




Characterization of traditional Algerian cheese “*Bouhezza*” prepared with raw cow, goat and sheep milks

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Abstract

“*Bouhezza*” is an Algerian traditional fermented soft-ripened cheese, found and consumed in the Northeast of Algeria. The objective of this study was to explore the preparation process (traditional making diagram) of “*Bouhezza*” cheese and to study the effect of the type of raw milk (cow, goat and sheep) on the yield and organoleptic characteristics of the fresh “*Bouhezza*” cheese. “*Bouhezza*” cheese was handmade in a traditional way using milk of three species (cow, goat and sheep). The milk used has been the subject of physicochemical and bacteriological analysis. Cheese yield for sheep’s milk is higher ($p < 0.05$) than cheese yield for cow’s and sheep’s milk. For sensory analysis, score registered for cheese of cow’s milk ≥ 5 suggested higher acceptability for this cheese. Here, we exposed the “*Bouhezza*” cheese, its history, origin and manufacturing processes. From the physicochemical and bacteriological analysis of milk, results show that all criteria analyzed respond almost to the required standard. The sensory qualities of the three types of cheese show that cow cheese was classified as the most satisfactory cheese for the majority of criteria (taste, color and texture). Finally, and for higher yield, results supported the use of sheep milk as a raw material.

Keywords: traditional cheese; “*Bouhezza*”; bacteriological criteria; physicochemical parameters; sensory evaluation.

Practical Application: Algerian “*Bouhezza*” cheese: his history, origin manufacturing processes and characteristics.

1 Introduction

Traditional products are considered as a very important way to keep the regional and national identity of peoples. We meet traditional recipes handed down from generation to generation, challenging time and space. Among these products, traditional cheeses are one of the food product that have become the image of different countries or region of origin, they differ from each other by their making process, ripening time (if applied), type of milk used, texture, color, flavor, coagulation type (enzymatic and/or acid)...etc. Among these traditional cheeses we can cite “*Klila*” chesses produced in Algeria (Leksir et al., 2019; Leksir & Chemmam, 2015); “*Roquefort*”, “*Cheddar*”, “*Emmental*”, “*Camembert*”, “*Parmesan*” and “*Picodon*” produced in France (Bertozzi & Panari, 1993; Leclercq-Perlat et al., 2019; Quetier et al., 2005); “*Maraj’ o*” cheese, “*Manteiga*”, “*Coalho*”, “*Caipira*”, “*Canastra*” and “*Minas*” cheeses produced in Brazil (Moraes et al., 2018; Sant’Anna et al., 2017; Kamimura et al., 2019); “*Quesillo*” cheese produced in Argentina (Oliszewski et al., 2007); “*Vlasina*” cheese produced in Serbia (Terzic-Vidojevic et al., 2013); “*Anevato*” cheese produced in Greece (Hatzikamari et al., 1999); “*Chihuahua*” cheese produced in Mexico (Sánchez-Gamboa et al., 2018) and “*Babia-Laciana*” cheese produced in Spain (Franco et al., 2003).

Unlike other countries, in Algeria traditional cheeses are few in number but not fully enumerated and as little been studied (Dubeuf et al., 2010); about ten types of cheese are known in different regions of the country (Aissaoui Zitoun et al., 2011). Among these cheeses are “*klila*”, “*bouhezza*”, “*mechouna*” and “*madghissa*”, in the region of Chaouia, “*takammérite*” and “*aoules*” in the south, “*igounanes*” in the region of Kabylie (Aissaoui Zitoun et al., 2011, 2012; Ben Danou, 1929; Benamara et al., 2016; Benkerroum, 2013; Khoualdi, 2017; Leksir & Chemmam, 2015; Licitra et al., 2019; McSweeney et al., 2017; Medjoudj et al., 2017a, b; Ramalho Ribeiro et al., 2006).

Unfortunately, several of these cheeses are endangered, for various reasons including the unavailability of fodder, rural exodus and changing dietary habits. We do not know the future of these products, but we must do everything possible to know them, maintain their existence and encourage their manufacture. The preparation processes of these cheeses come from earlier generations and have been passed down from generation to generation (Leksir et al., 2019). So, registration of different information about traditional cheeses is part of the preservation of a nation’s culinary heritage and culture which must be well characterized and protected. Also, the certification

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of a geographical indication “Protected Designation of Origin PDO) for these artisanal cheeses may encompass an essential milestone for adding value and, an economic resource for farmers (Kamimura et al., 2019).

