Safety and sensory quality of *wagashie*, a West African cottage cheese

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ABSTRACT

Wagashie, a West African traditional cottage cheese is a dairy product commonly consumed in Ghana due to its nutritional quality. Nonetheless, it can serve as a medium for the growth of pathogenic and spoilage microorganisms as producers and retailers do not employ adequate food hygiene measures in its handling. Additionally, despite its widespread consumption, there is little or no information about the sensory properties of traditional *wagashie*. This study was carried out to ascertain the safety of market *wagashie* and to evaluate the sensory quality using quantitative descriptive analysis (QDA). The safety of market fresh and fried *wagashie* was determined by testing for various indicator and pathogenic microorganisms and the sensory profile was described by a trained 13-member panel who evaluated traditional *wagashie* for desirable and undesirable attributes. The results of the microbiological safety assessment indicated the absence of *Salmonella* and *Staphylococcus aureus* in all samples whiles *Bacillus cereus* was detected in low counts in half of the samples assessed. The enteric microorganisms *E. coli*, Coliforms and Enterobacteriaceae had fairly high counts. QDA analysis was used to develop a lexicon for fresh and fried *wagashie* which included whitish colour, yoghurt aroma, cheesy taste, brown colour and fried egg taste etc. respectively.

Keywords: *Wagashie*; safety; pathogens; sensory evaluation; West African cottage cheese

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Introduction

Wagashie is a soft cheese made from raw milk and was developed as a means of preserving excess fresh milk by the nomadic Fulani in West Africa. Its consumption in Ghana is however restricted to only cattle rearing areas by the Fulani. Despite the nutritional benefits derived from dairy products like *wagashie*, they could serve as a medium for the growth of spoilage and pathogenic microorganisms. This is because they contain rich nutrients i.e., proteins, fats, lactose, vitamins and minerals and high moisture necessary for the growth of microbes (Ashaye *et al.,* 2006). According to Jayarao & Henning (2001), raw milk and milk products can contain pathogenic bacteria such as *Salmonella spp.*, *Staphylococcus spp.*, *E. coli*, *Bacillus spp.*, Enterobacteriaceae, yeasts, molds, and coliform bacteria.

Wagashie production involves the use of extract from Sodom apple plant (*Calotropis procera*) to coagulate milk by gently heating in a pot over fire. The curd formed is allowed to boil for about 20 min before draining in a raffia basket. Coagulated milk is moulded into shape (round or oval) in the raffia basket and kept in the drained whey in plastic containers covered with a transparent high density flexible polyethylene film as a form of storage during retailing at the market. This procedure is simple and low-cost, thus generating employment opportunities in rural milk-producing areas.

Notwithstanding, the traditional production and marketing of *wagashie* is a matter of public health concern as the sole producer does not apply appropriate and adequate hygienic practices in its processing. Also, due to the micro-scale level of its production carried out in the homes, it is difficult for its production to be monitored by the food regulatory agency (Food and Drugs Authority- Ghana, FDA). According to Sugrue (2019), soft raw milk cheeses can cause serious infectious diseases including *Listeriosis*, *Brucellosis*, *Salmonellosis* and *Tuberculosis*. Recently, the consumer desire for healthy microbiological-safe foods has increased due to increased incidence of food related illnesses; therefore, the importance of the production of cheese being properly packed in convenience, smaller size packages with longer product shelf life is important.

According to Ashaye *et al*. (2006), *wagashie* has a neutral pH of 6.0 to 6.5, a low salt content with high protein and moisture content (60%) which makes it highly susceptible to the growth of pathogens as well as spoilage microbes. It is highly perishable with a shelf life of two to three days and traditionally stored in the whey at room temperature (28°C), as documented by Belewu *et al.* (2005) and Adejunti (2011). Kèkè *et al.* (2008) reported a method of preservation using strains of *Lactobacillus plantarum*, however, traditional *wagashie* is not fermented. Information about the sensory properties of traditional *wagashie* has not been documented, as it has not been extensively described.

