PROXIMATE, ANTI-NUTRIENT COMPOSITION AND SENSORY PROPERTIES OF GERMINATED CEREAL GRAIN WITH ADDED SOURING FRUIT EXTRACT

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Abstract
Studies were conducted on the effect of souring fruits extract on chemical, sensory and some anti-nutritional properties of germinated maize, millet and sorghum. Flour produced from these grains were soured each with 9% concentration of three souring fruits extract (tamarind pulp, sour sop pulp and lime juice) while flour from the fermented cereal grains were used as control for the treated samples. There were significant differences among the proximate compositions of all the treated samples. The protein content of germinated sorghum soured with tamarind had the highest value (19.69%) while germinated maize soured with sour sop had the lowest value (13.98); the crude fibre content of germinated maize soured with tamarind had the highest value (2.32). Addition of the souring fruits extract significantly increased protein, fat, ash and crude fibre contents. The moisture content of the samples did not exhibit any definite trend while the carbohydrate content decreased significantly with the exception of germinated maize grains soured with sour sop pulp and lime juice that had slight increase. The anti-nutritional properties of the samples decreased significantly. All the samples were acceptable by the panelist in terms of all the sensory parameters evaluated.

Keywords: Germinated cereal grains, anti-nutritional properties, Souring fruits extract

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1. INTRODUCTION

Gruel made from fermented cereals such as maize, sorghum or millet is consumed in many parts of Africa including Nigeria. The gruel has a sour taste which is due to the fermentation of the cereal grains for about 2 to 5 days at room temperature (Laduni *et al.*, 2015). According to previous studies, the degree of sourness is dependent on the period of fermentation (Adeyemi and Beckley, 1986). Consumers relish the sour taste of the fermented gruel and hence may prefer longer period of fermentation during preparation. However, due to the growing demand for foods with convenience by consumers, products with similar colour and consistency have been made to mimic the traditional fermented gruel. Furthermore, the time required to ferment, mill and prepare the gruel has prompted the development of similar products to the gruel. One of such products which have hit the market is custard powder. Custard powder is produced from corn starch with added flavouring and colouring agents. Other ingredients which may be added include egg yolk solids, salt, vitamins, and minerals (Akinwale *et al.*, 2017). Custard is mainly consumed as a breakfast food or complementary foods. Custard powder is consumed as a fine textured semi-solid gruel or paste prepared by dissolving custard starch in water and then making it into a paste by adding calculated amount of boiling water (Alimi *et al.*, 2017). The resulting paste is commonly consumed as breakfast and weaning foods by adults and infant respectively (Tárrega and Costell, 2006). Although custard is similar to the fermented gruel in appearance consistency and possibly with comparable nutritional properties, the sour taste, typical of the fermented gruel is lacking in custard. In order to mimic the fermented taste of maize gruel, we considered it necessary to add souring fruit extracts such as tamarind pulp, sour sop pulp and lime orange juice as souring agents to the custard powder. Souring fruits extract such as lime (*Citrus aurantifolia*) juice, tamarind and sour sop pulp are known for its tart, tangy flavour due to a combination of high contents of tartaric acid. Their usage as seasoning in prepared foods, to flavor confections, curries and sauces, and as a major ingredient in juices and other beverages has been reported (De Caluwé *et al.*, 2010). These fruits are generally rich in organic acid, which contributes to their acidity and is chiefly responsible for their sourness. According to Jayana *et al.* (2010), lime have an acidic and tart taste and contain an array of nutrients including carbohydrates, sugar, fiber, sodium, vitamins and minerals. Limes also contain unique flavonoid compounds that have antioxidant and anti-cancer properties. The sourness of lime is associated with the high contents of citric acid (4.87 g/100 g) (Lime 5), while the sourness of soursop and tamarind is linked with the presence of malic acid (0.77 g/100 g) (Yusof and Ibrahim, 1994; Ceballos *et al.*, 2012) and tartaric acid (8-18 g/100 g) respectively (Shankaracharya, 1998; Obulesu and Bhattacharya, 2011).Therefore, this study determines the effect of the souring fruits extracts on the proximate compositions, anti-nutrients and sensory properties of germinated flour blends in comparison with the fermented cereal grains.

