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Effect of pasteurization on the physicochemical and nutritional quality of milk from the Korhogo dairy

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Abstract

Stabilization of the nutritional value of milk is essential for its conservation. It is in this context that the aim of this study was to evaluate the nutritional quality of raw and pasteurized cow's milk produced in Korhogo with a view to its valorization. Raw and pasteurized milk were sampled from June 24 to July 13, 2024, at the Korhogo dairy. The physicochemical and nutritional parameters of the two types of milk were determined according to AOAC methods. The results of the physicochemical parameters revealed that the values of pH, acidity, dry matter and degree brix are respectively 6.64 ± 0 .01 and 6.90 ± 0.00; 18.00 ± 0.10; 16.20 ± 0.04 °D; 121.93 ± 0.64; 126.23 ± 2.19 g/L and 10.10 ± 0.10; 11.20 ± 0.10 °Brix for raw and pasteurized milk. The nutritional parameters of raw and pasteurized milk show significant contents of ash (7.00 ± 0.01 and 7.47 ± 0.01 g/L), lipids (40.80 ± 0.02 and 36.30 ± 0.46 g/L), proteins (40.71 ± 0.01 and 37.02 ± 0.01 g/L) and carbohydrates (33.42 ± 0.03 and 45.44 ± 0.04 g/L). Pasteurization could be used to stabilize the nutritional value of milk.

Keywords: Korhogo; Milk; Nutritional characteristics; Pasteurization; Physicochemical characteristics

1. Introduction

Milk is a complete food that guarantees a significant supply of proteins, lipids, minerals, in particular calcium, phosphorus and vitamins [1]. It is an important part of the diet of pastoral and agro-pastoral families and of urban consumers [2]. In West Africa, milk is a locally available nutritious product that plays an important role in the rural economy and in the health of a growing number of children [3]. Consumption is on the rise as a result of population growth, urbanization and changing eating habits, particularly among the middle class [4]. With demographic growth and the emergence of a middle class, animal products, including milk, are becoming an increasingly important part of the Ivorian diet. In Ivory Coast, livestock production, in particular milk and dairy products, remains marginal in the country's economy [5]. In fact, livestock farming remains a secondary economic activity, contributing around 4.5 % to agricultural GDP and 2 % to total GDP; which is low in view of the country's enormous potential [6,7]. Milk production is estimated at around 34,000 tonnes [8]. Production is dominated by traditional methods. The north of the country is home to 70 % of the country's cattle population of the cattle population, with milk production essentially provided by cattle [9,10]. Korhogo, a town in the north of Côte d'Ivoire, is an area of high milk production. This production is ensured by herders in the vicinity of the town. Korhogo is home to a dairy supplied with milk by these farmers. The milk collected is sold to the local population in two forms: raw milk and pasteurized milk. Raw milk milk is the integral product of the

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complete and uninterrupted milking of a healthy, well-nourished and not overworked dairy cow [11]. Pasteurization consists of heating raw milk to 72 °C for 15 to 20 seconds to destroy pathogenic germs, while preserving its organoleptic quality and nutrients [12].

2. Material and methods

2.1. Biological material

The biological material consisted of raw cow's milk and pasteurized milk supplied by the Korhogo dairy. Korhogo is located in northern Ivory Coast (latitude 9°27'41"N, longitude 5°38'19" W), 565 km from Abidjan, the economic capital.

2.2. Sampling

Milk samples were collected over three successive days. Each morning, after the dairy had been supplied with raw milk by the farmers. First, a quantity of raw milk ready for processing was homogenized, then 1 L of sample was taken from it and placed in bottles. Then, after pasteurization at 90 °C for 5 minutes and cooling, 1 L of pasteurized milk was collected in the same way as before. Finally, the samples were transported directly to the laboratory in a cooler containing dry ice bottles. To avoid milk spoilage, the time between collection and the first analyses did not exceed 24 hours. Besides, before each sample was taken, the bottle was successively turned upside down to have a homogeneous content.

2.3. Methods

2.3.1. Physicochemical parameters determination of raw milk and pasteurized milk

pH

pH of the milk was determined according to the potentiometric method described by AFNOR [13], using a pH meter (HI 8915, Hanna Instruments). The pH meter was previously calibrated with two buffer solutions pH=4 and pH=7. The pH measurement was carried out by directly immersing the electrode of the previously calibrated pH meter in 50 mL of raw milk. The value displayed on the screen was read directly.

