NUTRITIONAL, MICROBIAL, SENSORY AND COST ATTRIBUTES OF *WARA*, *WAGASHI*, CHEDDAR AND MOZZARELLA CHEESE TYPES

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ABSTRACT

There is a need to compare the quality-cum-cost of cheese types available to consumers, and studying their nutritional value can enhance food security. This research compared the nutritional composition, microbial count, sensory properties, and cost attributes of Wara, Wagashi, Cheddar, and Mozzarella cheeses in Ilorin, Kwara State, Nigeria. Cheese samples were randomly collected from local markets and retail stores in February 2024 and studied using a completely randomised design. Parameters evaluated included proximate composition, microbial count, sensory analysis, and cost implications. Results showed that Wara and Wagashi cheeses had higher moisture content but lower protein and fat compared to Cheddar and Mozzarella. Microbial counts increased for all cheese types over a 3-day storage period, with Cheddar exhibiting the highest total viable count on day 3. Prominent bacteria identified were *Staphylococcus aureus* and *Lactobacillus plantarum*, while key fungi included *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*. Sensory evaluation revealed a preference for Mozzarella over Wara and Wagashi. Cost analysis indicated that Wara and Wagashi were significantly cheaper than Cheddar and Mozzarella. The study concluded that local cheeses, though more affordable, are less nutritious than imported varieties, but they have potential for improvement. Recommendations made from this study include enhancing production methods, hygiene practices, and quality control for Wara and Wagashi to improve their nutritional content, microbial safety, and market competitiveness.

Keywords: Cheese varieties, Nutritional composition, Microbial safety, Sensory evaluation, Cost analysis, Local production

INTRODUCTION

Cheese is a widely consumed dairy product, valued for its nutritional content and diverse flavors. The global cheese market has been experiencing steady growth, with increasing demand for both traditional and novel varieties (Fox *et al.*, 2017). In Nigeria, local cheese types such as *Wara* and *Wagashi,* which are soft cheese types coexist with imported varieties like Cheddar and Mozzarella, which are hard and semi soft respectively; presenting an interesting quality comparison and analysis (Adetunji and Salawu, 2008). Local cheese varieties play a crucial role in Nigerian cuisine and food culture, providing an affordable source of protein and other essential nutrients (Adebayo-Tayo *et al.*, 2017). However, these traditional cheese types often face challenges related to standardization, quality control, and market competitiveness (Oladipo and Jadesimi, 2013). Imported cheese varieties have gained acceptability, particularly among consumers in urban areas, but their higher costs may limit accessibility (Ogbonna *et al.*, 2019). The coexistence of diverse cheese varieties in the Nigerian market raises important questions about their comparative nutritional value, microbial safety, sensory attributes, and cost-effectiveness. Understanding these factors is crucial for informing consumer choices, guiding improvements in local cheese production, and contributing to the development of Nigeria's dairy industry (Adegoke *et al.*, 2021).

Earlier studies have examined various aspects of cheese production and quality in Nigeria. Aworh and Egounlety (2008) investigated the chemical composition of *Wara* cheese, Belewu *et al.* (2005) studied the nutritional and microbial quality of *Wagashi* cheese while Badmos *et al.*, (2021) evaluated the nutritional, sensory and microbial status of processed and preserved soft cheese types. Comprehensive comparative studies of local and imported cheese varieties in the Nigerian context are however limited. Hence, this study addressed the observed gap by providing a comparative analysis of nutritional composition, microbial safety, sensory properties, and cost attributes of *Wara*, *Wagashi*, Cheddar, and Mozzarella cheeses available in Nigeria. The side-by-side examination of this diverse cheese in this research provided valuable insights that can inform consumer choices, guide improvements in local cheese production, and contribute to the development of Nigeria's dairy product and processing industry.

MATERIAL AND METHODS

Sample Collection

Samples of the four cheese varieties (*Wara*, *Wagashi*, Cheddar, and Mozzarella were carefully selected and purchased from markets and retail stores at Ipata Market (8.4993N, 4.5616E), Ilorin, Kwara State, Nigeria. These samples were then taken to the Animal Production laboratory, University of Ilorin for analysis using sterile equipment and aseptic techniques.

Parameters Evaluated

The parameters evaluated include proximate composition, microbial enumeration, cost implication, sensory evaluation and statistical analysis. The analysis was done in triplicates and the mean value taken for precision. A completely randomized design was used.