2. MATERIALS AND METHODS

Plant materials

Yellow maize, red sorghum, millet, tamarind pulp, soursop pulp and lime orange were purchased from Oja Oba market at Ilorin. The cereal grains were selected with absolute care to ensure wholesomeness, disease free and without defects.

Germination of samples

Germination was carried out according to the method described by Ariahu *et al.* (1999). The three cereal grain seeds were washed differently in 5% (w/v) sodium chloride solution to suppress mould growth and soaked in tap water in ratio of 1:3 (w/v) grain for 12 h at room temperature (32±2°C), the water drained at 4 h interval after which the seeds were drained and spread separately on a clean jute bag, covered with damp cotton and were allowed to germinate for 72 h, respectively. Water was sprinkled at 12 h interval to facilitate the germination process. At the end of germination, root hairs were removed from the germinated seeds manually. The germinated seeds were dried separately at 60°C in an oven to a moisture content of 10% and ground into flour using attrition mill (globe p44 Chima). Each flour sample was passed through a 0.5 mm mesh size sieve.

Extraction of fruit pulp

Tamarind pulp was extracted according to a modified method described by Khairunnuur *et al.* (2009), while soursop pulp was extracted as described by Noel *et al.*, (2008). Lime juice was extracted by carefully squeezing out the juice. The juice was separated from the seeds using 0.25 mm size sieve.

Formulation of blends

Blends of the different flour samples with treatments; tamarind pulp, soursop pulp and lime orange juices were prepared separately according to the following ratios 91:9 (w/w) for each of the flour sample. The blends were formulated based on previous research (Ojinnaka and Ojimelukwe, 2012) and preliminary experiment conducted and the best concentration was chosen. The blends of the samples were thoroughly mixed with a laboratory mixer, dried separately at 60°C and ground using attrition mill. Each flour sample was passed through a 0.5 mm mesh size sieve. They were packaged in an air tight polyethylene bags, stored in plastic containers with lids and then stored in cool dry place from where samples were taken for analyses.

Analyses

Proximate composition

Moisture, fat and ash contents were determined using AOAC (2000) methods. Protein content was determined by the Kjeldahl method (6.25×N) and total carbohydrate was calculated by difference. Fibre contents were determined by digestion in sulfuric acid and sodium hydroxide (Kirk and Sawyer, 1991).

pH Determination

The pH was measured by making a 10% (w/v) flour suspension of each sample in distilled water (AOAC, 2005). Each sample was then mixed thoroughly in a plastic beaker, and the pH recorded with an electronic pH meter (Model PHN-850, Villeur-Banne, France).

Antinutrients content determination

Phytate contents of the samples was determined according to the method described by (Olagunju *et al.*, 2017), the total polyphenols were determined according to the Prussian blue spectrophotometric method (Price and Butler, 1977), oxalate content was determined using the method of (Siener *et al.*, 2017), saponin content was determined using the spectrophotometric method reported by (Armand *et al.*, 2017), while tannin contents were determined using the established method of Price *et al.* (1978).

Sensory evaluation

Sensory evaluation of the samples were carried out as described by Karim *et al.*, (2015). Briefly, a 9- point hedonic preference scale and a multiple comparison test were used to assess the acceptability of the gruel made from the samples. Thirty (30) semi-trained panelists, selected from student of the Department of Home Economics and Food Science, University of Ilorin, Nigeria were used for the evaluation. The selected students were those accustomed to eating gruel. Prior to the sensory analysis, they were screened with respect to their interest and ability to differentiate food sensory properties. The samples were reconstituted (20 g in 60 ml) in boiling water and thereafter evaluated for consistency, colour, taste, aroma, sourness and overall acceptability.

