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Effects of Breed and Lactation-stage of Goat on the Composition and Lipid Fraction of Milk in Algeria

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ABSTRACT

Background: Fatty acid profile plays an important role in human health and sensory quality of dairy products. This study focused on the influence of breed and lactation-stage, on the composition and lipid fraction of goat milk in Algeria.

Methods: Milk composition of a herd comprising a total of 50 dairy goats of various breeds was monitored during the 7 months of lactation.

Result: Results showed that Alpine breed milk is richer in fat, protein and casein as compared to Saanen and local breeds. Same changes were observed depending on the lactation stage in favour of the Late Lactation stage. Similarly, the fatty acid profile varies depending on the breed and lactation stage. This study highlights the potential benefits of selecting dairy goats by combining the hardiness of the local breed with the milk quality of imported breeds, which appear to have a healthier profile than the milk of the local breed.

Key words: Breed, Fatty acid profile, Goat milk, Lactation stage, Physico-chemical properties.

INTRODUCTION

According to FAO (2021), the goat population was around 1.11 billion producing around 20.7 million tons of milk. The major contributors to goat milk production are Asia, Africa and America contributing 12.37, 4.4 and 0.82 million tons, respectively. Furthermore, India is largest goat milk producing country with 6.07 million tons, contributing to almost 50% of total production from Asia (Faostat, 2021). Goat breeding in Algeria is one of the most skilled agricultural activities in rural areas, particularly in marginal regions (Sahraoui *et al.,* 2019). The total number of goat herds produced in 2022 was 3,261,085 heads, including 2,024,420 goats (MADR, 2024), ranking third after sheep and cattle (MADR, 2024). Goat breeding represents nearly 15% of the total national herd. With a production of 267.000 tons of milk (FAO, 2020).

Goat's milk is of particular interest because it is less allergenic and has higher nutritional value and digestibility of milk compounds compared to bovine milk (Verruck, *et al.*, 2019). A good knowledge of the characteristics of this milk and its quality could make it a good substitute for cow milk in Algeria. Goat milk is richer in unsaturated fatty acids (UFA), short chain fatty acids (SCFA) and medium chain fatty acids (MCFA) than cow milk (Mollica *et al*., 2021, Chen *etal*., 2022) and thus, it is of great interest for nutritional and beneficial aspects in human diet and health (Lordan *et al*., 2018). However, the existing literature about fatty acid profile characterization is limited to a restricted number of breeds and few studies have investigated the milk fatty acid composition of older, endangered goat breeds (Currò *et al*., 2019). Or, several factors affect the variations in goat milk production and composition, such as breed, feeding, lactation stage and environment (Hammam *et al.,* 2021).

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This work focuses on the study of the effect of breed and stage of lactation on the composition of goat's milk and its lipid fraction in Ghardaïa (southern Algeria).

MATERIALS AND METHODS

Collection of samples

The study was carried out between December 2021 and July 2022 at the level of the Palm Grove of El Atteuf in Ghardaia region, which lies downstream of OuedM'zab (32°27′15″N, 3°43′44″E). A herd composed of 50 dairy goats of different breeds (Alpine, Saanen and Mouzabite

(local breed) were chosen three weeks after their calving (the beginning of lactation). The herd was divided into three lots (each consisting of the same breed of dairy goats), each receiving the same type of food during the experimental period (7 months of lactation). Samples from mixed milk of each lot were drawn weekly in the evening shift for 7 months. The milk samples were collected in sterile, sealed and labelled flasks. They were kept at 4°C until they arrived at the laboratory for testing. Physicochemical analyses and gas chromatography were carried out at the Research Laboratory for Food Technology and Human Nutrition of Higher National Agronomic School, Algiers, Algeria.

Physicochemical analysis of milk

pH was measured using a pH meter. The milk acidity and density were respectively measured according to the AFNOR standards (NF V04-206, 1969 and NF V04-204, 2004). The total dry extract (TDE) was determined by drying milk in an oven at 103±2°C (NF V04-367, 1986). Protein levels (PL) were obtained after measuring the levels of total nitrogen (TN), soluble protein (SP), non-nitrogen protein (NNP) and casein (C) following Kjeldahl method (NF V04-211, 1986).

Fat levels (FL) were determined by the Gerber method (NF V04-210, 2000). The fat level (FL) was multiplied by 0.945 to deduce the fatty acids (Paul and Southgate, 1978).