“*Bouhezza*” cheese has long been known in the Chaouia region of eastern Algeria. It is made from goat, sheep, cow milk or mixture (Marino et al., 2012; Medjoudj et al., 2017a, b) and considered not only as a food product but also as an integral part of “*Chaouias*” people life. The manufacture of “*Bouhezza*” has the particularity of involving coagulation, draining, salting and refining simultaneously. The cheese is obtained after transformation of the “*Lben*” in a “*skinbag*” or a “*Chekoua*” made of goatskin previously treated with salt and juniper (Aissaoui Zitoun et al., 2011). “*Chekoua*” serves, at first sight, container and media filtering for sewage (Aissaoui Zitoun et al., 2011, 2012; Chaker, 1986). Outsidess, these elements, it is scientifically poorly studied. The current study deals with the traditional preparation of “*Bouhezza*” by the people of “*Chaouias*” (traditional making diagram) and at the same time explore the effect of the type of raw milk of three species (cow, goat and sheep) on the yield and organoleptic characteristics of the fresh “*Bouhezza*” cheese.

2 Materials and methods

2.1 Study area and sampling plan

The samples are collected from four areas located in the in North-East of Algeria (Guelma, Souk Ahras and Tébessa) and in the center of Algeria: (Djelfa) (Figure 1). A total of 27 samples of raw milk of three species (goat, cow, and sheep) were collected and used for cheese making. From each farm, about 1.5-2 L were taken in sterile glass bottles and placed immediately in a cooler, then transported to the laboratory, where they are stored at 4 °C until analysis and cheese making. All bottles are previously autoclaved at a temperature of 121 °C, under a pressure of 1 bar for 15 minutes.

The vials are filled from a container of mixing milk, respecting the Good Laboratory Practices (GLP), and the rules of asepsis (disinfection of the hands). In order to take account of the real field conditions, no conservative was added. Total volumes of 20-50 mL from each sample were collected for microbiological physicochemical analysis.

2.2 Raw milk analysis

Physicochemical and bacteriological analysis

For physicochemical analysis, pH was measured using a pH meter Adwa, AD1000 and acidity was determined according to the method described by Tadjine et al. (2019). Freezing point, conductivity, fat content, protein content, lactose content, mineral content and vitamins of milk were measured with a Lactoscan milk analyzer (Milkotronic LTD Europe) according to the manufacturer’s instructions.

For bacteriological analysis, samples preparation and dilutions were performed according to the recommendations of the International Dairy Federation (1991): 1) The Total Mesophilic Aerobic Flora (TMAF) was enumerated using Plate Count Agar (PCA) and incubated at 30 °C for 72 h; 2) The Total Coliforms and Fecal Coliforms were determined using Violet Red Lactose Bile agar (VRBL) incubated at 37 °C for total coliforms, and 44 °C for fecal coliforms; 3) Sulphite Reducing *Clostridium* was determined using enrichment method in a liquid medium; 4) The enumeration of Staphylococci suspected pathogens was conducted using a selective medium (Chapman) and incubated at 37 °C for 24 to 48 hours. A positive culture of Staphylococci is indicated by the formation of a black precipitate surrounded by a white halo; 5) For *Salmonella*, two mediums were used to enumerate the colonies: Selenite-Cystine for enrichment at 37 °C for 12 h, and SS medium (*Salmonella-Shigella*) for isolation at 37 °C for 24 h. *Salmonella* appears like colorless and transparent colonies with or without a black center of small size (2 to 4 mm in diameter).

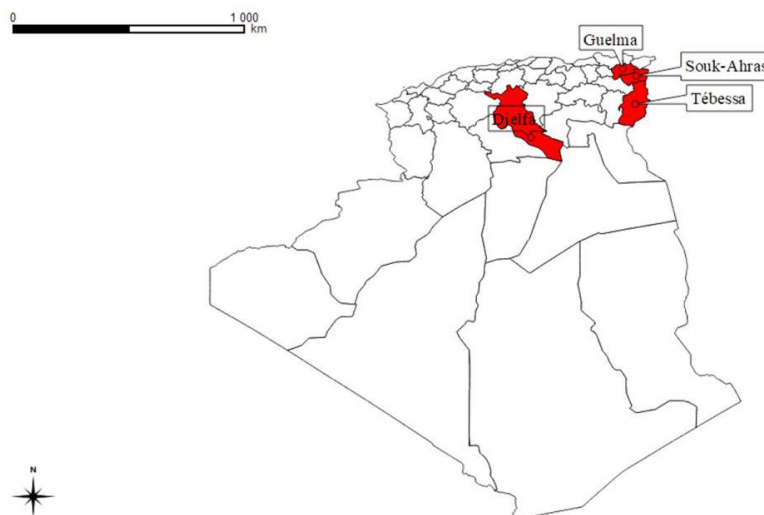


Figure 1. Location map of the study area. Milk samples are collected from four areas located in the North East of Algeria (Guelma, Souk Ahras and Tébessa) and in the center of Algeria: (Djelfa). Raw milk of three species (goat, cow, and sheep) were collected and used for “*Bouhezza*” cheese making.

