FORTIFYING EFFECTS OF SORGHUM *OGI* WITH COCOA POWDER ON NUTRITIONAL, PASTING AND ORGANOLEPTIC PROPERTIES

Odunlade, Tunji Victor[1*], **Taiwo** Kehinde Adekunbi[1], **Adeniran** Hezekiah Adekanmi[1]
[1]Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria
* Email: vodunlade@gmail.com

Abstract
In this study, the fortification of sorghum ogi with cocoa powder was investigated to establish the nutritional, sensory and pasting properties of the resultant fortified samples. Cocoa powder was blended in varying proportional gradients (0, 10, 20, 30, 40 and 50% w/w) with sorghum ogi to produce fortified sorghum ogi products. The proximate and mineral compositions, pasting and sensory properties of all the sorghum ogi samples were determined using standard procedures. The range of results for protein, ash, fibre and fat contents of the samples were 11.70 to 18.65%, 0.60 to 4.98%, 2.04 to 7.10% and 2.88 to 7.19%, respectively. The respective values for carbohydrate and energy of the samples were 55.45 to 75.32% and 3.61 to 3.74 kcal/g. The contents of potassium (26.77 to 996.87 mg/100 g), zinc (1.75 to 4.16 mg/100 g), iron (7.21 to 21.62 mg/100 g), calcium (26.86 to 77.45 mg/100 g) and magnesium (1.44 to 285.25 mg/100 g) of the sorghum ogi samples increased with inclusion of cocoa powder. The inclusion of cocoa solids significantly affected the pasting properties of the resultant samples. Also, the addition of cocoa powder had varying effects on the organoleptic perception of the developed food products. The work concluded that cocoa powder can be utilised in the production of sorghum ogi.

Keywords: *Fortification, energy values, sorghum ogi, cocoa powder, pasting*

Received: 06.01.2019 Reviewed: 07.03.2019 Accepted: 08.03.2019

1. INTRODUCTION

Sorghum *ogi* is a common Nigerian traditional complementary food. It is a fermented cereal porridge that is produced from sorghum grains. During the production of sorghum *ogi*, considerable amounts of nutrients including protein and minerals are lost thus having adverse effect on the nutritional quality of the food (Afolayan *et al*., 2010). Quite a number of studies have been done to improve the nutritional value of sorghum *ogi* through fortification (Odunlade *et al*., 2016). Malnutrition, most especially under-nutrition, contributes to increased susceptibility to diseases and the increase in child mortality rate (Iyang and Effiong, 2016) due to inadequate consumption of essential nutrients. Sorghum *ogi* is generally inadequate in dietary fibre, minerals and protein. These inadequacies make the nutritive composition of *ogi* deficient in meeting the nutritional requirements of infants and adults (Iyang and Idoko, 2006).
Cocoa powder is one of the products derived from cocoa bean processing. Cocoa bean is the fruit obtained from cocoa tree (*Theobroma cacao*). Cocoa powder is essentially rich in proteins, minerals, dietary fibre and some vitamins (Dietary Reference Intakes, 2003). It is also rich in antioxidants (Lee *et al*., 2003). Although cocoa is not high in certain vitamins, when consumed with cereal products, these complementary additions provide nutritionally enriched product (Dietary Reference Intakes, 2003). Therefore, cocoa powder can be considered as a good source for fortification of starchy foods. This work was aimed at evaluating the effects of different inclusion levels of cocoa powder on the proximate composition, mineral content, sensory and pasting properties of sorghum *ogi*. It was also conceived to expand the utilisation of cocoa powder which hitherto had been limited to the beverage and confectioneries industries.

2. MATERIALS AND METHODS

MaterialsSorghum grains (*Sorghum bicolor* L. Moench) were procured from the Training and Research farm of Obafemi Awolowo University, Nigeria. Cocoa powder was sourced from Cocoa Products (Ile-Oluji)

Limited, Nigeria. Analytical grade chemicals were purchased from Sigma Aldrich (St. Louis, MO).

Methods

Production of sorghum *ogi*

A method described by Odunlade *et al*. (2016) was used for the production of sorghum *ogi*. *Sorghum bicolor* L. Moench grains, freed from extraneous materials by winnowing and manual sorting, were washed under tap water to remove adhering dirt. The washed grains (2 kg) were steeped in water (5 L) for 48 h. After this, the steep water was decanted, and the grains were washed and wet milled. The resulting paste was then sieved using muslin cloth followed by the settling and fermentation of the remaining solid matter for 24 h to enhance souring of the sorghum *ogi* paste. The paste was dried to a moisture content of less than 10% in a cabinet dryer at 60°C for 24 h and dry milled to obtain the powdery form of sorghum *ogi* which was packaged in thick polythene bags until further usage.

Production of sorghum-cocoa ogi samples

A binary mixture of sorghum-cocoa *ogi* samples were produced by proportionately mixing cocoa powder with sorghum *ogi* powder at 0, 10, 20, 30, 40 and 50% using an electric blender (SAISHO magic blender S-742, China).

Chemical and pasting analyses

The samples were analyzed for proximate composition according to AOAC (2010) methods. Crude protein was determined by multiplying the total nitrogen content by a factor of 6.25. Carbohydrate was obtained by difference. The gross energy values were estimated using Atwater's conversion factor (Edem *et al*., 1990). Potassium, calcium, magnesium, iron and zinc were measured using a Flame Atomic Absorption Spectrophotometer (Perkin Elmer AAnalyst 400, USA) at 766.50, 422.70, 285.20, 248.30 and 213.90 nm, respectively. The pasting characteristics of the samples were determined using a Rapid Visco Analyser (Newport Scientific Pty Ltd., Narrabeen, Australia) according to the method described by Awolu (2017). Three grams of samples were dispersed in an aluminum canister containing 25 ml of distilled water. The samples were tested according to Standard Profile 1, where the flour-water suspension was held at 50°C for 1 min and then heated to 95°C, held for 10 min, and then cooled to 50°C and held for another 2 min and then the pasting parameters were obtained.

Sensory evaluation

A semi-trained panel of 20 tasters who were familiar with *ogi* product evaluated the sensory attributes of the cooked sorghum *ogi* and fortified sorghum *ogi* samples. The sorghum *ogi* flour samples (50 g) were reconstituted with 70 ml of cold water prior to the addition of 500 ml boiling water with constant stirring until the porridge is formed. The samples were presented hot. Taste, mouthfeel, appearance, flavour, colour, and overall acceptability were assessed. The scores were based on a nine-point hedonic scale, where 9 represented like extremely and 1 represented dislike extremely (Iwe, 2010).

Statistical analysis

The significant differences at 95% confidence level of the obtained experimental data were evaluated by analysis of variance using Duncan's multiple range test as post-hoc multiple comparison test (Odunlade *et al*., 2016).

3. RESULTS AND DISCUSSION

Proximate composition of sorghum *ogi* samples

The results of the proximate composition of sorghum *ogi* and sorghum-cocoa *ogi* samples are presented in Table 1. The addition of cocoa powder had significant effect on the proximate composition of the samples. The protein contents of the samples ranged between 11.70 and 18.65% which depicted an increase of 11.96 to 59.40% for 10 to 50% cocoa powder supplementation. The proportionate addition of cocoa powder to sorghum *ogi* increased the protein content. This increase may be largely due to the higher level of protein content (26.32%) inherent in the cocoa powder. This is an implication that the fortified products may be used to ameliorate the menace of protein-energy malnutrition and even prevent its occurrence (Pesta and Samuel, 2014). The increase in protein content of the fortified samples was similar to the protein content (10.15 to 15.40%) reported by Ijarotimi and Bakere (2006) for sorghum *ogi* fortified with African yam bean. Ijarotimi and Aroge (2005) also reported an increase of protein content (1.88 to 20.92%) when breadfruit was fortified with soybeans.

