacks β-carotene (Madsen et al., 2004). β-carotene from plants is converted by goats and ewes into colourless vitamin A (Chudy et al., 2020). Thus, the yellow colour of ewe colostrum is likely due to its high fat content (Madsen et al., 2004; Misawa et al., 2016). According to Todaro et al. (2023), the colour of colostrum can also be influenced by the season of parturition. They found significant differences for redness in the winter season of lambing with a higher value, and it can be explained by the existence of blood traces due to greater udder rubbing of grazing pregnant ewes. In this case, potential mammary gland damage may increase the blood presence in colostrum, which significantly affected its colour and resulted in a red colour (Madsen et al., 2004).

Fat and protein levels decreased from the first to the fourth day, confirming the study conducted by Elmaz et al. (2022) and Sánchez-Macías et al. (2014) during the first three days and by Koşum et al. (2018) within the 48 hours after parturition. The colostrum of the S × M population from the first four days has high fat levels compared to that of the Honamli goat colostrum reported by Elmaz et al. (2022), while protein levels are lower in our study. Djouza (2019) found a fat content of 3.48 ±0.21% for milk from local Arbia goats, supporting the higher fat content in colostrum compared to regular milk.

The S × M population's colostrum was richer in both fat and protein than that of the A × S population. This may be associated with the various ways that the animals are managed nutritionally (Agradi et al., 2023). The differences in the fat content of the colostrum could be attributed to breed characteristics. For heat production and the prevention of hypothermia, the fat in the colostrum is required by the newborn (Keskin et al., 2007). Compared to cow milk, the proteins in goat milk are easier to digest, and their components, or amino acids, are absorbed more quickly (Gills et al., 1990). Colostrum contains a high level of antibodies, which are proteins; this may explain the higher protein levels found in colostrum than in milk. As indicated by Hadjipanayiotou and Koumas (1991), the higher protein content can be the consequence of the feeding concentrate's higher protein level.

Similar changes (decrease from 2.97 ±0.68 to 1.85 ±0.15 $g \cdot L^{-1}$ in S × M goats for example) were observed for titratable acidity, which is in agreement with the results of Romero et al. (2013). For goat milk, Santos et al. (2019) observed a variation of 15.0 to 20.3 °D, with an average of 17.13 °D. Titratable acidity indicates the presence of phosphates, citrates, proteins, and gases in the milk (Mondeshka et al., 2023). The primary acidity depends on several factors, such as the animal's health condition, feeding, and the lactation period. At the beginning of lactation, colostrum has a very high acid degree, then it enters the above limits, and by the end of the lactation period it falls below 15 °D (Dimov et al., 1975).

Regarding pH and density, no significant changes were observed, with values remaining around 6.5 and ±1.030, respectively. Sánchez-Macías et al. (2014) also found no significant variation in pH values was observed for the colostrum of Majorera-breed goats in the first four days of the study. Dimov et al. (1975) stated that the milk active acidity (pH) decreases more slowly than the titratable acidity, which is due to the buffering milk properties, which are determined by the content of protein substances and salts.

As for density, values decreased from 1.038 ±0.01 to 1.027 ±0.01 $g \cdot L^{-1}$ for colostrum from the Saanen × Makatia (S × M) population, and from 1.035 ±0.003 to 1.028 ±0.005 $g \cdot L^{-1}$ for colostrum from the Alpine × Saanen population. Romero et al. (2013) showed a decrease in density from 1.052 to 1.031. With regard to conductivity, the same authors showed an increase up to 36 hours, then stabilization at around 5 on the fourth day. Compared with our study, this parameter increased to 5.31 ±0.21 in S × M and 6.63 ±0.32 in S × A by day 4. Mondeshka et al. (2023) indicated that the density decreases in proportion to the decrease in the remaining colostrum components (such as protein, fat, total solids, etc.).

