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RESEARCH ARTICLE

Comparative study of the physico-chemical and microbiological characteristics of raw and pasteurized camel milk

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ABSTRACT

Camel milk is three times richer in vitamin C than cow's milk, it is also rich in niacin, antimicrobial factors prostaglandins and insulin. Pasteurization is an adequate option for camel milk conservation, allowing it to be consumed by people not living in arid environments. However, the obvious problem is that people prefer to consume raw camel milk for its therapeutic virtues, which they think, loses its quality after pasteurization. Therefore, the aim of this research is to study the effect of pasteurization on camel milk nutritional and hygienic quality. This work consists on analyzing four camel milk samples: a sample of raw milk and three samples of this milk, pasteurized at 63°C/30min, 72°C/15sec and at 85°C/2min under laboratory conditions. The data was subjected to Kruskal-wallis using XL-Stat software. These results show stability of the physicochemical composition (PH, acidity, density) and chemical composition (dry matter, lactose, fat, vitamine C, protein) ($p > 0.05$) of camel milk pasteurized at 63°C (low pasteurization) and instability ($p < 0.05$) following pasteurization high at (85°C) except the fat content which remains intact ($p > 0.05$). For pasteurization at (72°C) we notice a instability ($p < 0.05$) in pH, acidity, dry matter, vitamine C and protein, a stability in the density, fat and lactose. Only low pasteurization (63°C for 30 min) can be an alternative for the conservation of camel milk while preserving its nutritional quality. To study its hygienic quality before and after pasteurization, the reductase test was carried out; it shows a good to fair quality for the raw milk sample and good for the pasteurized milk sample. Contaminating and original flora were counted on appropriate culture media. Results obtained shows that the pasteurization caused a total inhibition of the pathogenic flora (Halotolerants, Coliforms and *Enterobacteriaceae*), and partial destruction of the total aerobic mesophilic flora (TAMF), psychrotrophic and thermophilic lactic acid bacteria. This study confirms that the nutritional quality can be preserved almost intact after pasteurization at 63°C for 30min. In addition, pasteurization has an important role in camel milk sanitation by inhibiting pathogenic flora.

Key words: Camel; Hygienic quality; Milk; Nutritional quality; Pasteurization.

INTRODUCTION

Camel milk is exceptionally rich in vitamin C, almost three times higher than cow's milk (Farah et al., 1992; Anonymous, 1995; Siboukeur, 2007; Anonymous, 2021; Sboui, 2016). Constituting an important nutritional contribution in arid regions where fruits and plants containing this vitamin are rare (Sibokeur, 2007). It is also rich in niacin (an essential amino acids), valine, leucine and phenylalanine, unsaturated fatty acids, antimicrobial factors (lysozyme, lactoperoxidase and lactoferrin), prostaglandins and insulin (Farah, 1993; kanuspayeva, 2003). Its therapeutic virtues are also claimed by North African, Middle East and Asian inhabitant, who traditionally attribute it to anti-infectious, anti-cancerous, anti-diabetic and anti-fatigue properties (Yagil, and van Creveld, 2000; Kanuspayeva, 2007). According to Anonymous, 2021 the demand for camel milk will grow strongly in the up coming years due to this milk nutritional quality compared to cow's milk and its lack of whey protein (β-Lactoglobulin) which can trigger dairy allergies especially in children (Farah, 1993; Kappeler et al., 2004; El Hatmi et al., 2007; Elagamy et al., 2009). Unfortunately this bioproduct is consumed locally in raw or fermented form, of which other form of preservation are almost non existent at least in Algeria.

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Among the most commonly used milk preservation procedures is pasteurization. However, the obvious problem is that people prefer to consume raw camel milk for its therapeutic virtues, which they think, loses its quality after pasteurization. While the pasteurization of bovine milk has been the subject of numerous studies, this is far from being the case for camel milk, where only a few studies have been devoted to it. Through this study we realised a contribution by studying the effect of pasteurization on camel milk physicochemical, chemical and microbiological quality. For this fact we have studied the physico-chemical composition (PH, acidity, density), chemical (dry matter, lactose, fat, vitamine C, protein) and the microbiological quality of raw camel milk in comparison with that pasteurized according to three scales of pasteurization; low pasteurization (63°C/30min), HTST pasteurization (72°C/15sec) and high pasteurization (85°C) for the purpose of seeing the most suitable pasteurization schedule for camel milk.

