

## Composition and variation of milk from Djallonké goats fed with different diets in Burkina Faso

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### ABSTRACT

In Burkina Faso, feed availability for animals throughout the year remains a major problem. The study aimed to determine the chemical composition and variation of Djallonké goat milk according to diet. Therefore, *Pennisetum pedisellatum* Trin silage, maize bran, and groundnut haulm were tested in the diet of twelve goats divided into four (4) groups. Group 1 was fed exclusively on natural rangeland (PN), Group 2 on natural rangeland + 0.197 g of maize bran per goat per day (PNM), Group 3 in a barn + 1.88 g of silage, 0.115 g of groundnut haulm, and 0.099 g of maize bran per goat per day (SPEAM), and Group 4 in a barn with 1.820 g of silage + 0.197 g of maize bran per goat per day (SPEM). Milk density and the dry matter (DM), fat, protein, and lactose content of milk were determined over four fortnights of days, and an analysis of variance was performed in R software with the factors ration and fortnight. Milk chemical composition did not vary according to the ration. SPEAM goats had a lower fat content in the third fortnight (3.53%) than in the other fortnights (4.57%–5.19%) ( $p < 0.05$ ), which were similar. In PNM goats, the lactose content increased (from 3.27% to 3.72%). In both PN and SPEAM goats, milk density in the fourth fortnight (1.21 g/L) was higher than that from the first to the third fortnight (1.02–1.03 g/L). Thus, rations based on *Pennisetum pedisellatum* silage, maize bran, and groundnut haulm, whether fed on natural rangeland or in barns, did not influence the density or major chemical components of milk, but time did modify some milk components.

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## INTRODUCTION

Small ruminant farming plays a key role in the fight against poverty and food and nutritional insecurity. Sheep and goats are highly valued by local populations and, due to their adaptability to the environment, are an important asset for boosting animal production. In Burkina Faso, the small ruminant population is very large, with 11,410,270 sheep and 17,084,270 goats, and this population is constantly growing, with an estimated annual growth rate of 3% (INSD, 2021). Goats are a genetic resource well suited to diverse agro-ecological conditions. They are the appropriate livestock species in areas unsuitable for agriculture and in places where other livestock species cannot be raised (Onzima *et al.*, 2018). Goats represent a national treasure in terms of the size of the herd, the number of people involved in raising them, and the income they generate. However, despite this honorable status, they are facing problems of quantitative and qualitative food shortages. Indeed, variability and fluctuations in rainfall, combined with extensive animal husbandry practices, expose goats to recurrent nutritional deficiencies, especially during difficult seasons when grazing lands are virtually desert-like (Sanon *et al.*, 2014).

In addition, the practice of supplementing goats' diets by farmers is virtually non-existent, except on dairy farms. The high cost of most conventional raw materials forces farmers to use inadequate resources that limit the nutritional quality of rations (Sanon *et al.*, 2014; Sow, 2021). In urban and semi-urban areas, goats are often kept in confinement and have access almost exclusively to agro-industrial by-products, hay, and green fodder sold on the market (MRA, 2007). This fodder comes from natural pastures and surrounding crop areas.

According to Sanou *et al.* (2016), there is a widespread system of fodder sales in many African cities where livestock farming is a local activity that provides financial and/or food security for the population. With an estimated 773,205 goats (INSD, 2021), the city of Bobo-Dioulasso is a case in point in Burkina Faso.

