

NUTRITIONAL, SENSORY AND CAKING CHARACTERISTICS OF TATALE MIX: A PLANTAIN-BASED CONVENIENT FOOD

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ABSTRACT

*Tatale is a popular Ghanaian traditional fried pancake that is prepared from pulped ripe plantain fruit (*Musa paradisiaca*), cereal flour and spices. In view of the seasonality and perishability of plantain in Ghana, the study was conducted to develop a nutritious, sensory acceptable and free-flowing (shelf-stable) plantain-based convenient food, Tatale mix, that could conveniently be reconstituted for the preparation of Tatale or Kaklo (deep-fried pulped plantain). The nutritional and sensory quality characteristics, and caking behaviour of the experimental Tatale mix were evaluated. The study revealed that the quantities of most nutrients in ripe plantain were similar to those found in the experimental Tatale mix but protein and fibre contents were significantly higher in the Tatale mix developed. The sensory characteristics of the three experimental Tatale mixes were highly acceptable to trained sensory panellists. Experimental Tatale mix prepared with wheat flour was adjudged the best nutritionally with excellent sensory attributes. The study also revealed that calcium stearate was by far the best anticaking agent compared to the starches (maize, potato, rice, wheat) used for the study. The different starch samples used as anticaking agents prevented caking of Tatale mix to acceptable levels (<3.5% caking) for eight (8) months of storage. Potato starch was the best among the starches used for lump prevention in Tatale mix and wheat starch being the worst. Tatale mix could also be stored under refrigeration temperatures to ensure flowability without addition of anticaking agents.*

Key words: Plantain fruit, tatale mix, tatale, convenient food, anticaking agent.

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INTRODUCTION

Plantain is a member of the banana family (*Musa* genus), that is believed to have originated in Southeast Asia (Britannica, 2019). The plantain fruit is consumed worldwide and is a major food staple in Southeast Asia, West and Central Africa, Central America, the Caribbean Islands and regions of South America (Britannica, 2019; Cauthen et al, 2019). The fruit is consumed in West Africa region with variety of preparation methods (boiled, baked, or fried, both when ripe and in their green state) and serve an important role in many traditional diets. The fruit is traditionally used more like a vegetable, as a side dish or accompaniment, and it needs to be cooked before consumption. Production and consumption of bananas and plantains in West Africa has risen steadily in recent years (FAOSTAT, 2019). Per capita consumption of plantain in Ghana in 2020 was 165.46 kg, representing over 266% increase from 45.09 kg in 2016 (MoFA-SRID, 2021). Plantain fruit has many nutritional benefits typical of the banana family, and in its raw state it is fat-free, cholesterol-free and high in potassium, vitamin A and vitamin C (Britannica, 2019; Oyeyinka and Afolayan, 2019; Agama-Acevedo et al, 2016). The fruit is reported to be good feedstock for making beer especially in parts of East Africa, notably in central and eastern Uganda and Tanzania (Mounjouenpou et al, 2017; Arup et al, 2015).

West Africa is one of the major plantain-producing regions of the world, accounting for approximately 32% of worldwide production (Cauthen et al, 2019). The annual plantain production figures in Ghana for 2011, 2016 and 2020 are over 3.6, 4.2 and 5.8 million tonnes respectively representing an over 60% increment in production from 2011 to 2020 (MoFA-SRID, 2021). The use of appropriate postharvest technologies and food processing methods contributes to food security by reducing postharvest losses,

stabilising food supply and seasonal prices. Sugri et al (2021) reported that postharvest losses were reduced to 3.1% from 36.7% in maize and 6.4% from 77.8% in cowpea during 12 months of storage by disseminating appropriate technologies to farmers. In the absence of modern technology and advanced harvesting practices, the crops must be consumed within three weeks post-harvest, which requires rapid distribution and marketing (Olumba and Onunka, 2020).

Plantain and banana fruits are highly perishable and subject to rapid deterioration after harvest (Cauthen et al, 2019; Olawoye et al, 2017). Postharvest loss assessment of plantain in Takoradi (Market Circle), Ghana, revealed that there were postharvest losses of 53.3% due to poor handling during transportation and the use of poor marketing structures to sell the plantains (Koduah, 2018). Postharvest losses of 20% at the production, 15% at the market level and less than 5% at the consumption level were reported by Tortoe et al (2021). Efforts were made by scientists to reduce postharvest losses of plantain fruits in Ghana. Plantain fruits wrapped in plastic bags mixed with dry cocoa leaf powder or rice husk had a shelf life of 14 to 27 days depending on the temperature (Cauthen et al, 2019). Studies by Asante-Kyei et al (2019) revealed that clay container made with combination of clay and sawdust was successful in storing fresh plantains to ripe stage after five weeks.