3.2 Microbiological Analysis

The microbiological characteristics of colostrum are summarized in Tables 2 and 3. In general, some colostrum samples of the two populations were found to be contaminated with *S. aureus* (values less than 2.5 $CFU \cdot ml^{-1}$) and *E. coli* (with values less than 4.7×10^2 $CFU \cdot ml^{-1}$). In the Saanen × Makatia (S × M) population, colostrum collected on the first day after parturition

showed a high load of FTAM, with an estimated value of $13.55 \times 10^3 \pm 19{,}021$ CFU·ml^{-1}. A significant difference in total coliform counts was observed between the two populations, with the Saanen × Alpine (S × A) population exhibiting higher counts compared to the S × M population.

No *Salmonella*, sulphite-reducing clostridia, or yeasts were detected in any of the colostrum samples from both goat populations throughout the study period. All colostrum samples from the S × A population over the four days, though the load did exceed 1.4×10^2 CFU·ml^{-1}. Molds were present in low concentrations, with a maximum load of 19.5 ±12.02 CFU·ml^{-1}. Additionally, the load of faecal coliforms reached $1.5 \times 10^3 \pm 2{,}121$ CFU·ml^{-1} in the goat colostrum of both populations.

Certain colostrum samples were found to be contaminated with *S. aureus*, but the load is very low compared with the standards of the JORA (2017), which considers a value of 10^2 CFU·ml^{-1} as acceptable for product quality. Thieulin (2005) suggests that this contamination likely arises from mammary infections, which are the primary source of milk contamination. The first milk sprays are highly contaminated, hence the need to eliminate them; human skin, especially when there are lesions; and the respiratory tract in the case of angina and contamination at the dairy. According to Saidane et al. (2023), the presence of this pathogenic germ in raw bovine milk constitutes a real risk to public health, causing food poisoning capable of producing, under certain conditions, thermostable enterotoxins that can withstand even the most severe pasteurization treatments.

When pathogenic bacteria associated with gastroenteritis, such as *E. coli*, are present in certain samples, it may indicate that the udder, milking equipment, or water were contaminated by bacteria (Fotou et al., 2011). Diseases like diarrhea can be caused by *E. coli*. As mentioned by Quigley et al. (1994), inadequate handling, a high bacterial load in the environment, and low animal resistance are some of the diarrhea reasons in newborns. Thus, the supply of colostrum contaminated with diarrhea-causing microorganisms, while it does reduce the capacity of the animal to absorb immunoglobulin G (James et al., 1981). Therefore, it becomes essential to assess the microbiological counts in colostrum and follow handling procedures to prevent contamination and bacterial growth (Santos et al., 2017).

For the S × M population, a high load of lactic flora was observed on the first day after parturition. These bacteria were part of the total mesophilic aerobic flora counted, and the FAMT load gradually decreased over time. The FAMT load did not exceed 3×10^6 CFU·ml^{-1} (raw milk standards in JORA (2017)) for all colostrum samples, which proves its satisfying quality. Faye and Loiseau (2002) have argued that when the load exceeds 10^6 germs·ml^{-1}, the milk becomes of poor quality and cannot be used.

The results revealed a significant difference in total coliform counts between the two populations, with samples from the S × A population showing higher levels compared to those from the S × M population. However, the obtained results were very low compared with those found by Saidane et al. (2023), 1.70×10^6 and 2.10 ×

Table 2 Colostrum microbiological analysis of (Saanen × Makatia) and (Saanen× Alpine) goat populations during the first four days postpartum

