EVALUATION OF HYGIENIC AND NUTRITIONAL QUALITY OF PEULH CHEESE TREATED BY *SORGHUM VULGARIS* (L) AND *PIMENTA RACEMOSA* (MILLER) EXTRACTS

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Abstract: The present study has been carried out for evaluating hygienic and nutritional quality of treated Peulh cheese using *Sorghum vulgaris* and *Pimenta racemosa* extracts. After the treatment of cheeses with the two extracts, a significant reduction of the microbial flora occurs during the conservation. It seems however worthy that combining temperature and extracts is necessary. The decrease of *pH* values of fresh cheeses compared to those of treated ones has been observed and connected to the amount of lactic acid present (0.17% for fresh cheese and 0.21% for treated ones). It results a lowering of the *pH* values of fresh cheeses and those treated with extracts are respectively 6.47 and 6.08. Titrable acidity values as a percentage of lactic acid, which is related to the *pH* values. The amount of

water in studied cheeses decreases from 64.02% to 58.37% leading to a reduction in their osmophile flora.
In nutritional terms, there is a conservation of lipid level (47.20%), protein (38.56%) and an increase of ash (minerals) from 4.23% to 5.21% in treated cheeses. These results indicate an important cheese quality improvement in hygienic and level, induced by conservation.

Keywords: *Cheese, Sorghum vulgaris, Pimenta racemosa, Hygienic and nutritional aspects*

INTRODUCTION

Benin economy as many of other African countries in the south of Sahara is based on agricultural production, in which livestock plays an important role. Among farmed products (skins for the preparation of leather products, meat), milk occupies an important place in African economies. The roughly permanent high temperature in these countries responsible of the quick degradation of cow milk has brought the actors to be involved in developing techniques for processing milk for long conservation including the preparation of cheeses. Cow milk once entirely self-consumed is now transformed into products fermented or not, including yoghurt and cheese. The Peulh cheese process technique is part of the traditional old know-how of Fulani women. This activity is restricted to Fulani women of Benin by a process curiously ignored in the rest of West Africa [18, 26, 27]. The Fulani cheese is made from cow milk. In fact the products deriving from this ancient technique are not completely safe and intoxication sometimes occurs [17]. In order to guarantee the conservation of Peulh cheese, Kèkè *et al.* used a freeze-dried strain of *Lactobacillus plantarum* [28], while Ashaye *et al.* introduced the aqueous extract of *Aframomum danielli* treating Warakanshi cheese and maintain its sensorial characteristics [10]. The aim of this work is to enhance the hygienic and nutrional quality of Peulh cheese by treating it with *Sorghum vulgaris* and *Pimenta racemosa*.

MATERIALS AND METHODS

Plant material

Leaves of *Pimenta racemosa* were collected from Ifangni farmhouse in the department of Plateau. Panicles of sorghum were collected in a farmhouse of Parakou in the department of Borgou. The coagulant plant was *Calatropis* [3, 14, 38].

Animal equipment

It is mainly cow milk from the Kpinnou farmhouse in the department of Mono and Calavi farm in the department of the Atlantic. The milk was stored in canisters and

immediately transported to laboratory for analysis and used as raw material for cheese making.

Essential oil extraction and analysis

The leaves of *Pimenta racemosa* were submitted to hydrodistillation for 2 or 3 h using a Clevenger. The essential oils obtained were dried over anhydrous sodium sulfate. The various components of the dried essential oil were identified by GC and GC/MS.

Characterization of *Sorghum vulgaris* extracts

a- Chloroform extract
To 1 g of *Sorghum vulgaris* powder is added 10 mL of chloroform; the mixture is then heated with caution during 3 min in a water bath. The filtration of the warm solution follows, completed to 10 mL with chloroform if necessary.

b- Hydrolysate
To an amount of powder residue exhausted by chloroform, 10 mL of water and 1 mL of concentrated HCl is added; the tube test is kept in a boiling water bath for 15 min, then cooled under running water, filtered, up to 10 mL with water.

Anthraquinones free
To eliminate anthraquinone, to 1 mL of chloroform extract (a) is added 1 mL of NH_4OH diluted to 50% while shaking. The more or less red color indicates anthraquinones.

Combined Anthraquinones
-O-glycosidic
Take 5 mL of hydrolysate (b) and shake it with 5 mL of $CHCl_3$ with a separating funnel, remove the organic phase (as below) and submit it into a test tube and then retain the aqueous phase. Add to the organic phase 1 mL of NH_4OH diluted to 50% and then shake. The presence of o-glycosidic is revealed by a more or less intense red coloration.

-C-glycosidic
Taking over the aqueous phase, which was kept by 10 mL of water and add 1 mL of $FeCl_3$ 10%, maintain the test tube in a boiling water bath for 30 min, cool under running water, shake with 5 mL of $CHCl_3$, evaporate the chloroform phase and collect in a test tube, add 1 mL of NH_4OH (50%) diluted and shake; a more or less intense red coloration indicated the presence of C-glycosidic.

