Impact of Different Regime of Diet on the Composition, Fatty Acid Profile and Storage Capacity of Traditional Butter Made from Local Sheep Milk 'Ouled Djellal'

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Summary

The aim of this work is to study the physico-chemical composition in fatty acids and the aptitude of the storage of the butters of the ewes' milk from different food systems such as the pastures in Algeria. 60 ewes were used in this study. Animals were divided into 3 groups, group 1 was kept outdoors on pasture (G), group (HC) was housed indoors and fed concentrate with hay (concentrate of 1.5 kg), and group 3 received a mixed diet of grass and concentrate (GC). Thirty butter samples were made from a mixture of sheep milk. The samples were kept at 4 °C for 21 days in order to carry out physico-chemical analyzes and the fatty acid composition and to evaluate their storage stability. The amount of grass in the diet of ewes has a great influence on the composition of butter in all three groups Total dry extract and fat of group GC were higher (81.49% and 81.05% respectively) compared to the groups (G) and (HC). Grazing resulted in an increase in unsaturated fatty acids including 18:3n-3ALA and CLA c9 t11. Increasing total grass in the ration reduced the n6/n3 ratio to values below 4. In addition, butter from pasture has better stability during its conservation. This work made it possible to confirm the situation of grazing on the qualitative level, the a priori beneficial effects of an increase in the proportion of grass in the ration on the profile in fatty acids and on the aptitude of conservation of the butter.

Key words

sheep, fatty acid, butter, grass, milk

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Received: January 1, 2023 | Accepted: April 26, 2024 | Online first version published: July 5, 2024

Introduction

Pastures are the main food source for dairy ewes, especially during lactation (Zaazaa et al., 2022). However, indoor feeding is practiced in many countries such as Algeria. The Mediterranean basin and the Middle East are known for a significant production of sheep and goat milk. Algeria has 29 million sheep heads in 2019 (MADR), which may represent an important source for the dairy sector. Ewe's milk in Algeria is consumed by breeders or traditionally self-transformed after use in the feeding of lambs (Yabrir et al., 2013). Sheep milk contains more proteins, lipids, minerals and vitamins than bovine or goat milks (Lordan and Zabetakis, 2017).

Keeping the animals outside allows for high consumption of feed (the fodder: concentrate ratio must be at least 70:30). The purpose is to remove the poor effects (e.g. decreased rumen pH, subclinical acidosis) on the metabolic homeostasis of the animal (cow) and to improve the nutritional value of milk by reducing the w6:w3 ratio and increasing conjugated linoleic acid (CLA) (Hanuš et al., 2018). Therefore, increasing forage/concentrate ratio can increase the nutritional quality of milk. This increase affects the rumen and metabolic status (e.g., increased ruminal pH) (Musco et al., 2020). In addition, the use of nutrients is good for the synthesis of milk components and improving rumen microbial activity (Aguerre et al., 2011).

Given the consumer's interest in healthy foods and in determining their nutritional value, the composition of fatty acids is one of the most important parameters, in particular the w6:w3 ratio, which must be between 2.1 and 4. (Musco et al., 2020). Biohydrogenation in the rumen inhibited by grazed plants reduces the loss of FA in the form of local C18:3n-3 during the digestion process (Jayanegara et al., 2012). Dairy products from cows that have grazed and eaten fresh grass are "more natural" than those from concentrate-based feeding, as consumers perceive (Verkerk, 2003). The latter has become an important system for cows feeding on grass. However, little information is currently available on sheep milk products. The fatty acid (FA) profile of the milk produced can have profound effects on the texture, nutrition, shelf life properties and sensory quality of fatty dairy products such as butter (Couvreur et al., 2006; Hurtaud et al., 2007).

Milk from barn-fed corn silage contains more unsaturated fatty acids (UFA) than milk from dairy cows that have grazed, so a small amount of UFA results in a better spread of butter. However, this high UFA content in milk can result in oxidative flavor defects (Couvreur et al., 2006). Agenäs et al., (2002) and Hurtaud et al., (2002) report that grass effects are established at the beginning of the transition period, before animals are completely grazed; these effects appear on the lipid properties of milk and the sensory and nutritional characteristics of butter. Similarly, CLA concentrations in the milk of sheep, cattle and goats are known to be significantly higher as a consequence of feeding with whole fresh forage in comparison to the total mixed diet (Musco et al., 2020). In contrast to fresh forage, hay and silage show reduced PUFA content due to oxidation processes during the storage process (Chilliard et al., 2007).

