

## EFFECT OF PROCESSING METHOD II: ANTI-NUTRITIONAL, MICROBIAL AND SENSORY QUALITY OF MAIZE-MILLET-SOYBEAN COMPLEMENTARY FOOD

Akinsola Akinjide Olubunmi<sup>1,2\*</sup>, Idowu Michael Ayodele<sup>2</sup>, Karim Olayinka. R<sup>3</sup>., Segilola Victoria Omowumi<sup>1</sup>, Obisesan Dorcas Olajoju<sup>1</sup>

<sup>1</sup> Department of Home Economics, Federal College of Education (Special), Oyo

<sup>2</sup> Department of Food Science and Technology, Federal University of Agriculture, Abeokuta

<sup>3</sup> Department of Home Economics and Food Science, University of Ilorin, Ilorin

\* E-mail: [akinsola4gold@gmail.com](mailto:akinsola4gold@gmail.com), Phone No. +2348034800734, +2348052209288

### Abstract

Many researchers in Nigeria have worked extensively on how to improve the nutrient value of existing complementary foods, but silent on the microbial and safety of the product. This study was carried out to investigate the effect of processing method on antinutritional, microbial and sensory quality of maize-millet-soybean complementary food. Maize, millet, and soybean grains were processed using submerged fermentation, germination and roasting methods ( $120 \pm 5$  °C) combined. Four complementary food samples (including the control) were formulated and mixed in ratio 50:30:20 maize, millet, and soybean respectively, and analyzed for antinutritional factors, microbial quality, total aflatoxin, and sensory attributes. Results showed that combining fermentation or germination with roasting method significantly ( $p < 0.05$ ) reduced phytic acid and amylase inhibitor by 83% and 41%, respectively. Microbial and aflatoxin contents of the complementary food samples were significantly reduced compared to control sample. Fungal spp, *Salmonella-Shigella*, *Cronobacter* spp, and aflatoxin contamination were not detected in fermented and roasted sample. Fermented and roasted sample was significantly preferred ( $p < 0.05$ ) than other samples in terms of colour, texture, and overall acceptability. The study showed that combination of fermentation and roasting methods significantly reduced microbial loads and enhanced safety and sensory acceptability of complementary food produced from maize-millet-soybean for infants and young children.

Keywords: anti-nutritional, complementary foods, microbial loads, safety, sensory quality.

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## 1. INTRODUCTION

Complementary foods are foods introduced to infants between the age of three and six months to compensate for insufficiency of breast milk as source of nutrient for their growth and development (Onofiok and Nnanyelugo, 2007; Temesgen, 2013). The usual first complementary food in Nigeria is called pap, “akamu”, “ogi”, or “koko” and is made by fermentation of maize, millet, or guinea corn (Onabanjo *et al.*, 2008; Omemu, 2011). After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child; such foods include yam, rice, gari, and cocoyam, which may be eaten with sauce or soup (Onofiok and Nnanyelugo, 2007; Ikegwu, 2010). Research has shown that processing methods such as fermentation, germination, roasting, boiling, grilling,

steaming, etc, have also been shown to have significant effect on the anti-nutritional factors, microbial load, and safety of most traditional complementary foods (Rasane *et al.*, 2015). Fermentation is a common way of preserving food, improving digestibility and increasing appetizing flavours (Brown, 2003; Igyor *et al.*, 2010). During fermentation, the amount of available iron is increased because some anti-nutrients such as phytate which chelate minerals are removed (Ezeocha and Onwuka, 2010; Aderonke *et al.*, 2014). Germination on the other hand could improve nutritive value, and increase digestibility, appetizing flavours are also developed and palatability is improved. Sprouting also has been reported to reduce anti-nutrients in legumes such as phytate and flatulent factors (Rasane *et al.*, 2015). Muhimbula *et al.* (2011) also reported that germination as a processing method causes a

decrease in antinutrients factors of such food products. In soybean, sprouting has been shown to reduce anti-nutritive factors such as trypsin inhibitors and hemagglutinins (Aminu *et al.*, 2010; Balasubramanian *et al.*, 2014).