-Saponosides or saponins: Index foam
Two grams of dry and ground *Sorghum vulgaris* are used to prepare a decoction with 100 mL of distilled water and submitted to boiling for 30 min and divided in 10 tubes. (1.3 cm in diameter inside) 1 mL, 2 mL, 3 mL, …, 10 mL of decoction. Adjust the contents of each tube to 10 mL with distilled water. Each tube is shaken vigorously in a horizontal position for 15 seconds. After 15 min in vertical position persistent foam, measured is obtained. If it is close to 1cm in the 10^{th} tube, then the foam index is calculated by the following formula: I = foam level (cm) in the 10^{th} tube × 5/0,0X.

The presence of saponinsis is confirmed by an index exceeding 100.

Tannins
An infusion with 5 g of plant powder in 100 mL of distilled boiling water is prepared and infused for 15 min. Filtered and rinsed with a little hot water for obtaining 100 mL of solution.
To 30 mL of brewed, add 15 mL of Stiasny reagent. All is heated in a bath at 90 °C for 15 min. The appearance of precipitate indicates the presence of catechique tannins.

Flavonols
Flavonols were determined by cyanidine reaction. The emergence of a red coloration in the supernatant layer indicates the presence of the flavonols.

Leucoanthocyanes
Taking over the cyanidine reaction without magnesium chips. The leucoanthocyanes appear with a red cherry coloration.

The sterols and triterpenes
The Sterol and triterpenes have been identified by Liebermann-Buchard reaction [15].

Cheeses treatment with *Sorghum vulgaris* extracts

Extracts of *Sorghum vulgaris* are obtained by the following method:
Five, ten, fifteen, twenty and thirty grams of panicles of Sorghum previously washed with water are respectively immersed in a litter of water in an aluminum pot and then heated. 10 $g.L^{-1}$ of salt and potash (3-4 $g.L^{-1}$) are added. The white cheeses are put in the aqueous solution of panicles contained in the pot. All is cooked low heat for ten minutes to about 70°C. The extract of *Sorghum vulgaris* leaves settle on the cheese. After coloring, cheeses are exposed to a colander to drain.

Oils inoculation on samples of cheese

After the draining phase of the cheese, are injected 0 mL, 0.25 mL, 0.5 mL, 0.75 mL; 1 mL; 1.25 mL of oil respectively in 100 g of cheese (100 g × 6). The same injections are considered for cheese treated with sorghum panicles extracts. After treatment, the cheeses are wrapped in foil and then left exposed to different temperatures to room temperature 25 °C (temperature laboratory air conditioning) and 7 °C (refrigerator temperature).
It will be determined the amount to incorporate one or the other extracts cheese for optimal activity.