The fat contents of the samples which increased with cocoa powder addition varied between 2.88 and 7.19%. The fat content (2.88%) of sample A agreed with 2.80% of fat content reported by Adejuyitan *et al*. (2012) for maize *ogi* powder. The fat contents of the sorghum *ogi* and fortified sorghum *ogi* samples were however lower than the recommended upper limit of 10% for fat by the Protein Advisory Group (PAG) of the United Nations for complementary foods (PAG, 1971). The increase in fat contents of the sorghum-cocoa *ogi* samples with increase in cocoa powder addition could be due to higher level of fat in cocoa powder when compared to sorghum grain. Aminigo and Akingbala (2004) similarly reported increase in fat content (2.56 to 7.20%) of okra-seed-meal-fortified *ogi* samples at 0 to 20% inclusion level.

The fibre content of all the sorghum *ogi* samples ranged between 2.04 and 7.10%. This exhibited an increase of about 44.60 to 248% for 10 to 50% cocoa powder inclusion. The unfortified sorghum *ogi* had the lowest fibre content (2.04%) which was lower than the reported 3.39% for plain sieved maize *ogi* by Farinde (2015) but comparable to 2.86% reported by Pikuda and Ilelaboye (2013) for sorghum *ogi*. The highest fibre content (7.10%) was recorded for sorghum *ogi* fortified with 50% cocoa powder. The increase observed for the crude fibre content of sorghum-cocoa *ogi* samples as the levels of fortification increased may be attributed to high proportion of crude fibre (12.70%) in cocoa powder as compared to that (2.04%) contained in sorghum *ogi*. Fibre had been reported to be desirable in foods, most especially for adults, because it helps in reducing the risk of bowel diseases, including colon cancer and also reduction in osteoporosis incidence (Sirtori and Lovati, 2001).

There was also an increase in the ash contents of the fortified sorghum *ogi* samples as substitution levels increased. The ash content of sample A was 0.60% which was similar to 0.63% fat reported by Adegbehingbe (2014) for sorghum *ogi*. The fortified sorghum *ogi* samples at 10, 20, 30, 40 and 50% had ash contents of 1.19, 2.20, 2.82, 3.65 and 4.98%, respectively which were individually significantly higher ($p < 0.05$) than that (0.60%) of the unfortified sorghum *ogi* sample. The incorporation of cocoa powder to sorghum *ogi* at the highest (50%) inclusion level did not exceed the recommended total ash limit (5%) in complementary foods by the PAG (1971). The increase in the ash content was expected since cocoa powder is a relatively good source of minerals which is justified by its high ash content (8.17%).

The moisture content for sorghum *ogi* and sorghum-cocoa *ogi* samples are presented in Table 1. Moisture contents of the sorghum *ogi* (fortified and unfortified) samples ranged from 6.63 to 7.46%. The moisture content obtained agrees with the range (5.32 to 8.90%) reported by Aminigo and Akingbala (2004) for the fortification of maize *ogi* with okra seed meal. The values obtained for all sorghum *ogi* samples in this study were lower than the upper set value of 10% moisture that is usually recommended (Makinde and Ladipo, 2012) for flour products. Moisture is an important factor in food quality and preservation. Moisture content above 10% can lead to the growth of certain pathogenic microorganisms which may be injurious to health. In other words, low moisture content inhibits the growth and proliferation of microorganisms thereby extending the shelf stability of the product (Makinde and Ladipo, 2012).

The carbohydrate content of the samples (Table 1) ranged between 55.45 and 75.32%. The unfortified sample had the highest (75.32%) content of carbohydrate among all the samples. The addition of cocoa powder to sorghum *ogi* caused reductions in the carbohydrate content of the fortified sorghum *ogi* samples. This could be attributed to the lower amount of carbohydrate (35.49%) and significant amount of protein (26.32%) in the cocoa powder when compared with those of sorghum *ogi*. The sorghum *ogi* samples at 10 to 30% fortification levels compared favourably in terms of carbohydrate content (71.59 to 63.55%) with commercially available weaning foods. The samples of sorghum *ogi* fortified with cocoa powder could be used to combat protein energy malnutrition.

In comparison with the carbohydrate content of cereal based foods reported by other researchers, Aminigo and Akingbala (2004) reported higher carbohydrate contents ranging from 74.30 to 81.50% for maize *ogi* samples fortified with 20 to 10% okra seed meal, respectively. Oluwamukomi *et al*. (2005) reported a lower range of carbohydrate contents (57.70 to 59.10%) for maize *ogi* fortified with 30% soybean. The range of the carbohydrate contents of the sorghum-cocoa *ogi* samples were lower than the carbohydrate quantities of 75.74, 71.48 and 70.12% reported by Adegbehingbe (2014) for non-fermented blend of sorghum *ogi* and lima bean at 10, 20 and 30% fortification levels respectively. Likewise, the measure of the carbohydrate contents of all the sorghum-cocoa *ogi* samples were also lower than the reported content of 72.38 and 70.72% by Adegbehingbe (2014) for the fermented blends of sorghum *ogi* and lima bean at 10 and 20% fortification levels. The observed decrease in the carbohydrate content in the sorghum-cocoa *ogi* samples in this study would aid in providing protein and energy to the consumers of the products. This is because the lower the carbohydrate, the higher the other food macromolecules namely protein and fat.

Energy values of sorghum *ogi* samples

The metabolisable energy values of sorghum *ogi* and fortified sorghum *ogi* samples as presented in Figure 1 ranged from 3.61 to 3.74 kcal/g. The energy values, though having similar range, was less than the reported values (3.84 to 4.01 kcal/g) for millet flour samples fortified with African oil bean seed flour by James *et al*. (2015). The metabolisable energy (digestible energy which had been corrected for urine losses (Henry and Ahlstrom, 2009) values were influenced by the inclusion of cocoa powder in this study. It was observed that the metabolisable energy decreased as the cocoa powder addition increased. The unfortified sorghum *ogi* sample had the highest energy value (3.74 kcal/g) while the sorghum *ogi* fortified with 50% cocoa powder had the lowest (3.61 kcal/g). The variation in the metabolisable energy values of the samples could be largely attributed to the carbohydrate contents. This is because the carbohydrate content of all the samples had the largest mass fraction among all other nutritional components present.

