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Full Length Research Paper

Proximate composition micronutrient and sensory properties of complementary food formulated from fermented maize, soybeans and carrot flours

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An improved complementary food consisting of fermented maize, soybeans and carrots was formulated and evaluated for proximate, micronutrient and sensory properties. Protein content increased from 11.66% in the control to 23.99% for sample containing 20% soybeans. The fat and ash contents also showed similar increases from 3.40 – 7.80% and 0.56 – 2.00% respectively. There was no significant difference (P≤ 0.05) in the moisture content with the addition of soybeans and carrot flours. The fiber content decreased with addition of soy and carrot flours from 1.82 – 0.31%. Micro nutrients Ca (260 - 540 mg/kg), Mg (365 - 760 mg/kg), P (890 - 1795 mg/kg), Cu (0.88 - 3.36 mg/kg) and Zn (4.82 - 7.58 mg/kg) increased significantly with increase in substitution except Fe. The control without substitution had significantly the highest Fe value of 254.33 mg/kg. The colour, taste, mouthfeel and texture of the 10% substitution were significantly (P ≤ 0.05) the most acceptable to the assessors. It meets the consumers' sensory attributes, though not significantly (P≤ 0.05) the highest in the other nutrients. This study reveals that the macro and micro nutrient content of pap can be increased by substituting maize flour with soybeans and carrot flours with 10% as the most preferred substitution level.

Key words: Complementary food, fermented maize, carrot soybean flour, proximate composition, micronutrient, sensory properties.

INTRODUCTION

Childhood malnutrition is widely prevalent in many parts of the world, particularly in developing countries like Nigeria (Onis, 1997). Protein, energy and micronutrient malnutrition are the commonest forms. Micronutrients malnutrition in infants and young children became a major concern to public health nutrition just before the World Summit for Children in the late 80's (Solomons, 2000). The focus expanded from just protein and energy malnutrition to include vitamin A, iodine and iron deficiencies. There is an emerging interest on zinc and copper nutrition. Control of Vitamin A deficiency (VAD), iron deficiency anaemia (IDA) and iodine deficiency disorders (IDD) remain a big challenge for nutritionists and health workers. Food-based approaches have been recognized as the principal way of combating these nutritional problems although some other forms of intervention could serve as a complement. Dietary diversifications to include micronutrient rich foods in the diet appear more feasible than other methods in most developing countries.

Complementary foods are used to meet the infant nutritional requirement, when mother's milk is no longer adequate to meet its nutritional requirement after the exclusive period of breastfeeding (Kleinman, 2004). Complementary food is mostly produced from food which include cereals, such as wheat, maize and rice, roots and tubers and legumes such as soybeans, cowpeas etc. Formulation of complementary food can be made by using one or a combination of more than one plant product, cereal with legume (Akpapunam and Dedeh, 1995).

In Nigeria as in most other developing countries, infant

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complementary food consisting mainly of un-supplemented cereal pap made from maize, sorghum and or millet are grossly inadequate in some macro- and micronutrients (Nnam, 2000). Adequate processing and judicious blending of locally available foods could result in improved intake of nutrients to prevent malnutrition problems. Maize, groundnut, pawpaw and mango are readily available foods in Nigeria. They have promising nutritional attributes. Maize protein in common varieties varies from about 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, 1992; Okoh, 1998). The crude protein content of most legumes varies between 16.0% in bambara groundnut to 35.1% in soybeans. Soy protein is limiting in essential sulphur containing amino acids (methionine, cysteine, etc), but rich in lysine and tryptophan (FAO 1992). Hence soybean could form a good supplement to maize which is low in tryptophan (FAO, 1992; Elegbede, 1998). Maize contains high levels of dietary fiber (12.19%) but is low in 'trace minerals and ascorbate. 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*), soybeans (*Glycin max*) and bambara groundnut (*Voandixia subterranean)*, regarded as good sources of calcium and iron (Elegbede, 1998).

Complementary foods in developing countries are often low in fat and essential fatty acids, which are required for growth and development. Non-breastfed children in developing countries are thus often at higher risk of inadequate fat intake. Animal-source foods such as milk are important for complementary feeding as they provide high quality protein, bioavailable micronutrients, and have low levels of anti-nutrients and fibre. However, these are unaffordable for majority of the population in Sub-Saharan African countries like Nigeria. Consequently, most mothers use local alternatives to milk such as soy beans to complement cereals such as maize, millet and rice gruels. Soybean contains about 19% fat. It is low in saturated fat, cholesterol-free and high in many important nutrients such as B-vitamins, calcium, potassium, magnesium, fiber and isoflavones, iron and vitamin D (USDA, 2007).