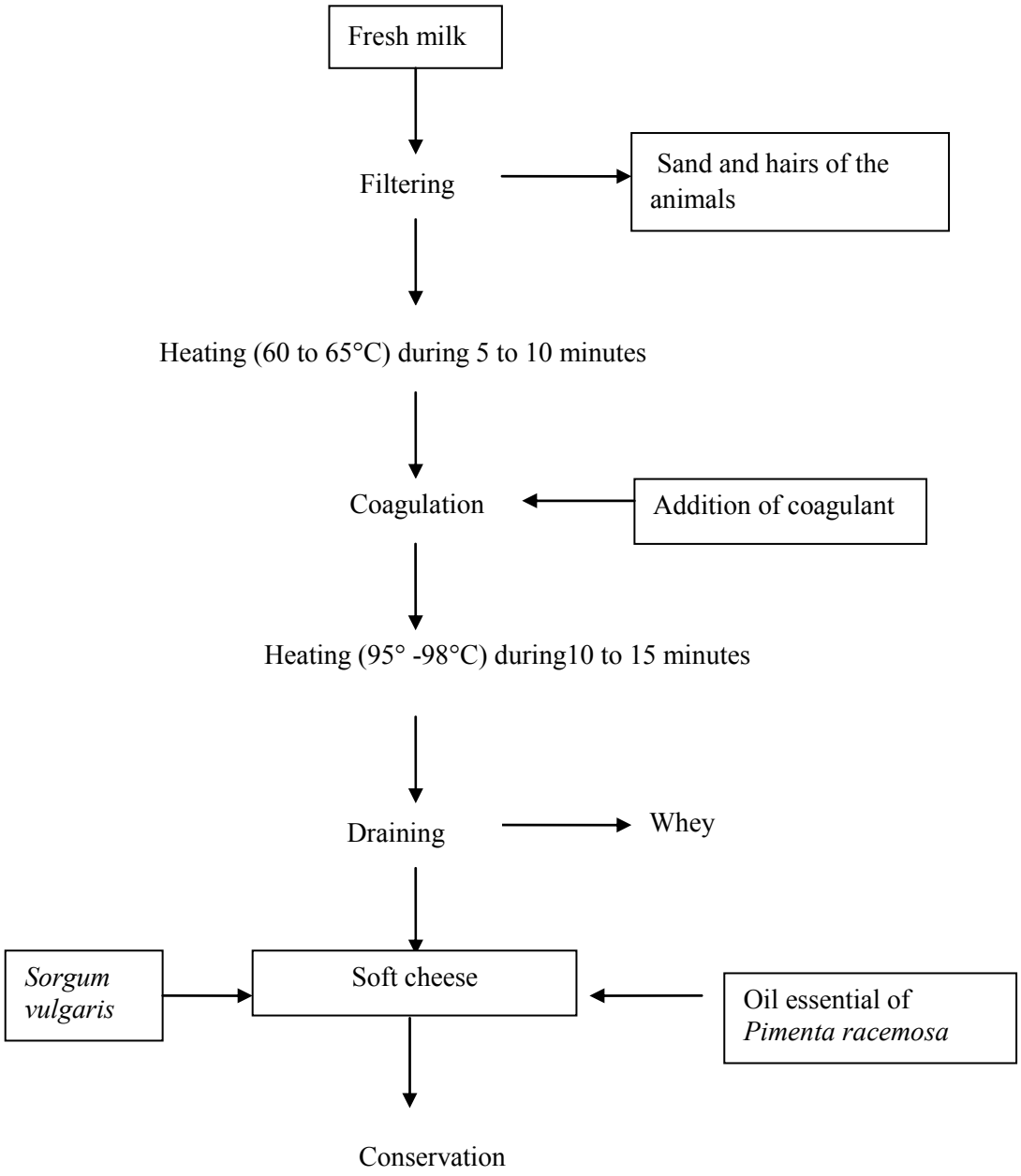

***Figure 1**. Technological diagram of production of Peulh cheese treated with Sorghum vulgaris and Pimenta racemosa extracts*

Microbiological analyses of milk and various types of cheeses

The total aerobic flora was counted on PCA (Plat Count Agar) after 72 h at 30 °C, the yeasts and moulds on OGA (Oxytetracycline Glucose Agar) after 5 days at 25 °C, mean coliform in BLBVB (Bubble Belie Lactose with the brilliant Green) after 48 hours at 30 °C, Staphylococci on Baird Parker plate after 48 h at 37 °C and the lactobacilli flora in Rogosa in microaerophil at 37 °C during 72 h, Streptococcus by sowing of 1 mL of the first suspension (and diluted solutions) in 10 mL Rothe medium. After 24 h (or 48

h) of incubation at 37 °C, any tube presenting a bacterial disorder is considered positive, the Anaerobic Sulfito-Reducers on solid medium TSC (Tryptone Sulfite Cyclosérine), after 20 h of incubation to 35 or 37 °C in anaerobia then Salmonellas are determined by ISO 6579 method.

Physico-chemical analyses of milk and cheese

pH, water content, acidity degree, lipids and rough proteins content were determined by the A.O.A.C. (Association off Official Analytical Chemist) methods [11, 12].

RESULTS

Yield of the essential oil extracted from *Pimenta racemosa* leaves

The essential oil is extracted from *Pimenta racemosa* leaves with an output of 2.03%.

Table 1. *Chemical composition of essential oil Pimenta racemosa collected in Ifangni*

Name of the compounds	*IR	%
α-pinene	940	0.5
octèn-3-ol	974	1.9
β-pinene	982	-
myrcene	**993**	**30.9**
α-ter pinene	1018	0.6
P-cymène	1022	0.4
Limonene	1034	3.4*
1,8-cineole	1043	3.2*
(E) -β-ocimene	1092	0.3
linalol	1178	0.3
terpinèn-4-ol	1188	1.9
α-terpineol	1188	0.9
chavicol	1250	**8**
eugenol	1368	**46.6**
(E E)-α -farnescene	1502	0.3
Monoterpenes hydrocarbones		**36.1**
Monoterpenes oxygenes		**5.1**
Sesquiterpenes hydrocarbones		**0.3**
Aliphatics derived		**1.9**
Aromatics compounds		**54.6**
Total		**98.0**

Table 2 shows the chemical composition of sorghum panicles extracts. The number of "+" is function of the intensity of coloring and/or precipitates. The reactions were positive with C heterosides, flavonols, leucoanthocyanes and catechic tannins, anthraquinones free then with sterols and triterpens.

Phytochemical data: tube reactions

Table 2. *Chemical composition Sorghum vulgaris extracts*

Compound	Results
Free anthraquinone	++ Staining red
c-heteroside	+++
Saponins (foam index)	250 ±002 visible foam
Catechics tanins (stiasny reaction)	++ red hasty
Flavonols (cyanidine reaction)	+++ violet ring
Leucoanthocyans	+++ red Cherry
Sterols et triterpens (Liebermann-Buchard reaction)	+ + + violet ring

Caption: + + Positive; + + + Very positive

Physical and chemical characteristics of cow milk

Table 3. *Physical and chemical characteristics of cow milk*

Types of cow milk	Calavi	Kpinnou
pH	6.63 ± 0.20a	6.59 ± 0.01a
Water content (%)	86.01 ± 0,48a	80.61± 0.53b
Acidity (% of lactic acid)	0.17 ± 0.03a	0.24± 0.01b
Proteins (%)	29.94 ± 0.07a	31.96± 0.41b
Lipids (%)	34.52± 0.59a	35.13 ±0.13a
Ash (%)	2.01 ± 0.23a	2.23 ± 0.32b

Averages followed by the same letter are not significantly different threshold of 5% (test Student)

Test of Student is used for the statistical analysis of table 3 results. The averages followed by the same letter are not significantly different with the threshold from 5%. The probability P < 5% show a significant difference on values level of milk samples parameters. In a contrary case there is equality between the samples.

