



Pasteurization effects on yield and physicochemical parameters of cheese in cow and goat milk

Dahmane TADJINE¹, Sofiane BOUDALIA^{2,3*} , Aissam BOUSBIA^{2,3}, Rassim KHELIFA⁴, Lamia MEBIROUK BOUDECHICHE¹, Aicha TADJINE⁵, Mabrouk CHEMMAM^{2,3}

Abstract

Cheese production is one of the most common forms of valorization of dairy production, adding value and preserving milk. Various types of cheese produced from raw and pasteurized milk are known worldwide. In the present work, we are interested in studying the effect of the type of milk (raw and pasteurized) of two species (cow and goat) on the yield and physicochemical characteristics of the fresh cheese. In the northeastern Algeria, on 5 cow farms and 3 goat farms; 5 raw and 5 pasteurized milk cheese manufacturing trials were conducted. The analysis of the results of the 80 samples of milk and cheese of both cow and goat species showed that the latter contained significantly more fat and protein than cow's milk and that pasteurized milk contained more protein than raw milk. As a result, actual cheese yield of goat cheese was higher than that of cows in pasteurized and raw milk. For higher yield, our result supported the use of pasteurized milk as a raw material in the manufacture of farmhouse cheese.

Keywords: cheese yield; manufacturing; pasteurized; raw milk; livestock.

Practical Application: For cheese-making under small scale using milk from cow or goat: pasteurization can increase actual cheese yield.

1 Introduction

In Algeria, as in all regions of the world, consumption of dairy products like cheeses is an old tradition linked to livestock farming, since dairy products are made using ancient artisanal processes, employing milk or mixtures of milk from different species (Boudalia et al., 2016; Leksir et al., 2019; Leksir & Chemmam, 2015; Shori, 2017).

Cheese is one of the most common milk products, which is produced by raw or pasteurized cow's milk, or other species such as goats and sheep milk (Mahieddine et al., 2017). Whatever the species, the consumption of cheeses produced from raw milk has advantages and disadvantages, it tends to display greater variability in comparison with their cheese counterparts made of pasteurised milk, and characterised by strong and unique organoleptic, which is highly appreciated by the consumers in the case of raw cows' milk cheese (Beuquier et al., 1997; Montel et al., 2014), or not always gaining the consumers' sensory acceptance in the case of raw goats' milk cheese due essentially to the short-chain fatty acids presence (Mituniewicz-Małek et al., 2019). Several studies show that raw milk cheese contains a wide variety of microflora including beneficial bacteria, especially lactic acid bacteria, which also contribute to more intense and stronger flavor production than that of pasteurized milk cheeses (Casalta et al., 2009; Grappin & Beuquier, 1997). These results

have been attributed to several indigenous microbiota, such as *Lactococcus* spp., *Lactobacillus* spp., *Leuconostoc* spp., and *Enterococcus* spp. Moreover, indigenous microflora, especially lactic acid bacteria can control the proliferation of many contaminating bacterial pathogens and thus protect the cheeses from microbiological risk via growth inhibition of food-borne pathogens within raw milk cheese using bacteriocin-mediated mechanism (Yoon et al., 2016). In the same way, from literature, populations with a similar genetic background shown that children growing up on a farm have a lower risk of developing asthma and allergies due to the consumption of raw unpasteurized milk (Waser et al., 2007); especially, those who consume goat milk, which has been identified as more favorable allergenic characteristics (Verruck et al., 2019; Ranadheera et al., 2019).

However, the use of raw milk unpasteurized in the production of cheeses carries a potential health risk; linked to the possible occurrence of antibiotics and other drugs residues, mycotoxins, estrogenic hormones, pesticides, industrial pollutants and zoonotic pathogens (Alegbeleye et al., 2018). It also can be linked to the presence of *Listeria monocytogenes*, verocytotoxin-producing *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* and *Campylobacter* and other pathogenic bacteria (Yoon et al., 2016; Kousta et al., 2010; Verraes et al., 2015).

Received 17 May, 2019

Accepted 28 Sept., 2019

¹Laboratoire d'Épidémiologie-Surveillance, Santé, Productions et Reproduction, Expérimentation et Thérapie Cellulaire des Animaux Domestiques et Sauvages, Faculté des Sciences de la Nature et de la Vie, Université d'El Tarf, El-Tarf, Algérie

²Laboratoire de Biologie, Eau et Environnement, Université 8 Mai 1945, Guelma, Algérie

³Département d'Écologie et Génie de l'Environnement, Faculté des Sciences de la Nature et de la Vie & Sciences de la Terre et l'Univers, Université 8 Mai 1945, Guelma, Algérie

⁴Department of Botany, University of British Columbia, British Columbia, Canada

⁵Laboratoire d'Écologie Évolutive et Fonctionnelle – EFE, Faculté des Sciences de la Nature et de la Vie, Université d'El Tarf, El-Tarf, Algérie

*Corresponding author: sofiane.boudalia@hotmail.com, boudalia.sofiane@univ-guelma.dz

To avoid risk for human health from raw milk consumption, pasteurization is considered the most widely used method in the dairy industry. It consists of a treatment process that heats raw milk with specified time and temperature combinations, designed to eliminate all known milk-borne pathogens and undesirable bacteria resulting in a not harmful product of constant quality. Hence, cheese manufactured from unpasteurized milk may seem to be superior to cheese made from pasteurized milk in its microbiological safety (Yoon et al., 2016). Also, this treatment can slightly affect milk composition, physicochemical characteristics, nutritive profile and sensory properties (Alegbeleye et al., 2018).

