

Effect of Post-Production Handling Practices (Whey and Water Dipping) on the Microbial and Sensory Quality of Wagashi Cheese Sold in Gogounou

Polycarpe Ulbad Tougan^{1*}, Léila Sale², Florence Y. O. Akpo², Larissa Atchade¹, Rogatien A. Tohozin², Delphin Dohonou¹, Yasmine D. Gatta¹, Amidath Sinabaragui¹, Reine S. Ahouanto¹, Bakassidi Gounou N'gobi²

¹Department of Nutrition and Food Sciences, Faculty of Agronomy, University of Parakou, Parakou, Benin

²School of Agronomical Sciences and Water, the University of Parakou, Parakou, Benin

Email: *ulbad.tougan1@gmail.com

How to cite this paper: Tougan, P.U., Sale, L., Akpo, F.Y.O., Atchade, L., Tohozin, R.A., Dohonou, D., Gatta, Y.D., Sinabaragui, A., Ahouanto, R.S., and Gounou N'gobi, B. (2025) Effect of Post-Production Handling Practices (Whey and Water Dipping) on the Microbial and Sensory Quality of Wagashi Cheese Sold in Gogounou. *Journal of Biosciences and Medicines*, 13, 108-121.
<https://doi.org/10.4236/jbm.2025.1312009>

Received: October 12, 2025

Accepted: December 2, 2025

Published: December 5, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Cheese handling practices can affect soft Wagashi cheese quality. The study aimed to assess the effect of whey and water dipping practices on the microbiological, physico-chemical, and sensory quality of Wagashi cheese marketed in the Alibori Department of Northern Benin. Therefore, ten (10) samples of cheese stored in water and ten (10) samples of cheese stored in milk whey during marketing were collected and analyzed according to the AOAC and ISO standards. The results showed that the type of dipping medium significantly influenced the microbial load of the cheese. Water-dipped samples exhibited higher counts of total aerobic mesophilic flora (3.6×10^6 CFU/g) compared to whey-dipped cheeses (1.6×10^6 CFU/g; $p = 0.002$). Likewise, faecal coliforms, *Staphylococcus aureus*, *Escherichia coli*, and yeasts and moulds were all significantly higher in water-stored samples ($p < 0.01$), exceeding or approaching AFNOR (1980) limits, whereas no *Salmonella spp.* were detected in any sample. These results indicate that water dipping increases microbial contamination risk, likely due to poor water quality and inadequate hygiene, while whey acts as a protective medium through its residual acidity and antimicrobial properties. Physico-chemical analyses revealed that whey storage enhanced brightness (L) and yellowness (b) values (89.3 ± 0.4 and 13.9 ± 0.3 , respectively) compared with water storage (85.5 ± 0.3 and 12.1 ± 0.1 ; $p < 0.05$). Cheese stored in whey also showed slightly lower pH (6.4 ± 0.01 vs. 6.65 ± 0.02 ; $p = 0.04$) and higher crude protein content ($p = 0.035$), while dry matter content remained unaffected. Sensory evaluation demonstrated that whey-

preserved cheeses were preferred for all attributes: color, flavor, texture, taste, and overall acceptability, recording mean scores of 4.5 compared to 3.8 for water-preserved samples ($p < 0.05$). Overall, milk whey proved to be a superior natural preservation medium for Wagashi cheese, maintaining better microbiological safety, nutritional integrity, and sensory quality than traditional water dipping.

Keywords

Cheese Quality, Handling Practice, Contamination, Water Safety, Whey Dipping, Benin

1. Introduction

Wagashi is a traditional soft cheese widely consumed in Benin and other West African countries. It is produced mainly from raw cow's milk, often of the Borgou or Azawak breeds, through spontaneous coagulation using *Calotropis procera* latex as the milk-clotting agent [1] [2]. This artisanal cheese plays an important role in the diet and local economy, particularly for women involved in processing and marketing. Despite its cultural and nutritional importance, Wagashi remains a highly perishable product whose quality and safety are strongly influenced by post-processing handling and storage conditions [1] [3].

In rural and peri-urban markets, Wagashi is typically sold under ambient conditions without refrigeration. Traders commonly immerse the cheese in either water or the whey obtained after pressing to maintain moisture and improve visual appearance during marketing [3]. However, these practices may have contrasting effects on the microbiological, physico-chemical, and sensory quality of the product. Water immersion is often associated with rapid microbial proliferation due to the poor microbiological quality of water sources and inadequate hygiene practices at the processing and retail levels [4] [5]. On the other hand, whey, a by-product rich in proteins, organic acids, and bioactive peptides, may provide a slightly acidic environment that limits microbial growth and preserves desirable sensory traits [1]. Microbiological contamination of artisanal dairy products remains a public-health concern in West Africa. Several studies have reported high loads of coliforms, *Staphylococcus aureus*, *Escherichia coli*, and fungi in local cheeses sold in Benin, reflecting hygiene deficiencies along the value chain [4] [6]. These microorganisms originate from multiple sources, including contaminated water, utensils, handlers, and the processing environment [7] [8]. Poor-quality water used for washing equipment or diluting milk can be a major vector of contamination [4]. Such contamination not only compromises consumer safety but also reduces shelf life and alters sensory attributes, limiting the marketability of Wagashi. Conversely, endogenous preservation approaches, such as storage in whey or plant extracts, have been investigated as low-cost strategies to extend the shelf life of traditional cheeses. The authors [3] and [9] demonstrated that essen-

