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Comparative Evaluation of five formulated Maize-Soybean Complementary foods and a commercial Complementary Food

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Abstract

This study evaluated the nutrient, sensory and functional properties of complementary food formulated from maize-soybean blends. Clean maize grains (1.5kg) were parboiled (100^{0}C, 15min), washed and fermented overnight (24h) in cold water. This was washed, oven-dried (50^{0}C, 24h), coarsely ground and the seed coats winnowed out. Also, clean soybeans (1.5kg) were soaked in water for 90min, dehulled and cooked for 45min. This was washed, drained and oven-dried (50^{0}C, 48h) The maize sample was blended in proportions with 0%, 10%, 20%, 30% and 40% of the soybean sample to give 500g of each of the blends, A, B, C, D and E respectively which were separately milled into flour. These were sieved into fine powder using a 4mm sieve. Each of the blends was mixed with sucrose 25%), sodium citrate (2%), vegetable oil (1.75%) and common salt (0.5%). This was blended into fine powder and analyzed alongside with a commercial infant formula for physicochemical and sensory properties. The formulated weaning foods were relatively high in nutrient contents. All the samples had safe, low moisture content of 4.72 to 6.32%. Protein content increased from 10.15% in the 100% maize and the commercial samples to 20.05% in the 40% soybean blends. Also carbohydrate content ranged from 62.27% in E to 74.5% in F, crude fibre increased with increasing soybean addition in the formulated samples and ranged from 0.97% in A to 1.47% in D but was 1.01% in the control (F). Maize-soybean complementary blends gave better consistency and homogenous mixes of the gruel, and could balance the limiting essential amino acids of both in the complementary foods. The minerals (mg/100) calcium, potassium and phosphorus were high in samples A, B, C and D while magnesium (mg/100) was high in E (8.46). There were significant differences ($P < 0.05$) in appearance, texture, flavour, mouth feel and overall acceptability of the samples. Soybean in combination with maize produced better quality of complementary foods and is therefore recommended for infant formula. Complementary food D with 30% soybean addition had the best balanced nutrient composition and functional properties than every other of the samples; and is therefore recommended the best of all the samples.

Keywords: Maize, soybean, complementary food, quality.

Introduction

Weaning period is a phase during which some soft, easily swallowed food, adequate enough to complement the mother's breast milk supplies an increased proportion of the child's nutritional requirements and gradually replaces the breast milk altogether (WHO, 2004). It is a critical phase when the digestive and physiological system of the infant undergoes developmental changes for adaptation. As a result, weaning has received considerable attention from nutritionists (Ezeji and Ojimelukwe**,** 2001). Weaning provides additional energy and nutrients to aid normal feeding development such as swallowing and chewing in the growing infant (Hofvander and Underwood, 2000). As from 4-6 months the mothers' breast milk becomes increasingly inadequate to support the nutritional demands of the growing infant. It becomes exceedingly important to introduce some soft, easily swallowed food adequate enough to complement the mother's breast milk for the required energy and nutrients (Uvere and Ukaoha, 2003).

In the developing countries, commercial weaning foods available in the markets are expensive for the average families to afford. Most nursing mothers often depend on normal adult foods such as mashed boiled yam, beans, stewed and jollof rice, and sometimes on traditional weaning foods to wean their babies. These traditional complementary foods are mainly fermented starchy foods. They are mainly composed of cooked gruels prepared from fermented starchy pastes from cereals such as rice, maize, sorghum and millet. In Nigeria, these cereals are not evenly distributed across regions. Maize remains the staple cereal in the Southern zone; maize and sorghum in the Western; sorghum and millet in the North-Central; and millet in the far Northern zone. Maize is the most common cereal used in Abia State, one of the states in the Southern zone of Nigeria. In most cases the steps involved in the preparation of pap from maize are steeping in cold water for about 4 to 18 hours, wet-milling, wet-sieving and decanting to get the solid starchy paste (Inyang and Idoko, 2006). A blend of cereals and legumes in complementary food is recommended for adequate nutrition where animal protein is not always affordable. In this study, blends of maize and soybean which are readily available in Nigeria are investigated for adequate nutrients to meet the nutritional needs of the infants.