In fact, lipolysis and oxidation are often the crucial factors determining the shelf life of food products and are responsible for the rancidity in butter. In the early oxidation stage, the reaction between unsaturated fatty acids and the oxygen molecule causes the formation of peroxides (Abid et al., 2017). This causes deleterious changes that lead to the loss of color and nutritional value and development of flavour defects, which can be detrimental to the health of consumers (Şenel, Atamer, & Öztekin, 2011).

In order to obtain appreciable quality products, feeding systems replace conventional techniques with natural alternatives, often modifying grass fractions and animals' access times to these natural resources. According to Jenkins and McGuire (2006); Schwendel et al., (2015) changes in diets affect the composition of milk, which has the most variable fat content and fatty acid profile and is sensitive to dietary changes.

Interest in milk and dairy products from grazing animals is increasing as many consumers continue to become more aware of their diet (Magan et al., 2021). However, the aim of this study was to determine the impact of a diet with various proportions of grass, including native plants, on the oxidation, chemical properties and fatty acid profile of traditional Algerian butter. (TAB) during storage.

Materials and Methods

Ewes, Experimental Design and Diets

The experiments were carried out on milk from an indigenous Algerian Ouled-Djellel breed. The period of the experiments took place in autumn season. During the tests, 60 ewes of average live weight of 40 ± 2 kg and aged 3 ± 1 years were divided by a group of 20 ewes. The animals were given different diets depending on their feeding system. Those 3 groups were kept under different conditions: group 1 was kept outdoor on a pasture for the whole day (G), group 2 (HC) was housed indoors and fed a concentrate with hay (1.5 kg concentrate), and group 3 was fed with mixed diet of grass and concentrate (GC).

Sampling and Chemical Analysis of the Diets

Representative samples of each of the feeds were collected at the beginning, in middle and end of the test period in order to determine their chemical composition. During the trial period, the grazed grass samples were obtained by grouping 4 sub-samples (cut using scissors) randomly collected from 4 different places in the grassland on which the ewes grazed. Pastures represent small to medium herbaceous fodder or volunteer plants. After identifying these plants, the samples are dried, crushed and stored before being analyzed according to standardized methods.

The experimental diets were analyzed (three samples from each ration) according to the AOAC 1990 method for dry matter (105 °C in a forced-air oven for 24 h), ashes (weight retained during incineration at 550 °C for 4 hours). The crude protein (CP) was determined according to the Khjeldal method (AOAC 1990). Extraction and methylation were performed at the same time according to the method cited by Mancilla-Leytón et al. (2013).

Lignin from acid detergents (ADL) was determined by solubilization of cellulose with sulphuric acid (72%). Neutral detergent fibres (NDF) and acid detergent fibres (ADF) were determined using the Van Soest et al. (1991) method.

Determination of Total Phenolic Content in Diets

Determination of Phenols

Phenols from herb extracts were determined using the modified method of Basma et al. (2011) using Folin-Ciocalteu. A volume of 200 µL of standard gallic acid, extract or blank (methanol) was added with 500 µL of 10% reagent Folin-Ciocalteu plus 500 µL of distilled water in a tube. Then, the solution was thoroughly mixed and incubated for 5 min. Subsequently, 800 µL of 7.5% (w/v) aqueous sodium carbonate (Na_2CO_3) was added to the reaction mixture which was thoroughly mixed using a vortex. The incubation of the solutions was launched in the dark for 30 min at room temperature. Finally, the absorbance was measured at 765 nm using a microplate spectrophotometer. The calibration curve was drawn using gallic acid as a standard. The total phenolic content was expressed in milligrams of gallic acid equivalent per gram of extract dry weight (mg GAE g^{-1} DW).

Determination of Total Flavonoid Content

The total flavonoid content was measured by the aluminum chloride method detailed by Olajire and Azeez. (2011) using quercetin as a standard.

