Discourse Journal of Agriculture and Food Sciences
www.resjournals.org/JAFS
ISSN: 2346-7002
Vol. 6(3): 17-24, July, 2018

Nutritional and Sensory Properties of Maize-Based Complementary Foods Fortified with Soybean and Sweet Potato Flours

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Abstract

Low-cost, nutritive and bulk-reduced complementary foods formulated from the blends of malted maize, soybean and sweet potato flour were evaluated for proximate, mineral and sensory properties. The protein, fat, ash and crude fibre contents increased significantly ($p<0.05$) from 8.51±0.07 - 12.20±0.03%, 2.09±0.01 – 2.97±0.07%, 1.91±0.01 – 3.18±0.08% and 2.33±0.01 – 3.18±0.08%, respectively as the ratios of soybean and sweet potato flours increased in the formulations, while the carbohydrate and energy contents decreased. The control sample without soybean and sweet potato flours substitution (100% malted maize flour) had the highest carbohydrate (78.82±0.11%) and energy (368.13±0.58KJ/100g) contents. The mineral content of the samples revealed that the calcium, phosphorus, potassium, iron, zinc and magnesium contents also increased with increased substitution of soybean and sweet potato flours from 9.08±0.02 – 12.32±0.14 mg/100g, 5.40±0.08 – 6.08±0.05 mg/100g, 4.55±0.05 – 5.32±0.14 mg/100g, 3.65±0.01 – 4.61±0.07 mg/100g, 3.70+0.12 – 4.30+0.02 mg/100g and 3.47±0.12 – 4.15±0.01 mg/100g, respectively. The sensory attributes: colour, taste, mouth-feel and texture of the control sample were significantly ($p<0.05$) the most acceptable to the assessors compared to the samples substituted with soybean and sweet potato flours at different levels. However, the study showed that the maize-based complementary foods supplemented with soybean and sweet potato flours could help to alleviate the problem of protein-energy malnutrition that is prevalent among infants and children in developing countries by providing them with adequate nutrients needed for optimum growth, development and well-being during the period of complementary feeding.

Keywords: Complementary foods, fortification, proximate composition, mineral content, sensory properties, maize flour, soybean flour, sweet potato flour.

INTRODUCTION

Infancy period (0-2 years) is a critical period of children's growth, during which they experience optimal growth, health and behavioral development (Onoja *et al*., 2014). Breast milk is the most balanced food for infants during their first six months (FAO, 2001). However, the high nutrient requirements of infants after six months make breast milk inadequate for them during these periods. Feeding of infants with foods that are low in protein and micronutrients during the first six months of life can lead to permanent stunting in growth (Solomon, 2005). Malnourished children are often victims of various infections and nutrient deficiencies. One of the ways to ensure the prevention of malnutrition is by providing nutrient dense complementary foods to the children. Even after 48years of independence and reforms, malnutrition continues to remain a chronic public health problem in Nigeria (UNICEF, 2008). The critical period when a child is most likely to develop malnutrition coincides with the age of introduction of complementary foods, which are most often nutritionally inadequate. There is need to feed the older infants and young children with complementary foods that are energy-dense, nutritionally balanced, and easily digestible.

To provide nutritionally adequate and balanced complementary foods, it is important to have food mixtures or variety of foods that fulfill macro and micro nutrient needs of the infants. The young infant has a small stomach and can only consume small amounts of food at a time. Thus, it is important to feed the child with energy and nutrient dense meals (Adenuga, 2010). Complementary foods are traditionally started with cereals which provide some energy, minerals and vitamins. However, cereals contain phytates which inhibit the absorption of iron. They also contain minimal amounts of vitamin A and vitamin C and are not protein dense (Gibson *et al*., 2010; Abbaspour *et al*., 2014). Therefore, cereals need to be enriched with pulses, legumes or animal food products such as milk, meat, fish and egg etc. Nuts and oilseeds help to increase the energy density and further contribute to some of the protective nutrients. The addition of sugar and fat can also increase the nutrient density of complementary foods (Nandutu and Howell, 2009).

In developing countries, complementary foods are usually produced traditionally from locally available crops such as cereals, fruits and starchy roots and tubers (Makinde and Ladipo, 2012; Akinola *et al*., 2014). Infants are mostly fed with gruels or porridges that contain low nutrients, thus protein deficiency in the diets is common and it is usually associated with deficiencies in calories and micronutrients leading to endemic protein-energy malnutrition with its attendant health consequencies. In Nigeria, the traditional complementary foods are mainly gruels or porridges produced from either maize, sorghum or millet which are deficient in energy and other nutrients (Yusufu *et al.*, 2013). In some cases, the gruel may be too watery with low energy density or too bulky, causing reduction in infant consumption rate. Improper feeding during the period of complementary feeding results in infant morbidity and mortality as well as delayed mental development (Onyeka and Dibia, 2002). In order to prevent infant malnutrition and its associated health problems in Nigeria and other developing countries of the world, complementary foods should be formulated from locally available nutrient dense crops.