tial oils and natural extracts from local plants can significantly improve the microbiological stability and sensory properties of Wagashi. More recently, [1] reported that decoctions of *Lippia multiflora* leaves exhibit antimicrobial activity and help preserve the nutritional and sensory quality of Wagashi cheese. These findings suggest that the composition of the preservation medium, its acidity, nutrient content, and antimicrobial compounds, plays a determining role in maintaining cheese quality during marketing.

Cheese color and appearance are also critical for consumer acceptance. Parameters such as luminance (L), redness (a), and yellowness (b*) depend on milk composition, processing method, and post-production handling [2]. Exposure to light, air, and contaminated water can cause pigment oxidation and surface discoloration. Whey immersion, by contrast, may reduce oxidative reactions through the formation of a protective film on the cheese surface, thereby preserving brightness and the characteristic yellow hue [10]-[12]. In addition to sensory and microbiological aspects, storage practices can affect the nutritional composition of Wagashi. Immersion in plain water may cause leaching of soluble proteins and minerals, while whey, already rich in these components, can act as a buffer medium minimizing diffusion losses [1] [2]. Understanding these effects is therefore crucial for improving both the safety and the nutritional value of this traditional dairy product. Given the absence of standardized preservation methods and the growing consumer demand for safe, high-quality traditional foods, there is a need to scientifically assess the impact of local storage practices on Wagashi quality.

The present study aimed to evaluate the effects of water and whey dipping practices on the microbiological, physico-chemical, and sensory properties of Wagashi cheese sold in the Alibori Department of Northern Benin.

2. Materials and Methods

2.1. Study Area

The study was carried out from July to September 2025 at the University of Parakou (Faculty of Agronomy) and at the Lab of the Food Safety Agency of Benin. The milk processing and cheese sampling were performed in the municipalities of Gogounou (**Figure 1**) in the Department of Alibori (**Figure 1**) in Northern Benin. This department is characterized by a landscape of plains and savannas, covering an area of 26,242 km² and sharing borders with Nigeria, Burkina Faso, and Niger. Its climate is tropical, of the northern Sudanian type [13].

2.2. Wagashi Cheese Sampling and Data Collection

The study was designed as a comparative cross-sectional investigation and was conducted in Gogounou town, located in the Alibori Department of Northern Benin, from July to September 2025. Ten (10) Wagashi cheese retailers covering the main selling points in the Gogounou local market and its surrounding areas were identified. Among them, five (5) traders stored their cheese in water during

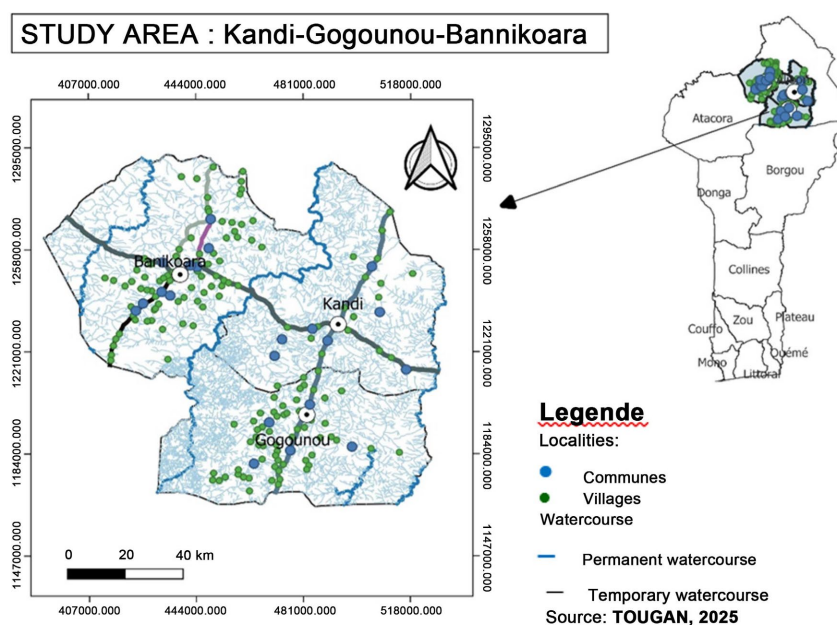


Figure 1. Study area.

marketing, while the other five (5) stored their cheese in milk whey. All ten retailers obtained their products from the same cheese processor, which transforms Borgou cow milk into soft Wagashi cheese in the locality. Cheese samples were processed and distributed to the retailers in the morning, and sampling for the present study was carried out in the afternoon at 18:00 PM using the unsold remaining cheese. In total, ten (10) samples of cheese stored in water and ten (10) samples of cheese stored in milk whey during marketing were collected for analysis. Each sample, weighing approximately 250 grams, was aseptically collected using sterile gloves and instruments. Samples were placed in sterile, properly labeled containers indicating location, date, storage method, and temperature at the time of sampling. They were transported to the microbiology laboratory in insulated boxes containing ice packs to maintain a temperature of about $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$. All microbiological analyses were performed within 24 hours of collection.