However, it is traditionally known to have a mild taste with a greenish colouration due to the use of the extract of the Sodom apple plant as a coagulant. Therefore, it will be relevant to assess quantitatively the sensory attributes that briefly describe the traditional *wagashie* for future improvement and also find new methods for its preservation. This study was carried out to assess the microbiological safety of traditional *wagashie* both fried and fresh, and to determine their sensory attributes in comparison to a standardized laboratory prepared *wagashie* using Quantitative Descriptive Analysis (QDA).

Materials and Methods

Sampling of wagashie for microbiological analysis

Wagashie samples were obtained from Nima and Ashaiman markets in Accra and Tema Metropolis, respectively. These two markets are popular *zongo* occupied by the Fulanis and the Hausa tribe who are the main producers of *wagashie* in Ghana. Also, the availability of obtaining *wagashie* in the fresh and fried forms was easy compared to other zongo markets in Accra. Fresh and fried *wagashie* samples were obtained from more than two retailers from both open markets, packaged in sterile stomacher bags and transported in an ice chest to the laboratory for analysis. Samples were collected on five different occasions over a period of 12 months (one year) from different processors in the market.

Microbiological analysis of market wagashie

Ten grams of the *wagashie* sample was homogenised in 90 ml of sterile diluent (0.8% Saline, 0.1% Peptone Solution, 7.2 pH) in a stomacher (Lab Blender, Model 4001, Seward Medical, London, England) at medium speed for 30 s. Ten-fold serial dilutions were made with the diluents and 1 ml or 0.11 ml of each diluted sample was pour-plated or spread-plated respectively on different media for enumeration or detection. Aerobic mesophiles were enumerated on Plate Count Agar (Oxoid CM 325) incubated at 37°C for 48 to 72 h in accordance with NMKL. no. 86:2013. Yeast and molds were enumerated on Dichloran-Rose Bengal Chloramphenicol Agar (Oxoid CM 0727) incubated at 25°C for three to five days in accordance with ISO 21527-1:2008. Coliform bacteria were enumerated on Tryptone Soya Agar (Oxoid CM 0131) incubated at 25°C for 2 h overlaid with Violet Red Bile Lactose Agar (Oxoid CM 0107) incubated at 37°C for 24 ± 3 h.

Colonies suspected to be Coliforms were confirmed on Brilliant Green Bile Broth (Oxoid CM31) in accordance with NMKL. no. 44:2004. *E. coli* was enumerated on Tryptone Soya Agar (Oxoid CM 0131) incubated at 25°C for 2 h and overlaid with Violet Red Bile agar (Oxoid CM 0107) at 44°C for 24 ± 3 h and subcultured in E. coli broth (Oxoid CM853) incubated at 44°C for 24 ± 3 h, sub-cultured in Tryptone water (Oxoid CM87), at 44°C for 24 ± 3 h and an indole test with Kovac reagent in accordance with NMKL no. 125:2005. *Staphylococcus aureus* was enumerated by spread plate on Bird Parker media (Oxoid CM 0275) supplemented with Egg Yolk Tellurite Emulsion (SR54) and incubated at 37°C for 24 ± 3 h in accordance with NMKL no. 66, 4th edition (2009).

Bacillus cereus was enumerated by spread plate on Bacillus cereus agar (Oxoid CM 617 and SR 99) supplemented with polymycin B and egg yolk emulsion and incubated at 30°C for 24 ± 3 h in accordance with NMKL no. 67:2010. *Enterobacteriaceae* was enumerated on Tryptone Soya agar (Oxoid CM 0131) incubated at 25°C for 2h overlaid with Violet Red Bile Glucose Agar in accordance with NMKL no. 144:2005. *Enterococcus* was enumerated on Tryptone Soya agar (Oxoid CM 0131) overlaid with Slanetz and Bartley (Oxoid CM) incubated at 44°C for 48 h in accordance with NMKL no. 68, 5th edition (2011). *Salmonella spp.* was detected by pre-enriching 25 g of the *wagashie* sample in 225 ml of Buffered Peptone Water in sterile bags and incubated at 44°C, subcultured in Rappaport Vasilides and incubated at 42°C for 24 h and streaked on Xylose Lysine Deoxycholate (Oxoid CM), incubated at 37°C for 24h in accordance with NMKL no. 71:1999.

