Production of powdered maize Ogi (indigenous complementary food) flours complemented with soybean and sorghum malt

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Abstract - The study was conducted to produce and evaluate dried Ogi from different maize grains complemented with soybeans and sorghum malt. Maize grains were characterized and flours of Ogi were mixed in the ratios of maize and soybeans 70:30 with and without sorghum malt. Their particle size distribution, functional properties, proximate composition, microbiological plate counts and sensory attributes were evaluated. Data obtained were subjected to statistical analysis. Result of particle size distribution showed total of 72.01% flours passed through 600 µm sieve. Bulk density of blends ranged from 0.59 to 0.64 g/cm³, water absorption capacity 1.90 to 2.18 ml/g, swelling capacity 2.47 to 9.43 g/g, proteins 12.88 to 14.48 g, ash 1.31 to 1.43 g, fat 8.34 to 9.95 g, moisture 6.21 to 7.76 g, carbohydrates 67.71 to 70.31. There was significant (P<0.05) changes in the composition of Ogi upon complementation. Total plate count ranged from 3.0 x 10⁵ to 5.0 x 10⁵ CFU/g, yeast-mould count 1.0 x 10⁵ to 2.0 x 10⁵ CFU/g and coliforms not detected. Sensory attributes of all blends are comparable to the conventional complementary food. Blends from the two varieties of yellow colour maize were observed to be superior in terms of their protein contents.

Key words: blends, flour, infants, nutrients, yellow

I. INTRODUCTION

Ogi is a common indigenous complementary food and sometimes called pap. In Nigeria it is called Akamu in Igbo, Ogi in Yoruba and Koko in Hausa. It is an extract of wet soluble carbohydrate (starch extract) from cereal grains with poor storage stability because of its high moisture level. Usually is prepared as thin cereal gruel. In the ancient times Ogi was designed specifically to suit young children during feeding. But later is being consumed by all groups of people. This wide range of acceptability was found to be attributed to sensory qualities such as in terms of taste and mouth feel [1-4].

Ogi is usually made from maize grains. Maize grains were known to be an important cereal for producing Ogi because of its functional and sensory attributes [5]. However, in Nigeria the pop corn varieties are underutilized and are often limited for the production of pop corn snack. While others such as the yellow and white colour maize varieties which were reported to be rich in vitamin A and sugar respectively, are often use for most food production such as ‘tuwu’ [1, 6, 7].

On the other hand, Ogi was reported to be inadequate in terms of its protein content [1, 4]. But most of its consumers were not aware of the consequences of malnutrition related issues of such inferior diet. There are also many people with notion that food having a good taste or taste sweet in the mouth is already an indication of being nutritious and so good for infants, which is not always so. Nevertheless, appropriate technologies of food processing such as malting of cereal grains, was reported to cause starch modification and improve functional, nutrients and texture characteristics of food and so add values to food [8-11]. For this reason, malting technology can be used to improve quality varieties of maize Ogi.
It is because of these issues and also nutrient deficiency of Ogi such as in protein that prompted the need to complement it with available protein rich source such as soybeans. Besides this, addition of sorghum malt would be an added advantage as it was reported to increase nutrient density of gruel through viscosity reduction. Similarly, reduction of moisture level of such product through drying would be another benefit. This would help in prolonging its shelf life and at the same time meeting food quality analog with global appeal and standard. These have been the areas of concern to many researchers in Nigeria as advocated by Bolaji et al. [4]. Drying would also create an avenue for its conversion into powdered flour and facilitate uniform particle size distribution during blending. If such are successfully achieved, then the difficulties leading to its production on commercial scale and subsequent utilization would be abated. Recent study on Ogi by Bolaji et al. [4] about its economic implications of industrialization, which highlighted those needed areas for improvement would make this research commercial centre for industrial attraction.

Therefore, the objective of this study is to produce powdered flour blends of Ogi and to examine its suitable quality characteristics for infants feeding through particle size distribution, functional properties, proximate composition, microbiological plate counts and sensory attributes.

II. MATERIALS AND METHODS

A. Chemicals and reagents used

All chemicals and reagents used are those of the Department of Food Science and Technology, University of Maiduduri, Nigeria.

B. Raw materials collection

The following cereal and legume grains used for this study are: yellow colour maize (Zea mays), white colour maize (Zea mays), yellow colour popcorn (Zea mays var. everta), soybeans (Glycine max- cultivated) and sorghum (sorghum bicolor). All were procured from Monday Market in Maiduguri, Borno State.

C. Determination of physical properties of maize grains

The purity, 1000-kernel weight and bulk density of grain was determined using 100 grains samples as described by Mathew [12] and Iwouno and Ojukwu [13]. Similarly, the grain dimension was determined by random selection of 10 kernels at a time and measuring the major axis length, width and thickness with a sliding vernier caliper as described by Djouab et al. [14].