2.3. Microbiological Evaluation

The microbiological evaluation targeted key indicator organisms and potential pathogens. Total aerobic mesophilic bacteria, coliforms, *Escherichia coli*, *Staphylococcus aureus*, yeasts and molds, and *Salmonella spp.* were analyzed following standard ISO and AOAC methods. Each 25 g portion of cheese was homogenized in 225 mL of Buffered Peptone Water (BPW) to obtain a 1:10 dilution, and serial decimal dilutions were prepared. Enumeration of total viable counts was performed on Plate Count Agar incubated at 30°C for 48 hours. Coliforms and *E. coli* were enumerated using Violet Red Bile Glucose Agar and confirmed biochemically according to ISO 16649-2:2001. *Staphylococcus aureus* was isolated on Baird-Parker agar supplemented with egg yolk tellurite emulsion and confirmed by the

coagulase test. Yeasts and molds were enumerated on Sabouraud Dextrose Agar and incubated at 25°C for 3 to 5 days. *Salmonella spp.* detection was carried out following pre-enrichment in BPW and selective enrichment in Rappaport-Vassiliadis and Tetrathionate broths, followed by plating on XLD and Hektoen media. All counts were expressed as Colony-Forming Units per gram (CFU/g), and *Salmonella* results were reported as present or absent in 25 g of sample. Analytical duplicates were run for 10% of the samples as quality control, and reference strains were used as positive and negative controls throughout.

Microbial count data were expressed in UFC/gram of cheese. Throughout the study, strict adherence to biosafety and quality assurance procedures was maintained. All analytical methods complied with ISO and AOAC standards; instruments were calibrated regularly. Informed consent was secured from vendors and panelists. Vendor identities and sampling locations were anonymized to ensure confidentiality.

2.4. Evaluation of Physico-Chemical Traits of Wagashi Cheese According to the Handling Practices during Sale

The physico-chemical traits of Wagashi analyzed included Luminance (L), the red index (a), the yellow index (b), and pH. Color was determined according to CIE Lab standards: L (lightness), a (redness), b* (yellowness).

pH was measured 24 hours post-slaughter using a HANNA portable pH meter with a muscle-specific probe, with three repetitions per sample [1].

The proximate composition of the samples was determined following the methods outlined by [14] and detailed in [1]. Moisture content was measured gravimetrically by oven-drying the samples at 105°C to a constant weight, in accordance with the NF V 04-401 standard. Ash content was determined following the procedure described in the NF V 04-2018 standard [2]. Fat concentration was quantified using the Mojonnier acid-butyrometric method, as specified by ISO 1884 [1]. Crude protein content was assessed through the Kjeldahl method, following the NF V 04-211 standard. All proximate analyses were conducted in triplicate.

2.5. Evaluation of Sensory Attributes of Wagashi Cheese According to the Handling Practices during Sale

Sensorial evaluation of the cheese of both handling practices (water dipping and whey dipping) was done using a 5-score scale where 5 corresponds to Like Extremely, 4 to Like Very Much, 3 to Like Fairly, 2 to Dislike Moderately, and 1 to Dislike Extremely, and sensory profile score sheets [15]. This sensory evaluation was conducted by an expert panel of 30 members. The sensory panel was composed of trained assessors with prior experience in evaluating dairy products, particularly traditional cheeses. Panelists were selected based on the following criteria: 1) a minimum of two years of experience in sensory evaluation, 2) prior participation in at least three training sessions on sensory analysis methods, and 3) familiarity with the sensory attributes of Wagashi cheese through routine labora-

tory or field evaluations. These qualifications justify their designation as an “expert panel”. The sensory attributes assessed were: color, flavor, taste, texture, and overall acceptability [2].

2.6. Statistical Analyses

Statistical analyses were conducted using SAS software [16]. Means were calculated using PROC MEANS. The Proc GLM procedure of SAS software was used for variance analysis. The significance of the effect of cheese handling practice (water dipping vs. whey dipping) was evaluated using the Student’s t-test.

