Physicochemical and Sensory Qualities of Pap (O*gi*) Produced from Bio-Fortified Maize (*Zea Mays l.)* and Tamarind Fruit Pulp (*Tamarindus Indica l.)*

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Abstract

Ogi, a fermented cereal-based product that is low in vitamin A, and needs fortification, most especially for children. Tamarind fruit pulp was added at 5%, 10%, 15%, 20%, 25%, 30% levels to the biofortified maize before wet-milling for processing into ogi. The samples were A (100% maize), B (95% maize, 5% tamarind), C (90% maize, 10% tamarind), D (85% maize, 15% tamarind), E (80% maize, 20% tamarind), F (75% maize, 25% tamarind) and G (70% maize, 30% tamarind). Physico-chemical and sensory qualities of the fortified ogi were evaluated. . Beta carotene, proximate composition, swelling power, mineral, anti-nutritional and sensory properties of the samples were analysed using standard methods. The control (sample A) had the highest β-carotene content (35.98 µg/ml), but reduced with increasing tamarind pulp addition. Proximate composition was moisture (66.70–65.40%), protein (10.40–9.74%), fat (5.56–7.66%), fibre (0.61–1.02%), ash (0.88–1.19%), and carbohydrate (15.85–14.99%). The swelling power decreased as tamarind quantity increased. Calcium, magnesium, sodium, potassium, copper, zinc ranged thus: 3.00–2.00 mg/L; 2.00-2.32 mg/L; 1.84-1.88 mg/L; 1.28 – 1.02 mg/L; 0.02-0.01 mg/L and 0.68-0.59 respectively, with the treated samples having the highest quantities. The oxalates, tannins, phytates were 13.13-4.18mg; 1.16-0.68mg and 0.93-0.60mg respectively. The lightness, redness and yellowness of the samples reduced with increased tamarind addition. Sensory evaluation showed that sample G (70% maize, 30% tamarind) was the most preferred, and can be concluded that addition of tamarind to pap will improve its quality in terms of organoleptic and nutritional properties.

Keywords: *Bio-fortified maize, tamarind seed, fermentation, pro-vitamin A, ogi*

Introduction

Breakfast is commonly referred to as the most important meal of the day, a meal that ends a long overnight fast, and provides the body with energy for the day's use (Hochberg-Garrett, 2008). Breakfast of cereals in developing countries, has a recognized role in balanced diet. Dietary guidelines says high nutrient density of breakfast cereals makes an important source of key nutrients, as they provide vital vitamins and minerals, as well as supplying important antioxidants (Williams, 2014). Cereal account for about 35% worldwide daily calorie intake, and locally, fermented cereal foods (e.g. *ogi* or pap) are key part of human diet in Africa, where their nutrients are being derived from (Obinna-Echem *et al.*, 2014).

Cereals are cultivated fruit grasses of the monocotyledonous family *Graminae* (Usman, 2012*)*, and are staples providing carbohydrate, protein, B-vitamins and minerals for world's population (Uwagbale *et al.*, 2016), with the main ones being wheat, barley, rice, maize, sorghum and millets. However, maize, rice, sorghum and millets are most common in developing countries. Maize is important, as it provides food and fuel for humans and animals, nutritionally rich and useful industrially (Afzal *et al.*, 2009). Maize has high phosphorus, small amounts of calcium, iron, thiamine, niacin, fat (Adeyemo, 1984); it equally yield high energy per unit land, ensures food availability and security to consumers etc. (Mboya *et al.*, 2011).

Pap, also known as *ogi/akamu*, is a lactic acid fermented cereal porridge from sorghum, millet or maize, and traditionally consumed mostly in the morning across Nigeria and West Africa, with mostly beans, *moimoi* (bean pudding) or *Akara* (bean cake) etc. Maize, sorghum and millet have protein contents between 9 and 13 % that is deficient in essential amino acids, lysine and tryptophan, threonine, with some lost during steeping and sieving operations of the traditional method. This reported losses led to the use of several seed protein supplements in increasing the protein content and improving the nutritional quality of *ogi* (Akingbala *et al.*, 2003).