2.3 Data collection about the traditional preparation of “*Bouhezza*”

A household survey focused on group discussion was performed in this study (Ghosh et al., 2014; Leksir et al., 2019). The present documentation of “*Bouhezza*” preparation is based on the questionnaires and insight observation from farmers. A total of 45 people including producers, sellers, and consumers were involved in the interviews and discussions, after taking their prior consent. The survey was conducted through face-to-face interaction to either heads or knowledgeable adults of households. During the data collection on “*Bouhezza*”, especially while conducting the interviews, observations were made and the comments of responders and other people were noted.

The research protocol for the sensory study and the household survey have been developed and validated by the ethics committee of the University of Guelma-Algeria.

2.4 Cheese making

The raw milk is left at room temperature, until its spontaneous coagulation that takes 24 to 72 hours depending on the seasonal temperature. This curdled milk by natural fermentation is called “*Rayeb*” (or *Raïb*). Then “*Rayeb*” must be churned for 30 to 40 minutes to make the “*Lben*” in the the “*Chekoua*”. The addition of lukewarm water to the “*Raïb*” (about 10% (v/v)) makes it possible to reduce the temperature to the proper level to collect the grains of butter. After partial extraction of the traditional butter (*Zebda Beldia*), one obtains a thick liquid, the buttermilk named “*Lben*”.

After thorough conversation and field observation, “*Bouhezza*” preparation stretches over a period of eight days, and it can be broadly divided into the following steps: salting is done in the “*Lben*”. The added amount is an average of 1 tablespoon/L. The “*Chekoua*”, in which the “*Lben*” is introduced (a quantity of 3.6 to 3.8 L) is suspended in a ventilated place and in the shade. Once the cheese is refined, the raw milk (100 mL/4 L) is added to adjust the acidity and salinity of the finished product. Cheese was stored in pottery jars/ glass or food containers for a few weeks at a temperature that varies between 4 °C and 8 °C.

2.5 Real yields in cheese, dairy whey and butter

After each series of production, the amount of whey, butter, and cheese is measured in order to calculate the yield using the Equation 1 (Tadjine et al., 2019).

$$\text{Real yield of cheese (butter or whey)} = \frac{\text{The weight of cheese obtained (kg)}}{\text{volume of milk (L)} \times 100 \text{ (in kg / 100 L)}} \quad (1)$$

2.6 Sensory analysis

In order to obtain basic information about the sensory characteristics of “*Bouhezza*” cheese, a consumer acceptability test was conducted using 9 point unstructured hedonic scale (Boudalia et al., 2016b; Oliveira et al., 2017; Ruvalcaba-Gómez et al., 2020); a randomized panel consisting of 20 students, and teachers-researchers of both sexes from University of 8 Mai 1945 Guelma: 91% of people are under the age of 30 years old, and 9% between 30 to 45 years old.

The following five sensory characteristics were selected for evaluation, overall appreciation, taste, texture, smell and color. They were scored from 1 (dislike extremely) to 9 (like extremely). The overall assessment is requested at the beginning of the questionnaire to get as close as possible to the real conditions of purchase and to prevent the consumer from decomposing the sensations. Additional information on the sex, age and frequency of consumption of cheeses is also required to enable the characterization of the sample population interviewed.

Cheese is considered acceptable (from a hedonic point of view) if at least 50% of our participants give a score greater than or equal to 6 (likes slightly) (Conti-Silva et al., 2011; Volpini-Rapina et al., 2012).

Prior to the start of testing, all participants spread to questions about possible food allergies to cheese components (milk protein). Then, the cheese (40 g), which was freshly prepared, placed in plastic plates, then presented to the panelist for tasting. Participants answered questionnaires (Sęczyk et al., 2016). The questionnaires duly completed by the tasters were removed at the end of the evaluation and the data was organized and processed.

The research protocol for the sensory study and the household survey have been developed and validated by the ethics committee of the University of Guelma-Algeria.