Apart from fermentation and germination methods, roasting have also been found to improve colour, flavour, and overall acceptability of some food products. Roasting also reduces anti-nutritional factors (protease inhibitor and lectins, phytic acids, oxalic acids, and tannin) of composite flours (Keku, 2006; Nisar *et al.*, 2015).

A complementary food developed from maize-millet-soybean mixture and processed using fermentation, germination, and roasting combined would therefore be expected to provide a safe and sensory acceptable complementary foods. Most of the previous researchers on complementary foods in Nigeria did not report microbial load of their complementary foods, while many are also silent on the safety and toxicity (aflatoxin) of the products (Temesgen, 2013; Aderonke *et al.*, 2014; Rasane *et al.*, 2015; Rafiya *et al.*, 2016). Therefore, the aim of this study was to develop an acceptable, and safe complementary food that could be produced at a cottage level using yellow maize, millet and soybean as raw food materials.

## 2. MATERIALS AND METHODS

### *Materials*

The yellow maize (*Zea mays*), finger millet (*Eleusine coracana*), and soybean (*Glycine max*) used in this study were purchased at a popular local (Lafenwa) market, Abeokuta, Ogun State, Nigeria. Three kilogram of each raw material (yellow maize, millet and soya bean) was sorted to remove dirt, stones, damaged and discoloured grains. All the materials were winnowed, washed in clean distilled water, drained and dried overnight at room temperature under a ceiling fan.

### **Preparation of raw samples**

#### *Preparation of control sample*

The dried samples was milled separately using locally fabricated attrition milling machine and sieved to approximately mesh size of 450 microns. Flours obtained served as control samples [SC], stored at room temperature ( $30 \pm 2$  °C) in an airtight low-density polyethylene bag for analysis.

#### *Preparation of fermented samples*

Each of the raw materials was germinated using a modified method described by Adeyemi and Beckley (1991). Each material was soaked in a volume of water three times the weight of the grains in a plastic bucket at  $30 \pm 2$  °C for 48 hr, drained for 10 min, transferred to aluminum trays, and dried in an air oven (Gallenkamp BS Oven 250 °C, Model ED-5) at 55 °C for 48 hr.

The dried fermented samples were further roasted at  $120 \pm 5$  °C for 10 min. Allowed to cool, winnowed, milled using a locally fabricated attrition milling machine and sieved to approximately mesh size of 450 microns. The fermented-roasted flour obtained [SFR] was stored at room temperature ( $30 \pm 2$  °C) separately in an air tight low-density polyethylene bag for analysis.

#### *Preparation of germinated samples*

Each of the raw materials was germinated using a modified method described by Kulkarni *et al.* (1991). Each material was soaked separately for 12 hr in volume of water three times its weight, drained, spread on a jute sack placed on a wooden platform and covered with another jute sack for germination at room temperature ( $30 \pm 2$  °C) for 48 hr and watered every 12 hr. After 48 hr, the germinated samples were collected, drained for 10 min, transferred to aluminum trays, and dried in an air oven at 55 °C for 48 hr. The dried malted samples were further roasted at  $120 \pm 5$  °C for 10 min. Allowed to cool, winnowed, milled using a locally fabricated attrition milling machine and sieved to approximately mesh size of 450 microns. The fermented-roasted flour obtained [SFR] was stored at room temperature ( $30 \pm 2$  °C) separately in an air tight low-density polyethylene bag for analysis.

### ***Preparation of germinated, solid fermentation and dried samples***

A portion of each dried sample of germinated samples were soaked in a volume of water of its weight in a clean plastic bucket at  $30 \pm 2$  °C for 48 hr, transferred to aluminum trays, and dried in an air oven (Gallenkamp BS Oven 250 °C, Model ED-5) at 55 °C for 48 hr. The dried samples were milled using a locally fabricated attrition milling machine, and sieved to approximately mesh size of 450 microns. Samples obtained were further roasted at  $120 \pm 5$  °C for 10 min. Allowed to cool, winnowed, milled using a locally fabricated attrition milling machine and sieved to approximately mesh size of 450 microns. The germinated-solid fermented and roasted flour obtained [SGFR] was stored at room temperature ( $30 \pm 2$  °C) separately in an air tight low-density polyethylene bag for analysis.