Statistical analysis

All analyses were performed in triplicate. Data was analysed using analysis of variance (ANOVA) and means were compared using the Fisher Least Significant Difference (LSD) test ($p<0.05$).

3. RESULTS AND DISCUSSION

Effect of souring fruits extracts on the proximate composition of germinated cereal grains

The proximate composition of the raw, fermented and cereal grains with added souring fruit extracts are presented in Table 1.

Table 1: Proximate composition of raw and processed cereal grains with added souring fruits extracts (%)

Cereal grains	Souring agent	Protein	Crude Fat	Crude Fibre	Moisture	Ash	Carbohydrate
Raw Maize	-	10.88 ± 0.01^{h}	4.77 ± 0.01^{e}	2.02 ± 0.01^{de}	10.18 ± 0.01^{a}	1.88 ± 0.01^{c}	70.27 ± 0.00^{ab}
Raw Millet	-	12.60 ± 0.01^{g}	5.70 ± 0.03^{a}	2.10 ± 0.06^{cd}	9.68 ± 0.01^{b}	2.10 ± 0.06^{b}	67.82 ± 0.06^{d}
Raw Sorghum	-	12.30 ± 0.01^{g}	4.06 ± 0.01^{hi}	1.80 ± 0.01^{f}	9.44 ± 0.06^{c}	2.70 ± 0.01^{a}	69.70 ± 0.03^{bc}
Fermented Maize	-	15.15 ± 0.03^{e}	4.12 ± 0.01^{g}	2.00 ± 0.01^{de}	8.60 ± 0.01^{e}	0.60 ± 0.01^{h}	69.54 ± 0.02^{c}
Fermented Millet	-	17.72 ± 0.06^{c}	5.20 ± 0.12^{d}	1.80 ± 0.06^{f}	7.92 ± 0.01^{h}	0.80 ± 0.01^{g}	66.56 ± 0.44^{e}
Fermented Sorghum	-	17.94 ± 0.01^{bc}	3.53 ± 0.01^{l}	1.78 ± 0.01^{f}	8.02 ± 0.01^{g}	0.60 ± 0.01^{h}	68.12 ± 0.02^{d}
Germinated Maize	Tamarind	16.32 ± 0.12^{d}	4.32 ± 0.01^{f}	2.32 ± 0.01^{a}	8.99 ± 0.01^{d}	1.20 ± 0.01^{f}	66.85 ± 0.13^{e}
Germinated Maize	Sour sop	13.98 ± 0.01^{f}	4.18 ± 0.01^{g}	2.29 ± 0.01^{ab}	7.67 ± 0.01^{j}	1.40 ± 0.01^{e}	70.48 ± 0.03^{a}
Germinated Maize	Lime juice	14.92 ± 0.58^{e}	4.28 ± 0.01^{f}	2.26 ± 0.01^{ab}	7.23 ± 0.01^{k}	1.20 ± 0.02^{f}	70.11 ± 0.58^{abc}
Germinated Millet	Tamarind	18.44 ± 0.01^{b}	5.50 ± 0.01^{b}	2.20 ± 0.06^{bc}	8.65 ± 0.03^{e}	1.60 ± 0.01^{d}	63.61 ± 0.08^{h}
Germinated Millet	Sour sop	19.20 ± 0.03^{a}	5.22 ± 0.01^{cd}	2.15 ± 0.01^{c}	7.20 ± 0.06^{k}	1.40 ± 0.02^{e}	64.83 ± 0.04^{g}
Germinated Millet	Lime juice	17.63 ± 0.06^{c}	5.30 ± 0.01^{c}	2.10 ± 0.06^{cd}	8.17 ± 0.02^{f}	1.40 ± 0.02^{e}	65.40 ± 0.01^{f}
Germinated Sorghum	Tamarind	19.69 ± 0.12^{a}	3.98 ± 0.01^{ij}	2.00 ± 0.06^{de}	9.48 ± 0.01^{c}	1.20 ± 0.01^{f}	63.65 ± 0.07^{h}
Germinated Sorghum	Sour sop	18.03 ± 0.02^{bc}	3.88 ± 0.06^{k}	1.98 ± 0.01^{e}	7.78 ± 0.06^{i}	1.20 ± 0.01^{f}	67.13 ± 0.06^{e}
Germinated Sorghum	Lime juice	18.29 ± 0.06^{bc}	3.96 ± 0.01^{jk}	1.95 ± 0.01^{e}	7.89 ± 0.02^{h}	1.22 ± 0.01^{f}	66.69 ± 0.02^{e}