MATERIAL AND METHODS

Milk sampling

Seven of the mixed camel milk samples were collected, during winter seasons from herds of dromedaries (*Camelus dromedarius*) of the Sahraoui population in mid-lactation living in extensive breeding in natural ranges of region of south-eastern Algeria: Ouargla. Milk samples are stored in a cooler containing an ice pack. Samples are immediately transported to the laboratory where a panel of analysis is realised.

ANALYSIS METHOD

Laboratory pasteurization of milk

In the laboratory, the analysis was realized by pasteurised part of the raw milk according to 3 temperature/time pairs at 63°C/30min, at 72 °C/15sec and at 85°C/2min.

Pasteurization was carried out by immersing a glass tube containing 3 mL of milk in water maintained at a desired temperature (63°C, 72°C and 85°C°) in a water bath. The temperature and holding time are controlled, with the use of a glass tube equiped with a thermometer as a control. Then rapidely cooled successively in cold ice water (Male et al.,2003).

Physico-chemical and biochemical analysis

The physico-chemical and biochemical analysis therefore focused on the four milk preparation: raw milk, pasteurized milk at 63°C/30min, at 72°C/15 sec, and at 85°C/2min. Physicochemical and biochemical determined parameters are: pH, acidity, density, dry and fat matter, protein, lactose and vitamin C.

- The pH measurement was carried out by a pH meter (inoLab pH 720, Germany);
- The total acidity was determined by titrating 10 mL of milk with the basic NaOH solution (N/9) using the pH indicator phenolphthalein according to the standard (NF V04-305, 1985);
- Density is determined using a lactodensimeter (NF V 04-204, 2004);
- The dry matter content was obtained by dehydration of the milk placed in a capsule at 105°C for 3 hours in a desiccator filled with phosphoric anhydride according to (NF V04.207, 1970);
- The protein content (total protein, whey protein and caseins) is determined by the method of Lowry (1957). The principle behind the Lowry method of determining protein concentrations lies in the reactivity of the peptide nitrogen with the copper ions under alkaline conditions and the subsequent reduction of the Folin Ciocalteu phosphomolybdic phosphotungstic acid to heteropolymolybdenum blue by the copper-catalyzed oxidation of aromatic acids (Lowery et al., 1951);
- The separation between caseins and whey proteins is obtained by precipitation of milk at pH 4.3 in the presence of hydrochloric acid solution (4N) followed by centrifugation at 3500 g/5min (Siboukeur, 2007);
- The fat content was measured by the acid-butyrometric method of Gerber (AFNOR standard: NFV04-210 of December 1974);
- The lactose determination is carried out on the filtrate. After defecation with zinc ferrocyanide, by the method of Bertrand (Bourdon, and Gielfrich, 1972).
- The vitamin C assay is done by titrimetry using an iodine solution (Boudjenah, 2012).

Microbiological analysis

The analyses were realized out as follows:

Reductase test

The reductase test is used to estimate the microbial load in milk. Its principle is based on the discoloration of methylene blue (1 mL of methylene blue in 10 mL of milk). The speed of this discoloration is directly proportional to the number of microorganismes present (Larpent et al.,1997).

Determination of microbial flora

A count of some group is part of the original flora and contamination has been carried out. The inoculations were carried out in petri dishes. Counts were performed using a colony counter. Counted petri plates should range between 30 and 300 colonies per plate (Guiraud, 2012). For this purpose, it is necessary to carry out dilutions of the milk sample (10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}). The culture used media are:

- PCA medium (plate count agar), inoculation is carried out in depth and incubation at 30°C/72h for enumeration of total Aerobic mesophilic flora (TAMF), at 55°C/48h after heating the sample at 106°C for enumeration of Thermoresistant bacteria and at 6,5°C/7 to 10 days for enumeration of psychrotrophic bacteria (AFNOR NF T 90-401 and 402 standard; ISO 8553/IDF 131; ISO 6730/FIL 101) (Marshall,1992; Guiraud, 2012);
- CHAPMAN medium for halotolerant, inoculation was carried out on the surface and incubation at 37°C/48h (NF V08-057-2) (Marshall et al., 1992);
- VRBG (Violet Red Bile Glucose Agar) and VRBL (Violet Red Bile Lactose Agar) medium were used to enumerate *Enterobacteriaceae* and coliforms respectively, seeding is done in double layers (NF V 08-054; NF V 08-050). After incubation for 24 hours at 30°C (Guiraud, 1998).
- Elliker medium used for the enumeration of lactic acid bacteria (mesophilic and thermophilic lactococci), incubation was carried out at 30°C and 45°C for 48 hours respectively (Kassas, 2017);
- M.R.S medium (Man, Rogosa and Sharp) is used for the enumeration of *Lactobacillus*, incubation was carried out at 37 °C/48h (NF: 15787. 2009) (Larpent et al.,1997).