3. Results

3.1. Effect of Whey and Water Dipping Practices on the Microbial Quality of Wagashi Cheese

The effect of whey and water dipping practices on the microbial quality of Wagashi cheese is given in **Table 1**. They show a significant influence of the dipping practice on the microbial quality of Wagashi cheese sold in the Alibori Department. Overall, cheeses dipped in water exhibited higher microbial loads than those dipped in whey, indicating that the type of immersion medium plays a crucial role in post-processing contamination. The total aerobic mesophilic flora was significantly higher (3.6×10^6 CFU/g) in water-dipped cheeses compared to 1.6×10^6 CFU/g in whey-dipped samples ($p = 0.002$), suggesting that water dipping promotes microbial proliferation. Similarly, faecal coliforms, *Staphylococcus aureus*, *E. coli*, and yeasts and moulds showed significantly greater counts in the water-dipped samples ($p < 0.01$). These microbial levels exceeded or approached the limits set by AFNOR (1980) standards, particularly for coliforms and *S. aureus*, highlighting potential hygiene deficiencies during cheese handling and storage.

Table 1. Effect of whey and water dipping practices on the microbial quality of Wagashi Cheese.

Variables	Cheese Dipping practice	Mean \pm SE	Effect of Dipping Practice (p-value)	Norms of AFNOR (1980)
Total aerobic mesophilic flora (10^6 CFU/g)	Water	3.6 ± 0.26^b	0.002	NS
	Milk Wey	1.6 ± 0.18^a		
<i>Faecal coliforms</i> (10^2 CFU/g)	Water	2.85 ± 0.2^b	0.003	≤ 1 CFU/g
	Milk Wey	1.2 ± 0.1^a		
<i>Salmonella spp.</i> (CFU/25 g)	Water	0 ± 0	NS	Absent in 25 g of product
	Milk Wey	0 ± 0		
<i>Staphylococcus aureus</i> (10^2 CFU/g)	Water	1.36 ± 0.1^b	0.001	≤ 10 CFU/g
	Milk Wey	0.5 ± 0.02^a		
<i>E. coli</i> (10^2 CFU/g)	Water	1.4 ± 0.1^b	0.000	NS
	Milk Wey	0 ± 0^a		
Yeast and Mould (10^1 CFU/g)	Water	2.85 ± 0.2^b	0.001	NS
	Milk Wey	1.1 ± 0.1^a		

The mean values of the same column with the same letter are not significantly different ($p > 0.05$). NS: Not Stated by the standards.

In contrast, no *Salmonella spp.* were detected in any of the samples, indicating the absence of this specific pathogen in both dipping practices.

Taken together, these findings suggest that whey dipping acts as a protective medium, possibly due to its residual acidity and antimicrobial compounds that inhibit microbial growth, whereas water dipping increases contamination risks, likely associated with poor water quality and unhygienic handling practices. Therefore, the use of whey rather than water for preserving Wagashi cheese could be recommended as a traditional yet effective strategy to enhance its microbiological safety.

3.2. Physico-Chemical Traits of Wagashi Cheese Stored in Water and Whey during Marketing

The physico-chemical characteristics of Wagashi cheese stored in water and whey during marketing are presented in **Table 2**. The results showed notable differences in some parameters between the two storage practices. The Luminance (L) values were slightly higher in cheese stored in whey (89.3 ± 0.4) compared to that stored in water (85.5 ± 0.3), indicating a brighter appearance in the former, with the difference being statistically significant ($p = 0.02$). The redness index (a) did not differ significantly between the two treatments, with values of -1.7 ± 0.01 for water-stored cheese and -1.9 ± 0.02 for whey-stored cheese ($p = 0.9$), suggesting that the dipping medium had no effect on the red coloration of the cheese. Conversely, the yellowness index (b^*) was significantly higher in the whey-stored cheese (13.9 ± 0.3) than in the water-stored cheese (12.1 ± 0.1) ($p = 0.00$), reflecting a more intense yellow coloration likely due to pigment interactions or fat retention in the whey environment.

Table 2. Physico-chemical traits of Wagashi cheese stored in water and whey during marketing.

Variables	Cheese stored in water (Mean \pm SE)	Cheese stored in whey (Mean \pm SE)	Effect of dipping practice (p-value)
Luminance L*	85.5 \pm 0.3a	89.3 \pm 0.4a	0.02*
Red Index a*	-1.7 \pm 0.01a	-1.9 \pm 0.02a	0.9
Yellow Index b*	12.1 \pm 0.1a	13.9 \pm 0.3b	0.00**
pH	6.65 \pm 0.02a	6.4 \pm 0.01b	0.04*
Dry matter (g/100 g)	37.2 \pm 0.17a	37.4 \pm 0.21a	0.3
Crude protein (g/100 g)	9.1 \pm 0.1a	9.35 \pm 0.17b	0.035*

The mean values of the same line with the same letter are not significantly different ($p > 0.05$).