2.7 Statistical analysis

The results of the physicochemical analysis, cheese yield, as well as the results of the sensory analysis, are expressed in the form of means \pm SEM (Standard Error Mean). The differences between the different parameters are the subject of an analysis of variance (ANOVA) followed by a comparison of means (Dunnet test or Tukey test) when the conditions of normality and homogeneity of the variances are respected (test Kolmogorov-Smirnov), and possibly a non-parametric analysis of variance (Kruskal-Wallis). For bacteriological analyses, results were expressed by the presence or absence of germs. All the colonies were counted as Colony Forming Units per mL of milk (CFU/mL) (International Dairy Federation, 1991).

For sensory analysis, statistical analysis of the data was analyzed on the basis of a two-factor analysis of variance (ANOVA) “hedonic score vs. cheese, sex”, considering “sex” and “cheese” as independent variables. “sex \times cheese” interactions are also reported.

The data was processed using Minitab software (Minitab, Ltb., United Kingdom, Version 16). The minimum threshold of significance retained is $p < 0.05$.

3 Results and discussion

3.1 Physicochemical and bacteriological qualities of raw milk

Results from physicochemical and bacteriological analyses of raw milk for the three species presented respectively in Tables 1 and 2 satisfy the standard of analyzes criteria (Food and Agriculture Organization of the United Nations, 2002).

Table 1. Physicochemical qualities of the analyzed samples (N = 27 samples).

Parameters	Species	Mean	SEM	CV (%)	Min	Max
Fat content (%)	Cow	3.28 ^a	0.08	7.18	3.00	3.58
	Goat	3.23 ^a	0.09	8.36	2.81	3.80
	Sheep	1.82 ^b	0.08	13.44	1.57	2.30
Protein content (%)	Cow	3.13 ^b	0.20	18.69	2.44	4.15
	Goat	3.05 ^b	0.32	31.48	1.98	4.74
	Sheep	4.63 ^a	0.05	2.93	4.49	4.87
Lactose (%)	Cow	4.70 ^a	0.29	18.65	3.67	6.23
	Goat	2.97 ^b	0.29	29.33	1.89	4.50
	Sheep	4.30 ^a	0.07	4.63	3.90	4.62
Minerals and Vitamins (%)	Cow	0.70 ^a	0.04	18.69	0.55	0.93
	Goat	0.50 ^b	0.05	28.85	0.32	0.75
	Sheep	0.73 ^a	0.01	3.31	0.70	0.77
Dry Degreased Extract (%)	Cow	8.55 ^a	0.53	18.60	6.67	11.33
	Goat	6.61 ^b	0.65	29.28	4.21	10.01
	Sheep	9.77 ^a	0.10	3.13	9.40	10.28
Added Water (%)	Cow	3.62 ^b	2.11	174.46	0.00	18.44
	Goat	25.79 ^a	7.24	84.21	0.00	56.53
	Sheep	0.00 ^b	0.00	0.00	0.00	0.00
pH	Cow	6.48 ^a	0.06	2.93	6.00	6.63
	Goat	6.63 ^{ab}	0.03	1.18	6.52	6.78
	Sheep	6.71 ^b	0.08	3.65	6.26	7.05
Density (mg.cm ⁻³)	Cow	1031.90 ^a	2.11	0.61	1024.90	1042.80
	Goat	1022.7 ^b	2.48	0.73	1013.00	1035.50
	Sheep	1033.10 ^a	1.36	0.39	1023.20	1035.90
Freezing point (°C)	Cow	-0.55 ^b	0.04	-20.57	-0.75	-0.42
	Goat	-0.38 ^a	0.04	-33.37	-0.58	-0.23
	Sheep	-0.56 ^b	0.01	-4.74	-0.60	-0.52
Conductivity (µS.cm ⁻¹)	Cow	4.94 ^a	0.25	15.15	4.03	5.82
	Goat	4.55 ^a	0.19	12.18	3.59	5.12
	Sheep	3.87 ^b	0.06	4.81	3.60	4.13

SEM: Standard Error Mean; CV: coefficient of variation; Max: maximum; Min: minimum. Means which are denoted by different letters (a, b) indicate significantly different mean values between milk from the here species and for the same parameter (Fat, protein and lactose, minerals and vitamins, Dry Degreased Extract, Added Water, pH, Density, Freezing point and Conductivity).

Table 2. Bacteriological qualities of the analyzed samples (N = 27 samples).