Statistical analysis

For better exploitation of the work's results, the data were expressed as means and standard deviation ± SD. Obtained mean values were compared using the XL STAT statistical software based on Kruskal-wallis.

RESULTS AND DISCUSSION

Physicochemical characteristic

In this study the taste of camel milk was salty, Farah et al. (1992) reported that the taste differed depending on the animal feed and water availability. Ingestion of forages such as alfalfa gives a sweet taste, and some halophytic plants make it salty according to Siboukeur (2007). In our case, the pasture is rich in halophilic plants, which is why the samples have a relatively salty taste.

The results of physico-chemical analysis of raw and pasteurized milk samples are shown in Table 1.

Comparing of the mean value of pH, titratable acidity and density of raw camel milk with those of milk pasteurized at 85°C (high pasteurization), have shown that they are statistically different ($p < 0.05$), however the difference is not significant ($p > 0.05$) after pasteurization at 63°C (low pasteurization). For pasteurization at (72°C) (HTST: High-Temperature Short-Time Pasteurization), we notice a significant difference ($p < 0.05$) in pH and acidity and not significant for the density. We can explain the decrease in acidity after pasteurization by the reduction of the microbial load under the effect of temperature, this which leads to the lowering of lactic acid production by lactic bacteria (Erdam and Yuksel, 2005; Walstra et al., 2006).

The average pH value of raw camel milk to be analyzed is equal to 6.341 ±0.063. Camel milk to be slightly more acidic than human (pH= 7.01) and bovine (pH= 6.6) milk. the pH values recorded in the present study are close to those reported by certain authors such as Siboukeur; (2007) (pH 6.31± 0.15) in Algeria and Sboui et al. (2009) cited a value (pH = 6.41) and Arroum et al. (2015) cited a value (pH= 6.59) in Tunisia. Other authors report higher values, such as Kamoun; (1995) in Tunisia (pH 6.51±0.12) and Si Ahmed; (2015) in Algeria (pH= 6.5). The samples of raw camel's milk analyzed show a titratable acidity of the order of 18.029 ±0.296 °D. This higher value compared to that of bovine milk which is of the order of 15 °D, is close to that reported by Djaman (2018) in Algeria which quotes a range between 18.136 ± 1.0627 and 18.524±1.0929°D. However, many authors report values greater than or equal to 15 °D, such as Abu-Lehia (1994) in Saudi Arabia (15°D±4); Sboui et al. (2009) (17.2 °D) and Arroum et al. (2015) (18.64°D) in Tunisia. The value of the density of the samples of raw camel milk is equal to 1.022±0.002. It is comparable to the values cited by Siboukeur (2007) or 1.022±0.0002 and Djaman (2018) which cites a range between 1.028 and 1.030. Density of cow's milk, is higher than that of camel's milk. This observation has been mentioned by many authors. Kamoun (1995) and Ramet (2003). Indeed, this low density is one of the main characteristics of camel milk and is largely responsible for the difficulties of its transformation into chees.

Chemical characteristics

The results of chemical analyzes of raw and pasteurized milk samples are compiled in Table 2. This table shows that there is not a significant difference ($p > 0.05$) in chemical composition (dry matter, fat, lactose, vitamine C, protein) between raw and pasteurized milk at (63°C), but there is a significant difference ($p < 0.05$) following pasteurization at (85°C), however the fat content does not show any significant modification following the various heat treatments applied during the present study. A significant difference was noticed in dry matter, vitamine C, protein and there is not significant difference in fat and lactose following pasteurization at (72°C).