Fruits and vegetables are valuable sources of vitamins and minerals and could provide significant quantities of micronutrients when blended with maize diets. Carrot (*Dacus carota L.*) is one of the popular root vegetables grown throughout the world and it is the most important source of dietary carotenoids in Western countries including United States of America (Block, 1994, Torrento et al., 1996). Carrot contains high amounts of pro -vitamin A in the form of beta carotene which when metabolized, is converted to vitamin A in the liver. Carrot seed oil also contains potassium, vitamin B6, copper, folic acid, thiamine and magnesium. It also provides protection against heart disease, stroke and is necessary in the building of strong bones and healthy nervous system (USDA, 2007, WHO, 2009).

The micro and macronutrient deficiencies of complementary foods could be responsible for certain growth and development disorders. There is therefore the need to formulate and evaluate the nutrient constituents and acceptability of improved complementary foods. This study was therefore aimed at the formulation, evaluation of proximate and micronutrient composition and sensory properties of traditional fermented maize supplemented with soybeans and carrot flours.

MATERIALS AND METHODS

Preparation of the fermented maize, soybean and carrot flour

The yellow variety of maize (*Zea mays*), soybean (*Glycine max)* and carrot (*Dacus carota*) were bought from a local market (Mile 3) in Diobu, Port Harcourt, Rivers State, Nigeria. The fermented maize slurry was prepared as described by Obinna-Echem et al. (2015) with slight modifications. Briefly, after wet milling and sieving the resultant slurry was left to ferment in the water for 12 h. Thereafter, excess water was decanted, the slurry was dewatered using a muslin cloth and the cake obtained was dried overnight at 50°C. The dried fermented product was ground into powder using an electric blender (QBL-18L40, Taipei city, Taiwan) to obtain fermented maize flour (M). Three kilograms of sorted and washed soybeans were blanched at 85°C for 2 min, and then soaked in 6 L of water for 24 h with a change of water after every 6 h. The soybean seed testae were removed, the seeds washed and dried in a cabinet at 50°C for 24 h. The product was milled with hammer mill and sieved with a sieve size of 150 µm to obtain the fermented soy flour (S). Fresh carrots were washed and the outer layers scraped. About 3 kg of the carrot were grated, dried at 50^{o}C for 8 h and blended with hammer mill to obtain carrot flour (C). The prepared flours were packaged separately in well labelled plastic containers and preserved in a deep freezer until required for use.

Recipe formulation for the Maize, Soybean and Carrot (MSC) complementary food

Maize flour was supplemented with different proportions (0, 5, 10, 15, and 20 %) each of the soybeans and carrot flour as shown in Table 1. To obtained a homogenous flour, the different combinations were individually homogenized in a rotary mixer (Philips, type HR 1500/A, Holland), and then stored in airtight plastic containers and preserved in a deep freezer until required for analyses. Fermented maize flour without any substitution and branded proprietary maize based complementary food

Table 1. Recipe for the formulation of maize-soybean-carrot complementary Food.

Sample ID	Maize Flour (%)	Levels of Substitution (%)	
		Soybean Flour	Carrot Flour
A	100	0	0
B	90	5	5
C	80	10	10
D	70	15	15
E	60	20	20

served as negative and positive controls respectively.

Proximate analysis

Proximate analyses were carried out on the samples using standard AOAC, (2005) methods. Moisture content was calculated after drying at 105°C to constant weight in an air oven (Thermo Scientific-UT 6200, Germany). Lipids were estimated by exhaustive extraction of known weight of samples with petroleum ether using rapid Soxhlet extraction apparatus (Gerhardt Soxtherm SE-416, Germany). Determination of protein was by Kjeldahl method. The efficiency of the nitrogen values were corrected with acetanilide values and multiplied by the factor of 6.25 to obtain the protein value. Ash was determined gravimetrically after incineration in a muffle furnace (Carbolite AAF-11/18, UK) for 24 h at 550°C. Crude fibre was obtained by difference after the incineration of the ash-less filter paper containing the insoluble materials from the hydrolysis and washing of moisture free defatted sample (0.5 g). Carbohydrate content was determined by the difference: 100% - (% MC + % Ash + % Crude protein + % Fat + % Crude fibre). Energy (Kcal/g) was calculated using the Atwater factor of 4.0 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat.