To complement the efforts of postharvest loss of plantain fruits in Ghana, the fruit could be processed into shelf-stable products that would ensure its availability throughout the year. One of such potential convenient plantain food products is *Tatale* mix. *Tatale* is the traditional (Ghanaian) name for a pancake made from a mixture of pulped soft ripe fruit of plantain and flours such as fermented maize, roasted maize, potato flour or wheat flour. The mixture is mostly seasoned with

ginger, pepper, onion and salt, and kneaded into a paste and shallow fried in vegetable oil into *Tatale* or deep fried into *Kaklo* that may be served alone or with beans as a main meal, snack or dessert. Though *Tatale* and *Kaklo* are delicious and nutritious, their preparation is cumbersome, involving peeling, pounding/blending, mixing and frying. Product development efforts were made at CSIR-Food Research Institute, Accra, Ghana, to produce a dehydrated convenience food, *Tatale* mix, to eliminate most of the laborious aspects of *Tatale* preparation and to preserve plantain whose storage has been a problem in Ghana. The major challenges that hindered the success of the objective were the drying and milling processes of the pulped plantain as well as caking of the dehydrated flour shortly (within a month) after preparation.

For food powders to be acceptable at the consumer level and proper handling in manufacturing operations, they must have good flow characteristics (Sun and Wang, 2017; Chen et al, 2018). Many food powders however, undergo physical changes during their storage and handling that result in the loss of flowability and the formation of agglomerates (Ribeiro et al, 2016). Though the physical mechanisms that may be involved are of a diverse nature, the phenomenon as a whole is normally referred to as a caking problem (Sun and Wang, 2017). The most successful method for caking inhibition in hygroscopic food powders is drying the powder to a low moisture content (below 3%), followed by storage in a water impermeable package (Ribeiro et al, 2016). Additional means like vacuum packaging, in-package desiccation and refrigerated storage are also effective though in many cases their application is avoided for economic reasons. An economically feasible method for improving the situation is the application of flow conditioners also known as anticaking agents. An anticaking agent is an additive placed in powdered or granulated materials,

such as table salt or confectioneries, to prevent the formation of lumps (caking) and for easing packaging, transport, flowability and consumption (Sun and Wang, 2017). The most important anticaking agents used in food are calcium stearate and magnesium stearate, silicon dioxide, silicates, talc, starch, and for common salt, alkali-metal ferrocyanides (Sun and Wang, 2017).

To complement the efforts of postharvest loss of plantain fruits in Ghana, the fruit could be processed into shelf- stable products that would ensure its availability throughout the year. One of such potential convenient plantain food products is *Tatale* mix. The objective of the study was to develop a nutritious, sensory acceptable and free flowing (shelf- stable) plantain base convenient food, *Tatale* mix, which will complement the preservation efforts of plantain in Ghana against perennial postharvest losses to ensure food security. The study focused on the formulation of *Tatale* mix, sensory analysis of the product developed to test consumer acceptability and addition of flow conditioners to the *Tatale* mix to reduce lump formation of the food powder.

MATERIALS AND METHODS

Source of plantain and other materials

Mature green plantain (*Apentu*) of average finger length of 38 cm, average circumference of 19 cm, average weight of 250 g and dark green skin colour was bought from Madina market, Accra, Ghana. Dry maize (10% moisture, mold free), fresh ginger, wheat flour, fresh pepper, fresh onion and palm oil (Frytol brand) were all acquired from the same market. Wheat, rice, potato and maize starches were obtained from Puer Yongji Biological and Technique Co. Ltd, China. Calcium stearate was obtained from KIC Chemicals Inc., USA.

Ripening of Plantain

The mature green plantain bunches were removed from the head and packed in a jute sac and stored in warm room (temperature of $38 \pm 1^\circ\text{C}$) to ripe. The sample was left until the whole plantain fruits became yellow with dark brown patches (after 144 h). The plantain fruit at this stage was described as soft ripe.

Ripe plantain processing

Soft ripe plantain fruit was washed under potable running water, weighed and hand peeled with stainless steel kitchen knife. The fruit was sliced after peeling with a stainless steel knife into a kitchen blender (Philips model HL 7777/00, Koninklijke Philips N.V., Amsterdam) after which potable water (15% of weight of plantain) was added to the peeled fruits and pulped. The pulped plantain was transferred into a bigger receptacle (clean bowl) after which either wheat flour, roasted maize flour or fermented maize flour (5% of weight of pulped plantain) was added and mixed thoroughly. Water was added to the resulting pulp, stirred thoroughly, with a wooden ladle, to make it more flowy and spray-dried using a drum dryer (Gouda drum dryer E5/5, Waddinxveen-Holland). The dried sample was collected, pulverised with a kitchen mill (model HR-16B, Zhejiang Horus Industry and Trade Co. Ltd, China), sieved through a 560μ sieve (Impact Company, UK), packed in a polyethene bag and stored in the refrigerator at 4°C for further work.