D. Preparation of Ogi and their blends

The three different varieties of maize grains obtained were measured into three different portions of 1.4 kg each. These were sorted to remove contaminants and subsequently steeped in 1000 ml of clean water in a plastic container for two days at room temperature (30 ± 2°C). The water used was drained and the wet grains were washed again thoroughly with clean water. The wet grains were then wet milled using attrition mill and each of the three portions was mixed with 1000 ml of clean water. The slurry of the mixture was then placed in a muslin clothe and was squeezed (filtered) thoroughly.
The filtrate was then allowed to stand for 24 hours sedimentation. After decantation, the material collected which is known as *Ogi* was placed inside muslin clothe and left to stand for another twelve hours for proper draining of excess water [2]. This was sun dried in a solar tent drier for 12 hours at 55 ± 3°C. Materials were milled using hammer mill and were let to pass through a 0.8 mm mesh size screen (Christy Hunt Agricultural Ltd, Foxhills Ind. Est Scunthorpe, Model DE DN15 8QW, South Humbers, England) to obtained fine *Ogi* flours. Flours were then packaged in a plastic container and stored in metal lagged cupboard until when needed for use as described by Badau et al. [15].

The soybean grains were also sorted to remove contaminants. It was steeped in water at 30 ± 2°C for twelve hours. This was then washed with clean water and boiled for one hour at 100°C. The cooked soybeans was led down and cooled. The husks were separated from the cooked soybeans through rubbing between the two palms and at the same time draining it away [16]. This was sun dried in a solar tent drier for 12 hours at 55 ± 3°C. It was then milled and stored for used as described by Badau et al. [15].

The sorghum grains were also sorted to remove contaminants. Then 100 g of the sorghum grains were thoroughly washed in cleaned water for three times and soaked in water (1:3 w/v) at room temperature for six hours with an air rest of one hour. This was placed in woven kin basket lined with clean moist jute sack for germination. The grains were sprinkled with clean watered for two times a day at regular intervals to maintain moisture level appropriate for germination. After 3 days germination period [17], the grains were removed out of the jute sack and dried in a solar tent drier at 55 ± 3°C for 12 hours. These were polished using piston and mortar for detachment of roots and rootlets and finally winnowed to obtained sorghum malt. This was then milled and stored for used as described by Badau et al. [15].

**E. Formulation of Ogi blends**

The prepared flours were then mixed in a ratio of maize and soybeans 70:30 with sorghum malt (each maize = 63 g, + 27 g soybean + 5 g sorghum malt + 5 g sugar) and also without sorghum malt (each maize = 66.5 g, + 28.5 g soybean + 5 g sugar) as described by Almeda-Dominguez et al. [18]. These were blended to obtain six formulations using 3 x 2 factorial in a completely randomize design as described by Gomez and Gomez [19] and Mead et al. [20].

**F. Determination of percentage particle size distribution of Ogi blends**

The flour particle size distribution was determined by placing 100 g of each flour sample on a tier of sieves (Endecotts Ltd London, England) of decreasing apertures (140 mm, 850 μm, 600 μm, 425 μm, 300 μm, 150 μm, 75 μm and base pan) on a laboratory test sieve shaker. A pan collector (base pan) was placed beneath the last sieve aperture. The shaker was operated for ten minutes each time and the retention on each sieve was then weighed and expressed as percentage particle size distribution as described by Nishita and Bean [21].

**G. Determination of water absorption capacity**

This was determined as the weight of the water absorbed by one gram of the sample as described by Ojinnaka et al. [22]. One gram of the sample was weighed and placed into a weighed test tube. Ten ml of distilled water was added to the tube and mixed thoroughly. The mixture was then allowed to stand for 30 minutes at room temperature it was centrifuged as 3500 rpm for 30 minutes.
The supernatant was decanted and the residue in the test tube was inverted over an absorbent paper (tissue pad). It was allowed to drain completely before the tube and its content held by the flour was measured. This was expressed as volume of water held by flour per gram of flour.

Water absorption capacity = \frac{\text{Weight of water absorbed (ml)}}{\text{Weight of Flour (g)}}

**H. Determination of bulk density**

The bulk density of flour was determined as described by Ojinnaka et al. [22]. Ten grams of each flour sample was measured into a clean 100 ml graduated measuring cylinder. It was taped repeatedly on a padded table until constant volume of flour was obtained. This was express as weight of flour per its constant volume.

Bulk density = \frac{\text{Weight of constant volume of flour (cms)}}{\text{Weight of flour (g)}}

**I. Determination of swelling capacity**

The swelling capacity was determined using one gram flour. Then 30 ml of distilled water was added into 50 ml centrifugal tube containing the sample and was mixed gently. The slurry was heated in a water bath at 95°C for 30 minutes and later centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted and the weight of the paste was taken and expressed as weight of paste per weight of flour [23, 24].