The amount of fatty acids was quantified using gas chromatography (GC) equipped with a FFAP column and in the presence of a FID detector (Thermo-Finnigan). Nitrogen was flowing under a pressure of 6 psi. The lipid fraction was extracted using ether ammonium according to the Rose-Gottlieb method. Thus, methyl esters were obtained according to NF T60-233 (AFNOR, 2000). Analyses of the milk were carried out three times and the average mean value is reported herein.

Data were statistically processed by ANOVA with one criterion by analysis of variance using Statistica® version 6.1 (Statsoft, France) to study the relationship between the stages of lactation and the breeds on milk. A correlation test and a principal component analysis (ACP) were conducted using XLSTAT (2010) to quantify the relationship between the studied variables and individuals. For this, only one critical significance level of 5% was retained.

RESULTS AND DISCUSSION

Effect of lactation stage

The lactation stage has a very highly significant ($p<0.01$) influence on pH, acidity, density, FL, FA, TN, PL, C, C/PL ratio and SP in favour of the Late Lactation-Stage (Table 1). The lactation stage also has a significant influence ($p<0.05$) on TDE and NNP. The nitrogen fraction of goat's milk is higher at the end of lactation. Indeed, we note that the C/PL ratio, a particularly representative analytical reference factor of goat's milk cheese value, decreases in mid-lactation to reach a maximum at the end of lactation. The same tendency was observed for FL, FA, TN, PL and C. In general, our results show that, the major constituents of goat milk are high in early lactation, quickly decrease, then remain low for a variable length of time and increase again towards the end of lactation.

The physicochemical characteristics of milk can be affected by stage of lactation (Marković *et al.,* 2020). Late lactation leads to a reduction in milk yield, resulting in an increase in milk fat and protein (Jarczak, 2013). A similar trend is observed during the summer season (Li *et al*., 2022).

Table 1: Effect of lactation-stage on physico-chemical properties of goat-milk.

Physico-chemical characteristics	Lactation stage			
	Early lactation	Mid lactation	Late lactation	*p*
pH	6.53± 0.06	6.76±0.05	6.61±0.08	***
Acidity (°D)	15.77± 0.66	13.33±0.70	16.55±0.73	***
Density (gm/cc)	1.033±2.35	1.029±0.0005	1.032±0.0025	***
TDE (g/L)	128.33±12.53	118.11±3.26	130.16±8.46	*
FDE (g/L)	91.22±9.67	85.66±3.5	92.83±6.76	NS
FL (g/L)	37.11± 2.97	32.44±2.07	37.33±2	***
FA (g/L)	35.07± 2.81	30.66±1.95	35.28±1.89	***
TN (g/L)	29.93±2.51	27.92±2.41	32.33±2.74	***
PL (g/L)	28.89±2.69	27.11±2.50	31.48±2.77	***
C (g/L)	28.10±2.36	26.10±2.48	30.90±2.91	***
SP (g/L)	0.78±0.25	1±0.27	0.58±0.19	***
NPN (g/L)	1.04±0.19	0.81±0.25	0.84±0.09	*
PL/TN (%)	96.46±0.91	97.05±0.96	97.34±0.48	NS
C/PL (%)	97.30±0.65	96.29±0.84	97.92±1.10	***

P: Probability; * : $p<0.05$; **: $p<0.01$;*** : $p<0.001$; NS: Not significant ($p>0.05$).

3.TDE: Total dry extract, FDE: Fat-free dry extract, FL: Fat level, FA: Fatty acids, TN: Total nitrogen, PL: Protein level, C: Casein, SP: Soluble proteins, NPN: Non-protein nitrogen.

Kralièkova *et al.* (2013) found that PL and casein values are relatively stable between the 50th and 190th days of lactation and then increase significantly until the end of lactation. For all the solids contained in milk, the peak takes place towards the end of lactation (Darwesh *et al.,* 2013). This variation could be explained by the negative correlation between milk production and dry matter (Merkhan, 2011). Any changes in milk composition will be

Table 2: Effect of breed on physico-chemical properties of goat milk.