### **Formulation of complementary foods**

The flours already obtained using different processing methods (fermentation, germination, and roasting) were mixed singly based on each processing method in ratio of 50:30:20 for maize, millet, and soybean, respectively to obtain four complementary food samples coded as SC (control), SFR (fermented and roasted), SGR (germinated and roasted), and SGFR (germinated maize-germinated millet-germinated soybean, solid fermentation for 36 hr, re-dried and roasted). Each mixed complementary food sample was homogenous in an Orbital shaker (SOI model, Stuart Scientific, USA), and stored in an airtight low-density polyethylene at room temperature ( $30 \pm 2$ °C) until required for analysis.

### **Antinutritional factors**

#### ***Determination of phytic acid***

The extraction and precipitation of phytic acid were performed according to the method of Wheeler and Ferrell (1971). Five gramme of finely ground sample was weighed into a 125 ml Erlenmeyer flask containing 50 ml 3% TCA. Extraction was done by mechanical shaking of the mixture for 30min and then centrifugation for 15 min. A 10 ml aliquot of the supernatant was transferred into a 40 ml

conical centrifuge tube; 4 ml  $\text{FeCl}_3$  solution (made to contain 2 mg ferric iron per ml. in 3% TCA) was added by blowing rapidly from the pipette. The tube and contents were heated in a boiling water bath for 45 min. The suspension was centrifuged for 15mins and the supernatant carefully decanted. The precipitate was washed twice by dispersing in 25 ml 3% TCA, heated in boiled water bath for 5 min, and centrifuged. The washing was repeated once with water and the precipitate dispersed in 3 ml, 1.5M NaOH with mixing. The volume was made up to 30 ml with distilled water and the mixture heated in boiling water bath for 30 min. The suspension was filtered hot, and precipitate washed with 60 ml hot water. The filtrate was discarded; while the precipitate from the paper was dissolved with 40 ml hot 3.2M  $\text{HNO}_3$  into 100 ml volumetric flask. The paper was washed with several portions of water, the washings was collected in the same flask and diluted to volume. A 5 ml aliquot was transferred to another 100 ml volumetric flask and diluted to 70 ml. Twenty ml 1.5M KSCN was added and volume made to 100 ml. The absorbance of the solution was read (within 1 min) at 480 nm using spectrophotometer (Spectronic 601 model, Milton Roy Company, USA). A reagent blank was run with each set of samples. Iron in the precipitate was measured according to the method of Makower (1970). A 4 : 6 Fe/P atomic ratio was used to calculate the phytic acid content.

#### ***Determination of total polyphenol***

The method of Sofowora (1993) was used to determine the polyphenols of the complementary food samples. About zero point two gramme of each sample was weighed into a 50 ml beaker, 20 ml of acetone was added and homogenized properly for 1 hr to prevent lumping. The mixture was filtered through a Whatman No.1 filter paper into a 100 ml volumetric Flask using acetone to rinse and made up to mark with distilled water with thorough mixing. One milliliter of sample extract was pipetted into 50 ml Volumetric flask, 20 ml water added, 3 ml of phosphomolybdic acid added followed by the

addition of 5 ml of 23% Na<sub>2</sub>CO<sub>3</sub> and mixed thoroughly, made up to mark with distilled water and allowed to stand for 10 min to develop bluish-green colour. Standard phenols of concentration range 0 – 10 mg/ml were prepared from 100 mg/1 stock Phenol solution from Sigma-Aldrich chemicals, U.S.A. The absorbance of sample as well as that of standard concentrations of Phenol was read on a digital spectrophotometer (Spectronic 601 model, Milton Roy Company, USA) at a wavelength of 510 nm. The percentage polyphenols is calculated using the formula:  
Polyphenols (%) = (Absorbance of sample x gradient factor x dilution factor)/  
Wt. of sample (g) x 10,000