1 mL of sample plus 4 mL of water were put to a volumetric flask (10 mL of volume). After 5 minutes, 0.3 mL of 5% sodium nitrite, 0.3 mL of 10% aluminum chloride were added. After 6 minutes of incubation at room temperature, 1 mL of 1 M sodium hydroxide was added to the reaction mixture. The final volume was immediately made up to 10 mL with distilled water. The absorbance of the sample was measured at 510 nm using a spectrophotometer. The experiment was repeated three times for accuracy and the values were expressed as mean standard deviation in terms of flavonoid content (quercetin equivalent, EQ) per g of dry weight.

Butter Preparation

Thirty butter samples were made during the study period from a mixture of sheep milk. The milk was placed in a clean container and left at room temperature for three days to trigger spontaneous lactic fermentation. This fermentation, which resulted in the formation of curdled milk locally called "Raib", was followed by churning for 60 minutes at a temperature of 10 °C. A quantity of lukewarm water was added to help the grains of butter come together. Finally, the butter was recovered and was manually packaged in plastic containers. Samples were stored at -20 °C for fat extraction and fatty acid composition; the others were stored at 4 °C for 21 days in order to carry out physico-chemical analyzes and to evaluate their stability during storage.

Composition and Evaluation of Lipid Oxidation in Butter

The pH of the butter samples was determined using a pH meter (Hanna H211, Hanna Instrument, Portugal). Following the AOAC (1990), the dry matter of the butter samples was determined. The acid value was determined using AOAC (1995) 969.17 and expressed in milligrams of KOH needed to neutralize acids found in 1 g of fat. The fat content of the milk and butter samples were determined using a chloroform-methanol mixture (2v/1v) using the extraction method according to Folch et al., (1957).

The fat recovery efficiency was calculated as the ratio of the percentage of fat in whole milk minus the percentage of fat in buttermilk.

Peroxide Value (PV)

PV was measured according to the official method 8-53 of the AOAC with modifications. 3.00 g of butter was weighed and added to 30 mL of chloroform/acetic acid (2:3, v/v). A total of 1.0 mL of saturated potassium iodide was added as an indicator and stirred for 30 seconds with a trochanter before adding 100 mL of deionized water. The solution was titrated against 0.002 mol L^{-1} sodium thiosulphate using a potentiometric titrimeter until the endpoint was reached (Gong et al., 2018).

Fatty Acid Profile of Diets and Butter

Samples of diets and butter from each group stored were used for FA gas chromatography analyses. Separation and quantification of fatty acid methyl esters were effected under the same conditions used by Mancilla-Leytón et al. (2013) with an Agilent 6890N Network GS System gas chromatograph (Agilent, Santa Clara, USA), equipped with a flame ionization detector and with an HP capillary column -88 (100 m, 0.25 mm i.d., 0.2 m film thickness). Fatty acids content was expressed as the percentage of total methyl esters identified.

For methylation, 1 mL of n-hexane and 3 ml of HCl methanol were added to the butter samples, homogenized and heated for 90 min in a 70 °C water bath. After cooling the contents, 5 mL of K_2CO_3 (6%) was added, more than 2 mL of n-hexane. The contents of the tubes were vortexed, followed by centrifugation at 3500 rpm for 10 minutes.

The fatty acid content was expressed as a percentage of the total identified methyl esters. After analyses, the results of butter fatty acids FA were grouped as: saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), unsaturated fatty acids (USFA), n-3 PUFA, n-6 PUFA. Ratios between the different fractions, namely PUFA/SFA and n-6/n-3 were calculated. Finally, the atherogenicity (C12:0 + 4 × 14:0 + C16:0)/(MUFA + PUFA) indices were calculated according to Vargas-Bello-Perez et al. (2018).

Statistical Analysis

The results obtained for different butter parameters and FA fatty acids were analyzed by ANOVA, using an SPSS version 26.0 software for Windows (SPSS Inc., Chicago, USA), including the fixed effects of the feed group. Pairs of means comparisons were made where appropriate, using Bonferroni's difference tests. The results are presented as P values, the differences being considered significant at $P < 0.05$.

Results and Discussion

Chemical Composition and Percentage of Fatty Acids in Diets

The results showed lower dry matter levels in Group G (80.6%) than those found for concentrated foods (HC) at 87.45%.

Concentrated food had the highest percentages for total fat. Regarding the fatty acid content of diets, we found a significant gap (Table 1).