Flores (UFC/mL)	Species	Mean ± SEM	Standard (CFU/mL)
TMAF (10 ⁵)	Cow	1.13 ± 1.26	10 ⁵
	Goat	0.87 ± 1.05	10 ⁵
	Sheep	1.37 ± 1.66	10 ⁵
F. Col. (10 ³)	Cow	1.03 ± 1.65	10 ³
	Goat	0.56 ± 0.84	10 ³
	Sheep	1.12 ± 1.33	10 ³
T. Col. (10 ³)	Cow	1.02 ± 1.45	10 ³
	Goat	0.96 ± 1.01	10 ³
	Sheep	1.15 ± 1.07	10 ³
Sulphite reducing <i>Clostridium</i>	Cow	27 ± 15.60	50
	Goat	13 ± 18.35	50
	Sheep	51 ± 11.30	50
<i>S. aureus</i>	Cow	Absence	Absence
	Goat	Absence	Absence
	Sheep	Absence	Absence
<i>Salmonella</i> spp.	Cow	Absence	Absence
	Goat	Absence	Absence
	Sheep	Absence	Absence

TMAF: Total Mesophilic Aerobic Flora; T. Col.: total Coliforms; F. Col.: fecal Coliforms; SEM: Standard Error Mean.

Milk density is between 1.03 ± 6.33 ; 1.02 ± 7.44 and 1.03 ± 4.08 kg/m³ for cow's milk, goat's milk, and sheep's milk, respectively. In addition, a significant difference is recorded between the milk of the three species, where the density of goat's milk is the lowest ($p < 0.05$).

Fat content recorded is 3.28% and 3.23% for cow's milk and goat milk respectively. These results are very close to those cited in the literature (3.7% and 4.1% for cow's milk and goat's milk, respectively) (Boudalia et al., 2016a; El Galiou et al., 2015). However, a very lean fat content was recorded for sheep's milk (1.82%). This significant difference ($p < 0.05$) is not consistent with data from the literature, where sheep's milk is considered as being a fatty milk (Fat content: 7.9%) (Park, 2006; Park et al., 2007). However, these results are probably due to the feed abundance, Hamidi et al. (2018) found lower fat content in a semiarid region of Algeria where plant abundant and richness is lower.

Results from dry degreased extract (TDE) shown that goat's milk contains less TDE (6.61%); this result is much below the standard (13.4%). In the same way, TDE results recorded in cow's milk (8.55%) and sheep's milk (9.77%)

remain relatively low compared to the standards (12.8% and 18.3% for cow’s milk and sheep’s milk respectively) (Food and Agriculture Organization of the United Nations, 2002; Renhe et al., 2019). The lactose content is (2.97%, 4.70% and 4.30%) in goat, cow and sheep respectively ($p < 0.05$, Table 1). The results obtained are slightly lower than data from the literature (Renhe et al., 2019).

Total protein (Table 1) indicates that the raw cow’s milk is between 2.75 to 4.15% [27.5-41.5 g/L]. For goat and sheep respectively, the protein level of 3.05% and 4.63% was recorded. These rates are in line with the norms for goat’s milk. In sheep, protein level remains higher than the protein content in milk from the other two species ($p < 0.05$).

Conductivity rate is 4.94 ± 0.75 mS/cm; 4.55 ± 0.55 mS/cm; 3.87 ± 0.19 mS/cm for cow, goat and sheep’s milk respectively. These values were in good agreement with the data published by Park et al. (2007). The pH recorded is 6.48 ± 0.19 , 6.63 ± 0.08 , 6.71 ± 0.24 for cow, goat and sheep milk, respectively. These values are consistent with the standards (Park, 2006). Also, a significant difference is recorded between the pH of cow’s milk and that of the sheep ($p < 0.05$), where cow’s milk appears to be more acidic (Table 1).

Minerals and Vitamins (%) level observed were $0.70 \pm 0.13\%$; $0.50 \pm 0.14\%$; $0.73 \pm 0.02\%$ for cow’s, goat’s and sheep’s milk, respectively. A significant difference was found between the level of minerals and vitamins (%) in cow’s and sheep’s milk vs. goat’s milk where a goat’s milk seems to be less rich (Table 1).

The freezing point recorded was -0.55 ± 0.11 °C; -0.38 ± 0.13 °C; -0.56 ± 0.03 °C for cow, goat and sheep milk respectively (Table 1). A significant difference was recorded, where goat’s milk has a higher freezing point compared to the other two types of milk (cow and sheep). The values of cow’s milk and sheep’s milk are consistent with standards; however, the results of goat’s milk are relatively lower compared to standards (Food and Agriculture Organization of the United Nations, 2002; Renhe et al., 2019). This difference in physicochemical qualities for goat milk may be due to a wetting of six samples of goat’s milk (6/9).