Swelling capacity = \frac{\text{Weight of paste (g)}}{\text{Weight of flour (g)}}

**J. Determination of proximate composition of raw materials, Ogi and blends**

The official method of AOAC [25] was used to determine the proximate composition of raw materials, Ogi and their blends. However, the available percentage of carbohydrates was estimated by difference (i.e. 100% - % (moisture + protein + fat+ ash) and the protein content was determined using micro-Kjeldahl procedure and nitrogen conversion factor of 100/16 (N% x 6.25).

**K. Determination of microbiological plate counts of Ogi blends**

The total microbiological plate counts were determined using pour plate techniques. Potato-dextrose agar, nutrient agar and MacConkey agar were prepared and used for this study according to methods described by Harrigan and McCance [26], Cheesbrough [27] and Jideani and Jideani [28]. One gram of sample was suspended in 9 ml of sterile water for a ten-fold that was then further diluted to a 10⁴ dilution. Each sample diluent was plated in triplicate with an agar of about 18 ml each. To assess bacterial growth, plates were incubated at 35°C for 24 hours. Plates for yeast-mould growth were incubated at room temperature (32±2°C) for 5 days and were observed daily. After incubation period, resulting bacterial and yeast-mould colonies were counted using a digital colony counter. The average colony number obtained from the countable triplicate plates were expressed as colony forming unit per gram (CFU/g).

Colony Forming Unit Per gram (CFU/g) = \frac{\text{Number of Colonies}}{\text{Volume transferred to plate X dilution blank factor}}

**L. Preparation and sensory evaluation of Ogi blends (gruel)**

The gruel produced from Ogi flour blends were prepared by constituting 40 g each in 50 ml of clean water and was introduced into 150 ml of boiling water to give 20% (w/v) concentration. It was then heated for 1 minute and constantly stirred [29].
Twenty taste panellists were selected from among the students of Food Science and Technology Department who were familiar with gruel made from *Ogi* and conventional complementary foods. Selection of these taste panellists was based on quality criteria needed for a good taste panelists. These panellists were then served with the prepared samples in white transparent plastic cups and spoons. The containers with the samples were coded with three-digit random numbers and were kept far apart to avoid crowding and allow independent judgement. Participants were reminded to rinse their mouth with fresh distilled water between samples. A 9-point hedonic scale was used to rank the gruels on taste, texture, colour, aroma and overall acceptability as described by Larmond [30] and Badau et al. [15].

M. Statistical analysis

Data generated were subjected to analysis of variance (ANOVA) using IBM SPSS Statistics version 20 [31] and means were separated by Duncan’s multiple range tests at 5% significance level [32].

III. RESULTS AND DISCUSSION

N. Physical properties of maize grains

Table 1 shows the physical properties of maize grains. The result of physical properties of maize grain shows significant (p < 0.05) variations. Percentage purity of different varieties of maize (white colour maize, yellow colour maize and yellow colour popcorn) ranged from 93.74 – 97.33 g, broken fractions 0.40 – 2.14 g, bulk density 0.80 – 0.83 g/cm³, kernel weight 124.53 – 233.85 g, kernel length 4.18 – 9.57 mm, width 4.58 – 9.67 mm, and thickness 3.65 – 9.00 mm. Popcorn mostly had lowest values for physical properties while white maize mostly indicated highest values.

Percentage purity is generally considered as criteria for market value [33, 34] and so it can be used to compare superiority of grain over another. The percentage purity was observed to be higher in this study as compared to the work conducted by Iwouno and Ojukwu [13] on effects of experimental variable on the malting quality of Nigerian yellow maize. This could be due to ability to retain quality grain by the research institutes than the marketers. Grain is often marketed according to three main properties such as size, colour and condition of damaged kernel [35, 34]. The standard requirement is that grain especially wheat must contain no more than 0.4% kernels damage of the total weight, if be regarded as grade one [35]. The broken fractions were found to higher in this study when compared to the study by Iwouno and Ojukwu [13]. Kernel weights were observed to be much lower as compared to 223 – 294 g kernels reported for other selected Nigerian maize varieties [36]. This could be due to climate factors and farming technologies.
TABLE I. Physical properties of maize grain