Determination of minerals

Calcium (Ca), potassium (K), magnesium (Mg), iron (Fe), copper (Cu) and zinc (Zn) content of the pap were evaluated using Atomic Absorption spectrophotometer (Perkin Elmer, 2380, Germany) according to the standard methods of AOAC, (2005).

Sensory analysis of the Maize, Soybean and Carrot (MSC) complementary porridge

Each of the various blends as shown in Table 1 was mixed with 200 mL of cold water to make slurry. Then equal part of boiling water was added to the slurry with continuous stirring to obtain the Maize-Soybean-Carrot (MSC) pap. Sensory properties (colour, mouth-feel, taste, texture and overall acceptability) of the pap from different soybean and carrot substitutions were carried out using a panel of 20 assessors consisting of nursing mothers, staff and students of the Department of Food Science and Technology, River State University of Science and Technology, Port Harcourt (Figure 1). The assessors are regular consumers of fermented maize porridges (Pap). The colour, mouth-feel, taste, texture and overall acceptability of the samples were evaluated in sensory evaluation boots. The coded porridge samples were presented in random order with a ballot sheet for each sample. The scores were based on a 9-point hedonic scale, with the degree of likeness of the product attribute. Assessors were instructed to score colour first and water was provided for rinsing the mouth. Expectoration cups with lids were provided for panelists who did not wish to swallow the samples.

Statistical analysis

Results were analyzed statistically by the analysis of variance and difference between means separated using the Least Significance Difference (LSD) procedure. The non-parametric Friedman test and 2-sample t-test were employed in determining the statistical differences among the product sensory attributes.

RESULTS AND DISCUSSION

Proximate composition of Maize, Soybean and Carrot (MSC) complementary food

The proximate compositions of the porridges are shown in Table 2. The control without soybean and carrot substitution had the highest ($P \leq 0.5$) moisture content of 12.59%. The decrease of the moisture content is as a result of addition of soy and carrot flour. This is good for the enhanced keeping quality of the product.

The fat and protein content of the samples increased ($P \leq 0.5$) with the increase in soy and carrot substitution.

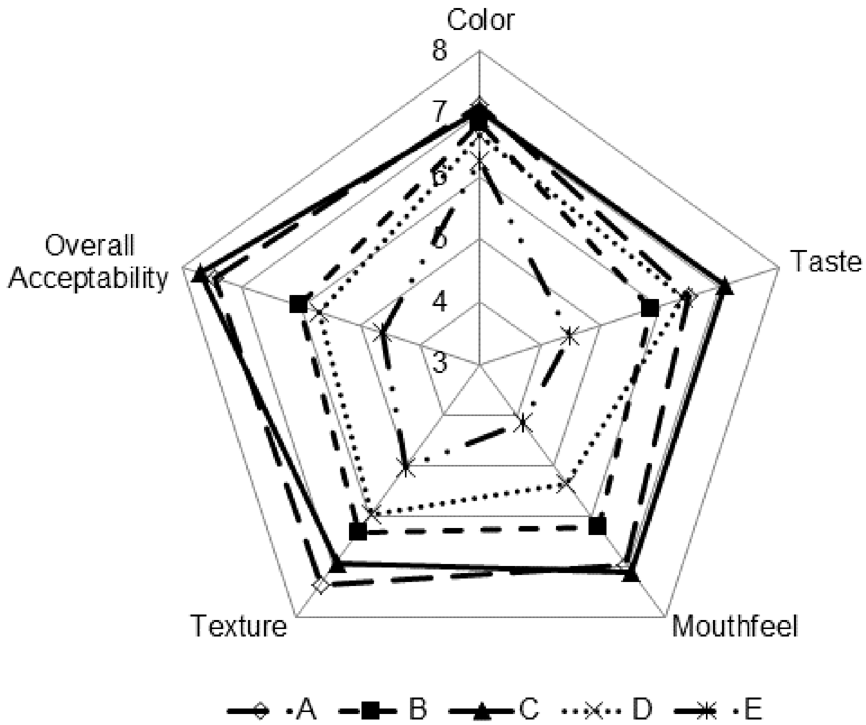

Figure 1. Sensory properties of a complementary food formulated from different blends maize, soybean and carrot flour.

A - 100% fermented maize, 0% soybean flour, 0% carrot flour
B - 90% fermented maize, 5% soybean flour, 5% carrot flour
C - 80% fermented maize, 10% soybean flour, 10% carrot flour
D - 70% fermented maize, 15% soybean flour, 15% carrot flour
E - 60% fermented maize, 20% soybean flour, 20% carrot flour

Table 2. Proximate composition (%) of a complementary food formulated from different blends maize, soybean and carrot flour.