Table 1 **Proximate composition (%) of sorghum *ogi* samples**

Sample	Protein	Carbohydrate	Fat	Fibre	Ash	Moisture
B	13.10 ± 0.01^{f}	71.59 ± 0.02^{b}	3.75 ± 0.02^{f}	2.95 ± 0.03^{f}	1.19 ± 0.03^{f}	7.42 ± 0.02^{ab}
C	14.35 ± 0.03^{e}	67.51 ± 0.06^{c}	4.61 ± 0.01^{e}	4.01 ± 0.01^{e}	2.20 ± 0.01^{e}	7.32 ± 0.01^{b}
D	15.82 ± 0.07^{d}	63.55 ± 0.01^{d}	5.32 ± 0.03^{d}	5.26 ± 0.03^{d}	2.82 ± 0.02^{d}	7.23 ± 0.11^{c}
E	17.04 ± 0.02^{c}	59.50 ± 0.04^{e}	6.46 ± 0.01^{c}	6.39 ± 0.01^{c}	3.65 ± 0.01^{c}	6.96 ± 0.03^{d}
F	18.65 ± 0.03^{b}	55.45 ± 0.05^{f}	7.19 ± 0.03^{b}	7.10 ± 0.03^{b}	4.98 ± 0.02^{b}	6.63 ± 0.12^{e}
G	26.32 ± 0.05^{a}	35.49 ± 0.02^{g}	12.11 ± 0.02^{a}	12.70 ± 0.03^{a}	8.17 ± 0.01^{a}	5.21 ± 0.03^{f}

Values are means of triplicate determinations ± standard deviation. The mean values along the same row with different superscripts are significantly different ($p < 0.05$).

A - 100% Sorghum *ogi*; B - Sorghum *ogi* fortified with 10% cocoa powder; C - Sorghum *ogi* fortified with 20% cocoa powder; D - Sorghum *ogi* fortified with 30% cocoa powder; E - Sorghum *ogi* fortified with 40% cocoa powder; F - Sorghum *ogi* fortified with 50% cocoa powder; G - 100% Cocoa powder

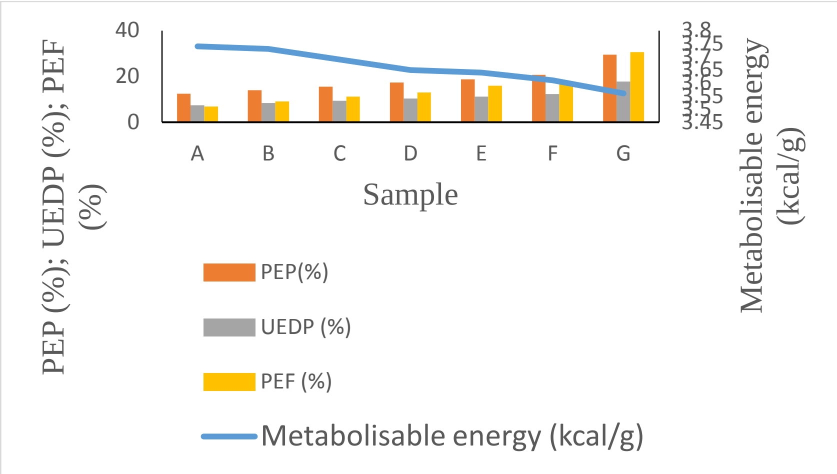

Figure 1:Energy values of sorghum *ogi* samples

PEP - Proportion of total energy due to protein; UEDP - Utilisable energy due to protein; PEF - Proportion of total energy due to fat; A - 100% Sorghum *ogi*; B - Sorghum *ogi* fortified with 10% cocoa powder; C - Sorghum *ogi* fortified with 20% cocoa powder; D - Sorghum *ogi* fortified with 30% cocoa powder; E - Sorghum *ogi* fortified with 40% cocoa powder; F - Sorghum *ogi* fortified with 50% cocoa powder; G - 100% Cocoa powder

The daily energy requirement for an adult is 2500 kcal depending on his/her physiological state while that of an infant is 740 kcal (Bingham, 1978; Edem *et al*., 1990). This implies that an adult man would require about 670, 678, 685, 689 and 693 g of 10, 20, 30, 40 and 50% cocoa powder fortified sorghum *ogi* samples respectively to meet 2500 kcal minimum daily energy requirements only from sorghum *ogi*. Infants would respectively require about 198, 201, 203, 203 and 205 g of 10, 20, 30, 40 and 50% cocoa powder fortified sorghum *ogi* samples to meet 740 kcal energy requirement.

The various energy values as contributed by protein and fat are shown in Figure 1. The proportions of energy contributed by fat of the sorghum *ogi* samples were less than the recommended maximum level of 30% (COMA, 1984) for foods that would not be implicated in obesity. This implies that none of the sorghum *ogi* as well as the fortified sorghum *ogi* samples would contribute to the development of obesity. This therefore means that all the samples could be useful for people wishing to adopt the guidelines for a healthy diet (NACNE, 1983).

The proportion of energy contributed by protein, on the other hand, cannot be utilised fully due to losses of energy that are attributed to other metabolic losses (FAO, 2003) which necessitated for 60% utilisation assumption (Beaton and Swiss, 1974) usually used in foods. The utilisable energy values due to protein obtained in this work for all the fortified sorghum *ogi* samples were higher than the recommended lowest limit of 8% for an adult man who requires about 55 g of protein per day with 60% utilisation (Beaton and Swiss, 1974). This implies that the protein concentration in any of the fortified sorghum *ogi* samples in terms of energy may be enough to prevent malnutrition in children and adult fed solely on any of the fortified sorghum *ogi* sample as their main meal. However, unfortified sorghum *ogi* sample with a utilisable energy due to protein of 7.51% would not meet up in this regard.

Mineral composition of sorghum *ogi* samples

The results of the mineral composition of sorghum *ogi* and sorghum-cocoa *ogi* samples are presented in Table 2. The addition of cocoa powder had significant effect on the mineral composition of the samples. The potassium in the sorghum *ogi* and fortified sorghum *ogi* samples as presented in Table 2 ranged between 26.77 and 996.87 mg/100 g. This showed an increase of about 8 to 37-fold for 10 to 50% cocoa powder inclusion. This increase could be largely attributed to the inherently large amount of potassium (1965 mg/100 g) in cocoa powder. The values of potassium of all the fortified samples were significantly ($p < 0.05$) higher than that (26.77 mg/100 g) of the unfortified sorghum *ogi*. The values of potassium in this study therefore suggest that the potassium level of all the fortified sorghum *ogi* samples were influenced by fortification variations with cocoa powder. None of the fortified samples could supply the adequate intake values of 4700 mg/d for adults. However, if taken in adequate amount (400 g and higher per day), the samples could supply the adequate intakes of potassium. Sorghum *ogi* sample with 20 to 30% cocoa powder inclusion could supply the adequate intake (700 mg/d) of an infant that is less than 12 months.

As presented in Table 2, zinc content was significantly lower ($p < 0.05$) in sorghum *ogi* when compared with the fortified samples. The zinc content ranged between 1.75 and 4.16 mg/100 g which depicted an increase of about 34 to 137% for 10 to 50% cocoa powder addition. The unfortified sorghum *ogi* had a zinc composition of 1.75 mg/100 g. This was higher than the zinc (1.41 mg/100 g) content reported for co-fermented mixture of millet and cowpea *ogi* by Oyarekua (2011). The zinc composition in the reference sorghum *ogi* was however lower than the recommended zinc composition of 2.08 mg/100 g for complementary foods for 11 to 23 months' infants based on Krebbs standards and 4.7 mg/100 g based on British standards (WHO/NUT/98). Sorghum *ogi* samples fortified with 10 to 50% cocoa powder are however lower in zinc content than the recommended intake of 10 mg/100 g (CODEX, 1991) required from supplementary foods for older infants and young children. This was however not surprising because the zinc content in the cocoa powder used for fortification was less than 10 mg/100 g.