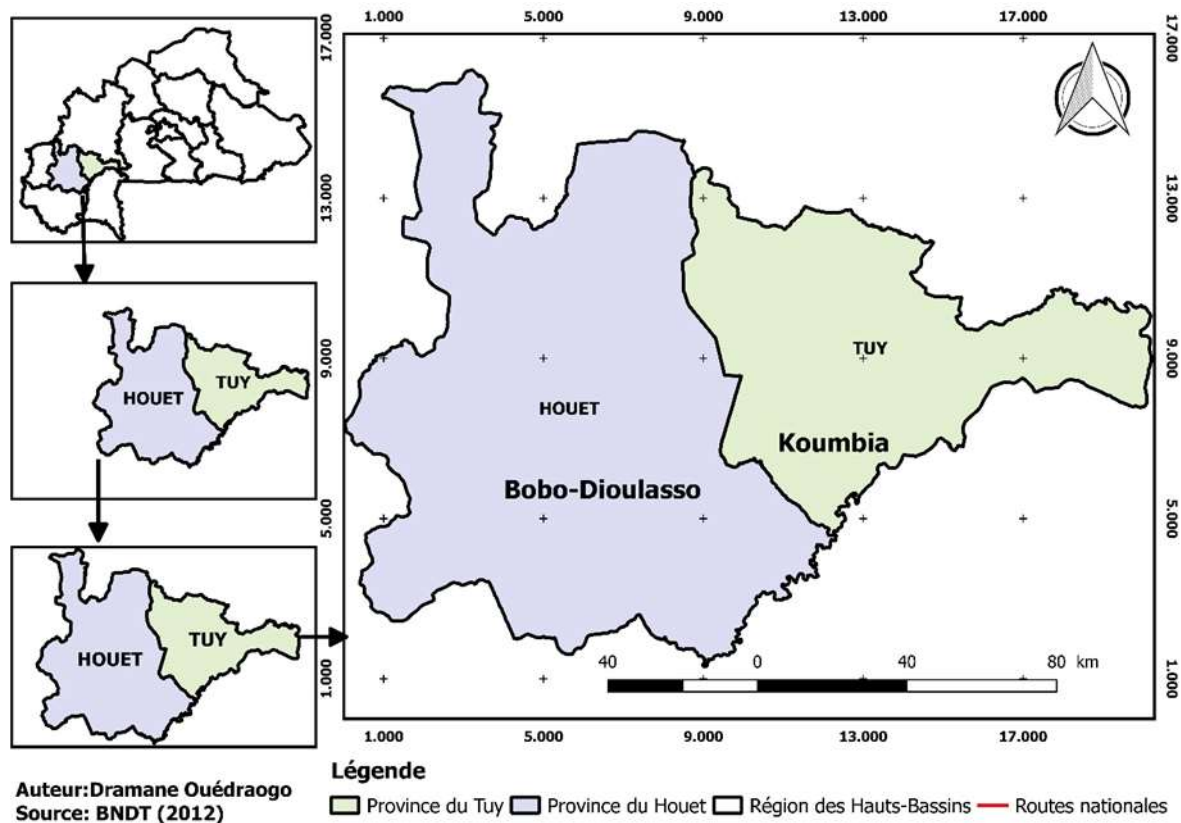
Aware of the central role of livestock farming for the population, the Ministry of Livestock, with the support of development partners, is working to disseminate techniques and technologies to producers in order to resolve the issue of food insecurity for livestock (forage crops, straw treatment with urea, provision of equipment for the collection, preservation, and valorization of agro-pastoral products, etc.). Among the strategies for conserving fodder, silage has proven effective in many parts of the world, but it remains little practiced in Burkina Faso. The production of fresh grass silage sold in Bobo-Dioulasso has been proven suitable for feeding goats (Sissao *et al.*, 2024). However, when incorporated into feed, its impact on goat milk production remains poorly documented. This study was therefore initiated to determine the chemical composition and variation of Djallonké goat milk according to diet. Specifically, the aim was to determine:

1. The composition of goat milk according to rations based on *Pennisetum pedisellatum* silage, maize bran, and groundnut haulms on natural pasture or in stalls.
2. The composition of goat milk according to time for rations based on *Pennisetum pedisellatum* silage, maize bran, and groundnut haulms on natural pasture or in stalls.

## MATERIALS AND METHODS

### Study area

The work was carried out at two sites in the Hauts Bassins region in western Burkina Faso. These were the Bobo-Dioulasso urban center in Houet province for silage production and the model farm in the Appropriate Agricultural Mechanization Project (ASMC) zone in the village of Koumbia, Tuy province, for the experimental trial. This region is located in the Sudanian phytogeographic domain with a South Sudanian climate and rainfall of between 1,000 and 1,400 mm/year during the 5- to 6-month rainy season. It is located between three international watersheds: the Comoé, the Volta, and the Niger, making it one of the rainiest regions in the country. The map in Fig. 1 provides an overview of the location of the study area.