Table 1. Composition of the experimental diets

Diets	G	GC	HC
	Composition (%)		
Dry matter	80.6	82.8	87.45
Total lipids	2.9	3.4	4.5
Ash	9.1	7.3	2.7
Crude protein	11.32	12.9	14.6
NDF	15.25	36.74	39.8
ADF	4.65	25.44	26.11
ADL	7.16	4.75	5.08
	FA Analysis (Percentage of FA identified)		
12: 0	0.09	0.44	0.36
14:0	2.63	2.54	1.64
16:0	44.84	47.46	33.65
16:1	1.39	2.23	1.23
18:0	29.85	28.54	17.53
18:1 n-9c	8.89	2.98	10.69
18:2 n-6c	14.45	8.53	38.1
18:3 n-3	3.43	14.22	3.74
∑ SFA	76.64	76.92	50.83
∑ MUFA	9.21	14.15	10.85
∑ PUFA	17.13	21.84	41.25
∑ n-6	14.62	8.61	38.54
∑ n-3	3.44	14.23	3.72
n-6/n-3	6.51	1.54	14.82
PUFA/SFA	1.23	1.29	1.82

Note: G: Grass. GC: Grass + concentrate. C: concentrated feed. H: Hay. PUFA: Polyunsaturated Fatty Acids. MUFA: Monounsaturated Fatty Acids. SFA: Saturated Fatty Acids. NDF: Neutral Detergent Fiber. ADF: Acid Detergent Fiber. ADL: Acid Detergent Lignin. FA: Fatty Acid.

This variation in FA content was mainly associated with the variation of the three main FA. C16: 0. C18: 2n-6 and C18: 3n-3. The C18:3n-3 content had the greatest variation ranging from 3.74 to 14.22g 100 g^{-1} DM for the Grass and steppe grass + concentrate diets respectively. These variations incorporated the levels of saturated and polyunsaturated fatty acids and their PUFA/SFA ratio in diets.

The highest lignin values and the lowest digestibility values were recorded in hay, which induced revealed variations in digestibility between diets due to the chemical composition of the selected species.

The herb (group G) contained more polyphenols 9.67 mg Eq gallic acid g^{-1} DM than the other two regimens (group HC and group GC). For flavonoids a higher 8.33 mg Eq quercitine g^{-1} DM was obtained in herb regimens (G) against the other two groups (Table 2).

Table 2. Total polyphenols and flavonoid concentrations for each diet

	Groups		
	G	GC	HC
Total polyphenols (mg Eq gallic acid g^{-1} DM)	9.67 ± 1.92	7.72 ± 1.34	2.55 ± 0.76
Flavonoids (mg Eq quercitine g^{-1} DM)	8.33 ± 1.74	7.52 ± 1.03	1.46 ± 0.53

Note: G: grass. HG: Hay + concentrate. GC: grass + concentrate

The large variation in chemical composition was also affected by the bioavailability of forage nutrients (Ali et al., 2014). The reduction in fat content (FA) based on forage maturity was consistent with previous results (Clapham et al., 2005; Khan et al., 2012).

The total amount of FA in forages was therefore strongly influenced by the concentration of chloroplasts. Generally, the decrease in chloroplastic lipids with forage maturation was due to flowering initiation (Dewhurst et al., 2006), leaf maturation (Khan et al., 2012) and to a decrease in leaf/stem ratio (Boufaïed et al., 2003; Khan et al., 2012).

Composition and Evaluation of Lipid Oxidation in Butter

Table 3 presents churning physicochemical properties of butter made from sheep milk. The observed pH was significantly affected by the regime of diet ($P < 0.05$) and is consistent with the pH values (4.75 and 5.09) reported by Erkaya et al., (2015) for cheese. The results indicate that the amount of dry matter was very different.

This content in traditional butters is justified by the traditional method of preparing butters. Unlike the industrial preparation method, milk fat does not completely incorporate in butter and water substitutes fat during butter making (Idoui et al., 2013). High lipase activity predisposes to moisture and stimulates the growth of microorganisms and hydrolysis of triglycerides (Idoui et al., 2013). Diet with concentrate increases the protein content of milk relative to grazing, which may be related to dietary effects on the intake of amino acids in the rumen (Wu and Huber, 1994), while grazing increases the fat and solids content. The fat recovery efficiency of approximately 80% observed in this study (Table 3) was reported by Berhe et al. (2013) for camel milk. In this study significant fat recovery in butter samples could be the result of a high proportion of total solids of diet.