Pasteurization has been shown to have either a positive influence (Lau et al., 1990; Salwa & Galal, 2002; San Martín-González et al., 2007) or no effect on cheese yield (Drake et al., 1997). Such differences in results might be related to the breeds or the methodology of cheese making, thus assessing the effects of pasteurization of cheese yield on local breeds with a standard methodology is key and might shed light on the influence of pasteurization and give guidance to cheese producers. Besides, given that most local cheese is made from pasteurized milk, it is important to reveal potential differences in quality and yield of cheese using raw and pasteurized milk. Here, we investigate the effect of pasteurization on yield and physicochemical characteristics of cheese made from cow and goat milk collected from five different farms in Northeast Algeria. We have two hypotheses based on literature: (1) due to the interspecific similarity in milk content (Arora et al., 2013), we hypothesize that cows and goats have comparable cheese yield; (2) due to the dominance of the positive effect of pasteurization on cheese yield (Jørgensen et al., 2019), we expect the same outcome in both species. These aspects are of the primary social, economic and health importance for local dairy production.

2 Materials and methods

2.1 Study sites

The samples are collected from five county (Tamlouka, Ain Makhlouf, Ain Larbi, Belkheir, and Bouchegouf) located in the wilaya of Guelma which is located in North-East Algeria. The region is characterized by a subhumid climate in the center and in the North and semi-arid in the South. The climate is mild and rainy in winter and hot and dry in summer.

2.2 Milk sampling

A total of 80 samples of milk from both cow ($n = 50$) and goat ($n = 30$) were studied. Raw milk samples were collected every other week during a period of two and a half months (from May to mid-July 2018) from five cow and three goat breeding farms. A quantity of 1.3 liters of a mixture milk was collected in sterile flasks, and then transported in a cooler with an ice-bath to the cheese factory in Ain Makhlouf (Guelma, Algeria). All bottles are previously autoclaved at a temperature of 121 °C, under a pressure of 1 bar for 15 minutes. The transport times vary depending on the remoteness of the sampling sites. In order to take account of the real field conditions, no conservative was added. For physicochemical analysis, flasks are transported in

a cooler to the laboratory of Biochemistry of the University May 8, 1945, Guelma-Algeria. For the manufacture of the two types of cheese (raw and pasteurized), 0.5 liter of the milk was pasteurized at a temperature of 82 °C for 10 seconds and 0.5 liter was used raw.

2.3 Milk analysis

pH and acidity were measured during the manufacture of cheeses; pH was measured using a pH meter Adwa, AD1000 and acidity was determined according to the method described by Rhiat et al. (2013). At the dairy processing units, fat, protein content, temperature and density of milk were measured with Lactoscan milk analyser (series number 15-1030, made in Bulgaria).

2.4 Cheese making

At a temperature of 20 °C, both types of milk are inoculated with commercial mesophyll ferment of the brand Dupont-Danisco (Dangé-Saint-Romain, France) which contains lactic ferments *Lactococcus lactis sub. lactis*, *Lactococcus lactis sub. cremori* and *Lactococcus lactis sub. lactis* biovar *diacetylactis* at a dose of 2 g/100 L then is smoothed and matured for three hours, then is rennet with a rennet of animal origin dose 1 L/15000 and left curdled for 13 hours, this curd is molded for 24 hours. Finally it is demolded and drained for 24 hours. The manufacturing process lasts about three days. In total, 40 samples of raw milk cheese and 40 samples of pasteurized milk cheese were analyzed to determine the physico-chemical properties and yield.

2.5 Cheese analysis

The real cheese yield for all cheeses is calculated after demolding and theoretical cheese yield was determined using pradal model equation, which based on fat and protein content of milk: Theoretical yield = $0.211 \times FC + 0.093 PC + 4.0$ (FC, PC designated fat and protein content respectively).

Cheese physico-chemical analyses were carried out on the fifth day of manufacture in the university laboratory. For fresh cheese, the following analyses were carried out: pH measurement, determination of titratable acidity, total dry extract, ash content humidity and theoretical and real cheese yield. Hydrogen potential (pH) is measured using a pH-meter "Adwa, AD1000". Total dry extract (TDE) was determined using a method which consists of evaporating water from the test socket in an oven (Memmert) at a temperature of 103 °C and weighing the residue according to the method AOAC 926.08 (Association of Official Analytical Chemists, 1995). The determination of the ash rate is made by incineration of the sample at 550 °C for 3 hours in an electric muffler furnace with thermostat. The water content (humidity) is determined according to Amariglio (1986).

2.6 Statistical analyses

The results were expressed in form of the mean \pm SD (Standard Deviation). The experiments were carried out in duplicates. Two-way ANOVA was conducted to test if there was a significant difference in actual cheese yield between species (cow vs. goat) and cheese type (raw vs. pasteurized).

Linear mixed-effects models were carried out to calculate average yield across farms (using farm as a random intercept), and assess differences in fat and protein content and humidity among species and milk type, and reveal potential relationship between theoretical and actual yield. PCA was carried out to see which physicochemical variables best explain yield. Significance was considered at $p < 0.05$ using R 3.5.1 (R Development Core Team, 2018).

3 Results

3.1 Physicochemical analysis of milk

The mean \pm SD of fat, protein, temperature, acidity, density and pH of the raw and pasteurized milk of cow and goat are presented in Table 1. There was a significantly higher fat content in goat milk than in cow milk (LME: $p = 0.0001$), but no significant difference between raw and pasteurized milk (LME: $p = 0.95$). The average fat content was 52.7 ± 6.36 g/L ($n = 30$) in goats and 47.7 ± 6.85 g/L in cows ($n = 50$). Similarly, there was a higher protein content in goat milk than in cow milk (LME: $p < 0.0001$), and in pasteurized milk than in raw milk (LME: $p = 0.002$). The average protein content was 37.5 ± 2.35 g/L ($n = 30$) in goats and 30.5 ± 1.62 g/L in cows ($n = 50$), whereas it was 33.8 g/L in pasteurized milk ($n = 40$) and 32.5 g/L in raw milk ($n = 40$).