Fermented maize flour preparation

The dry maize bought from the Madina market, Accra was sorted to remove moldy grains and foreign materials, cleaned twice in potable water (by rubbing between clean hands) and steeped in potable water (200% the weight of the maize) for twenty-four (24) hours under room temperature ($30 \pm 2^\circ\text{C}$). The soaked maize was washed with fresh potable water, milled in a Jacobson full

circle hammer mill (Carter Day International Inc., Minneapolis, USA), kneaded with water (25% of weight of milled maize) and allowed to ferment for twenty-four hours under room temperature ($30 \pm 2^\circ\text{C}$). The fermented wet dough was spread thinly (about 2 mm thick) on clean stainless steel drying trays and dried in an Apex dryer No. A27685 (Apex Construction Ltd, London) at 60°C for four hours. The dried maize grits was allowed to cool, milled using a Jacobson full circle hammer mill (Carter Day International Inc., Minneapolis, USA), sieved through a 560μ sieve (Impact Company, UK), bagged in polyethylene bags and stored in the refrigerator at 4°C for further work.

Roasted maize flour preparation

The dry maize bought from the Madina market was sorted (to remove any foreign material), roasted in a motorised stainless steel roasting pot (Massis Enterprise, Tema, Ghana), with continuous stirring at an average temperature of 110°C , on open fire to golden brown color. The roasted corn was milled with a Jacobson full circle hammer mill (Carter Day International Inc., Minneapolis, USA), sieved through a 560μ sieve (Impact Company, UK) and bagged into a polyethene bag for further work.

Powdered ginger preparation

Whole fresh ginger bought from the Madina market was soaked in potable water (200% of the weight of ginger) for one hour to get rid of sand particles. The ginger was further cleaned (by rubbing between clean hands) in potable running water, sliced thinly (2 mm thick), spread on a clean stainless steel drying tray and dried in the Apex dryer No. A27685 (Apex Construction Ltd, London) for 6 h at a temperature of 60°C . The dried sample was milled with a kitchen mill HR-16B (Zhejiang Horus Industry and Trade Co. Ltd, China), sieved through a 560μ sieve (Impact Company, UK) and bagged in polyethene bags for further work.

Powdered pepper (red hot)

preparation

Ripe fresh hot pepper bought from the Madina market was sorted to remove rotten and infested peppers. The stalk was removed by hand and the wholesome pepper was washed under running potable water. The pepper was steam blanched for 3 min, spread thinly on a stainless steel drying tray and dried at a temperature of 60 °C in the Apex dryer No. A27685 (Apex Construction Ltd, London) for 6 h. The dried pepper was cooled, milled with a kitchen mill (model HR-16B, Zhejiang Horus Industry and Trade Co. Ltd, China), sieved through a 560 µ sieve (Impact Company, UK) and bagged in polyethane bag for further work.

Powdered onion preparation

Fresh whole onion (bulbs) bought from the Madina market was sorted (to remove unwholesome bulbs), the outer dry scale leaves removed, washed and sliced thinly (2

mm thick). The sliced onion was spread on a clean stainless steel drying tray and dried at a temperature of 60 °C in an Apex dryer No. A27685 (Apex Construction Ltd, London) for 6 h. The sample was cooled, milled with a kitchen mill (model HR-16B, Zhejiang Horus Industry and Trade Co. Ltd, China) and bagged in polyethene bag for further work.

Formulation of *Tatale* mix

Tatale mix formulation, frying and sensory trials were done to arrive at the best formulations as presented in Table 1. The main ingredients of the *Tatale* mix are ripe plantain flour (90% by composition) and either wheat flour, fermented maize flour or roasted maize flour (5% by composition). The other ingredients (powdered pepper, ginger and onion) are used mainly for seasoning the product and they together make up the rest 5% of the product. The main difference between the *Tatale* mix samples is the cereals that are used in their composition.