Physical and chemical characteristics of types of cheese

Table 4. *Physical and chemical characteristics of types of cheese*

Characteristics	Types of cheese			
	Fresh cheese (1st day)	Cheeses treated with sorghum Panicle's	Cheeses and essential oil	Cheeses treated with the sorghum Panicle's and essential oil
pH	6.48a	6.22b	6.12c	6.04d
Water content (%)	64.01a	60.13b	58.77c	58.39d
Acidity (% of lactic acid)	0.17a	0.18a	0.20b	0.21b
Proteins (%)	38.61ac	38.61ac	38.56ab	38.57ab
Lipids (%)	47.86a	47.61a	47.57ac	47.57bc
Ash (%)	4.24a	4.39b	4.84c	5.21d

Medians followed by the same letter are not significantly different threshold of 5% (Kruskal- Wallis and Mann-Whitney Test)

The variation of the pH of cheese according to the time and preserved at 7 °C and 25 °C

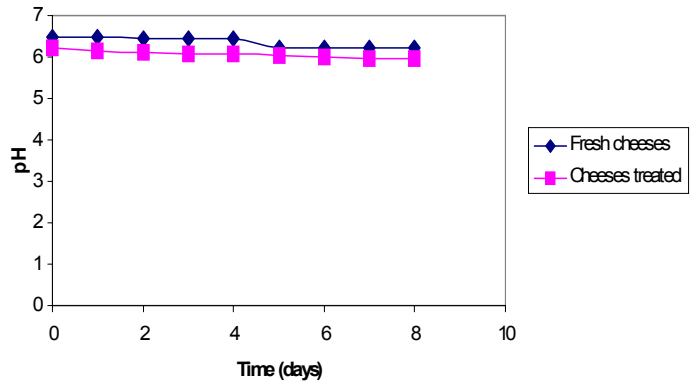

Figure 2. *The variation of the pH of fresh cheese and cheeses treated versus the time and kept at 7°C*

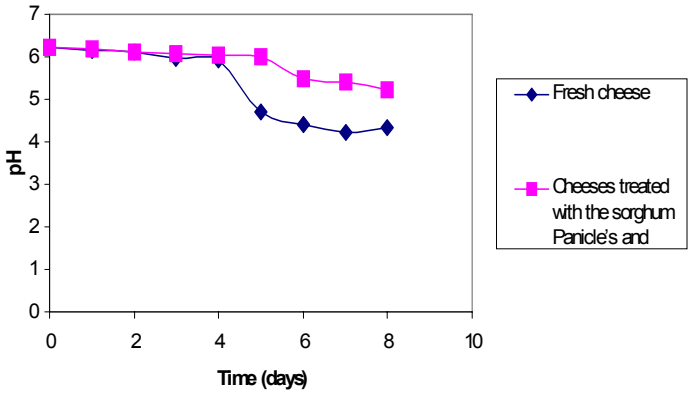

Figure 3. *The variation of the pH of fresh cheese and cheeses treated versus to the time kept at 25°C*

The analysis of figure 2 indicates that from 0 to 8 days, the *pH* is constant whereas figure 3 shows that from 0 to 4 days, the *pH* of fresh cheeses decreases by 6.22 to 6.00 whereas in the same period the *pH* of cheeses treated with the extracts of *Sorghum vulgaris* and *Pimenta racemosa* is always constant at the same temperature. By 4 to 8 days the *pH* of untreated cheeses decreases quickly reaching the value of 4.

Variation of the water content of cheeses according to the time and preserved at 7 °C and 25 °C

Figure 4 represents the variation of the water content of fresh cheese and cheeses treated versus the time at 7 °C shows that from 0 to 5 days the water content of fresh cheese untreated and treated has decreased by 64.02% to reach a value by 58%. From 5th to the 7th day a reduction of the amount of water in extracts treated cheeses going from 58% to 48%. Figure 5 represents the variation of the water amount in fresh cheeses and cheeses treated according to the time and preserved at 25 °C indicates that

the reduction in the water amount in cheeses treated with the two extracts is more important that in the pilot cheese.

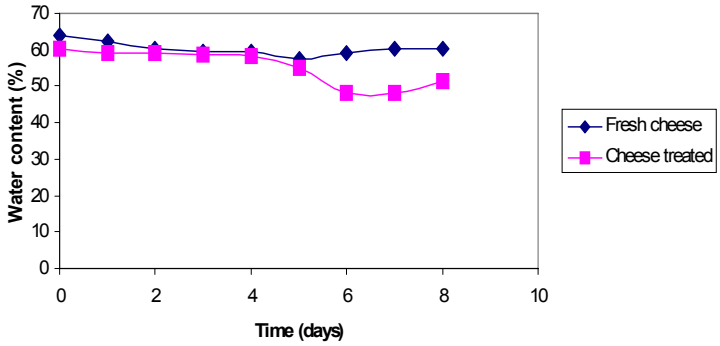

Figure 4. *The variation of the water content of fresh cheese and cheeses treated according to the time and preserved at 7°C*