Pop	Days	*Sa*	*E. coli*	FAMT	Tot C	Fec C	SRC	Fec stp	*S*	Y	M
S × M	1	0^a	$2.5^a \pm 3.54$	$13.55 \times 10^{3a} \pm 19{,}021$	$11^a \pm 15.6$	$8.5^a \pm 12.02$	0	0^a	0	0	$1^a \pm 1.41$
	2	0^a	0^a	$4.25 \times 10^{3a} \pm 5{,}869$	$1^a \pm 1.41$	$0.5^a \pm 0.70$	0	$55^a \pm 77.8$	0	0	$1^a \pm 1.41$
	3	$0.5^a \pm 0.70$	$4^a \pm 5.66$	$2 \times 10^{2a} \pm 141$	$13.5^a \pm 19.1$	$10.5^a \pm 14.8$	0	0^a	0	0	0
	4	0^a	0^a	$1.1 \times 10^{3a} \pm 1{,}273$	$1.5^a \pm 2.12$	0^a	0	0^a	0	0	$5.5^a \pm 7.78$
S × A	1	$2.5^a \pm 3.54$	$4.7 \times 10^{2a} \pm 665$	$2.05 \times 10^{5a} \pm 134{,}350$	$6.5 \times 10^{2a} \pm 919$	$6.5 \times 10^{2a} \pm 919$	0	$1.4 \times 10^{2a} \pm 0.00$	0	0	$3^a \pm 2.83$
	2	$1.5^a \pm 2.12$	$1^a \pm 1.41$	$8.15 \times 10^{5a} \pm 968{,}736$	$19.45 \times 10^{2a} \pm 1{,}492$	$1.5 \times 10^{3a} \pm 2121$	0	$1.4 \times 10^{2a} \pm 0.00$	0	0	$19.5^a \pm 12.02$
	3	0^a	$19^a \pm 26.9$	$1.5 \times 10^{6a} \pm 0.00$	$12.53 \times 10^{2a} \pm 1{,}764$	$9 \times 10^{2a} \pm 1{,}273$	0	$72^a \pm 96.2$	0	0	$9.5^a \pm 12.02$
	4	0^a	$21^a \pm 29.7$	$8.35 \times 10^{5a} \pm 940{,}452$	$49.5^a \pm 67.2$	$22.5^a \pm 31.8$	0	$1.4 \times 10^{2a} \pm 0.00$	0	0	$7^a \pm 5.66$

Pop – population; S × M – Saanen × Makatia; S × A – Saanen × Alpine; *Sa* – *Staphylococcus aureus*; *E. coli* – *Escherichia coli*; FAMT – total mesophilic aerobic flora; Tot C – total coliforms; Fec C – faecal coliforms; SRC – sulphite-reducing clostridia; Fec stp – faecal streptococci; *S* – *Salmonella*; Y – yeasts; M – molds
values in the same column with same superscripts are not statistically different

10^6 CFU·ml^{-1} for raw bovine milk. For McGuirk and Collins (2004), the total coliform count (TCC) should be less than 10^4 total colony forming units·mL^{-1} (CFU·mL^{-1}) in bovin colostrum.

The presence of faecal coliforms in colostrum serves as an indicator of the possible presence of faecal contamination. It was higher in S × A population colostrum comparatively to the other population colostrum. Compared with JORA (2017) standards for raw milk estimated at 5×10^3 CFU·ml^{-1}, and Yabrir et al. (2013) for raw sheep's milk (1.5×10^4 CFU·ml^{-1}) and Saidan et al. (2023) for raw bovine milk (1.28×10^4 CFU·ml^{-1}) colostrum samples are of acceptable quality. According to Ounine et al. (2004), total and faecal coliform counts increase proportionally with total flora. However, Faye and Loiseau (2002) and Yabrir et al. (2013) have emphasized that the presence of coliform bacteria does not necessarily imply direct faecal contamination of the milk, but rather suggests poor sanitary and hygienic practices during milking, subsequent handling, and the absence of proper refrigeration.

In our study, *Salmonella* is absent in all the colostrum samples of the two goat populations. According to JORA (2017) standards for raw milk, colostrum samples are considered to be of satisfactory quality.

Sulphite-reducing clostridia were not detected in any of the colostrum samples from both goat populations throughout the study period, indicating that the colostrum meets the quality standards set by JORA (1998) for raw milk. Our findings align with those found by Saidane et al. (2023) on raw bovine milk, confirming that goat feed is not contaminated. Clostridia can exist in the endospore form and can lie dormant in the environment for years before germinating when the right conditions arise (Zagorec and Champomier-Verges, 2017), contaminating any type of food or equipment if hygiene and sterilization conditions are not respected.

All colostrum samples from the S × A population were contaminated with faecal streptococci over the four days, although according to the JORA (1998) raw milk standards, this species should be absent in 0.1 ml of product. In a study on the immunological and bacteriological quality of colostrum from dairy cows, Eichinger (2014) did not detect the presence of faecal streptococci, knowing that streptococci are among the main germs responsible for udder inflammation. According to Yabrir et al. (2013), the absence of faecal streptococci confirms the correct practice of milking colostrum under the strictest hygienic conditions.