<table>
<thead>
<tr>
<th>Maize grains</th>
<th>% Purity</th>
<th>% Broken fraction</th>
<th>Kernel Weight (g/1000)</th>
<th>Bulk density (g/cm³)</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White colour maize</td>
<td>93.74±0.64</td>
<td>2.14±0.14</td>
<td>231.17±8.25</td>
<td>0.80±0.00</td>
<td>9.57±0.69</td>
<td>9.67±0.95</td>
<td>9.00±0.45</td>
</tr>
<tr>
<td>Yellow colour maize</td>
<td>97.33±0.55</td>
<td>1.17±0.03</td>
<td>233.85±6.65</td>
<td>0.80±0.00</td>
<td>8.62±0.92</td>
<td>8.67±0.43</td>
<td>5.51±0.41</td>
</tr>
<tr>
<td>Yellow colour popcorn</td>
<td>95.00±2.26</td>
<td>0.40±0.12</td>
<td>124.53±0.06</td>
<td>0.83±0.01</td>
<td>4.18±0.37</td>
<td>4.58±1.11</td>
<td>3.65±0.54</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).
Mathew [12] reported that kernel weight was generally observed to have a strong evaluation on grain yield. Bulk density is important in the transportation of materials such as in conveyor carriage and staking in the food industry [37]. The bulk density was to be similar to the value (ranged from 0.78 to 0.88 g/cm³) reported for the evaluation of suitability of commercially available maize grains for ‘tuwo’ production in Nigeria [12]. Similarly, grain length, width and thickness are physical parameter which determines sizes and shapes of grains. It affects consumers’ acceptability especially during processing [14]. The results of grain dimension obtained from this study agreed with the reports of Mathew (2010) but slightly lower than the results obtained from the reports of Barnwal et al. [38]). The variation as reported by Barnwal et al. [38] could be due to differences in moisture contents and also genetic and climatic conditions under which grains were stored or cultivated.

A. Percentage particle size distribution of complemented Ogi

The particle size distribution of completed Ogi is presented in Table 2. Results of the percentage particle size distribution indicated much variation. Mesh with 850 µm and 425 µm indicated highest percentage retention. A total weight of 72.01% particles passed through 600 µm sieve.

Iwe [39] reported that a minimum of 99% blends must pass through U.S standard screen No.6 and a maximum of 60% must pass through U.S standard screen No.6 for good wetting characteristics. However, there was higher percentage retention of particles on sieves above 600 µm mesh more than it was expected. This effect was observed to be due to the agglomeration of flour particles as reported by Hossen et al. [40]. In other words, the blends of Ogi flour particles were much finer which possibly caused aggregation and prevented passage of materials through the sieve aperture of mesh 140 mm, 850 µm and 600 µm. Bolade et al. [41] observed that particle size of flours usually play an important technological role in food processing as it can influence the quality parameters of the food product derived from such flours. Similarly, the smaller the particle sizes of flour, the better the uniform constitution with water (i.e. the better the wetting characteristics) as reported by Iwe [39]. Also the better the solubility and interaction of starch molecules by enzymes [42, 40]. Some studies on traditional methods of production of maize tuwo (a Nigerian non-fermented maize dumpling) by Bolade et al.[41] and on computer-optimized weaning food blends by Hayes et al. [43] still had some similarity with the results obtained.

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Sieve sizes used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>140mm</td>
</tr>
<tr>
<td>(a)</td>
<td>0.30</td>
</tr>
<tr>
<td>(b)</td>
<td>0.90</td>
</tr>
<tr>
<td>(c)</td>
<td>0.10</td>
</tr>
<tr>
<td>(d)</td>
<td>0.30</td>
</tr>
<tr>
<td>(e)</td>
<td>0.30</td>
</tr>
<tr>
<td>(f)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).

Note: Formulation (a) = 63 g White maize, (b) = 63 g Yellow maize, (c) = 63 g Yellow popcorn, + 27 g soybean + 5 g sorghum malt + 5 g sugar each.
(d) = 66.5 g White maize, (e) = 66.5 g Yellow maize, (f) = 66.5 g Yellow popcorn, + 28.5 g soybean + 5 g sugar each.

B. Functional properties of complemented Ogi

The results of the functional properties of formulations are shown in Table 3. Results of the functional properties of Ogi showed no significant (P<0.05) difference except in swelling capacity. The bulk density of the formulations ranged from 0.59 – 0.64 g/cm³, water absorption capacity 1.93 – 2.18 ml/g, swelling capacity 2.47 – 9.43 g/g.
The bulk density of blends obtained in this study is much comparable to the buck density (0.63-0.69 g/cm³) of complementary food produced from Ofada rice blended with bambara groundnut [44]. Much similar results of bulk density (0.54-0.65 g/cm³) on complementary foods were obtained by Asma et al. [45]. However, Chandra and Shamer [46] obtained higher values from a range of 0.72-0.91 g/cm³ and it may be because is not from blends but from single wheat, rice, millet and potato flours. Also the water absorption capacity and swelling capacity of blends were found much comparable to the value of complementary foods obtained by Ali et al. [47] and Adebayo-Oyetoro et al. [44] respectively. Higher and lower, and also comparable values were also recorded by Asma et al. [45] and Chandra and Shamer [46]. This was observed to be probably due to much varied levels of supplementations and also use of single grain flour respectively.