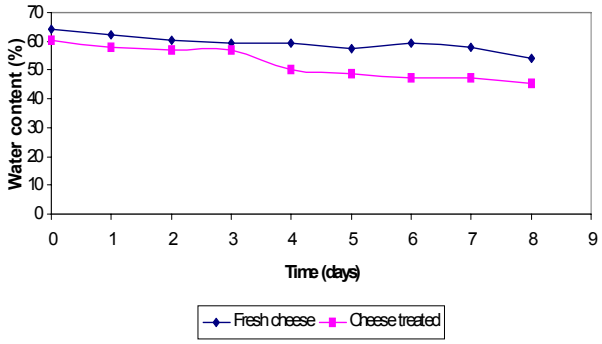

Figure 5. *The variation of the water content of fresh cheese and cheeses treated according to the time and preserved at 25°C*

Microbiological characteristics of cow milk

Table 5. *Microbiological characteristics of cow milk according to locality*

Locality / Germs in Milk CFU/mL	Calavi	Kpinnou	Criteria AFNOR Germs/mL
Mesophil aerobic count germs	2.83×10^6	2.06×10^5	5×10^5
Coliforms count	4.5×10^2	9.5×10^1	100
Thermo tolerant coliforms	3.9×10^2	1.2×10^1	Non consider
Staphylococcus aureus	3.3×10^1	2.2×10^1	100
Clostridium sulfito- reducer	absence	absence	50
Streptocoques	12	7	10
Yeast and mould	absence	absence	Non consider
Lactic flora	1.68×10^5	$1.16 \times x\ 10^4$	Non consider
Salmonella sp	Absence/25 mL	Absence/25 mL	Absence/25 mL

Microbiological characteristics of fresh cheese and cheese treated with *Sorghum vulgaris* and *Pimenta racemosa* extracts

Microbiological analysis of the different cheeses is consigned in table 6.

Table 6. *Microbiological characteristics of fresh cheese and Sorghum vulgaris and Pimenta racemosa extracts treated cheese*

Microorganisms sought CFU / g of cheese	Types of cheese				
	Fresh cheese	Cheeses treated with sorghum Panicle's	Cheeses and essential oil	Cheeses treated with the sorghum Panicle's and essential oil	Criteria AFNOR Germs/mL
Mesophil aerobic count germs	5.2×10^4	4.6×10^4	$2{,}1 \times 10^4$	$9{,}2 \times 10^3$	Non consider
Coliforms count	Absence	Absence	Absence	Absence	10^3
Thermo tolerant coliforms	Absence	Absence	Absence	Absence	10^2
Clostridium sulfito-reducing	Absence	Absence	Absence	Absence	10^3
Staphylococcus aureus	Absence	Absence	Absence	Absence	10^2
Streptocoques	Absence	Absence	Absence	Absence	50
Lactobacilles	1.3×10^3	$4{,}32 \times 10^3$	$5{,}24 \times 10^4$	$6{,}23 \times 10^5$	Non consider
Yeast	2.1×10^2	$4{,}5 \times 10^3$	$2{,}3 \times 10^3$	$2{,}3 \times 10^3$	Non consider
Mould	1.5×10^1	$1{,}1 \times 10^1$	7×10^0	Absence	Non consider
Salmonelles	Absence/25 g	Absence/25 g	Absence/25 g	Absence/25 g	Absence/25 g

Evolution of the microbial flora in the fresh cheese according to the time and preserved at 7°C and 25°C

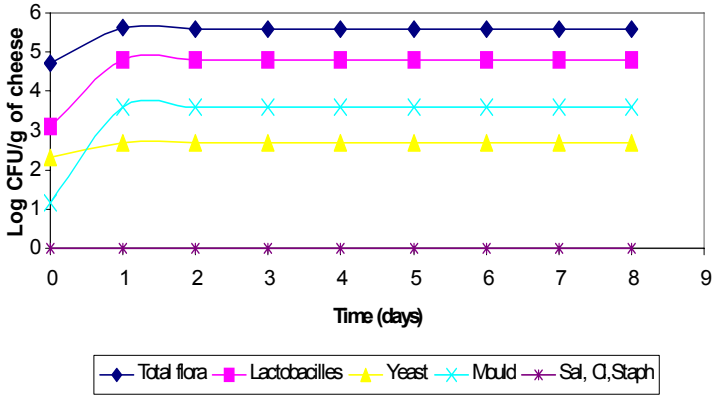

Figure 6. *Evolution of the microbial flora in the fresh cheese according to the time at 7 °C*

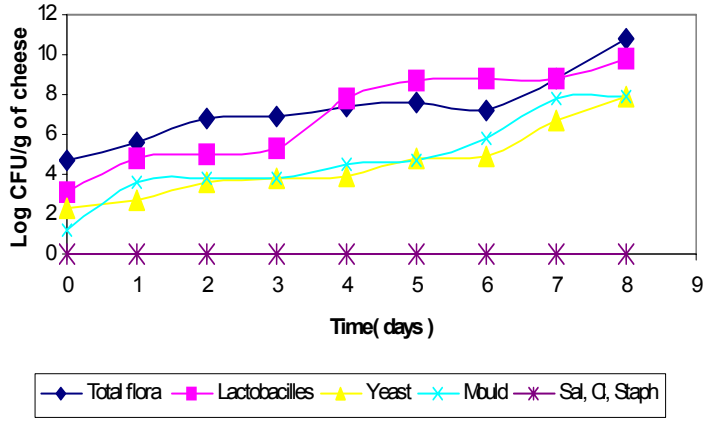

Figure 7. *Evolution of the microbial flora in the fresh cheese according to the time at 25 °C*