Dornic acidity

The determination of dornic acidity was based on titration of acidity with sodium hydroxide (N/9) in the presence of phenolphthalein as a colored indicator, according to standard NF 04-206 [14]. The number of ml of soda used was read on the graduated burette. The titratable acidity value, expressed in degrees Dornic (°D), was calculated by the following expression:

$$\text{Acidité Dornic (°D)} = 10 \times V_{NaOH}$$

With V_{NaOH} is the volume (in ml) of Dornic soda (N/9) poured to have the turn of the indicator.

Total dry matter

Total dry matter content was determined following the gravimetric method described by AFNOR [15]. Five (5) mL of raw milk were introduced into a previously tared capsule. The whole was heated in a boiling water bath for 30 min then steamed at 103 °C ± 2 °C until a constant mass was obtained. After cooling in a desiccator, the capsule containing the dry matter was weighed. The following expression was used to calculate the dry matter content:

$$\text{Total dry matter (g/L)} = (M_1 - M_0) \times 1000 / V$$

- M0 = mass of the empty capsule
- M1 = mass of capsule and residue
- V = volume of test portion.

2.3.2. Nutritional parameters determination of raw and pasteurized milk

Ash

Ash content was determined following the gravimetric method described by AOAC [16]. Five (5) mL of raw milk were introduced into a previously tared crucible. The whole was heated in a boiling water bath for 30 min then incinerated in a muffle furnace at 550 °C ± 5 °C for 8 hours. After cooling in a desiccator, the crucible containing the ash was weighed. The following expression was used to calculate the ash content:

$$\text{Ash (g/L)} = (M_1 - M_0) \times 1000 / V$$

- M0 = mass of empty crucible
- M1 = crucible mass + ash
- V = volume of test portion.

Lipids

Lipids were quantified according to the method described by AFNOR [15]. Ten (10) mL of raw milk were added to 10 mL of concentrated sulfuric acid contained in a butyrometer. To the mixture was added 1 mL of isoamyl alcohol. After tightly capping the butyrometer, it was shaken and inverted then centrifuged at 1200 rpm for 5 min. After centrifugation, the butyrometer is placed at 65 °C in a water bath for 5 min. After removing the butyrometer from the water bath and the cap being adjusted downwards, the value of the lower end of the fat column was noted (A) then the value of the upper end of the fat column was noted was graded (B). The fat content was determined by the following expression:

$$\text{Lipids (g/L)} = B - A$$

Proteins

Proteins were determined from the determination of total nitrogen according to the Kjeldhal method [16]. Five (5) mL of raw milk were mineralized at 400 °C for 2 hours in the presence of a pinch of catalyst (selenium + potassium sulfate) and 20 mL of concentrated sulfuric acid. The mineralized material obtained was transferred into a 100 mL volumetric flask and made up to the mark with distilled water. Ten (10) mL of 40 % NaOH are added to 10 mL of mineralized material and the mixture is distilled for 10 min, taking care to trap the distillate in 20 mL of 4 % boric acid added with a mixed indicator. The distillate is then dosed with a 0.1 N sulfuric acid solution until it changes from green to orange. Total protein content was calculated using the following expression:

$$\text{Proteins } \left(\frac{g}{L}\right) = \frac{(V_1 - V_0) \times 14 \times 6.39 \times N}{Ve}$$

- V0: volume (mL) of sulfuric acid solution (0.1 N) poured for the blank test.
- V1: volume (mL) of sulfuric acid solution (0.1 N) poured for the test (sample).
- N: normality of the sulfuric acid solution.
- Ve: volume (mL) of the sample.

Carbohydrate content

The total carbohydrate content was determined according to the formula proposed by AOAC [16].

Total carbohydrates (g/L) = Dry matter – (Ashes + Proteins+ Lipides).

3. Results

3.1. Physicochemical characteristics of raw and pasteurized milk

Table 1 shows the results of the physicochemical analyses of the milk samples. The dry matter of the two types of milk was not significantly different ($p > 0.05$), with values of 121.93 ± 0.64 g/L for raw milk and 126.23 ± 2.19 g/L for pasteurized milk. On the other hand, the other physicochemical parameters showed a significant difference ($p < 0.05$) between the two samples. Indeed, the pH of raw milk was 6.64 ± 0.0, with an acidity of 18 ± 0.1 °D and a Brix degree of

10.10 ± 0.1 °B. Pasteurized milk, on the other hand, has a pH of 6.90 ± 0.0, an acidity of 16.20 ± 0.04 °D and a Brix of 11.20 ± 0.1 °B.