Table 3. Composition and quality indices of sheep butter according to diet regime

Parameter	Groups			*P*
	G (n = 10)	GC (n = 10)	HC (n = 10)	
pH	5.09 ± 0.02[a]	5.02 ± 0.01[a]	4.85 ± 0.01[b]	< 0.05
Total solids (%)	75.17 ± 2.45[c]	81.49 ± 2.67[a]	79.22 ± 3.07[b]	< 0.01
Fat recovery (%)	78.96 ± 3.02	81.05 ± 2.64	80.25 ± 2.55	NS
Fat (%)	69.18 ± 2.09[b]	75.08 ± 1.84[a]	71.62 ± 1.17[b]	< 0.01
Acidic value (mg Eq g butter)	21.59 ± 0.05	23.66 ± 0.04	22.67 ± 0.04	Ns

Note: Each value represents the mean of 10 samples (n = 10). G: grass. HC: Hay + concentrate. GC: grass + concentrate.

For fats content in butter statistically significant differences between samples ($P > 0.05$) were detected. (GC) (HC) and G butter samples were 75.08, 71.6 and 69.18 respectively. The values were slightly lower than those determined by O'Callaghan et al., (2016) for butter in cow milk and higher than those obtained for butter samples in camel milk (Berhe et al., 2013).

In addition, the diet did not affect the butter acid value with similar averages (22.67, 21.59 and 23.66 mg Eq g^{-1} butter in the HC, G and GC groups). The results of the peroxide value in butter between the different groups changed significantly over 15 days. We noted a higher level in the HC group which was 3.74 mg Eq/g butter in D1 and reached 6.27 mg Eq g^{-1} butter after 15 days of storage. Thus for group G and GC the peroxide value increased during the storage period but with small quantities compared to the HC group with values of 2.57 to 4.31 mg Eq/g butter in group G and 3.62 to 4.92 mEq g^{-1} butter in group GC (Fig 1).

However, it can generally be stated that the PV is an indicator of the primary level of oxidation. O¨zkanlı and Kaya (2007) have found that the peroxide value increases with the time of its storage, which is consistent with our results. Benkerroum and Tamime (2004) reported peroxide index values of 0.5 and 3.7 meq O_2 kg^{-1} fat respectively in butter and Moroccan smen. According to the same authors, it is possible that there is some proteolysis of residual milk proteins in the aqueous phase. The main process that influences the characteristic aroma of the product is lipolysis, which could be the result of microbial activity of cells and/or free lipases. Chemical oxidation also contributes to a lesser degree to the smen flavor. It is evident that the value of peroxide increases to 3.7 meq/kg of butterfat compared to 0.5 meq kg^{-1} of butter. These results are consistent with those found by Benkerroum and Tamime (2004).

The peroxide value of all samples (Fig. 1) was higher at the end of storage (8 and 15 days) than on the first day of storage ($P < 0.05$). These results are in agreement with Dagdemir et al., (2009) and Simsek, (2011), who indicated that the butter peroxide index values were the highest at the end of storage time. In this study, the values were lower than those reported by these authors.

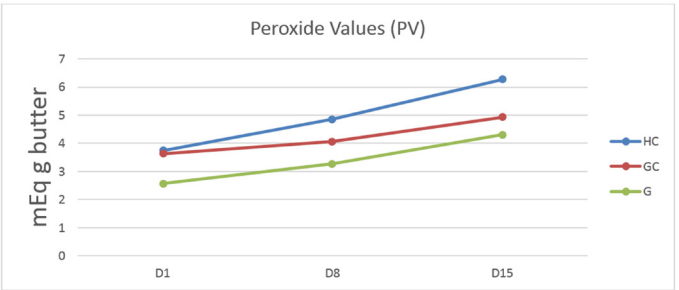

Figure 1. Sheep's butter peroxide value by diet

Note: HC: Hay + Concentrate. GC: Grass+ Concentrate. G: Grass

Fatty Acid Composition of Sheep Butter

The results of the proportions of fatty acids in butter according to different diets are shown in Table 4.