The results revealed the absence of yeasts, and the presence of a low load of molds in the goat colostrum of both populations without exceeding the standards set by ISO and AFNOR. Our results are acceptable compared with those obtained by Yabrir et al. (2013) for raw sheep's milk, estimated at 2.4×10^5 CFU·ml^{-1} and 3.4×10^3 CFU·ml^{-1} for yeasts and molds respectively. Beldjilali et al. (2013) claimed that low humidity is cause of low levels of yeast and mould. For Benkrizi (2019), the presence of molds suggests that the goats were fed mold-contaminated feed during the winter season, as they were unable to go out to graze. According to Dieng (2001), the presence of fungal flora can be attributed to poor hygienic conditions during handling and especially air quality. In addition, the manipulation of the immunological status of animals by vaccination has been described, as the quality of colostrum tends to be influenced by vaccination against pathogens (Lotito et al., 2023).

Physico-chemical parameters are closely linked to the microbiota that constitutes the colostrum. Lactose is converted to lactic acid (acquired acidity) by the proliferation of lactic bacteria in colostrum, which lowers pH. It can be produced voluntarily depending on the milk conditions (Amiot, 1991), and although lactic acid bacteria cannot grow below 5 °C, they can increase the lactose content and produce lactic acid under favourable conditions (Prata, 1998). The decrease in pH associated with this process helps inhibit the growth of pathogenic microorganisms, thus contributing to the preservation of colostrum.

Table 3 Comparison between colostrum microbiological analysis of (Saanen × Makatia) and (Saanen × Alpine) goat populations

Pop	*Sa*	*E. coli*	FAMT	Tot col	Fec col	SRC	Fec strep	*S*	Y	M
S × M	0.125^{a} ±0.35	1.63^{a} ±3.11	47.75×10^{2b} ±9421	6.75^{b} ±11.09	4.88^{a} ±8.79	0	13.8^{b}±38.9	0	0	1.88^{b} ±3.8
S × A	1^{a} ±1.92	1.28×10^{2a} ±329	838.75×10^{3a} ±709 113	9.74×10^{2a} ±1,204	7.68×10^{2a} ±1,147	0	1.23×10^{2a} ±48.1	0	0	9.75^{a} ±9.45
p	0.22 ns	0.29 ns	0.005**	0.03*	0.08 ns	/	0	/	/	0.04*

Pop – population; S × M – Saanen × Makatia; S × A – Saanen × Alpine; *Sa* – *Staphylococcus aureus*; *E. coli* – *Escherichia coli*; FAMT – total mesophilic aerobic flora; Tot col – total coliforms; Fec col – faecal coliforms; SRC – sulphite-reducing clostridia; Fec strep – faecal streptococci; *S* – *Salmonella*; Y – yeasts; M – molds

a, b – values in the same column with different superscripts are statistically different. ns: non significant (P >0.05). *: P <0.05. **: P <0.01

Zimmerman et al. (2001) observed in their study on raw milk that bacteria are more prevalent at higher storage temperatures or longer storage times. The same study proved that milk protein was degraded preferentially over lactose or milk fat. As the milk storage temperature increased from 3.8 to 7.2 °C, protein degradation became more pronounced. Milk fat remained relatively stable, though some degradation products were observed, especially after 4 days of storage at 3.8 °C. Both the degradation of proteins and milk fat can produce small, volatile compounds that can negatively affect the flavor and odor of milk. This highlights the importance of proper storage conditions to maintain the quality of colostrum and milk.