**Fig. 1.** Map of the study area and site

## Materials

The biological material used for the study included twelve (12) goats (*Caprahircus*) from the Southwest, also known as "Djallonké goats." These goats were between 2 and 5 years old and had given birth twice (multiparous). Their live weights ranged from 20 to 23 kg. They belonged to the wives of livestock farmers in the rural commune of Koumbia.

The silage equipment consisted mainly of a chopper (a straw chopper designed and manufactured for small producers by the appropriate agricultural mechanization project team at the Institute of Rural Development at Nazi Boni University (Millogo *et al.*, 2021)), plastic barrels, medium-sized transparent white plastic bags, and large black plastic tarpaulins.

## Silage production

The fodder was purchased based on the fodder requirements for feeding a goat and the volume of

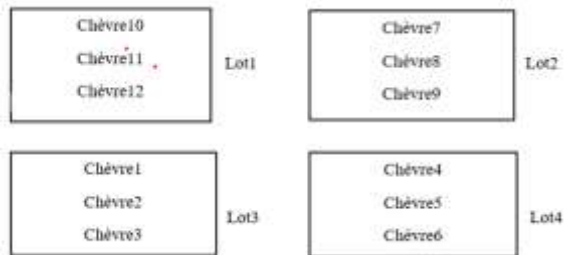
the barrel silos. A total of five barrels were used for the silage operation (Fig. 2). Plastic bags were placed in the barrels to ensure adequate anaerobic conditions before filling them with pre-wilted fodder in successive layers to achieve better compaction (Koudougou, 2018). The barrels were hermetically sealed after the forage had been compacted and wrapped in plastic film. The packaged forage underwent anaerobic fermentation for three months before being used.

## Experimental design

The experimental design consisted of 12 goats randomly divided into four groups of three goats each (Fig. 3). Group 1 served as a control and the animals were fed mainly with forage on natural pasture. Group 2 received a supplement of maize bran after grazing on natural pasture. Group 3 was fed in total confinement with a ration consisted of maize bran combined with silage and groundnut haulms. Group 4 was also fed in confinement with a ration of silage and maize bran.



**Fig. 2.** Silage production



**Fig. 3.** Experimental setup

### Health care and animal feeding

The twelve goats underwent bleaching with the following treatments:

1. Internal deworming with Bolumisole M1 at the start of the trial.
2. An injection of trypanocide (Veriben) at the start of the trial;
3. Boluvit as a mineral and vitamin supplement administered at the start of the trial.

The goats in confinement (lots 3 and 4) were fed rations A and B, respectively (Table 1).

**Table 1.** Composition of rations

Ingredients	Ration A (in g)	Ration B (in g)
Silage	1,880	1,820
Groundnut haulms	115	0
Maize bran	99	197
Total	2,094	2,017

These rations were calculated based on:

1. The nutritional requirements of goats (CTA, 2015)
2. The nutritional values of the feed (CIRAD, 2002)
3. The feed available in the study area
4. Local feeding practices

Grass silage was considered the main source of energy in both rations. The protein sources were maize bran and groundnut haulms (equal amounts of each ingredient) for ration A and maize bran alone for

ration B. Group 2 received a daily supplement of 0.197 g of maize bran per goat.

Every morning during the trial, silage was given to the six goats in total housing according to the ration calculations for the two groups. Groundnut haulms were brought in the afternoon to group 3, then maize bran in the evening to groups 3 and 4 respectively. Group 2, which was grazing on natural pasture, was supplemented with maize bran on a weekly basis.

### Sampling of goat milk

The trial was conducted with twelve Djallonké goats in a real area, i.e., under the producer's farming conditions. Milking was performed manually every two weeks, followed by analyses at the Animal Health and Biotechnology Research and Teaching Laboratory (LARESBA). The kids were kept in pens with those that were stabled and grazing on natural pasture.

### Milk quality analysis

The chemical composition of the milk was analyzed at LARESBA using Miris® FMA (farm milk analysis). The FMA is an electronic device that enabled infrared physicochemical analysis of the milk (Fig. 4).



**Fig. 4.** FMA Miris AB, Sweden

This device measures the light intensity transmitted by each of the sample's constituents in the infrared range and converts it into a percentage of the total sample at room temperature before analyzing the raw milk. This operation took place after the samples had been placed in a water bath (Fig. 5) for milk at a temperature of 40°C, which is the temperature set by the device for analyzing milk. The analysis itself consisted of introducing the raw milk into the device using a syringe. The control buttons were pressed to

start the analysis. The FMA was cleaned with liquid (water) and then the following samples. Once all the samples had been analyzed and the instrument cleaned with distilled water in the machine, the syringe had to be left with distilled water.