Bio-fortification is the development of micronutrient-dense staple crops with the best traditional breeding practices and modern biotechnology (Nestel *et al.*, 2006), which is hinged on the regular daily intake of consistent amount of staple foods by family members. This helps to reach the undernourished people in remote areas with naturally fortified foods for people with limited access to such foods marketed and consumed in urban areas, and may have important effects by increasing farm productivity in developing countries in an environmentally beneficial way.

For vitamin A deficiency in plant-based diet, concentrating pro-vitamin A carotenoids such as beta-carotene in staple food crops could improve vitamin A potentials (Howe and Tanumihardjo, 2006). Ogi, *which is a popular breakfast cereal and infant weaning food among Nigerians (Nwokoro and Chukwu, 2012), is* high in water, and this improves water supply and makes nursing mothers lactate easily after delivery.

Tamarind (*Tamarindus indica L.*) is one of the most widespread trees of Indian subcontinent (Rao and Mathew, 2012); a multipurpose tropical tree useful for its fruits that are eaten fresh or processed, used as seasonings or spice, or processed for other uses (El-Siddig, 2006). The seed has protein, fat, sugars and carbohydrates (El-Siddig, 2006); pulp and seeds of Tamarind are rich in potassium, calcium and phosphorous, and many other minerals (Rao and Mathew, 2012). The fruit is the most useful part of tamarind tree; the pulp constitutes 30-50% of the fruit (Shankaracharya, 1998), shell and fibre, 11-30%, and the seed, 25-40% (Duncan and Chapman, 1999).

Tamarind supports the liver, and as reported, an extract of tamarind fruit stimulated production of the liver's natural antioxidants, superoxide dismutase and glutathione (Bettermann, 2019), while its consumption lowers fasting and blood glucose levels within five days (Bettermann, 2019), and detox fluoride for health support. The numerous health and nutrient benefits of tamarind informed its incorporation into *ogi* product for maximum utilization, with the aims of investigating the physico-chemical and sensory qualities of the pap paste made from bio-fortified maize and tamarind fruit.

The traditional method of *ogi* preparation as stated by Nwokoro and Chukwu, 2012, was thereafter adopted. Maize grains were soaked in water for 1-3 days, wet-milled to slurry, and sieved through a screen mesh (sieve size of no. 36). The extract settled for 1 or 2days at ambient temperature (26±2°C) to sediment and turns sour. The paste is boiled in water to give gruel with about 5% solids. It is consumed by both adults and infants. Over fermented product is nutritionally inadequate (Ashaye *et al.*, 2004), and needed fortification with legumes (Nwokoro and Chukwu, 2012). Pap from bio-fortified maize blended with tamarind pulp could give consumers better nutrition and health benefits. Fortification helps to increase concentration and bioavailability of required nutrients from plant based foods (Olayiwola *et al.*, 2017), which can be used to solve nutrition problems peculiar with about 1/3 of children below 5yrs i.e. those having risk of vitamin A deficiency and blindness. The research looked at the physicochemical and sensory qualities of pap produced from the blend of bio-fortified maize and tamarind fruit.

Material and methods

Material Sourcing and Preparation

Bio-fortified maize (*Zea mays L.*) was sourced from International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria, Tamarind (*Tamarindus indica L.)* was purchased from *Oja-oba* market, Ilorin, Kwara state, Nigeria, and the pap paste processed in the laboratory of Department of Home Economics and Food Science, University of Ilorin.

Production of Pap and Product Formulation

Cleaned maize grains and tamarind fruit were wet-milled with an attrition mill to obtain slurry, which was sieved with a muslin cloth to obtained a suspension left for 24-48hrs, while the supernatant was decanted to collect the pap for analyses (Akingbala *et al.*, 2003). Six samples were formulated (Table 1), with the control pap being made from the bio-fortified maize only.

Table 1: Product formulated from the Bio-fortified maize and Graded levels of Tamarind

Ingredients	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Bio-fortified maize	100	95	90	85	80	75	70
Tamarind	0	5	10	15	20	25	30

Determination of Proximate Composition of the Pap Samples

Proximate composition of the pap samples was determined with standard method of Association of Official Analytical Chemists (AOAC, 2010). The moisture, crude fibre, crude protein, crude fat, ash and carbohydrate were determined.