For bacteriological analysis, counting of aerobic mesophilic flora for raw milk samples showed an average microbial load of 1.13×10^5 ; 0.87×10^5 ; 1.37×10^5 CFU/mL for cow, goat and sheep milk respectively. These values consistent with the results of raw cow milk gathered in Guelma region in the northeastern of Algeria (Boudalia et al., 2016a), and who have been a satisfactory quality of raw milk in light of standard (10^5 UFC/mL). The sulphite reducing *Clostridium* was less present with low concentrations in the samples analyzed for the three species. The averages of the enumerated bacteria for cow, goat and sheep’s milk are <50 CFU/mL. Unlike studies of Ghazi & Niar (2011), Hamiroune et al. (2014) and Bachtarzi et al. (2015) in other regions in Algeria, no *Staphylococcus aureus* contamination was recorded. These results provide that the hygienic quality of the milk of the three species is very satisfactory and suitable for consumption or processing.

3.2 Data collection about the traditional preparation of “Bouhezza”

A survey was conducted among the local people of several provinces in the northeastern of Algeria to understand the traditional process and knowledge of “Bouhezza” preparation. This survey permitted to identify a common procedure for the “Bouhezza” cheese production. This procedure is schematically represented in Figure 2.

“Bouhezza” was traditionally the product of the processing of goat and sheep milk, but the current trend seems to be towards the use of cow milk (Aissaoui Zitoun et al., 2011, 2012; Licitra et al., 2019; Medjoudj et al., 2017a, b).

The cheese is obtained after transformation of the “Lben” in a “Chekoua” made of goatskin previously treated with salt and juniper (Aissaoui Zitoun et al., 2011). Draining, salting and refining “Bouhezza” are performed simultaneously in the “Chekoua”. During the ripening period, “Lben” and milk are added to the contents of the “Chekoua”.

In our study, nine manufacturing experiments were carried out via the traditional diagram and for ten weeks. During each experiment, “Chekoua” received each three-day an amount of 1.5 L of salted “lben” (25 g of salt per L). At the end of the manufacturing (for about 1 to 1.5 last weeks) and to adjust organoleptic characteristics of the “Bouhezza” cheese (salt and acidity), additions of whole raw milk were done. In this study, the additions of fresh whole milk were perused until the tenth week to observe eventual evolutions in this case. During manufacturing, the “Chekoua” was suspended in an aerated room and daily washed and scraped on the external face (Figure 3).

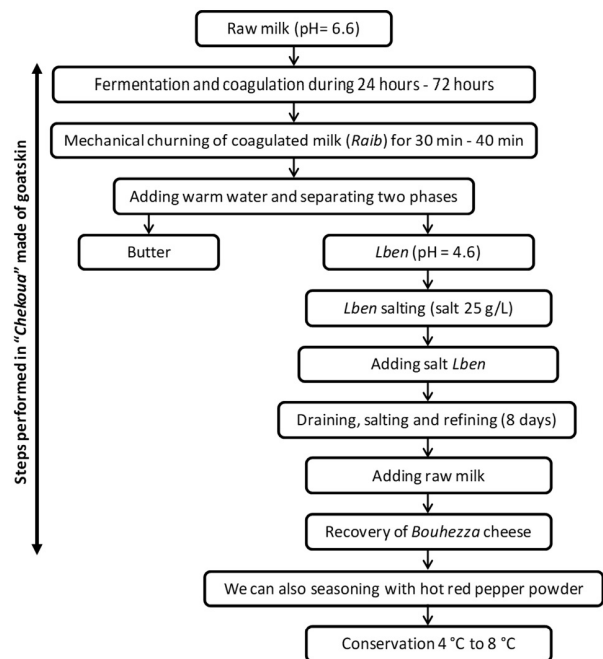


Figure 2. Illustrative global traditional diagram of the manufacturing processes of “Bouhezza” cheese-making. “Bouhezza” is obtained after transformation of the “Lben” in “Chekoua” made of goatskin previously treated with salt and juniper. Draining, salting and refining of cheese are performed simultaneously in the “Chekoua”.