#### **Determination of trypsin inhibitor**

The trypsin inhibitor activity of the samples was determined by the method of Kakade *et al.* (1977) using casein as substrate. The sample flours were defatted with petroleum ether and methanol in the ratio 1:2. One gramme of the sample was suspended in 19 ml distilled water and the pH of the suspension adjusted to 7.6 with an Orion model 720A pH meter. After mechanical shaking for 1 hr, the suspension was diluted to 50 ml with phosphate buffer. One milliliter of the inhibitor extract was pipette into a triplicate set of test tubes; 1 ml of trypsin solution was added to each tube, and the tubes were placed in a water bath at 37 °C. Two milliliter of the casein solution previously warmed to 37 °C for exactly 20 min, at which time the reaction was stopped by adding 6 ml of 5% trichloroacetic acid to the tubes. After standing for 1 hr at room temperature, the suspension was filtered, and the absorbance of the filtrate was measured at 280 nm with digital spectrophotometer (Spectronic 601 model, Milton Roy Company, USA). The blank contained 6 ml of 5% TCA and 4 ml buffer. Trypsin inhibitor activity was obtained by dividing the absorbance by 0.01.  
Trypsin Inhibitor (TIU/mg) = Absorbance reading/ 0.01

#### **Determination of amylase inhibitor**

The amylase inhibitor activity was determined using the method described by Figueira *et al.*

(2003). Finely ground complementary food samples were defatted by shaking them with acetone (1:1 v/v) for 15 min and decanted. The defatted flour was dried at room temperature and stored at – 20 °C. Twenty gramme of each of the flour was mixed with 100 ml of 0.1M acetate buffer, pH 6.0, and continuously stirred for 90 min at 4 °C. The soluble proteins were obtained by centrifuging at 30000 rpm for 20 min at 4 °C and precipitating them by adding ammonium sulfate to reach 60% saturation. After standing for 12 hr at 4 °C, the precipitate was recovered by centrifuging at 30000 rpm for 20 min at 4 °C. The pellet was dissolved in 6 ml of 0.05 M KH<sub>2</sub>PO<sub>4</sub>-NaOH buffers, pH 6.7, and dialyzed extensively against the same buffer. The sample was centrifuged at 15000 rpm for 15 min at 4 °C and the supernatant stored at -20 °C. The AI activity was analyzed by pre-incubating 0.25 ml of fungal amylase after appropriate dilution (corresponding to 15 AIU) with 0.25 ml of the complementary food flour extract to obtain 50% reduction of the original amylase activity. Amylase Inhibitor activity (AIU) is equivalent to the amount of protein that inhibited 1 AU of fungal amylase and expressed as AIU/g of the complementary food flour on dry weight basis. The extraction and precipitation of phytic acid were performed according to the method of Wheeler and Ferrell (1971) while the method of Sofowora (1993) was used to determine total polyphenols of the complementary flours samples. The trypsin inhibitor activity of the samples was determined by the method of Kakade *et al.* (1977) using casein as substrate while amylase inhibitor activity was determined using the method described by Figueira *et al.* (2003).

#### **Determination of microbiological quality and safety**

Microbiological quality (total plate, coliform, fungal counts) and safety (*Salmonella* and *Shigella* count, *Cronobacter spp.*, and aflatoxin contamination) of the complementary flour samples were determined using standard methods. The method of Harrigan and MacCance (1982) was used to determine the total plate count, while presumptive coliform

count was determined by plating 1ml of the serially diluted formulated complementary flours on MacConkey's agar and incubated at 37 °C for 24 hr according to Hartman (1985). Rose pink, non-mucoid colonies measured 0.5mm or more uncrowded plate's colonies were counted. Confirmation was done by fermenting on lactose and indole at 44 °C after 24 hrs incubation. Coliform counts value was expressed in logarithm colony forming unit per gramme (log cfu/g). The method of Raper and Fennell (1973) was used to determine the total plate fungal, while the method of AOAC (2005) was used to determine the Salmonella and Shigella count of the formulated complementary flours.

#### ***Cronobacter spp* count**

The method of AOAC (2005) was used to determine the incidence of *Cronobacter spp*, while the method described by Romer (2009) was used to determine the incidence of total aflatoxin of the complementary samples. Twenty gramme of each complementary food sample was weighed into a cleaned, sterilized jar and tightly sealed. Approximately 100 ml of 70/30 (v/v) methanol/water solution was added and tightly sealed. After shaking for 3 min, it was allowed to settle. The extract obtained through Whatman #1 filter and standard solution was allowed to compete with enzyme-conjugated aflatoxin in the antibody-coated microwell for the antibody binding sites. After washing with distilled water, enzyme-substrate was added and blue colour developed. A stop solution was then added which changed the colour from blue to yellow. The microwell was measured optically using a microwell reader with an absorbance filter of 450 nm and a differential filter of 630 nm. The optical densities (OD) of the samples were compared to the OD's of the standards and an interpretative result was determined using the OD's standard graphs' that comes with the machine, and expressed as µg/100g.