Maize (*Zea mays*), soybean (*Glycine max)* and sweet potato (*Ipomoea batatas*) are food crops that are readily available in Nigeria. They have promising nutritional attributes. Maize protein in common varieties varies from 8 to 11% of the kernel weight (FAO, 1992). The protein has moderate amounts of sulphur containing amino acids, methionine and cystine but is low in lysine and very low in tryptophan (FAO, 2009). The crude protein content of most legumes varies between 16% in bambara groundnut to 35% in soybean. Soybean protein is limiting in essential sulphur containing amino acids (methionine and cystine etc), but is rich in lysine and tryptophan. Hence, soybean could form a good supplement to maize which is low in tryptophan (Barber *et al*., 2017). Maize contains high levels of dietary fibre (12.02%) but low in trace minerals and ascorbic acid. Thus, there is need to enrich maize diets with both protein and micronutrient rich foods. Legumes also contain substantial amounts of minerals and vitamins with cowpea (*Vigna unguiculata*), soybean (*Glycine max)* and bamabara groundnut (*Vigna subterrenea L. Verde*) regarded as good sources of calcium and iron (Okaka, 2005). Soybean is low in saturated fat, cholesterol free and high in many important nutrients such as B – vitamins, calcium, potassium, magnesium, fibre, iron, isoflavones and vitamin D (USDA, 2007). Sweet potato roots are an excellent ingredient for the preparation of complementary foods. Sweet potato provides higher energy compared to other root vegetables (Amagloh *et al.,* 2013). The starch in sweet potato is easily digestible and is therefore a useful ingredient in the preparation of infant food. Sweet potato is the only starchy staple with a significant amount of beta-carotene. The beta-carotene content of the sweet potato depends on its flesh colour and is mostly found in large quantity in deep orange-fleshed varieties. Sweet potato roots have low phytate content which does not interfere with the absorption of vitamins and minerals (Gibson *et al.,* 2010). Therefore, the formulation of complementary foods with these locally available food ingredients could be an avenue for the utilization of the comparatively and rarely used food products for feeding infants. In addition, the use of these locally available nutrient dense ingredients in the development of infant foods will also help to enhance the nutritional quality of the home-made products. This study was, therefore, aimed at the formulation and evaluation of the proximate, mineral and sensory properties of maize-based complementary foods supplemented with soybean and sweet potato flours.

MATERIALS AND METHODS

The yellow variety of maize (*Zea mays*), soybean *Glycine max*) and sweet potato (*Ipomoea batatas*) used for the study were bought from Mayor Market, Enugu, Enugu State, Nigeria.

Preparation of Malted Maize Flour

The malted maize flour was prepared according to the method of Abasiekong *et al*. (2010). During preparation, one kilogramme (1kg) of maize grains which were free from dirt and other extraneous materials were thoroughly cleaned and steeped in 3 liters of potable water in a plastic bowl at room temperature (30 ± 2^0C) for 24 hours with a change of water at every 6 hours to prevent fermentation. The steeped grains were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the grains. The grains were rinsed for five consecutive times with excess water and cast on a damped jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The grains were carefully spread on the jute bag and allowed to germinate at room temperature (30 ± 2^0C) and relative humidity of 95% in the germinating chamber for 96 h. During this period, the grains were sprinkled with water at intervals of 12 h to facilitate germination. Non-germinated grains were handpicked and discarded and the germinated grains were collected, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50^0C for 24 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. Thereafter, the malted maize grains were cleaned and rubbed in-between palms to remove the roots and the sprouts. The dried maize malts were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and stored in a refrigerator until needed for further use.

Preparation of Malted Soybean Flour

The malted soybean flour was prepared according to the method of Makinde and Ladipo (2012). During preparation, one kilogramme (1kg) of soybean seeds which were free from dirt and other contaminants were thoroughly cleaned and soaked in 3 liters of potable water in a plastic bowl at room temperature (30 ± 2^0C) for 20 h with a change of water at every 5 h to prevent fermentation. The soaked seeds were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the seeds. The seeds were rinsed for five consecutive times with excess water and cast on a damped jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The seeds were carefully spread on the jute bag and allowed to germinate at ambient temperature (30 ± 2^0C) and relative humidity of 95% in the germinating chamber for 96 h. During this period, the seeds were sprinkled with water at intervals of 10 h to facilitate germination. Non-germinated seeds were handpicked and discarded and the germinated seeds were collected, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50^0C for 24 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried malted soybean seeds were cleaned and rubbed in-between palms to remove the roots and the sprouts along with the hulls. The dehulled malted seeds were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and stored in a refrigerator until needed for further use.