Physicochemical characteristics	Breed			
	Alpine	Saanen	Local	*P*
pH	6.59±0.17	6.63±0,06	6.67±0.079	NS
Acidity (°D)	15.33±1	15.44±2	14.88±1.61	NS
Density (gm/cc)	1.030±0.002	1.032±0.002	1.032±0.002	NS
TDE (g/L)	134.77±10.98	125.16±4.37	116.66±3.13	***
FDE (g/L)	98±6,38	88,61±3,08	83,11±2,35	***
FL (g/L)	36.77±4,68	36.55±1.5	33.55±1.66	NS
FA (g/L)	34.75± 4.43	34.54±1.43	31.71±1.57	NS
TN (g/L)	32.75±2.04	30.43±0.07	27.00±1.80	***
PL (g/L)	32.02±1.89	29.44±2.25	26.02±1.75	***
C (g/L)	31.01±2.22	28.87±2.4	25.21±1.80	***
SP (g/L)	1.00±0.35	0.56±0.14	0.81±0.14	***
NPN (g/L)	0.73±0.16	0.99±0.19	0.97±0.18	***
PL/TN (%)	97.77±0.38	96.69±0.82	96.39±0.64	***
C/PL (%)	96.79±1.26	98.03±0.63	96.68±0.77	***

P: Probability; *: p<0.05; **: p<0.01;***: p<0.001; NS: Not significant (p>0,05).

Table 3: Effect of Lactation-stage on fatty acid composition of goat milk.

Fatty acids (%)	Lactation stage		
	Early lactation	Mid lactation	Late lactation
Butyric acid C4:0	0.83±0.01	0.49±0.02	1.15±0.01
Caproic acid C6:0	1.05±0.01	0.92±0.01	1.09±0.04
Caprylic acid C8:0	1.29±0.03	1.98±0.01	1.75±0.01
Capric acid C10:0	7.14±0.05	7.10±0.03	7.51±0.01
Lauric acid C12:0	3.65±0.02	3.39±0.07	3.29±0.06
Myristic acid C14:0	9.80±0.09	9.73±0.08	9.88±0.13
C14 ISO	0.09±0.01	0.00±0.00	0.00±0.00
Pantadecanoic acid C15 :0C15:0	1.05±0.01	0.65±0.01	0.78±0.01
Palmitic acid C16:0	29.54±0.14	31.87±0.24	27.24±0.19
Margaric acid C17:0	0.20±0.00	0.43±0.01	0.62±0.01
SMCSFA	54.68±0.25	57.02±0.43	53.33±0.38
Stearic acid C18:0	10.65±0.20	11.20±0.16	10.30±0.09
C18 ISO	0.09±0.01	0.00±0.00	0.00±0.00
Arachidic acid C20:0	0.07±0.01	0.00±0.00	0.31±0.01
LCSFA	10.82±0.10	11.20±0.08	10.61±0.09
SFA	65.50±0.46	68.22±0.25	63.94±0.54
MyristoleicC14:1	0.10±0.01	0.00±0.00	0.41±0.01
Palmetoleic acid C16:1	0.25±0.01	0.47±0.01	0.65±0.03
Heptadecenoic acidC17:1	0.11±0.00	0.55±0.01	0.32±0.02
SMCUFA	0.47±0.01	1.03±0.03	1.38±0.01
Oleic acid C18:1	25.12±0.12	26.23±0.32	26.22±0.19
Linoleic acid C18:2	0.69±0.02	2.26±0.01	2.09±0.03
α-Linolenic acid C18:3	0.21±0.01	0.21±0.01	0.62±0.01
LCUFA	26.02±0.12	28.7±0.14	28.95±0.26
UFA	26.50±0.12	29.73±0.19	30.33±0.21

reflected in the nutritional, technological and economic values of goats' milk as well as of other dairy products (Alok Kumar *et al*., 2016).

Effect of breed

In the analysis of the composition of milk based on breed (Table 2), highly significant differences were observed at the level of TDE, TN, PL, C, SP, NNP and PL/TN and C/PL ratios. No significant effect was observed on the FL and FA; however, differences in the levels obtained are reported between the breeds.

Milk quality is influenced by many factors, like environment, breeding system, genetics, animal health, hygiene standards at the farm, breed and stage of lactation (Žan-Lotriè *et al*., 2017). Alpine and Saanen goats are the most common milk goat breeds in the world. According to Žan Lotriè *et al*. (2017) the chemical composition between these two breeds differs slightly. These results confirm our data on imported breeds. Only few studies have investigated the effect of goat breed on milk fatty acid composition in Algeria. Moreover, information on milk composition of native goat breeds is scarce, especially about FA profile. However, many studies found that impact of breed effect on milk FA is lower as compared to diet (Nantapo *et al*., 2014). The local breed has a lower content than the other two breeds. This value is lower than that found by Boubezari (2010) for the local breed in Jijel (4.63%). But it is higher than the one found by Benaissa *et al*. (2023) for the Arbia breed (23.33±0.33 g/l) in the Touggourt region of southern Algeria. Indeed, the breed has been frequently reported in the literature as one of the main variables affecting goat's milk composition, including casein fractions (Vulić *et al.,* 2021).