3.2 Actual cheese yield

In cows, the analysis of the actual cheese yield measured on 50 individuals in five farms with two methods (raw and pasteurized milk) showed that there was a significant effect of the type of cheese on the actual cheese yield (ANOVA: $F_{1,40} = 6.31, p = 0.01$) (Figure 1). However, neither was farm (ANOVA: $F_{4,40} = 1.93, p = 0.12$) nor the interaction between farm and type of cheese was not significant (ANOVA: $F_{4,40} = 0.94, p = 0.44$). When we consider farm as a random effect, the mixed effect linear model showed a significant effect of the type of cheese ($t\text{-value} = 2.51, p = 0.01$), revealing that the actual cheese yield in pasteurized milk (24.0 ± 2.64 kg) was 8.1% higher than in raw milk (22.2 ± 2.64 kg).

By analyzing data on 30 goats from three farms, we found that the type of cheese (ANOVA: $F_{1,24} = 12.68, p = 0.001$) and the farm (ANOVA: $F_{2,24} = 4.14, p = 0.02$) had a significant effect on actual cheese yield (Figure 2). The interaction between farm and type of cheese was not significant (ANOVA: $F_{2,24} = 2.40, p = 0.11$). By estimating the difference in the actual cheese yield between raw and pasteurized milk using a mixed effect model, we found that cheese yield with pasteurized milk (27.1 ± 2.7 kg) was 13.9% higher than with raw milk (23.8 ± 3.18 kg) ($t\text{-value} = 3.38, p = 0.002$).

The comparison of the actual cheese yield between the two species (cow and goat) showed that goats had higher actual cheese yield than cows (LME: species effect, $p = 0.04$) in both pasteurized and raw milk (LME: milk type effect, $p = 0.0001$). On average, goat milk produced 10.3% more cheese yield than cow milk. Pasteurized goat milk yielded 12.9% (difference = 3.1 kg) more cheese than pasteurized cow milk, whereas raw goat milk yielded 6.7% (difference = 1.6 kg) more cheese than raw cow milk (Figure 3).

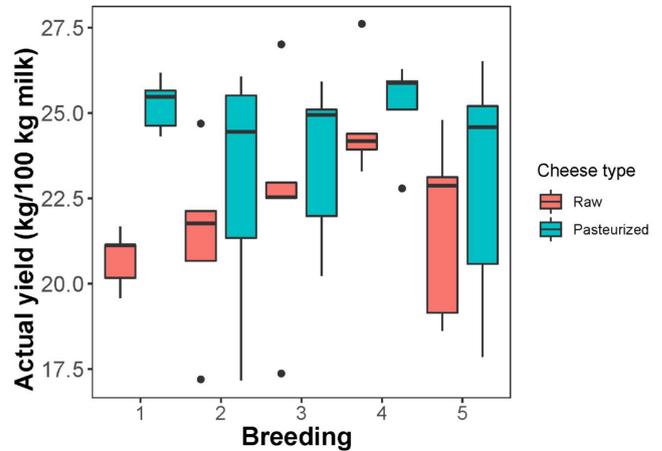


Figure 1. Actual cheese yield of cows in five farms using raw and pasteurized milk. Error bars are 95% confidence intervals.

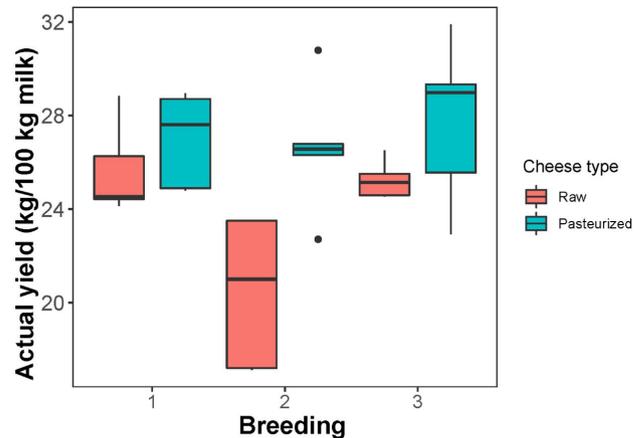


Figure 2. Actual cheese yield of goats in three farms using raw and pasteurized milk. Error bars are 95% confidence intervals.

Table 1. Mean \pm SD of six parameters of the raw pasteurized milk of both goat and cow.

Species	Milk type	Fat (g/L)	Protein (g/L)	Temperature ($^{\circ}$ C)	Acidity ($^{\circ}$ D)	Density (kg/m ³)	pH	N
Goat	Raw	51.3 ± 6.35	36.7 ± 2.25	19.5 ± 1.55	18.2 ± 1.47	1029 ± 1.26	6.74 ± 0.05	15
	Pasteurized	54.1 ± 6.25	38.4 ± 2.22	20.3 ± 1.16	18.3 ± 1.45	1031 ± 1.02	6.67 ± 0.05	15
Cow	Raw	48.6 ± 6.11	30.0 ± 1.68	20.7 ± 1.26	18.7 ± 1.62	1030 ± 1.38	6.77 ± 0.07	25
	Pasteurized	46.8 ± 7.54	31.0 ± 1.40	20.5 ± 0.644	18.8 ± 1.58	1031 ± 1.31	6.72 ± 0.07	25

N = sample size.

3.3 Physicochemical analysis of cheese

The mean \pm SD of ash, moisture, temperature, acidity, dry matter and pH of the raw and pasteurized milk of cow and goat are presented in Table 2. A principal component analysis using

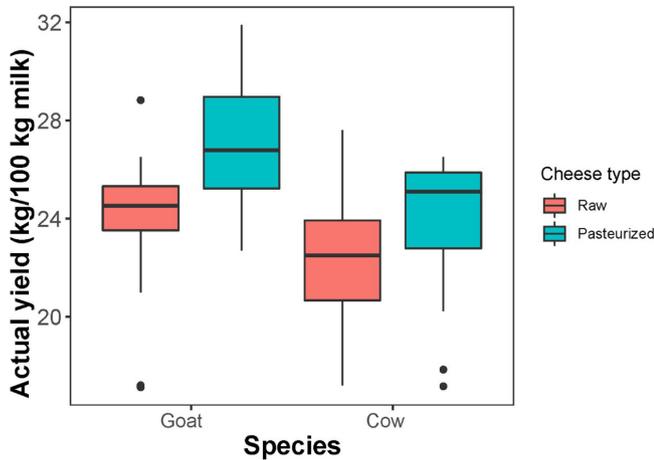


Figure 3. Actual cheese yield of cows and goats using raw and pasteurized milk. Error bars are 95% confidence intervals.