The iron content ranged between 7.21 and 21.62 mg/100 g. This showed an increase of 41 to 199% for 10 to 50% cocoa powder addition. Iron content is highest in the sorghum *ogi* sample fortified with 50% cocoa powder. Increase in iron content was similarly reported by Onoja *et al*. (2014) for fermented mixtures of sorghum, soybean and plantain gruel. Iron intake is inadequate during 6 months to 4 years of age because of rapid growth rate in infants and children as well as low iron content of breast milk (Rossander-Hulthén and Hallberg, 1996). The iron content in any of the fortified sorghum *ogi* samples can adequately provide infants with the recommended dietary allowance (9.13 mg/100 g) iron for infants with medium breast milk intake and 5.8 mg/100 g for infants with high breast milk intake (CODEX, 1991). However, sorghum *ogi* samples fortified with 40 to 50% cocoa powder can adequately nourish a low breast milk intake infant with the recommended dietary allowance of 17.8 mg/100 g expected from complementary food (CODEX, 1991).

For young children, sorghum *ogi* samples fortified with 20 to 50% cocoa powder can produce the required daily allowance of iron of 12 mg/100 g adopted by CODEX (1991) on formulated supplementary foods for older children as well as adults. Although pregnant mothers require a recommended dietary allowance of 27 mg, this could nearly be supplied by sorghum *ogi* sample with 50% cocoa powder inclusion which had an iron content of 21.62 mg/100 g. The iron requirement of lactating mothers (9 mg/100 g) could be sufficiently provided with sorghum *ogi* samples containing 10% cocoa powder and above.

The calcium content in the sorghum *ogi* and fortified samples as presented in Table 2 varied from 26.86 to 77.45 mg/100 g. This depicted an increase of about 38 to 188% for 10 to 50% cocoa powder substitution. Calcium values in this study were significantly ($p < 0.05$) higher in the fortified sorghum *ogi* samples than in the unfortified sorghum *ogi* sample owing to the high composition of calcium (127.86 mg/100 g) in cocoa powder when compared to the average calcium content (28 mg/100 g) of sorghum grain (USDA National Nutrient Database, 2011).

The sorghum *ogi* sample with the highest (50%) inclusion of cocoa powder had the highest composition (77.45 mg/100 g) of calcium. The calcium content of each of the fortified samples was lower than the recommended daily allowance of 255 mg/d required from complementary foods for 6 to 23 months' infant and 1000 mg/d for adults (CODEX, 1991). The fortified samples could be significant sources of calcium for humans, though inadequate by themselves, the rest of the calcium required would come from other meals.

The calcium content for 20% cocoa powder inclusion in sorghum *ogi* (47.83 mg/100 g) was slightly higher than the reported calcium content (44.16 mg/100 g) of sieved soy *ogi* with spices reported by Farinde (2015). It was also higher than the reported calcium value (31.6 mg/100 g) for laboratory co-fermented millet and cowpea as well as 20.6 mg/100 g calcium content for laboratory co-fermented sorghum/cowpea reported by Oyarekua (2011). Calcium is required for bone and teeth formation and its deficiency can lead to rickets in infants and children as well as osteoporosis in pre-menopausal and post-menopausal women (Wu *et al*., 1990).

The results of magnesium in sorghum *ogi* and fortified sorghum *ogi* samples are presented in Table 2. The content of magnesium ranged between 1.44 and 285.25 mg/100 g. In this study, magnesium content was significantly ($p < 0.05$) higher in fortified sorghum *ogi* samples than in the unfortified sorghum *ogi*. The low level of magnesium (1.44 mg/100 g) in sorghum *ogi* agreed with the report of FAO/WHO (1998) that stated that corn flour, cassava flour, sago flour and polished rice flour have extremely low magnesium contents. The fortified sorghum *ogi* samples had improved magnesium content as the cocoa powder inclusion increased. Sorghum *ogi* with 50% cocoa powder inclusion had the highest magnesium content (285.25 mg/100 g) when compared with other sorghum-cocoa *ogi* samples. The increase in the magnesium content of all the fortified sorghum *ogi* samples would aid in preventing hypomagnesemia and intracellular deficit in magnesium which are often caused by decreased dietary intake of magnesium (Seitz and Suter, 2002).

Sorghum *ogi* sample with 10% cocoa powder inclusion would be a good source of magnesium (57.77 mg/100 g) for supplying the recommended daily allowance of 75 mg/d for an infant between 6 and 12 months if 150 g of the sample is consumed per day. Moreso, sorghum *ogi* samples incorporated with 20% cocoa powder can readily be an adequate source (112.55 mg/100 g) of the recommended magnesium intake of 100 mg/d for a child under the age of 10. Sorghum *ogi* samples with 30 to 50% cocoa powder supplementation having magnesium content of 172.28 to 285.25 mg/100 g, respectively cannot by themselves supply the recommended daily allowance (320 mg/d) for adults but these fortified sorghum *ogi* samples are readily good sources of magnesium.

Table 2 **Mineral composition (mg/100 g) of sorghum *ogi* and fortified sorghum *ogi* samples**

Sample	Potassium	Zinc	Iron	Calcium	Magnesium
A	26.77 ± 0.02^g	1.75 ± 0.01^g	7.21 ± 0.03^g	26.86 ± 0.01^g	1.44 ± 0.02^g
B	221.35 ± 0.02^f	2.34 ± 0.04^f	10.17 ± 0.01^f	36.97 ± 0.03^f	57.77 ± 0.15^f
C	415.60 ± 0.02^e	2.70 ± 0.02^e	12.97 ± 0.05^e	47.83 ± 0.02^e	112.55 ± 0.03^e
D	610.34 ± 0.03^d	3.23 ± 0.01^d	15.96 ± 0.01^d	58.05 ± 0.02^d	172.28 ± 0.59^d
E	803.36 ± 0.02^c	3.68 ± 0.01^c	18.65 ± 0.01^c	67.16 ± 0.03^c	228.45 ± 0.03^c
F	996.87 ± 0.02^b	4.16 ± 0.02^f	21.62 ± 0.02^b	77.45 ± 0.03^b	285.25 ± 0.04^b
G	1965.50 ± 0.02^a	7.15 ± 0.02^g	35.75 ± 0.01^a	127.86 ± 0.02^a	554.34 ± 0.03^a

Values are means of triplicate determinations ± standard deviation. The mean values along the same row with different superscripts are significantly different ($p < 0.05$).

A - 100% Sorghum *ogi*; B - Sorghum *ogi* fortified with 10% cocoa powder; C - Sorghum *ogi* fortified with 20% cocoa powder; D - Sorghum *ogi* fortified with 30% cocoa powder; E - Sorghum *ogi* fortified with 40% cocoa powder; F - Sorghum *ogi* fortified with 50% cocoa powder; G - 100% Cocoa powder

Organoleptic characteristics of sorghum *ogi* samples

The organoleptic properties of food products are essentially part of the limiting factors affecting consumers' acceptability. Therefore, organoleptic evaluation of colour, aroma, taste, after-taste, mouthfeel and overall acceptability were performed on sorghum *ogi* and fortified sorghum *ogi* samples. The mean sensory scores of sorghum *ogi* and fortified samples are presented in Table 3. The mean colour scores, as assessed by the sensory panelists, were significantly different ($p < 0.05$) among the sorghum *ogi* samples. The colour of the porridge made from 100% sorghum *ogi* was liked very much. Samples with 10 to 30% cocoa powder substitution level, though significantly ($p < 0.05$) different from one another, were also preferred in reducing degrees. Sorghum *ogi* samples fortified with 10 and 20% cocoa powder were liked moderately in terms of colour with hedonic scores of 6.78 and 6.67, respectively. Sorghum *ogi* sample fortified with 30% cocoa powder was preferred slightly while samples with 40 to 50% cocoa powder fortification level were neither liked nor disliked. The reduction in the degree of preference in terms of colour of the samples may be linked to the hue of the cocoa powder which has a characteristic light chocolate to dark brown colour.