Analysis of the fatty acid profile

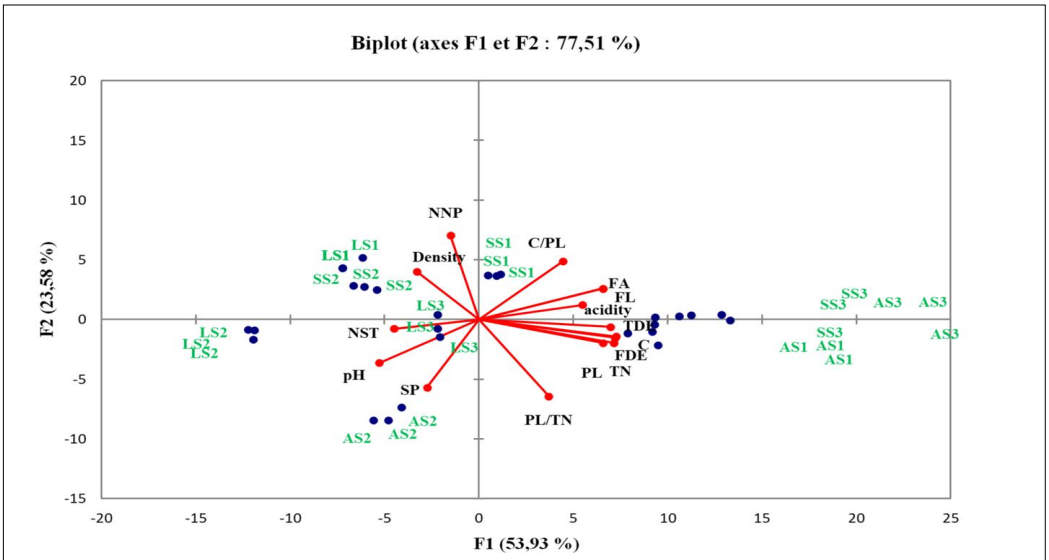
Effect of lactation stage

The rate of saturated fatty acids is higher (Table 3) for the Mid lactation (68.22±0.25%), with 57.02±0.43% in short- and medium-chain fatty acids and 11.20±0.08% in long-chain fatty acids, compared to the Early and Late stages (65.50±0.46 % and 63.94±0.54%, respectively). Unlike the saturated fatty acids, the unsaturated fatty acid rate is higher for the late stage (30.33±0.21%) than for the early (26.50±0.12%) and mid stages of lactation (29.73±0.19%).

The effect of lactation stage on goat milk FA composition has been reported by several authors; however, the pattern 2019). In the present study, stage of lactation highly affected all indices of FA, similarly to Kuchtik *et al*. (2015) and Currò *et al*. (2019). On the other hand, StrzałKowska *et al*. (2009) did not observe an affect of stage of lactation on C4:0, C14:0, C16:0, C17:0. In detail,

Table 4: Effect of breeds on fatty acid composition of goat milk.

Fatty acids (%)	Breed		
	Alpine	Saanen	Local
Butyric acid C4:0	0.85±0.02	0.93±0.01	1.15±0.03
Caproic acid C6:0	1.18±0.03	0.48±0.02	1.41±0.02
Caprylic acid C8:0	1.47±0.06	1.60±0.05	1.94±0.02
Capric acid C10:0	5.56±0.12	8.03±0.10	8.16±0.05
Lauric acid C12:0	2.47±0.01	3.76±0.08	3.83±0.06
Myristic acid C14:0	9.17±0.10	9.44±0.18	10.79±0.14
C14 ISO	0.09±0.01	0.00±0.00	0.00±0.00
Pentadecanoic acid C15:0	1.33±0.02	0.62±0.01	0.54±0.03
Palmitic acid C16:0	30.22±0.25	25.46±0.23	32.96±0.35
Margaric acid C17:0	0.42±0.01	0.43±0.04	0.39±0.02
SMCSFA	53.06±0.28	50.77±0.24	61.18±0.48
Stearic acid C18:0	10.76±0.13	10.60±0.10	10.78±0.18
C18 ISO	0.09±0.01	0.00±0.00	0.00±0.00
Arachidic acid C20:0	0.19±0.01	0.10±0.01	0.09±0.00
LCSFA	11.05±0.09	10.70±0.13	10.87±0.08
SFA	64.11±0.19	61.48±0.47	72.06±0.56
MyristoleicC14:1	0.24±0.01	0.15±0.05	0.11±0.01
Palmetoleic acid C16:1	0.49±0.02	0.46±0.02	0.42±0.03
Heptadecenoic acidC17:1	0.21±0.01	0.42±0.01	0.34±0.02
SMCUFA	0.95±0.01	1.04±0.03	0.88±0.04
Oleic acid C18:1	27.36±0.17	27.13±0.08	23.08±0.14
Linoleic acid C18:2	2.23±0.02	1.53±0.01	1.28±0.03
α-Linolenic acid C18:3	0.42±0.01	0.25±0.01	0.37±0.02
LCUFA	30.02±0.25	28.91±0.39	24.74±0.47
UFA	30.97±0.43	29.95±0.17	25.62±0.28