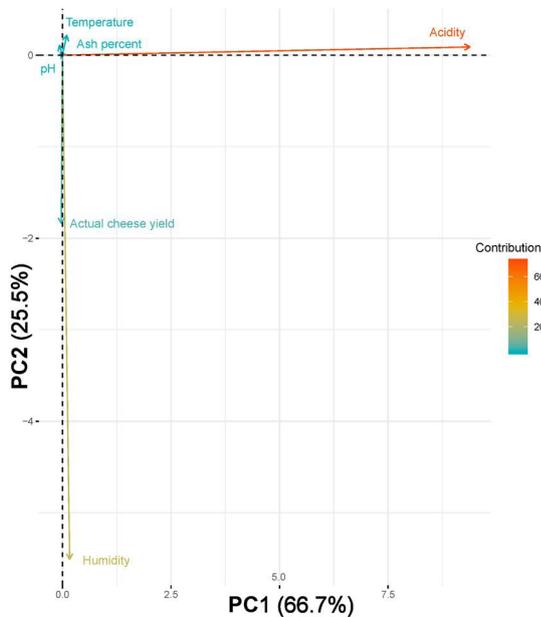


Figure 4. Principal component analysis based on six physicochemical variables, 80 samples of the two species (cow and goat). The percentage of contribution of each variable to the PCs is indicated with colors.

six factors, 80 samples of the two species showed that the two first components explained 92.2% of the variance (Figure 4). PC1 which explained 66.6% of the variance was positively correlated with actual cheese yield ($r = 0.81, p < 0.0001$) and cheese humidity ($r = 0.72, p < 0.0001$), but negatively correlated with pH ($r = -0.33, p = 0.0002$) and ash percent ($r = -0.71, p < 0.0001$). PC2 which explained 25.5% of the variance was highly positively correlated with acidity ($r = 0.91, p < 0.0001$) and weakly negatively correlated with actual cheese yield, pH, humidity and ash percent ($r = -0.30 - -0.23, p < 0.05$). Thus, based on the PCA, our data suggest that humidity was a good explanatory variable for actual cheese yield.

Linear mixed-effects model regressing actual cheese yield against humidity, type of cheese and species (farm as a random effect) showed: (1) no significant effect of species and its interactions with other variables (two and three-way interactions); and (2) no significant effect of type of cheese and its interactions, expect a significant effect in the interaction between humidity and type of cheese ($p = 0.04$) (Table 3). The latter significant interaction indicates that only humidity of pasteurized cheese showed a positive relationship with actual cheese yield in both cows and goats.

However, there was no significant effect in the humidity of cheese between raw and pasteurized milk in both cows (LME: t -value = 0.35, $p = 0.72$) and goats (LME: t -value = 1.79, $p = 0.08$). The average humidity of cow cheese was $61.7 \pm 5.61\%$ using raw milk and $62.3 \pm 7.16\%$ using pasteurized milk, whereas the average humidity of goat cheese was $62.9 \pm 4.05\%$ using raw milk and $65.2 \pm 2.94\%$ using pasteurized milk.

3.4 Comparison between actual and theoretical yield

The theoretical and actual yield were positively correlated in raw and pasteurized cheese of both cows and goats (LM: slope = 1.02 ± 0.18 (\pm SE), $R^2 = 0.48, p < 0.0001$; Figure 5). The comparison between theoretical and actual yield using a linear mixed-effects model with milk sample as a random effect showed that although theoretical yield was on average greater than the actual yield (Table 4; LME, Yield: $p < 0.0001$), this difference occurred only in raw cheese and not in pasteurized cheese (Table 4; LME, Yield \times Cheese: $p = 0.04$) (Figure 6). The difference between theoretical and actual yield in raw cheese was 2.38 ± 2.28 kg in cows and 3.67 ± 2.95 kg in goats, which represent 10.7% and 15.4% of the actual yield in cows and goats, respectively. However, the difference between theoretical and actual yield in pasteurized cheese was 0.57 ± 2.07 kg in cows and 1.49 ± 2.24 kg in goats, which account for 2.41% and 5.48% of the actual yield in cows and goats, respectively.

Table 2. Mean \pm SD of six parameters of the raw pasteurized cheese made from goat and cow milk.

Species	Cheese type	Ash (%)	Moisture (%)	Temperature ($^{\circ}$ C)	Acidity ($^{\circ}$ D)	Dry matter (%)	pH	N
Goat	Raw	0.997 ± 0.25	62.9 ± 4.05	19.9 ± 1.41	46.1 ± 8.45	37.2 ± 4.03	4.60 ± 0.17	15
	Pasteurized	1.04 ± 0.39	65.2 ± 2.94	19.7 ± 1.26	45.7 ± 10.7	35.7 ± 3.37	4.56 ± 0.15	15
Cow	Raw	1.21 ± 0.34	61.7 ± 5.61	19.9 ± 2.11	43.9 ± 10.2	38.3 ± 5.61	4.69 ± 0.12	25
	Pasteurized	1.08 ± 0.45	62.3 ± 7.16	21.1 ± 0.95	46.9 ± 8.49	37.5 ± 7.01	4.55 ± 0.12	25

N = sample size.

Table 3. Summary statistics of the linear mixed-effects model regressing the actual cheese yield against humidity, cheese type, and species.