The percentage moisture content was calculated thus:

$$\%\text{ moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where, W_1 = Initial weight of the empty dish; W_2 = weight of dish + sample before drying; W_3 = weight of dish + sample after drying. Fat content was determined with Soxhlet extraction method of AOAC (2010), and percentage fat content calculated thus:

$$\%\text{fat} = \frac{\text{weight of fat}}{\text{weight of sample}} \text{ X } 100\%$$

Determination of Crude Protein*:* The Micro-Kjeldahl method (AOAC, 2010) was adopted, with percentage crude protein content determined thus:

$$\%\text{ Nitrogen} = \frac{\text{T} \times 14.01 \text{ x } 0.01 \text{ x } 20}{1.0\text{x}100} \text{ x } 100$$

Where
T = Titre value; 1.0g = Weight of the sample;
20 = Dilution factor (i.e. from 10015)
0.01 = Normality of HCl;
14.01 = Atomic mass of nitrogen;
% Protein = %Nitrogen x 6.25
(where: 6.25 => Conversion factor of protein).

Determination of Total Ash Content: The AOAC, 2010 method was used to determine the percentage ash content with the formula:

$$\% \text{ ash: } = \frac{\text{weight of ash}}{\text{weight of sample used}} \times 100$$

Determination of Crude Fiber Content: This was determined by AOAC (2010) method, and the crude fibre content of the samples was determined thus:

$$\% \text{ Crude fiber } = \frac{\text{loss in weight on ignition}}{\text{weight of sample used}} \times 100$$

Determination of Carbohydrate Content
Carbohydrate content was estimated by the difference.

Determination of mineral content: Ca, Mg, Na, K, Cu, and Zn were analyzed with standard methods of AOAC (2010) using atomic absorption spectrometer.

Swelling Capacity and Solubility
Tester and Morrison method of 1990 was adopted, where 1 g sample was weighed into a clean, dry test tube (W1), with slurry heated at 40°C, 50°C, 60°C and 70°C respectively for 30mins using thermostatically controlled water bath, cooled to room temperature and centrifuged at 2,200 rpm for 15mins. It was processed, and the residue obtained after centrifuge, was poured into a clean dried test tube and weighed (W2).

Swelling capacity of starch= $\frac{W_2 - W_1}{Weight\ of\ flour} \times 100$

Beta-carotene*:* High performance liquid chromatography UV detector was used to analyze carotenoid content of the extracted sample using N200 chromatography software.

Determination of Anti-nutritional Factor

Phytates

Phytate was determined by Dahdouh *et al.* (2019) method and calculated thus:.

$$\text{Phytate} = \frac{X \text{ x dilutions (if any) x original volume of digest} \quad x \quad 100\%}{\text{Weight of sample x } 106}$$

Where

X = value of the curve or optical density X reading from spectrophotometer

Tannins

AOAC, 2010 method was adopted, with absorbance of Tannic acid standard solutions and samples read after colour development on a spectronic 21D spectrophotometer at wavelength of 760nm.

$$\% \text{ Tannin} = \frac{A \times B \times T}{W \times 10{,}000}$$

Where

A= Absorbance of sample;

B=Average gradient;

T= dilution factor;

W= weight of sample

Oxalates

Method of Dahdouh *et al.* (2019) was used, where 1 mL 0.05m $KMnO_4$ was equated to 2.2mg oxalate.

Colour

Colour values (L*, a*, b*) of samples were determined with Lab scan XE spectro-colorimeter (Hunter Associate Laboratory Virginia, ModelLX16244).

Sensory Evaluation of the Samples

Samples were assessed by 35-man panelists that were familiar with pap using a 9-point hedonic scale, with 9= extremely acceptable, and 1= **e**xtremely unacceptable to assess appearance, flavour, taste and overall acceptability, with data analysed with ANOVA.

Results and Discussion

Beta carotene, pH and TTA contents of Samples: The raw bio-fortified maize had 41.5µg/ml of beta carotene, which reduced slightly in the pap, perhaps due to leaching or heating effect, with the nutrients mostly discarded with water during processing. In Table 2, significant differences ($p<0.05$) were noticed in the β-carotene content of the samples. The values decreased with with increasing addition of tamarind pulp to between 33.62±0.07 and 26.34±0.07 in the treated samples, as against 35.98±0.07 recorded in the control. The values were different from that of moringa fortified maize-*ogi* by Abioye and Aka (2015), having increased beta-carotene with increased moringa addition.

