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Full Length Research Paper

Evaluation of Nutritional and Organoleptic Properties of Maize-Based Complementary Foods Supplemented with Black Bean and Crayfish Flours

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The use of maize, black bean and crayfish flour blends in the formulation of complementary foods was studied. The maize, black bean and crayfish flours were blended in the ratios of 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25, respectively and used to formulate complementary foods. The proximate, mineral, vitamin and sensory properties of the formulated products were determined using standard analytical methods. The protein content of the samples increased as the ratios of black bean and crayfish flours increased from 8.70% in the control (100% malted maize flour) to 15.05% for the sample fortified with 25% black bean and 25%crayfish flours. The fat, ash and crude fibre contents of the blends showed similar increases from 2.35 -5.17%, 2.08-4.13% and 2.35-4.05%, respectively, while the carbohydrate decreased. The control and the sample substituted with 25% black bean and 25% crayfish flours had the highest (78.08%) and the least (65.34%) carbohydrate contents, respectively. The mineral composition of the complementary foods showed that the calcium, zinc, magnesium, iron, potassium and phosphorus contents of the samples varied between 11.10-14.15mg/100g, 3.90-5.36mg/100g, 3.57-5.78mg/100g, 3.79-5.68mg/100g, 4.61-6.02mg/100g and 5.51-8.02mg/100g, respectively. The vitamin content of the samples also showed that the ascorbic acid, riboflavin, niacin, vitamin E, vitamin A and thiamine contents of the complementary foods increased significantly ($p<0.05$) as the levels of substitution with black bean and crayfish flours increased in the products compared to the control sample which had the least values for all the vitamins evaluated. The colour, taste, mouthfeel and texture of the sample fortified with 10% black bean and 10% crayfish flours were significantly ($p<0.05$) the most acceptable to the assessors. Although the sample meets the consumers' sensory attributes, it is not relatively the highest in other nutrients. The study, however, showed that the developed complementary food samples could help to alleviate the problem of protein-energy malnutrition among infants and children in developing countries by providing them with adequate nutrients needed for optimum growth and development.

Keywords: Complementary foods, supplementation, nutrient composition, sensory properties, maize flour, black bean flour, crayfish flour.

INTRODUCTION

Breast milk provides all the nourishment a baby needs for the first six months of life. However, once an infant reaches six months, there is need to introduce semi-solid or solid foods into the diet of the infant to improve the nutrition, growth and development of the infant. Complementary foods are those foods given to older infants and young children once breast milk alone is no longer adequate to meet their nutritional needs after the exclusive period of breast feeding (Kleinman, 2004).

Complementary foods are generally introduced between the ages of six months to two years old as breast feeding is discontinued (WHO, 2009). Most infants suffer from malnutrition not mainly because of the economic status, but also due to inability to utilize the locally available raw materials to formulate infant foods that will meet their daily requirements (Ojinnaka *et al.*, 2013; Yusufu *et al.*, 2013). Complementary feeding is the period when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children that are less than five years of age all over the world (Ibironke *et al.*, 2004). Infant feeding and rearing practices have a major effect on short term and long term nutritional status of children as most of under nutrition is associated with faltering practices that occur in weaning period. Faulty feeding practices as well as lack of suitable complementary foods are responsible for under nutrition in older infants and young children (Daelmans and Saadeh, 2003). As in Nigeria and most other developing countries of the world, the high cost of fortified, nutritious and proprietary complementary foods is always beyond the reach of most Nigerian families. Such families often depend on inadequately processed traditional foods consisting mainly of un-supplemented cereal-based porridges made from maize, sorghum and millet which are grossly inadequate in some macro and micronutrients (Nnam, 2001). However, there is need for low-cost complementary foods that can be easily prepared at home and community kitchens from locally available food crops using the simple processing techniques that are within the reach of the general public in developing countries. Such foods can be more nutritious than most of the commercial brands that abounds in major markets. This approach would require the knowledge about the nutritional values of a variety of local food commodities that are indigenous to the affected communities. Maize (*Zea mays*), black bean (*Phaseolus vulgaris*) and crayfish (*Euastacus spp*) are food materials that are readily available in Nigeria and they have the potential to produce nutritious complementary foods when judiciously blended together. Whole maize grain is an important source of complex vitamins and some minerals like phosphorus, magnesium, calcium and iron (Ibironke *et al.*, 2012). The protein content of