The results of aroma as determined by the sensory panelists are presented in Table 3. There were significant differences ($p < 0.05$) among the samples. The porridge made from 100% sorghum *ogi* recorded the lowest score of 5.56 while the sample with 50% cocoa powder fortification level ranked highest with a score of 8.34. This indicates that the sample with 50% cocoa powder was the most preferred in terms of aroma. Sorghum *ogi* samples with 10 to 40% cocoa powder substitution levels had increasing preference as the cocoa powder substitution increased which was evidenced by the score range of 6.56 and 8.34. It was therefore observed that cocoa powder substitution contributed greatly to the aroma of the samples due to the richness/intensity of the flavour associated with cocoa powder when compared to 100% sorghum *ogi*.

The scores for taste from sensory evaluation by sensory panelists are presented in Table 3. The scores for the sorghum *ogi* samples ranged between 4.33 and 6.89. There were significant ($p < 0.05$) differences among the samples based on this quality attribute. Porridge prepared from 100% sorghum *ogi* had the highest score of 6.89 which indicates its high preference. Sorghum *ogi* sample with 50% cocoa powder recorded the lowest score of 4.33 which indicates that the sample was disliked slightly. Sorghum *ogi* samples fortified with 10 to 30% cocoa powder were preferred in reducing intensities as cocoa powder substitution increased. There was however no significant ($p > 0.05$) difference among the reference sorghum *ogi*, 10 and 20% cocoa fortified sorghum *ogi* based on taste as they were all preferred. Sorghum *ogi* sample with 30% cocoa powder was also preferred slightly. Sorghum *ogi* with 40 and 50% cocoa powder having scores of 4.67 and 4.33, respectively were not largely preferred.

The results of the mouthfeel are presented in Table 3. The values ranged between 5.67 and 6.56. There was no significant difference ($p > 0.05$) in the mouthfeel of all the samples. This implies that cocoa powder substitution in sorghum *ogi* did not have any pronounced effect on the mouthfeel of sorghum *ogi* as no lumps were formed.

Significant differences ($p < 0.05$) were observed among samples of sorghum *ogi* in terms of overall acceptability. Unfortified sorghum *ogi* had the highest value of preference with 7.45 while sorghum *ogi* with 50% cocoa powder had the lowest value of 4.45. It was observed that the likeness of sorghum *ogi* samples decreased with increase in cocoa powder substitution. Additionally, there was no significant difference in the overall acceptability of 100% sorghum *ogi* and sorghum *ogi* fortified with 10% cocoa powder in terms of overall acceptability as they were both preferred alike with high degree. Samples with 20 and 30% were similarly preferred but in a lower degree when compared to sample with 10% fortification level. There was however no significant difference ($p > 0.05$) between samples with 40 and 50% cocoa powder fortification level as they were both disliked slightly. The overall acceptability results from this study showed that the panellist preferred cocoa powder fortified sorghum *ogi* up to 30% substitution level.

Pasting properties of sorghum *ogi* samples

Pasting property is one of the most important properties that influence functional quality, sensorial quality and aesthetic consideration in foods since it generally affects digestibility, texture and the end use of starch based food products (Onweluzo and Nnamuchi, 2009). The properties of pasting include the peak, trough, breakdown, final and setback viscosities, peak time and pasting temperature. The pasting properties of sorghum *ogi* and fortified sorghum *ogi* samples are presented in Table 4.

Peak viscosities

The peak viscosities as presented in Table 4 ranged between 64.50 and 130.12 RVU with the unfortified sorghum *ogi* sample having the highest peak viscosity. There were significant decreases ($p < 0.05$) in the values of the peak viscosity as the proportion of cocoa powder increased in the fortified sorghum *ogi* samples. High peak viscosity indicates high pure starch content in a sample and this could probably be the reason why 100% sorghum *ogi* sample had the highest peak viscosity while 100% cocoa powder had the lowest peak viscosity of 57.42 RVU among the samples. The peak viscosity had strong positive correlation (Table 5) with carbohydrate ($R = 0.85$) and moisture ($R= 0.72$). The reductions observed in the peak viscosity values of the fortified sorghum *ogi* samples as the proportion of cocoa powder increased however reflect the degree of their respective resistance to stirring of the swollen mass gel particles of the fortified sorghum *ogi* samples.

Reduction in peak viscosity values of the fortified samples observed could be due to the presence and interaction of nutritional component like proteins of cocoa powder. Also, the gelling properties of the starch component of sorghum *ogi* flour could also be responsible. These observations were also documented by Oluwamukomi *et al*. (2005) for maize *ogi* fortified with soybean. The higher the viscosity, the higher the resistance to stirring (Iwe *et al*., 1998) of the cooked samples. The decrease observed for peak viscosities was similar to the observations of Osungbaro *et al*. (2010) for composite cassava starch with sorghum *ogi* and Aminigo and Akingbala (2004) for maize *ogi* fortified with okra seed meal.

The peak viscosity is described as the maximum viscosity developed during or soon after the heating portion of the rapid visco analysis. It is also an index of the ability of starch-based food to swell freely before their physical breakdown under deformation caused as a result of the continuous mixing of the Rapid Visco Analyzer (Sanni *et al*., 2006; Adebowale *et al*., 2008).

Table 3 Mean sensory scores of sorghum *ogi* and fortified sorghum *ogi* samples

Sample	Colour	Aroma	Taste	Mouthfeel	Acceptability
A	7.89 ± 1.27^{a}	5.56 ± 0.73^{d}	6.89 ± 1.54^{a}	6.56 ± 1.13^{a}	7.45 ± 1.01^{a}
B	6.78 ± 0.83^{ab}	6.56 ± 0.88^{c}	6.78 ± 1.20^{a}	6.45 ± 1.24^{a}	7.00 ± 1.22^{a}
C	6.67 ± 0.50^{b}	7.11 ± 0.60^{bc}	6.22 ± 1.20^{a}	6.56 ± 1.01^{a}	6.45 ± 1.13^{ab}
D	6.33 ± 0.87^{c}	7.67 ± 0.71^{ab}	5.67 ± 1.00^{ab}	6.00 ± 1.12^{a}	5.78 ± 0.97^{b}
E	5.45 ± 1.51^{cd}	7.78 ± 0.44^{b}	4.67 ± 0.50^{b}	5.78 ± 0.44^{a}	4.56 ± 1.13^{c}
F	5.33 ± 1.87^{d}	8.34 ± 1.12^{a}	4.33 ± 1.58^{c}	5.67 ± 1.12^{a}	4.45 ± 1.67^{c}

Values are means of triplicate determinations ± standard deviation.
The mean values along the same row with different superscripts are significantly different ($p < 0.05$). A - 100% Sorghum *ogi*; B - Sorghum *ogi* fortified with 10% cocoa powder; C - Sorghum *ogi* fortified with 20% cocoa powder; D - Sorghum *ogi* fortified with 30% cocoa powder; E - Sorghum *ogi* fortified with 40% cocoa powder; F - Sorghum *ogi* fortified with 50% cocoa powder; G - 100% Cocoa powder

Final viscosities

The final viscosity values of sorghum *ogi* and fortified sorghum *ogi* samples as presented in Table 4 ranged between 110.54 and 190.17 RVU. Unfortified sorghum *ogi* recorded the highest final viscosity while sorghum *ogi* fortified with 50% cocoa powder recorded the least final viscosity (110.54 RVU). The final viscosity is the magnitude of the stability of starch granules. The incorporation of cocoa powder in sorghum *ogi* resulted in significant ($p < 0.05$) decrease in the final viscosities of the fortified sorghum *ogi* samples. This decrease of final viscosity was also reported by Adegunwa *et al*. (2014) for wheat flour fortified with millet flour and by Falola *et al*. (2014) for modified cocoyam-wheat composite flours. Aminigo and Akingbala (2004) also reported a similar trend for final viscosities of maize *ogi* fortified with okra seed meal.