Recorded results was however similar to that of Ukom *et al.* (2019) on yellow maize-*ogi* porridge enriched with orange-fleshed sweet potato and African yam bean, where β-carotene content decreased with increased addition of African yam bean. According to Ortiz *et al*. (2019), light, oxygen, extremes of pH, or a combination of these, as well as anaerobic fermentation, normally degrade carotenoid in food products.

The pH was significant, with samples D and E respectively being the least and most acidic of the samples (3.8 and 3.14), similar to that of Odugbemi *et al.* (1991). TTA was significant, but the differences in value were attributed to fermentation, probably backed by the ratio of maize/tamarind during the fermentation process. Swelling is a function of the ratio of amylose and amylopectin. Swelling power was significant; the control and sample B were similar, but with highest value, while sample G, the least. This inferred that the swelling power decreased with increasing quantities of tamarind pulp.

Table 2: Beta Carotene, pH, TTA and Swelling Power of Pap Paste Samples

Samples	Beta carotene (µg/ml)	pH	TTA	Swelling Power (%)
A	35.98±0.07^{a}	3.23±0.00^{c}	0.47±0.03^{c}	3.07±0.00^{a}
B	33.62±0.07^{b}	3.35±0.01^{b}	0.80±0.00^{b}	3.01±0.01^{a}
C	34.53±0.07^{b}	3.44±0.01^{b}	0.41±0.00^{c}	2.75±0.00^{b}
D	28.02±0.07^{d}	3.80±0.00^{a}	0.23±0.00^{e}	2.68±0.00^{b}
E	31.92±0.07^{c}	3.14±0.00^{c}	1.00±0.00^{a}	2.65±0.00^{c}
F	26.79±0.07^{d}	3.54±0.01^{b}	0.70±0.00^{b}	2.42±0.00^{d}
G	26.34±0.07^{e}	3.26±0.00^{c}	0.34±0.03^{d}	2.17±0.00^{e}

Values in the same column with different superscript are significantly different (P<0.05)

A= 100% Biofortified maize pap paste;
B= 95% Biofortified maize, 5% Tamarind pap paste.
C= 90% Biofortified maize, 10% Tamarind pap paste;
D= 85% Biofortified maize, 15% Tamarind pap paste;
E= 80% Biofortified maize, 20% Tamarind pap paste;
F=75% Biofortified maize, 25%Tamarind pap paste;
G=70% Biofortified maize, 30% Tamarind pap paste.

Proximate Composition of Pap Paste Samples

In Table 3, the control sample was different from sample G, and both were significantly different from others. Moisture content, an index of water activity of foods (Asouzu and Umerah, 2020), was <82%. Moisture variation may be due to the processing method, quantity of water retained (Asouzu and Umerah, 2020), and characteristics of the added tamarind; probably, it might have been soaked in water before milling. Crude protein of treated samples were significant ($p<0.05$) with values of 10.24±0.07% to 9.74±0.07%; the control had the highest value though not significant to that of samples B and C, but significantly different from that of D, E, and F. Germ removal and processing steps could have also influenced the loss, though Abioye and Aka (2015) reported increased value in *ogi* fortified with moringa leaf.

Fat content of the samples was significant to the control by increasing with tamarind addition, however, Ukom *et al.* (2019), opined that the increase may have resulted from the fermentation process. Crude fibre of treated samples was not significantly different ($p<0.05$) from one another but was significant to the control. The control had crude fibre content of 0.61±0.07%, while others ranged from 0.84±0.07% to 1.02±0.07%. Sieving process may have contributed to the low fibre content, though Farinde (2015) opined that fibrous removal is highly plausible, and linked it to enzymatic breakdown during the fermentation process.

Ash content of the control and sample with 5% tamarind (0.88±0.07 and 0.94±0.07 respectively) were not significant from each other but were significant to the others. Since Tamarind was said to be rich in minerals, high values of the treated samples were justified. Carbohydrate content was significant, though with no particular trend. However, sample B had the highest value and sample G, the least.

Table 3: Proximate Composition of Pap Paste Samples.