The dry matter content value of the analyses milk samples is 108.874±1.353 g/l. It is within the range of a previous study reported by Arroum et al. (2015) (100.77 g/L) and Benmohamed (2019) (109.77±9.54 g/L). One of the

Table 1: Physicochemical characteristics of raw camel milk compared to pasteurized camel milk

Parameter	Raw milk	Pasteurized milk at : 63°C/30 min	Pasteurized milk at : 72°C/15 sec	Pasteurized milk at : 85°C/2 min
pH	6.341±0.063	6.384±0.059[a]	6.463±0.047[c]	6.494±0.06[d]
Acidity (°D)	18.029±0.296	17.664±0.23[a]	17.486±0.164[b]	17.169±0.127[d]
Density	1.022±0.002	1.023±0.001[a]	1.022±0.002[a]	1.024±0.001[b]

[a]: the difference is not significant (p>0,05)
[b]: the difference is significant (p<0,05)
[c] : the difference is highly significant (p<0,01)
[d]: the difference is very highly significant (p<0,0001)

Table 2: Chemical characteristics of raw camel milk compared to pasteurized camel milk

Parameter	Raw Milk	Pasteurized milk at: 63°C/30 min	Pasteurized milk at: 72°C/15 sec	Pasteurized milk at: 85°C/2 min
Dry matter (g/L)	108.874±1.353	110.171±1.238[a]	111.403±1.585[c]	111.329±2.217[c]
Fat (g/L)	28.447±0.734	27.576±0.825[a]	27.833±0.845[a]	27.766±0.653[a]
Lactose (g/L)	42.643±1.481	43.786±1.508[a]	44.971±2.64[a]	45.643±2.655[b]
Total protein (g/L)	28.821±0.933	26.207±1.069[a]	24.543±0.857[c]	24.370±0.628[d]
Whey protein (g/L)	8.213±0.347	7.783±0.466[a]	5.206±0.422[c]	5.610±0.672[d]
Caseins (g/L)	20.981±0.672	18.730±0.407[a]	17.863±0.589[c]	17.479±0.472[d]

[a]: the difference is not significant (p>0,05)
[b]: the difference is significant (p<0,05)
[c]: the difference is highly significant (p<0,01)
[d]: the difference is very highly significant (p<0,0001)

Table 3: Reductase test

Samples	Methylene blue discoloration time	Milk quality according to Larpent, 1997
Raw milk	2 hours 30 min.	good to fair
Pasteurized milk at : 63°C/30 min	> 5 hours	Good
Pasteurized milk at : 72°C/15 sec	> 5 hours	Good
Pasteurized milk at : 85°C/2 min	> 5 hours	Good

main characteristics of camel milk is indeed its reduced dry matter content compared to that of milk from other species. The average fat content of the milk analyzed is equal to 28.447±0.734 g/L. It seems lower than that of bovine (37 g/L) and human (45 g/L) milk. Arroum et al. (2015) indicate variable values depending on the husbandry system 25 g/L, 32.66 g/L and 42.87 g/L for intensive, semi-intensive and extensive farming respectively. Djaman (2018) reports a value of 30.97±4.0964 g/L and Sboui (2016) reports higher values (37.5 g/L). The average lactose content of camel milk is equal to 42.643±1.451 g/L. This content appears to be comparable to that of bovine milk (44.13 g/L), but it is lower than that of human milk (70 g/L). It is within the range of works reported by Siboukeur (2007) 43.87 g/L ± 3.10 for the Sahraoui breed and Mehaia, (1995) for the Hamra, Majaheem and Wardah breeds (44 g/L, 44.3 g/L and 44.4 g/L respectively) and Sboui, (2016) 42.78 g/L. The vitamin C content of the analyzed samples of raw milk is equal to 45.486 ±0.582 mg/L. It is comparable to that reported by Siboukeur (2007) 41.40±8.20 mg/L and lower than that recorded by Sboui (2016) 169.73±5.12 mg/L and Benmohamed (2019) 66.75±17.96 mg/L. Farah et al. (1992) and Haddadin et al. (2008) mention significantly lower proportions (24.9 mg/L and 33 mg/L respectively). Despite this variability, it remains understood that the vitamin C content of camel milk is very much above the threshold noted in bovine milk, which is around 20 mg/L. This characteristic further enhances the nutritional value of camel's milk for its significant contribution of this vitamin for the benefit of nomadic populations often deprived of fresh fruits and vegetables. An average total protein content of raw milk is equal to 28.821±0.933 g/L. This is lower to that of bovine milk (32 g/L) and is twice as high compared to that of human milk (12 g/L). The rate we found in this study is in the range works cited by Arroum et al. (2015) and Si Ahmed (2015) namely 31±2 g/L and 19.93±4.55 g/L respectively. It is however comparable to that reported by Mehaia, (1995) for the Majaheem and Hamra races (29.1 g/L and 25.2 g/L). The whey protein content of raw camel's milk analyzed is equal to 8.213± 0.347 g/L. Which represents 28.76% of total proteins. This rate seems to be higher that of milk, bovine (6 g/L) and human (7 g/L). This rate is comparable to that reported by Si Ahmed (2015) either 8 g/L and Boudjenah Haroun (2012) 9.21 g/L and Alloui-Lombarkia et al. (2007) (8.40 g/L). It seems slightly higher than that reported by Siboukeur (2007) 7.51 g/L±0.50 and by Farah (1993) (7 g/L). Higher levels are mentioned by other authors, 10 g/L according to Bayoumi (1990) and 11.2±0.6 g/L for the Majaheem breed, according to Abu-Lehia (1994) and (40 g/L) according to Haddadin et al. (2008). The average casein content of the raw milk samples analyzed is equal to 20.98 ±0.672 g/L or 72.79% of the total proteins. It is lower than that of bovine caseins (26 g/L) either 81% of total proteins. On the other hand, it is clearly higher than that of humain milk which is equal to (5 g/L) or 42% of total proteins. This content seems lower than that reported by certain authors such as Siboukeur (2007) (28.15g/L±5.28 or 79% of total proteins) and Boudjenah Haroun (2012) (27.77 g/L), Alloui-Lombarkia et al. (2007) (19.80 g/L), Si Ahmed (2015) (23 g/L, or 73% of total proteins).