4 Conclusion

As a conclusion, the findings of this study highlighted the variability in colostrum composition across the four post-partum days. Both fat and protein content a consistent decrease from the first to the last day. Furthermore, the differences observed between the two goat populations, Saanen × Makatia and Saanen × Alpine, can likely be attributed to genetic factors as well as natural adaptation to the environment. The higher quality of colostrum produced by Saanen × Makatia goats may be linked to their hardiness and rusticity, contributes to the growth and survival of the kids. Farm management practices were also identified as key factors influencing the microbiological quality of colostrum intended for new-borns feeding. Improving hygienic practices can help reduce the level of undesirable microorganisms in colostrum, ensuring better quality for newborns. The findings emphasize the importance of providing colostrum to newborns as soon as possible after birth to maximize its nutritional value and benefits. Furthermore, understanding the biological processes of colostrum production, especially in less-studied goat populations such as native breeds, is crucial for optimizing newborn health. For future studies, expanding the sample size would provide more robust data. Despite these limitations, our study represents a useful contribution to the field, serving as a foundation for further studies aimed to enhance, more accurately, such a valuable product.

References

Agradi, S. et al. (2023). Colostrum Quality in Different Goat Breeds Reared in Northern Italy. *Animals*, 13(19), 3146. https://doi.org/10.3390/ani13193146

Amiot, J. (1991). *Milk science and technology/Ciencia y tecnología de la leche* (in Spanish). Editorial Acribia, S.A. Zaragoza.

Beldjilali. A. F. et al. (2013). Evaluation of microbiological and sanitary quality of ewe's raw milk in Western of Algeria and detection of antibiotic residue by Delvotest. *Advances in Environmental Biology*, 7(6), 1027–1033

Chudy, S. et al. (2020). Colour of milk and milk products in CIE L* a* b* space. *Medycyna Weterynaryjna*, 76(2), 77–81.

Core Team R. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria.

Djouza, L. (2019). *Phenotypic characteristics of goat breeds raised in Saharan regions, case study of the Ouargla and Biskra regions/Caractéristiques phénotypiques des races caprines élevées en régions sahariennes, cas des régions d'Ouargla et Biskra* (in French). Thèse de doctorat. Faculté des sciences de la nature et de la vie, Université Kasdi Merbah-Ouargla.

Dieng, M. (2001). *Contribution to the study of the microbiological quality of industrial curdled milk sold on the Dakar market/Contribution à l'étude de la qualité microbiologique des laits caillés industriels commercialisés sur le marché Dakarois* (in French). Thèse de Médecine Vétérinaire.

Dimov, N. et al. (1975). *Dairying*. State publishing house for agricultural literature.

Eichinger, M. L. (2014). *Study of the quality (immunological and bacteriological) of colostrums from dairy cows in the Chamousset en Lyonnais community of communes as part of the valorization of bovine colostrum/Etude de la qualité (immunologique et bactériologique) de colostrums de vaches laitières de la communauté de communes Chamousset en Lyonnais dans le cadre d'une valorisation du colostrum bovin* (in French). Thèse de doctorat. Vetagro sup campus vétérinaire de Lyon. Université Claude-Bernard.

El-Hatmi, H. et al. (2007). Characterisation of whey proteins of camel (*Camelus dromedarius*) milk and colostrum. *Small Ruminant Research*, 70(2007), 267–271.

Elmaz, O. et al. (2022). Characteristics of the colostrum composition of Honamli goats. *Animal & Food Sciences Journal Iasi*, 157–160.

Faye, B., & Loiseau, G. (2002). Sources de contamination dans les filières laitières et exemples de démarches qualité. In Hanak, E., Boutrif, E., Fabre, P., & Pineiro M. (eds). *Food safety management in developing countries: Proceedings of the international workshop*. CIRAD-FAO, 11–13 December 2000. International Workshop on Food Safety Management in Developing Countries.

Fotou, K. et al. (2011). Isolation of microbial pathogens of subclinical mastitis from raw sheep's milk of Epirus (Greece) and their role in its hygiene. *Anaerobe*, 17(6), 315–319.

Gills, R. et al. (1990). Economics of mastitis control. *Journal of Dairy Science*, 73, 3340–3348.

Godden, S. M. et al. (2012). Heat-treated colostrum and reduced morbidity in preweaned dairy calves: Results of a randomized trial and examination of mechanisms of effectiveness. *Journal of Dairy Science*, 95(7), 4029–4040.

Guiraud, J. P. (1998). *Microbiologie alimentaire*. Edition Dunot (652 p.).