Values are mean ±SD of triplicate determination. Column means with different superscripts are significantly different at 5% probability level ($p\leq 0.05$). *SD = standard deviation

Raw millet and sorghum had similar protein contents and were higher than that of maize. However, after fermentation, the protein content of all the samples increased significantly (P≤ 0.05). Similarly, as observed for the raw cereal grains, both fermented millet and sorghum had higher protein content than the fermented maize. Fermentation has been reported to improve the nutrient profile of foods (Inyang and Zakari, 2008; Fasasi, 2009). Significant differences (P≤ 0.05) were observed among the cereal grains with added souring fruit extracts. With the exception of germinated millets, all the tamarind soured cereal grains had higher protein content than other grains with added souring fruit extracts. This may suggest that tamarind addition may have slight influence on the protein content of the samples. The protein content ranged from 13.98-16.32% (germinated soured maize grains); 17.63-19.20% (germinated soured millet grains) and 18.03-19.69% (germinated soured sorghum grains). The protein contents in this study were slightly higher than the values previously reported for germinated cereal grains without souring (Inyang and Idoko, 2006). This suggests that the added souring fruits extract had positive effect on the protein content. Since the proximate composition of the germinated cereal grains only was not done it may be difficult to compare the effect of souring fruit extracts on the proximate composition of the germinated cereal grain. However, in comparison with the raw grains, the germinated grains with added souring fruit extracts had higher protein content. The germination process may have accounted for the higher protein content of the grains (Inyang and Zakari, 2008; Fasasi, 2009).
The moisture content of the raw, fermented and cereal grains with added souring fruit extracts are within values previously reported (Falmata et al., 2013). However, after fermentation, the moisture content was found to reduce. All the tamarind added samples had higher moisture content compared to those soured with lime juice and sour sop. The higher moisture content of the tamarind added samples may be attributed to its relatively higher moisture content. The moisture content ranged from 7.23-8.99% for germinated soured maize samples; 7.20-8.65% (germinated soured millet samples) and 7.78-9.48% (germinated soured sorghum samples). The results were comparable to the findings previously reported (Inyang and Idoko, 2006). The low moisture content of all the samples may be advantageous in the keeping quality of the samples during storage. The carbohydrate content of the samples was not very much different, while fat, ash and crude fibre content of the grains were generally low and varied significantly among the samples.

Effect of souring fruits extract on the pH value of germinated cereal grains

The effect of souring fruits extract on the pH value of germinated cereal grains is presented in Table 2. The result shows that germinated cereal grains had very high pH values ranging from 6.10-6.20% while the fermented cereal grains had lower pH values ranging from 3.50-3.60%.On addition of the souring fruits extract to the germinated cereal grains, the pH value significantly reduced. The reduced pH value is associated with the high acidic content of the fruits extract as reflected in their low pH values (Table 2).
The pH value of the soured cereal grains ranged from 3.82-4.60 (maize); 3.80-4.56 (millet) and 3.83-4.58 (sorghum). Germinated grains soured with lime juice had lower pH values compared with those soured with tamarind and sour sop pulp. This may be attributed to the very much low values of the lime juice compared to the other souring agents (Table 2).