Preparation of Sweet Potato Flour

The sweet potato flour was prepared according to the method of Adenuga (2010). During preparation, one kilogramme (1kg) of sweet potato tubers which were free from dirt and other extraneous materials were cleaned thoroughly with 3.5 liters of potable water and peeled manually with a kitchen knife. The peeled tubers were sliced into smaller sweet potato slices. The slices were rinsed, placed into a stainless pot and blanched with 2.5 litres of potable water on a hot plate at 85^0C for 20 min. The blanched sweet potato slices were drained, rinsed, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 60^0C for 12 h with occasional stirring of the slices at intervals of 30 min to ensure uniform drying. The dried slices were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and stored in a refrigerator until needed for further use.

Preparation of Complementary Food Samples

Maize, soybean and sweet potato flours were mixed thoroughly in the ratios of 90:5:5, 80:15:5, 70:20:10, 60:25:15 and 50:30:20 in a rotary mixer (Philips, type HR 1500/A Holland) to produce homogenous samples of complementary food. The complementary foods formulated were separately packaged in airtight plastic containers, labeled and preserved in a refrigerator until needed for analyses. The malted maize flour without any substitution with soybean and sweet potato flours (100% malted maize flour) was used as control.

Chemical Analysis

The moisture, crude protein, fat, ash and crude fibre contents of the complementary food samples were determined in triplicate according to the standard analytical methods (AOAC, 2006). Carbohydrate was obtained by subtracting the differences of moisture, protein, fat and ash from 100% (Onwuka, 2005). The energy content was calculated using the Atwater factor of 4.0 for protein and carbohydrate and 9.0 for fat (Okoye and Obi, 2017). The potassium and iron contents of the samples were determined by the use of a flame photometer (Model 405, Corning UK) according to the method of Ndie *et al.* (2010). The calcium, magnesium and zinc contents of the formulations were determined using atomic absorption spectrophotometer (Perkin-Elmer Model 1033, Norwalk CT, USA) according to the method of AOAC (2006). Phosphorus was determined by the vanadomolybdate colorimetric method of Yusufu *et al.* (2013).

Sensory Analysis

Porridges were prepared from both the control and various samples of formulated complementary food. Sixty grammes (60g) of each sample were mixed with 150mL of cold water to produce slurry. Thereafter, 100mL of boiling water was added to each of the slurry with continuous stirring to obtain homogenous porridges. Three grammes (3g) of granulated sugar were added to each sample of the porridge. The porridges were evaluated in sensory evaluation boots for attributes of colour, taste, mouthfeel, texture and overall acceptability by a panel of twenty (20) semi-trained judges consisting of nursing mothers, staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu. Prior to the sensory test, the porridges were individually coded and served to the panelists in white plastic cups with teaspoons at room temperature (30 ± 2^0C). Clean water was provided to the judges to rinse the mouth in-between testing of the porridges to avoid residual effect. The judges were instructed to assess and score the samples based on the degree of likeness and acceptance of the porridges using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Iwe, 2007). Expectoration cups with lids were provided for the panelists who did not wish to swallow the samples.

Statistical Analysis

The results were expressed as mean ± standard deviation and the test for statistical significance was carried out using one-way analysis of variance (ANOVA). The statistical package used to determine significant differences was Statistical Package for Social Sciences (SPSS, Version 20). Significant means were separated using Turkey's Least Significance Difference (LSD) test. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Proximate Composition of Complementary Food Samples