Determination of pH

Ten (10) g of *wagashie* was added to 100 ml of distilled water, homogenized in a stomacher, and pH was determined with a pH meter (Mettle Toledo pH meter) after calibration with standard buffers, (AOAC, 2005).

Sampling traditional wagashie for sensory analysis

Traditional *wagashie*, both fresh and fried, were obtained from Nima and Ashaiman markets in Accra and Tema Metropolis, respectively. *Wagashie* samples were obtained from one selected retailer, labelled as market fresh and fried *wagashie* and used for the sensory evaluation.

Laboratory preparation of wagashie for sensory analysis

The traditional method of making *wagashie* as according to Tohibu *et al.* (2013) with minor modification through observation from four traditional processors at Nima and old Ashongman Accra, where by 100 ml fresh cow milk was coagulated with 150 ml extract from the stems of *Calotropis procera* heated on fire for 20 min until coagulation was used under sterile conditions in the laboratory. The *wagashie* samples were drained for 20 min in cheese cloth, fresh samples were packaged in flexible high density polyethylene films whiles the fried samples were fried in oil at 110°C for two min and packaged for the sensory evaluation. These samples were labeled as laboratory fresh and fried *wagashie*.

Quantitative descriptive analysis (QDA)

Quantitative descriptive analysis (QDA) was conducted on *wagashie* according to Stone & Sidel (1993). Both fresh and fried forms of samples obtained from the market and samples prepared in the laboratory (standardized traditional *wagashie*) were used. Samples prepared in the laboratory served as the control.

Selection of panelist

A 12-member panel was selected to develop sensory profiles for *wagashie*. The criteria for selection were based on familiarity with *wagashie*, ability to provide similar responses to similar products on different occasions, high sensory acuity, interest, an availability. To prevent interference in describing the aroma and flavor of the products, panelists were asked not to use perfume or strong-scented cosmetics at least 30 min before the session (Leighton *et al.,* 2010). Panelists were trained in 2 h sessions for two consecutive days to clearly define selected sensory attributes, i.e., aroma, texture, taste, and colour for the *wagashie* samples (Lawless & Heyman, 2013). The panelists developed descriptors and definitions (Table 3) for each selected sensory attribute. Selection of the descriptors was confirmed using reference samples, including cheese and yoghurt, whose attributes (aroma, taste, texture and colour) were closely related or the same as the descriptors developed for *wagashie.* The panelists scored for the descriptors on an unstructured 10 cm line scale with ‘1’ being the lowest intensity and ‘10’ the highest attribute intensity.

Assessment of wagashie using QDA

XLSTAT V. 14 was used to develop a Balanced Block Design where the pattern for serving the samples was completely randomized to eliminate any form of bias during the evaluation. The sensory evaluation was done in a sensory evaluation laboratory consistent with ISO 8589, fitted with individual booths and uniform lighting conditions. Four samples of *wagashie* denoted as market fresh, market fried, laboratory fresh and laboratory fried were assessed. Ten grams of each sample, at room temperature, was served to each panellist for assessment on a food-grade polystyrene platter identified by a random three-digit code. Samples were randomized during serving to exclude bias due to position effect. The panellists were presented with still water to refresh their palate after assessing each sample. All samples were evaluated in a day by the trained panellists, who quantified the taste, texture, colour, and aroma of *wagashie* on the unstructured 10 cm line scale.

Statistical analysis

One-way Analysis of variance (ANOVA) was used to analyse the microbial population in the *wagashie* samples using Minitab 17.1.0, Minitab Inc, USA. XL STAT 2014 was used to analyse the sensory data for Principal Component Analysis (PCA) and Spider plots were generated using Microsoft Excel 2007.