Evolution of the microbial flora in fresh cheese treated according to the time and preserved at 7 °C and 25 °C

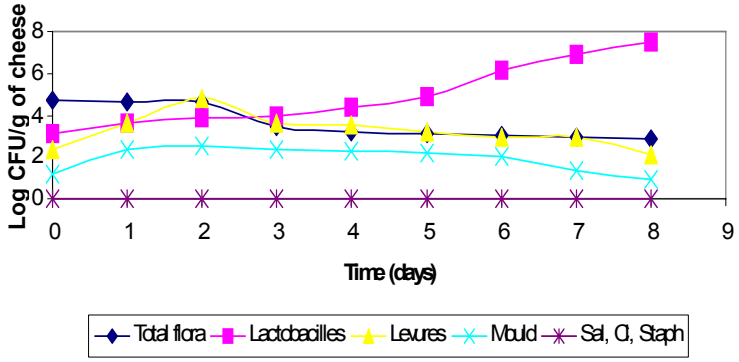

Figure 8. *Evolution of the microbial flora in fresh cheese treated according to the time at 7 °C*

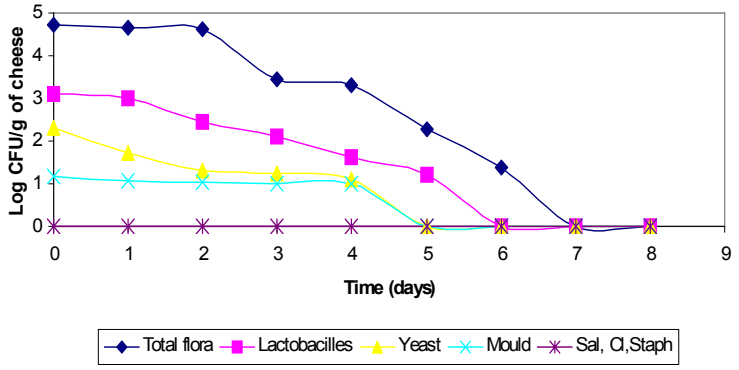

Figure 9. *Evolution of the microbial flora in fresh cheese treated according to the time at 25 °C*

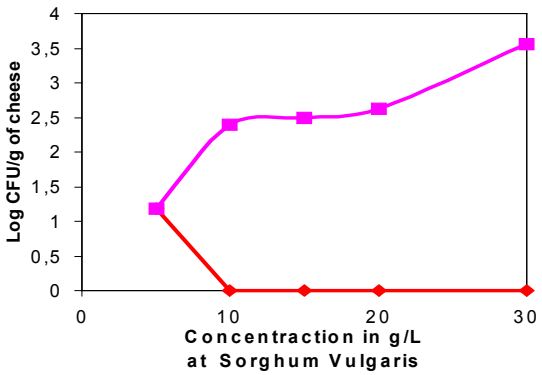

Figure 10. *Evolution of yeast and mould in cheese treated with the sorghum vulgaris extracts to concentrations various*

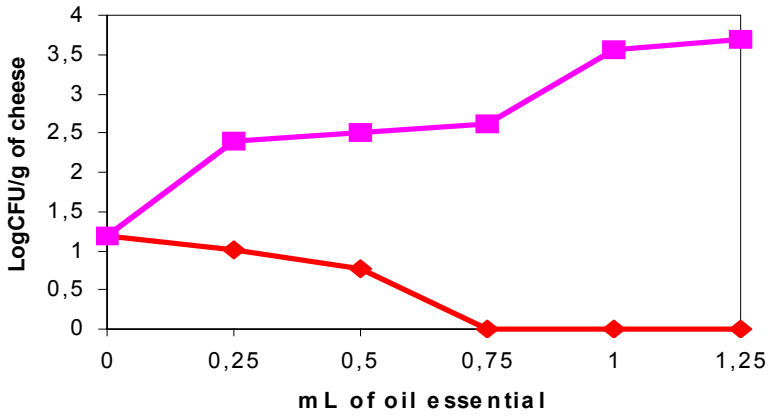

Figure 11. *Evolution of yeast and mould in cheeses treated according to the essential oil amounts of Pimenta racemosa*

DISCUSSION

The present study was devoted to the evaluation of hygienic and nutritional quality of Peulh cheese treated with *Sorghum vulgaris* and *Pimenta racemosa* extracts. The chemical composition of *Pimenta racemosa* essential oil shows it rich in phenolic derivatives (eugenol - 46.6%, chavicol - 8%; table 1). The presence of these phenolic compounds plays an important radical inhibitor role activity required in agro business industry to delay degradation of substances rich in lipidic compounds [6, 34]. The analysis of *Sorghum vulgaris* extracts (table 2) reveals the presence of C heterosides, flavonols, leucoanthocyanes and catechic tannins, free anthraquinones, sterols and triterpens.