maize is similar to that of wheat and sorghum with lysine as the most limiting amino acid. Black bean is a legume that contains better quality protein than most legumes. It is also rich in vitamins and minerals such as calcium, potassium, iron, phosphorus, vitamin C, folic acid, thiamine and vitamin B₆ (Audu and Aremu, 2011). Crayfish is one of the cheapest sources of animal protein. Generally, fish flesh contains mainly water, protein and fat with traces of carbohydrates, amino acids and other non-protein nitrogenous extractives, various minerals and vitamins (Onabanjo *et al.*, 2009). The fibres of crayfish are shorter than those of other meat and hence, they are easier to digest. The nutrient potentials of the triple mixes (maize, black bean and crayfish) as composites for use as complementary foods can be of great nutritional importance in the prevention of protein-energy malnutrition among infants and young children. This study was, therefore, conducted to evaluate the nutrient composition and sensory properties of locally formulated complementary foods from blends of maize, black bean and crayfish flour.

MATERIALS AND METHODS

The yellow variety of maize (*Zea mays*), black bean (*Phaseolus vulgaris*) and crayfish (*Euastacus spp*) used for the study were bought from Eke-Agbani Market, Enugu, Enugu State, Nigeria.

Preparation of Malted Maize Flour

The malted maize flour was prepared according to the method of Abasiokong *et al.* (2010). During preparation, one kilogramme (1kg) of maize grains which were free from dirt and other extraneous materials were manually winnowed and steeped in 3.5 litres of potable water in a plastic bowl at room temperature ($29\pm 2^{\circ}\text{C}$) for 24 h with a change of water at every 6 h to prevent fermentation. The soaked 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 moistened jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The grains were quietly spread on the jute bag and allowed to germinate in the germinating chamber at ambient temperature ($29\pm 2^{\circ}\text{C}$) and relative humidity of 95% for 120 h. During this period, the grains were sprinkled with water at intervals of 10 h to facilitate germination. Non-germinated grains were handpicked and discarded. The germinated grains were spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60°C for 20 h with occasional stirring of the grains

at intervals of 30 min to ensure uniform drying. The dried malted grains were cleaned and rubbed in-between palms to remove the roots and the sprouts. The 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 kept in a freezer until needed for further use.

Preparation of Malted Black Bean Flour

The malted black bean flour was prepared according to the method of Oladele *et al.* (2009) with slight modifications. During preparation, one kilogramme (1kg) of black bean seeds were sorted to remove the stones, dirt and other contaminants. The sorted seeds were thoroughly cleaned and steeped in 3 litres of potable water in a plastic bowl at room temperature ($29 \pm 2^{\circ}\text{C}$) for 18 h with a change of water at every 6 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 moistened jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The seeds were quietly spread on the jute bag and allowed to germinate at ambient temperature ($29 \pm 2^{\circ}\text{C}$) and relative humidity of 95% in the germinating chamber for 120 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. The germinated seeds were spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60°C for 18 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried black bean malts were cleaned and rubbed in-between palms to remove the roots and the sprouts along with the hulls. The dehulled 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 kept in a freezer until needed for further use.

Preparation of Crayfish Flour

The crayfish flour was prepared according to the method of Onabanjo *et al.* (2009). During preparation, one kilogramme (1kg) of crayfish was sorted to remove dirt and other extraneous materials and cleaned thoroughly with 2.5 litres of potable water. The cleaned crayfish was drained, spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60°C for 10 h with occasional stirring of the crayfish at intervals of 30 min to ensure uniform drying. The dried crayfish was 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 kept in a freezer until needed for further use.