The proximate composition of complementary food samples are presented in Table 1. The moisture content of the complementary food samples varied from 8.67 to 10.37% with the control sample without soybean and sweet potato flours substitution (100% malted maize flour) and the formulation substituted with 30% soybean and 20% sweet potato flours having the least (8.67%) and highest (10.367%) values, respectively. The moisture content was observed to increase with increased substitution with soybean and sweet potato flours in the blends. High moisture content in food has been shown to encourage microbial growth (Asma *et al.,* 2006). The values obtained in this study were lower than the moisture content (10.03-12.59%) of complementary food formulated from fermented maize, soybean and carrot flours reported by Barber *et al*. (2017). The low residual moisture content in a food product is advantageous in that microbial proliferation is reduced and storage life is enhanced and prolonged. The protein content of the samples increased significantly ($p<0.05$) with the increase in soybean flour substitution. The sample substituted with 30% soybean and 20% sweet potato flours had the highest protein content (12.20%). This increase could be attributed to the addition of high proportion of soybean flour in the blends. Maize is limiting in essential amino acids, lysine and tryptophan. It is expected that the amino acid of soybean will complement that of the cereal flour. Protein is important for tissue replacement, deposition of lean body mass and growth (Dewey and Brown, 2002). The fat content of the formulations ranged from 2.09 to 2.97%. The fat content of the samples increased sequentially with increased substitution of soybean flour in the products. This increase could be due to the addition of high proportion of soybean flour which has high fat content. Fat is important in the diets of infants and young children as it provides essential fatty acids, facilitate the absorption of fat soluble vitamins, enhances dietary energy density and also helps in the prevention of undesirable weight gain in infants (Amagloh *et al*., 2013). It has been recommended that during the complementary feeding period (6-12 months) a child's diet should derive 30-40% of energy from fat (Michaelsen *et al*., 2000). The ash

Table 1. Proximate composition (%) of complementary food samples

Sample ID	%Substitution MF:SF:SPF	Moisture	Protein (Nx6.25)	Fat	Ash	Fibre	Carbohydrate	Energy KJ/100g
A	100: 0: 0	8.67^{f}±0.70	8.51^{f}±0.07	2.09^{f}±0.01	1.91^{f}±0.01	2.33^{f}±0.01	78.82^{a}±0.11	368.13^{a}±0.58
B	90: 5: 5	8.90^{e}±0.03	9.51^{e}±0.07	2.51^{e}±0.07	2.49^{e}±0.09	2.47^{e}±0.02	76.59^{b}±0.21	366.99^{b}±0.88
C	80: 15: 5	9.25^{d}±0.03	9.89^{d}±0.09	2.61^{d}±0.04	2.66^{d}±0.02	2.79^{d}±0.01	75.61^{c}±0.60	365.49^{c}±1.18
D	70: 20: 10	9.69^{c}±0.09	10.40^{c}±0.08	2.77^{c}±0.04	2.78^{c}±0.04	2.84^{c}±0.02	74.38^{d}±0.26	364.05^{d}±1.20
E	60: 25: 15	10.04^{b}±0.25	11.09^{b}±0.03	2.86^{b}±0.02	2.98^{b}±0.08	2.98^{b}±0.08	73.17^{e}±0.63	362.28^{e}±1.16
F	50: 30: 20	10.37^{a}±0.07	12.20^{a}±0.03	2.97^{a}±0.07	3.18^{a}±0.08	3.18^{a}±0.08	71.49^{f}±0.46	361.49^{f}±1.17

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p<0.05$).
MF – Malted maize flour, SF – Malted soybean flour, SPF – Sweet potato flour.

content of the samples increased significantly ($p<0.05$) with increase in the levels of soybean and sweet potato flours in the blends. The ash content of a food material is an indication of the amount of minerals in the food product. The ash content (1.91-3.18%) obtained in this study was similar to the ash content (1.88-3.17%) of complementary food formulated from sorghum, groundnut and crayfish reported by Nzeagwu and Nwaejike (2008). The crude fibre content of the complementary food samples ranged from 2.33 to 3.18%. The values obtained in this study were close to the fibre content (2.72-3.52%) of complementary food produced from malted millet, plantain and soybean blends reported by Bolarinwa *et al*. (2016) but higher than the fibre content (0.04-2.27%) of complementary food produced from sorghum, plantain and soybean flour blends reported by Onoja *et al.* (2014). The high fibre content of three food crops that constitute the complementary foods developed in this study could be responsible for the slightly high crude fibre content of the formulated complementary foods. Nwakalor and Obi (2014) reported that soybeans are rich in dietary fibre. However, the fibre contents of the developed complementary foods are within the range (0.36-2.5%) reported for infant cereal-based food (Lutter and Dewey, 2003). The carbohydrate content of the samples decreased gradually with increase in substitution with soybean and sweet potato flours. The carbohydrate content (71.49 to 78.82%) of the complementary food samples was relatively high. The high carbohydrate content of the complementary food samples could be due to the high carbohydrate content of maize and sweet potato flours used (Amagloh *et al*., 2013). However, the carbohydrate content of the complementary foods developed in this study was similar to the carbohydrate content (67.59-78.02) of complementary food prepared from sorghum, African yam bean and mango mesocarp flour blends reported by Yusufu *et al.* (2013). The relatively high carbohydrate content of the formulated complementary foods is an indication that the products will provide the infants with adequate amount of energy required for optimum growth and development. The energy content of the complementary food samples also decreased gradually with increased substitution with soybean and sweet potato flours in the products. The significant ($p<0.05$) differences observed in the energy levels of the developed complementary food samples could be attributed to variations in protein, fat and carbohydrate contents of the blends. The result obtained in this study was similar to the finding of Okafor and Usman (2013) who reported a decrease in energy content of breakfast cereals produced from maize, African yam bean and defatted coconut flour blends as the ratios of African yam bean and defatted coconut flours increased in the products. The substitution of maize-based porridges with soybean and sweet flours greatly increased the nutrient contents of the formulations.