Contents of vitamin C, total protein, whey protein and casein (Table 2) are statistically slightly different to those of pasteurized milk (p <0.05).According to Anonymous, (1995) pasteurization denatures 10 to 20 percent of the whey protein in cow's milk and that the caseins would resist the thermal effect. Furthermore Farah and Bachman, (1987) reported that the heat sensitivity of camel whey protein is twice as low as bovine whey protein, which seems to be in agreement with our results. Renner (1989) reported that the loss of vitamin C after pasteurization treatment was (10-25%), on the other hand Wernery et al. (2006) indicated that the reduction in vitamin C concentration after pasteurization of camel milk was minimal which seems to agree with our results.

MICROBIOLOGICAL QUALITY

Reductase test

Methylene blue discoloration occurs after two and a half hours for the raw milk sample versus five hours for the pasteurized milk sample, which shows good to fair quality for the raw milk sample and good for pasteurized milk sample according to Larpent et al. (1997) which shows the efficiency of pasteurization.

Contamination flora

It is made up of spoilage and pathogenic flora, that are mainly of exogenous origin and in particular of faecal origin, they are mainly brought by workers, equipment and rinsing water equipment.

Total aerobic mesophilic flora (TAMF)

It is the set of microorganisms capable of multiplying at the optimum growth temperature is between 25 and 40°C. They can be pathogenic or spoilage microorganisms (Bourgeois and Leveau,1996). The enumeration of the total aerobic mesophilic flora in raw milk reveals an amount of 9.5×10^6 cfu/mL (Table 4). These results indicate that the total flora of raw camel's milk exceeded European standards (5×105 cfu/mL) for cow's milk, according to (Official Journal of the European Communities 1992). It is understood that there are no specific microbiological criteria for camel milk.

On the other hand, samples of pasteurized camel milk show acceptable values, including the rate of total mesophilic aerobic flora becomes 3.6×105± 8.1×10^4 ufc/ml, $3.7\times10^3\pm8.1\times10^2$ ufc/ml and $1.48\times10^3\pm 3.8\times10^2$ for milk pasteurized at 63°C, 72°C and 85°C respectively, which shows the need for pasteurization of raw camel milk.