Formulation of Complementary Foods

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

Chemical Analysis

The moisture, crude protein, fat, ash and crude fibre contents of the samples were determined in triplicate using standard analytical procedures (AOAC, 2006). Carbohydrate was calculated by subtracting the differences of moisture, protein, fat and ash from 100% (Okoye *et al.*, 2015). The calcium, zinc, magnesium, iron, potassium and phosphorus contents of the complementary foods were determined using atomic absorption spectrophotometer (Perker Elmer, 2380, Germany) according to the methods of AOAC (2006). The ascorbic acid, niacin, thiamine and riboflavin contents of the samples were determined according the methods of AOAC (2006). The vitamin A and vitamin E contents were determined using the flourimetric methods of Onwuka (2005).

Sensory Analysis

Porridges were prepared from both the control and the formulated complementary food samples. Fifty grammes (50g) of each sample of complementary food were mixed with 150 mL of cold water to make slurry. Thereafter, 100mL of boiling water was added to the slurry in each case with continuous stirring to obtain homogenous porridges. Two grammes (2g) of granulated sugar were added to each sample of the porridge. The porridges were evaluated for the attributes of colour, taste, mouthfeel, texture and overall acceptability in sensory evaluation boots using 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

Table 1. Proximate composition (%) complementary food samples

Sample ID	% Substitution MF:BBF:CF	Moisture	Protein (N x 6.25)	Fat	Ash	Fibre	Carbohydrate
A	100: 0 : 0	8.80 ^f ±0.28	8.70 ^f ±0.35	2.35 ^f ±0.10	2.08 ^f ±0.14	2.35 ^f ±0.10	78.08 ^a ±1.48
B	90 : 5 : 5	8.95 ^e ±0.42	10.97 ^e ±0.21	2.94 ^e ±0.17	2.67 ^e ±0.21	2.42 ^e ±0.06	74.07 ^b ±1.20
C	80 : 10 : 10	9.25 ^d ±0.19	11.87 ^d ±0.28	3.45 ^d ±0.24	2.97 ^d ±0.17	2.74 ^d ±0.11	72.47 ^c ±1.28
D	70 : 15 : 15	9.60 ^c ±0.17	12.98 ^c ±0.23	3.97 ^c ±0.21	3.38 ^c ±0.10	2.89 ^c ±0.04	70.30 ^d ±0.49
E	60 : 20 : 20	10.04 ^b ±0.11	13.85 ^b ±0.30	4.57 ^b ±0.16	3.75 ^b ±0.18	3.15 ^b ±0.10	67.77 ^e ±0.78
F	50 : 25 : 25	10.57 ^a ±0.15	15.05 ^a ±0.33	5.17 ^a ±0.12	4.13 ^a ±0.13	4.05 ^a ±0.15	65.34 ^f ±0.97

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, BBF - Malted black bean flour, CF - Crayfish flour

room temperature ($29 \pm 2^{\circ}\text{C}$). Clean water was provided to the judges to rinse their mouth in-between testing of the porridges to avoid residual effect. The judges were asked to assess and score the samples based on the degree of likeness and acceptance of the products using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Okaka, 2010). Expectoration cups with lids were provided for the panelists who were not interested to swallow the samples.

Statistical Analysis

The results were expressed as mean ± standard deviation and the test for statistical difference was performed 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 Duncan's New Multiple Range Test (DNMRT). 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 shown in Table 1. The moisture content of the samples ranged from 8.80 to 10.57%. The moisture content of the control and the sample supplemented with 25% black bean and 25% crayfish flours had the least (8.80%) and highest (10.57%) values, respectively. The low moisture content obtained in this study is in agreement with the report of Yusufu *et al.* (2013) for complementary food formulated from sorghum, African yam bean and mango mesocarp flour blends. The low