Mineral composition of Complementary Food Samples

The mineral composition of the complementary food samples are presented in Table 2. The levels of minerals: calcium, phosphorus, potassium, iron, zinc and magnesium increased with increase in substitution with soybean and sweet potato flours. The increase in the mineral content of the formulated complementary food samples confirms the beneficial effect of supplementation. The calcium content of the samples ranged from 9.08 to 12.32 mg/100g. The sample formulated with 50% maize, 30% soybean and 20% sweet potato flours had the highest calcium content (12.32mg/100g), while the control sample (100% malted maize flour) had the least value (9.08mg/100g). The increase in calcium content observed in all the formulated samples could be attributed to increase in the addition of soybean flour in the products. Nandutu and Howell (2009) reported that soybeans are rich source of calcium. Calcium is important for proper bone development in infants and young children. Thus, feeding of infants with the formulated complementary foods will promote the development of teeth and bone in infants. The phosphorus content of the samples varied

Table 2. Mineral composition (mg/100g) of complementary food samples

Sample ID	%Substitution MF:SF:SPF	Calcium	Phosphorus	Potassium	Iron	Zinc	Magnesium
A	100: 0: 0	$9.08^{f}\pm0.02$	$5.4^{f}\pm0.08$	$4.55^{f}\pm0.05$	$3.65^{f}\pm0.01$	$3.70^{e}\pm0.02$	$3.47^{e}\pm0.12$
B	90: 5: 5	$11.80^{e}\pm0.16$	$5.55^{e}\pm0.01$	$4.76^{e}\pm0.05$	$3.99^{e}\pm0.29$	$3.89^{d}\pm0.09$	$3.65^{d}\pm0.04$
C	80: 15: 5	$11.99^{d}\pm0.04$	$5.75^{d}\pm0.01$	$4.98^{d}\pm0.08$	$4.28^{d}\pm0.05$	$4.07^{c}\pm0.01$	$3.76^{c}\pm0.05$
D	70: 20: 10	$12.06^{c}\pm0.02$	$5.89^{c}\pm0.09$	$5.02^{c}\pm0.08$	$4.40^{c}\pm0.02$	$4.15^{b}\pm0.01$	$3.97^{b}\pm0.07$
E	60: 25: 15	$12.13^{b}\pm0.01$	$6.00^{b}\pm0.02$	$5.11^{b}\pm0.01$	$4.47^{b}\pm0.01$	$4.20^{b}\pm0.02$	$4.10^{a}\pm0.02$
F	50: 30: 20	$12.32^{a}\pm0.14$	$6.08^{a}\pm0.05$	$6.32^{a}\pm0.14$	$4.61^{a}\pm0.07$	$4.30^{a}\pm0.02$	$4.15^{a}\pm0.01$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p<0.05$).
MF – Malted maize flour, SF – Malted soybean flour, SPF – Sweet potato flour.