The enumeration of the total aerobic mesophilic flora in raw camel milk reveals an amount of 9.5×10^6 cfu/mL. This value is almost similar to those given by other studies such as 9×10^6 ufc/mL by Male et al. (2003), 1.6×10^6 ufc/mL by Tourette et al. (2003) and 2.7×10^7 ufc/mL by Younan et al. (2003). After pasteurization this flora decreased as a function of the temperature. According to many authors, like Farah and Bachman (1987) and Faye (1997) camel's milk has high anti-bacterial properties which ensure good conservation in the fridge without immediate fermentation. This finding contrasts with the abnormally high microbial load in the samples analyzed. In this sense Calvo and Olano (1992) report that when the milk is collected under suitable hygienic conditions, its total flora does not exceed 10^3 to 10^4 cfu/mL. This load microbial high in camel milk is thought to be due to several factors: poor hygienic conditions during milking or storage which lead to contamination of the milk and high temperatures in arid and semi-arid areas favorable to the growth of microorganisms.

Similar rsultes was recorded by Tammam et al. (2015) for pasterized cow's milk. Table 4. Descriptive characteristics of microbial flora (cfu/mL)

Pathogenic flora

Coliforms, *Enterobacteriaceae*, and halotolerant bacteria are among the pathogenic flora of raw milk, with average values of 3.6×10^5 cfu/mL, 5.3×10^4 cfu/mL and 3.7×10^4 cfu/mL respectively. After pasteurization, they are fully destroyed (Fig.1; Table 4), regardless of the scale utilized. This has demonstrated the need of pasteurization in camel milk sanitation, despite the fact that Yagil et al. (1994) stated that pasteurization of camel milk is not necessary if the herd is in good health.

On the other hand, people in southern Algeria prefer to drink camel milk raw because of its therapeutic properties, which they believe are lost after pasteurization. Our study reveals that it improves in quality after being pasteurized using various methods, temperatures, and time frames.

Table 4: Descriptive characteristics of microbial flora (cfu/mL)

Microbial flora	Raw Milk	Pasteurized milk at: 63°C/30 min	Pasteurized milk at: 72°C/15 sec	Pasteurized milk at: 85°C/2 min
Total Aerobic Mesophilic Flora (TAMF)	$9.5\times10^6\pm1.8\times10^6$	$3.6\times10^5\pm8.1\times10^4$	$3.7\times10^3\pm8.1\times10^2$	$1.48\times10^3\pm3.8\times10^2$
Thermorésistant bacteria	$4.3\times10^3\pm2.5\times10^3$	$5.1\times10^3\pm2.5\times10^3$	$3.9\times10^3\pm2.3\times10^3$	$4.5\times10^3\pm2.4\times10^3$
Psychrotrophic bacteria	$5.1\times10^3\pm2.5\times10^3$	7.5×10±5.46	2×10±2.820	1.5×10±1.323
Halotolerant bacteria	$3.7\times10^4\pm8.1\times10^3$	0±0.00	0±0.00	0±0.00
Enterobacteriaceae	$5.3\times10^4\pm2.5\times10^4$	0±0.00	0±0.00	0±0.00
Coliforms	$3.6\times10^5\pm8.4\times10^4$	3.5×10±4.082	0±0.00	0±0.00

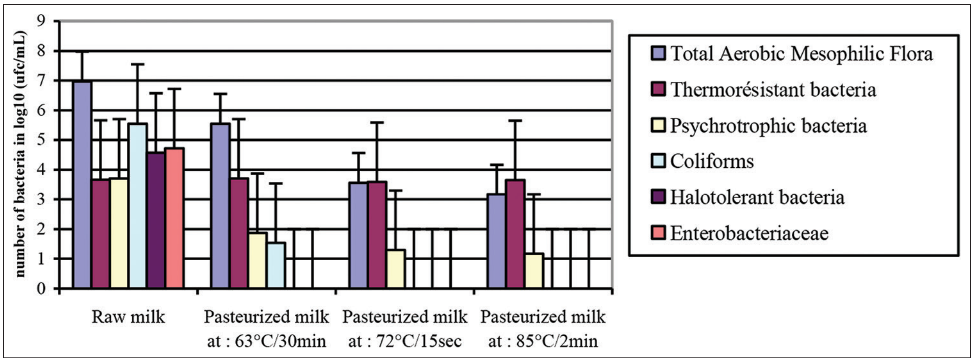

Fig 1. Pasteurization effect on the contamination flora of camel milk.

These bacteria being sensitive to heat, constitute a good witness of the effectiveness of heat treatments and/or recontamination (Faye,1997). We point out that this flora poses various problems for human health (Anonymous,1995; Bourgeois et al., 1996; Joffin and Joffin,1996; Larpent et al.,1997; Guiraud,2012).