The high final viscosity of 100% sorghum *ogi* (190.17 RVU) when compared to other fortified sorghum *ogi* samples indicates the extent of the stability of the paste that would be formed from the sorghum *ogi* samples. Final viscosity correlated strongly (Table 5) with carbohydrate (R = 0.98) and moisture (R = 0.91). The cooked paste formed by 100% sorghum *ogi* would therefore be much more stable (Fasasi, 2009) than pastes formed by other fortified sorghum *ogi* samples because of its high final viscosity.

Breakdown viscosities

The breakdown viscosity values of the sorghum *ogi* and fortified sorghum *ogi* samples as presented in Table 4 ranged between 4.92 and 6.84 RVU. The unfortified sorghum *ogi* had the highest breakdown viscosity (6.84 RVU) while the sample with 50% cocoa powder fortification level recorded the lowest breakdown (4.92 RVU) viscosity among the sorghum *ogi* samples. High stability of starch paste is commonly accompanied with high value of breakdown. The rate of starch breakdown depends on the nature of the material, temperature and degree of mixing and shear applied to the mixture (Osungbaro *et al*., 2010). It was observed that fortification had significant ($p < 0.05$) effect on the breakdown viscosities of the fortified samples as evidenced by the reductions (Table 4) in the breakdown viscosities of the fortified samples. This decrease may be due to the differential quantity of carbohydrate in the samples. Cocoa powder recorded the lowest breakdown viscosity (4.58 RVU) and it has the lowest composition of carbohydrate content among all the evaluated samples. Breakdown correlated positively (Table 5) with carbohydrate (R = 0.93) and moisture (R = 0.84). The decrease observed for breakdown viscosities with fortification in this study, was in agreement with the report of Osungbaro *et al*. (2010) on a mixture of fermented cassava flour with fermented sorghum flour. Similar observation was also reported for maize *ogi* fortified with okra seed meal by Aminigo and Akingbala (2004).

Trough viscosities

Trough viscosity values for the sorghum *ogi* and fortified sorghum *ogi* samples as presented in Table 4 ranged between 59.58 and 123.28 RVU. The unfortified sorghum *ogi*, similarly to peak viscosity, had the highest trough viscosity (123.28 RVU) while the sorghum *ogi* with 50% cocoa powder had the lowest trough viscosity (59.58 RVU) among all the sorghum *ogi* samples. Trough positively correlated (Table 5) with carbohydrate (R = 0.85) and moisture (R = 0.72). Trough viscosity, being the measure of the ability of the paste to withstand breakdown during cooling, was observed to decrease significantly with increase in cocoa powder substitution. This decrease was also observed by Osungbaro *et al*. (2010) for cassava-sorghum composite flours. The increase in millet substitution in wheat flour by Adegunwa *et al*. (2014) similarly resulted in decrease in trough viscosity.

Setback viscosities

The setback viscosities of the sorghum *ogi* and the fortified samples are presented in Table 4. The values ranged between 50.96 and 66.89 RVU which was nearly similar to the reported range of 46.92 and 60.58 RVU by Osungbaro *et al*. (2010) for cassava-sorghum composite flours. Setback viscosity indicates the extent to which dissolved starch macromolecules (especially solubilised amyloses) are able to re-associate with themselves through the formation of a three dimensional network which results in a gel (Aviara *et al*., 2010).

There were significant differences ($p < 0.05$) in the setback viscosities of the sorghum *ogi* samples. The unfortified sorghum *ogi* sample had the highest setback viscosity while sorghum *ogi* with 50% cocoa powder supplementation had the lowest setback viscosity among all the sorghum *ogi* samples. This signifies that cocoa powder substitution caused reduction in the setback values of fortified sorghum *ogi*.

The higher the setback values, the higher the ability of the starch molecules to re-associate to form a gel (Aviara *et al*., 2010) and vice versa. From the results obtained for setback viscosities of sorghum *ogi* samples, it was evident that the ability of starch molecules to re-associate to form a gel decreased with increase in cocoa powder substitution. Aminigo and Akingbala (2004) reported similar observation for maize *ogi* fortified with increased addition of okra seed meal. Osungbaro *et al*. (2010) also reported a similar remark for cassava-sorghum composite flours. Set back correlated strongly (Table 5) with carbohydrate (R= 0.96) and moisture (R = 0.99).

Pasting temperature and peak time

The pasting temperature which indicates the gelatinization temperature of the sorghum *ogi* and fortified sorghum *ogi* samples as presented in Table 4 ranged between 83.35 and 85.59°C. The results indicated that the pasting temperature increased with increase in addition of cocoa powder to sorghum *ogi*. The ease of gelatinization is a reflection of the nature of starch or the level of contamination of starch by other food components (Iwe *et al*., 1998).

It was observed from the results that the unfortified sorghum *ogi* sample had lower gelatinization temperature compared to the fortified sorghum *ogi* samples, probably due to the increased content of fibre as well as the buffering effect of fat on starch which interferes with the gelatinization activity of the fortified samples (Egouletey and Aworh, 1991) as cocoa powder inclusion increased. A higher pasting temperature indicates higher water absorption capacity and lower swelling properties of powdery products (Adebowale *et al*., 2012). All of these characteristics were associated with the sorghum *ogi* samples as fortification with cocoa powder increased.

The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability. It can thus be inferred that cocoa powder substitution had numerical effect on the minimum temperature required for cooking of fortified sorghum *ogi* as the fortified samples would require higher temperature (invariably higher energy) to form cooked pastes than the unfortified sorghum *ogi* sample. Succinctly, samples with lower gelatinization temperature like the reference sorghum *ogi* would be easier to cook (Akinwande *et al*., 2007) when compared to the fortified sorghum *ogi* samples. The pasting temperature had negative correlation with carbohydrate and moisture but positive correlation with fat (R = 0.96), fibre (R = 0.96), ash (R = 0.93) and protein (R = 0.96).

The peak times of sorghum *ogi* and fortified sorghum *ogi* samples, on the other hand, ranged (Table 4) between 6.87 and 5.75 min. The peak times of the fortified samples were lower than the reference sorghum *ogi* flour. This may be due to the gelatinization temperature of the products and the composition of the food components in the cocoa powder. The peak time also correlated positively with carbohydrate (R = 0.94) and moisture content (R = 0.84) of the samples. The peak time is a measure of the cooking time required by the product to form a paste (Adebowale *et al*., 2005). Adegunwa *et al*. (2014) reported a similar decrease in peak time (6.16 to 5.53 min) when wheat flour was increasingly fortified with millet flour. The incorporation of cocoa powder into sorghum *ogi* at increased pasting temperature may reduce the cooking time required by the fortified samples to form a paste and vice versa. Increased pasting temperature could influence processing times because high temperature treatment causes reduction in processing time (Jena and Das, 2014).

