



Preservation of Wagashi Cheese with *Lippia multiflora* Leaf Decoction: Effects on Microbiological, Nutritional and Sensory Quality

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ABSTRACT

Background: Wagashi cheese is the main dairy product processed from the milk of indigenous cow breeds of Benin. Its important water activity limits its preservation. The study aimed to evaluate the influence of the use of *Lippia multiflora* aqueous extract during ripening on the microbiological, physico-chemical and sensorial qualities of Wagashi cheeses.

Methods: A sample of 4 kilograms of fresh cheeses were processed from raw Borgou cow milk and divided into two batches. The batch 1 was the control batch consisting of 2 kilograms of cheeses ripened in boiling water without any aqueous extract of the aromatic plant. The batch 2 was consisted of cheeses ripened in the decoction of dry leaves of *Lippia multiflora* (50 g/L). These cheeses from batches 1 and 2 were drained and preserved at +4°C for two week and used for physicochemical, microbial and sensory analyses.

Result: Technologically, it appears that the pH, luminance, red index, yellow index, hue and chromability of cheeses of batch 2 cured with the decoction of *Lippia* leaves were respectively 6.18; 74.13; -1.33; 17.64; -1, 49 and 17.49 to the respective values of 6.45; 88.68; -2.72; 12.46; -1.35 and 12.75 for the control batch. Microbiologically, it appears that the aqueous extract of *Lippia multiflora* leaves reduced significantly ($P<0.05$) the total aerobic mesophilic flora and the loads of yeast and mould. Sensorially, cheeses cured with *Lippia multiflora* leaves recorded the best scores of textures, flavour, taste, juiciness and overall acceptability. Only the color was most appreciated in cheeses cured without the leaves of *Lippia multiflora*. The antifungal activity of *Lippia multiflora* leaves obtained is very interesting for the promotion of traditional cheese technology and the preservation of Wagashi cheeses.

Key words: Antimicrobial, Benin, Cheese, *Lippia multiflora*, Preservation, Quality.

INTRODUCTION

Dairy products, especially soft cheeses, play an essential role in human nutrition worldwide (Arkan *et al.*, 2024; Prajapati *et al.*, 2023; Dahou *et al.*, 2020). In sub-Saharan Africa, the demand for dairy products continues to grow, with global cheese and butter consumption increasing at about 2.1% per year (Tougan *et al.*, 2021; O'Connor, 1993). In Benin, milk production mainly comes from indigenous cow breeds raised under traditional systems and a large portion is processed into dairy products such as yogurt, curdled milk and predominantly artisanal Wagashi cheese (Tougan *et al.*, 2021; Sessou *et al.*, 2016).

Wagashi, an artisanal soft cheese of Benin, is a viscoelastic dairy product produced through traditional Peuhl techniques using a plant-based coagulant, *Calotropis procera* (Tougan *et al.*, 2021; Dossou *et al.*, 2016). It is an excellent source of protein, contributing to food security and reducing protein-energy deficiency and malnutrition, especially among low-income households (Ariceaga *et al.*, 2019). Wagashi is also suitable for people with lactose intolerance due to its very low lactose content. Its production and marketing provide important income for local producers.

However, Wagashi's high water activity limits its shelf life, promoting spoilage microorganisms and flavor defects. Developing low-cost, innovative preservation methods

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using local aromatic plants to inhibit bacterial, yeast and mold growth is crucial to safeguard the Wagashi value chain in Benin. Previous studies have explored the use of essential oils (Sessou *et al.*, 2016; Omotoso *et al.*, 2011) or antioxidant-rich spices such as cinnamon, lemongrass and turmeric (Arkan *et al.*, 2024). These studies showed that essential oils from *Cymbopogon citratus* and Pimenta

racemosa can replace chemical additives to preserve Wagashi effectively. However, these essential oils are expensive and not easily accessible to artisanal producers.

An alternative is the use of local aromatic plants, such as *Lippia multiflora* leaves and flowers, which are widely used as vegetables and could be incorporated during Wagashi ripening for their antimicrobial properties (Sessou *et al.*, 2016; Soro *et al.*, 2015). *Lippia multiflora* leaves are rich in polyphenols, flavonoids and alkaloids, with carvacrol and thymol representing about 30% of the phenols and capable of inhibiting microbial growth at concentrations of 0.08–0.12 mg/mL (Soro *et al.*, 2015).