The coliforms is present at values of 3.6 $\times10^5$ ufc/mL, this value located in the range cited by Siboukeur (2007) $10^5 – 10^6$ cfu/mL, and is greater to the values given by El Ziney and Al-Turki (2007) (1.4 Log_{10} cfu/mL).

The raw milk tested for *Enterobacteriaceae* had an average of 5.3×10^4 cfu/mL.These values are higher than the values reported by El Ziney and Al-Turki (2007) (2.72 Log_{10} cfu/mL) and are less than 10^6 cfu/ml cited by Siboukeur (2007).

Spoilage flora

This flora groups together heat-resistant (thermoresistant) bacteria and psychrotrophs. Thermoresistant bacteria in raw milk were found to be 4.3×10^3 cfu/mL, while pasteurized milk had 5.1×10^3 cfu/mL, 3.9×10^3 cfu/mL and $4.5\text{x}10^3$ cfu/mL, respectively (Fig.1; Table 4). Their continued development may alter products and, in some cases, pose a health risk. The components of this flora are: *Micrococcus*, *Microbacterium*, and *Bacillus*, the species of which cereus produces a stable enterotoxin after pasteurization (Dieng, 2001).

According to Anonymous (1995), thermoresistant bacteria are able to withstand common heat treatments like pasteurization, which is shown in our findings (Fig. 1). Mourgues et al. (1983) indicated that the heat-resistant number of raw milk affects not only the germ content but also the shelf life of pasteurized milk if there is no recontamination following pasteurization. Furthermore, due to insufficient cleaning and disinfection of equipment in contact with the milk, the heat-resistant flora is particularly introduced into the milk via soil, silage, feces, and residues. Furthermore, the psychrotrophic flora, was partially eradicated during pasteurization (Fig. 1; Table 4), with starting rates of 5.1×10^3 cfu/mL in raw milk samples becoming 7.5×10 cfu/mL, 2×10 cfu/mL and 1.5×10 cfu/mL, respectively corresponding to pasteurization at 63°C for 30 minutes, 72°C for 15 seconds, and 85°C for 2 minutes. As a result, we noticed a minor resistance of the psychrotrophic flora to pasteurization. Among the microorganisms that make up this group, mention may be made of *Micrococcus*, *Serratia, Pseudomonas*, *Corynebacterium*, the genus *Pseudomonas* being predominant (Dieng, 2001). These germs can produce heat-resistant lipases and proteases resulting in the appearance of very unpleasant tastes in dairy products: bitter taste, rancid, putrid, etc. The enumeration of the psychrotrophic bacteria in raw milk reveals an amount of 5.1×10^3 cfu/mL, these values are is less to the values given by Boudjenah Haroun (2012) 1.12×10^5 cfu/mL and similair to these given by El Ziney and Al-Turki (2007) 3.8 Log_{10}cfu/mL. these values becoming 7.5×10 cfu/mL, 2×10 cfu/mL and 1.5×10 cfu/mL, respectively corresponding to pasteurization at 63°C for 30 minutes, 72°C for 15 seconds, and 85°C for 2 minutes. As a result, we noticed a minor resistance of

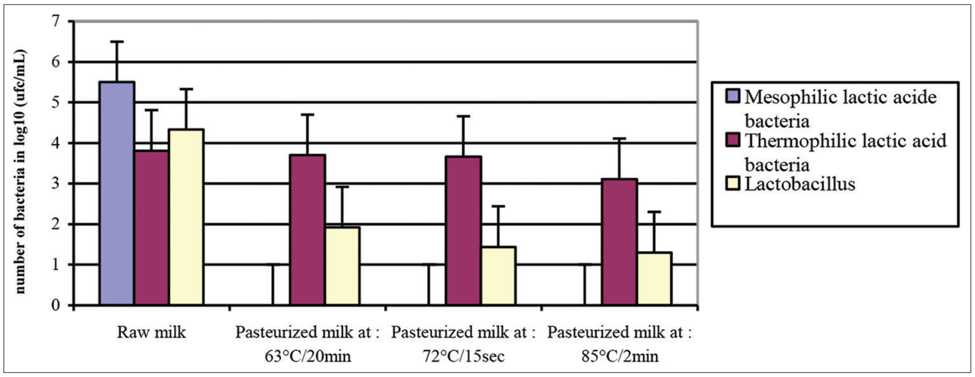

Fig 2. Effect of pasteurization on the original floraof camel milk.