	Estimate	Std. Error	df	t-value	P-value
Intercept	28.72	9.42	68.71	3.050	0.003
Humidity	-0.08	0.15	67.90	-0.526	0.601
Cheese.type[Pasteurized]	-30.59	16.42	68.18	-1.863	0.067
Species[cow]	-14.99	10.72	68.90	-1.398	0.167
Humidity: Cheese.type[Pasteurized]	0.52	0.25	68.18	2.054	0.044
Humidity: Species[cow]	0.22	0.17	67.90	1.264	0.210
Cheese.type[Pasteurized]: Species[cow]	21.70	17.68	68.24	1.227	0.224
Humidity: Cheese.type[Pasteurized]: Species[cow]	-0.35	0.28	68.25	-1.279	0.205

df = Degrees of freedom.

Table 4. Summary statistics of the linear mixed-effects model comparing the actual with theoretical yield in raw and pasteurized cheese of both cows and goats.

	Estimate	Std. Error	df	t value	P-value
Intercept	23.7913	0.6271	33.7405	37.941	< 2e-16
Yield[Theoretical]	3.6687	0.7648	148.00	4.797	3.89e-06
Species[Cow]	-1.6121	0.6840	148.00	-2.357	0.0197
Cheese[Pasteurized]	3.3293	0.7648	148.00	4.353	2.49e-05
Yield[Theoretical]:Species[Cow]	-1.2895	0.9674	148.00	-1.333	0.1846
Yield[Theoretical]: Cheese [Pasteurized]	-2.1833	1.0816	148.00	-2.019	0.0453
Species [Cow]: Cheese [Pasteurized]	-1.5221	0.9674	148.00	-1.573	0.1177
Yield[Theoretical]: Species[Cow]:Cheese[Pasteurized]	0.3813	1.3681	148.00	0.279	0.7808

df = Degrees of freedom.

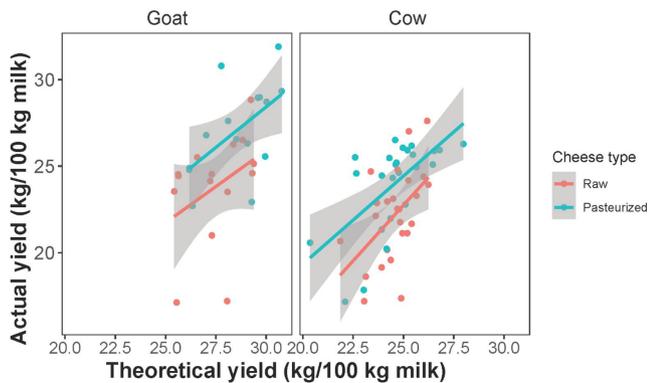


Figure 5. Relationship between actual and theoretical yield in raw and pasteurized cheese of both cows and goats. Regression lines are derived from a linear model that was fit independently for each group. The ribbons around regression lines represent standard error.

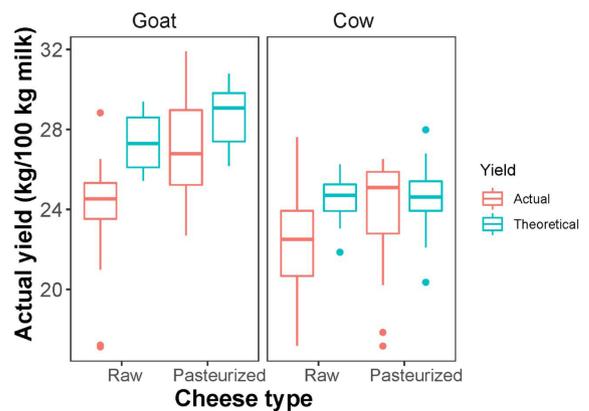


Figure 6. Comparison between actual and theoretical yield in raw and pasteurized cheese of both cows and goats. Error bars are 95% confidence intervals.

4 Discussion

Here, we assess the difference in the cheese yield using raw and pasteurized milk of cows and goats and it reveals that (1) in both cows and goats, pasteurized cheese had higher yield than raw cheese; (2) actual cheese yield was best explained by moisture content; and (3) although actual and theoretical yield were positively correlated, they presented a significant difference using raw milk but no difference using pasteurized milk.

Cheese yield is influenced by different factors divided into two groups: *i*) milk quality, which depends essentially on the animal breed, species, genetic variants of proteins, lactation stage, feeding system, animal management, and environmental

conditions; *ii*) cheese-making processes as cold storage of milk, heat treatment, standardization, coagulation, curd cutting and cooking, draining, pressing, and salting or ripening (Lucey & Kelly, 1994). Our results showed that pasteurized cheese produced more actual yield than the raw cheese in both cows and goats. Similar findings were found in other studies on different kinds of cheeses, namely in Cheddar cheese with 10.32% vs. 10.56% (San Martín-González et al., 2007) and 10.13 vs. 10.21% under 63 °C for 30 min) (Lau et al., 1990) and in Mashanza cheese in Africa with 29.30 vs. 30.95% (under 72 °C for 15s (Salwa & Galal, 2002)). Other studies that used pasteurization at 72 °C showed no difference in actual yield between raw and pasteurized cheese (10.6 vs. 10.5%) (Drake et al., 1997). The increased yield

in pasteurized cheese is probably, due to the higher cheese moisture retention which is known to increase in pasteurized milk leads to higher recovery of whey proteins and soluble solids (Goff, 2008; Lucey & Kelly, 1994). The other main finding of this study is that there was an interspecific difference in cheese yield between cows and goats. While some studies show that cheese yield is higher in cows than goat (Rasheed et al., 2016), our study and others show the opposite (Hamidi et al., 2018; Mallatou & Pappa, 2005). Different factors might produce this difference, including those related to the milk composition and quality such as genetic variants of casein, fat and protein (Banks et al., 1981; Fenelon & Guinee, 1999; Verdier-Metz et al., 2001) and cheese-processing methodology (Lawrence, 1993). Here, we found higher fat and protein content in goat milk, which probably contributed to the increase in cheese yield (Lucey & Kelly, 1994). Hamidi et al. (2018) found lower fat content in goat than cow's milk in semiarid regions of Algeria, in these regions plants abundance and richness are very low. These differences in cheese yield and milk content are of interest to the local and regional cheesemakers (North Africa) where such information is still not well known and goat cheese-making is still a minority. Moisture content is one of the key factors that determine the cheese yield (Banks et al., 1981; Emmons et al., 2001). Our results showed that pasteurized cheese had more water content than raw cheese in both cows and goats, which could to some, explain the higher yield in pasteurized cheese. It has been shown that cheese moisture retention increases with increasing temperature of milk pasteurization. Higher moisture reflects higher recovery of whey solids and salt in the cheese. In addition, a 1% increase in moisture result in a 1.8% increase in Cheddar cheese yield; in other words, 90 kg cheese/1000 kg milk, a moisture adjustment to 36% would result in 91.6 kg cheese/1000 kg milk (Hill, 2016).