#### ***Sensory analysis***

The formulated baby food samples were prepared into gruel and presented to twenty trained consumers that are familiar with

conventional products (Cerelac™ and Nutrend™). The trained consumers were selected women previously trained on what to expect and of child-bearing age. They were asked to score the weaning flours for colour, flavour, taste, texture and overall acceptability. Each panelist sat in an enclosed cubic designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples. The panelists were presented with a score sheet using 9-point hedonic scale where 1 is extremely disliked and 9 extremely liked.

#### ***Statistical analysis***

All data were statistically analyzed using SPSS version 21.0 for analysis of variance, while Duncan multiple range test (DMRT) was used to separate means where there is a significant difference. For each sample, triplicate determinations were carried out.

### **3. RESULTS**

#### ***Antinutritional Factors of the Complementary Food samples***

Table 1 shows the values of phytic acid, total polyphenols, trypsin inhibitor and amylase inhibitor of the complementary flours samples. Phytic acid ranged from 0.12 to 0.68% in SGR (germinated-roasted) and SC (control) samples respectively, while the total polyphenols ranged from 0.02% in SC to 0.05% in SFR (fermented-roasted) sample. Processing methods of fermentation and roasting, or germination and roasting employed in this study reduced phytic acid and amylase inhibitor content of the complementary flours to minimal levels. These results agree with the earlier reports of Marfo *et al.* (1990), Ikujenlola and Fashakin (2005), and Ezeocha and Onwuka (2010) that processing methods such as boiling, fermentation, germination, and roasting significantly reduced antinutritional factors in complementary diets prepared from vegetable proteins and maize soybean based complementary blends. Hurrell (2003) reported that phytic acid has 6 replaceable hydrogen atoms with which it could form insoluble salts with metals such as calcium, iron, zinc, and magnesium thereby inhibiting

their absorption. The levels of phytate and total polyphenol of the complementary blends were lower than 1% and this could be as a result of the processing method employed during the study. According to Osagie (1998), phenolic compounds found in food crops have significant effect on the nutritional and sensory qualities of food products which have been associated with the enzymatic browning reactions of phenolic substances.

Trypsin inhibitor ranged from 3.28 to 4.64 TIU/mg in SC and SGFR samples respectively. There were significant differences ( $p < 0.05$ ) in trypsin and amylase inhibitor components of the complementary flour samples. The trypsin inhibitor values obtained in this study were very low compared with the reports of Obizoba and Atti (1991), Olguin *et al.* (2003), and Bajpai *et al.* (2005) who worked on effect of soaking, sprouting, fermentation and cooking on the nutrition composition and some antinutritional factors of sorghum seeds assessed on weaning rats. According to Osagie, (1998), and Dhingra and Jood, (2001), fermentation, germination, and roasting could cause significant reduction in the trypsin inhibitor activities. The amylase inhibitor ranged from 3.08 AIU/mg in SGFR sample to 4.96 AIU/mg in SC (control) sample. Amylase inhibitors of the complementary flours were less than 6 AIU/100g which is far lower than recommended level (12 – 20 AIU/100g) of FAO/WHO/UNU (1985). Amylase inhibitor inhibits the action of pancreatic and salivary amylases, thereby increasing the amount of undigested starch in the faeces and subsequently decreasing the nutritional value of the foodstuffs. The result showed that multiple processing methods significantly ( $p < 0.05$ ) affected antinutritional factors of the complementary flour samples.