Tannins are chemical substances recognized for their ability to fixate on proteins in particular those of cheeses with a tendency to the no permeability of external layers and

the protection of the subjacent layers [13]. Leucoanthocyanes, sterols and triterpens are phenolic compounds which are recognized by their large variety of simple compounds like the salicylic acid, molecule giving thereafter aspirin and more complex substances, which could explain the activities antipyretic and anti-inflammatory properties drug of phenols like flavonols [35]. The physicochemical analysis of the milk of the two localities (table 3) shows that the *pH* of milk from Kpinnou and Calavi are respectively 6.59 and 6.63. Those values of the cow milk are close to neutrality, consequence of the presence of caseins, the phosphoric and citric anions mainly [9, 33]. These normal values of *pH* testify the good quality of milk and its stability to heat. No proteins coagulation risk appears during heating. The Calavi milk has a high content (86.01%) of water and weak proteins (29.94%), which translates a weak output for cheeses [29]. Compared to Kpinnou cow milk, the water content is less lower (80.61%) but proteins content is higher (31.96%): this involves a better cheese yield. The rates of fat contents, proteins and ashes indicate a good nutritive quality [37]. Table 4 shows that the *pH* values of the various types of cheeses lies between 6.47 and 6.08. This is in relation with assayable acidity: more the *pH* expressed as a percentage decreases more assayable acidity of lactic acid is high. But the water content of cheeses treated with *Sorghum vulgaris* of *Pimenta racemosa* extracts is low (58.37%) compared to fresh untreated cheese (64.02%). This reduction in water content in treated cheeses limits the development of the osmophile micro-organisms and ensures its best conservation. On nutritional level, fat and proteins contents are maintained after the treatment. But it is noted an increase of ashes i.e. in rock salt during the treatment. This increase in ashes would come from *Sorghum vulgaris* extracts than tannins of cheeses treated with *Sorghum vulgaris* and *Pimenta racemosa* testify to a good nutritive quality. This confirms the results obtained by Glew *et al.* which showed that *Sorghum vulgaris* is rich in rock salt and amino-acids [36]. Peulh cheese is a rich product on nutritive level [27], like Nigeria wara [37]. The analysis of Figure 2 shows that from 0 to 8 days the *pH* is constant. This constancy of *pH* derives from the absence of metabolic reactions of micro-organisms in the different cheeses. Thus the low temperature inhibits the micro-organisms activities on the level of the food products confirming the results obtained by Ashaye *et al*., that preserved the Warakanshi cheese treated with *Aframomum danielli* extracts and found a constant from 0 to 3 days [10].

Figure 3 represents the variation of *pH* in fresh and treated cheeses versus to the time and preserved at 25 °C indicates that from 0 to 4 days the *pH* of fresh cheeses decreases by 6.22 to 6.00 whereas in same time the *pH* of cheeses treated with *Sorghum vulgaris* and *Pimenta racemosa* extracts is always constant at the same temperature. From 4th to 8th day, the *pH* of untreated cheeses decreases quickly to reach a value of 4. This reduction of *pH* expresses the metabolic reactions of the lactobacillus present in cheese which turn lactose of cheese into lactic acid according to EM process (Embden-Meyerhof).These results confirm the results obtained by Egounlety *et al*. [21] and Casalta *et al.* [15], who found that the *pH* of Bastelicaccia cheese decreases with the time. Compared to cheeses treated with the two extracts, it is noted that the *pH* decreases slightly by 6.22 to 5.84 from 4 to 8 days. This slight reduction in *pH* in time is explained by the action of phenolic compounds found in essential oil which have antioxidant properties and delay the degradation of the food products rich in lipids such as cheese [6]. In the same way the sorghum panicles extract rich in tannins limits the development of the micro-organisms and develops a bactericidal activity. The

simultaneous use of these two extracts ensures a good conservation of cheese and improves its nutritional quality flavonols which are precursors of the vitamin PP. The variation of the water content in fresh cheeses and cheeses treated according to the time and preserved 7 °C at 25 °C (figures 4 and 5) shows a reduction in the water content of the different types of cheeses treated with extracts. This is due to the majority compounds found in *Pimenta racemosa* essential oil and in *Sorghum vulgaris* extracts which act on the availability of free water and concentrate the dry matter. The free water plays a very important role in the cheese conservation because its presence favors micro-organisms multiplication and reduces their shelf life. These results are in conformity with those obtained by Kèkè *et al.* [28] which used stump of *Lactobacillus plantarum* for a lengthening shelf life of cheese and Egounlety *et al.* [21] who showed that the water content of stored cheeses decreases in step with time.