Table 4 Pasting properties of sorghum *ogi* and fortified sorghum *ogi* samples

Sample	Peak (RVU)	Final viscosity (RVU)	Breakdown (RVU)	Trough (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (°C)
A	130.12[a]	190.17[a]	6.84[a]	123.28[a]	66.89[a]	6.87[a]	83.35[g]
B	116.90[b]	175.12[b]	6.67[b]	110.23[b]	64.89[b]	6.44[b]	83.56[f]
C	88.37[c]	145.67[c]	6.02[c]	82.34[c]	63.33[c]	6.20[c]	84.75[e]
D	77.85[d]	131.22[d]	5.69[d]	72.17[d]	59.05[d]	6.00[d]	85.35[d]
E	76.62[e]	129.14[e]	5.54[e]	71.08[e]	58.06[e]	5.85[e]	85.47[c]
F	64.50[f]	110.54[f]	4.92[f]	59.58[f]	50.96[f]	5.75[f]	85.59[b]
G	57.42[g]	63.42[g]	4.58[g]	52.83[g]	10.58[g]	5.31[g]	93.37[a]

Values along the same row with different superscripts are significantly different ($p < 0.05$).

A - 100% Sorghum *ogi*; B - Sorghum *ogi* fortified with 10% cocoa powder; C - Sorghum *ogi* fortified with 20% cocoa powder; D - Sorghum *ogi* fortified with 30% cocoa powder; E - Sorghum *ogi* fortified with 40% cocoa powder; F - Sorghum *ogi* fortified with 50% cocoa powder; G - 100% Cocoa powder

Table 5 Correlation coefficients of sorghum pasting parameters and proximate composition of samples

Parameters	Carbohydrate	Moisture	Fat	Fibre	Ash	Protein
Peak viscosity (RVU)	0.85	0.72	-0.83	-0.85	-0.87	-0.83
Final viscosity (RVU)	0.98	0.91	-0.97	-0.97	-0.98	-0.97
Breakdown viscosity (RVU)	0.93	0.84	-0.91	-0.92	-0.95	-0.92
Trough viscosity (RVU)	0.85	0.72	-0.83	-0.84	-0.87	-0.83
Setback viscosity (RVU)	0.96	0.99	-0.97	-0.96	-0.94	-0.97
Peak time (min)	0.94	0.84	-0.93	-0.94	-0.94	-0.93
Pasting temperature (˚C)	-0.96	-0.98	0.96	0.96	0.93	0.96

4. CONCLUSION

This work has explored a new utilization potential for cocoa powder in sorghum *ogi*. It has also indicated that the nutritional composition of plain sorghum *ogi* can be improved by fortification with cocoa powder. All the fortified samples can aid in meeting the nutritional and energy requirement. The higher the inclusion level, the better in meeting the nutritional requirements. However, based on consumer acceptability, sorghum *ogi* with more than 30% cocoa powder fortification level were not significantly preferred because of the apparent impact of cocoa powder on taste.

5. REFERENCES

[1]. Adebowale A.A., Adegoke, M.T., Sanni, S.A., Adegunwa, M.O. and Fetuga, G.O. Functional properties and biscuit making potentials of sorghum-wheat flour composite. American Journal of Food Technology, 2012, 7: 372-379.

[2]. Adebowale, A.A., Sanni, L.O. and Onitilo, M.O. Chemical composition and pasting properties of tapioca grit from different cassava varieties and roasting method. African Journal of Food Science, 2008, 2: 77-82.

[3]. Adebowale, K.O., Olu-Owolabi, B.I., Olayinka, O.O. and Olayide, S.L. Effect of heat moisture treatment and annealing on physicochemical properties of red sorghum starch. African Journal of Biotechnology, 2005, 4 (9): 923-933.

[4]. Adegunwa, M.O., Ganiyu, A.A., Bakare, H.A. and Adebowale, A.A. Quality evaluation of composite millet-wheat chinchin. Agriculture and Biology Journal of North America, 2014, 5 (1): 33-39.

[5]. Adejuyitan, J.A., Abioye, A.O., Otunola E.T. and Oyewole, Y.N. An evaluation of some properties of baobab fruit powder and *ogi* mixes. Transnational Journal of Science and Technology 2012, 2 (7): 99-102.

[6]. Afolayan, M.O., Afolayan, M. and Abuah, J.N. An investigation into sorghum based *ogi* (*ogi-baba*) storage characteristics. Advance Journal of Food Science and Technology, 2010, 2: 72-78.