significantly ($p<0.05$) from each other. The samples substituted with 30% soybean and 20% sweet potato flours had significantly ($p<0.05$) the highest phosphorus content (6.08mg/100g). The phosphorus content of the complementary foods formulated in this study was higher than the phosphorus content (3.20 – 5.80mg/100g) of gruel prepared from blends of fermented cereal, legume, tuber and root flour reported by Onoja and Obizoba (2009). Phosphorus is an important constituent of every living cell. It is also very essential in bone formation and other cellular reactions in the body (Berdanier and Zempleni, 2009). The potassium content of complementary food supplemented with 30% soybean and 20% sweet potato flours was the highest (5.32mg/100g), while the control (100% malted maize flour) had the least value (4.55mg/100g). The increase in potassium content observed in the blends could be due to the inclusion of high proportion of soybean flour in the products. The potassium content obtained in this study was similar to the potassium content (4.26-5.28mg/100g) of complementary food produced from malted millet, plantain and soybean flour blends reported by Bolarinwa *et al.* (2016). Potassium helps in blood clotting and in proper functioning of the muscles. The iron content of the samples increased with increased substitution with soybean and sweet potato flours in the blends. Similar increase in iron content with increase in substitution with African yam bean and soybean flours has been reported by Ishiwu and Onyeji (2004) for an instant gruel based on blends of maize starch, African yam bean and soybean flour. The regular consumption of food that is rich in iron has the potential to prevent anaemia in infants and children. It is also very important in the formation of blood cells. The zinc content of the complementary food samples ranged from 3.70 to 4.30mg/100g. The sample substituted with 30% soybean and 20% sweet potato flours had the highest zinc content (4.30mg/100g), while the control (100% malted maize flour) had the least value (3.70mg/100g). The level of zinc in the samples was observed to increase with increase in the proportion of soybean flour in the blends. However, soybeans have been reported to be an excellent source of zinc (Plahar *et al.,* 2003). Zinc is an important co-factor for more than 70 enzymes and it plays a central role in cell division, protein synthesis and growth. The deficiency of zinc will result to growth failure, anaemia, enlargement of liver and spleen and impairment of skeletal development. The magnesium content of the samples increased with increase in substitution with soybean and sweet potatoes flours only. The values ranged between 3.47 to 4.15mg/100g with the control sample (100% malted maize flour) and the sample substituted with 30% soybean and 20% sweet potato flours having the least (3.47mg/100g) and highest (4.15mg/100g) values, respectively. The increase in magnesium content of the samples substituted with soybean and sweet potato flours at different levels is an indication that soybean and sweet potato are rich sources of magnesium (Amankwah *et al*., 2009; Sharma and Sabharwal, 2015). Magnesium helps in the proper functioning of the muscles. It also serves as an activator in many enzyme systems. The substitution of maize-based porridges with soybean and sweet potato flours generally enhanced the mineral contents of the products.

Sensory Properties of Complementary Food Samples

The sensory properties of complementary food samples are presented in Table 3. The sensory scores of the porridges prepared from both the control and the formulated complementary food samples showed significant ($p<0.05$) differences in colour, taste, mouth feel, texture and overall acceptability. The control sample (100% malted maize flour) had significantly ($p<0.05$) the highest scores for colour taste, mouth-feel, texture and overall acceptability compared to the test samples, while the sample substituted with 30% soybean and 20% sweet potato flours had the lowest scores. The porridge made from 100% malted maize flour and those prepared from the formulated complementary foods substituted with 5-30% soybean and 5-20% sweet potato flours were generally acceptable. The increase in substitution resulted in

Table 3. Sensory properties of complementary food samples

Sample ID	%Substitution MF:SF:SPF	Colour	Taste	Mouthfeel	Texture	Overall Acceptability
A	100: 0: 0	$8.54^{a}\pm0.11$	$7.00^{a}\pm0.28$	$7.70^{a}\pm0.14$	$7.50^{a}\pm0.14$	$8.37^{a}\pm0.14$
B	90: 5: 5	$8.17^{b}\pm0.07$	$6.60^{b}\pm0.14$	$6.40^{b}\pm0.28$	$6.70^{b}\pm0.09$	$7.30^{b}\pm0.12$
C	80: 15: 5	$7.75^{c}\pm0.09$	$6.60^{b}\pm0.14$	$6.30^{c}\pm0.11$	$6.55^{c}\pm0.09$	$7.14^{c}\pm0.15$
D	70: 20: 10	$71.6^{d}\pm0.06$	$6.45^{c}\pm0.07$	$6.15^{d}\pm0.07$	$6.45^{d}\pm0.07$	$6.90^{d}\pm0.22$
E	60: 25: 15	$6.55^{e}\pm0.09$	$6.27^{d}\pm0.07$	$6.10^{e}\pm0.13$	$6.30^{e}\pm0.11$	$6.70^{e}\pm0.09$
F	50: 30: 20	$6.18^{f}\pm0.08$	$6.10^{e}\pm0.13$	$6.05^{e}\pm0.07$	$6.25^{e}\pm0.07$	$6.45^{f}\pm0.07$

Values are mean ± standard deviation of twenty (20) semi-trained judges. Means in the same column with different letters are significantly different ($p<0.05$).
MF – Malted maize flour, SF – Malted soybean flour, SPF – Sweet potato flour.

decrease in acceptability of the porridge as indicated by the significantly ($p<0.05$) low scores for the sample substituted with 30% soybean and 20% sweet potato flours. The variation observed in the colour could be due to increased substitution of the samples with soybean and sweet potato flours. The sample substituted with 30% soybean and 20% sweet potato flours was also reported to have crumbly texture and a beany flavour, attributable to the increased substitution and the beany flavour of soybean. However, the porridge made from the sample substituted with 5% soybean and 5% sweet potato flours was described by the panelists as having the best taste, mouthfeel and overall acceptability compared to other test samples. This 5% level of substitution though not the highest in other nutrients relatively meets the consumers' sensory attributes. It therefore implies that there is need for further investigation on the methods of preparation that can be used in the formulation of organoleptically acceptable complementary foods at higher levels of substitution.