Effect of souring fruits extracts on the anti-nutritional properties of germinated cereal grains

Oxalate and phenols were the major anti-nutrients in the raw, fermented and cereal grains with added fruit extracts (Table 3). Fermented millet and sorghum were higher in phytate compared to the fermented maize. Tannin and saponin contents of the fermented grains were similar.

Table 2: Effect of souring fruits extract on the pH value of germinated cereal grains

Samples	Souring agent	pH
Tamarind pulp		2.94±0.01[n]
Sour sop pulp		4.40±0.01[f]
Lime juice		2.65±0.01[o]
Fermented Maize	-	3.50±0.01[m]
Fermented Millet	-	3.50±0.01[m]
Fermented Sorghum	-	3.60±0.01[l]
Germinated Maize	-.	6.10±0.01[b]
Germinated Millet	-	6.10±0.01[b]
Germinated Sorghum	-	6.20±0.01[a]
Germinated Maize	Tamarind	3.85±0.01[i]
Germinated Maize	Sour sop	4.60±0.01[c]
Germinated Maize	Lime juice	3.82±0.01[j]
Germinated Millet	Tamarind	3.90±0.01[h]
Germinated Millet	Sour sop	4.56±0.01[e]
Germinated Millet	Lime juice	3.80±0.01[k]
Germinated Sorghum	Tamarind	3.92±0.01[g]
Germinated Sorghum	Sour sop	4.58±0.01[d]
Germinated Sorghum	Lime juice	3.83±0.01[j]

Values are mean ±SD of triplicate determination. Column means with different superscripts are significantly different ($p \leq 0.05$). *SD = standard deviation

Germinated grains with added souring fruit extract had low contents of phytate. Similar observation was observed for saponin, oxalate and phenol. The decrease in the anti-nutrients content may be attributed to the effect of germination rather than the added fruit extract. This is in agreement with previous studies (Inyang and Zakari, 2008; Fasasi, 2009).

Effect of souring fruits extracts on the sensory properties of germinated cereal grains

The effect of souring fruit extracts on the sensory properties of germinated cereal grains are presented in Table 4. With the exception of fermented sorghum, which had slightly higher rating for colour, fermented maize and millet had similar colour rating.

However, following the addition of the souring fruit extracts, colour ratings were lower for all the treated samples.

Table 3: Effect of souring fruits extracts on some of the anti-nutritional properties of germinated cereal grains (mg/g)

Cereal grains	Souring agent	Phytate	Tannin	Saponin	Oxalate	Phenol
Fermented Maize	-	0.11±0.01[de]	0.49±0.01[b]	0.03±0.01[ab]	1.70±0.01[ab]	1.00±0.01[i]
Fermented Millet	-	0.50±0.01[h]	0.32±0.01[e]	0.03±0.01[ab]	0.48±0.33[c]	1.78±0.01[b]
Fermented Sorghum	-	0.60±0.01[h]	0.45±0.01[c]	0.02±0.01[bc]	1.15±0.01[bc]	2.37±0.01[a]
Germinated Maize	Tamarind	0.09±0.01[fg]	0.05±0.01[i]	0.03±0.01[ab]	1.15±0.01[bc]	1.39±0.01[e]
Germinated Maize	Sour sop	0.12±0.01[d]	0.03±0.01[j]	0.02±0.01[bc]	2.30±0.01[a]	1.20±0.01[g]
Germinated Maize	Lime juice	0.08±0.01[g]	0.07±0.01[h]	0.03±0.01[ab]	1.15±0.01[bc]	0.95±0.01[j]
Germinated Millet	Tamarind	0.24±0.01[a]	0.44±0.01[c]	0.01±0.01[c]	0.48±0.33[c]	1.02±0.01[i]
Germinated Millet	Sour sop	0.14±0.01[c]	0.15±0.01[f]	0.04±0.01[a]	1.06±0.33[bc]	0.74±0.01[k]
Germinated Millet	Lime juice	0.20±0.01[b]	0.51±0.01[a]	0.01±0.01[c]	0.48±0.33[c]	1.28±0.01[f]
Germinated Sorghum	Tamarind	0.10±0.01[ef]	0.16±0.01[f]	0.02±0.01[bc]	0.96±0.67[bc]	1.69±0.01[d]
Germinated Sorghum	Sour sop	0.10±0.01[ef]	0.11±0.01[g]	0.04±0.01[a]	0.17±0.01[ab]	1.07±0.01[h]
Germinated Sorghum	Lime juice	0.12±0.01[d]	0.34±0.01[d]	0.03±0.01[ab]	0.23±0.01[a]	1.75±0.01[c]