Results and Discussion

pH and Microbiological safety of market wagashie

The mean pH values and mean population of microorganisms detected in samples of fresh and fried *wagashie* obtained from the open markets (Nima and Ashaiman) are shown in Table 1**.** The pH of the samples ranged from 5.09 (fresh *wagashie*) to 5.51 (fried *wagashie*), with significant differences ($p < 0.05$) observed in the pH of *wagashie* samples obtained from the two markets. The comparatively lower pH of *wagashie* sampled from the markets (particularly fresh samples) may be ascribed to the activity of non-starter lactic acid bacteria and other micro-organisms that may have been present in the fresh milk as raw milk used for processing traditional *wagashie* is not pasteurised.

Generally, the aerobic mesophilic count was high in all the *wagashie* samples (especially the fresh ones) with a count of (8.4 ± 1) x 10^9 and (1.9 ± 0.6) x 10^8 for Nima and Ashaiman markets respectively at $p \leq 0.05$. *Salmonella* and *Staphylococcus aureus* were not detected in any of the *wagashie* samples analyzed, whereas *Bacillus cereus* appeared in fairly high counts in the fresh *wagashie* obtained from both Nima (10 ± 2) x10^3 and Ashaiman (2.1 ± 2) x10^3 markets. Also, yeast and coliform bacteria were observed in fairly high counts (10^5) in fresh and fried *wagashie* obtained from *Nima* and *Ashiaman* markets, however, the population of yeast was high in *wagashie* obtained from the Nima market. On the other hand, *wagashie* obtained from the Ashaiman market had a higher population of coliform bacteria. Comparing fresh and fried *wagashie* purchased from the two markets, there were differences observed in the microbial population over the 12 months sampling period.

Fresh *wagashie* recorded higher counts for pathogenic and spoilage organisms compared to fried *wagashie*. This observation may be attributed to the fact that fresh *wagashie* is mostly stored in whey at the retail points under ambient conditions in plastic containers covered with high-density plastic polyethylene bags. This storage condition created the opportunity for the growth of opportunistic bacteria which caused the proliferation of both pathogens and spoilage microorganisms in the fresh samples.

Furthermore, the microbial population was impacted by the improper handling of fried *wagashie* at the market. The *wagashie* were exposed on metal trays and covered with clear flexible polyethylene film or a transparent cloth. *Wagashie* curds, either fried or fresh, were hand-selected and placed into flexible plastic bags for customers at retail locations, which added to the contamination. During the course of the 12-month sampling period, inadequate storage conditions and the absence of a standardized *wagashie* production method were identified as the causes of the inconsistent product safety and quality. Nevertheless, unpasteurized milk was used by processors, and milking was carried out in unsterilized containers in unhygienic settings, as revealed by retailers and personal observation.

Thus, as the current study has shown, there is a very significant chance of microbial contamination when fresh *wagashie* is handled inappropriately during the heating of the milk, cooking of the curd, and storage. Elkhider *et al*. (2011) found that elevated microbiological loads in cheese collected from producers in the Eastern Sudanese countryside were caused by elements like insufficient hygiene standards, *wagashie* production techniques, raw milk supply, and handling. Results from a study carried out in the Ashanti region by Tohibu *et al*. (2013) validate the behaviors seen among the vendors in the two marketplaces in Greater Accra. They stated that producer's hand-pick the curds into flexible polyethylene films, leaving the product exposed to contamination and shortening its shelf life. *Wagashie* is not packaged after preparation.

According to Sousa *et al*. (2001), psychotropic bacteria and non-starter lactic acid bacteria might contaminate fresh cheese produced without following hygiene practices. Another finding from this investigation (Table 2), which involved frying, packaging, and analyzing samples of *wagashie* in sterile bags, revealed a significant increase in the microbial counts in the fried *wagashie*. In accordance with Ghana Standard GS 955:2018, the observation showed that, frying brought the microbial population down to permissible levels. Also, because the product was exposed to the environment for a brief period of time after frying, packing it soon after enhanced *wagashie* safety by lowering the chance of contamination.