The aim of the work was to evaluate the influence of the use of *Lippia multiflora* aqueous extract during ripening on the microbiological, physico-chemical and sensorial qualities of Wagashi cheeses.

Specifically, it was to:

- Compare the physico-chemical properties of Wagashi cheeses ripened with and without *Lippia multiflora* aqueous extract.
- Evaluate the microbiological quality of Wagashi cheeses ripened with and without the *Lippia multiflora* aqueous extract before and after preservation.
- Determine sensorial quality of Wagashi cheeses ripened with and without *Lippia multiflora* aqueous extract.

MATERIALS AND METHODS

The study was carried out at the University of Parakou (Faculty of agronomy) and at the Lab of the Beninese Food Safety Agency from May 2023 to March 2024. The milk was sampled from the cows of Borgou Breed reared at the National Okpara Cattle farm of Benin (2°39'-2°53' East Longitude and 9°6'-9°21', North Latitude). The climate of this region is of Sudanese type with an annual average rainfall of 1125 mm. The annual temperature varies between 26 and 27°C.

The traditional cheese production process described by Tougan *et al.* (2021) and Dossou *et al.* (2016) was used for the Wagashi production (Fig 1). Indeed, ten liters of raw milk of Borgou cows were sampled, filtered and heated at 70°C for 10 minutes. An extract of 200 grams of *Callotropis Procera* leaves were added to the heated milk. The obtained curds were drained and then divided into two batches for the studies. The batch 1 was the control batch consisting of 2 kilograms of cheeses ripened in boiling water without any leave of aromatic plant. The batch 2 was consisted of cheeses ripened in the decoction of dry leaves of *Lippia multiflora* (50g/ L). The cheeses of both batches were then drained and divided into 2 subgroups and were kept at +4°C for two week. Aliquots of each subgroup of cheese were sampled at the beginning (D0) of the preservation and at the end of the trial at 14 days post-production (D14) for microbiological analysis. For the physicochemical analyses, only the cheeses sampled from each subgroup at J0 were used. Sensorial analysis was performed on cheese of both batches at D0 and D14.

The microbiological analyses were performed by the enumeration of total aerobic flora (TAF), *Staphylococcus aureus*, yeasts, moulds and *Salmonella spp.* The total flora was counted using the standard method NF IN ISO 6222: 1999 on Plate count agar at 30°C for 72 hours, while yeasts and moulds were enumerated according to ISO 7954:1987 method on Sabouraud media mixed with chloramphenicol at 25°C for 5 days. The counting of *Staphylococcus aureus* was performed according to the NF IN ISO 6888 -1:1999 standards on Baird Parker culture medium at 37°C. Detection of *Salmonella spp* was carried out following the NF IN ISO 6579:2002 standards (Sessou *et al.*, 2016).

The determination of titratable acidity and pH of the cheeses were done by sample according to the procedures used by Tougan *et al.* (2021). The pH was measured with a calibrated pH-meter (HANNA) from the aqueous suspension of 10 grams of cheese and 20 milliliters of distilled water. Then, 70 milliliters of distilled water were added to the prepared suspension for determination titratable acidity by dose-titration with NaOH 0,05N. The titratable acidity values were expressed as the content of lactic acid.

The analyses of Color of Wagashi cheeses ripened with and without the leaves of *Lippia multiflora* were performed with a colorimeter of the mark CR410, according to standard the International Commission on Illumination (CIE L*, a*, b*) (Tougan *et al.*, 2021). L* or indicates the luminance ranging from 0 for the black to 100 for the white. The parameter a* is the red index and represents the chromaticity coordinate. The parameter b* is the yellow index. All parameters were twice. The hue and chroma values were estimated according to the formula given below:

$$\text{Hue} = \frac{1}{\tan\left(\frac{b^*}{a^*}\right)}$$

$$\text{Chroma} = (a^{*2} + b^{*2})^{1/2}$$

The texture was analyzed by Warner-Bratzler shear force measurements and by using Texture analyzer (TAXT Plus, Lloyd Instrument). The Warner-Bratzler single blade was used. The shear velocity was 200 mm/min. Each value was an average of at least 5 measurements.