Materials and Methods

Materials: Mature, wholesome soybean, yellow maize, common salt and granulated sugar were purchased from Lafia Main Market, Nasarawa State, while vegetable oil and sodium citrate of food grade were purchased from a certified Food Chemical Store at Ojota Market, Lagos State, all in Nigeria.

Formulation of Maize-soybean weaning foods: Clean soybeans (1kg) were soaked (6 h) in excess lime water (juice extracts of 6 limes in 4 litres of water) for 30min and then dehulled manually. This was washed thrice in clean water, boiled for 30min, and then drained out of water and then oven-dried (50^{O}C; 48h). Also, clean maize grains (l.5kg) were parboiled for 15min (100°C), cooled and fermented in excess cold water for 24h and then washed twice with clean water. This was oven-dried (50^{O}C; 48h), cooled, coarsely ground using an attrition mill and then winnowed to remove the seed coats. The parboiled maize was blended with the fermented soybeans in the ratio of 10:0 (A), 9:1 (B), 8:2 (C), 7:3 (D) and 6:4 (E) to give 500g of each blend. Each blend was milled into fine flour, sieved through 2mm fine sieve and re-milled using an attrition mill. Each batch was blended with 1.5% Sucrose, 1.2% sodium citrate, 1% vegetable oil and 0.5% sodium chloride. These were milled together with an attrition mill and then blended using warring blender (Binatone) (Table 1).

Table 1: Recipe for the maize-soybean complementary foods

Ingredients	**A**	**B**	**C**	**D**	**E**
Maize (%)	77.6	70.0	62.0	54.0	54.0
Soybean (%)	0.0	7.6	15.6	23.6	31.6
Sucrose (%)	19.0	19.0	19.0	19.0	19.0
Sodium citrate (%)	1.6	1.6	1.6	1.6	1.6
Vegetable oil (%)	1.4	1.4	1.4	1.4	1.4
Sodium chloride (%)	0.4	0.4	0.4	0.4	0.4

Proximate analysis: Moisture, crude protein (%N x 6.25), fat, crude fibre and ash contents of the complementary foods were determined in triplicates using the methods of AOAC (2012). Carbohydrate content was determined by difference (by subtracting the sum of % moisture,

% crude fat, % crude protein, % ash and % crude fibre from 100%).

Mineral content determination: The mineral contents; calcium, iron, potassium, sodium, zinc, copper and calcium of the complementary foods were determined on the ash samples after dissolving in distilled water, using a Buck Model 200A flame atomic absorption spectrophotometer while phosphorus content was determined using the molybdovadate method (AOAC, 2012)

Vitamin contents determination:

Vitamin C (ascorbic acid) contents of the freshly prepared complementary foods were determined using the iodometric titration method (Andrade *et al*., 2002). The ß-carotene contents of extracts from homogenate of the complementary foods were determined by the spectrophotometirc method at 328nm as described by Onwuka (2005).

Niacin content was determined according to the method of Eitenmiller and DeSouza (1985). Ground spice sample (50 g) was admixed with 200 ml of 1N H_2SO_4 to extract niacin. This was autoclaved at 121 ^{O}C for 30 min, cooled and the pH adjusted to 4.5 before diluting to 250 ml mark. The mixture was filtered and purified by pipetting 40 ml of filtrate into a 50 ml volumetric flask containing 17 g $(NH_4)_2SO_4$, shaken and then filtered. To develop the colour, 1 ml of each filtrate and standard solution were pipetted into two separate test tubes. Then, 0.5 ml of 2 % aqueous NH_4OH, 2.0 ml of 2 % H_2SO_4 solution and 0.5 % of dilute HCl were added to each tube and mixed vigorously. Exactly 5.0 ml of H_2O was added into the filtrate while 5.0 ml of CNBr was added into the niacin standard; and both shaken vigorously. Both mixtures were allowed to stand for 2 min after which absorbance was read against a standard at 430 nm and niacin content extrapolated from niacin standard curve.