TABLE 1

Microbial population (CFU/g) and pH of wagashie sampled from Nima and 'Ashaiman' markets on five independent occasions over a period of Twelve (12) months

Microorganisms	**Nima Market**		**Ashaiman Market**	
	Wagashie	**Fried *Wagashie***	***Wagashie***	**Fried *Wagashie***
pH	$(5.09 \pm 0.01)^{b}$	$(5.51 \pm 0.01)^{a}$	$(5.17 \pm 0.2)^{ab}$	$(5.34 \pm 0.05)^{ab}$
Aerobic Mesophiles	$(8.4 \pm 1)\ 10^{9a}$	$(1.2 \pm 1)10^{7b}$	$(1.9 \pm 0.6)\ 10^{8a}$	$(1.8 \pm 1)\ 10^{6b}$
Yeast	$(6.6 \pm 3)\ 10^{6\ a}$	$(7.8 \pm 1)\ 10^{b}$	$(2.7 \pm 2)\ 10^{6ab}$	$(12 \pm 0.7)\ 10^{b}$
Mold	$(6 \pm 2)\ 10^{4a}$	$(3 \pm 0.9)10^{ab}$	-	$(6 \pm 0.5)^{ab}$
Coliform	$(3.4 \pm 0.4)\ 10^{5a}$	$(1.5 \pm 1)\ 10^{3b}$	$(1.8 \pm 0.1)\ 10^{5ab}$	$(2.2 \pm 2)\ 10^{3b}$
E. coli	$(3.1 \pm 0.2)\ 10^{4a}$	$(6 \pm 0.5)^{b}$	$(1.9 \pm 0.5)\ 10^{4a}$	$(6 \pm 0.6)^{b}$
Enterobacteriaceae	$(2.3 \pm 1)\ 10^{6a}$	$(10 \pm 1)\ 10^{5a}$	$(5.0 \pm 0.8)\ 10^{6a}$	$(3.4 \pm 2)\ 10^{3b}$
Bacillus cereus	$(10 \pm 2)\ 10^{3a}$	-	$(2.1 \pm 2)\ 10^{3a}$	-
Salmonella spp.	-	-	-	-
Staphylococcus aureus	-	-	-	-

Means that do not share the same alphabet are significantly different at $p \leq 0.05$. '-'means 'Not Detected'
Each value represents the mean and standard deviation of *wagashie* samples taken from 5 different occasions over a period of one (1) year. From the table; *Wagashie* represents fresh curds that are stored in whey at the retailing point. Fried *wagashie* represents curds that have been fried by the processor, usually exposed on metal trays at the open market.

TABLE 2

Effect of deep frying and aseptic packaging on the microbial population in fresh 'wagashie' obtained from Nima markt in CFU/g

Microorganism	***Wagashie***	**FPW**
PCA	$(2.4 \pm 0.05)\ 10^{8a}$	$(5.6 \pm 0.02)\ 10^{2b}$
Yeast	$(1.7 \pm 0.05)\ 10^{6a}$	-
Mold	$(1.6 \pm 0.1)\ 10^{3a}$	-
Coliform	$(1.8 \pm 0.06)\ 10^{6a}$	-
E. coli	$(2.6 \pm 0.08)\ 10^{5a}$	-
Enterococcus	$(7.4 \pm 0.01)\ 10^{5a}$	-
Bacillus cereus	$(9 \pm 0.1)\ 10^{a}$	-
Salmonella	-	-
Staph. Aureus	-	-

Means in the same column with the same letters are not significantly different $p < 0.05$. '-'means 'Not Detected'. *Wagashie* represents fresh *wagashie* obtained from Nima market; FPW represents *wagashie* that was packaged aseptically shortly after frying

Quantitative descriptive analysis of wagashie

The descriptors generated for *wagashie* during the training session and their definitions are shown in Table 3. Some of the descriptors generated were considered desirable, however, others were considered undesirable depending on the typical attributes that define fresh un-ripened cheeses such as *wagashie.* Principal Component Analysis was used to identify descriptors differentiating the various samples of *wagashie*. Below is the lexicon developed for the Quantitative Descriptive Analysis (QDA) of the *wagashie* samples (desirable and undesirable descriptors generated by the 12-member panel) on a Scale of (1 (low intensity) – 10 (high intensity).