Sample ID	% Substitution (M:S:C)	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate	Energy (Kcal/100g)
A	100:0:0	12.59 ± 0.46^{a}	0.56 ± 0.11^{d}	3.40 ± 0.11^{f}	11.66 ± 0.14^{d}	1.82 ± 0.00^{a}	70.00 ± 0.81^{a}	357.24 ± 0.00^{f}
B	90:5:5	9.32 ± 1.75^{b}	0.86 ± 0.10^{d}	5.35 ± 0.13^{e}	14.44 ± 0.00^{cd}	1.19 ± 0.00^{b}	68.85 ± 1.78^{a}	381.31 ± 00^{d}
C	80:10:10	11.19 ± 1.40^{ab}	1.32 ± 0.27^{c}	6.09 ± 0.20^{d}	17.99 ± 2.82^{bc}	0.28 ± 0.00^{c}	63.14 ± 4.29^{b}	379.33 ± 00^{e}
D	70:15:15	10.43 ± 0.21^{ab}	1.16 ± 0.22^{c}	7.04 ± 0.08^{c}	20.23 ± 1.17^{ab}	0.47 ± 0.00^{c}	60.70 ± 1.07^{bc}	388.08 ± 00^{c}
E	60:20:20	10.03 ± 0.6^{b}	2.00 ± 0.03^{b}	7.83 ± 0.06^{b}	23.99 ± 0.58^{a}	0.31 ± 0.00^{c}	55.86 ± 0.63^{c}	389.87 ± 00^{b}
PF	NA	NA	3.00^{a}	10.00^{a}	15.00^{cd}	NA	65.00^{b}	410.00^{a}
LSD		2.39	0.39	0.21	5.01	0.3	5.20	1.01

Values with the same superscript in the same column do not differ significantly ($P \leq 0.5$). (N=2±SD)
PF-Proprietary Complementary food
M:S:C – Fermented maize, soybeans and carrot flour

Sample with 20% substitution had significantly the highest fat and protein content of 7.83 and 23.99%, respectively. This increase could be attributed to the addition of soy flour. Proprietary complementary food used as a positive control had a protein content of 15%. This value is lower than that obtained for sample C (10% substitution). The higher protein content observed in the pap produced increased sequentially with supplementation of soybean and carrot flour. Maize is limiting in lysine and tryptophan. It is expected that the amino acid of soybean will complement that of cereal flour. The protein is important for tissue replacement, deposition of lean body mass and growth. Fat is important in the diets of infants and young children as it

Table 3. Mineral Content (mg/kg) of a complementary food formulated from different blends maize, soybean and carrot flour.

Sample ID	% Substitution (M:S:C)	Ca	Mg	P	Fe	Cu	Zn
A	100:00:00	260.00±14.14^{f}	365.00±7.07^{f}	890.00±14.14^{f}	254.33±7.67^{a}	0.88±0.02^{e}	4.82±0.10^{e}
B	90:05:05	265.00±7.07^{e}	400.00±28.28^{e}	1270.00±0.00^{e}	187.51±2.77^{b}	0.97±0.06^{d}	5.11±0.02^{d}
C	80:10:10	425.00±21.21^{d}	430.00±14.14^{d}	1485.00±35.36^{d}	186.17±2.87^{b}	1.21±0.02^{c}	5.54±0.00^{c}
D	70:15:15	510.00±14.14^{c}	640.00±98.99^{b}	1740.00±28.28^{c}	169.28±2.27^{c}	1.30±0.00^{b}	7.39±0.07^{c}
E	60:20:20	540.00±28.28^{b}	760.00±0.00^{a}	1795.00±7.07^{b}	160.34±0.76^{d}	3.36±0.08^{a}	7.58±0.05^{b}
PF		2145.00±35.36^{a}	565.00±21.21^{c}	2790.00±14.14^{a}	167.93±1.61^{c}	0.42±0.01^{f}	25.28±1.02^{a}
LSD		0.00	0.00	0.00	6.62	0.08	0.1

Values without superscript in the same column do not differ significantly ($P \leq 0.5$). (N=2±SD)
PF –Proprietary Complementary Food
M:S:C – Fermented maize, soybeans and carrot flour

provides essential fatty acids, facilitates absorption of fat soluble vitamins, enhances dietary energy density sensory qualities and the prevention of undesirable weight gain in infants. 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). However, the composition of this complementary food can be enhanced with available oil to increase the recommended fat ratio.