Riboflavin content was determined according to the method of AOAC (2012). Each of the complementary foods (5 g) was mixed with 50 ml of 0.2N HCl in a 100 ml conical flask, boiled for 1h and cooled under tap water. The pH of the mixtures was adjusted to 6.0, using 0.5 M NaOH solution and then readjusted to 4.5 using 1N HCl to facilitate precipitation of all interfering materials. It was diluted to the 100 ml mark of flask and then filtered through a double-fold filter paper. Ten (10) ml of the filtrate was added to each of four separate test tubes. To each of first two test tubes was added 1ml of distilled water while to each of the remaining two test tubes was added 1ml of riboflavin standard (0.5 µg / ml). One (1.0) ml of glacial acetic acid and 0.5 ml of 3% $KMnO_4$ were added to each of the tubes and the tubes shaken vigorously. Fluorescence was measured at

440nm extinction and at 565 nm emission for the sample tube containing water, and then repeated on the same sample after mixing with 20 mg of $Na_2S_2O_4$. Fluorescence of standard at same 440 nm excitation and 565nm emission was also measured.

Riboflavin concentration was calculated with the expression:

$$\mu g \text{ Riboflavin} / g \text{ sample} = [(A - C) / (B - A)] \times (S / V) \times (F / W)],$$

where A = Fluorescence of sample containing water, B = Fluorescence of sample containing riboflavin standard, C = Fluorescence of sample containing $Na_2S_2O_4$, S = Concentration of standard (µg / ml), V = Volume of sample extract used for fluorescence measurement, W = Weight (g) of sample used, F = Dilution factor.

The method of AOAC (2012) was used to determine thiamin content in the complementary foods. Five grams of each of the food samples was **homogenised with ethanolic sodium hydroxide (50 ml) solution. Each** homogenate was filtered into a 100 ml flask, and 10 ml of the filtrate pipetted into a test tube to which 10 ml of potassium dichromate was added to develop colour. A blank sample was prepared and the colour also developed. Absorbance of each sample was read at 360 nm. A standard solution was prepared using thiamic acid to get 100 ppm and serial dilutions of 0.0, 0.2, 0.4 and 0.8 ppm was made. This was used to plot a calibration curve from which thiamin contents of the spices were extrapolated using the absorbance values.

Analysis of functional properties

Water absorption capacities: Water absorption capacities (WAC) of the complementary foods were determined as described by Abbey and Ibeh (1988). Complementary food samples (1 g for each) were mixed with 10ml of distilled water in centrifuge tubes to form suspensions. The suspensions were agitated for one hour on a griffin flask shaker and then centrifuged for 15 min at 2200 rpm. The volume of water on the sediment was measured, and water absorption capacities calculated as ml of water absorbed per gram of flour.

Least gelation concentration: Least gelation concentrations of the complementary foods were determined using the method of Abbey and Ibeh (1988). Suspensions of 2%, 6%, 8%, 12%, 14%, 18% and 20% (w/v) of each of the complementary foods in 5ml distilled water in sets of 6 test tubes were prepared. The test tubes containing the suspensions were heated for 1 h in a boiling water bath, cooled rapidly under running tap water and further cooled for 2 h in a refrigerator at $4^{O}C$. The least gelation concentration was regarded as that concentration at which the sample from the inverted test tube did not fall or slip.

Viscosity: The apparent viscosity was determined using Oswald Viscometer. Ten grams of each of the flour samples was suspended in 100 ml of distilled water and stirred mechanically for 2 h at room temperature. The slurries were suspended in the holding cup of the viscometer and the apparent viscosities measured. Three readings were taken per replicate and two replicates were taken per sample (Martinez-Flores *et al*., 1998).

Analysis of sensory properties: Sixteen trained panellists of mothers between 21-36 years of age were drawn from 23 volunteers from staff and students of College of Agriculture, Lafia, Nasarawa state, Nigeria. Out of twenty-three volunteers interviewed, 16 were chosen based on their knowledgeable and frequent use of both commercial and traditional complementary foods, pap, to wean their newborns. The 16-member panellists were trained according to the method of Mellgaard *et al.* (1991). The panelists sat comfortably in the Sensory Evaluation Room of the Demonstrating Canteen of Department of Home and Rural Economics, College of Agriculture, Lafia, Nasarawa Staten, Nigeria. They were provided with score sheets coded on a 9- point hedonic scale with 1 for extremely disliked and 9 for extremely liked. Each of the six (6) complementary foods, including a commercial formula (F), was gelled into gruel of pourable consistency using a standard recipe of 100 ml of boiling water to gel 15g of each of the weaning food. The panelists consumed and scored intensities of standard sensory attributes of the gruels at about $36\pm2\ ^{0}C$, using the score sheet for appearance, flavour, mouth-feel, texture and overall acceptability.