Proximate Composition

The protein content was determined with the micro Kjeldal estimation of nitrogen, using the conversion factor of %N × 6.38. and the crude fat was determined by the solvent extraction

Microbial Enumeration

Analysis commenced with the preparation of various media including Nutrient agar, Mac Conkey agar, Eosin Methylene Blue Agar, and Potato Dextrose Agar. The cheese samples were then subjected to dilution and pour plate techniques, followed by incubation at 25 °C for bacterial and fungal growth. Colonies were isolated, sub-cultured, and identified through a series of morphological and biochemical tests. For bacterial identification, Gram staining, motility tests, and an array of biochemical tests such as catalase, coagulase, oxidase, and indole were performed. Fungal isolates were identified using Lactophenol cotton blue staining and microscopic examination (Harrigan, 1998).

Sensory Evaluation

Sensory evaluation was conducted with 20 volunteers from the University of Ilorin. The volunteers were trained on how to assess the samples. After receiving training, they assessed the appearance, aroma, taste, texture, and general acceptability of the cheese samples using a 9-point hedonic scale (Lawless and Heymann, 2010).

Cost Implications

The average prices of various cheese types were obtained from different stores and markets.

Statistical Analysis

The data collected from all these experiments were subjected to Analysis of Variance (ANOVA) and the mean separated with the Duncan Multiple Range Test (Steel *et al.*, 1997) at 5 % level of significance.

RESULTS AND DISCUSSION

Proximate Composition Analysis

The proximate composition of the four cheese types (*Wara*, *Wagashi*, Cheddar, and Mozzarella) was analyzed, and the results are presented in Table 1. The results show that moisture content was highest in *Wara*

and *Wagashi* cheese and lower in Cheddar and Mozzarella cheese types. Protein content was highest in Cheddar cheese followed by Mozzarella cheese, *Wagashi* cheese and *Wara* cheese. Fat content was highest in *Wagashi* cheese, while the other cheese types had similar fat contents. Carbohydrate content was highest in *Wara* cheese.

Moisture content varied considerably among the cheese types, with *Wara* and *Wagashi* cheeses having significantly higher moisture content compared to Cheddar and Mozzarella. This variation can be attributed to differences in processing methods as suggested by Krokida *et al*. (2000). The protein content was higher in Cheddar cheese than Mozzarella, *Wagashi*, and *Wara*.

This aligns with the findings of Nazim *et al*. (2013) who reported variations in nutrient composition between different cheese types. The lower protein content in *Wara* and *Wagashi* cheeses suggests a need for fortification to enhance their nutritional value.

Table 1: Proximate composition of various cheese types

Cheese Sample	MC	Ash	Fat	Fibre	CP	Carbohydrate
Wara	79.82^c	2.05^b	3.03^a	0.10^b	5.86^a	9.14^d
Wagashi	78.90^b	1.03^a	5.86^c	0.28^c	8.54^b	5.39^a
Chedder	75.87^a	1.85^b	3.23^a	0.18^a	11.41^d	7.51^b
Mozzarella	75.73^a	2.36^c	3.27^a	0.18^a	10.66^c	7.80^c
SEM	0.08	0.05	0.04	0.00	0.08	0.06

SEM = Standard Error of Mean;
Means having the same letter in the same column are not significantly different at p= 0.05, while means having different letters in the same column are significantly different at (P= 0.05). level of probability

Table 2: Microbial Composition of the various cheese types: TVC & TCC (CFU/mL)

Cheese Sample	TVC			TCC		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Wara	22.00^b	43.00^{ab}	86.50^b	0.00^a	0.00^a	0.00^a
Wagashi	18.00^{ab}	36.50^a	70.50^a	1.50^b	4.00^b	0.00^a
Cheddar	21.00^{ab}	54.00^c	96.00^c	0.00^a	0.00^a	0.00^a
Mozzarella	17.50^a	48.50^{bc}	82.00^b	0.00^a	0.00^a	0.00^a
SEM	1.06	1.80	1.80	0.35	0.707	0.00

Dilution factor x10-3; TVC = Total Viable Count; TCC = Total Coliform Count; SEM = Standard Error of Mean;
Means having the same letter in the same column are not significantly different at p = 0.05, while means having different letters in the same column are significantly different at (P = 0.05). level of probability

Microbial Enumeration

The microbial enumeration was determined by the Total Viable Count (TVC), Total Coliform Count (TCC), and Total Fungal Count (TFC) over a three-day storage period as shown in Tables 2 and 3. Results revealed that TVC increased for all cheese samples over the three days, with Cheddar cheese having the highest

TVC on day 3, followed by *Wara* cheese, Mozzarella cheese, and *Wagashi* cheese having the least count for the day. Coliforms were only detected in *Wagashi* cheese, over the 3 days.

As an additional part of the microbial analysis, the total fungal count was also tracked. As presented in Table 3, the TFC increased over time for all cheese samples, with Cheddar cheese having the highest fungal count on day 3, while *Wagashi* cheese had the least count among all over time.