The commercial infant formula had significantly ($P \leq 0.5$) the highest ash content (3%) in comparison to the fermented samples. There was significant increase in ash content with increase in soy and carrot substitution. The increase is attributed to the soy bean and the carrot and this is an indication of availability of minerals.

The fibre content of the samples decreased with increased substitution. The negative control (100% maize flour) had significantly ($P \leq 0.5$) the highest fibre content of 1.82%. The fibre content for the maize, soybean and carrot flour samples ranged between 1.19 and 0.31 for the 5 and 20% soybean and carrot flour substitution, while the proprietary complementary food had no fibre. This is in line with the report that food used for complementary feeding should contain low fibre as fibre can displace the energy rich foods that children under two year need for growth (Michaelsen et al., 2000). Though, fibre may help to increase the nitrogen utilization and absorption of some other micronutrients.

The carbohydrate content of the samples decreased with increase in soy and carrot substitution. It ranged from 55.8 – 70.0% for the 20 and 0% substitution respectively. Maize is mostly a carbohydrate food hence the reduction in maize content resulted in decrease in carbohydrate content of the samples. The carbohydrate content of samples with 5, 10 and 15% (68.85, 63.14 and 60.70%) maize flour was not different ($P \leq 0.5$) from that of the proprietary food (65.00%). The significant ($P \leq 0.5$) differences in energy levels could be attributed to variations in protein and fat contents of the samples. With increase in soy and carrot increased. The daily protein and energy requirements for a 6-month-old male involved in moderate physical activity are 1.12 g kg^{-1} and 355 kJ kg^{-1} body weight respectively (WHO, 2007). An infant weighing 7.34 kg would require 8.2 g of protein and 2605.7 KJ of energy daily. Protein content of all the samples varied from 11.66 – 23.99%. The consumption of 100 g of the maize-soybean and carrot formulated infant complementary food would meet up to 142 to 282 % of the daily requirement for the infant. This varied significantly from the report of Obinna-Echem et al. (2015) where the fermented maize slurries had no substitution. The protein content of the 15 and 20% soybeans and carrot substitution was greater ($P \leq 0.5$) than the commercial infant formula. The fat and energy content of the formula was significantly ($P \leq 0.5$) higher in comparison to the fermented maize, soybeans and carrot pap. Substitution with soybeans and carrot flours increased the nutrient composition of the pap and would be recommended for good quality pap.

Mineral content of Maize, Soybean and Carrot (MSC) complementary food

The levels of the minerals: calcium, magnesium, phosphorous, copper, iron and zinc (Table 3) increased with increase in substitution except for iron. The increase in the mineral content of the maize, soybean and carrot flour blends confirms beneficial effect of supplementation (Lutter and Dewey, 2003). The calcium content of the maize, soybeans and carrot formulation ranged from 265 - 540 mg/kg for the 5 and 20% substitution respectively. The negative and the positive controls had significantly ($P \leq 0.5$) the least and highest values of 260 and 2145 mg/kg respectively. Calcium is necessary for optimal growth and development of infant and young children. Although the 20% substitution had significantly ($P \leq 0.5$) the highest calcium value among the test samples, the expression of the amount of calcium per 100 g of the sample as percentage of the recommended calcium intake for infants of 7-12 months, 400 mg per day (FAO 2001) was ≤ 15%. This is higher than the 3.2% for fermented whole grain maize slurry reported by Obinna-Echem et al. (2015). The increase could be attributed to the substitution with soybean and carrot. The Proprietary complementary food would meet ≥ 50% of the recommended calcium intake. This could be attributed to fortification with calcium.

The level of magnesium in samples varied significantly. The 20% substitution had significantly (P ≤ 0.5) the highest levels of magnesium (76.0 mg/kg). Expression of the amount of magnesium per 100 g of the sample as percentage of the recommended magnesium intake for infants of 7 - 12 months (54 mg day^{-1}) (WHO/FAO 2004) was >100% and >200% for the 20 % substitution level. The consumption of 100 g of the maize, soybeans and carrot complementary food would meet the daily requirement. Carrot is also a good source of magnesium (Silva Dias, 2014). Manganese is involved in over 300 metabolic reactions and is needed for bone, protein, making new cells, activating B vitamins, relaxing nerves and muscles, clotting blood, and in energy production (Guerrera et al., 2009). Potassium and magnesium in carrots help in functioning of muscles (Silva Dias, 2014). The substitution with carrot resulted in increase in magnesium in the formulated infant complementary food.