Proximate composition analysis was performed according to A.O.A.C. (2000) procedures as described by Tougan *et al.* (2021). Moisture was determined gravimetrically by kiln drying at 105°C to constant weight (NF V 04-401). Ash content was measured per NF V 04-2018, fat by the Mojonnier acidobutyrometric method (ISO 1854) and crude protein by the Kjeldahl method (NF V 04-211). All measurements were performed in triplicate.

Sensorial analyses of the different subgroups of Wagashi was done using 5 score scale (5-Like Extremely, 4-Like Very Much, 3-Like fairly, 2-Dislike Moderately, 1-Dislike Extremely) and organoleptic profile score sheets (Amerine, 1965). Sensory evaluation was undergone by expert panel

of twenty members. The sensory attributes assessed were: color, flavor, taste, texture and overall acceptability (Tougan *et al.*, 2021).

The data were analyzed with the SAS software (SAS, 2016). The student T-test was used to compare the means quality characteristics of the cheeses ripened with and without *Lippia multiflora* aqueous extract.

RESULTS AND DISCUSSION

Microbiological quality of Wagashi cheeses

The use of the aqueous extract of *Lippia multiflora* in Wagashi cheese processing limits significantly the microbial growth in this artisanal dairy product ($P < 0.001$).

The microbiological quality of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora* is given in Table 1. The load of total aerobic flora (TAF) at D0 in cheese ripened with *Lippia multiflora* leaves decoction increase slightly from 1.19×10^2 CFU/g to 2.2×10^2 CFU/g at 14 days postproduction at 4°C while the load of TAF of cheeses ripened without any *Lippia multiflora* leaves extract increase significantly from 7.1×10^2 CFU/g to 65.2×10^2 CFU/g at 14 days postproduction at 4°C . Similarly, no mould, nor yeast was found in cheeses processed with *Lippia multiflora* leaves decoction at the beginning and at

14 days postproduction at 4°C while their respective load had increased respectively from 0 to 3.5×10^1 CFU/g for moulds and 2.5×10^1 CFU/g for yeast at 14 days postproduction at 4°C ($P < 0.001$). No *Salmonella spp.* and no *Staphylococcus aureus* was found in the wagashi cheese of all treatment undergone herein.

The greatest contaminations at 4°C occurred in the control group containing samples of Wagashi cheeses ripened without *Lippia multiflora* aqueous extract. The increase of mould and yeast loads in the control group made of wagashi ripened without *Lippia multiflora* aqueous extract indicates the antimicrobial and especially antifungal activities of *Lippia multiflora* aqueous extract. This result confirms the findings of Sessou *et al.* (2016), Soro *et al.* (2015). According to Soro *et al.* (2015), the leaves of *Lippia multiflora* are rich in polyphenols, flavonoids and alkaloids. Among the phenols of the leaves of *L. multiflora*, thymol and carvacrol were predominant (30%) and can inhibit microbial growth. The increase of mould and yeast loads in the control group made of wagashi ripened without *Lippia multiflora* aqueous extract can affect not only their sensorial and nutritional quality, but also can destroy their trade value. The absence of *Salmonella spp.* and *S. aureus* in the sampled cheese of both batches can be explained by the cooking time and high cooking temperature used in

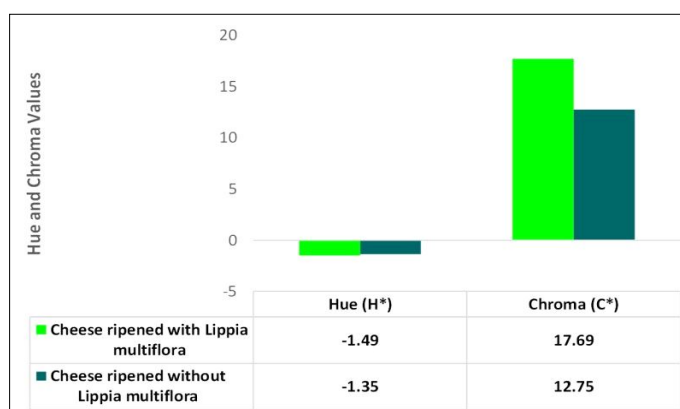


Fig 1: Hue and Chroma values of cheeses ripened with and without the leaves of *Lippia multiflora*.