Table 1: Composition of *Tatale* mix

No.	Ingredient	Composition (%)
1	Dried ripe plantain	90.0
2	Wheat flour or Fermented maize flour or Roasted maize flour.	5.0
3	Powdered red hot pepper	1.0
4	Powdered ginger	2.0
5	Powdered Onion	2.0
Total ingredients of <i>Tatale</i> mix		100%

Rehydration and frying of *Tatale* and *Kaklo*

The *Tatale* mix was rehydrated with three parts (by weight) of potable water. Two grammes (2 g) of table salt (NaCl) were dissolved in 300 mL of potable water by stirring gently with a clean spoon. The table salt solution (300 mL of salt solution per 100 g of *Tatale* mix) was then poured gradually onto the *Tatale* mix in a clean bowl while stirring with a wooden ladle. The mixture was

then kneaded with a wooden ladle for about five (5) minutes and parts of the kneaded paste scooped (40 – 50 g) at a time with a ladle and introduced into a preheated (115 °C) palm oil to shallow fry into *Tatale* or deep fry into *Kaklo*.

Traditional method of *Tatale* and *Kaklo* preparation (as observed from processors).

Plantain fruit is allowed to ripen into very soft texture with the peels of the plantain turning into a combination of black spots and yellow colour. The plantain is washed, hand-peeled with a knife and pounded in a wooden mortar with a wooden pestle into a pulp. The pulp is then mixed with 5% (per weight of pulp) of either fermented maize flour, roasted maize flour or wheat flour (depending on preference) and spiced with 5-10% (per weight of pulp) of fresh ginger, 5% (per weight of pulp) of fresh pepper, 5-10 % (per weight of pulp) of fresh onion

and 2 g of table salt per 100 g of pulp. The resulting pulp is shallow-fried in palm oil by scooping parts (40-50 g) at a time into *Tatale* or deep-fried into *Kaklo*.

Proximate analysis of *Tatale* mix

Moisture and protein contents were determined according to Helrich (1990), while ash and fat contents were determined according to Horwitz (2000) methods.

Crude fibre was determined using Pearson's Composition and Analysis of Foods, 9th edition, method (Kirk et al, 2021).

Total Carbohydrate (%) was determined by difference (Equation 1).

$$100 - [\%moisture + \%fat + \%ash + \%protein + \%crude\ fiber]$$
$$100 - [\%moisture + \%fat + \%ash + \%protein + \%crude\ fiber] \quad \text{eqn 1}$$

Equation 1: Total carbohydrate (%) determination by difference

Sensory evaluation

A fifteen (15) member trained sensory panel from CSIR-Food Research Institute, Accra, Ghana, evaluated the cooked experimental and traditional (control) *Tatale* samples for acceptability. The *Tatale* samples, which were labelled with a three-digit code, were served to the panellists to observe, feel, taste, smell and score. A nine-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) was used for scoring the sensory attributes of the samples. The attributes were appearance, taste, aroma, texture, mouth feel and overall acceptability. The data from the sensory rankings were analysed using Minitab version 17.1 (Kutner *et al.*, 2005).

Caking studies on *Tatale* mix

Eight (8) sets of packed caking study samples (*Tatale* mix with anticaking agents) were evaluated monthly, for eight (8) months, for caking behaviour. The 8 sets of samples comprised twelve (12) different *Tatale* mix and anticaking agents as presented in Table 2. The twelve samples were packed (200 g each) in 10 cm square polyethene pouches (in six replicates) for the caking study. Three of the six 200 g samples of each set of 12 samples were kept on the shelf in the laboratory at a temperature of 30 ± 2 °C and $75 \pm 3\%$ RH, and the other 3 were kept in the refrigerator at 4 °C throughout the study period. Monthly tests were conducted on the samples for eight (8) months to determine the level of caking.

Table 2: Composition of caking study samples

Caking studies sample	Tatale mix	Quantity of Tatale mix (g)	Anticaking agent	Quantity of anticaking agent (g)
FMCS*	633	196.0	Calcium stearate	4.0
FMRS	633	190.0	Rice starch	10.0
FMWS	633	190.0	Wheat starch	10.0
FMPS	633	190.0	Potato starch	10.0
FMMS	633	190.0	Maize starch	10.0
FMC1	633	200.0	Not applicable	0
WFCS	827	196.0	Calcium stearate	4.0
WFRS	827	190.0	Rice starch	10.0
WFWS	827	190.0	Wheat starch	10.0
WFPS	827	190.0	Potato starch	10.0
WFMS	827	190.0	Maize starch	10.0
WFC2	827	200.0	Not applicable	0

*Code of samples

FM = Fermented Maize flour *Tatale* mix, **WF** = Wheat flour *Tatale* mix, **CS** – Calcium stearate, **RS** – Rice starch, **WS** – Wheat starch, **PS** – Potato starch, **MS** – Maize starch, **C1** – Control 1, **C2** – Control 2.