Hadjipanyiotou, M., & Koumas, A. (1991). Effect of Protein Source on Performance of Lactating Damascus Goats. *Small Ruminant Research*, 5, 319–326.

Hernández-Castellano, L. E. et al. (2015). Colostrum protein uptake in neonatal lambs examined by descriptive

and quantitative liquid chromatography-tandem mass spectrometry. *Journal of Dairy Science*, 98(1), 135–147. https://doi.org/10.3168/jds.2014-8143

Hernandez-Castellano, L. E. et al. (2015). The effect of colostrum source (goat vs. sheep) and timing of the first colostrum feeding (2 h vs. 14 h after birth) on body weight and immune status of artificially reared newborn lambs. *Journal of Dairy Science*, 98(1), 204–210. https://doi.org/10.3168/jds.2014-8350

James, R. E. et al. (1981). Influence of administered indigenous microorganisms on uptake of (iodine-125) γ-globulin *in vivo* by intestinal segments of neonatal calves. *Journal of Dairy Science*, 64, 52–61.

https://doi.org/10.3168/jds.s0022-0302(81)82528-3

Joffin, J. N., & Leyral, G. (2006). *Technical Microbiology/ Microbiologie Technique*. Tome 1 "Dictionnaire des techniques" (in French). Centre régional de documentation d'Aquitaine (pp. 967–971).

J. O. R. A. n °35. (1998). Journal Officiel de la république algérienne, Normes microbiologiques des laits et produits laitiers (p. 26).

J. O. R. A. n °39. (2017). Journal Officiel de la république algérienne, Normes microbiologiques des laits et produits laitiers (p. 32).

Jrad, Z. et al. (2014). Effect of digestive enzymes on antimicrobial, radical scavenging and angiotensin I-converting enzyme inhibitory activities of camel colostrum and milk proteins. *Dairy Science Technology*, 94, 205–224.

Keskin, M. et al. (2007). Changes in gross chemical compositions of ewe and goat colostrum during ten days postpartum. *Journal of Applied Animal Research*, 32, 25–28. https://www.tandfonline.com/doi/pdf/10.1080/09712119.2007.9706840

Koşum, N. et al. (2018). A study on the change in postpartum immunoglobulins of goats and kids. *Journal of Animal Production,* 59(1), 1–8.

Lorenz, I. et al. (2011). Calf health from birth to weaning. I. General aspects of disease prevention. *Irish veterinary journal*, 64, 1–8. https://doi.org/10.1186/2046-0481-64-10

Lotito, D. et al. (2023). Colostrum Composition, Characteristics and Management for Buffalo Calves: A Review. *Veterinary Sciences*, 10(5), 358. https://doi.org/10.3390/vetsci10050358

Marshall, R. S., J. F. Steenbergen, and L. S. McClung. 1965. Rapid technique for the enumeration of *Clostridium perfringens*. *Appl. Microbial*., 10, 559–563.

Madsen, B. D. et al. (2004). Physical properties of mammary secretions in relation to chemical changes during transition from colostrum to milk. *Journal of dairy research*, 71(3), 263–272.

Mcguirk, S. M., & Collins, M. (2004). Managing the production, storage, and delivery of colostrum. *Veterinary Clinics of North America: Food Animal Practice*, 20, 593–603.

Misawa, N. et al. (2016). Influence of casein as a percentage of true protein and protein level on color and texture of milks containing 1 and 2% fat. *Journal of Dairy Science*, 99, 5284e5304. https://doi.org/10.3168/jds.2016-10846

Mondeshka, L., & Stoycheva, S. (2023). Study on the Physicochemical Profile of Colostrum from Toggenburg Goats on the First Day after Parturition. *Journal of Mountain Agriculture on the Balkans*, 26(3), 65–76.