CONCLUSION

Proper and judicious selection and combination of cheap and locally available food crops can be effectively utilized in the preparation of nutrient dense and organoleptically acceptable home-made complementary foods. The complementary foods formulated in this study could be used by mothers to feed their infants and children during the complementary feeding period. The high protein, fat, energy and mineral contents of the samples is an indication that the formulated complementary foods have the potentials to enhance the growth, development and well being of infants and young children, in addition to the affordability of the products. The feeding of infants with the complementary foods developed in this study will serve as a cheap and easy way of preventing the problem of protein-energy malnutrition among infants and children in Nigeria and other developing countries of the world.

REFERENCES

Abasiekong, KS., Akobundu, E.N.T Oti, E. (2010). Chemical, sensory and biological evaluation of maize-bambara groundnut based complementary foods. *Niger. J. Food Sci. Technol., 28(2): 25-31.*

Abbaspour N, Hurrell R, and Kelishadi R (2014). Review on iron and its importance for human health. *J. Res. Med. Sci., 19(2): 164-174.*

Adenuga, W. (2010). Nutritional and sensory profiles of sweet potato-based infant weaning food fortified with cowpea and peanut. *J. Food Technol., 8(5): 223-228.*

Akinola, OO., Opreh, O.P. and Hammed, I.A. (2014). Formulation of local ingredient-based complementary food in South-West, Nigeria. *IOSR J. Nur. Health Sciences; 3:57-61.*

Amagloh, F.K., Anthony, N.M., Brough, L., Janet Wehert, C., Harbacre, A. and Coad, J. (2013). Carbohydrate composition, viscosity, solubility and sensory acceptance of sweet potato and maize-based complementary foods. *Food Nutri. Res., 57:187-197.*

Amankwah EA., Barimah, .J., Nuamah, A.K.M., Oldham, JH. and Nnaji, CO. (2009). Formulation of weaning food from fermented maize, rice, soybean and fishmeal. *Pak. J. Nutri. 8(11):1747-1752.*

AOAC (2006). *Official Methods of Analysis*. Association of Official Analytical Chemists. 18th edn. Washington D.C. USA. pp. 158-168

.

Asma, MA., Babiker, EF. and Tinay, A.H. (2006). Development of weaning food from maize supplemented with legumes and oilseeds. *Food and Nutrition Bulletin; 27(1): 26-34.*

Barber LI., Obinna-Echem, PC, Ogburia, EM (2017). Proximate composition, micronutrient and sensory properties of complementary food from fermented maize, soybean and carrot flours. *Sky J. Food Sci. 6(3): 033-039.*

Berdanier, C.D. and Zempleni, J. (2009). *Advanced Nutrition: Macronutrients, Micronutrients and Metabolism.* CRC Press, Ltd, London. pp. 124-132.

Bolarinwa IF., Olajide, JO, Oke MO, Olaniya, SA, Faromik, OG (2016). Production and quality evaluation of complementary food from malted millet, plantain and soybean blends. *Int. J. Sci. Eng. Research; 7(5): 663-674.*

Deway, K.G. and Brown, K.H. (2002). Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and Nutrition Bulletin; 24(1): 5-28.*

FAO (1992). *Maize in Human Nutrition.* Report of Technical Meeting. Food and Nutrition Series, Rome, Italy. pp. 102-104.

FAO (2001). *Human Vitamin and Mineral Requirements.* Report of a joint FAO/WHO expert consultation. Bangkok, Thailand: Food and Agriculture Organization of the United Nations Rome, Italy. pp. 142-156.

FAO (2009). *Maize, Rice and Wheat: Area Harvested, Production Quality and Yield*. Food and Agriculture Organization of the United Nations, Rome, Italy. Pp. 105-112.

Gibson, R.S., Bailey, K.B., Gibbs, M. and Ferguson, E.L. (2010). A review of phytate, iron, zinc and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. *Food and Nutrition Bulletin; 31(2): 134-146*.

Ishiwu, C.N. and Onyeji, A.C. (2004). Properties of an instant gruel based on blends of maize (*Zea mays)* starch, African yam bean (*Sphenostylis stenocarpa and soybean. (Glycine max) flours. Nigerian Journal of Nutritional Sciences; 25:16-19.*

Iwe MO. (2007). *Current Trends in Sensory Evaluation of Foods*. Rojoint Communication Services Ltd, Enugu, Nigeria. Pp. 132-137.