Statistical analysis: Data were analysed using the general linear model (GLM) procedure with SAS software statistical package (SAS, 2003). Data generated were subjected to Analysis of Variance and difference between means determined by Least Significant difference (LSD) of 0.05 P value.

Results and Discussion

Proximate composition of weaning foods: Table 2 shows proximate composition of the maize-soybean complementary foods. Sample F was a popular commercial weaning food in this country used in this study as a positive control while sample A was a 100% yellow maize-based complementary food also used as a negative control. The moisture content (%) of the complementary food samples ranged from 4.72 in E (with 50% soybean) to 6.32 in C (with 20% soybean); the 100% maize-based complementary food (A) had 5.37%

moisture content while the commercial sample (F) had 5.73% moisture. Complementing maize with soybean significantly ($p<0.05$) increased moisture contents (%) of the blends from 5.37% in the 100% maize-based sample to 5.55% at 10 (B) and to 6.32% at 20% (C) soy additions. However, at subsequent complementation with 30 (D) and 40% (E) soybean, the 5.37% moisture content of the 100% maize-based (A) food decreased to 4.96 and 4.72% respectively. This implies that soybean increased protein contents of the blends; and that more hydrophilic sites of the soy proteins were exposed allowing more water to migrate in at 10 to 20 % addition in the blends. On the other hand, the decrease of moisture content in the blends at higher 30 to 40 % soy addition suggests hydrophobicity, probably due to increased fat content from the soybean. The moisture content was less than 12% (the maximum safe level for good keeping quality of food at ambient condition in the Tropics) in all the samples. The lower the moisture contents of a product, the better for the product; to prolong its shelf-life especially in rural areas where storage facilities may not be available. Also, higher moisture content encourage caking of complementary food (flour) and results in poor consistency of the gruel when prepared (Onuorah and Akinjide, 2004). Moisture contents (%) of ≤ 12, and as low as 6.32 to 4.72 imply high keeping quality of these complementary foods.

Carbohydrate (%) content decreased with increasing soybean addition from 74.59 in complementary food containing 100% maize (A) to 62.27 in E with 40% soybean addition while the commercial weaning food (F) had 71.55%. carbohydrate. Carbohydrate content (%) was 60.60 in the blend with 10% soybean (B), 66.18 in the blend with 20% soybean (C) and 62.68 in the blend with 30% soybean (D). Both the negative (A) and positive control complementary (F) food had higher carbohydrate content than the maize-soybean complementary blends. Protein content of the 100% maize blend and the commercial samples were 10.15% and 15.85% respectively while this increased with increase in the addition soybean from 14.97% in B (10% soybean) to 20.05% in E (40% soybean). Thus, protein content increased with increase in soybean in the samples. Fat contents (%) of the complementary food samples were significantly ($p < 0.05$) higher (6.12 to 10.42) than that (3.37) of the commercial sample (F). Progressive increase in fat content was observed as the addition of soybean increased. Higher quantity than the 3.37% fat found in the commercial complementary food is needed for the infants, but of most important is the quality of the fat. Polyunsaturated fatty acids (PUFA) are the most needed type in the food; and soybean is a good source of these (Emmanuel-Ikpeme *et al.*, 2012). The ash contents (%) were 2,78 in A, 2.86 in B, 2.96 in C, 2.98 in D, 2.59 in E and 2..39in F (the commercial control sample). Also, the laboratory complementary food samples had higher ash contents than the commercial sample, and this increased with increasing soybean content. Generally, diets high in fat contribute significantly to their energy supply to human while the protein content gives an indication of their nutrient quality. Traditional infant foods generally have high carbohydrate but low protein contents which manifest in protein-energy malnutrition. Increasing soybean contents in the complementary blends improved the content and quality of protein of the complementary foods. Fermented soybean contains over 30% crude protein with improved amino acid profile (Ikpeme-Emmanuel *et al.*, 2009). Blending fermented maize with fermented soybean will subsequently improve nutritional value of the complementary foods. Moreover, maize is deficient in the essential amino acids lysine and tryptophan while soybean is deficient in the sulphur-containing amino acids methionine and cystine (Ghasemzadeh and Ghavidel, 2011). The blends maize and soybean balances these and other essential amino acids in the complementary foods.