Table 5: Descriptive characteristics of original flora (cfu/mL)

Microbial flora	Raw Milk	Pasteurized milk at: 63°C/30 min	Pasteurized milk at: 72°C/15 sec	Pasteurized milk at: 85°C/2 min
Mesophilic lactic acid bacteria	$3.6\times10^5\pm8.4\times10^4$	not detected	not detected	not detected
Thermophilic lactic acid bacteria	$6.5\times10^4\pm1.3\times10^3$	$5.1\times10^3\pm2.5\times10^3$	$4.6\times10^3\pm2.5\times10^3$	$1.3\times10^3\pm2.7\times10^2$
Lactobacillus	$2.1\times10^4\pm2.8\times10^3$	8.5×10±3.873	2.8×10±4.152	2×10±2.646

the psychrotrophic flora to pasteurization, which can be explained by the presence of some heat-resistant species which can be explained by the presence of some heat-esistant species.

NATIVE OR ORIGINAL FLORA

Lactic flora

The lactic flora has an important role in the dairy industry; its main function is to produce lactic acid through lactose fermentation. Other strains also produce carbon dioxide and various compounds, some of which contribute to the flavor of dairy products. The lactic flora, which comprises mesophilic and thermophilic lactic acid bacteria as well as lactobacillus representsthe following values: 3.6×10^5 cfu/mL, 6.5×10^3 cfu/mL, 2.1×10^4 cfu/mL in the raw milk sample respectively (Fig. 2; Table 5).

Mesophilic lactic acid bacteria showed a very high sensitivity to pasteurization, with a decrease rate of 100% for the three pasteurization scales employed in this study. However, thermophilic lactic acid bacteria, are resistant to pasteurization; following pasteurization to 63°C/30 min (5.1×10^3 cfu/mL), 72°C/15sec (4.6×10^3 cfu/mL) and 85°C/2min (1.3×10^3 cfu/mL) respectively as shown in Fig. 2. These bacteria are used for the manufacture of cooked pressed cheeses (Benmohamed, 2019). Furthermore, *lactobacillus* show a slight resistance to pasteurization. After pasteurization at 63°C/30 min, 72°C/15 sec and 85°C/2 min, the *lactobacillus* level becames 8.5× 10 cfu/mL, 2.8×10 cfu/mL and 2×10 cfu/mL respectively.

Lactic acid bacteria including mesophilic, thermophiles lactococci and *lactobacillus*, represented respectively by a charge of 3.6×10^5 cfu/mL, 6.5×10^3 cfu/mL and 2.1×10^4 cfu/mL. These values located in the range cited by Khedid et al. (2009) 2.5×10^2 to 6×10^7 cfu/ml for *lactobacillus* and 5×10^2 to 6×10^7 cfu/ml for *lactococci*.

The ability of lactic acid bacteria (thermophilic and lactobacillus) isolated from camel milk to resist pasteurization treatment is demonstrated in this study. However, this genus is inhibited in pasteurized bovine milk and it is reseeded with two lactic strains (*Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*) for the manufacturing of yogurt.

We find that pasteurization improves the hygienic quality of milk. However, preventive measures must be taken against the presence and development of pathogenic and/or spoilage germs (heat-resistant and psychrotroph).

CONCLUSIONS

People in Southern Algeria prefer to drink camel milk in its raw form for its therapeutic benefits, which they believe loses its quality after pasteurization. Our research reveals that pasteurization improves the quality of the product. The physicochemical and chemical examination of camel milk before and after pasteurization revealed that pasteurization at 63°C/30min (low pasteurization) has not a significant effect on the physicochemical (pH, acidity and density) and chemical characteristics (dry and fatty matter, lactose, vitamin C and proteins) of the camel milk. This study confirmed that the organoleptic quality and nutritional value can be preserved almost intact after pasteurization. Finally, we can say that pasteurization enhances the hygienic quality of milk. However, precautions must be taken to avoid the presence and development of pathogenic and/ or spoiling bacteria (heat-resistant and psychrotrophic).

Authors' contributions

Chethouna fatma and Boudjenah Haroun Saliha contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript, Siboukeur Oumelkheir and Beldi nadia were involved in planning and supervised the work, All authors discussed the results and commented on the manuscript.

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