Table 1 Physicochemical charateristics of different milks

Milk samples	pH	Acidity (° D)	Dry matter (g/L)	Brix Degree (° B)
Raw	6.64 ± 0.01 b	18.0 ± 0.1 b	121.93 ± 0.64 a	10.10 ± 0.1 b
Pasteurized	6.90 ± 0.0 a	16.20 ± 0.04 a	126.23 ± 2.19 a	11.20 ± 0.1 a

The averages of the same line bearing the same letter do not present a significant difference at risk p=0.05

3.2. Nutritional characteristics of raw and pasteurized milk

The nutritional parameters of raw and pasteurized milk are shown in Table 2. Statistical analysis revealed that the fat content of raw and pasteurized milk was not significantly different ($p > 0.05$), with values of 40.8 ± 0.02 g/L and 36.30 ± 0.46 g/L respectively. However, significant differences ($p > 0.05$) were noted for the other parameters, namely ash, protein and carbohydrates. The ash content of raw milk was 7.00 ± 0.01 g/L, while that of pasteurized milk was 7.47 ± 0.01 g/L. The protein content of raw milk (40.71 ± 0.01 g/L) was lower than that of pasteurized milk (37.02 ± 0.01 g/L). The carbohydrate contents of raw and pasteurized milk were 33.42 ± 0.03 and 45.44 ± 0.04 g/L respectively.

Table 2 Nutritional charateristics of different milks

Milk samples	Ash (g/L)	Fat (g/L)	Proteins (g/L)	Carbohydrates content (g/L)
Raw	7.00 ± 0.01 b	40.80 ± 0.02 a	40.71 ± 0.01 a	33.42 ± 0.03 a
Pasteurized	7.47 ± 0.01 a	36.30 ± 0.46 a	37.02 ± 0.01 b	45.44 ± 0.04 b

The averages of the same line bearing the same letter do not present a significant difference at risk p=0.05

4. Discussion

The results showed a significant variation in physicochemical parameters depending on the type of milk. Indeed, milk pH increases significantly with heat treatment. The results are in line with those of Pestana *et al.* [17], who observed an increase in pH after milk pasteurization. This increase in pH translates into a significant decrease in titratable acidity. These results are corroborated by those of Haq *et al.* [18]. Indeed, the increase in milk pH following heat treatment is due to the decrease in acidity caused by the drop in whey proteins associated with micelles [17]. The drop in whey proteins is evidenced by the significant decrease in the protein content of raw milk after heat treatment. The results are similar to those of Fetahagic *et al.* [19], who noted a reduction in protein content during heat treatment due to protein denaturation. Indeed, temperatures above 60 °C lead to denaturation of the proteins contained in milk [20]. The results of this study show that the ash content of raw milk increased significantly with heat treatment. It should be noted that the quantity of ash reflects the presence of minerals in the feed. The results obtained differ from those of Bousbia *et al.* [21], who noted a constant mineral content after pasteurization (85 °C for 30 seconds). This difference can be explained by the temperature and time of heat treatment. The results of this study are similar to those of Haq *et al.* [18], who observed an increase in the ash content of milk after pasteurization. The increase in ash content is thought to be due to water evaporation, which promotes mineral concentration in the milk. At the same time, water evaporation led to a significant increase in the milk's brix and carbohydrate content. Indeed, lactose, which is the main reducing sugar in milk, concentrates with the evaporation of water, increasing the milk's sweetness [22,23]. The results are contrary to those of Bousbia *et al.* [21], who found a decrease in lactose after heat treatment. This decrease is due to Maillard reactions [24].

The dry matter results show no significant difference in dry matter between the two types of milk. The results are similar to those of Farzana *et al.* [25] and contrary to those of Nangraj [22], who noted an increase in dry matter due to moisture evaporation.

The results reveal a non-significant change in raw milk fat following heat treatment. These results differ from those of Petrus *et al.* [26], who observed a drop in milk fat after heat treatment. The decrease in milk lipid content is due to the high heating temperature, which reduces milk fat through the evaporation of compounds [27].

5. Conclusion

The physicochemical and nutritional parameters of raw milk vary after heat treatment. Pasteurization significantly altered the pH, acidity, Brix level, protein content and ash content of raw milk. However, it had no significant effect on milk fat and dry matter. So, although pasteurization has altered the physicochemical and nutritional quality of milk, it has a comparatively appreciable quality. It would be useful to know the microbiological quality of milk after pasteurization.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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