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CHARACTERISTICS OF COMPLEMENTARY FOODS PRODUCED FROM SORGHUM, SESAME, CARROT AND CRAYFISH

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ABSTRACT

Low-cost, nutritive but bulk-reduced complementary foods using sorghum, sesame, carrot and crayfish flour were evaluated for proximate compositions (energy, protein, fats, fibre, ash), minerals (Fe, Zn, Ca, Cu, Se), total carotenoids, vitamin C, organoleptic attributes, and functional characteristics with respect to bulk density, dispersibility, water absorption capacity, swelling power, solubility and pasting properties. The composite flours contained higher moisture, protein, fat, fiber, ash, Fe, Zn, Cu, Se, carotenoids, vitamin C than the control. There were significant differences ($p<0.05$) in the chemical, functional and pasting properties of the different blends and the control. The Sensory panelists ratings showed that porridge from the control was preferred over the others because it possessed good sensory qualities. With the satisfactory nutritive value and functional characteristics of the composite flours, they can be recommended to infants and young children.

Keywords: Complementary foods, Nutrient composition, Children, Functional and sensory properties

INTRODUCTION

Scientifically, it has been proven that breast milk is the perfect food for the growing infant during the first six months of life (Lutter and Rivera, 2003). It contains all the nutrient and immunological factors an infant's requires to maintain optimal health and growth. At this formative period, the supply of energy and protein and some nutrients from breast milk is no longer adequate to meet an infant's needs. Malnutrition during this period of life leads to permanent stunting in growth (Onis and Blossner, 1997) and there may also be irreversible sequence from micronutrient deficiencies that affect brain development and other functional outcomes (Martorell *et al*., 1995). Children in most developing countries are introduced directly to the regular household diet made of cereal or starchy root crops. Inadequate complementary food is a major cause for the high incidence of child malnutrition, morbidity and mortality in many developing countries (WHO/UNICEF, 1998). The weaning period is the most critical period in a child's life (WHO/UNICEF, 1998; Dewey and Brown, 2002; Lutter and Rivera, 2003).

As in most other developing countries, the high cost of fortified, nutritious, proprietary complementary foods is always, if not prohibitive, beyond the reach of most Nigerian families. Such families often depend on inadequately processed traditional foods consisting mainly of un-supplemented cereal porridges made from maize, sorghum and millet. In view of this, there is a need for low-cost weaning foods which can be prepared easily in home and community kitchens from locally available raw materials such as sorghum and sesame seed, using simple technology that is within the reach of the general public in developing countries and does not require sophisticated equipment, and which can be served quickly and conveniently. Such foods can be more nutritious than most of the commercial brands that abounds in major markets. This approach would require knowledge about the nutritive values of a variety of local food commodities, indigenous to the affected communities.

Sorghum (*Sorghum bicolor*), sesame (*Sesamum indicum*), carrot (*Daucus carota*) and crayfish (*Euastacus spp*) are food materials that are readily available in Nigeria and they have nutritional attributes. Whole sorghum grain is an important source of complex vitamins and some minerals like phosphorus, magnesium, calcium and iron (Osagie and Eka, 1998). The protein content of sorghum is similar to that of wheat and maize, with lysine as the most limiting amino acid (Osagie and Eka, 1998). Sesame is an oilseed that is popularly known as 'beniseed' because it contains better quality protein than most legumes, a large amount of vitamin E which is an antioxidant, calcium, potassium, phosphorus, vitamin B, iron and it has no cholesterol. Carrot is an herbaceous plant containing about 87% water, rich in mineral salts and vitamins (B, C, D, and E). Raw carrots are excellent source of pro-vitamin A and potassium; they contain vitamin C, vitamin B_6, thiamine, folic acid, and magnesium. The beta-carotene in carrots is an anti-oxidant scavenging the free radicals that contribute to conditions like cancer, heart disease, and muscular degeneration. The high level of beta-carotene is very important and gives carrots their distinctive orange colour. 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 (Onimawo and Egbekun, 1998). The fibers of crayfish are shorter than those of other meat, so are easier to digest. The nutrient potentials of the multimixes (Sorghum, Sesame, Carrot and Crayfish) as composite for use as complementary food can be of relevance in nutrition security of young children. Then the objectives of this study were to develop four complementary foods supplemented with legume and carrots with improved protein and vitamin A contents and to determine acceptability of the supplemented foods for use by mothers and their children.

MATERIALS AND METHODS

Source of Materials

The white Sorghum grains (*Sorghum bicolor*), sesame seeds (*Sesamum indicum*), carrot (*Daucus carota*) and Cray fish (*Euastacus spp*) were purchased from a local market in Abeokuta, Ogun State, Nigeria. A popular commercial brand of weaning food (Nestle Cerelac as control) was used for comparison with the experimental formulations.

Processing Methods

Sorghum grains were separately washed and cleaned with distilled water and air-dried for 12 hours. The grains were then milled into flours with a hammer mill. Sesame seed was cleaned and parboiled to de-bitter and dehull. The seeds were washed to sieve out the hulls and were drained out using a muslin cloth, sun dried to reduce the moisture content after which they were roasted to aid digestion and enhance the flavor of the seeds. The seeds were then milled with a Hammer mill into a paste after which the paste was pounded in a mortar and squeezed manually to remove the oil. Carrot powder was obtained by washing carrot roots with water and then slicing and drying them at 40 ^{0}C for 12hrs, and milling them into flour with a stainless steel milling machine. The Crayfish was cleaned and de-shelled to reduce the fiber content; sundried and milled with a hammer mill. The flour was then sieved and packaged in an air tight container and stored in a cool place. Lastly, the processed foods were analyzed for their chemical proximate, mineral, vitamin composition, and their functional properties.