### TABLE III.

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Bulk Density (g/cm³)</th>
<th>Water absorption capacity (ml/g)</th>
<th>Swelling capacity (g/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>0.64 ± 0.02</td>
<td>2.08 ± 0.05</td>
<td>2.47 ± 0.60</td>
</tr>
<tr>
<td>(b)</td>
<td>0.60 ± 0.02</td>
<td>1.93 ± 0.01</td>
<td>2.75 ± 0.61</td>
</tr>
<tr>
<td>(c)</td>
<td>0.60 ± 0.02</td>
<td>1.96 ± 0.08</td>
<td>2.69 ± 0.50</td>
</tr>
<tr>
<td>(d)</td>
<td>0.61 ± 0.02</td>
<td>2.04 ± 0.02</td>
<td>8.50 ± 1.07</td>
</tr>
<tr>
<td>(e)</td>
<td>0.60 ± 0.02</td>
<td>1.90 ± 0.03</td>
<td>9.43 ± 0.10</td>
</tr>
<tr>
<td>(f)</td>
<td>0.59 ± 0.02</td>
<td>1.99 ± 0.18</td>
<td>9.04 ± 0.09</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).

Note: Formulation (a) = 63 g White maize, (b) = 63 g Yellow maize, (c) = 63 g Yellow popcorn, + 27 g soybean + 5 g sorghum malt + 5 g sugar each. (d) = 66.5 g White maize, (e) = 66.5 g Yellow maize, (f) = 66.5 g Yellow popcorn, + 28.5 g soybean + 5 g sugar each.

### A. Proximate composition of raw materials

Table 4 indicates the proximate composition of raw materials, their moisture content ranged from 8.24 – 9.38 g, protein 8.58 – 32.97 g, ash 1.15 – 4.95 g, fat 4.86 – 20.62 g and carbohydrate 33.21 – 75.60 g. Results indicated significant variation (P<0.05) in all the raw materials. However, the moisture, ash and fat content of white and yellow maize showed no significant difference (P>0.05).

It is known that grain with high moisture is prone to deterioration and may be affected with fungi. Also high fat content of grain if not properly stored is prone to deterioration due to rancidity, especially if coupled with high moisture level above 10 g [48, 33, 34]. The moisture content of white maize in this study was 8.99 g much lower than 16.92 g moisture of white maize reported. Result of moisture content of yellow maize was 8.98 g which is also lower than 13.67 g reported by Oboh et al. [49]. But it is comparable to moisture contents of white and yellow maize as reported by Razzaq et al. [50]. Soybean had a moisture content of 8.24 g in this study lower than 12 g moisture reported by Michael [51]. Sorghum had a moisture content of 8.68 g lower than 11-12 g reported by Ihekoronye and Ngoddy [52]. All results of moisture contents of all grains used in this study indicated moderate moisture level needed for long storage period [48, 39, 34]. The ash contents of the three maize varieties in this study are lower than 1.93-1.98 g reported by Oboh et al. [49]. Soybean recorded an ash content of 4.95 g which is comparable to 5 g reported by Michael [51]. Sorghum also had an ash content of 1.65 g in this study which is lower when compared to 2 g as reported by Ihekoronye and Ngoddy [52].

The protein level of maize varieties ranged from 8.58-10.27 g and is much comparable to the results reported by Oboh et al. [49] and Razzaq et al. [50]. Soybean exhibited higher protein content than the other grains at a level of 32.97 g but lower than 40-50 g protein reported by MA EM [53] and Michael [51]. Sorghum protein was 11.37 g which is within the range of 10-12 g reported by Ihekoronye and Ngoddy [52]. The fat content of maize varieties ranged from 4.86-6.00 g which is comparable to the fat contents of 5.32-6.21 g of yellow and white maize [49, 50]. Soybeans had 20.62 g protein which is within the range of 13-20 g protein reported by MA EM [53]. Sorghum had 5.05 g fat higher than the 3 g sorghum fat reported by Ihekoronye and Ngoddy [52]. The carbohydrate contents of maize varieties in this study ranged from 73.32-75.60 g which is lower than the value of 84.97 g carbohydrate reported by Ihekoronye and Ngoddy [52].
Soybean had 33.21 g carbohydrate and it was found out that grains which have higher or lower in other components do affect outcome of other components. But its carbohydrate content is still comparable to 35 g carbohydrate reported by Michael [51]. Sorghum recorded 73.22 g carbohydrate in this study which is within the range of 68-80 g carbohydrate [52]. Variations in constituents of grains as reported may be due to climatic and genetic factors under which grains are cultivated and sometimes stored.

### TABLE IV. Table 4 Proximate composition of raw materials (g/100 g)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>White maize</td>
<td>8.99 ± 0.06</td>
<td>1.36 ± 0.11</td>
<td>8.58 ± 0.17</td>
<td>5.44 ± 0.87</td>
<td>75.60 ± 0.09</td>
</tr>
<tr>
<td>Yellow maize</td>
<td>9.89 ± 0.00</td>
<td>1.41 ± 0.02</td>
<td>10.27 ± 0.09</td>
<td>6.00 ± 0.02</td>
<td>73.32 ± 0.09</td>
</tr>
<tr>
<td>Yellow popcorn</td>
<td>9.38 ± 0.06</td>
<td>1.15 ± 0.12</td>
<td>9.78 ± 0.13</td>
<td>4.86 ± 0.46</td>
<td>74.80 ± 0.02</td>
</tr>
<tr>
<td>Whole soybean</td>
<td>8.24 ± 0.01</td>
<td>4.95 ± 0.04</td>
<td>32.97 ± 0.35</td>
<td>20.62 ± 0.93</td>
<td>33.21 ± 1.17</td>
</tr>
<tr>
<td>Whole sorghum</td>
<td>8.68 ± 0.00</td>
<td>1.65 ± 0.03</td>
<td>11.37 ± 0.09</td>
<td>5.05 ± 0.00</td>
<td>73.22 ± 0.05</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).