TABLE 3

Desirable and undesirable attributes of fresh and fried wagashie developed by a 12-member panel for Quantitative Descriptive Analysis (QDA)

Attribute	Desirable	Definition	Undesirable	Definition
Taste	Sour	Taste sensation associated with fermented milk	Bland	Tasteless sensation in a food product
	Cheesy	Taste sensation associated with cheese	Bitter taste	Taste sensation of quinine or caffeine
	Milky	Taste associated with fresh milk		
	Fried egg	Taste associated with omelet		
	Salty	Taste produced by a solution of sodium chloride		
Texture	Soft	Degree of stickiness in the mouth		
	Smooth	The spread ability of the cheese		
	Spongy	The texture characteristics of a bouncy cheese		
	Crumbly	The extent to which the cheese breaks in the mouth		
Aroma	Milky	Aromatics of milk from dairy origin	Spoilt milk	Aromatics of spoilt milk
	Yoghurt	Aromatics of plain yoghurt	Fermented cassava dough	Aromatics of fermented cassava dough
	Cheesy	The aromatic sensation of cheese		
	Beefy	Smell associated with cow meat		
	Fired sweet potato	The smell associated with ripe plantain		
	Doughnut	The smell associated with fried doughnut		
Colour	Whitish	Lighter colour		
	Brownish	Dark colour as a result of frying		

Principal Component Analysis (PCA) of market and laboratory made wagashie

Fig. 2, shows the PCA loadings of the sensory attributes for the quantitative descriptive analysis and the position of the *wagashie* samples relative to the rated attributes**.** All attributes were considered and analysis was done on the mean values of each individual attribute. The most intense in each sample is an indication of the correlation structure of the sensory attributes. Axis F1 alone accounted for 55.8% which shows the highest variation among the samples and was mainly related to aroma and color. F2 accounted for 32.95% and was essentially related to the taste of the samples. Samples in opposite quadrants were inversely related to each other for attribute intensities which indicated that their attributes were not related to one another.

The laboratory-prepared fresh sample had a higher intensity for milky aroma, cheesy taste, cheesy aroma, yogurt aroma, and milky taste. Market fresh *wagashie* was characterized by a whitish color, smooth, crumbly, soft texture, and sour taste with both a fermented cassava dough and spoilt milk aroma. All of these attributes with the exception of sour taste, smooth texture, whitish colour and soft texture were considered as undesirable attributes. The undesirable attributes of the market *wagashie* were formed because of poor handling of fresh curds which includes storage of fresh *wagashie* in whey (high moisture) under ambient conditions. This allows spontaneous fermentation by adventitious microorganisms in the product.

As a result, the laboratory-prepared *wagashie* was completely drained to achieve a decreased moisture content, and its sensory qualities were evaluated. The yogurt aroma, cheesy aroma, milky flavor, and cheesy smell were all desirable characteristics of the laboratory-fresh *wagashie* products. The characteristics of soft, unripened cheese that are characteristic of them include a smooth, soft texture, white color, and a milky taste (Mbaye *et al.*, 2020). Similar characteristics were shared by the fried *wagashie* from the market and the laboratory. These included a taste similar to fried eggs, an aroma similar to doughnuts, an aroma similar to fried ripe plantains, an aroma similar to fried sweet potatoes (due to the oil used to fry the samples), and a colour similar to brown. Frying was found to influence aroma, taste, and texture most critically.