FMCS therefore means; Fermented maize flour *Tatale* mix with Calcium stearate anticaking agent

633: *Tatale* mix made with soft ripe plantain and fermented maize flour.

827: *Tatale* mix made with soft ripe plantain and wheat flour.

Percent caking measurement

The adhesion and lump formation of the *Tatale* mix (flour) was the criteria of caking in this work. *Tatale* mix samples prepared with the anticaking agents was sieved through a laboratory sieve (Impact Company, UK) of mesh size 560 μ placed on Meinzer 11 test sieve shaker (Advantech Manufacturing Inc., Mentor, USA) for ten minutes with the speed set at one (1) on the first day of the caking behaviour evaluation. The entire mix of all samples went through the sifter on the first day of the caking study and this was

expressed as 0% caking. Sifting of the study samples was carried out at monthly intervals for eight months using the same procedure above and the percent caking behaviour was recorded using Equation 2.

$$\text{Percentage caking (\%)} = \frac{Y}{X+Y} \times 100 \quad \text{eqn 2}$$

Equation 2: Percent caking determination method where X is mass of sample that went through the sieve and Y = mass of sample that was retained by sieve.

RESULTS AND DISCUSSION

Nutritional composition of *Tatale* mix

The fruit of plantain has many nutritional benefits typical of the banana family, and in its raw state it is low in fat, high in fibre, cholesterol-free and high in potassium, vitamin A and vitamin C (Britannica, 2019; Oyeyinka and Afolayan, 2019; Agama-Acevedo et al, 2016). Table 3 shows the proximate composition of *Tatale* mix prepared with ripe plantain (90%), fermented maize flour/wheat flour (5%) and selected spices. The moisture content of the *Tatale*

mix samples was 9%. This moisture level is reasonably low to slow bacterial spoilage during storage and hence promotes the keeping quality or shelf life of the *Tatale* mix.

The fat, ash, and total carbohydrate contents in the *Tatale* mix samples (Table 3) are similar to nutrients in ripe plantain fruits as reported by Ibeanu et al, 2016; Kookal and Thimmaiah, 2018; Agbemaflle et al, 2017; Oyeyinka and Afolayan, 2019. The protein and fibre contents of the *Tatale* mix samples in this study are relatively higher compared to results reported by Ibeanu et al, 2016; Kookal and Thimmaiah, 2018; Agbemaflle et al, 2017; Oyeyinka and Afolayan, 2019 but similar to findings by Ayodele et al (2019) who reported that protein, moisture, fibre, and oxalate were found to be significantly higher in ripe plantain than in unripe. The relatively higher protein and fibre contents of the experimental *Tatale* mix could be

attributed to the wheat and fermented maize flours that were added to the *Tatale* mix in its formulation (Ibeanu et al, 2016).

Analysis of variance (ANOVA) on the nutrient composition of the experimental *Tatale* mix indicates that there is no significant difference ($P > 0.05$) in moisture, ash, fibre, fat and total carbohydrates contents of the *Tatale* mix prepared with wheat flour and fermented maize flour. There was, however a significant difference between the protein content of wheat flour *Tatale* mix and fermented maize flour *Tatale* mix. The relatively high protein content in wheat flour *Tatale* mix could be attributed to the fact that wheat grain has relatively higher protein than maize grain on a weight-by-weight basis (Ibeanu et al, 2016). *Tatale* mix made with wheat flour was thus found to be more nutritious in terms of protein content than that made with maize flour.

Table 3: Proximate composition of *Tatale* mix

Parameter	Fermented maize-based <i>Tatale</i> mix	Wheat flour base <i>Tatale</i> mix
Moisture (%)	8.90 ± 0.02 ^a	9.01 ± 0.01 ^a
Protein (%)	8.35 ± 0.01 ^b	9.60 ± 0.01 ^c
Fat (%)	2.60 ± 0.01 ^d	2.63 ± 0.01 ^d
Ash (%)	4.72 ± 0.01 ^e	4.68 ± 0.02 ^e
Fiber (%)	12.01 ± 0.02 ^f	11.86 ± 0.01 ^f
Total carbohydrates (%)	63.42 ± 0.20 ^g	62.22 ± 0.21 ^g

Results are reported as mean of triplicate analysis.

^aMeans in the same row with different letters (a-g) are significantly different ($p < 0.05$)

Sensory evaluation of *Tatale* samples.

Tatale prepared from soft ripe fruits of plantain and cereal flours (fermented maize, roasted maize, wheat flour) and seasonings was served to sensory panellists for ranking.