[7]. Ajanaku, K.O., Ajanaku, C.O., Edobor-Osoh, A. and Nwinyi, O.C. Nutritive value of sorghum *ogi* fortified with groundnut seed (*Arachis hypogaea* L.) American Journal of Food Technology, 2012, 7 (2): 82-88.
[8]. Akinwande, B.A., Adeyemi, I.A., Maziya-Dixon, B. and Asiedu, R. Effect of tuber harvest time and storage period on the pasting properties of yam (*Dioscorea rotundata*) starch. World Journal of Agricultural Sciences, 2007, 3 (6): 781-787.
[9]. Aminigo, E.R. and Akingbala, J.O. Nutritive composition of *ogi* fortified with okra seed meal. Journal of Applied Sciences and Environmental Management, 2004, 8 (2): 23-28.
[10]. AOAC. Official Methods of Analysis, Association of Official Analytical Chemists, 18th Edition Association, Maryland, USA, 2010
[11]. Aviara, N.A., Igbeka, J.C. and Nwokocha, L.M. Physicochemical properties of sorghum (*Sorghum Bicolor L. Moench*) starch as affected by drying temperature. Agricultural Engineering International: The CIGR Ejournal 2010, 12: 1-24.
[12]. Awolu, O. O. Optimization of the functional characteristics, pasting and rheological properties of pearl millet-based composite flour. Heliyon, 2017, 3(2017) : e00240.
[13]. Beaton, G.H. and Swiss, L.D. Evaluation of the nutritional quality, of food suppliers, prediction of desirable and "safe" protein caloric ratios. American Journal of Clinical Nutrition, 1974, 27: 485-504.
[14]. Bingham, S. Nutrition: A consumer's guide to good eating. London, Transworld publishers. 1978, pp. 123-127.
[15]. CODEX. The guidelines on formulated supplementary foods for older infants and young children adopted by CODEX Alimentarius Commission at its 19th session. 1991, pp. 1-10.
[16]. COMA (Committee on Medical Aspects of Food Policy). Diet and cardiovascular disease: Report of the panel on diet in relation to cardiovascular disease. HMSO, London. 1984.
[17]. Dietary Reference Intakes, Dietary reference intakes: guiding principles for nutrition labeling and fortification. Washington DC, The National Academies Press, 2003, pp. 79. Doi: 10.17226/10872 x.
[18]. Edem, D.O., Amugo, C.I. and Eka, O.U. Chemical composition of yam beans (*Sphenostylis stenocarpa*). Tropical Science, 1990, 30 (1): 59-63.
[19]. Egouletey, M. and Aworh, O.C. Production and physicochemical properties of tempe-fortified maize based weaning food. In: Sefa Dedeh, S. (ed.) Proceedings of seminar on Development of the protein energy foods from grain legumes. University of Lagos. 1991, pp. 5-7.
[20]. Falola, A.O., Olatidoye, O.P., Adesala, S.O. and Amusan, M. Modification and quality characteristics of cocoyam starch and its potential for chin-chin production. Pakistan Journal of Nutrition, 2014, 13 (12): 768-773.
[21]. FAO. Food energy-methods of analysis and conversion factors. A report of a technical workshop. FAO Food and Nutrition Paper, 2003, 77: 20-22.
[22]. FAO/WHO. Carbohydrates in Human Nutrition. In: International Report of a Joint Expert Consultation. Rome. 1998 pp. 140.
[23]. Farinde, E.O. Chemical and sensory properties of sieved and unsieved fortified *ogi*. Nature and Science, 2015, 13 (1): 49-53.
[24]. Fasasi, O.S. Proximate, anti-nutritional factors and functional properties of processed pear millet. Journal of Food Technology 2009, 7: 92-97.
[25]. Henry, C.J. and Ahlstrom, L. Nutrition. In: Campbell-Platt, G. (ed.) Food science and technology. West Sussex, Wiley-blackwell, 2009, pp. 299-322.
[26]. Ijarotimi, S.O. and Aroge, F. Evaluation of the nutritional composition, sensory and physical properties of a potential weaning food from locally available food materials-breadfruit (*A. altilis*) and soybean (*Glycine max*). Polish Journal of Food and Nutrition Sciences, 2005, 4: 411-415.
[27]. Ijarotimi, S.O. and Bakere, S.S. Evaluation of proximate, mineral and antinutritional factor homemade processed complementary diet from locally available food materials (*Sorghum bicolor* and *Sphenostylis stenocarpa*). Journal of Food Technology, 2006, 4: 339-344.
[28]. Iwe, M.O. Handbook of sensory methods and analysis. Enugu, Rojoint communication services limited, 2010, pp. 75-78.
[29]. Iwe, M.O., Wolters, I., Gort, G., Stolp, W. and Van Zuilichem, D.J. Behaviour of gelatinization and viscosity in soy-sweet potato mixtures by single screw extrusion: a response surface analysis. Journal of Food Engineering, 1998, 38 (3): 369-379.
[30]. Inyang, U.E. and Effiong, W.E. Chemical composition, functional and sensory properties of maize *ogi* fortified with periwinkle meat flour. International Journal of Nutrition and Food Sciences, 2016, 5 (3): 195-200.
[31]. Iyang, C.U. and Idoko, C.A. Assessment of the quality of *ogi* made from malted millet. African Journal of Biotechnology, 2006, 5 (22): 2334-2337.
[32]. James, S., Oloyede, O.O., Ocheme, O.B., Chinma, C.E. and Agbejule, A.Y. Proximate, anti-nutrient and sensory properties of *ogi*, a millet based gruel supplemented with treated African oil bean (*Pentaclethra macrophylla* Benth.) seed flour. African Journal of Food Science, 2015, 9 (3): 136-141.
[33]. Jena, S. and Das, H. Osmo-concentration of foods. In: Sahu, J. K. (ed.) Introduction to advanced food process engineering. Boca Raton, CRC Press, 2014, pp. 95.

[34]. Lee, K.W., Kim, Y.J., Lee, H.J. and Lee, C.Y. Cocoa has more phenolic phytochemicals and a higher antioxidant capacity than teas and red wine. Journal of Agricultural and Food Chemistry, 2003, 51, 7292-7295.
[35]. Makinde, F.M. and Ladipo, A.T. Physicochemical and microbial quality of sorghum-based complementary food enriched with soybean (*Glycine max*) and sesame (*Sesamum indicum*). Journal of Food Technology, 2012, 10 (2): 46-49.
[36]. NACNE (National Advisory Committee on Nutrition Education). Proposal for nutritional guidelines for healthy education in Britain, Health Education Council, London. 1983.
[37]. Odunlade, T.V., Taiwo, K.A. and Adeniran, H.A. Functional and antioxidative properties of sorghum *ogi* flour enriched with cocoa. Annals. Food Science and Technology, 2016, 17 (2): 497-506.
[38]. Oladeji, B.S., Akanbi, C.T. and Ibironke, S.I. Physicochemical and nutritional evaluation of co-processed fermented yellow maize *ogi* (an infant diet) and carrot blends. Annals Food Science and Technology, 2014, 15 (1): 82-91.
[39]. Oluwamukomi, M.O., Eleyinmi, A.F. and Enujiugha, V.N. Effect of soy supplementation and its stage of inclusion on the quality of *ogi* - a fermented maize meal. Food Chemistry, 2005, 91: 651-657.
[40]. Onoja, U.S., Akubor, P.I., Gernar, D.I. and Chinmma, C.E. Evaluation of complementary food formulated from local staples and fortified with calcium, iron and zinc. Journal of Nutrition and Food Sciences, 2014, 4: 326.
[41]. Onweluzo, J.C. and Nnamuchi, O.M. Production and evaluation of porridge type breakfast product *Trecuila africana* and *Sorghum bicolor* flours. Pakistan Journal of Nutrition, 2009, 8: 731-736.
[42]. Osungbaro, T.O., Jimoh, D. and Osundeyi, E. Functional and pasting properties of composite cassava-sorghum flour meals. Agriculture and Biology Journal of North America, 2010, 2151-7525.
[43]. Oyarekua, M.A. Evaluation of the nutritional and microbiol*ogi*cal status of co-fermented cereals/cowpea '*ogi*'. Agriculture and Biology Journal of North America, 2011, doi: 10.5251/abjna.2011.2.1.61.73.
[44]. PAG. Protein Advisory Group of the United Nations, PAG guideline no. 8, protein-rich mixtures for use as weaning foods. New York: FAO/WHO/UNICEF, 1971.
[45]. Pesta, D.H. and Samuel, V.T. A high-protein diet for reducing body fat: mechanisms and possible caveats. Nutrition and Metabolism, 2014, 11 (53).
[46]. Pikuda, O.O. and Ilelaboye, N.O. Proximate and chemical composition of *ogi* produced from whole and powdered grains (maize, sorghum and millet). Annals of Biological Research, 2013, 4 (7): 239-242.
[47]. Rossander-Hulthén, L. and Hallberg, L. Prevalence of iron deficiency in adolescents. In: Hallberg L. and Asp, N. G. (eds.) Iron nutrition in health and disease. London, John Libby. 1996, pp. 149-156.
[48]. Sanni, L.O., Adebowale, A.A. and Tafa, S.O. Proximate, functional, pasting and sensory qualities of instant yam flour. A paper presented at the 14th ISTRC Symposium, Central Tuber Crops the Research Institute, Trivandrum, Kerala State, India. 2006.
[49]. Seitz, H.K. and Suter, P.M. Ethanol toxicity and nutritional status, In: Kotsonis, F. N. and Mackey, M. A. (eds.) Nutritional toxicology. London, Taylor and Francis, 2002, pp. 136.
[50]. Sirtori, C.R. and Lovati, M.R. Soy proteins and cardiovascular disease. Current Atherosclerosis Reports 2001, 3 (1): 47-53.
[51]. USDA National Nutrient Database, Standard Reference, 2011, Release 25, 24
[52]. Wu, D.D., Boyd, R.D., Fix, T.J. and Burr, D.B. Regional patterns of bone loss and altered bone remodeling in response to calcium deprivation in laboratory rabbits. Calcified Tissue International, 1990, 47: 18-23.