Figure 3. “Bouhezza” processing steps: After spontaneous coagulation of raw milk at room temperature which it takes 24 to 72 hours depending on the seasonal temperature, the curdled milk called “Rayeb” (or “Raïb”) was obtained. A farmer woman use “Chekoua” or “skinbag” made of goatskin previously treated with salt and juniper to transform the “Raïb” (a quantity of 3.6 to 3.8 L) into “Lben” by churning for 30 to 40 minutes. During this step, the addition of lukewarm water to the “Raïb” (about 10% (v/v)) makes it possible to reduce the temperature to the proper level to collect the grains of butter. Extraction of traditional butter (*Zebda Beldia*) and salt adding (1 tablespoon/L) is realized at this stage (a) and (b). (c), (d) and (e) cheese draining; this step is carried out in “Chekoua”. However, it can also be done in cloth bags to facilitate sewage. Raw milk (100 mL/4 L) can be added to adjust the acidity and salinity of the finished product. (f), (g) and (h) recovery of “Bouhezza” cheese is carried out after the draining step. (i), (j) and (k) “Bouhezza” Cheese is stored in pottery jars/ glass or food containers for a few weeks at a temperature that varies between 4 °C and 8 °C. People generally take it after lunch and dinner.

3.3 Cheese yields analysis

Figure 4 show the quantities of dairy products (whey, butter and cheese) following the transformation of milk from three species into “Bouhezza” cheese. Although the initial volume of milk used in cheese making is almost the same (no significant difference), a significant difference was recorded after processing in terms of *i*) volume of whey harvested after draining. This volume is greater than three liters for all the milks except for sheep’s milk, which gave the lowest volume ($p < 0.05$); *ii*) butter quantity manufactured after churning which is around 0.24 kg for sheep’s milk and 0.15 kg for cow’s and goat’s milk ($p < 0.05$); *iii*) “Bouhezza” quantity and cheese yield, indeed sheep’s milk seems to be the most efficient in terms of cheese yield ($p < 0.05$) (Figure 4).

“Bouhezza” yield is an economically relevant variable which is influenced by different factors such as milk quality and cheese-making methods (Lucey & Kelly, 1994). Our results showed that there was an interspecific difference in cheese yield between cows, goats and sheep. 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 interspecific 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), seasonal variations (Sánchez-Gamboa et al., 2018), microbial counts and diversity (Vladimír et al., 2020) and cheese-processing methodology (Lawrence, 1993). In our study, “Bouhezza”-processing methodology and season are the same, however, we found higher fat and protein content in goat compared to cow milk,

which probably contributed to the increase in cheese yield (Lucey & Kelly, 1994). In sheep milk, we found higher larger casein micelle size, which affect their renneting properties and coagulation time. Also, the higher casein content *n*, which functions as a chelator of divalent (or higher valence) ions, is associated with higher content of those mineral contents than in cow, and goat milk. The average fat globule size is smallest ($< 3.5 \mu\text{m}$) in sheep milk followed by goat and cow milk. Therefore, cheese yield per volume of milk is the highest among ruminant milk (Silanikove et al., 2016).

3.4 Sensory analysis of “Bouhezza” cheese

The sensory evaluation scores are shown in Table 3 and Figure 5. From our panelist 50% are women, they are between 18 and 30 years old, and 95% of them consume cheese at least once a week. “Bouhezza” cheese from cow milk had a hedonic score greater than or equal to 5 for the 5 descriptors (overall appreciation, taste, texture, smell and color).

Panelists determined that “Bouhezza” cheese is accepted except “Bouhezza” from goat’s milk, in which the hedonic note is less than 5. Furthermore, the sensory acceptance of the product tested in this study is very similar to that found by Dal Bello et al. (2017) for fresh cheese from raw cow milk. Also, from literature, goat and sheep cheese are not preferred by large proportion of people which are not appreciate a strong goaty or sheepy aroma, even though they are not very familiar with these aromas (Ryffel et al., 2008). In the same way, Costa et al. (2015) have evaluated the acceptance of fermented cow’s and goat’s milks. Results have shown that fermented cow’s milk was well accepted compared to fermented goat’s milk.

Table 3. Hedonic scoring test for “Bouhezza” cheese (with 5 descriptors).

Descriptors		Global appreciation	Taste	Texture	Odor	Color
Hedonic note	Cow	5.90 ± 0.81	5.25 ± 0.87	6.25 ± 0.82	7.75 ± 0.78	6.45 ± 0.86
	Goat	4.75 ± 0.90	4.00 ± 0.76	4.60 ± 0.71	7.60 ± 0.72	5.10 ± 0.92
	Sheep	5.50 ± 0.65	4.65 ± 0.76	4.55 ± 0.72	7.70 ± 0.64	5.10 ± 0.64