A. Proximate composition of Ogi, soybeans and sorghum malt flours

Table 5 shows the proximate composition of Ogi, soybean flour and sorghum malt flour. Results of Ogi, soybeans and sorghum malt flours showed significant (p < 0.05) difference. The moisture content of Ogi ranged from 6.99-8.20 g, ash 0.52-0.79 g, protein 6.57-8.62 g, fat 3.28-5.96 g and carbohydrate 78.24-81.17 g. The results of proximate composition of all raw materials decreased upon processing with significant increased in carbohydrate, except for the fat content of soybeans. The decrease in ash contents was observed to be much significant in all the samples. This could be described as the effect of leaching of essential mineral elements into the water used for processing which resulted in the decrease in ash contents of the samples especially that of Ogi.

For this reason, Ogi is therefore recommended to be complemented and fortified after processing. Since all the results of proximate composition are below the recommended levels of conventional complementary foods except the moisture and fat contents [54-56, 10, 57].

### TABLE V. Table 5 Proximate composition of Ogi, soybeans and sorghum malt flours (g/100 g)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>White maize</td>
<td>7.42 ± 0.12</td>
<td>0.52 ± 0.12</td>
<td>6.57 ± 0.23</td>
<td>4.28 ± 0.27</td>
<td>81.17 ± 0.22</td>
</tr>
<tr>
<td>Yellow maize</td>
<td>6.99 ± 0.03</td>
<td>0.63 ± 0.03</td>
<td>8.16 ± 0.02</td>
<td>5.96 ± 0.01</td>
<td>78.24 ± 0.07</td>
</tr>
<tr>
<td>Yellow popcorn</td>
<td>8.20 ± 0.02</td>
<td>0.79 ± 0.31</td>
<td>8.62 ± 0.31</td>
<td>3.40 ± 0.02</td>
<td>79.14 ± 0.32</td>
</tr>
<tr>
<td>Soybean flour</td>
<td>6.17 ± 0.63</td>
<td>3.45 ± 0.14</td>
<td>31.58 ± 0.45</td>
<td>22.31 ± 0.01</td>
<td>37.35 ± 1.80</td>
</tr>
<tr>
<td>Sorghum malt</td>
<td>9.00 ± 0.01</td>
<td>1.32 ± 0.16</td>
<td>9.20 ± 0.10</td>
<td>4.03 ± 0.01</td>
<td>76.38 ± 0.07</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).

B. Proximate composition of complemented Ogi

Table 6 indicates the proximate composition of complemented Ogi. All results of proximate composition of blends showed significant (p < 0.05) difference. Results indicated slight increase in ash, protein, fat and decrease in moisture and carbohydrate content of blends without malt than blends with malt.

The moisture contents of all the formulations ranged from 6.21-7.26 g which are much less than 10 g moisture level as the recommended maximum limit for complementary foods [54-57]. It was reported that food with 5 - 15 g moisture level would have a shelf life of more than year [48]. It was also observed that all formulations had significant increased
in their ash content after complementing with soybeans flour from a range of 0.52-0.79 g (Table 5) and to a range of 1.31-1.43 g (Table 6). This was observed to be due to the fact that soybean flour had more ash content and so it contributed in the increase in ash contents of the formulations. It is also an indication of mineral increase as reported by Adejuyitan et al. [58]. The result of ash obtained is slightly comparable to the ash contents (from 1.80-2.30 g) in complementary foods produced from sorghum, soybeans and oil seed [45]. All formulations showed significant increase in protein contents from a range of 6.57-8.16 g (table 5) and to a range of 12.88 - 14.48 g (Table 6). The addition of soybean had significantly causes an increase in the levels of protein. All formulations reasonably are within the 10 - 15 g protein, which are the Codex standard limit for infants follow – on formulae [54]. This standard limit is obtainable and advocated by most researchers [54-56, 10, 57]. Toxicological risk of excess protein than those recommended may cause metabolic effects in infants and hence increases later risk of obesity [55, 56, 59]. So the level of protein obtained in this study can be considered as an achievement in meeting the global need and standard. The fat contents of all formulations increased from a range of 3.40-5.96 g (Table 5) and to a range of 8.34-10.37 g (Table 6) after complementation with soybeans. All values of fat are comparable to the maximum level of 10 g recommended for complementary foods [54, 10]. These values are also comparable with the work of Asma et al. [45] and Eshun et al. [60]. The carbohydrate contents of all formulations decreased from a range of 78.24-81.17 g (Table 5) and to a range of 67.71-70.31 g (Table 6), which are also comparable to carbohydrate contents of complementary foods produced from cereal grain and legumes [45, 60].