Values are mean ± SD of triplicate determination. Column means with different superscripts are significantly different ($p \leq 0.05$). *SD = standard deviation

The lower colour rating observed for the samples may be attributed to the added fruit extract. Further, all the samples treated with sour sop pulp had higher colour rating compared to those treated with tamarind and lime juice. The least colour rating for tamarind soured samples could be associated with dark brown colouration of the tamarind pulp imparted to the gruel. Fermented millet had had higher rating for aroma compared to fermented maize and sorghum (Table 4).

Table 4: Mean sensory scores of germinated cereal grains treated with souring fruits extracts

Cereal grains	Souring agent	Colour	Aroma	Taste	Mouth feel	Consistency	Sourness	Overall acceptability
Fermented Maize	-	6.73 ± 0.21^{abc}	6.33 ± 0.24^{ab}	5.50 ± 0.32^{c}	5.93 ± 0.30^{b}	6.20 ± 0.32^{abc}	6.60 ± 0.11^{def}	5.87 ± 0.40^{b}
Fermented Millet	-	6.87 ± 0.20^{ab}	6.83 ± 0.18^{a}	6.33 ± 0.20^{ab}	6.27 ± 0.19^{ab}	6.13 ± 0.21^{bc}	6.73 ± 0.11^{cde}	6.30 ± 0.25^{ab}
Fermented Sorghum	-	7.10 ± 0.20^{a}	6.43 ± 0.26^{ab}	6.23 ± 0.16^{ab}	6.50 ± 0.15^{ab}	6.77 ± 0.20^{a}	6.80 ± 0.12^{bcd}	6.90 ± 0.24^{a}
Germinated Maize	Tamarind	6.37 ± 0.22^{bc}	6.37 ± 0.23^{ab}	6.80 ± 0.22^{a}	6.70 ± 0.23^{a}	6.53 ± 0.20^{abc}	7.07 ± 0.13^{abc}	6.67 ± 0.21^{a}
Germinated Maize	Sour sop	6.60 ± 0.21^{abc}	6.57 ± 0.17^{ab}	6.70 ± 0.16^{ab}	6.57 ± 0.16^{a}	6.30 ± 0.15^{abc}	5.77 ± 0.12^{hi}	6.40 ± 0.16^{ab}
Germinated Maize	Lime juice	6.53 ± 0.18^{abc}	6.30 ± 0.17^{ab}	6.33 ± 0.15^{ab}	6.20 ± 0.19^{ab}	5.93 ± 0.17^{c}	6.33 ± 0.15^{efg}	6.20 ± 0.23^{ab}
Germinated Millet	Tamarind	6.20 ± 0.16^{c}	6.27 ± 0.51^{ab}	6.40 ± 0.21^{ab}	6.17 ± 0.17^{ab}	6.30 ± 0.15^{abc}	7.20 ± 0.18^{ab}	6.43 ± 0.14^{ab}
Germinated Millet	Sour sop	6.53 ± 0.20^{abc}	6.50 ± 0.21^{ab}	6.50 ± 0.16^{ab}	6.13 ± 0.16^{ab}	6.57 ± 0.16^{ab}	5.67 ± 0.17^{i}	6.47 ± 0.15^{ab}
Germinated Millet	Lime juice	6.23 ± 0.15^{c}	$6.23\pm0.^{17ab}$	6.20 ± 0.19^{ab}	6.30 ± 0.14^{ab}	6.17 ± 0.16^{abc}	6.20 ± 0.17^{gh}	6.37 ± 0.17^{ab}
Germinated Sorghum	Tamarind	6.43 ± 0.16^{bc}	6.17 ± 0.14^{b}	6.20 ± 0.14^{ab}	6.27 ± 0.16^{ab}	6.60 ± 0.14^{ab}	7.23 ± 0.15^{a}	6.63 ± 0.12^{a}
Germinated Sorghum	Sour sop	6.80 ± 0.19^{abc}	6.17 ± 0.17^{b}	6.10 ± 0.14^{b}	6.23 ± 0.16^{ab}	6.30 ± 0.14^{abc}	5.90 ± 0.22^{ghi}	6.40 ± 0.18^{ab}
Germinated Sorghum	Lime juice	6.37 ± 0.17^{bc}	6.50 ± 0.15^{ab}	6.27 ± 0.19^{ab}	6.37 ± 0.16^{ab}	6.47 ± 0.16^{abc}	6.47 ± 0.13^{def}	6.60 ± 0.16^{a}