Table 2: Proximate composition of complementary foods from fermented maize-soybean blends

Samples	Moisture	Carbohydrate	Protein	Fat	Total ash	Crude fibre
A	5.37^{d}	74.59^{a}	10.15^{e}	6.12^{e}	$2,78^{d}$	$0..97^{f}$
B	5.55^{c}	68.60^{C}	14.97^{d}	6.82^{d}	2.86^{C}	1.13^{C}
C	6.32^{a}	66.18^{d}	$I5.67^{c}$	7.41^{C}	2.96^{b}	1.43^{b}
D	4.96^{e}	62.68^{e}	17.46^{b}	10.42^{a}	2.98^{a}	$1\ .47^{a}$
E	4.72^{f}	62.27^{f}	20.05^{a}	9.43^{b}	2.59^{e}	1.05^{d}
F	5.73^{b}	71.55^{b}	15.85^{C}	3.37^{f}	2.39^{f}	1.01^{e}
S.EM	0.04	0.02	0.001	0.02	0.02	0.003

Values are means of 3 determinations ± standard deviation, means on the same column with different superscript are significantly different at $P < 0.05$. Samples A, B, C, D, and E are maize-soybean complementary foods with 0, 10, 20, 30 and 40 % soybean respectively while F is a commercial infant formula.

Mineral contents determination:

Table 3 shows the mineral contents of the complementary foods. They have high contents of calcium, sodium, potassium, magnesium, phosphorus and zinc. Calcium content mg/100g) in the complementary food samples ranged from 156.4 in E with 40% soybean addition to 446.27 in D with 30% soybean addition, sodium (mg/100g) from 275.28 in A with 100% maize to 480.34 in D, potassium (mg/100g) from 18.25 in A to 43.33 D, magnesium (mg/100g) from 1.28 in A to 1.86 in E with 40% soybean addition, and zinc (mg/100g) from 1.35 in A to 2.45 in D. Phosphorus content (mg/100g) decreased 7.01 in the 100% maize-based food to 3.96 in the maize-soybean complementary foods. While all the metallic minerals increased, the only one non-metallic mineral analysed, phosphorus decreased with increase in the addition of soybean. This implies that soybean is deficient in phosphorus-containing compounds but rich in most of the metallic minerals. Phosphorus content, although decreased with the addition of soybean but was adequate (3.96 to 7.01 mg/100g) in all the blends and commercial infant formular. Phosporus is essential for bone mineralization as well as in structural development of cellular membranes, nucleic acids and nucleotides, including adenosine triphosphate (Vitabase, 2009). Magnesium is essential in enzyme systems and helps to maintain electrical potential in nerves.

The potassium (K): sodium (Na) ratio in the complementary food samples indicated high sodium than potassium in the food samples. Dietary intake leading to reduced consumption of potassium than sodium has health implications such as hypertension and high blood pressure.

Diets with high K: Na ratios are recommended for healthy living but these are found usually in whole plant foods (Arbeit *et al.*, 1992). According to Kemi *et al.* (2010), dietary phosphorus intake alone can be deleterious to bone through increased parathyroid hormone (PTH) secretion; but adverse effects on bone increases when dietary calcium intake is low. There is a hypothesis that if there is more phosphorus than calcium in the diet, the body will start taking calcium from its own reserves (the bones) to compensate. Over a period, this may drastically affect the bones (Patenaude, 2007).