The sensory results, as presented in Table 4, show that all the samples were liked by the taste panel, as the mean scores for all the attributes were rated as “liked moderately” or better (mean score of 7 or higher). Samples made from the different flours had similar ($p > 0.05$) attribute scores. For instance, the scores for taste and texture ranged from 7.1-8.4 and 7.0-8.5, respectively. Although the sensory characteristics of the *Tatale* samples were found to be very acceptable by the

sensory panellists, there were significant differences in the overall acceptability of the six *Tatale* samples using one-way ANOVA ($p < 0.001$). A Tukey post-hoc test revealed that the *Tatale* samples prepared traditionally with the various flours had statistically significantly higher acceptability values (8.6, 8.3, 8.0; representing *like very much*) compared to the acceptability values; 7.6, 7.4, 7.1 (representing *like very moderately*) of the *Tatale* samples that were made from the experimental *Tatale* mix. The drying of the pulp (with the drum dryer) could have contributed to the lower acceptability values in the experimental *Tatale* as reported by Adewale et al, 2017, that drying and dewatering impact the mechanical, sensory and nutritional properties of food products (Omolola et al, 2017).

A very important attribute that influences the acceptability or otherwise of food products is taste. The stage of maturity affects the nutritional composition and taste of fruits (Mansour, 2019). This informed the decision of the authors to select matured plantain fruits for the development of *Tatale* mix. The taste of the *Tatale* samples ranged between 7.0 and 8.5 with the taste scores of the experimental samples lower than those prepared traditionally (Table 4). The taste of the experimental samples was moderately liked, with the sample made with wheat flour preferred best, followed by that made with fermented maize flour and the least with roasted maize flour *Tatale* mix (Table 4). This observation is consistent with Adi *et al.* (2021), who reported sweetness as an influential quality attribute of senescent plantain products. In that same study, consumers ranked taste as the most important indicator for purchasing powdered mix made from ripe plantain.

Ripe plantain generally contains high amounts of reducing sugars, which contribute to the taste of products made with the

fruit. The spices used to season the *Tatale* may have contributed to the taste of the final product as well.

The texture and appearance of the experimental *Tatale* samples were all moderately liked by the sensory panellists (Table 4). However, the *Tatale* made with roasted maize flour appeared loose and broke apart after frying. This made the roasted maize *Tatale* sample less appealing, which resulted in the panellists ranking the *Tatale* low compared to those made with wheat flour and fermented maize flour. The *Tatale* made with fermented maize and wheat flours looked very attractive in appearance and their texture on feel were very acceptable according to the panellists. The texture and appearance of foods have been shown to have a profound effect on the perception and acceptability of foods. Visual sensory properties are, thus, of critical importance, especially in situations where the products are sold primarily through appearance properties rather than through packaging (Sinesio et al, 2018). The rich gluten content of wheat flour could be linked to the enhanced sensory qualities of the *Tatale* made with wheat flour because of its binding properties. In general, the *Tatale* prepared with wheat flour and fermented maize flour were more acceptable in terms of texture and appearance by the panellists than those made with roasted maize flour.

The best cereal flour for making *Tatale* mix, from the above results, is wheat flour. However, wheat flour is relatively expensive and not readily available in most rural areas in Ghana. Fermented maize flour could therefore be an alternative flour for making *Tatale* mix for small-scale businesses since maize is readily available all year round in every part of Ghana and relatively less expensive compared to wheat flour (SELINA WAMUCII, 2023).

To improve the quality of *Tatale* mix, however, a compromise could be made by using a

mixture of wheat and fermented maize flour for the production of *Tatale* mix.

Table 4. Mean sensory scores of *Tatale* samples.

SENSORY ATTRIBUTE	MEAN SCORES OF SAMPLES*					
	827**	633	722	935	947	968
Appearance	7.8 ± 0.6	7.3 ± 0.8	6.9 ± 0.9	8.5 ± 0.6	8.2 ± 0.6	7.4 ± 1.1
Taste	7.6 ± 0.5	7.3 ± 0.7	7.1 ± 0.7	8.4 ± 0.6	8.3 ± 0.7	8.1 ± 0.8
Texture	7.7 ± 0.8	7.4 ± 0.7	7.0 ± 0.5	8.5 ± 0.6	8.3 ± 0.8	7.4 ± 1.0
Aroma	7.3 ± 0.8	7.3 ± 0.7	7.1 ± 0.7	8.5 ± 0.5	8.2 ± 0.6	7.9 ± 0.7
Mouth feel	7.6 ± 0.5	7.4 ± 0.6	7.1 ± 0.9	8.4 ± 0.6	8.3 ± 0.5	8.1 ± 0.7
Overall acceptability	7.6 ± 0.5 ^a	7.4 ± 0.7 ^b	7.1 ± 0.5 ^c	8.6 ± 0.5 ^d	8.3 ± 0.5 ^e	8.0 ± 0.8 ^f

*Means in the same row with different letters (a-f) are significantly different (p<0.05)

*Sensory attributes were rated on a scale of 1 (dislike extremely) – 9 (like extremely).