Table 1: Microbiological quality of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora*.

Variables	Cheese ripened with <i>L. multiflora</i> extract				Cheese ripened without <i>L. multiflora</i> extract				Effect of <i>L. multiflora</i> (P. value)
	Day 0		Day 14		Day 0		Day 14		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Total aerobic mesophilic flora (10 ² CFU/g)	1.19	0.3	2.2	0.61	7.1	1.1	65.2	19.4	***
Mould (10 ¹ CFU/g)	00	00	00	00	1	0.0	3.5	0.2	***
Yeast (10 ¹ CFU/g)	00	00	00	00	00	00	2.5	0.63	***
<i>Salmonella</i> spp. (CFU/g)	00	00	00	00	00	00	00	00	NS
<i>Staphylococcus aureus</i> (10 ¹ CFU/g)	00	00	00	00	00	00	00	00	NS

SE: Standard error; NS: $P > 0.05$; *** : $P < 0.001$.

the current study during the cheese processing and ripening. Both of *Salmonella* spp. and *S. aureus* may be destroyed by pasteurization. According to Avens *et al.* (2002), over 90% of pathogenic and spoilage germs are destroyed by cooking in boiling water at 95°C for 3 minutes. The absence of germs indicators of hygiene in all investigated cheese samples are the result of the good hygienic practices implemented during the cheese samples processing and preservation and may be shared with artisanal cheese Wagashi producers of Benin. The different microbial loads recorded herein for Wagashi cheese processed with aqueous extract of *Lippia multiflora* aqueous extract are lower than those reported by Sánchez-Gamboa *et al.* (2018) and Vladimír *et al.* (2020) for raw cheese.

Overall, the consumption of Wagashi ripened with *Lippia multiflora* aqueous extract have no health risk.

Technological characteristics of Wagashi cheeses

Table 2 shows the variation of technological quality of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora*.

It appears that apart from the titratable acidity that was not affected by the treatment ($p>0.05$), all other physico-chemical parameters were affected by the treatment. Indeed, the Ph, luminance, red index, yellow index, hue and chromability of cheeses of batch 2 cured with the aqueous extract of *Lippia* were respectively 6.18; 74.13; -1.33; 17.64; -1, 49 and 17.49 to the values of 6.45; 88.68; -2.72; 12.46; -1.35 and 12.75 for the control batch. The texture of wagashi processed with aqueous extract of *Lippia*

multiflora were firmer than those processed without *Lippia multiflora* (7.5N vs 6.6N; $P<0.05$).

Fig 1 presents the Chroma and Hue of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora*. This figure reveals that the hue of Wagashi processed without the aqueous extract of *Lippia multiflora* was higher than the value found for Wagashi ripened with the aqueous extract while the higher chroma value was obtained in wagashi processed with the aqueous extract of *Lippia multiflora* ($P<0.01$).

Overall, the study shows that Wagashi processed with *Lippia multiflora* extract had the lowest whiteness and highest yellowness compared to cheese made without the extract, likely due to the bioactive compounds in the leaves affecting color development. Titratable acidity and pH were consistent with Tougan *et al.* (2021) and Dossou *et al.* (2016), but lower than values reported by Ariceaga *et al.* (2019) and Aworth *et al.* (1987). Minor differences in shear force across batches may reflect the firming effect of *Lippia multiflora* compounds during ripening. The extract also slightly reduced lipid content, which can alter texture: lower fat leads to a denser protein network, increasing elasticity and hardness while reducing cohesiveness and adhesiveness (Tougan *et al.*, 2021; Ariceaga *et al.*, 2019; Dossou *et al.*, 2016).

Proximate composition of Wagashi cheeses

Table 3 presents the proximate composition of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora*.

Table 2: Variation of technological characteristics of Wagashi cheeses ripened with and without the aqueous extract of *Lippia multiflora*.