On the microbiological level, analysis of the cow milk of Calavi and Kpinnou (table 5) shows that the Kpinnou milk contains fewer germs than the Calavi milk according to AFNOR criteria [4]. The cow milk of Kpinnou is of a more satisfactory hygienic quality compared to the criteria and Calavi milk is of a less satisfactory hygienic quality. But these germs are generally destroyed during the cooking of cheese at a temperature close to 100 °C. These results confirm those obtained by Egounlety *et al.* [21] which have showed that the milk of the campings peulh is contaminated by the micro-organisms at the time of the during draft period. On the microbiological level of the various types of cheese (table 6), one notes complete absence of the total coliforms, thermo-tolerant coliforms, *Clostridium* sulfito-reducing, *Staphylococcus aureus* and *Salmonellas* in all the categories of cheese. In accordance with AFNOR criteria [4] the fresh cheeses and the treated cheeses are satisfactory hygienic good quality and do not involve any risk of toxinfection on the level of the consumer [32]. The presence of the moulds in cheeses involves a deterioration of the marketable quality of cheese. The fresh cheeses treated simultaneously with the extracts of *Sorghum vulgaris* and of *Pimenta racemosa* show a major reduction in the aerobic germs mesophiles, a complete abolition of the moulds. This complete abolition of the moulds is at the origin of tannins catechic present in the extracts of *Sorghum vulgaris* which have a fungicidal effect on micro-organisms osmophiles responsible for the deterioration of the marketable quality of the food products. This confirms the results obtained by Dohou *et al.* [16] which have showed that tannins have antimicrobial properties. It is what justifies the use of the panicles of sorghum in campings for the conservation of cheese. But one notes a multiplication of the microbial flora in fresh cheeses and treaties preserved at 25 °C (figure 6). This multiplication of yeasts and moulds in time involves the deterioration of the marketable quality of cheese and causes the loss of its nutritional and organoleptic quality. These results confirm those obtained by Marlies [27], Martin *et al.* [31] and Öner *et al.* [39] which showed that the microbial load of untreated cheeses increases and reduces the marketable quality and nutritional of this product. The increase in Lactobacillus in time involves a degradation of glucose in lactic acid. This confirms the results obtained by Kèkè *et al.* which used a stock of *Lactobacillus plantarum* for the production of the lactic acid with the aim of increasing the shelf life of cheese [28]. Within fresh cheeses preserved at 7 °C (figure 7), there are complete absence of the coliforms, *clostridium* and the *staphylococcus* microorganisms. The absence of these micro-organisms is explained by the compliance with the rules of hygiene there are no contaminations during the conservation. But from zero at the 1st day one notes an increase in all the

microbial flora (total Flora, lactobacilli, yeasts and moulds) in cheese whereas from the 1st to the 8th day one notes that the growth of the microbial flora stops. This none growing of microbial flora the time of conservation is explained by the absence of metabolism of the micro-organisms which stopped by lowering the temperature. The cold blocks the multiplication of the micro-organisms but does not have any bactericidal effect on these micro-organisms. Compared to cheeses treated with the extracts (figures 8 and 9), one needs a combined action of the cold and extracts to have an inhibition of the total flora, lactobacilli, yeasts and moulds during the conservation. It is that the food products are preserved at a temperature of 7 °C. Consequently the cold plays a big role in the conservation of the foodstuffs and the maintenance of their nutritional qualities. This confirms the results obtained by Adegoke and Gopalakrishna [1], Adegoke *et al.* [2] and Ashaye *et al.* [10] which showed that the Warakanshi cheeses treated with *Afromomum danielli* preserved at a temperature of 7±2 °C during 3 days maintain its nutritional and sensory characteristics. For cheeses treated with various concentrations of *Sorghum vulgaris* (figure 10), it is noted that a concentration of 5 g panicles of sorghum in one liter of water does not present any activity with respect to yeasts and moulds. But a strong bactericidal and fungicidal activity is noted with a concentration of 10 g of the panicles of sorghum in one liter of water, 5 for 10 $g.L^{-1}$ of *Sorghum vulgaris* is used to obtain an optimal activity in the conservation of Peulh cheese. These results are different from those obtained by Djègga [17] which showed that in Peulh campings the women use 15 $g.L^{-1}$ of *Sorghum vulgaris* to colour cheeses and to lengthen their shelf life. With an amount of essential oil of 0.75 mL (figure 10), it is observed a complete abolition of germs which are at the origin of the deterioration of the commercial and nutritional quality of cheese. The minimal amount of incorporation for an optimal activity lies between 0.50 mL and 0.75 mL of essential oil. This confirms the results obtained by Adegoke and Gopalakrishna [1] who showed that aromatic plants extracts are used as suction pipes of taste or to prevent the food contaminations development.

CONCLUSION

This work made possible to note that hygienic and nutritional quality cheese depends on a great number of factors, bound at the same time to the manufacturing technique, the chemical and microbiological characteristics of the raw material implemented and also to the temperature of conservation. This work indicates the important role of the extracts added to cheese in the shelf life duration on one side and confirmed on the other side the know how of this insemination applied by the Peulh women in an empirical way. The association of the two vegetable extracts to cheese not only makes possible the limitation of the contaminations bacterial as fungi, but still plays the part of suction pipe of its taste in particular the extract of *Pimenta racemosa.* The combined action of the extracts and the temperature of conservation of treated cheeses present the multiplication of the micro-organisms. *Pimenta racemosa* extract by its majority compounds have antioxidant properties and contributes to maintain the nutritional characteristics of the cheese. Peulh cheese produced in West Africa is involved positively not only in the socio-economic life of the producers, but also it satisfies the

proteins requirements of the consumers and is also an essential component of the agricultural GDP growth.

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