**Fig. 5.** Water bath (Photo Djikoldingam 2022)

### Statistical analysis

Statistical analysis was performed using R software and an analysis of variance (ANOVA) was performed

with ration and time/fortnight as factors. The comparison of means was performed using Tukey's test at a 5% threshold.

## RESULTS

### Composition of goat milk according to diet

The composition of Djallonké goat milk according to feed ration is presented in Table 2. Milk density was similar for goats fed only on natural pasture (PN), on natural pasture with a daily supplement of 0.197 g of maize bran (PNM), in permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms and 0.099 g of maize bran (SPEAM), and permanent housing with 1.820 g of silage and 0.197 g of maize bran (SPEM). Milk density values ranged from 1.03 to 1.08 g/l. Dry matter, fat, protein, and lactose contents were also similar among goats for the four types of rations.

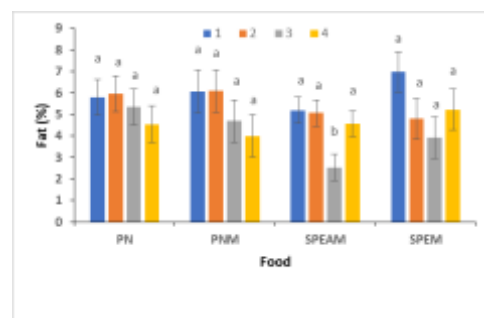
**Table 2.** Variation in the composition of Djallonké goat milk according to diet

Variable	PN	PNM	SPEAM	SPEM	SEM	<i>p</i>
MG (%)	5.42	5.21	4.34	5.23	0.43	0.31
Protein (%)	4.50	4.70	4.35	4.82	0.32	0.74
Lactose (%)	3.64	3.51	3.82	3.64	0.12	0.40
MS (%)	14.23	14.22	13.33	14.29	0.58	0.60
Density (g/L)	1.08	1.05	1.03	1.03	0.02	0.18

MG: Fat content; DM: Dry matter, PN: Natural pasture; PNM: Natural pasture with daily supplementation of 0.197 g of maize bran; SPEAM: permanent stabling/confinement with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize; SEM: Standard Error of the Mean.

### Variation in the composition of milk from goats fed different diets over time

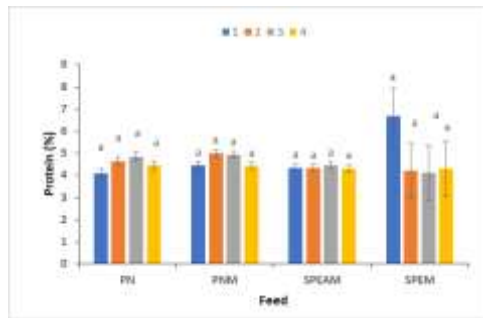
The variation in the composition of milk from Djallonké goats fed different rations over time showed different trends depending on the components. The fat content (Fig. 6) did not vary from the first to the fourth fortnight for goats fed on natural pasture, on natural pasture with a daily supplement of 0.197 g of maize bran, and in permanent stabling with 1.820 g of silage and 0.197 g of maize bran. However, goats kept in permanent stalls with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran had a lower fat content in the third fortnight than in the other fortnights ( $p < 0.05$ ), which were similar.



**Fig. 6.** Variation in the fat content of Djallonké goat milk over time

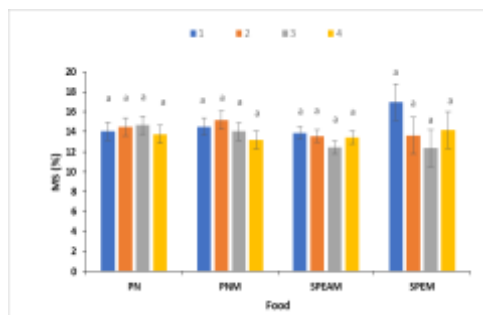
PN: Natural pasture; PNM: Natural pasture with daily supplementation of 0.197 g of maize bran; SPEAM: permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize bran.