Iron content (mg/100g) was generally low in all the samples, and ranged from 0.69 in the 100% maize-based complementary food (A) to 1.12 in D with 30% soybean addition. Iron content was significantly ($p < 0.05$) higher (1.21mg/100g) in the commercial infant formular (F) than in the complementary food samples where it ranged from 0.69 to 1.12mg/100g. Iron is an important constituent of haemoglobin found in blood and is important in oxygen carriage of blood. According to The National Academy of Science (2004), the recommended daily allowance of iron is between 8 mg/day to 18 mg/day. Thus only complementary food with 30% soybean (D) which has 1.12 mg/100g iron and the commercial infant formular (F) which is the positive control and has iron content of 1.22mg/100g) can meet this recommended dietary iron need at 800g or more of the complementary food per daily consumption (The National Academy of Science, 2004). Increasing soybean content in the blends increased contents of metallic minerals but decreased contents of the non-metallic mineral, phosphorus in all the complementary foods. The sample with 30% soybean (D) was significantly ($p < 0.05$) higher in these minerals than the other samples, and therefore was the best in terms of mineral content. The complementary food sample D with 30% soybean had overall highest mineral contents than every other maize-soybean complementary foods and the commercial infant formular (the positive control), and is recommended the best for mineral content.

Table 3: Minerals composition (mg/100g) of complementary foods from fermented maize-soybean blends

Samples	Calcium mg/l00g	Magnesium Mg/l00g	Ironmg/ l00g	Phosphorus mg/l00g	Zinc mg/l00g	Sodium mg/100g	Potassium mg/100g
A	380.14^{C}	1.28^{d}	0.69^{e}	7.01^{a}	1.35^{f}	275. 28^{f}	18.25^{d}
B	300.49^{d}	1.43^{c}	0.76^{cd}	6. 89^{h}	1.6.6^{d}	287. 74^{e}	26.66^{c}
C	420.26^{b}	1.56^{b}	0.89^{C}	5. 42^{C}	1.68^{b}	310.86^{d}	40.26^{b}
D	446. 27^{a}	1.85^{a}	1.12^{b}	5.29^{d}	2.45^{a}	480. 34^{a}	43.33^{a}
E	156.40^{r}	1.86^{a}	0.66^{e}	3.96'	1.57^{e}	397. 39^{c}	I8.18^{e}
F	280. 36^{e}	1.27^{d}	1.21^{a}	4.25^{e}	1.67c	437. 26^{b}	16.92^{f}
S.E.M	0.000	0.001	0.003	0.008	0.036	0.002	0.002

Values are means of 3 determinations ± standard deviation, means on the same column with different superscript are significantly different at $P < 0.05$. Samples A, B, C, D, and E are maize-soybean complementary foods with 0, 10, 20, 30 and 40 % soybean respectively while F is a commercial infant formula.

Vitamin contents of the complementary foods

Table 4 shows the vitamin contents of the complementary foods. The complementary foods and commercial infant formular were generally poor in vitamins B_1, B_2, folic acid and vitamin D. None of these vitamins was up to 1.00 mg/100g in any of the food samples. All the vitamins increased with increase in soybean addition in the maize-soybean complementary foods. Thus, the soybean has more of these vitamins than the maize. Vitamin B_1 content (mg/100g) ranged from 0.59 in the 100% maize blend (A) and the 40% soybean blend (E) to 0.86 in the 30% soybean blend (D); B_2 (mg/100g) ranged from 0.43 in the E to 0.68 in D and was significantly ($p < 0.05$) lower (0.15 mg/100g) in the commercial infant formular (F) than in the complementary food samples. Among the complementary food samples, the 30% soybean blend (D) had the highest contents of vitamins B_1, B_2, D and folic acid. Also, the complementary blend with 30% soybean (D) was higher in most of the vitamin contents than the commercial infant formular which had claims of high vitamin fortification on the packaging. Complementing cereals with soybean is recommended to improve vitamin content of the complementary foods.