### Table VI. Table 6 Proximate composition of complemented Ogi (g/100 g)

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>6.62 ± 0.03</td>
<td>1.31 ± 0.02</td>
<td>12.88 ± 0.05</td>
<td>8.84 ± 0.05</td>
<td>70.31 ± 0.04</td>
</tr>
<tr>
<td>(b)</td>
<td>6.36 ± 0.03</td>
<td>1.38 ± 0.02</td>
<td>14.12 ± 0.10</td>
<td>9.95 ± 0.01</td>
<td>68.05 ± 0.25</td>
</tr>
<tr>
<td>(c)</td>
<td>7.26 ± 0.34</td>
<td>1.40 ± 0.04</td>
<td>14.24 ± 0.09</td>
<td>8.34 ± 0.03</td>
<td>68.73 ± 0.34</td>
</tr>
<tr>
<td>(d)</td>
<td>6.56 ± 0.05</td>
<td>1.33 ± 0.00</td>
<td>13.18 ± 0.02</td>
<td>9.12 ± 0.10</td>
<td>69.80 ± 0.16</td>
</tr>
<tr>
<td>(e)</td>
<td>6.21 ± 0.00</td>
<td>1.43 ± 0.00</td>
<td>14.26 ± 0.05</td>
<td>10.37 ± 0.07</td>
<td>67.71 ± 0.10</td>
</tr>
<tr>
<td>(f)</td>
<td>7.00 ± 0.00</td>
<td>1.42 ± 0.01</td>
<td>14.48 ± 0.02</td>
<td>8.59 ± 0.04</td>
<td>68.49 ± 0.04</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of triplicate determinations. Values with different superscript within the same column are significantly different (P<0.05).

Note: Formulation (a) = 63 g White maize, (b) = 63 g Yellow maize, (c) = 63 g Yellow popcorn, + 27 g soybean + 5 g sorghum malt + 5 g sugar each. (d) = 66.5 g White maize, (e) = 66.5 g Yellow maize, (f) = 66.5 g Yellow popcorn, + 28.5 g soybean + 5 g sugar each.

#### A. Microbiological plate count of complemented Ogi

Table 7 shows the microbial count of Ogi blends. The total plate counts ranged from $3.0 \times 10^5$ to $5.0 \times 10^5$ CFU/g, yeast-mould count $1.0 \times 10^5$ to $2.0 \times 10^5$ CFU/g and coliform plate count indicated no growth. Formulation containing yellow maize and soybeans with malt was observed to have the least total plate count of $3.0 \times 10^5$ CFU/g. However, total plate counts of all formulations were observed to show no much variation. Similarly yeast-mould count, except formulations containing white or yellow popcorn and soybeans without malt which showed no growth.

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Total plate count is very important. It measures the quantity of aerobic and facultatively aerobic, mesophilic bacteria per unit volume of food sample [26]. It is often used for estimating food shelf life and also suitability of food for human consumption [28]. In cereal and soybeans blends not more than 50,000 bacteria per gram excluding Salmonella [39]. However, the values obtained are more than the one recommended. This is possible because of the fact that fermented food such as Ogi is colonized and fermented by many beneficial bacteria such as lactic acid bacteria. So there is expectation of high bacterial load since bacteria are agents of its production. Such product was reported to pose no health hazard since microorganisms of importance are either deliberately or indirectly used for their production [28, 4]. Other studies on complementary foods reported comparable bacterial loads [29, 16, 11]. On the other hand, coliform is regarded as any member of the Enterobacteriaceae which grows at temperature of 37°C and which normally possesses the enzymes β-galactosidase and often used as index of sanitation in assessing both microbiological safety and quality of food [61]. Their presence in any food reveal possible presence of any other pathogenic bacteria and so is an indication of microbial health hazard to the consumer. The processes adopted for this study has proven safety of this product since they are not detected. Therefore, the dried form of powdered Ogi is superior since diverse microorganisms were reported to associates with wet ones ([16, 62, 3, 4]). Yeast-moulds plate count also measures the total number of yeast and moulds per unit volume of food sample and is recommended to be no more than 20 load per unit food volume [26]. Two formulations containing white maize, popcorn, without malt showed no yeast-moulds. The other four had more than those specified in foods. This may be due to addition of malt as it was reported that there are some beneficial yeast which often associates with malt and ferment foods. However, the moisture contents of these blends are in condition that it will not promote growth of moulds and subsequent introduction of mycotoxins [9]. Other studies also reviled diverse and higher microbial counts associated with wet Ogi [16, 62, 3].