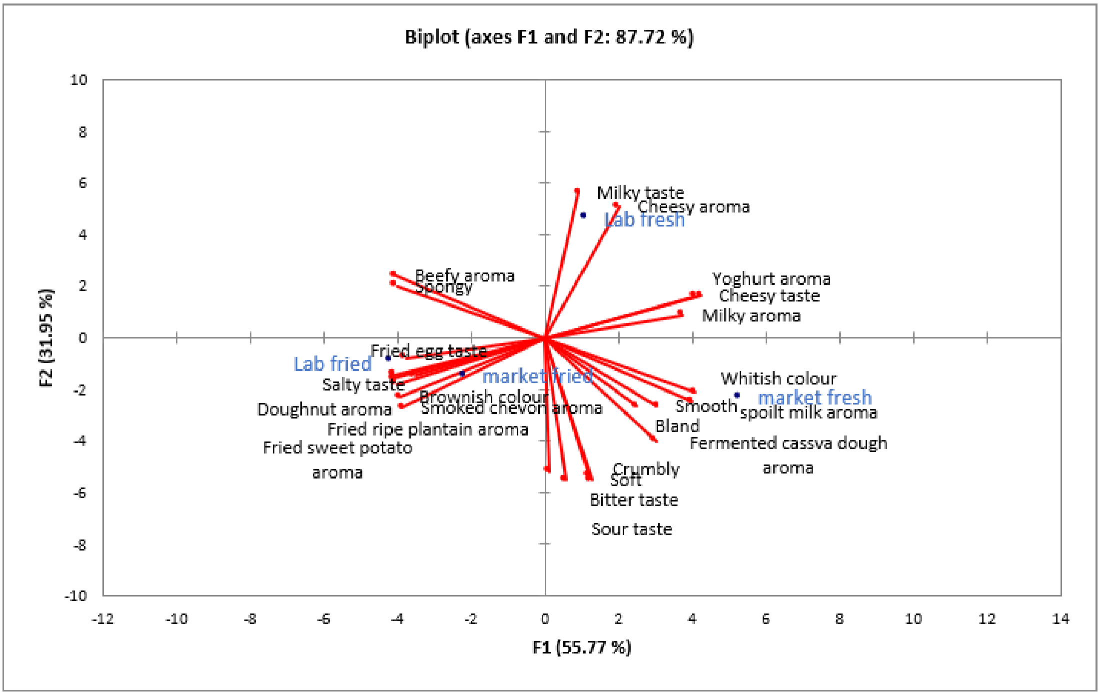

Fig 2: PCA Bi-plot for quantitative descriptive analysis used to describe the variation between the sensory attributes for the market *wagashie* and the laboratory prepared samples

Sensory profile of wagashie

A pictorial profile of the sensory attributes of *wagashie* was created by plotting mean intensity values for the various attributes on individual scales and joining them (Fig. 3**).** This presents a more vivid outlook of the sensory attributes of *wagashie* samples. Each spoke symbolizes one attribute, and the relative intensity corresponds to that point where the product line crosses, with the lowest and highest intensities toward the center point and farthest from the center respectively. The web showed that the "market fresh" and the "laboratory fresh" *wagashie* had a similar pattern, although their intensities in attributes was different. The "market fresh" *wagashie* scored higher for attributes related to fermented milk product than the laboratory fresh *wagashie*. This resulted in the generation of undesirable attributes for the market fresh sample.

Similarly, the market-fried *wagashie* sample and the laboratory-fried *wagashie* sample also had a similar profile. Here, the similarities were mostly influenced by the ingredients (oil) involved in their processing. The market-fried *wagashie* however, had high intensity for related attributes than the laboratory-fried samples. Generally, however, the profiles reveal "brownish color" (market fried *wagashie*), "smoothness" and "yogurt aroma" (market unfried *wagashie*) as the most prominent attributes of the product. In a study carried out by (Arthur, 2016), the prominent attributes of fresh and fried market *wagashie* was described to be smooth texture, yoghurt aroma and brownish colour respectively.