Variables	Cheese ripened with <i>L. multiflora</i> extract		Cheese ripened without <i>L. multiflora</i> extract		Effect of <i>L. multiflora</i> (P- value)
	Mean	SE	Mean	SE	
Luminance (L*)	74.13	0.83	88.68	0.77	**
Red index (a*)	-1.33	0.05	-2.72	0.09	**
Yellow index (b*)	17.64	0.30	12.46	0.31	**
Hue (H*)	-1.49	0.00	-1.35	0.00	**
Chroma (C*)	17.69	0.30	12.75	0.30	**
pH	6.18	0.01	6.45	0.00	**
Titratable acidity (°D)	0.32	0.22	0.12	0.00	NS
Texture (N)	7.5	0.21	6.6	0.15	*

NS: $P>0.05$; * : $P<0.05$; ** : $P<0.01$. SE: Standard error.

Table 3: Variation of proximate composition of Wagashi ripened with and without the aqueous extract of *Lippia multiflora*.

Variables	Cheese ripened with <i>Lippia multiflora</i>		Cheese ripened without <i>Lippia multiflora</i>		Effect of <i>Lippia multiflora</i> (P. value)
	Mean	Standard error	Mean	Standard error	
Dry matter (g/100 g)	37.8	0.31	37.55	0.49	NS
Fat (g/100 g)	6.3	0.2	6.5	0.22	NS
Protein (g/100 g)	8.9	0.21	8.78	0.17	NS
Ash (g/100 g)	1.54	0.1	1.46	0.1	NS

NS: $P>0.05$.

The results show that the contents in dry matter, fat, crude protein and ash of Wagashi cheeses ripened with or without aqueous extract of *Lippia multiflora* were similar ($p>0.05$). The dry matter concentration of both types of Wagashi varies between 37.55 g/100 g and 37.8 g/100 g. The fat content of the cheese fluctuates between 6.3 g/100 g and 6.5 g/100 g. The protein and ash contents vary respectively between 8.78 g/100 g and 8.9 g/100 g and between 1.46 g/100 g and 1.54 g/100 g.

Nutritional quality of cheese gathers several relevant parameters which can be affected by different non genetic factors such as raw milk physico-chemical characteristics and cheese-making methods and raw materials (Boudalia *et al.*, 2020; Ruvalcaba-Gómez *et al.*, 2020; Bittante *et al.*, 2016). Our results showed that there was no significant difference in the proximate composition of cheeses processed with or without *Lippia multiflora* leaves. This finding indicates that *Lippia multiflora* aqueous extract preserves the cheese without affect its nutritional quality. The different values of dry matter content, fat content, ash content and crude protein content complies with the finding of Tougan *et al.* (2021) and Dossou *et al.* (2016) on the Wagashi made from milk of different indigenous genotype of cow of Benin.

Sensory attributes of Wagashi cheese ripened with and without the aqueous extract of *Lippia multiflora*

Fig 2 and 3 show the scores of the six sensory parameters evaluated on cheeses ripened with or without *Lippia multiflora* aqueous extract on days D0 and D14.

The sensory attributes analyzed were color, taste, flavor, appearance, texture and overall acceptability. Fig 2 shows that at the beginning of the experiment (days D 0), cheeses ripened with *Lippia multiflora* aqueous extract recorded the highest scores for texture, flavour, taste, juiciness and overall acceptability. Only the colour was the sensory parameter most appreciated for cheeses processed without *Lippia multiflora* aqueous extract. From Fig 3, it appears that preservation length of 14 days reduced the scores of cheeses ripened without *Lippia multiflora* aqueous extract while the scores of cheeses ripened with *Lippia multiflora* aqueous extract preserved in the same conditions did not decrease.

Sensory analysis is a scientific method used to measure and interpret reaction to food material characteristics as they are perceived by the senses (sight, smell, taste, touch and hearing) (Tougan *et al.*, 2021). The sensory attributes of food quality are measured to find consumer preference or acceptance in order to produce a desirable