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Total plate count CFU/g</th>
<th>Coliform count CFU/g</th>
<th>Yeast-mould count CFU/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>4.0 x 10⁵</td>
<td>-</td>
<td>1.0 x 10⁵</td>
</tr>
<tr>
<td>(b)</td>
<td>3.0 x 10⁵</td>
<td>-</td>
<td>1.0 x 10⁵</td>
</tr>
<tr>
<td>(c)</td>
<td>5.0 x 10⁵</td>
<td>-</td>
<td>2.0 x 10⁵</td>
</tr>
<tr>
<td>(d)</td>
<td>5.0 x 10⁵</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(e)</td>
<td>4.0 x 10⁵</td>
<td>-</td>
<td>1.0 x 10⁵</td>
</tr>
<tr>
<td>(f)</td>
<td>4.0 x 10⁵</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Values are mean of triplicate determinations. 
- = Not detected

Note: Formulation (a) = 63 g White maize, (b) = 63 g Yellow maize, (c) = 63 g Yellow popcorn, + 27 g soybean + 5 g sorghum malt + 5 g sugar each. (d) = 66.5 g White maize, (e) = 66.5 g Yellow maize, (f) = 66.5 g Yellow popcorn, + 28.5 g soybean + 5 g sugar each.

O. Sensory attributes of complemented Ogi

Table 8 showed the results of panelist rating of sensory attributes of complemented Ogi and cerecal (control). All results of formulations showed no significant (p > 0.05) difference. However, the conventional complementary food (cerecal) used as control was observed to be slightly higher in all the sensory attributes than those of formulations. This could be due to additional sweeteners and flavour of the control (cerecal) which in turns influence panelists preference. In fact, aroma and taste had prominent effect on the panelists rating. Other studies that used conventional complementary food as control had similar issues [60, 11].
### Table VIII. Table 8 Sensory attributes of complemented Ogi

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Colour</th>
<th>Aroma</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>7.13b ± 0.99</td>
<td>6.86b ± 1.12</td>
<td>7.06b ± 1.57</td>
<td>7.06b ± 1.03</td>
<td>7.06b ± 1.90</td>
</tr>
<tr>
<td>(b)</td>
<td>6.73b ± 2.01</td>
<td>6.86b ± 1.99</td>
<td>6.66ab ± 1.92</td>
<td>7.46b ± 1.55</td>
<td>7.33b ± 1.39</td>
</tr>
<tr>
<td>(c)</td>
<td>7.00b ± 1.85</td>
<td>6.80b ± 1.65</td>
<td>6.53b ± 1.64</td>
<td>7.73b ± 1.38</td>
<td>7.46b ± 1.35</td>
</tr>
<tr>
<td>(d)</td>
<td>6.93b ± 1.33</td>
<td>6.93b ± 1.38</td>
<td>6.73ab ± 1.83</td>
<td>7.06b ± 1.62</td>
<td>7.06b ± 1.66</td>
</tr>
<tr>
<td>(e)</td>
<td>7.06b ± 1.27</td>
<td>6.86b ± 1.30</td>
<td>7.13ab ± 1.24</td>
<td>6.80b ± 0.86</td>
<td>7.26b ± 1.09</td>
</tr>
<tr>
<td>(f)</td>
<td>6.60b ± 1.59</td>
<td>6.46b ± 1.18</td>
<td>6.86ab ± 1.64</td>
<td>6.86b ± 1.24</td>
<td>6.93b ± 1.43</td>
</tr>
<tr>
<td>control (cerelac)</td>
<td>8.73a ± 0.45</td>
<td>8.60a ± 0.50</td>
<td>8.00a ± 1.73</td>
<td>8.73a ± 0.45</td>
<td>8.66a ± 0.48</td>
</tr>
</tbody>
</table>

Values are means ± standard deviations of twenty panellists. Values with different superscript within the same column are significantly different (P<0.05).

Note: Formulation (a) = 63 g White maize, (b) = 63 g Yellow maize, (c) = 63 g Yellow popcorn, + 27 g soybean + 5 g sorghum malt + 5 g sugar each. (d) = 66.5 g White maize, (e) = 66.5 g Yellow maize, (f) = 66.5 g Yellow popcorn, + 28.5 g soybean + 5 g sugar each.

### IV. CONCLUSION

In this study it was observed that the physical and chemical properties of the raw materials influenced the general product yield. The functional properties of blends are much comparable to many researchers work on complementary foods. Particle size distribution of blends varied but 72.01% of the total weight passed through 600 µm sieve. No indication of microbiological counts of health hazards. Proximate composition of Ogi changed significantly (P<0.05) upon complementation and that of Ogi blends are within the standard level required for infants’ follow-on formulae. However, blends from the two varieties of yellow colour maize varieties were observed to be superior in terms of their protein contents. Sensory attributes of all blends are also comparable to conventional complementary foods. Nutritional composition of Ogi greatly improved upon complementation and results obtained were quite awesome for conventional use.

### ACKNOWLEDGEMENT

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### REFERENCES