#### **Microbiological Quality of the Complementary Food samples**

Table 2 shows the microbiological quality of the complementary food samples. There were significant differences ( $p < 0.05$ ) in the total plate and coliform count of the complementary food samples. Total plate count ranged from

1.10 to  $2.83 \times 10^5$  log cfu/g in SGFR (germinated-fermented-roasted) and SGR (germinated-roasted) samples, while coliform count ranged from 1.40 to  $2.65 \times 10^5$  log cfu/g in SFR and SGFR (germinated-fermented-roasted) samples, respectively. The highest total plate ( $2.83 \times 10^5$  log cfu/g) and coliform counts ( $2.65 \times 10^5$  log cfu/g) were observed in the SGR and SGFR, while SGFR and SFR had the lowest count for both total plate and coliform count ( $1.01 \times 10^5$  log cfu/g and  $1.24 \times 10^5$  log cfu/g) respectively. Coliform when found in processed foods indicates contamination with fecal matter that also conceivably includes enteric pathogens. This might have been introduced during handling and packaging of the complementary foods (Aminu *et al.*, 2010). This agrees with the reports of Wadud *et al.* (2004) that post-processing handling of food products is very essential in order not to contaminate the product with microorganisms. SFR (fermented-roasted) and SGR (germinated-roasted) samples showed no growth in fungal. The highest value of  $2.3 \times 10^5$  log cfu/g was observed in SC (control), while the lowest value of  $1.55 \times 10^5$  log cfu/g was observed in SGFR for fungal species and this indicate that the presence of fungi was observed only in SC and SGFR samples.

*Salmonella-Shigella* and *Cronobacter spp* were found to be absent in all the complementary flours with the exception of SC samples with count of  $3.0 \times 10^4$  log cfu/g and  $1.67 \times 10^4$  log cfu/g respectively. Most of these microorganisms found in the complementary foods could have been introduced as a result of unhygienic handling of the raw materials prior to processing and during packaging. The surviving microorganisms found in SC during processing could have multiplied between holding time and packaging of the complementary flour samples. All the complementary flours had presence of aflatoxin with the exception of SFR (fermented-roasted) sample. The incidence of aflatoxin contamination was high in control sample (8.0  $\mu\text{g}/\text{kg}$ ), while SGR (germinated-roasted) sample had the lowest level of 1.20  $\mu\text{g}/\text{kg}$ .

Only the SFR (fermented-roasted) sample of the complementary flour had no aflatoxin contamination. Aflatoxins are toxic and carcinogenic metabolites of the fungi *Aspergillus flavus* and *Aspergillus parasiticus*. Atehukeng *et al.* (2007) reported that pre-harvest infections greatly influence the mycoflora during storage especially when the storage conditions become conducive for mycotoxin production. Cardwell and Henry (2005) reported that risk of aflatoxin contamination in grain is the result of many complex relationships among insects, fungi, cereal genotypes and the environment. This result showed that combining fermentation and/or germination and roasting methods together could be used to produce complementary diet that conformed to the aflatoxin standards of WHO (2002) of less than or equal to 2 µg/kg. Moreover, good food manufacturing practice (GFMP) should be employed in the preparation, processing and packaging of complementary food in order to

produce a complementary food that is safe from microorganism and mycotoxin.

### Sensory attributes of the Complementary Food samples

Table 3 shows the mean scores of sensory attributes of the complementary food samples. The complementary food of the sample was significantly different ( $p < 0.05$ ) in colour, flavour, texture, taste, and overall acceptability. The mean scores for colour ranged from 5.14 to 7.90 in SC (control) and SFR (fermented-roasted) samples, respectively, while flavour mean scores ranged from 4.63 in SC (control) to 7.70 in SGR (germinated-roasted) sample. Mean scores for texture ranged from 6.22 to 7.25 in SC and SFR samples respectively, while mean scores for taste ranged from 5.03 in SC (control) to 7.35 in SGR (germinated-roasted) sample. Overall acceptability mean scores ranged from 4.37 in SC (control) sample to 7.80 in SFR (fermented-roasted) sample.