Phosphorus is an important constituent of every living cell. It is very essential in bone formation and other cellular reactions in the body (Berdanier and Zempleni, 2009). Phosphorus levels among the samples varied significantly (P ≤ 0.5). The levels of phosphorus in the maize, soybeans and carrot flour ranged from 1270 - 1795 mg/kg for the 5 and 20% substitution respectively. The negative and the positive controls had significantly (P ≤ 0.5) the least and highest values of 890 and 2790 mg/kg respectively. Expression of the amount of phosphorus per 100 g of the sample as percentage of the recommended phosphorus intake for infants of 7 - 12 months (275 mg day^{-1}) (WHO/FAO 2004) would meet about 65% for the 20% substitution level and >100% for the Proprietary complementary food. Substitution with carrot and soybeans flour contributed to the increase in phosphorus level of the formulation.

Copper is an essential trace element associated with many enzymes with the consumption of a variety of food is deficiency is rare (Berdanier and Zempleni, 2009). The level of copper (Cu) in the Proprietary complementary food (0.42 mg/kg) was significantly the least. In the maize, soybeans and carrot flour formulation copper levels ranged from 0.97 - 3.36 mg/kg. The increase in copper levels could be attributed to the substitution with soybeans and carrot flour. Expression of the amount of copper per 100 g of the sample as percentage of the recommended copper intake for infants of 7 - 12 months (0.22 mg day^{-1}) (WHO/FAO 2004) would met about 59% for the 15% substitution level and >100% for the 20% substitution level.

Iron content in the samples decreased with increased substitution levels. The negative control without substitution had significantly (P ≤ 0.5) the highest zinc level of 254.33 mg/g. The substituted samples had iron values between 160.34 and 187.51 mg/kg for the 20 and 5% substitution respectively. Consumption of 100 g of the maize, soybean and carrot flour formulated complementary food will meet <130% of the recommended iron intake for infants of 7 - 12 months (11.6 mg day^{-1}) (WHO/FAO, 2004). This is very important as iron is essential for formation of blood cells and the prevention of anaemia in infants and children

Zinc is an important co-factor for more than 70 enzymes and plays a central role in cell division, protein synthesis and growth. Zinc deficiency will result to growth failure, anemia, enlarged liver and spleen, impaired skeletal development. Zinc content of the samples increased with increase in substitution. The value ranged between 5.11 and 7.58 mg/kg for the 5 and 20% substitution respectively. Consumption of 100 g of the maize, soybean and carrot flour formulated complementary food will meet <10% of the recommended zinc intake for infants of 7 - 12 months, 8.6 mg day^{-1} (WHO/FAO 2004).

Sensory evaluation

There are significant differences (P ≤ 0.5) among the samples in colour, taste, mouthfeel, texture and over-all acceptability (Table 1). The 10% substitution had (P ≤ 0.5) the highest score for taste, mouthfeel and overall acceptability, while the 20% substitution had the lowest scores. Pap made from 100% fermented maize flour (control) and those produced from the composite flour of 5% - 20% levels of substitution were generally acceptable. The increase in substitution resulted in decrease in acceptability of the pap as indicated by the significantly (P ≤ 0.5) low values for the 20% substitution. The variation observed in the color, could be due to the increased substitution of the soybean and carrot flour and the addition of sugar which gave the pap a slightly dark coloration. Colour darkening of pap can be attributed to sugar caramelization and the maillard reactions between sugar and amino acids. The 20% substitution also was reported to have crumbly texture and a beany flavor, attributable to the increased substitution and the beany flavor of soybean. Panelist described pap from the 10% substitution as having the best test, mouth-feel and overall acceptability. This 10% level of substitution though not the highest in other nutrients better meets the consumers sensory attributes. It therefore implies that there is need for further investigation on processing methods to enhance the overall acceptability of higher substitution levels.

Conclusion

Proper selection of this combination of locally available food can be used as home-based complementary foods.

The blends formulated in this study could be used by mothers to feed their infant and children during the complementary feeding period. Its protein and energy, and mineral content that meet the recommended daily requirement is an advantage for the growth and wellbeing of the child, in addition to the affordability of the local raw materials for the preparation of the complementary food. The 10% substitution would be recommended as that was significantly (P≤ 0.05) the most acceptable to the assessors.

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