Samples	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
A	66.70±0.07^{a}	10.40±0.07^{a}	5.56±0.07^{e}	0.61±0.07^{b}	0.88±0.07^{b}	15.85±0.07^{d}
B	63.00±0.07^{bc}	10.24±0.07^{a}	6.15±0.07^{d}	0.84±0.07^{a}	0.94±0.07^{b}	18.83±0.07^{a}
C	64.20±0.07^{b}	10.06±0.07^{a}	6.58±0.07^{d}	0.90±0.07^{a}	1.08±0.07^{ab}	17.18±0.07^{b}
D	64.80±0.07^{b}	9.92±0.07^{b}	6.75±0.07^{c}	0.95±0.07^{a}	1.10±0.07^{a}	16.48±0.07^{c}
E	64.20±0.07^{b}	9.88±0.07^{b}	6.98±0.07^{b}	0.96±0.07^{a}	1.12±0.07^{a}	16.86±0.07^{c}
F	64.10±0.07^{b}	9.76±0.07^{b}	7.10±0.07^{b}	0.98±0.07^{a}	1.15±0.07^{a}	16.91±0.07^{c}
G	65.40±0.07^{a}	9.74±0.07^{b}	7.66±0.07^{a}	1.02±0.07^{a}	1.19±0.07^{a}	14.99±0.07^{d}

Values in the same column with different superscript are significantly different ($P<0.05$)
A= 100% Biofortified maize pap paste;
B= 95% Biofortified maize, 5% Tamarind pap paste.
C= 90% Biofortified maize, 10% Tamarind pap paste;
D= 85% Biofortified maize, 15% Tamarind pap paste;
E= 80% Biofortified maize, 20% Tamarind pap paste;
F=75% Biofortifies maize, 25%Tamarind pap paste;
G=70% Biofortified maize, 30% Tamarind pap paste.

Colour Analysis of the Samples

Colour is an important parameter in bio-fortified foods. Lightness of the samples was significant, with values from 46.72 to 47.25. The control was not different from samples D and E. However, redness values were not significant ($p<0.05$) from one other, though the control had the highest value, but the yellowness was significant, as it decreased with tamarind pulp increment and reducing bio-fortified maize content.

Table 4: Colour Analysis of Pap Paste Samples

Samples	L*	a*	b*
A	47.25 ± 0.05^{a}	3.38 ± 0.01^{a}	5.95 ± 0.01^{a}
B	46.87 ± 0.06^{b}	3.33 ± 0.01^{a}	5.57 ± 0.01^{b}
C	46.91 ± 0.04^{b}	3.33 ± 0.01^{a}	5.62 ± 0.00^{b}
D	47.07 ± 0.02^{a}	3.33 ± 0.00^{a}	5.64 ± 0.00^{b}
E	47.06 ± 0.04^{a}	3.31 ± 0.01^{ab}	5.57 ± 0.02^{b}
F	46.84 ± 0.02^{b}	3.31 ± 0.01^{ab}	5.52 ± 0.02^{bc}
G	46.72 ± 0.04^{b}	3.34 ± 0.01^{a}	5.49 ± 0.02^{c}

Values in the same column with different superscript are significantly different ($P<0.05$). L*, a*, b* means Lightness, redness and yellowness respectively.

A= 100% Biofortified maize pap paste;
B= 95% Biofortified maize, 5% Tamarind pap paste;
C= 90% Biofortified maize, 10% Tamarind pap paste;
D= 85% Biofortified maize, 15% Tamarind pap paste;
E= 80% Biofortified maize, 20% Tamarind pap paste,
F=75% Biofortifies maize, 25%Tamarind pap paste;
G=70% Biofortified maize, 30% Tamarind pap paste.

Mineral Content of Pap Paste Samples: Minerals analysed include Calcium (Ca), magnesium (Mg), sodium (Na), pottasium (K), copper (Cu) and zinc (Zn) (Table 5). The Ca was significant ($p<0.05$), with the control sample having the least value, which was significantly different from the values of the treated samples.

Samples C and F were not significant from each other, though sample F had the highest value (4.01±0.00). According to Oyarekua (2011), recommended dietary allowance (RDA) of Ca in infants' food is 295 mg/100 g, which was not met by the samples; probably due to the sieving operation.