residual moisture content of the blends is advantageous in that microbial proliferation is reduced and storage life is enhanced and prolonged. The protein content of the formulated complementary foods varied significantly ($p < 0.05$) from each other. The protein content of the samples was observed to increase as the ratios of black bean and crayfish flours increased in the products. The exceptionally high levels of protein recorded by the formulated samples could be due to supplementation with black bean and crayfish flours. The observation is similar to the report of Nzeagwu and Nwaejike (2008) for sorghum-based complementary food supplemented with groundnut and crayfish flours. Protein is essential for tissue replacement, growth and development in infants and young children. The fat content of the complementary food samples which ranged from 2.35 to 5.17% increased significantly ($p < 0.05$) with increase in the proportion of crayfish flour in the products. The fat content obtained in this study was lower than the recommended 10% for complementary foods (FAO/WHO, 1991). Fat is important in the diets of infants and young children as it provides high energy density and facilitates the absorption of fat soluble vitamins. It also provides essential fatty acids such as omega-3 and omega-6 polyunsaturated fatty acids (PUFA'S) needed for proper neural development in infants and young children (Igyor *et al.*, 2011). The ash content of the formulated complementary food samples increased with increase in substitution with black bean and crayfish flours. The ash content of the samples ranged from 2.08 to 4.13% with control (100% malted maize flour) and the sample substituted with 25% black bean and 25% crayfish flours having the least (2.08%) and highest (4.13%) values, respectively. The ash content of a food material could be used as an index of mineral constituents of the food (Fusuan *et al.*, 2017). The ash content obtained in this study was higher than the ash content (0.56-2.00%) of complementary food formulated from fermented maize, soybean and carrot flours

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

Sample ID	% Substitution MF:BBF:CF	Calcium	Zinc	Magnesium	Iron	Potassium	Phosphorus
A	100: 0 : 0	11.10 ^f ±0.25	3.90 ^f ±0.11	3.57 ^f ±0.12	3.79 ^f ±0.10	4.16 ^f ±0.11	5.51 ^f ±0.07
B	90 : 5 : 5	11.94 ^e ±0.28	4.10 ^e ±0.09	3.81 ^e ±0.08	3.92 ^e ±0.14	4.84 ^e ±0.08	5.97 ^e ±0.16
C	80 : 10 : 10	12.40 ^d ±0.23	4.32 ^d ±0.14	4.02 ^d ±0.14	4.17 ^d ±0.08	5.20 ^d ±0.20	6.23 ^d ±0.81
D	70 : 15 : 15	13.03 ^c ±0.27	4.75 ^c ±0.09	4.28 ^c ±0.06	4.57 ^c ±0.16	5.36 ^c ±0.28	6.58 ^c ±0.14
E	60 : 20 : 20	13.75 ^b ±0.23	5.02 ^b ±0.14	5.02 ^b ±0.14	5.14 ^b ±0.11	5.57 ^b ±0.16	7.08 ^b ±0.20
F	50 : 25 : 25	14.15 ^a ±0.27	5.36 ^a ±0.12	5.78 ^a ±0.09	5.68 ^a ±0.07	6.02 ^a ±0.22	8.02 ^a ±0.23

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, BBF - Malted black bean flour, CF - Crayfish flour

reported by Barber *et al.* (2017). The crude fibre content of the complementary food samples varied between 2.35 to 4.05%. The significant ($p < 0.05$) difference between the fibre content of the control and those of the substituted samples could be due to the low fibre content of maize which formed the major ingredient of the formulated complementary foods. Although, fibre is one of the non-energy yielding nutrients, it helps to increase the nitrogen utilization and absorption of some micronutrients (Michaelsen *et al.*, 2000). The carbohydrate content of the complementary blends ranged from 65.34 to 78.08%. The carbohydrate contents of all the substituted samples were significantly ($p < 0.05$) lower than the control (100% malted maize flour). The increase in total carbohydrate content of the samples is principally due to increase in the proportion of maize flour used. The high carbohydrate contents of the samples observed in this study are nutritionally desirable as children require energy to carry out their rigorous physical and physiological activities as growth continues (Ibironke *et al.*, 2012). The substitution of maize-based complementary foods with black bean and crayfish flours enhanced the nutrient contents of the porridges.