Several studies have investigated the physico-chemical parameters of milk in Algeria (Bachtarzi et al., 2015; Djouza & Chehma, 2018; Elhadj et al., 2015; Mahieddine et al., 2017; Matallah et al., 2017), Africa (Kra et al., 2013; Soliman, 2005), Europe (Desjeux, 1993) and elsewhere in the world (Jenness, 1980). Due to difference in race, diet, and life style, we restricted our comparison with Algerian studies of milk and cheese. For instance, the study of Matallah et al. (2017) showed similar results to ours for cow raw milk from El Taref province with an average pH of 6.7 ± 0.07 vs. 6.5 ± 0.07 , acidity of $18.9 \pm 1.11^\circ\text{D}$ vs. $18.7 \pm 1.62^\circ\text{D}$, density of 1030 ± 2.78 vs. 1030.138 , protein content of 32.8 ± 4.32 g/L vs. 30.0 ± 1.68 g/L, but a lower fat content of 32.8 ± 4.32 g/L vs. 48.6 ± 6.11 g/L. Similarly, Elhadj et al. (2015) who conducted study on the raw milk of central Algerian farms from Tissemsilt province reported an average pH of 6.48 ± 0.18 , acidity $20.21 \pm 1.19^\circ\text{D}$, density of 1029.7 ± 0.75 kg/m³, but a lower fat content of 25.14 ± 2.88 g/L. Moreover, our results on physico-chemical parameters of goat raw milk compared to a study carried out on four provinces (Guelma, Souk Ahras, Annaba and El Taref) (Mahieddine et al., 2017) showed results that fall within the range of values for the acidity [16.83 - 20.71°D], fat [32.01 - 60.00 g/L], lower for pH [6.97 - 7.23], but greater for density [1025 - 1027 kg/m³] and protein [28.7 - 31.23 g/L]. Furthermore, a study in the Kabylie region in highlands of central-North Algeria showed higher density (1032 ± 0.06 kg/m³), fat (61.6 ± 2.64 g/L) and protein (69.8 ± 5.61 g/L). This could

be due to the higher plant species richness and abundance in alpine areas (Manganelli et al., 2001).

In summary, our study assessing the effect of pasteurization on yield of cow's and goat's cheese reveals that using pasteurized milk increases yield through an increased moisture content of the cheese. Moreover, goat milk produces higher cheese yield than cow milk, showing higher protein and fat content. These results are of primary important for local and region milk and cheese industry, particularly for goat whose cheese production has received more local attention in recent years. These results show the importance of the techniques used in the dairy industry, in particular, the heat treatment. Raw milk pasteurization has not only a positive effect on cheese yield but also protects consumer following the elimination of pathogenic flora. It can also increase more profits for the farmers following milk transformation and cheese yield increasing.

Although yield was higher in pasteurized cheese, there are other components such as vitamins and enzymes that might be ruptured during the heating process; an aspect that warrant investigation. Finally, further studies should assess the microbiological quality of the two types of milks in both species and determine the best conditions under which each type of cheese should be produced and conserved.

Acknowledgements

This work is part of the research activity carried out within the "Dairy production: Optimization of production techniques, valorization and quality control" project funded by the Algerian Ministry of Higher Education and Scientific Research, grant agreement n^o: D00L01UN240120180001. We thank the breeders from different county and different farms who gave the milk necessary for the realization of this study.

References

- Alegbeleye, O. O., Guimarães, J. T., Cruz, A. G., & Sant'Ana, A. S. (2018). Hazards of a 'healthy' trend? An appraisal of the risks of raw milk consumption and the potential of novel treatment technologies to serve as alternatives to pasteurization. *Trends in Food Science & Technology*, 82, 148-166. <http://dx.doi.org/10.1016/j.tifs.2018.10.007>.
- Amariglio, S. (1986). *Contrôle de qualité des produits laitiers* (3ème éd.). Paris: AFNOR.
- Arora, R., Bhojak, N., & Joshi, R. (2013). Comparative aspects of goat and cow milk. *International Journal of Engineering Science Invention*, 2(1), 7-10.
- Association of Official Analytical Chemists – AOAC. (1995). *Official method 926.08: moisture in cheese* (16th ed.). Maryland: AOAC.
- Bachtarzi, N., Amourache, L., & Dehkal, G. (2015). Qualité du lait cru destiné à la fabrication d'un fromage à pâte molle type Camembert dans une laiterie de Constantine (Est Algérien). *International Journal of Innovation and Scientific Research*, 17(1), 34-42.
- Banks, J. M., Muir, D., Banks, W., & Wilson, A. (1981). Cheese yield: composition does matter. *Dairy Industries International*, 46, 15.
- Beuviel, E., Berthaud, K., Cegarra, S., Dasen, A., Pochet, S., Buchin, S., & Duboz, G. (1997). Ripening and quality of Swiss-type cheese made from raw, pasteurized or microfiltered milk. *International*