Table 3: Microbial composition of the cheese types: Total Fungi Count (CFU/mL)

Cheese Sample	Day 1	Day 2	Day 3
Wara Cheese	7.00[a]	16.00[ab]	22.50[b]
Wagashi Cheese	5.50[a]	13.00[a]	18.50[a]
Cheddar Cheese	10.50[c]	19.00[b]	24.00[c]
Mozzarella Cheese	7.50[b]	16.00[ab]	22.50[b]
SEM	0.61	1.22	1.37

SEM = Standard Error of Mean; Dilution factor x10-3
Means having the same letter in the same column are not significantly different at p = 0.05, level of probability

Table 4: Percentage prevalence of bacteria isolates

Bacteria isolate	Numbers of occurrence	% Prevalence
Lactobacillus lactis	2.00	14.29
Staphylococcus aureus	5.00	35.71
Bacillus subtilis	2.00	14.29
Micrococcus luteus	2.00	14.29
Lactobacillus plantarum	3.00	21.43
Total	**14.00**	**100.00**

Table 5: Percentage Prevalence of Fungi Isolates

Fungi isolate	Numbers of occurrence	% Prevalence
Saccharomyces cerevisiae	5.00	50.00
Schizosaccharomyces pombe	2.00	20.00
Candida krusei	2.00	20.00
Penicillium chrysogenum	1.00	10.00
Total	**10.00**	**100.00**

Bacterial and Fungal Isolates
The specific bacteria and fungi present in the cheese samples were also identified. As shown in Tables 4 and 5, the prevalence of bacterial and fungal isolates revealed that *Staphylococcus aureus* was the most prevalent bacterial isolate, while *Saccharomyces cerevisiae* was the most prevalent fungal isolate.

Sensory Evaluation
The results of the sensory evaluation presented in Table 6 shows that Mozzarella cheese consistently received high scores across most sensory attributes, particularly excelling in appearance and texture. Wara cheese also performed remarkably well, achieving the highest general acceptability score and tying with Mozzarella for the highest taste score. This aligns with the observations of Tserveni-Gousi (2001), who noted the importance of sensory attributes in food acceptance. The lower sensory scores for *Wara* and *Wagashi*

cheeses suggest potential for improvement, possibly through the addition of flavoring agents or spices, as suggested by Sharma *et al*. (2015) for soy cheese.

Table 6: Sensory evaluation of cheese types

Cheese Sample	Appearance	Aroma	Taste	Texture	General Acceptability
Wara	5.55[a]	4.60[a]	4.45	5.40[a]	4.65[c]
Wagashi	6.05[b]	5.50[b]	5.30[b]	5.60[b]	6.10[b]
Chedder	6.90[c]	5.75[c]	5.65[c]	7.10[d]	6.65[c]
Mozzarella	6.80[c]	5.75[c]	5.65[c]	6.30[c]	6.85[c]
SEM	0.23	0.20	0.15	0.18	0.22

SEM = Standard Error of Mean;
Means having the same letter in the same column are not significantly different at p = 0.05, level of probability

Table 7: Cost Attributes of Various Cheese Types

Cheese Samples	Price per Kg (Naira)
Wara	1000
Wagashi	1250
Chedder	48,571
Mozzarella	18,826
Total	**6.063**

Cost Analysis
The cost implications of the cheese types were also analyzed. Cheddar cheese was the most expensive, followed by Mozzarella, while the *Wara* and *Wagashi* cheeses were significantly less expensive and therefore more affordable to consumers (Table 7). The cost analysis revealed that *Wara* and *Wagashi* cheeses were significantly less expensive than Cheddar and Mozzarella. As noted by Jeewanthi and Paik (2018), the high nutritional quality and lower cost associated with developing cheese types can help address increasing milk shortages and improve protein bioavailability in low-income areas. The presence of potentially beneficial phytochemicals in some cheese types, as reported by Nascimento *et al*. (2014) and Kumaran and Citarasu (2015), suggests potential health benefits beyond basic nutrition. However, the processing methods may affect the retention of these compounds, as noted by Rungapamestry *et al*. (2007).

CONCLUSION
This study examined the variations among *Wara*, *Wagashi*, Cheddar, and Mozzarella cheeses in terms of proximate composition, microbial quality, sensory characteristics, and cost. The study concludes that Cheddar and Mozzarella cheese types are of low moisture and high nutrient content but are highly disposed to microbial contamination due to long distance of importation and time interval between production and consumption. They are also far higher in cost. Our findings highlight the potential of *Wara* and *Wagashi* as affordable protein sources and also underscore the need for improved safety, packaging and nutritional quality. Based on these results, the *Wara* and *Wagashi* cheese types are recommended for improved packaging and consumption for affordable protein

biosecurity. This will not only enhance the nutritional value and safety of these local cheese varieties but also contribute to global protein accessibility and economic development through potential exports.

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