Protein (Fig. 7) and dry matter (Fig. 8) contents did not vary significantly ( $p > 0.05$ ) from the first to the fourth fortnight in goats on the four types of feed.



**Fig. 7.** Variation in the protein content of Djallonké goat milk over time

PN: Natural grazing; PNM: natural grazing with daily supplementation of 0.197 g of maize bran; SPEAM: permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulm and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize bran.

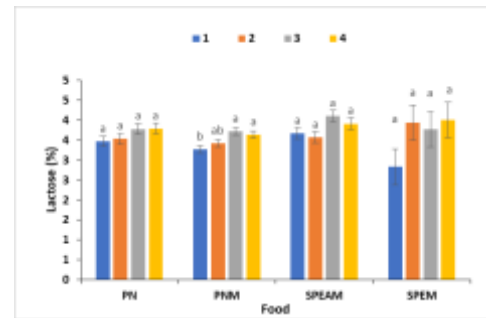


**Fig. 8.** Variation in the dry matter content of Djallonké goat milk over time

DM: Dry Matter; NM: Natural pasture; NMF: Natural pasture with daily supplementation of 0.197 g of maize bran; SPEAM: permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize bran.

Lactose levels increased over time, with a significant difference ( $p < 0.05$ ) in goats on natural pasture that received a daily supplement of 0.197 g of maize bran (Fig. 9). In fact, the lactose content in the first fortnight was lower than in the third and fourth fortnights ( $p < 0.05$ ), while the lactose content in goats in the second fortnight was intermediate and

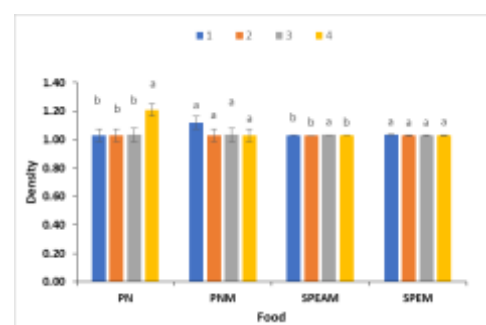
similar to that in the other fortnights. For other foods, lactose contents were similar for the four fortnights in goats.



**Fig. 9.** Variation in the lactose content of Djallonké goat milk over time

PN: Natural grazing; PNM: Natural grazing with daily supplementation of 0.197 g of maize bran; SPEAM: permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize bran.

Milk density did not vary between the first and fourth fortnights in goats fed on natural pasture with a daily supplement of 0.197 g of maize bran, in permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran, and those kept in permanent confinement with 1.820 g of silage and 0.197 g of maize bran per day (Fig. 10).



**Fig. 10.** Variation in milk density of Djallonké goats over time

PN: Natural diet; PNM: Natural diet with daily supplement of 0.197 g maize bran; SPEAM: permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran; SPEM: permanent stabling with 1.820 g of silage and 0.197 g of maize bran.

However, for animals fed exclusively on natural pasture and those in permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran, the milk density obtained in the fourth fortnight was higher than that of animals in the first to third fortnights, which had similar values.

## DISCUSSION

### Composition of goat milk according to diet

Milk density, dry matter content, fat content, protein content, and lactose content do not vary for the four types of feed in Djallonké goats in Burkina Faso in our study. The unconventional types of feed, namely natural grazing with a daily supplement of 0.197 g of maize bran, permanent stabling with 1.88 g of silage, 0.115 g of groundnut haulms and 0.099 g of maize bran, and permanent stabling with 1.820 g of silage and 0.197 g of maize bran, are effective for milk production by Djallonké goats in terms of major chemical components, as is the conventional diet, which consists of feeding the goats mainly on natural pasture. The goats' dietary requirements were met by the non-traditional feeding methods used. The success of the feed in terms of the milk components considered in this study is a significant advantage for year-round Djallonké goat farming in Burkina Faso, given the ingredients used.

In fact, groundnut haulms, maize bran, and *Pennisetum pedisellatum* silage are food resources that can be used year-round, provided that the necessary arrangements are made. Their successful incorporation into milk production also bodes well for their effectiveness in animal growth, reproduction, and meat production. As in our study, other authors have reported similarities between rations for major milk components. Indeed, according to Ganda *et al.* (2005), the dry matter, fat, protein, and mineral contents of milk did not vary significantly depending on the ration in Sahelian goats.