The pH of Wagashi cheese stored in water (6.65 ± 0.02) was significantly higher than that of cheese stored in whey (6.4 ± 0.01) ($p = 0.04$), indicating a slightly

more acidic condition in the whey-stored samples, possibly linked to ongoing lactic fermentation. However, the dry matter content did not differ significantly between treatments, with values of 37.2 ± 0.17 g/100 g and 37.4 ± 0.21 g/100 g for cheese stored in water and whey, respectively ($p = 0.3$). The crude protein content of cheese stored in water during marketing was lower than the value obtained in cheese stored in whey ($p = 0.035$). Overall, these findings suggest that storage in whey tends to preserve the brightness and enhance the yellow coloration of Wagashi cheese, while slightly increasing its acidity and protein content, without significantly affecting its dry matter content.

3.3. Effect of Whey and Water Dipping Practices on the Sensory Quality of Wagashi Cheese

Figure 2 presents the effect of whey and water dipping practices on the sensory quality of Wagashi Cheese. This figure reveals notable differences between samples stored in water and those preserved in milk whey. Across all assessed attributes—color, flavor, texture, taste, and overall acceptability—the cheese stored in milk whey consistently obtained higher sensory scores than the one stored in water.

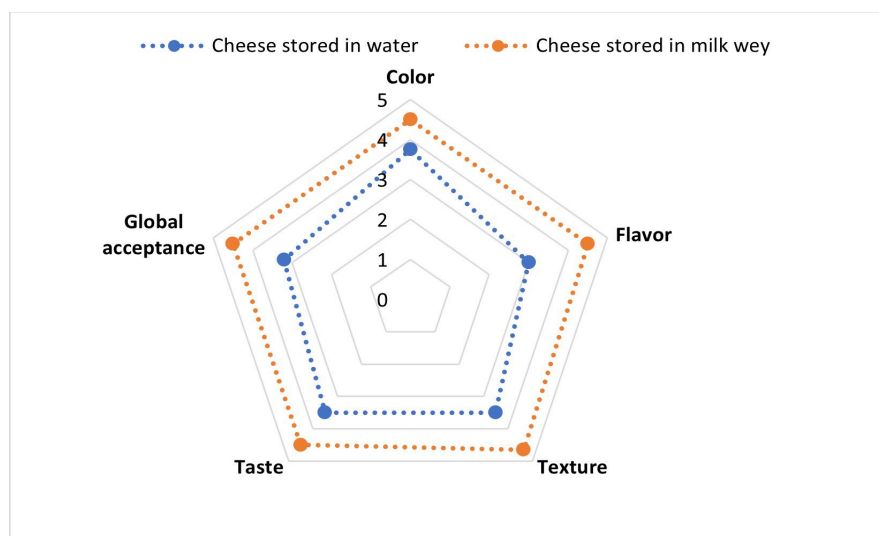


Figure 2. Sensory quality of Wagashi cheese according to the handling practice.

The color of whey-stored cheese was rated at 4.5, compared with 3.75 for water-stored cheese, indicating that preservation in whey helps maintain a more appealing and fresh appearance. The flavor score followed a similar trend, reaching 4.5 in whey-stored samples against 3.0 in those stored in water, suggesting that milk whey contributes to the retention of desirable aromatic compounds and reduces the development of off-flavors. Likewise, the texture of whey-preserved cheese was rated at 4.65, substantially higher than the 3.5 recorded for water-preserved cheese, highlighting better firmness and cohesiveness, possibly linked to lower microbial or enzymatic degradation.

In terms of taste, panelists awarded a mean score of 4.5 to whey-stored cheese compared to 3.5 for water-stored cheese, demonstrating that whey preservation helps maintain the characteristic mild and pleasant flavor of Wagashi. The global acceptability score was also markedly higher for cheese stored in whey (4.5) than for that stored in water (3.2), confirming an overall preference for the sensory qualities of whey-preserved cheese.

4. Discussion

The results revealed that Wagashi cheese dipping practice significantly affected both the microbial and sensory quality of the product. Samples stored in milk whey exhibited lower microbial loads and higher sensory scores than those stored in water, confirming that the preservation medium plays a crucial role in maintaining the hygienic and organoleptic stability of traditional cheese.

4.1. Effect of Whey and Water Dipping Practices on the Microbial Quality of Wagashi Cheese

The total aerobic mesophilic flora, fecal coliforms, *Staphylococcus aureus*, *E. coli*, and yeast and mold counts were all significantly higher ($p < 0.05$) in cheeses dipped in water compared to those preserved in milk whey. Specifically, water-stored samples exhibited 3.6×10^6 CFU/g of total aerobic flora versus 1.6×10^6 CFU/g in whey-preserved cheese, while fecal coliforms were 2.85×10^2 CFU/g against 1.2×10^2 CFU/g, respectively. Similarly, *S. aureus* and *E. coli* counts were markedly reduced in whey-stored cheese (0.5×10^2 and 0 CFU/g) compared with water-stored cheese (1.36×10^2 and 1.4×10^2 CFU/g). These values indicate that the microbial quality of Wagashi preserved in milk whey meets or approaches international microbiological standards for soft cheese (AFNOR, 1980; Commission Regulation No 2073/2005).