Mg content was significant ($p<0.05$), with the control having the least value and significantly different from the treated samples. Treated samples were significant. Samples D, E and F were not significant to one another. According to King *et al.* (2005), RDA of Mg is between 310 and 420 mg to maintain health and lower the risk of cardiovascular disease, but the values recorded here were below it, and could only met the daily requirement except augmented/complemented with other food product that is high in magnesium.

The Na contents were slightly different from each other. Sample C had the highest value, while sample G, the least. All values were <2 mg hence, can all be considered Na free. For K, samples A and B had same value (1.28), and significant to others, while Cu values were not significant. Singh *et al.* (2019), reported 0.14mg/g Cu in maize, which literally, was similar to 0.11-0.12 observed here. However, reduced values could be due to leaching during sieving. The Zn values were significant. Samples B and C had the highest values, and significant to others, as tamarind addition increased mineral contents.

Table 5: Mineral content of pap paste samples (mg/L).

Samples	Ca	Mg	Na	K	Cu	Zn
A	2.01±0.00^{c}	1.32±0.00^{c}	1.84±0.01^{b}	1.28±0.01^{b}	0.12±0.01^{a}	0.48±0.01^{c}
B	3.00±0.00^{b}	2.00±0.00^{b}	1.87±0.01^{a}	1.28±0.01^{b}	0.12±0.01^{a}	0.77±0.01^{a}
C	4.00±0.00^{a}	2.00±0.00^{b}	1.90±0.01^{a}	1.40±0.04^{a}	0.11±0.01^{a}	0.77±0.01^{a}
D	3.03±0.01^{b}	2.14±0.01^{a}	1.86±0.01^{b}	1.11±0.00^{c}	0.12±0.00^{a}	0.55±0.01^{c}
E	3.00±0.00^{b}	2.32±0.00^{a}	1.88±0.01^{a}	1.02±0.04^{d}	0.11±0.00^{a}	0.69±0.01^{b}
F	4.01±0.00^{a}	2.16±0.01^{a}	1.89±0.02^{a}	1.08±0.00^{c}	0.12±0.01^{a}	0.58±0.01^{c}
G	3.01±0.01^{b}	2.04±0.01^{b}	1.83±0.01^{b}	1.07±0.02^{cd}	0.11±0.00^{a}	0.66±0.01^{b}

Values in the same column with different superscript are significantly different ($P<0.05$).

A= 100% Biofortified maize pap paste;
B= 95% Biofortified maize, 5% Tamarind pap paste;
C= 90% Biofortified maize, 10% Tamarind pap paste;
D= 85% Biofortified maize, 15% Tamarind pap paste;
E= 80% Biofortified maize, 20% Tamarind pap paste;
F=75% Biofortified maize, 25%Tamarind pap paste;
G=70% Biofortified maize, 30% Tamarind pap paste.

Anti-nutrients Contents of Pap Paste Samples: Anti-nutrients decreased digestibility and palatability of nutrients by forming insoluble complexes. The Tannin, Oxalate and Phytate contents of the samples were analysed. Oxalate contents were significant ($p<0.05$), as the control sample had the highest value but not significantly different from the sample with 5% tamarind pulp, though all the samples were within safe limits. Tannin contents were significant ($p<.05$) but did not follow a particular pattern.

Tannin contents of all samples were fair except samples B, C and E, which were slightly high, when compared to the lethal dose, which should be values over 0.9 mg/100g (Ilelaboye *et al.*, 2013). Phytate content except for samples B and E, were significant. It forms complexes with Fe, Zn, Ca, and Mg, making them less available and inadequate in food, mostly for children, and which could have been the problem with the values observed for the mineral contents. Values of 10–50 mg/100g may not negatively affect Zn and Fe absorption (Ilelaboye *et al.*, 2013), as different fermentation products values were from 0.60 to 0.93 mg/100g, and within safe consumption range.