- Dairy Journal*, 7(5), 311-323. [http://dx.doi.org/10.1016/S0958-6946\(97\)00015-0](http://dx.doi.org/10.1016/S0958-6946(97)00015-0).
- Boudalia, S., Benati, D., Boukharoub, R., Chemakh, B., & Chemmam, M. (2016). Physico-chemical properties and hygienic quality of raw and reconstituted milk in the region of Guelma-Algeria. *International Journal of Agricultural Research*, 11(2), 77-83. <http://dx.doi.org/10.3923/ijar.2016.77.83>.
- Casalta, E., Sorba, J.-M., Aigle, M., & Ogier, J.-C. (2009). Diversity and dynamics of the microbial community during the manufacture of Calenzana, an artisanal Corsican cheese. *International Journal of Food Microbiology*, 133(3), 243-251. <http://dx.doi.org/10.1016/j.ijfoodmicro.2009.05.022>. PMID:19545924.
- Desjeux, J. (1993). Valeur nutritionnelle du lait de chèvre. *Le Lait*, 73(5-6), 573-580. <http://dx.doi.org/10.1051/lait:19935-655>.
- Djouza, L., & Chehma, A. (2018). Production characteristics of Arabia goats in Biskra wilayah, Algeria. *Livestock Research for Rural Development*, 30(7). Retrieved from <http://www.lrrd.org/lrrd30/37/loub30113.html>
- Drake, M., Harrison, S., Asplund, M., Barbosa-Canovas, G., & Swanson, B. (1997). High pressure treatment of milk and effects on microbiological and sensory quality of Cheddar cheese. *Journal of Food Science*, 62(4), 843-860. <http://dx.doi.org/10.1111/j.1365-2621.1997.tb15468.x>.
- Elhadj, T., Samira, B., Messaouda, H., & Nassira, B. (2015). Etude de la qualité physico-chimique et microbiologique de laits crus de vache dans deux fermes de la wilaya de Tissemsilt (Algérie). *Revue ElWahat pour les Recherches et les Etudes*, 8(2), 26-33.
- Emmons, D. B., Bradley, R. L. Jr., Sauvé, J. P., Campbell, C., Lacroix, C., & Jimenez-Marquez, S. A. (2001). Variations of moisture measurements in cheese. *Journal of AOAC International*, 84(2), 593-604. PMID:11324628.
- Fenelon, M., & Guinee, T. (1999). The effect of milk fat on Cheddar cheese yield and its prediction, using modifications of the Van Slyke cheese yield formula. *Journal of Dairy Science*, 82(11), 2287-2299. [http://dx.doi.org/10.3168/jds.S0022-0302\(99\)75477-9](http://dx.doi.org/10.3168/jds.S0022-0302(99)75477-9).
- Goff, H. D. (2008). *Dairy science and technology education series*. Guelph: University of Guelph. Retrieved from <http://foodsci.aps.uoguelph.ca/dairyedu/grading.html>
- Grappin, R., & Beuvier, E. (1997). Possible implications of milk pasteurization on the manufacture and sensory quality of ripened cheese. *International Dairy Journal*, 7(12), 751-761. [http://dx.doi.org/10.1016/S0958-6946\(98\)00006-5](http://dx.doi.org/10.1016/S0958-6946(98)00006-5).
- Hamidi, M., Hachi, M., Lahrech, A., & Choukri, A. (2018). Production fromagère par un extrait de kaolin du gésier de poulet avec du lait de vache, de brebis ou de chèvre dans la steppe Algérienne. *Livestock Research for Rural Development*, 30(11). Retrieved from <http://www.lrrd.org/lrrd30/11/med.h30192.html>
- Hill, A. R. (2016). *Cheese making technology*. Guelph: University of Guelph. eBook.
- Jenness, R. (1980). Composition and characteristics of goat milk: review 1968-1979. *Journal of Dairy Science*, 63(10), 1605-1630. [http://dx.doi.org/10.3168/jds.S0022-0302\(80\)83125-0](http://dx.doi.org/10.3168/jds.S0022-0302(80)83125-0).
- Jørgensen, C. E., Abrahamsen, R. K., Rukke, E.-O., Hoffmann, T. K., Johansen, A.-G., & Skeie, S. B. (2019). Processing of high-protein yoghurt: a review. *International Dairy Journal*, 88, 42-59. <http://dx.doi.org/10.1016/j.idairyj.2018.08.002>.
- Kousta, M., Mataragas, M., Skandamis, P., & Drosinos, E. H. (2010). Prevalence and sources of cheese contamination with pathogens at farm and processing levels. *Food Control*, 21(6), 805-815. <http://dx.doi.org/10.1016/j.foodcont.2009.11.015>.
- Kra, K., Mégnanou, R., Akpa, E., Assidjo, N., & Niamké, L. (2013). Evaluation of physico-chemical, nutritional and microbiological quality of raw cow's milk usually consumed in the central part of Côte d'Ivoire. *African Journal of Food, Agriculture, Nutrition and Development*, 13(3), 7888-7904.
- Lau, K. Y., Barbano, D. M., & Rasmussen, R. R. (1990). Influence of pasteurization on fat and nitrogen recoveries and cheddar cheese yield. *Journal of Dairy Science*, 73(3), 561-570. [http://dx.doi.org/10.3168/jds.S0022-0302\(90\)78703-6](http://dx.doi.org/10.3168/jds.S0022-0302(90)78703-6).
- Lawrence, R. (1993). *Processing conditions: factors affecting the yield of cheese* (pp. 64-78). Brussels: International Dairy Federation.
- Leksir, C., & Chemmam, M. (2015). Contribution on the characterization of Klila, a traditional cheese in east of Algeria. *Livestock Research for Rural Development*, 27(5).
- Leksir, C., Boudalia, S., Moujahed, N., & Chemmam, M. (2019). Traditional dairy products in Algeria: case of Klila cheese. *Journal of Ethnic Foods*, 6(1), 7. <http://dx.doi.org/10.1186/s42779-019-0008-4>.
- Lucey, J., & Kelly, J. (1994). Cheese yield. *International Journal of Dairy Technology*, 47(1), 1-14. <http://dx.doi.org/10.1111/j.1471-0307.1994.tb01264.x>.
- Mahieddine, B., Feknous, N., Farah, M., Dalichaouche, N., Ines, F., Lynda, T., et al. (2017). Caractérisation du lait de chèvre produit dans la région du Nord-Est Algérien: essai de fabrication du fromage frais. *Algerian Journal of Natural Products*, 5(2), 492-506.
- Mallatou, H., & Pappa, E. (2005). Comparison of the characteristics of teleme cheese made from ewe's, goat's and cow's milk or a mixture of ewe's and goat's milk. *International Journal of Dairy Technology*, 58(3), 158-163. <http://dx.doi.org/10.1111/j.1471-0307.2005.00204.x>.
- Manganelli, R. U., Camangi, F., & Tomei, P. (2001). Curing animals with plants: traditional usage in Tuscany (Italy). *Journal of Ethnopharmacology*, 78(2-3), 171-191. [http://dx.doi.org/10.1016/S0378-8741\(01\)00341-5](http://dx.doi.org/10.1016/S0378-8741(01)00341-5). PMID:11694363.
- Matallah, S., Matallah, F., Djedidi, I., Mostefaoui, K. N., & Boukhris, R. (2017). Qualités physico-chimique et microbiologique de laits crus de vaches élevées en extensif au Nord-Est Algérien. *Livestock Research for Rural Development*, 29(11). Retrieved from <http://www.lrrd.org/lrrd29/11/said29211.html>
- Mituniewicz-Małek, A., Zielińska, D., & Ziarno, M. (2019). Probiotic monocultures in fermented goat milk beverages – sensory quality of final product. *International Journal of Dairy Technology*, 72(2), 240-247. <http://dx.doi.org/10.1111/1471-0307.12576>.
- Montel, M.-C., Buchin, S., Mallet, A., Delbes-Paus, C., Vuitton, D. A., Desmases, N., & Berthier, F. (2014). Traditional cheeses: Rich and diverse microbiota with associated benefits. *International Journal of Food Microbiology*, 177, 136-154. <http://dx.doi.org/10.1016/j.ijfoodmicro.2014.02.019>. PMID:24642348.
- R Development Core Team (2018). *R: a language and environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.
- Ranadheera, C. S., Evans, C. A., Baines, S. K., Balthazar, C. F., Cruz, A. G., Esmerino, E. A., Freitas, M. Q., Pimentel, T. C., Wittwer, A. E., Naumovski, N., Graça, J. S., Sant'Ana, A. S., Ajlouni, S., & Vasiljevic, T. (2019). Probiotics in goat milk products: delivery capacity and ability to improve sensory attributes. *Comprehensive Reviews in Food Science and Food Safety*, 18(4), 867-882. <http://dx.doi.org/10.1111/1541-4337.12447>.
- Rasheed, S., Qazi, I. M., Ahmed, I., Durrani, Y., & Azmat, Z. (2016). Comparative study of cottage cheese prepared from various sources of milk. *Proceedings of the Pakistan Academy of Sciences*, 53(4), 269-282.