The higher microbial contamination in cheese stored in water can be attributed to the lack of inhibitory compounds and potential contamination from handling water, as previously reported in traditional dairy products [4] [7]. In contrast, milk whey possesses natural antimicrobial properties due to its acidic pH and the presence of bioactive peptides and lactic acid bacteria, which inhibit the proliferation of spoilage and pathogenic microorganisms [10] [12]. [3] similarly demonstrated that endogenous preservation methods, including storage in whey, essential oils, or spices, significantly reduced microbial loads and extended the shelf life of Wagashi cheese in Benin.

Furthermore, whey dipping may limit post-processing contamination by acting as a protective medium that prevents oxygen diffusion and microbial adhesion, in contrast to plain water, where microbial regrowth and environmental contamination are more likely [5] [8]. Similar trends have been observed in other traditional cheeses, such as Poro and Livanjski cheeses, where handling and ripening environments strongly influence the final microbial profile [11] [17].

4.2. Effect of Whey and Water Dipping Practices on the Physico-Chemical Characteristics of Wagashi Cheese

The observed variations in the physico-chemical characteristics of Wagashi cheese stored in water and whey during marketing reflect the influence of post-production handling practices on cheese quality. The higher Luminance (L) and yellowness index (b) recorded in whey-stored cheese indicate a brighter and more appealing visual appearance, which may be attributed to the protective and nutritive composition of whey. Similar findings were reported by [2], who observed that the color parameters of artisanal Wagashi cheese are closely related to milk composition and storage conditions. The presence of residual fat and soluble proteins in whey could help preserve color intensity by limiting oxidative degradation and pigment loss during storage [10] [12].

The slightly lower pH observed in cheese stored in whey (6.4 ± 0.01) compared to water (6.65 ± 0.02) suggests a mild acidification process, probably resulting from residual lactic acid bacteria activity. According to [10] and [12], such microorganisms are commonly present in raw milk cheeses and can continue fermentative activity during storage, influencing both flavor and texture. The increase in acidity in whey-stored cheese could contribute to a firmer texture and enhanced microbial stability, as noted in traditional fermented cheeses from Lebanon and Mexico.

In contrast, storage in water may promote a more neutral pH environment, potentially leading to faster microbial proliferation, as indicated by [6] in their assessment of local Beninese cheeses. The reduced microbial stability of cheese kept in water is also supported by the findings of [4] and [5], who emphasized the role of water as a possible vector for microbial contamination in dairy systems when hygiene conditions are not strictly maintained.

The absence of significant differences in dry matter content between the two dipping practices aligns with the findings of [3] and [9], who reported that endogenous preservation techniques of Wagashi do not substantially affect total solids, as the cheese matrix remains relatively stable after coagulation and draining. This similarity also indicates that storing the cheese in either potable water or milk whey during marketing produced comparable overall dry matter levels. The absence of a treatment effect on dry matter suggests that neither treatment caused substantial water loss or gain at the scale and sampling timing used; both media presumably maintained similar hydration equilibria during the short-term marketing period. This finding is consistent with observations in artisanal fresh cheeses, where short-term post-production handling often affects surface properties more than bulk solids content.

These findings are also in line with previous studies emphasizing the importance of handling and storage practices on artisanal cheese quality [2] [3] [6] [10] [12]. The use of whey, a by-product naturally rich in nutrients and bioactive compounds, appears to offer a simple, low-cost, and sustainable method for maintaining Wagashi cheese quality during marketing. Promoting this traditional practice

could contribute to improved food safety, consumer satisfaction, and the valorization of local dairy resources in Benin and other parts of West Africa [18].

By contrast, crude protein was significantly lower in cheeses stored in water than in those stored in whey ($p = 0.035$). This variation could be due to the fact that storage in plain water promotes leaching of water-soluble nitrogenous compounds (whey proteins, small peptides, free amino acids) from the cheese into the surrounding water, whereas storage in whey, which already contains these soluble proteins and peptides, reduces the concentration gradient and therefore limits net losses from the cheese. In other words, whey as a storage medium is nearer to the cheese's soluble-protein composition and so tends to preserve soluble nitrogenous components, while immersion in plain water favors their diffusion out of the curd. This mechanism has been suggested for other artisanal cheeses where storage medium composition governs migration of soluble constituents. In this study, the values of dry matter content of Wagashi of both treatments vary between 37.2 ± 0.17 and 37.4 ± 0.21 g/100 are close to the findings of [1] and [2], but the crude protein contents are slightly higher than the values obtained by these authors.

[19] Specifically, we note from the current study that immersion of fresh cheeses in water can lead to the diffusion of soluble proteins and nitrogenous compounds into the surrounding medium due to concentration gradients and the porous structure of fresh curds. This mechanism has been described in previous studies on fresh and unripened cheeses, where soaking or brining processes resulted in measurable protein leaching [19] [20].