Lutter, C.K. and Dewey, K.G. (2003). Proposed nutrient composition for fortified complementary foods. *J.Nutri,.133:30115-30205.*

Makinde, F.M. and Ladipo, A.T. (2012). Physico-chemical and microbial quality of sorghum-based complementary food enriched with soybean (*Glycine max)* and sesame (*Sesamum indicum). J.Food Technol. 10(2): 46-49.*

Michaelsen, K.F., Weaver, L., Branca, F. and Robertson, A. (2000). Feeding and nutrition in infants and young children-Guidelines for the WHO European Region, with emphasis on the former Soviet countries. *WHO Regional Publications, European Series; 87:45-80.*

Nandutu, A. and Howell, N. (2009). Nutritional and rheological properties of sweet potato based infant food and its preservation using antioxidants. *African Journal of Food Agriculture Nutrition and Development; 9(4): 1076-1090.*

Ndie, E.C., Nnamani, C.V. and Oselebe, H.O. (2010). Some physicochemical characteristics of defatted flour derived from African walnut *(Tetracarpidium conophorum):* an under utilized legume. *Pak. J.Nutri. 9(9): 909-911.*

Nwakalor, C.N. and Obi, C.D. (2014). Formulation and sensory evaluation of sorghum-based weaning food fortified with soybean and unripe plantain flours: *Int. J. Food . 3(5): 387-390.*

Nzeagwu, OC. and Nwaejike, N.J. (2008). Nutrient composition, functional and organoleptic properties of complementary foods formulated from sorghum, groundnut and crayfish. *Niger. J.Food Sci.Technol. 26(1): 13-20.*

Okafor, .G. and Usman, G.O. (2013). Production and evaluation of breakfast cereals from blends of African yam bean (*Sphenostylis stenocarpa),* maize (*Zea mays)* and defatted coconut (*Cocus mucifera). J.Food Processing and Preservation; 38(3): 1037-1043.*

Okaka, J.C. (2005). *Handling, Storage and Processing of Plant Foods.* Ocjanco Academic Publishers, Enugu, Nigeria. pp. 182-190.

Okoye, J.I and Obi, C.D. (2017). Proximate composition, physical and sensory properties of wheat-pigeon pea composite flour biscuits. *Int. J.Food Sci.Nutri. Technol.1(1): 1-10.*

Onoja, U.S. and Obizoba, I.C. (2009). Nutrient composition and organoleptic attributes of gruel based on fermented cereal, legume, tuber and root flour. *Journal of tropical Agriculture Food Environment and Extension; 8: 162-168.*

Onoja, U.S., Akubor, P.I. Gemar, D.I. and Chinmma, C.E. (2014). Evaluation of complementary food formulated from local staples and fortified with calcium, iron and zinc. *J. Nutri. Food Sci.4: 326-392.*

Onwuka, G.I. (2005). *Food and Instrumentation Analysis: Theory and Practice*. Naphthali Publishers Ltd, Lagos, Nigeria. Pp. 62-72.

Onyeka, .U. and Dibia, .I. (2002). Malted weaning food made from maize, soybean, groundnut and cooking banana. *Journal of Science of Food and Agriculture; 82(5): 513-516.*

Planhar, W.A., Okezie, B.O. and Gyato, C.K. (2003). Development of a high protein weaning food by extrusion cooking using peanuts, maize and soybeans. *Plant Foods for Human Nutrition; 58(3): 1-12.*

Sharma, .P. and Sabharwal, .V. (2015). Development of a nutritious infant food premix using household food processing techniques. *Int. J.Food Nutri.Sci.; 4(5): 64-70.*

Solomon, M. (2005). Nutritive value of three potential complementary foods based on cereals and legumes. *Afr. J. Food Nutri. Sci.5(2): 1-14.*

UNICEF (2008). Available at URL http://www.unicef.org/nigeria/chidlren-2356 htm. Accessed on 26 January, 2014.

USDA (2007). USDA Table of Nutrient Retention Factors, Release 6" USDA. Prepared by the Nutrient Data Laboratory, Beltsville Human Nutrition Research Centre (BHNRC), Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA), December, 2007. http://www. ars.usdagov/ARSUserFiles/80400525/Data/retn/retnob.pdf.

Yusufu, P.A., Egbunu, F.A., Egwujeh, S.I.D., Opega, G.L. and Adikwu, M.O. (2013). Evaluation of Complemtnary food prepared from sorghum, African yam bean (*Sphenostytis stenocarpa)* and mango mesocarp flour blends. *Pak. J. Nutri. 12(2): 205-208.*