From the results, it can be stated that the FA composition of butter was strongly influenced by the diet of the ewes. The research of Alothman et al. (2019) noted that the milk fat from pasture feed of cows contained higher amounts of beneficial fatty acid than the milk fat produced by a total mixed ration TMR, which is consistent with this work.

Palmitic acid (C 16: 0) and stearic acid (C 18: 0) expressed in g $100g^{-1}$ of lipids or fatty acids had comparable proportions in the butter samples in the 3 groups, meaning that these two fatty acids showed no significant differences. We also observed that diet had a significant effect on the quantity of C 18:1 n-9 t in butter .

Vaccenic acid (C 18: 1t11) and remunic acid (CLA C 18: 2 c9 t11) are the majority in the GC group. For C18:3n-3ALA, it is significantly lower ($P < 0.01$) in the G group compared to the HG and GC groups. On the other hand, the diet showed no significant effect on the quantities of C 22:5 n-3 and C 22:6 n3.

Table 4. Fatty acid composition of sheep butter according to different diet (g/100 g lipids)

Fatty acids (%)	Groups			*P*
	G (n = 10)	GC (n = 10)	HC (n = 10)	
Fat	69.18 ± 2.09^{b}	75.08 ± 1.84^{a}	71.62 ± 1.17^{b}	< 0.05
14 : 0	9.43 ± 0.88	10.92 ± 0.87	11.27 ± 0.84	NS
16 : 0	32.00 ± 0.94	30.81 ± 1.03	31.45 ± 0.98	NS
16 : 1	1.56 ± 0.08	1.67 ± 0.07	1.64 ± 0.07	NS
18 :1 n-9 t	0.32 ± 0.03^{b}	0.50 ± 0.03^{a}	0.53 ± 0.05^{a}	< 0.05
18 : 0	10.70 ± 1.53	10.82 ± 1.51	11.27 ± 1.51	NS
18 : 1 cis 9	21.85 ± 0.80	21.10 ± 0.81	18.91 ± 0.71	NS
18 : 1t11	0.73 ± 0.04^{c}	1.11 ± 0.07^{a}	0.83 ± 0.05^{b}	< 0.05
18 :3n-3ALA	0.98 ± 0.03^{a}	0.86 ± 0.01^{b}	0.50 ± 0.01^{c}	< 0.01
CLA c9 t11	0.36 ± 0.12^{c}	0.49 ± 0.14^{a}	0.48 ± 0.16^{ab}	< 0.05
20 : 0	0.17 ± 0.02	0.17 ± 0.03	0.12 ± 0.02	NS
20 :3 n-6	0.12 ± 0.02	0.13 ± 0.02	0.11 ± 0.02	NS
20 :5 n-3	0.03 ± 0.02^{b}	0.08 ± 0.02^{a}	0.05 ± 0.02^{b}	< 0.05
22 :5 n-3	0.08 ± 0.01	0.11 ± 0.01	0.09 ± 0.01	NS
22 : 6 n3	0.06 ± 0.02	0.07 ± 0.01	0.08 ± 0.01	NS
∑ SFA	71.74 ± 4.65	68.82 ± 3.51	68.46 ± 3.42	NS
∑ MUFA	26.65 ± 2.30	26.94 ± 3.33	23.71 ± 1.17	NS
∑ PUFA	4.26 ± 0.11	4.52 ± 0.13	4.88 ± 0.13	NS
∑ n-6	2.95 ± 0.03^{b}	3.20 ± 0.03^{a}	2.77 ± 0.03^{c}	< 0.05
∑ n-3	1.12 ± 0.03^{a}	0.72 ± 0.01^{b}	1.07 ± 0.03^{a}	< 0.05
n6/n3	2.62 ± 0.07^{b}	4.62 ± 0.06^{a}	2.58 ± 0.05^{c}	< 0.05
Atherogenicity index IA	2.86 ± 0.22^{b}	2.70 ± 0.23^{b}	3.37 ± 0.20^{a}	< 0.05

Note: Each value represents the mean of 10 samples (n =10). HC: Hay + Concentrate. G: Grass. GC: Grass+ Concentrate. CLA: conjugated linoleic acid. VA: vaccenic acid. NS: not significant. $P < 0.05$= significant effect. $P < 0.01$ = highly significant effect according Bonferroni's test.