Nowak, W. et al. (2012). The impact of cow nutrition in the dry period on colostrum quality and immune status of calves. *Polish Journal of Veterinary Sciences*, 15 (1), 77–82. https://doi.org/10.2478/v10181-011-0117-5

Ouchene-Khelifi, N. A. et al. (2021). Characterization and typology of goat production systems in Algeria based on producers survey. *Bulletin of the National Research Centre*, 45, 1–11. https://doi.org/10.1186/s42269-020-00480-z

Ounine, K. et al. (2004). Bacteriological characterization of raw milk produced in the stables of the Gharb region/ Caractérisation bactériologique du lait cru produit dans les étables de la région du Gharb (in French). *Al awamia*, 109, 110.

Park, Y. W. et al. (2007). Physico-chemical characteristics of goat and sheep milk. *Small ruminant research*, 68(1–2), 88–113.

Prata, L. F. et al. (1998). Comparison, nitrogen profile and characteristics of goat milk (Saanen) in the Southeast region of Brazil/Comparação, perfil nitrogenado e características do leite caprino (Saanen) na região Sudeste Brasil (in Portugal) (in Portuguese). *Ciência e Tecnologia de Alimentos*, 18(4), 428–432. https://doi.org/10.1590/S0101-20611998000400014

Quigley, J. D. et al. (1994). Immunoglobulin concentration, specific gravity, and nitrogen fractions of colostrum from Jersey cattle. *Journal of Dairy Science*, 77(1), 264–269. https://doi.org/10.3168/jds.s0022-0302(94)76950-2

Romero, T. et al. (2013). Short communication: Goat colostrum quality: Litter size and lactation number effects. *Journal of Dairy Science*, 96 (12), 7526–7531. https://doi.org/10.3168/jds.2013-6900

Saidane, Z. et al. (2023). Breeding practices in a dairy farm in Hassi-Mamèche and their impacts on the physicochemical and microbiological parameters of milk/Pratiques d'élevage dans une ferme laitière à Hassi-Mamèche et leurs impacts sur les paramètres physico-chimiques et microbiologiques du lait (in French). *Journal of natural science & sustainability*. 109030, 74–78.

Sánchez-Macías, D. et al. (2014). From goat colostrum to milk: Physical, chemical, and immune evolution from partum to 90 days postpartum. *Journal of Dairy Science*, 97(1), 10–16. https://doi.org/10.3168/jds.2013-6811

Santos, G. D. et al. (2017). Nutritional and microbiological quality of bovine colostrum samples in Brazil. *Revista Brasileira de Zootecnia*, 46(1), 72–79. https://doi.org/10.1590/S1806-92902017000100011

Santos, J. V. I. et al. (2019). Evaluation of the quality of goat's milk on a property in the municipality of Monteiro – PB/ Avaliação da qualidade do leite de cabra em uma propriedade no município de Monteiro – PB (in Portuguese). *Revista Craibeiras de Agroecologia*, 4(1), e7682.

Thieulon, M. (2005). Milk pathogens staphylococci/Lait pathogènes staphylocoques (in French). *Revue de la chambre d'agriculture du Cantal*, 1–2.

Todaro, M. et al. (2023). Effect of lambing season on ewe's colostrum composition. *Ital. Journal of Animal Science*, 22(1), 14–23. https://doi.org/10.1080/1828051X.2022.2155587

Yabrir, B. et al. (2013). Microbiological quality of raw sheep milk collected in the central steppe of Algeria/Qualité microbiologique du lait cru ovin collecté dans la steppe centrale de l'Algérie (in French). *Afrique science*, 09(2), 86–92.

Zagorec, M. and Champomier-Vergès, M.C. (2017). "Chapter 6 – meat microbiology and spoilage". In Toldr´a, F. (Ed.). *Lawrie's meat science*. 9th ed. (pp. 195–218). Woodhead Publishing. http://dx.doi.org/10.1016/B978-0-08-100694-8.00006-6

Zimmerman, S. et al. (2001). Bacterial degradation of milk components is affected by storage temperature and time. *Report of Progress 881*. Kansas State University Agricultural Experimental Station and Cooperative Extension Service. https://doi.org/10.4148/2378-5977.3226

Zulkifli, T. I. N. T. M. et al. (2023). Consumer preferences towards goat milk and goat milk products: a mini review. *Food Research*, 7(2), 57–69. https://doi.org/10.26656/fr.2017.7(S2).15