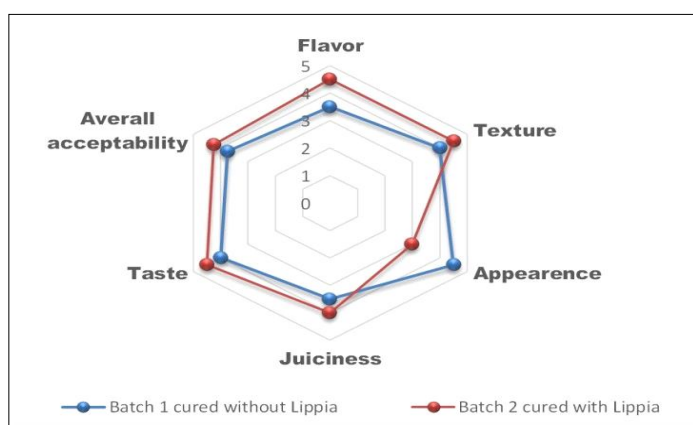


Fig 2: Sensory quality of raw cheeses ripened with or without *Lippia multiflora* aqueous extract at day D0.

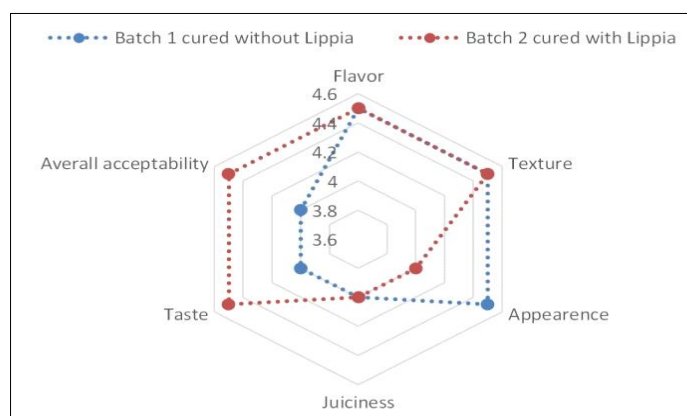


Fig 3: Sensory quality of cheeses ripened with or without *Lippia multiflora* aqueous extract and preserved during 14 days.

and acceptable product and include appearance, kinesthetic, flavor and taste (Dal Bello *et al.*, 2017).

The scores found for sensory parameters for the wagashi ripened with *Lippia multiflora* aqueous extract tested herein are higher than the values found by Tougan *et al.* (2021) and Ryffel *et al.* (2008) for cheese processed without any aromatic plant extract. Wagashi is an artisanal cheese of Benin, a visco-elastic casein net containing dispersed fat globules and water (Tougan *et al.*, 2021; Fox *et al.*, 2000). The texture is a very important cheese quality attribute for the consumers (Fox *et al.*, 2000). Wagashi with high fat concentration are characterized by good flavor and more softness and cohesiveness attributes (Dossou *et al.*, 2016).

The cheese texture can be affected by numerous factors including the raw-material composition (Tougan *et al.*, 2021; Ramirez-Rivera *et al.*, 2017; Ryffel *et al.*, 2008). The variation of texture also depends on the contents of protein, water, pH and fat (Ramirez-Rivera *et al.*, 2017; Ryffel *et al.*, 2008; Fox *et al.*, 2000; Chen *et al.*, 1979). Furthermore, color traits (L^* , a^* , b^*) represent differential indicators of cheese characterization (Fox *et al.*, 2000; Chen *et al.*, 1979). Overall acceptability is a key parameter of sensory analysis. The current study established clearly that the use of the aromatic plant *Lippia multiflora* aqueous extract can improve the organoleptic properties of Wagashi cheese.

CONCLUSION

The study reveals that the microbiological and nutritional quality of wagashi can be preserved by the use of the aromatic plant *Lippia multiflora* aqueous extract during the ripening process. Sensorially, cheeses cured with *Lippia multiflora* leaves recorded the best scores of textures, flavour, taste, juiciness and overall acceptability. Only the color was most appreciated in cheeses cured without the aqueous extract of *Lippia multiflora*. The antifungal activity of *Lippia multiflora* aqueous extract obtained herein is very interesting for the promotion of traditional cheese technology and the preservation of Wagashi cheeses.