Values are mean ±SD of thirty scores. Means along a column with different superscripts are significantly different ($p\leq 0.05$). *SD = standard deviation

Similar observation has been reported previously (Ladunni et al., 2013). The addition of the souring fruit extracts to the cereal grains changed the aroma of the samples but not significantly ($p\leq 0.05$). Among the samples, Panel members rated the aroma of cereals soured with sour sop better when compared to those soured with tamarind and lime juice. The least aroma rating for samples soured with lime juice could be as a result of the tart and tangy taste of the juice. With the exception of fermented maize, which had lower rating for taste, fermented millet and sorghum had similar ratings. The addition of the souring fruit extracts seems to improve the taste of the samples. However, germinated maize soured with tamarind, sour sop and lime juice had higher ratings compared to germinated sorghum and millet with added souring fruit extracts. Millet soured with sour sop had higher rating for taste than those soured with tamarind and lime juice. The highest mean score obtained could be due to the juicy pulpy white, stringy and sour bland tasting tissues of the sour sop pulp imparted to the gruel (Akubor and Egbekun, 2007). Ratings for mouth feel were very much similar across the samples (Table 4). Germinated maize with added tamarind and sour sop had higher ratings for mouth feel compared to all other samples, while fermented maize had the lowest rating for mouth feel.

The consistency of the samples varied slightly with fermented sorghum having the highest rating, while germinated maize soured with lime juice had the lowest rating for consistency. The addition of souring fruit extracts seems to improve the consistency of the samples has reflected in their higher ratings. The addition of the souring agents was found to significantly influence the sourness of the cereal grains. Tamarind soured grains had better ratings compared to those soured with lime and sour sop. The better rating may be attributed to the sourness of the fresh tamarind juice. Among the tamarind sour grains, germinated sorghum had the highest rating. The initially higher sourness of the fermented sorghum grain may have accounted for its higher sourness after the addition of the souring fruit extracts. On the whole, all the samples had very similar ratings for overall acceptability. However, fermented sorghum had better acceptance by the panel members compared to other samples. The addition of souring fruit extracts therefore did not significantly alter the sensory properties of the grains.

4. CONCLUSION

The research work revealed that addition of souring fruits extract to the germinated cereal grains significantly improves the nutritional, decreased the anti-nutritional properties of the samples and the gruel produced from the flours were all accepted. More so, the processing method (germination of the cereal grains and inclusion of the souring fruits extract) which is less laborious and less time consuming compared to fermentation processing method will encourage large scale production of the germinated soured cereal grains. Therefore, the germinated soured cereal grains could serve in place of fermented cereal grains.

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