Overall, the results of this study demonstrate that dipping Wagashi cheese in whey rather than water during marketing enhances its color stability and maintains better sensory appeal while contributing to moderate acidification that may improve safety. These findings are consistent with previous research on artisanal cheese quality management [1] [3] and [12], and underline the importance of promoting traditional, low-cost preservation methods rooted in local knowledge systems to improve the safety and marketability of African dairy products.

4.3. Effect of Whey and Water Dipping Practices on the Sensory Quality of Wagashi Cheese

The sensory analysis corroborates the microbiological findings. Cheeses stored in milk whey consistently received higher scores across all sensory attributes: color (4.5 vs. 3.75), flavor (4.5 vs. 3.0), texture (4.65 vs. 3.5), taste (4.5 vs. 3.5), and overall acceptance (4.5 vs. 3.2). The superior sensory characteristics of whey-stored cheese could be explained by better moisture retention, enhanced proteolysis, and preservation of flavor compounds [2] and [10]. Whey may act as a natural buffer, maintaining the cheese's pH and preventing surface hardening or discoloration observed in water-stored samples [2].

These findings align with reports by [3] and [6], who noted that handling and storage practices have a decisive influence on both consumer acceptance and microbial safety of Wagashi sold in Benin. The high global acceptability score (4.5)

of whey-preserved cheese suggests that this traditional preservation technique is not only microbiologically safer but also enhances consumer satisfaction, supporting its potential adoption in small-scale dairy value chains.

Beyond product quality, the valorization of whey as a preservation medium also represents an eco-efficient approach, promoting waste reduction and the circular use of dairy by-products in artisanal cheese processing [21]. In the context of northern Benin, where Wagashi production constitutes a key income source for women and smallholders, improving traditional preservation techniques using locally available resources like whey could strengthen food safety, nutritional quality, and market competitiveness [22] [23].

5. Conclusions

In conclusion, the present study demonstrates that the type of dipping medium used during the marketing of Wagashi cheese significantly influences its physico-chemical and sensory characteristics. Storage in whey resulted in higher luminance and yellowness, indicating better color preservation and visual quality, while also promoting a slightly lower pH that could enhance microbial stability. In contrast, water-stored cheese exhibited a duller appearance and higher pH, conditions that may increase the risk of microbial contamination under market conditions. The similarity in dry matter content between treatments suggests that the dipping medium primarily affects surface and biochemical properties rather than total solids.

In summary, storing Wagashi cheese in milk whey substantially improved its microbial safety, nutritional value, and sensory quality compared with storage in water. The results suggest that whey preservation should be promoted as a best practice within artisanal dairy systems to ensure both consumer health protection and enhanced product acceptability.

Acknowledgements

The authors gratefully acknowledge the support provided by the TWAS-UNESCO/IsDB Program.

Conflicts of Interest

The authors have declared that no competing interests exist.

References

- [1] Ulbad, T.P., Modeste, D., Franck, H. and André, T. (2025) Preservation of Wagashi Cheese with *Lippia multiflora* Leaf Decoction: Effects on Microbiological, Nutritional and Sensory Quality. *Asian Journal of Dairy and Food Research*. <https://doi.org/10.18805/ajdfr.drf-552>
- [2] Ulbad, T.P., Franck, H., Adama, K., Tiatou, S., Rebecca, A.R.A., Ilonka, D.A., *et al.* (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, 530-537. <https://doi.org/10.26855/ijfsa.2021.09.025>