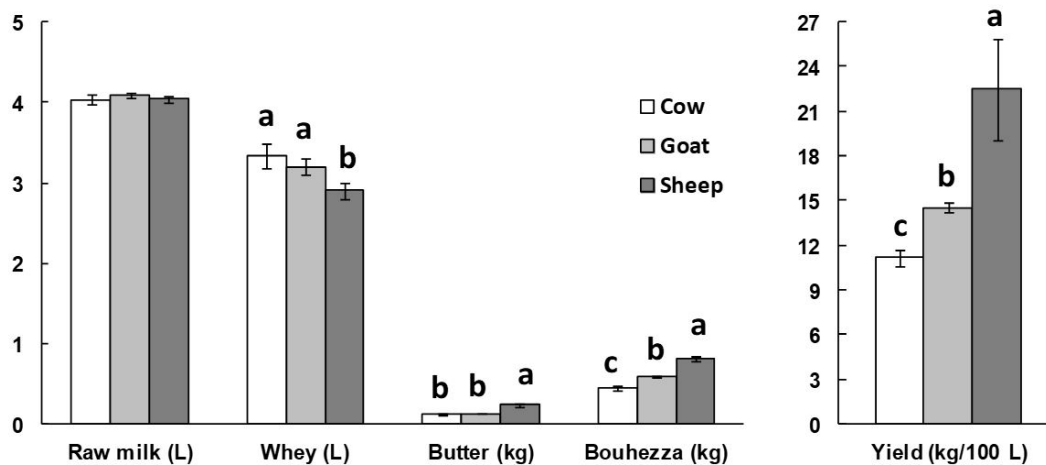


Figure 4. “Bouhezza” cheese yield analysis from cow’s, goat’s and sheep’s milk collected in the regions of Guelma, Souk Ahras, Tebessa and Djelfa (n= 9/species). Results are expressed on average ± SEM. The letters on the diagrams show significant differences between each milk for the same parameter ($p < 0.05$) (One-way ANOVA, Tukey in post-hoc).

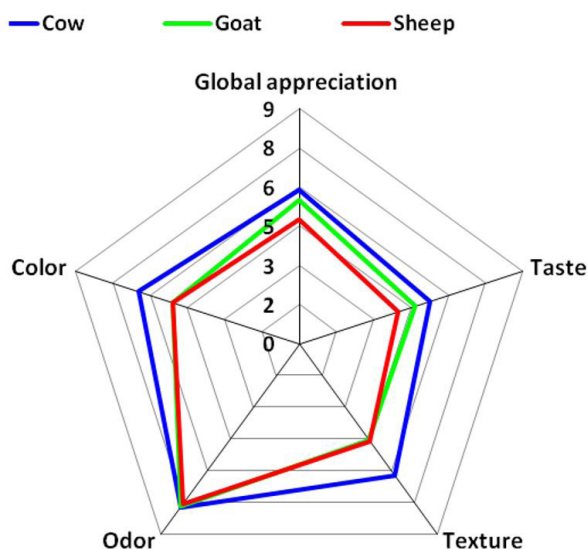


Figure 5. Mean scores of sensory acceptability test (with 5 descriptors) of different artisanal “Bouhezza” cheese produced from cow’s, goat’s and sheep’s milk collected in the regions of Guelma, Souk Ahras, Tebessa and Djelfa.

4 Conclusions

In summary, “Bouhezza” cheese occupies a very important socio-economic place established in the rural and peri-urban environment. It is a fermented soft-ripened cheese produced empirically in several regions of Algeria. Originally, “Bouhezza” was traditionally the product of the processing of goat milk and sheep, but the current trend seems to be towards the use of cow milk (Aissaoui Zitoun et al., 2011, 2012; Licitra et al., 2019; Medjoudj et al., 2017a, b). In this study, we have elaborated the traditional fabrication diagram of this cheese from a field survey, and then we have produced the “Bouhezza” cheese from cow’s milk, goat’s milk and sheep’s milk. Before cheese making, the raw milk from the tree species (cow, goat and sheep) was analyzed (physical, chemical, and microbiological properties). The cheese is obtained after transformation of the “Lben” in a “Chekoua” made of goatskin. Draining, salting and refining “Bouhezza” are performed simultaneously in the “Chekoua”. During the ripening period, “Lben” and milk are added to the contents of the “Chekoua”.

Results from the physicochemical and bacteriological analysis of milk show that all criteria analyzed respond almost to the required standard. The sensory qualities of the three types of cheese show that cow cheese was classified as the most satisfactory cheese for the majority of criteria (taste, color and texture). Based on a rate of return equivalent to that obtained in our milk production trials, the cheese processing seems very viable and cost-effective for the breeder better than their marketing as raw milk.

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