****Code of samples**

827 – *Tatale* prepared with *Tatale* mix made with soft ripe plantain and wheat flour.

633 – *Tatale* prepared with *Tatale* mix made with soft ripe plantain and fermented maize flour.

722 – *Tatale* prepared with *Tatale* mix made with soft ripe plantain and roasted maize flour.

935 - Traditional *Tatale* prepared with soft ripe plantain and wheat flour

947 - Traditional *Tatale* prepared with soft ripe plantain and fermented maize flour.

968 - Traditional *Tatale* prepared with soft ripe plantain and roasted maize flour.

Caking behaviour of *Tatale* mix samples

The criteria for caking of samples was adhesion and lump formation of the *Tatale*

mix (flour). Experimental *Tatale* mixes prepared with fermented maize flour and wheat flour were used for the caking study because they were the preferred *Tatale* by the sensory panelists. Figures 1 and 2 show the level of caking in the dehydrated (<10% moisture) *Tatale* mix samples kept on the laboratory bench over eight months period. It was observed that there was caking of between 0.08% and 8.0% in the samples at the end of the eighth month. The control sample (*Tatale* mix with no anticaking agent) had significantly higher level of caking (8%) compared to *Tatale* mix samples with calcium stearate and starches as anticaking agents.

An anticaking agent is a food additive placed in powdered or granulated materials to prevent the formation of lumps (caking) and for easing packaging, transport, flowability (Chen et al, 2018). The most important anticaking agents used in food are calcium stearate, magnesium stearate, silicon dioxide, silicates, talc, starch, and for common salt, alkali-metal ferrocyanides (Chen et al, 2018). The anticaking agents (calcium stearate and the starches) used for this study prevented caking in the experimental compared to the control which had no anticaking agent. The study demonstrated that the incorporation of anticaking agents is largely effective in

maintaining the flowability of the *Tatale* mix as reported by Sun and Wang, 2017 and Lee et al, 2019 (Chen et al, 2018; Chang et al, 2019).

Comparing the effectiveness of all anticaking agents used in the study (Figures 1 and 2), it was observed that calcium stearate was by far the most effective anticaking agent by maintaining the flowability of all mixes tested and reducing the caking phenomenon in the *Tatale* mix samples. Since the caking study samples had 2% of calcium stearate compared to the other samples, which had 5% starch as an anticaking agent, it could be said that calcium stearate is a better anticaking agent compared to the starches. This result is in agreement with studies by Ribeiro et al (2016) and Nurhadi and Roos (2017). However, the use of calcium stearate could be avoided for economic reasons as well as consumers' perception about chemical food additives. Comparing the caking prevention by the four starches used, it was observed that the potato starch samples had the least caking behaviour (Figures 1 and 2) and the

wheat starch samples had the most caking behaviour. The order of starches for use as anticaking agents in *Tatale* mix should therefore be potato starch, rice starch, maize starch and wheat starch according to the results of the study.

There was no caking in all the *Tatale* mix samples kept in the refrigerator throughout the eight (8) months of storage. Since the temperature (4 °C) in the refrigerator was relatively low, it could be said that the relatively high temperature (30 ± 2 °C) in the laboratory, where the samples were kept during the study, contributed to the caking in the samples kept on the laboratory bench. Relatively higher temperature in the laboratory seem to play a significant role in the caking of the *Tatale* mix as reported by Afrassiabian et al (2019). *Tatale* mix samples could therefore be stored under relatively lower temperature conditions (around refrigeration temperature) to prolong the shelf life of the product without the addition of anticaking agents, although this might come with cost implications.