Sissao *et al.* (2024) comparing two feeding methods, found that milk from goats fed on natural pasture had higher levels of dry matter, protein, and fat (14.34%, 4.89%, 5.02%, and 3.75%, respectively) than milk

from goats kept in confinement (12.19%, 4.20%, and 3.30%, respectively), while milk from confined goats was richer in lactose (3.94%). The differences observed by these authors are clearly not significant and, as they have not been statistically proven, they could be insignificant, as in the present study, since the feed given to stabled animals is of the same type as that used in our study.

Although in our case and in those of other authors, unconventional feeds produce milk similar in dry matter, fat, protein, lactose, and density to that produced on an exclusively natural pasture diet, the ration can influence milk composition. For example, the addition of extruded soybeans increased the fat content of milk by 27% with an inclusion rate of 20% of the dry matter of the ration (Schmidely *et al.*, 2005).

Furthermore, the milk component contents obtained in our study can be compared to those of other studies. Indeed, the dry matter content of around 13-14% in our study is close to the 13.3% obtained by Zantar *et al.* (2016) in goats in northern Morocco. The average protein content of 4.35 to 4.82% in Djallonké goats in Burkina Faso is higher than the 3.52% reported by Zahraddeen *et al.* (2009) in local goats in Nigeria and the 3.9% recorded by Zantar *et al.* (2016) in goats in northern Morocco. The fat content of 4.34 to 5.42% in the milk analyzed in this study is similar to the 4.77% reported by Zahraddeen *et al.* (2009) in local goats in Nigeria, but higher than the 3.5% obtained by Zantar *et al.* (2016) in goats in northern Morocco. The lactose content of 3.51 to 3.82% in this study is below that of 4.77% reported by Zahraddeen *et al.* (2009) in local goats in Nigeria. These different variations in milk composition are likely to be linked to intrinsic and extrinsic factors such as genetic type, stage of lactation, parity, diet, season, and other environmental factors.

### Variation in the milk composition of goats on different diets over time

Goats in permanent housing fed 1.88 g of silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran

have a lower fat content in the third fortnight than in the other fortnights ( $p < 0.05$ ), which were similar. In goats on natural pasture that received a daily supplement of 0.197 g of maize bran, the lactose content increased over time. In animals fed exclusively on natural pasture, the milk density obtained in the fourth fortnight is higher than that of animals in the first to third fortnights, which have similar values. These variations must be due to the effect of the feed combined with the variability of environmental conditions. Indeed, feed is a factor that influences milk composition, even though its effect is not very noticeable in our study, meaning that all the feed given to the goats is similar. Changes in environmental conditions are also decisive in the chemical composition of milk. The effect of weather on milk composition is particularly noticeable from one season to another. Weather also influenced the chemical composition of milk from Kabyle goats in the mountains of Algeria (Amroun *et al.*, 2023). In their study, the protein content of Kabyle goat milk, for example, varied significantly depending on the season, with the highest levels in summer and autumn and a very significant decrease in winter and spring. In addition, changes in the stage of lactation over time also play a role in changes in the chemical composition of milk. Zantar *et al.* (2016) characterizing goat milk in northern Morocco, observed that the dry matter, fat, lactose, and total nitrogen content increased significantly as lactation progressed. During lactation, a significant increase was noted for C4:0, C16:0, AGC, and saturated fatty acids.

## CONCLUSION

The study of the characteristics of milk from Djallonké goats in Burkina Faso reveals that goats fed on natural pasture, on natural pasture with a daily supplement of 0.197 g of maize bran, in permanent stabling with 1.88 g of *Pennisetum pedicellatum* silage, 0.115 g of groundnut haulms, and 0.099 g of maize bran, and permanent stabling with 1.820 g of *Pennisetum pedicellatum* silage and 0.197 g of maize bran, produces milk with the same composition in terms of density, dry matter, fat, protein and lactose.

However, from the first to the fourth fortnight, variations in milk composition were observed in terms of fat and lactose content as well as milk density.

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## Conflicts of interest

The authors declare that there are no conflicts of interest.

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