The antioxidant status of milk from "concentrated" or "corn silage" diets is lower than that obtained from grass-based diets. The most abundant source of cis-9 fatty acids, trans-11 oleic acid and CLA (remunic acid) was also grass, in contrast to corn silage and the concentrate diet. Advanced grazed grass produced milk with a remunic acid content that was twice as high as late-grazed grass. The initial determination of polyphenols also seemed to show variability depending on the type of diet distributed to the animals. Pasture milk was the richest in phenolic compounds compared to concentrate milk (Martin et al., 2002).

Couvreur et al., (2006) assumed a linear increase in C18:3 intake and a linear decrease in C18:2 intake as the proportion of fresh grass increased. This linear increase in C18:3 intake could explain the linear increase in the percentage of C18:3 in milk because C18:3 in milk comes only from non-hydrogenated C18:3 in the rumen, and the level of hydrogenation in C18:3 is quite similar between schemes. In our work, we observed an increase in the levels of fatty acids in n-3 butter, while the levels of n-6 fatty acids remained more or less constant regardless of the season. The dry matter of fresh grass contains 1-3% fatty acids, the highest values being in spring and autumn and about 50-75% of these fatty acids as ALA (Elgersma et al., 2006).

Dairy products derived from ruminants are natural sources of CLA, and their feeding system is an important factor influencing the concentration of CLA in milk and dairy products. Butters from grazing diet contained concentrations of CLA (cis-9, trans-11) greater than twice that of butters produced from a total mixed TMR ration with 1.71 g 100 g^{-1} of grass-based butterfat compared to 0.58 g 100 g^{-1} butterfat for TMR (O'Callaghan et al., 2016). The health-oriented marketing of dairy products derived from pastures often focuses on the fatty acid (FA) profile of milk, with particular attention to conjugated linoleic acid (CLA) and omega-3 fatty acids such as α-linolenic acid (Clancy, 2006).

In addition, grazing diet has been shown to alter the fatty acid composition of butter, including a significant increase in CLA concentrations (O'Callaghan et al., 2016; Pustjens et al., 2017), ALA (Pustjens et al., 2017). and C18:1 trans (Couvreur et al., 2006; Pustjens et al., 2017). As a result, grass-fed animals have lower atherogenic and thrombogenic indices (Couvreur et al., 2006; O`Callaghan et al., 2016). However, dairy products derived with low indices of atherogenicity and thrombogenic are therefore more positive to the health of consumers, as seen from reported reductions in total lipoprotein cholesterol (Poppitt et al., 2002).

In addition, there were slight variations in the proportions of SFA, MUFA and PUFA in butter with more or less similar quantities between the 3 groups. PUFA content n-3 was higher in group G with an average of 1.14 g/100g, resulting in a n6/n3 ratio of 2.6. Our results confirm those found by White et al. (2001); Kučević et al. (2016) with the butter of a TMR having a significantly higher SFA content and a significantly lower PUFA content than the two pasture-based feeding systems.

Conclusion

The results of this study show that traditional Algerian butter has an appreciable nutritional quality, particularly regarding the composition of essential fatty acids Omega 3 and CLA. It also represents an important contribution to the literature with regard to the stability and oxidative properties of butter prepared from local sheep milk of which little information is currently available. The results of this study prove that the diet (grazing in Algeria) has important positive effects on the physical and chemical properties of butter such as pH, fat, PV, acid index and fatty acid composition, which have all improved its storage capacity. Finally, this work confirms that grazing positively changes the fatty acid composition of butter in nutritional terms.

Acknowledgements

The authors thank all breeders for their help and support in carrying out our study. A big thank you to Doctors DAHOU, who took part in this study as well as in the drafting and revision of the manuscript before its submission.

CRediT Authorship Contribution Statement

Mohamed Belabbes: Conceived the project, supervised the work and writing the manuscript, Conceptualization, Investigation, performed most of the experiments. **Sahnoun Attou:** analyzed the data and drafted the manuscript, conducting a research and investigation process, specifically performing the experiments, or data/evidence collection. **Mohamed Elaffifi:** Application of statistical to analyse or synthesize study data. **Samia Benhamimed:** Performed some of the experiments. **Kaddour Bouderoua:** Oversight and leadership responsibility for the research activity planning and execution, contributed to the editing of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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