In short, the development of the values chains of artisanal cheese in Benin, by integrating local aromatic plants such as *Lippia multiflora* in the cheese processing may contribute to the food system preservation and food security.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

REFERENCES

- A.O.A.C. (2000). Official Methods of Analysis. Hornitz. W. Ed. Washington, Association of Official Analytical Chemists. 16th ed. Washington, D.C., U.S.A.
- Amerine, M.A., Pangborn, R.M. and Rosseler, E.B. (1965). In Principles of Sensory Evaluation of Food. Academic Press: New York.
- Ariceaga, C.C.G., Afzal, M.I., Umer, M., Abbas, S., Ahmad, H., Sajjad, M., Parvaiz, F., Imdad, K., Imran, M., Maan, A.A., Khan, M.K.I., Ullah, A., Hernández-Montes, A., Aguirre-Mandujano, E., de Gante, A.V., Jacquot, M., Cailliez-Grimal, C. (2019). Physicochemical, sensorial and microbiological characterization of porocheese, an artisanal mexican cheese made from raw milk. *Foods*. **8**: 509. doi:10.3390/foods8100509.
- Arkan, N.D., Setyawardani, T., Sumarmono, J., Naufalin, R., Santosa, S.S., Rahardjo, A.H.D. (2024). Effect of spice powder on physicochemical characteristics, functional properties and microbiological quality in soft cheese. *Asian Journal of Dairy and Food Research*. **43**(3): 396-403. doi: 10.18805/ajdfr.DRF-374.
- Avens, S.J., Albright, N.S., Morton, S.A., Prewitt, E.B., Kendall, A.P., Sofos, N.J. (2002). Destruction of microorganisms on chicken carcasses by steam and boiling water immersion. *Food Control*. **13**(6-7): 445-450. doi: 10.1016/s0956-7135(01)00073-1.
- Aworth, O.C. and Muller, H.G. (1987). Cheese-making properties of vegetable rennet from sodom apple (*Calotropis procera*). *Food Chemistry*. **26**(1): 71-79. doi: 10.1016/0308-8146(87)90168-3.
- Bittante, G., Cipolat-Gotet, C., Pazzola, M., Dettori, M.L., Vacca, G.M. and Cecchinato, A. (2016). Genetic analysis of coagulation properties, curd firming modeling, milk yield, composition and acidity in Sarda dairy sheep. *J. Dairy Sci.* **100**: 385-394. doi: 10.3168/jds.2016-11212.
- Boudalia, S., Boudebouz, A., Gueroui, Y., Bousbia, A., Benada, M., Leksir, C., Boukaabene, Z., Saihi, A., Touaimia, H., Aït-Kaddour, A., Chemmam, M. (2020). Characterization of traditional Algerian cheese "Bouhezza" prepared with raw cow, goat and sheep milks. *Food Science and Technology, Campinas*. **40**(2): 528-537. doi:10.1590/fst.35919.
- Chen, A.H., Larkin, J.W., Clark, C.J., Irwin, W.E. (1979). Textural analysis of cheese. *Journal of Dairy Science*. **62**: 901-907. doi: 10.3168/jds.S0022-0302(79)83346-9.