Table 4: Vitamin content of complementary foods from fermented maize-soybean blends

Samples	Vitamin B_1 (mg/100g)	Vitamin B_2 (mg/100g)	Folic acid (mg/100g)	Vitamin D (mg/100g)	Vitamin C (mg/100g)
A	0.59^{b}	0.47^{c}	0.24^{b}	0.32^{e}	1.02^{e}
B	0.66^{ab}	0.59^{b}	0.27^{b}	0.42^{C}	1.06^{C}
C	0.82^{a}	0.62^{ab}	0.28^{ab}	0.45^{b}	1.09^{b}
D	0.86^{a}	0.68^{a}	0.29^{a}	0.47^{a}	1.05^{d}
E	0.59^{b}	0.43^{c}	0.17^{c}	0.31^{f}	1.01^{f}
F	0.62^{b}	0.15^{d}	0.33^{a}	0.33^{d}	1.63^{a}
S.E.M	0.002	0.002	0.002	0.002	0.001

Values are means of 3 determinations ± standard deviation, means on the same column with different superscript are significantly different at $P < 0.05$. Samples A, B, C, D, and E are maize-soybean complementary foods with 0, 10, 20, 30 and 40 % soybean respectively while F is a commercial infant formula.

Functional properties of the complementary food samples

Table 5 shows functional properties of the complementary foods and commercial infant formular. Complementing maize with soybean from 10% to 30% increased water absorption capacity of the blends but further complementing with 40% soybean decreased water absorption capacity (WAC) of the blends. Water absorption capacity of the 100% maize complementary food was 26.7%, and increased to 30.0% and 36.7% in the respective 20% and 30% soybean blends. However, this 36.7% WAC of the 30% soybean blend decreased to 23.3% in the next 40% soybean blend. The 10% soybean addition showed no increase in water absorption capacity, indicating low increased protein content with limited hydrophilic sites. The increased water absorption at 20 to 30% soybean addition was due to increased water soluble protein which provided more hydrophilic sites for more water holding capacity in the blends. Also, the decreased WAC in the 40% soybean blend could be due to highly increased fat content of the sample which facilitated high hydrophobicity, repelling water imbibitions by the sample. Water absorption capacity in flours and powders indicate ability of the flours and powders to associate with water under conditions with limiting water. Flours with higher water absorption capacity yield thicker pastes when mixed with water. Such thick pastes limit calorific intake when fed to children but is of good quality as thickening agent in soups and sauces where such quality is desired. Odoemelam (2005) suggested that flours with high water absorption capacities could be of high content of hydrophilic proteins and/or polar amino acid residues.

Also, least gelation concentration (%) of the complementary foods ranged from 16.0 in the 10% soybean blend (B) to 18.7 in the 40% soybean blend (E). Least gelation concentration of the complementary food samples was significantly ($p < 0.05$) influenced by addition of soybean. The commercial complementary food (F) had least gelation concentration of 18.0%, exactly the same value for 20% soybean complementary blend (C), but was significantly ($p<0.05$) higher than 17.3% of the 100% maize-based (A) and 30% soybean (D) complementary food blends, and the 16.0% of the 10% soybean blend (B). The 40% soybean complementary food (E) had the highest LGC value of 18.7%. Least gelation concentration is a function of polysaccharide concentration, the amylase and amylopectin proportions in this polysaccharide, ionic strength and pH of the solvent and the influence of other food components in the complementary food samples (Wang and Steve, 2005). According to Udensi *et al.* (2001) gelation is an important property which influences the texture of food. As starch granules are heated in water they swell and form gel when the amorphous region becomes hydrated (Adebowale *et al.*, 2005). High least gelation concentration might be attributed to high quantity of the amorphous phase during heating in the presence of water. Flours with low least gelation concentrations are thickened easily with little flour concentration in hot water; and when used in infant formula need little dilution. This improves the energy density per unit volume of porridge prepared with such flours (Udensi *et al.*, 2001).

All the complementary food samples were of low apparent viscosities. The apparent viscosities ranged from 0.88 to 0.93, and there was no significant difference ($p > 0.05$) in the apparent viscosities of A, D and F, which ranged from 0.89 to 0.93. Samples C and D had apparent viscosities of 0.88. High apparent viscosity in infant formula suggests high content of carbohydrate, particularly of resistant starch. The low viscosities in these samples indicate high nutrient low density food. Soybean improved water absorption capacities but decreased apparent viscosities of the weaning food samples; and this implies better consistency and homogenous mixes of the gruel.