**Table 1. Antinutritional factors of the Complementary Food samples**

Antinutritional factor	SC	SFR	SGR	SGFR
Phytic Acid (%)	0.68±0.17 <sup>b</sup>	0.13±0.03 <sup>a</sup>	0.12±0.03 <sup>a</sup>	0.13±0.06 <sup>a</sup>
Total Polyphenol (%)	0.02±0.00 <sup>a</sup>	0.05±0.01 <sup>ab</sup>	0.03±0.00 <sup>b</sup>	0.04±0.01 <sup>ab</sup>
Trypsin Inhibitor (TIU/mg)	3.28±0.31 <sup>bc</sup>	3.59±0.23 <sup>c</sup>	3.67±0.41 <sup>c</sup>	4.64±0.35 <sup>d</sup>
Amylase Inhibitor (AIU/mg)	4.96±0.09 <sup>b</sup>	3.18±0.23 <sup>a</sup>	3.79±0.30 <sup>a</sup>	3.08±0.10 <sup>a</sup>

Values are means of triplicate determination. Mean values in the same row with different superscript are significantly different ( $p < 0.05$ )

**Table 2. Microbiological quality of the Complementary Food samples**

Microbial count	SC	SFR	SGR	SGFR
Total Plate Count ( $\times 10^3$ log cfu/g)	2.61±0.04 <sup>d</sup>	1.30±0.13 <sup>ab</sup>	2.83±0.41 <sup>de</sup>	1.10±0.08 <sup>a</sup>
Coliform Count ( $\times 10^5$ log cfu/g)	2.58±0.14 <sup>ef</sup>	1.40±0.04 <sup>ab</sup>	2.26±0.02 <sup>e</sup>	2.65±0.04 <sup>f</sup>
Fungal count ( $\times 10^5$ log cfu/g)	2.30±0.12 <sup>d</sup>	Nil	Nil	1.55±0.10 <sup>b</sup>
<i>Salmonella/Shigella</i> ( $\times 10^4$ log cfu/g)	3.00±0.08 <sup>a</sup>	Nil	Nil	Nil
<i>Cronobacter spp</i> ( $\times 10^4$ log cfu/g)	1.67±0.11 <sup>a</sup>	Nil	Nil	Nil
Total Aflatoxin (µg/kg)	8.0±0.26 <sup>e</sup>	Nil	1.20±0.00 <sup>a</sup>	2.40±0.14 <sup>b</sup>

Values are means of triplicate determination. Mean values in the same row with different superscript are significantly different ( $p < 0.05$ ). CfU: Colonies forming unit; NIL: No growth.

**Table 3. Sensory evaluation of the Complementary Food samples**

Sensory Attribute	SC	SFR	SGR	SGFR
Colour	5.14±0.21 <sup>a</sup>	7.90±0.08 <sup>gh</sup>	7.21±0.10 <sup>d</sup>	7.05±0.16 <sup>c</sup>
Flavour	4.63±0.08 <sup>a</sup>	7.03±1.03 <sup>cd</sup>	7.70±0.92 <sup>d</sup>	6.40±0.95 <sup>b</sup>
Texture	6.22±0.30 <sup>a</sup>	7.25±0.79 <sup>c</sup>	7.00±1.03 <sup>bc</sup>	6.50±0.83 <sup>b</sup>
Taste	5.03±0.65 <sup>a</sup>	7.00±1.34 <sup>bc</sup>	7.35±1.14 <sup>c</sup>	6.45±1.05 <sup>b</sup>
Overall Acceptability	4.37±0.32 <sup>a</sup>	7.80±1.06 <sup>e</sup>	7.20±1.06 <sup>de</sup>	6.35±0.75 <sup>b</sup>

Values are means of triplicate determination. Mean values in the same row with different superscript are significantly different ( $p < 0.05$ ).

The high mean scores obtained for the sensory attributes showed that all the formulated complementary foods were acceptable to the panelists with the exception of the control sample. Fermentation, germination and roasting methods significantly affected ( $p > 0.05$ ) both the flavour and texture of the complementary foods. The formulated complementary food SFR were highly preferred and acceptable by the trained panelists with mean scores of 7.80

#### 4. CONCLUSION

The results obtained in this study showed that combination of fermentation and roasting methods are found not only to improve sensory quality, but also reduced the aflatoxin contamination and *Cronobacter spp* of the complementary diet. The results of this study also indicated that the adoption of fermentation and roasting processing methods in the production of maize-millet-soybean complementary foods would not only bring about generally improved complementary foods, it will also give rise to the production of complementary foods that is safe (aflatoxin contamination and *Cronobacter spp*), and sensory acceptable.

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#### Competing Interest

The authors declare no competing interest

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