- Dahou, A.A., Bekada, A.M.A., Medjahed, M., Tahlaiti, H., Rechidi, S.N., Homrani, A. (2020). Characterization of natural lactic flora in a soft cheese "Camembert of the tessala" made from thermised milk of local breed cow "Brown of the atlas". *Asian Journal of Dairy and Food Research*. **39(1)**: 30-34. doi: 10.18805/ajdfr.DR-158.
- Dal Bello, B., Torri, L., Piochi, M., Bertolino, M., Zeppa, G. (2017). Fresh cheese as a vehicle for polyunsaturated fatty acids integration: Effect on physico-chemical, microbiological and sensory characteristics. *International Journal of Food Sciences and Nutrition*. **68(7)**: 800-810. Doi: 10.1080/09637486.2017.1301891.
- Dossou, J., Montcho, J.K., Londji, S., Atchouké, G.D.L., Odjo, S. (2016). Procédé amélioré de conservation et de stabilisation du fromage peuhl par l'effet combiné du traitement thermique et du conditionnement sous vide. *European Scientific Journal*. **12(36)**: 1857-7881. doi: 10.19044/esj.2016.v12n36p189.
- Fox, P.F., Guinee, T.P., Cogan T.M. and Mc Sweeney, P.L.H. (2000). Cheese rheology and texture, in: Fundamentals of cheese science (Fox P.F. *et al.*, editor: Aspen Publisher Inc, 2000).
- ISO. (1954). Fromage de serum- Détermination de la teneur en matière grasse- Méthode gravimétrique (Méthode de référence).
- O'Connor, C. (1993). Traditional cheese making manual, ILCA, (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 1-24.
- Omotoso, O.E., Oboh, G. and Iweala, E.E.J. (2011). Comparative effects of local coagulants on the nutritional value, *in vitro* multienzyme protein digestibility and sensory properties of wara cheese. *International Journal of Dairy Sciences*. **6(1)**: 58-65. doi: 10.3923/ijds.2011.58.65.
- Prajapati, P., Garg, M., Singh, N., Chopra, R., Mittal, A. (2023). Extension of shelf life of Paneer-an Indian variety of soft cheese: A review. *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DR-1990.
- Ramirez-Rivera, E.D.J., Juarez-Barrientos, J.M., Rodriguez-Miranda, J., Diaz-Rivera, P., Ramon-Canul, L.G., Herrera-Corredor, J.A., Hernandez-Serrano, M.I., Herman-Lara, E. (2017). Typification of a fresh goat cheese of Mexico by path models. *Turk. J. Vet. Anim. Sci.* **41**: 213-220. doi: 10.3906/vet-1605-66.
- Ruvalcaba-Gómez, J.M., Ruiz-Espinosa, H., Arteaga-Garibay, R.I., Rojas-López, M., Amador-Espejo, G.G., Anaya-Esparza, L.M., Delgado-Macuil, R.J. (2020). Texture, physicochemical and sensory properties of artisanal Adobera cheese from Los Altos de Jalisco, a genuine Mexican cheese. *International Journal of Dairy Technology*. **73(2)**: 411-420. doi: 10.1111/1471-0307.12676.
- Ryffel, S., Piccinali, P. and Bütikofer, U. (2008). Sensory descriptive analysis and consumer acceptability of selected Swiss goat and sheep cheeses. *Small Ruminant Research*. **79(1)**: 80-86. doi: 10.1016/j.smallrumres.
- Sánchez-Gamboa, C., Hicks-Pérez, L., Gutiérrez-Méndez, N., Heredia, N., García, S., Nevárez-Moorillón, G.V. (2018). Seasonal influence on the microbial profile of Chihuahua cheese manufactured from raw milk. *International Journal of Dairy Technology*. **71(S1)**: 81-89. doi: 10.1111/1471-0307.12423.
- SAS Institute (2016). Statistical Analysis Software (SAS) User's Guide Version 9.4. Cary, NC: SAS Institute, Inc.
- Sessou, P., Boko, C., Hounmanou, G., Osseni, S.D., Hounkpe, E., Azokpota, P., Youssao, I., Sohounhloue, D., Farougou, S. (2016). Preservation of traditional cheese wagashi using essential oils: Impact on microbiological, physico-chemical and sensorial characteristics. *Microbiology Research Journal International*. **15(4)**: 1-13. doi: 10.9734/BMRJ/2016/27536.
- Soro, C., L., Munier, S., Louise Ocho-Anin Atchibri, A., Grosmaire, L., Menut, C., Anglade Malan, K., Pelissier, Y. (2015). Chemical composition of leaf essential oils of *lippia multiflora* mold. grown in savannah and forest area in the ivory coast. *J. Essent. Oil Bear. Plants*. **18**: 154-160. doi: 10.1080/0972060X.2014.977.
- Tougan, P.U, Hongbete, F., Konate, A., Souho, T., Assa, R.A.R., Domingo, A.I., Beckers, Y., Sindic, M., Thewis, A. (2021). Color (CIE L*, a*, b*), nutritional and sensory characterization of artisanal "Wagashi" cheese processed from Borgou and Azawak cow milks in Benin. *International Journal of Food Science and Agriculture*. **5(3)**: 530-537. doi: 10.26855/ijfsa.2025.06.001.
- Vladimír, D., Miloslava, K., Markéta, M., Jaroslava, H. and Petr, R. (2020). Microbial diversity of Livanjski cheese with the emphasis on lactic acid bacteria based on culture-dependent and sequencing method. *International Journal of Dairy Technology*. **73(1)**: 202-214. doi: 10.1111/1471-0307.12638.