A: Alpine; S: Saanen; L: Local; S1: Early lactation; S2: Mid lactation; S3: Late lactation; TDE: Total dry extract; FDE: Fat-free dry extract; FL: Fat level; FA: Fatty acids; TN: Total nitrogen; PL: Protein level; C: Casein; SP: Soluble proteins; NPN: Non-protein nitrogen.

Fig 1: Simplified representation of the 1×2 factorial CPA.

discrepancies to StrzałKowska *et al.* (2009) could be related to the different feeding strategy used in his study. The higher content of C8:0 to C16:0 SFA and consequently total SFA, in mid-lactation could be linked to the pasture, which may be responsible for an increase in the synthesis of SFA. The C6:0 to C10:0 are responsible for goat flavor of dairy products (Clark *et al.,* 2017) and therefore the higher content of C6:0 to C10:0 in milk during the last stage of lactation could be responsible for the more pronounced goat flavour in dairy products. The trend of C18:2 was similar to the one reported by StrzałKowska *et al.* (2009) who found lower content in early than mid and late lactation.

Effect of breed

The fatty acid profile is strongly modified by the breed factor (Table 4). Milk from Local breed showed greater C4:0, C10:0, C12:0, C14:0, C16:0 and lower C15:0 and C17:0 contents than the Alpine and Saanen breeds. The low saturated fatty acid content of milk from the Apline and Saanen breeds could be linked to their low adaptability to environmental conditions. Thus, the lower levels of C15:0 and C17:0 in Local breed than Alpine and Saanen breeds suggest that FA contents were affected by breed as reported in Hanus *et al.* (2018) study on cow breeds. Yurchenko *et al.* (2018), in a similar study showed that milk from Saanen goats has higher portions SFA and lower proportions of C16:0, C16:1 and C18:1 comparing to Swedish Landrace goats. Among imported breeds, very few differences were detected in the FA profile.

Principal component analysis

The 1×2 factorial PCA, from individuals and variables that describe the physicochemical composition of milk, presents a projection of the various samples on the first two axes (F1 and F2) (Fig 1). The PCA shows that the first two axes (F1 and F2) represent 77.51% of the variability. In Fig 1, the F1 axis divides individuals into two groups. The first group (on the positive side of the axis) brings together individuals from the Alpine and Saanen breeds in the first and third stages of lactation. Looking at the biplot of variables and of individuals, we note that this first group is the richest in TFA, FT, DDE, NT, C and PL, with a higher acidity and low pH. The second group (on the minus side of the axis) brings together individuals from the local breed for the three stages of lactation as well as those of the Alpine and Saanen breeds for the second stage of lactation. We notice from the biplot that, unlike the first group, the second group has low levels of TFA, FT, acidity, DDE, NT, Ca and PL and a higher pH.

CONCLUSION

This work has helped to determine the chemical composition of goat's milk during lactation for Alpine, Saanen and local breeds in Algeria. Data on the chemical composition of milk reveal higher levels of dry matter for the milk samples from the end of lactation and those of the Alpine breed. Although there are differences between breeds, the effects of breed are often confused with those of the production system, which are very varied. Farmers should be aware of this type of research when considering a long-term genetic investment and the opportunity to develop processes such as manufacturing cheese from goat's milk.

Conflict of interest

In relation to the publishing of this paper, the authors declare that they have no conflicts of interest.

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