- Rhiat, M., Labioui, H., Driouich, A., Mennane, Z., & Ouhssine, M. (2013). Preparation of the starter Trial production of cheese (Jben) and Klila at laboratory scale. *Food Science and Quality Management*, 13, 1-8.
- Salwa, A. A., & Galal, E. A. (2002). Effect of milk pretreatment on the keeping quality of domiati cheese. *Pakistan Journal of Nutrition*, 1(3), 132-136. <http://dx.doi.org/10.3923/pjn.2002.132.136>.
- San Martín-González, M., Rodríguez, J., Gurrám, S., Clark, S., Swanson, B., & Barbosa-Cánovas, G. (2007). Yield, composition and rheological characteristics of cheddar cheese made with high pressure processed milk. *Lebensmittel-Wissenschaft + Technologie*, 40(4), 697-705. <http://dx.doi.org/10.1016/j.lwt.2006.03.022>.
- Shori, A. B. (2017). Camel milk and its fermented products as a source of potential probiotic strains and novel food cultures: a mini review. *PharmaNutrition*, 5(3), 84-88. <http://dx.doi.org/10.1016/j.phanu.2017.06.003>.
- Soliman, G. Z. (2005). Comparison of chemical and mineral content of milk from human, cow, buffalo, camel and goat in Egypt. *The Egyptian Journal of Hospital Medicine*, 21, 116-130.
- Verdier-Metz, I., Coulon, J.-B., & Pradel, P. (2001). Relationship between milk fat and protein contents and cheese yield. *Animal Research*, 50(5), 365-371. <http://dx.doi.org/10.1051/animres:2001138>.
- Verraes, C., Vlaemynck, G., Van Weyenberg, S., De Zutter, L., Daube, G., Sindic, M., Uyttendaele, M., & Herman, L. (2015). A review of the microbiological hazards of dairy products made from raw milk. *International Dairy Journal*, 50, 32-44. <http://dx.doi.org/10.1016/j.idairyj.2015.05.011>.
- Verruck, S., Dantas, A., & Prudencio, E. S. (2019). Functionality of the components from goat's milk, recent advances for functional dairy products development and its implications on human health. *Journal of Functional Foods*, 52, 243-257. <http://dx.doi.org/10.1016/j.jff.2018.11.017>.
- Waser, M., Michels, K. B., Bieli, C., Flöistrup, H., Pershagen, G., Von Mutius, E., Ege, M., Riedler, J., Schram-Bijkerk, D., Brunekreef, B., van Hage, M., Lauener, R., & Braun-Fahrländer, C. (2007). Inverse association of farm milk consumption with asthma and allergy in rural and suburban populations across Europe. *Clinical and Experimental Allergy*, 37(5), 661-670. <http://dx.doi.org/10.1111/j.1365-2222.2006.02640.x>. PMID:17456213.
- Yoon, Y., Lee, S., & Choi, K.-H. (2016). Microbial benefits and risks of raw milk cheese. *Food Control*, 63, 201-215. <http://dx.doi.org/10.1016/j.foodcont.2015.11.013>.