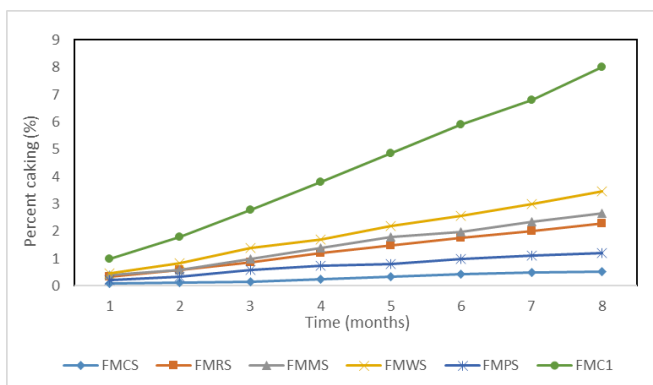


Figure 1: Caking behavior of fermented maize flour *Tatale* mix samples over 8 months of storage.

Codes: **FMCS** - Fermented maize flour *Tatale* mix with Calcium stearate anticaking agent.

FMRS - Fermented maize flour *Tatale* mix with Rice starch as an anticaking agent.

FMMS - Fermented maize flour *Tatale* mix with Maize starch as an anticaking agent

FMWS - Fermented maize flour *Tatale* mix with Wheat starch as an anticaking agent

FMPS - Fermented maize flour *Tatale* mix with Potato starch as anticaking agent

FMC1 - Fermented maize flour *Tatale* mix with no anticaking agent

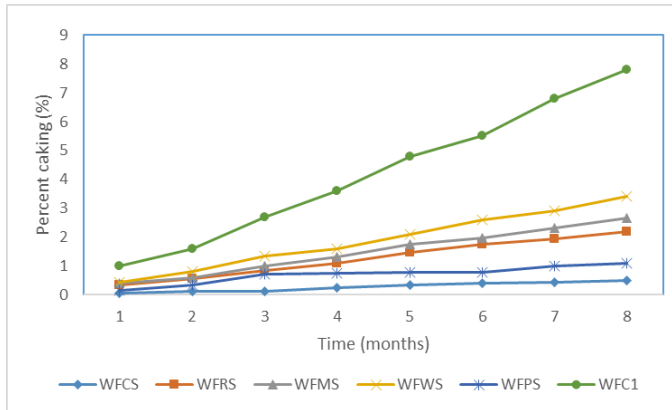


Figure 2: Caking behaviour of wheat flour *Tatale* mix samples over 8 months storage.

Codes: **WFCS** – Wheat flour *Tatale* mix with Calcium stearate anticaking agent.

WFRS – Wheat flour *Tatale* mix with Rice starch as an anticaking agent.

WFMS – Wheat flour *Tatale* mix with Maize starch as an anticaking agent

WFWS – Wheat flour *Tatale* mix with Wheat starch as an anticaking agent

WFPS – Wheat flour *Tatale* mix with Potato starch as an anticaking agent

WFC1 – Wheat flour *Tatale* mix with no anticaking agent

CONCLUSION

Experimental *Tatale* mix made with wheat flour was the best among the experimental *Tatale* mix samples developed. The wheat flour *Tatale* mix was more nutritious and had the best sensory characteristics compared to *Tatale* mix made with maize flours. The sensory characteristics of all three *Tatale* mix products developed were found to be very acceptable by trained sensory panellists. This suggests that the *Tatale* mix developed

could be adopted by entrepreneurs for commercialisation. The experimental *Tatale* mix prepared with wheat flour and fermented maize flour had better sensory characteristics and was liked more by respondents compared to that made with roasted maize flour. However, wheat flour is relatively expensive and not readily available in most rural areas in Ghana. Fermented maize flour could therefore be an alternative flour for making *Tatale* mix for small-scale businesses since maize is readily available all year round in Ghana and less expensive compared to wheat flour. To improve the quality of *Tatale* mix, however, a compromise could be made by using a mixture of wheat and fermented maize flour for the commercial production of *Tatale* mix. Calcium stearate was by far the most effective anticaking agent by maintaining the flowability of all *Tatale* mix tested and reducing the caking phenomenon in the *Tatale* mix samples. However, the use of calcium stearate could be avoided for economic reasons as well as consumers' perception about chemical food additives. Potato starch was the best starch of the four starches used to prevent caking in *Tatale* mix and could be used at 5% level to prevent caking in *Tatale* mix for a period

of eight months. Wheat starch was the worst of the starches used as an anticaking agent but could be used in the absence of potato, rice and maize starches to prevent caking in *Tatale* mix for at least 8 months. *Tatale* mix samples could also be best preserved under relatively lower temperature conditions (around refrigeration temperature) to maintain the flowability of the product without the addition of anticaking agents. The *Tatale* mix developed if promoted and taken up by entrepreneurs in Ghana, could complement, to a large extent, the reduction of annual post-harvest losses of plantain in Ghana during the bumper harvest and thereby ensure food security. This could improve the incomes of farmers and the economy of Ghana at large.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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