Mineral Contents of Complementary Food Samples

The mineral composition of the complementary food samples are shown in Table 2. The calcium, zinc, magnesium, iron, potassium and phosphorus contents of the formulated complementary food samples increased with increased substitution with black bean and crayfish flours. The increase in mineral content of the samples confirms the beneficial effect of supplementation (Lutter and Rivera, 2003). The calcium content of the complementary foods increased significantly ($p < 0.05$) with increased substitution with black bean and crayfish flours. The calcium contents of all the blends formulated in this present study were generally lower than that of

the control (100% malted maize flour). The values (11.10-13.15mg/100g) obtained in this study were lower than the calcium content (15.01-25.10mg/100g) of complementary food formulated from malted millet, plantain and soybean flour blends reported by Bolarinwa *et al.* (2016). Calcium is necessary for optimal growth and development of infants and young children. The zinc content of the formulations varied significantly ($p < 0.05$) among the samples. The zinc content of the complementary foods ranged from 3.90 to 5.36mg/100g with the control and the sample substituted with 25% black bean and crayfish flours having the least (3.90mg/100g) and highest (5.36mg/100g) values, respectively. The substitution of the products with crayfish resulted in increase in the zinc content of the formulated samples and this is in agreement with the report that crayfish is a good source of zinc (Onabanjo *et al.*, 2009). Zinc plays a central role in cell division, protein synthesis and growth. The magnesium content of the samples increased sequentially with increased substitution with black bean and 25% crayfish flours. The magnesium content ranged from 3.57 to 5.78mg/100g for the control and the sample substituted with 25% black bean and crayfish flours. The magnesium content of the complementary food samples developed in this study were higher than the magnesium content (0.64 - 1.26mg/100g) of sorghum-based weaning food fortified with soybean and unripe plantain flours reported by Nwakalor and Obi (2014). Magnesium helps in the relaxation of nerves and muscles. It is also essential for the formation of bone and clotting of the blood. The iron content of the samples increased significantly ($p < 0.05$) as the level of substitution with crayfish flour increased in the blends. The observed increase in the iron content of the substituted samples is an indication that crayfish is a good source of iron (Fasuan *et al.* 2017). Iron is essential for the formation of blood cells and prevention of anemia in infants and children. The potassium content of the formulations which ranged from 4.61 to

Table 3. Vitamin content (mg/100g) of complementary food samples

Sample ID	% Substitution MF:BBF:CF	Ascorbic Acid	Riboflavin	Vitamin E	Vitamin A	Niacin	Thiamine
A	100: 0 : 0	8.32 ^f ±0.07	8.10 ^f ±0.10	2.84 ^f ±0.03	3.01 ^f ±0.07	5.07 ^f ±0.15	6.75 ^f ±0.10
B	90 : 5 : 5	10.80 ^e ±0.04	9.55 ^e ±0.11	4.09 ^e ±0.04	5.42 ^e ±0.06	7.12 ^e ±0.09	8.55 ^e ±0.05
C	80 : 10 : 10	11.34 ^d ±0.06	10.27 ^d ±0.08	6.55 ^d ±0.10	8.78 ^d ±0.08	8.87 ^d ±0.07	9.08 ^d ±0.02
D	70 : 15 : 15	11.90 ^c ±0.11	10.90 ^c ±0.04	8.98 ^c ±0.07	10.38 ^c ±0.06	9.46 ^c ±0.03	10.04 ^c ±0.04
E	60 : 20 : 20	12.38 ^b ±0.20	12.39 ^b ±0.13	10.70 ^b ±0.05	12.02 ^b ±0.17	10.15 ^b ±0.05	10.86 ^b ±0.06
F	50 : 25 : 25	13.23 ^a ±0.16	14.02 ^a ±0.24	12.45 ^a ±0.20	14.66 ^a ±0.18	11.08 ^a ±0.09	11.02 ^a ±0.08

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p < 0.05$)

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6.02mg/100g increased significantly ($p < 0.05$) as the ratios of black bean and crayfish flours increased in the products. The values obtained in this study were higher than the potassium content (2.39-4.86mg/100g) of sorghum-based weaning food supplemented with legumes and oilseeds reported by Asma *et al.* (2006). Potassium is very important in that it is essential for blood clotting and relaxation of muscles. The phosphorus content of the samples increased significantly ($p < 0.05$) from 5.51mg/100g in the control (100% malted maize flour) to 8.02mg/100g for the formulation substituted with 25% black bean and 25% crayfish flours. The increase in the phosphorus content observed in the blends could be attributed to the supplementation effect of crayfish flour added to the formulations and this is in agreement with the report that crayfish is a rich source of phosphorus (Onabanjo *et al.*, 2009). Phosphorus is an important constituent of every living cell. It is also essential for the formation of bone. Generally, the mineral levels of the formulated complementary foods were nutritionally superior to the control probably because of the inclusion of black bean and crayfish flours in the blends