Table 5: Functional properties of complementary food from fermented maize-soybean blends

Samples	Water absorption capacity (%)	Least gelation concentration (%)	Apparent viscosity (%)
A	26.7^{c}	$17..3^{c}$	0.93^{a}
B	26.7^{c}	16.0^{d}	0.90^{a}
C	30.0^{b}	I8.0^{b}	0.88^{b}
D	36.7^{a}	17.3^{c}	0.89^{ab}
E	23.3^{d}	18.7^{a}	0.88^{b}
F	36.7^{a}	I8.0^{b}	0.90^{a}
S.E.M	3.16	0.50	0.03

Values are means of 3 determinations ± standard deviation, means on the same column with different superscript are significantly different at $P < 0.05$. Samples A, B, C, D, and E are maize-soybean complementary foods with 0, 10, 20, 30 and 40 % soybean respectively while F is a commercial infant formula.

Sensory properties of complementary foods

Table 6 shows the sensory properties of the complementary food samples. All the samples, both the complementary and the commercial, were acceptable to the sensory panelists; none scored less than 4.5, the mid-mark of the 9-point Hedonic scale used, in the sensory analysis test. The range of scores was from 7.11 to 8.44 for flavour, 6.61 to 7.89 for mouth-feel and 7.11 to 8.1 for over-all acceptability. The added Soybean significantly ($p <0.05$) influenced the different sensory attributes of the complementary foods differently, and changed with increasing addition of the soybean. However, the commercial sample, F, significantly ($p < 0.05$) scored highest values in the entire sensory attributes than every other sample. Ideally, it was rated the best in sensory quality, and was followed by A (100% maize blend) on over-all acceptability. Sensory properties of any food are the driving force for its acceptability in the society. However, sometimes it is abused by addiction due to prolonged consumption of particular brands of products. Thus consumers' liking for any food improves with time as the product is continually consumed. A new brand of a product sparingly accepted at the earlier period of its introduction may become highly acceptable with time. Thus, high nutrient content of a new brand of products must be rated first and high for grading food products.

Table 6: Sensory scores of the complementary food from fermented maize-soybean blends

Samples	**Colour**	**Texture**	**Flavour**	**Mouth feel**	**Overall acceptability**
A	$7.22^{c}\pm1.70$	$7.78^{ab}\pm0.88$	$7.22^{d}\pm1.35$	$7.28^{c}\pm1.28$	$7.22^{b}+1.17$
B	$8.17^{ab}\pm 1.10$	$7.78^{ab}\pm1.17$	$7.00^{ef}\pm0.97$	$7.38^{h}\pm 1.02$	$7.17^{c\ d}+1.10$
C	$7.39^{c}\pm1.19$	$7.89^{a}\pm1.23$	*$7.61^{cb}\pm1.15$*	$6.78^{e}\pm1.31$	$7.1l^{dc}$ +1 21
D	$7.11^{c}\pm 1.49$	$7.83^{a}\pm1.25$	$7.78^{b}\pm1.11$	$6.83^{d}\pm1.15$	$7. 11^{dc}+0.83$
E	$7.89^{b}\pm 1.78$	$7.56^{b}\pm 1.72$	7.11^{e}+l78	$6.6l^{f}\pm 1.58$	6.72^{d} +1 76
F	$8,44^{a}\pm 0.78$	$8.00^{a}\pm1.09$	$7.89^{a} + 0.68$	$7. 89^{a}\pm 0.62$	$8.11^{a}+ 0.58$
S.E.M	0.32	0.28	0.27	0.24	0.23

Values are means of 3 determinations ± standard deviation, means on the same column with different superscript are significantly different at $P < 0.05$. Samples A, B, C, D, and E are maize-soybean complementary foods with 0, 10, 20, 30 and 40 % soybean respectively while F is a commercial infant formula.

Conclusion

Blending maize with soybean improved the nutrient composition and functional properties of maize-based complementary food. Thus, the complementary blends were better than the negative control which had 100% maize. Also, all the complementary foods had higher nutrient contents than the commercial infant formular. Proximate, mineral and vitamin contents, and functional properties increased with gradual increase with the addition of soybean. Also, maize-soybean blends had better gelling ability and water absorption capacity than the 100% maize-based. Sample D (with 30% soybean) had the best nutrient composition and functional properties; and is recommended the best of all the samples. Complementing maize with soybean in complementary foods should be encouraged to promote good health of Nigerian child since both crops are cultivated and abundant in Nigeria.

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