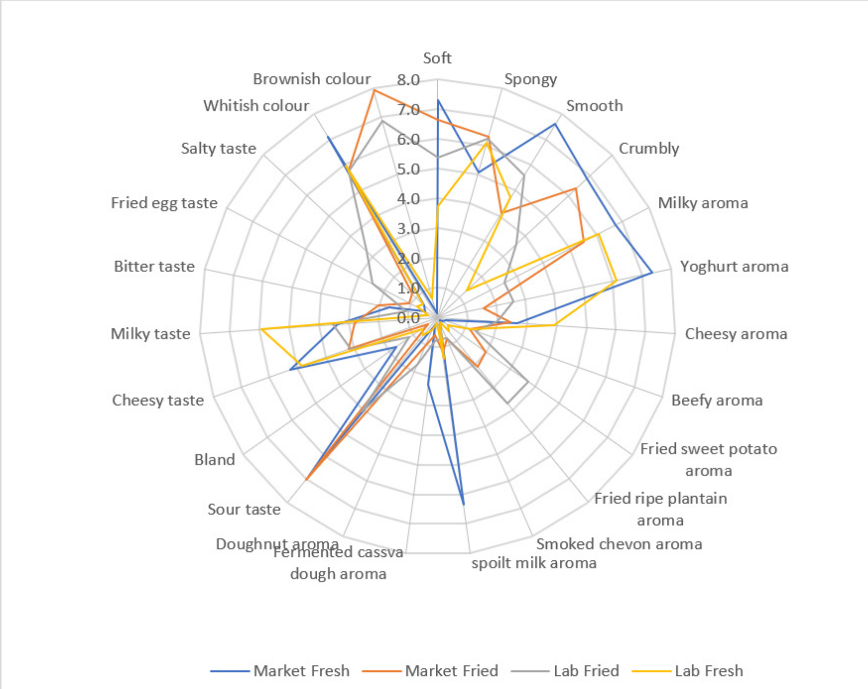

Fig. 3: Spider plot for the market and laboratory prepared *wagashie* samples for QDA

Conclusion and Recommendation

Based on data gathered at five sample points over a twelve-month period, traditional *wagashie* offered in the market contains microbiological hazards that may be harmful to customers' health. The maximum allowable level for the presence of germs in *wagashie* and other cheeses is 102 for *E. Coli*, zero (0) tolerance for *Salmonella spp*. and *Listeria spp*., 103 for APC, and 102 for *Staphylococcus aureus*, according to Ghana Standard, GS 955:2018.

The study found that market *wagashie*, in both fried and fresh versions, included dangerous and spoilage bacteria like as *E. Coli*, *Bacillus cereus*, yeasts and molds in fairly significant concentrations. Some of these microbes exceeded the requirements set by the Ghana Standard Authority. The main reasons for the microbial count in the fresh and fried *wagashie* were post-production contamination from improper handling, insufficient packaging, and unfavorable storage conditions, as well as noncompliance during processing.

The study also showed that the concentration of contaminants in the fresh *wagashie* can be reduced when *wagashie* is fried and packaged properly with minimum exposure to the environment. The taste and aroma of traditional *wagashie* were also impacted by high microbial counts in the market fresh *wagashie*, which scored highly for undesirable sensory attributes like "sourness," "fermented cassava dough aroma," and "spoilt milk aroma" whereas traditional *wagashie* is not fermented. *Wagashie's* sensory quality will therefore improve when it is manufactured, stored, and handled with adequate hygiene, as shown in samples that were prepared in a lab. Furthermore, a quantitative assessment of the sensory qualities and the link between the descriptive sensory attributes and preset reference products were provided by the preference mapping.

The preference mapping provided a numerical assessment of the sensory characteristics as well as the correlation between the descriptive sensory characteristics and preset reference items, which could be helpful for future improvements in *wagashie*. Using a quantitative descriptive analysis, a lexicon was constructed that best captures the sensory qualities of traditional *wagashie*, both fried and fresh. These characteristics include "milky taste," "cheesy taste," "milky aroma," "cheesy aroma," and "yogurt aroma". In future, the process variables for wagashie can be optimized to improve its safety and sensory evaluation.

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