Vitamin Composition of Complementary Food Samples

The vitamin composition of complementary food samples are shown in Table 3. The ascorbic acid, riboflavin, vitamin E, vitamin A, niacin and thiamine contents of the samples increased with increased substitution with black bean and crayfish flours. The increase in the vitamin content of the formulations confirms the beneficial effect of supplementation (Okaka *et al.*, 2006). The ascorbic acid content of the complementary food samples ranged from 8.32 to 13.23 mg/100g for the control and the sample substituted with

25% black bean and 25% crayfish flours. The increase in ascorbic acid content observed in the samples could be attributed to the addition of black bean and crayfish flours in the blends. The values obtained in this present study were lower than the ascorbic acid content (10.28-15.32 mg/100g) of complementary food prepared from sorghum, African yam bean and mango mesocarp flour blends reported by Yusufu *et al.* (2013). Ascorbic acid is necessary for the prevention of scurvy and development of healthy immune system in infants and young children. The riboflavin content of the samples varied significantly ($p < 0.05$) from each other. The sample substituted with 25% black bean and 25% crayfish flours had the highest riboflavin content (14.02mg/100g), while the control sample (100% malted maize flour) had the least value (8.10mg/100g). The higher riboflavin content observed in the complementary food samples produced could be due to supplementation with black bean and crayfish flours. Similar increase in riboflavin content with increase in substitution with soybean and crayfish flours has been reported by Oti and Akobundu (2008) for complementary food made from cocoyam, soybean and crayfish flour blends. Riboflavin is necessary for growth and development in infants and young children. The vitamin E content of the formulations varied between 2.84 and 12.45mg/100g with the control and the sample supplemented with 25% black bean and 25% crayfish flours having the least and highest values, respectively. The increase in vitamin E content observed in the formulated samples could be attributed to the addition of crayfish flour and this is in agreement with the report that crayfish is a good source of vitamin E (Oyarekua and Adeyeye, 2009). Vitamin E is an important vitamin required for proper function of many organs in the body. It is also an antioxidant which protects the body tissue from damage caused by substances called free radicals that harms the cells, tissues and organs (Berdanier and Zemleni, 2009). The

Table 4. Sensory properties of complementary food samples

Sample ID	% Substitution MF:BBF:CF	Colour	Taste	Mouthfeel	Texture	Overall Acceptability
A	100: 0 : 0	6.47 ^c ±0.10	6.13 ^c ±0.07	6.13 ^c ±0.07	6.07 ^c ±0.09	7.20 ^c ±0.05
B	90 : 5 : 5	7.67 ^b ±0.06	7.80 ^b ±0.06	7.87 ^b ±0.07	7.73 ^b ±0.07	7.53 ^b ±0.06
C	80 : 10 : 10	7.93 ^a ±0.07	7.96 ^a ±0.08	8.13 ^a ±0.08	8.10 ^a ±0.08	7.80 ^a ±0.06
D	70 : 15 : 15	6.84 ^d ±0.10	6.20 ^d ±0.07	6.87 ^d ±0.10	6.56 ^d ±0.11	6.46 ^d ±0.12
E	60 : 20 : 20	5.82 ^e ±0.07	5.80 ^e ±0.06	5.60 ^e ±0.07	5.42 ^e ±0.07	6.32 ^e ±0.09
F	50 : 25 : 25	5.34 ^f ±0.08	5.40 ^f ±0.07	5.08 ^f ±0.11	5.20 ^f ±0.10	6.04 ^f ±0.14