- [3] Sessou, P., Boko, C., Hounmanou, G., Osseni, S., Hounkpe, E., Azokpota, P., *et al.* (2016) Preservation of Traditional Cheese Wagashi Using Essential Oils: Impact on Microbiological, Physico-Chemical and Sensorial Characteristics. *British Microbiology Research Journal*, **15**, 1-13. <https://doi.org/10.9734/bmrj/2016/27536>
- [4] Burke, N., O'Dwyer, J., Southern, M. and Adley, C.C. (2017) An Analysis of the Microbial Quality of Water in a Milk Production Plant. *LWT*, **78**, 41-46. <https://doi.org/10.1016/j.lwt.2016.11.058>
- [5] Terplan, G. (1980) The Role of Water in the Production and Processing of Milk. *Zentralblatt für Bakteriologie, Mikrobiologie und Hygiene, Serie B*, **172**, 96-104. <https://europepmc.org/article/med/6893888>
- [6] Aïssi, V.M., Soumanou, M.M., Bankolé, H., Toukourou, F. and de Souza, C.A. (2009) Mycological Quality of Local Cheese Marketed in Benin. *Australian Evaluation of Hygienic and Journal of Basic and Applied Sciences*, **3**, 2397-2404.
- [7] Verraes, C., Vlaemynck, G., Van Weyenberg, S., De Zutter, L., Daube, G., Sindic, M., *et al.* (2015) A Review of the Microbiological Hazards of Dairy Products Made from Raw Milk. *International Dairy Journal*, **50**, 32-44. <https://doi.org/10.1016/j.idairyj.2015.05.011>
- [8] Fischer, W.J., Schilter, B., Tritscher, A.M. and Stadler, R.H. (2016) Contaminants of Milk and Dairy Products: Contamination Resulting from Farm and Dairy Practices. In: McSweeney, P.L.H. and McNamara, J.P., Eds., *Encyclopedia of Dairy Sciences*, Elsevier, 809-821. <https://doi.org/10.1016/b978-0-08-100596-5.00698-3>
- [9] Sessou, P., Farougou, S., Azokpota, P., Youssao, A.K.I., Fanou, B., Kaneho, S., Agniwo, B., Yèhouenou, B., Ahounou, G.S., Chabi-Egba, M. and Sohounhloué, D. (2013) Endogenous Methods for Preservation of Wagashi, a Beninese Traditional Cheese. *African Journal of Agricultural Research*, **8**, 4254-4261.
- [10] Dal Bello, B., Torri, L., Piochi, M., Bertolino, M. and 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**, 800-810. <https://doi.org/10.1080/09637486.2017.1301891>
- [11] González Ariceaga, C.C., Afzal, M.I., Umer, M., Abbas, S., Ahmad, H., Sajjad, M., *et al.* (2019) Physicochemical, Sensorial and Microbiological Characterization of Porocheese, an Artisanal Mexican Cheese Made from Raw Milk. *Foods*, **8**, Article 509. <https://doi.org/10.3390/foods8100509>
- [12] Chedid, M., Shaib, H., Jaber, L., El Iskandarani, Y. and Hamadeh, S.K. (2025) Microbial Quality and Production Methods of Traditional Fermented Cheeses in Lebanon. *International Journal of Food Science*, **2025**, Article ID: 5673559. <https://doi.org/10.1155/ijfo/5673559>
- [13] Adam, S.K. and Boko, M. (1993) *Le climat du Bénin*. Éditions Karthala.
- [14] A.O.A.C. and Horwitz, W. (2000) *Official Methods of Analysis*. 16th Edition, Association of Official Analytical Chemists.
- [15] Amerine, M.A., Pangborn, R.M. and Rosseler, E.B. (1965) *In Principles of Sensory Evaluation of Food*. Academic Press.
- [16] SAS (2006) *SAS/STAT User's Guide*, Version 6. 4th Edition, SAS Institute.
- [17] Vladimír, D., Miloslava, K., Markéta, M., Jaroslava, H. and Petr, R. (2019) 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**, 202-214. <https://doi.org/10.1111/1471-0307.12638>
- [18] Benyahia Krid, F.A., Aissaoui Zitoun, O., Boughellout, H., Adoui, F., Harkati, A.,

- Bakou, C.R., *et al.* (2016) Fresh Cheese “Peulh Type”: Characterization and Sensory Aspects. *Advances in Dairy Research*, **4**, Article ID: 1000163.
<https://doi.org/10.4172/2329-888x.1000163>
- [19] Ramón, M., Legarra, A., Ugarte, E., Garde, J.J. and Pérez-Guzmán, M.D. (2010) Economic Weights for Major Milk Constituents of Manchega Dairy Ewes. *Journal of Dairy Science*, **93**, 3303-3309. <https://doi.org/10.3168/jds.2009-2787>
- [20] Guinee, T.P. and Fox, P.F. (2004) Salt in Cheese: Physical, Chemical and Biological Aspects. In: Fox, P.F., McSweeney, P.L.H., Cogan, T.M. and Guinee, T.P., Eds., *Cheese: Chemistry, Physics and Microbiology* (Vol. 1, 3rd Edition), Academic Press, 207-259.
- [21] Aho, E. and Capo-Chichi, G. (2017) Le coton africain entre pratiques modernes et traditionnelles: Le changement de paradigme d’une économie sociale en Afrique de l’Ouest. Bulletin de la Recherche Agronomique du Bénin, Numéro Spécial Développement Agricole Durable.
<https://publications-chercheurs.inrab.bj/uploads/fichiers/re-cents/7f0a0593f885e4d4ae94eda2389d7443.pdf>
- [22] Chabi Toko, L., Toléba, S.S. and Dahouda, M. (2010) Cottonseed Meal and *Vitellaria paradoxa* Leaves Supplementation of Borgou Cows in Rainy Season. *International Journal of Biological and Chemical Sciences*, **2**, 555-559.
- [23] Sraïri, M.T., Benhouda, H., Kuper, M. and Le Gal, P.Y. (2008) Effect of Cattle Management Practices on Raw Milk Quality on Farms Operating in a Two-Stage Dairy Chain. *Tropical Animal Health and Production*, **41**, 259-272.
<https://doi.org/10.1007/s11250-008-9183-9>