Table 6: Anti-nutrient contents of pap paste samples

Samples	Oxalate (mg/100g)	Tannin (mg/100g)	Phytate (mg/100g)
A	13.13 ± 0.74^{a}	0.78 ± 0.01^{c}	0.60 ± 0.03^{c}
B	12.81 ± 0.30^{a}	0.96 ± 0.01^{b}	0.87 ± 0.00^{a}
C	4.73 ± 0.74^{d}	0.93 ± 0.01^{b}	0.79 ± 0.00^{b}
D	4.18 ± 0.74^{d}	0.78 ± 0.03^{c}	0.86 ± 0.02^{a}
E	4.91 ± 0.30^{d}	1.16 ± 0.01^{a}	0.71 ± 0.03^{b}
F	8.40 ± 0.00^{c}	0.68 ± 0.02^{d}	0.85 ± 0.00^{a}
G	11.03 ± 0.74^{b}	0.83 ± 0.01^{c}	0.93 ± 0.03^{a}

Values in the same column with different superscript are significantly different ($P<0.05$).

A=100% Biofortified maize pap paste;
B= 95% Bio-fortified maize, 5% Tamarind pap paste;
C= 90% Bio-fortified maize, 10% Tamarind pap paste;
D= 85% Bio-fortified maize, 15% Tamarind pap paste;
E= 80% Bio-fortified maize, 20% Tamarind pap paste;
F=75% Bio-fortified maize, 25%Tamarind pap paste;
G=70% Bio-fortified maize, 30% Tamarind pap paste.

Sensory Attributes of the Samples

Sensory scores are shown in Table 7 and were significant. Although all samples were accepted, sample G was however, the most preferred. For appearance, sample G was better preferred, perhaps due to combined colour of reddish brown (tamarind) and yellow (maize) giving a slightly deep yet bright appearance. The taste was due to the titratable acidity according to Odugbemi *et al.* (1991) and added tamarind. Sample G and F were most preferred, likely due to high tamarind content.

Sample G was most preferred for aroma, due likely to flavour release by lactic acid bacteria during fermentation with tamarind presence. The flavour and viscosity were significant. The viscosity increased with added tamarind, confirming the report of Ukom *et al*., 2019 that viscosity increased with decreasing maize content. The general acceptability of the samples was influenced by individual preferences in appearance, taste, flavour, and viscosity. The panelists generally preferred sample G. Tamarind addition influenced the appearance, taste and general acceptability of the pap.

Table 7: Mean Sensory Scores of Pap Paste Samples.

Samples	Appearance	Taste	Flavour	Viscosity	General acceptability
A	5.75±1.21^{d}	5.90±1.02^{b}	5.90±1.07^{c}	5.60±0.82^{d}	6.00±1.08^{c}
B	6.00±1.08^{c}	5.90±0.72^{b}	5.60±0.75^{d}	6.05±0.99^{c}	6.00±0.79^{c}
C	5.65±0.93^{d}	5.95±0.95^{b}	5.65±0.75^{d}	6.15±0.67^{c}	5.95±0.51^{c}
D	5.95±0.89^{c}	5.90±0.85^{b}	6.05±0.61^{c}	6.50±0.83^{b}	6.35±0.67^{c}
E	6.60±1.14^{bc}	6.75±0.97^{a}	6.60±0.82^{b}	6.95±0.89^{ab}	6.85±0.75^{b}
F	7.05±0.95^{b}	6.65±1.18^{a}	6.55±1.47^{b}	7.20±1.32^{a}	7.00±0.79^{b}
G	7.70±0.80^{a}	6.65±1.14^{a}	7.20±1.20^{a}	7.50±0.83^{a}	7.50±0.76^{a}

Values in the same column with different superscript are significantly different ($P<0.05$)

A= 100% Biofortified maize pap paste;
B= 95% Biofortified maize, 5% Tamarind pap paste;
C= 90% Biofortified maize, 10% Tamarind pap paste;
D= 85% Biofortified maize, 15% Tamarind pap paste;
E= 80% Biofortified maize, 20% Tamarind pap paste;
F=75% Biofortifies maize, 25%Tamarind pap paste;
G=70% Biofortified maize, 30% Tamarind pap paste.

Conclusion

The beta carotene content of samples decreased with tamarind addition, though tamarind addition positively influenced nutritional quality of the treated samples. Tamarind reduced the protein content, but increased fat, ash and fibre contents, thus making it a good mineral source. The slightly high tannin content, as well as that of oxalate and phytate, could have caused the reduced protein content and the reduction in the values of the other nutritional components. It is therefore recommended that fermentation time should be increased during production in order to properly breakdown the anti-nutrients and thus increase bioavailability of nutrients.

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