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, BBF - Malted black bean flour, CF - Crayfish flour

vitamin A content of the samples which ranged from 3.01 to 14.66mg/100g increased significantly ($p < 0.05$) with increased substitution with crayfish flour. Onabanjo *et al.* (2009) reported that crayfish is a rich source of vitamin A. The values obtained in this study were higher than the vitamin A content (1.86-6.42mg/100g) of food gruels formulated from blends of soybean flour and ginger modified cocoyam starch reported by Ojinnaka *et al.* (2013). Vitamin A plays a vital role in the maintenance of good sight. The levels of niacin in the blends varied significantly ($p < 0.05$) among the samples. The control sample had the least niacin content (5.07mg/100g), while the sample substituted with 25% black bean and 25% crayfish flours had the highest value (11.08mg/100g). The increase in niacin content observed in the samples could be due to the inclusion of black bean and crayfish flours in the blends. The niacin content of the complementary food formulated in this study was higher than the niacin content (3.17-8.72 mg/100g) of complementary food prepared from malted millet, plantain and soybean blends reported by Bolarinwa *et al.* (2016). Niacin helps in the reduction of the level of blood cholesterol in humans. The thiamine content of the formulations increased significantly ($p < 0.05$) from 6.75mg/100g in the control sample to 11.02mg /100g for the sample substituted with 25% black bean and 25% crayfish flours. The observed increase in the thiamine content is an indication that black bean and crayfish are excellent sources of thiamine (Nzeagwu and Nwaejike, 2008; Audu and Aremu, 2011). Thiamine helps in the treatment of beriberi and in the maintenance of healthy mental attitude. The substitution of maize-based porridges with black bean and crayfish flours greatly improved the vitamin content of the samples.

Sensory Properties of Complementary Food Samples

The sensory properties of complementary food samples are shown in Table 4. The sensory scores of porridges prepared from both the control and developed complementary food samples showed significant ($p < 0.05$) differences in colour, taste, mouthfeel, texture and overall acceptability. The sample substituted with 10% black bean and 10% crayfish flours had significantly ($p < 0.05$) the highest scores for colour, mouthfeel, taste and overall acceptability, while the sample with 25% black bean and crayfish flours substitution had the least scores. The porridge made from 100% malted maize flour (control) and those prepared from the blends with 5 -25% black bean and crayfish flours substitution were generally acceptable. The increase in substitution resulted in decrease in acceptability of the porridge as indicated by the significantly ($p < 0.05$) low scores for the 25% substitution. The variation observed in the colour of the porridges could be due to increased substitution with black bean and crayfish flours and the addition of sugar which gave the products a slightly dark colouration. The development of dark colour in the porridges could be attributed to the mallard browning reaction which occurred as a result of interaction between the sugar and amino acids. The porridge produced from the sample with 25% black bean and crayfish flours substitution was also reported to have crumbly texture and a beany flavour probably due to increased substitution and the beany flavour of black bean flour. The porridge prepared from the sample with 10% black bean and crayfish flours substitution was described by the assessors as having the best colour, taste, mouthfeel and overall acceptability. This 10% level of

substitution produced the porridge that had better consumers' sensory attributes than the other test samples although it was not the highest in other nutrients. It therefore implies that there is need for further investigation on the methods of preparation that would be adopted to enhance the overall acceptability of the porridges at higher levels of substitution.

CONCLUSION

The study showed that the use of maize, black bean and crayfish in the preparation of complementary food formulations yielded products with high nutritional value. The complementary foods formulated showed nutritional superiority over the control in terms of protein, fat, ash, crude fibre, calcium, phosphorus, magnesium, iron, potassium, ascorbic acid, riboflavin, thiamine, vitamin E, niacin and vitamin A contents. Although, the products had high mineral and vitamin contents, there is need for further supplementation of the composite blends with better sources of minerals and vitamins. The porridge prepared from the sample with 10% black bean and crayfish flours substitution had better acceptability than both the control and other test samples. The colour, taste, mouthfeel and texture of all the porridges were acceptable by the panelists. Crayfish and black beans are cheap and readily available food ingredients that can be used by nursing mothers and care givers to supplement traditional complementary foods in Nigeria and other developing countries of the world in order to reduce the problem of protein-energy malnutrition among infants and young children due to their high nutrient density.

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