Formulation of Composite Flours

The processed foodstuffs were mixed on protein basis as follows:

Sample A: Sorghum 70%: Sesame 17%: carrot, 8%: Cray fish, 5% (w/w)

Sample B: Sorghum 70%: Sesame 15%: carrot, 10%: Cray fish, 5% (w/w)

Sample C: Sorghum 67%: Sesame 18%: carrot, 10%: Cray fish, 5% (w/w)

Sample D: Sorghum 65%: Sesame, 20%: carrot, 8%: Cray fish, 7% (w/w)

Control: Nestle Cerelac

Chemical Analysis

The composite flours were analyzed for their proximate composition, minerals, vitamins and functional properties to ascertain their conformity with the standards. Proximate chemical analysis was carried out using standard procedures (AOAC, 2005). The crude protein was determined by the Microkjeldahl method using 6.25 as a conversion factor. Fat and ash content were determined by soxhlet extraction and dry ashing method respectively. Minerals (calcium, iron, copper, zinc and selenium were determined by atomic absorption spectrophotometer. Carotenoids was extracted with petroleum ether and quantified colorimetrically as described in the HarvestPlus Handbook for Carotenoid Analysis (2004). Vitamin C was determined colorimetrically by the standard method of AOAC (2005). Total carbohydrate was calculated from the summation of total starch and sugar determined by method of (Dubois *et al.,* 1956). Energy values were calculated based on the Atwater's conversion factors, protein and carbohydrate (4kcal/g) and fat (9kcal/g) (Passmore and Eastwood, 1986). All assays were performed in triplicates.

Methods validation

The accuracy of the concentrations determined in this study was checked by measurements of the reference materials SRM no. 2383 Baby Food Composite from the National Institute of Standards and Technology of the Department of Commerce, NY, United States of America.

Determination of Functional Properties

Particle size distribution was evaluated by passing the ingredients and formulations through an automatic standard sieve shaker. The percentage fraction of the sample retained on each sieve was measured by weighing. Bulk density was determined by measuring the packed volume of a known weight of sample (Wondimu and Malleshi, 1996). Pasting properties were determined with a Rapid Visco Analyser 3 C (RVA, model 3C, Newport Scientific PTY Ltd, Sydney, Australia) (Ross *et al.,* 1987; Walker *et al.*, 1988). Dispersibility was measured by placing 10 g of the sample in a 100-ml stoppered measuring cylinder, adding distilled water to reach a volume of 100 ml, stirring vigorously, and allowing it to settle for three hours. The volume of settled particles was subtracted from

100 and the difference reported as percentage dispersibility (Kulkarni *et al.*, 1991). Water absorption capacity, measured as grams of water absorbed by 100 g of solid matter, was determined using the method described by Sosulski (1962). Swelling power and solubility were determined by the Leach *et at.* (1959) method.

Preparation of porridges

Porridges were prepared from both the composite flours and Cerelac. One hundred grams of each flour were mixed with 550 ml of deionized water. The slurry was heated in a thermostatically controlled water bath (Thermo stirrer 95, Gallenkamp, England) set at 75^0 C for 15 min. Two grams of granulated sugar were added to the porridge. The samples were allowed to cool at room temperature (28±2^{0}C) to 40^{0}C (serving temperature). The porridges were kept separate in thermos flasks to maintain the serving temperature of 40^{0}C.

Sensory Evaluation

Sensory evaluation of the porridges was conducted at the Federal Medical Centre, Idi- Aba, Abeokuta, Ogun State. Fifty nursing mothers were randomly selected and trained. Each of the panelists was seated in an individual compartment with fluorescent lighting and free from distraction. The judges evaluated the samples for flavour, taste, colour, texture and overall acceptability using a nine point hedonic scale, where 9 was the highest score and 1 the lowest (Watts *et al.,* 1989). The degree to which a product was liked was expressed as like extremely (9 points), like very much (8 points), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), and dislike extremely (1 point). The panelists were presented with five coded samples presented in a Thermos flask (20 ml of sample), coded as in the hedonic scale. Each panelist was given five white plastic cups and teaspoons for use in the sensory test. Clean water was provided to the judges to rinse their mouth in-between testing of the porridges to avoid carry over effect. Room temperature of 28 ±20^{0}C was maintained throughout the testing sessions.

Statistical Analysis

Data obtained from the study were analyzed using means and standard variation for triplicate values. Analysis of variance was used to establish any significant difference between the multimix blends and control. Amounts of nutrients present in 65 g (dry weight estimate of the daily intake of local weaning foods were calculated and compared with some recommended daily allowance to see whether the local blends can meet the recommendations.

RESULTS

The nutrient composition of the sorghum, sesame, carrot and crayfish composite flours and the proprietary formula are presented in Table 1. The moisture content, ash, crude protein, crude fiber, and fats values were significantly higher ($p<0.05$) in the composite than in the control (Cerelac). The energy values in two of the formulated blends were higher than that in the control with significant ($p<0.05$) difference in the energy values among the composite blends and the control. The total carbohydrates comprising of the free sugars and starch were significantly ($p<0.05$) higher in the control than the composites. Table 1 also revealed significant differences ($p<0.05$) in the minerals and vitamin content of the different blends. The calcium, iron, and zinc content were higher in the control diet than in the different blends,

Table 1: Proximate, Mineral and Vitamin Contents of blends prepared from sorghum, sesame, carrot and crayfish flours per 100 g dry weight

Nutrients (%DM)	A	B	C	D	Control
Moisture	4.78±0.12a	4.42±0.22ab	5.08±0.35a	4.19±0.22b	4.18±0.32b
Ash	4.05±0.21b	4.09±0.11b	4.22±0.66a	4.81±0.76a	3.99±0.11b
Crude Protein	17.33±2.11b	17.09±1.98b	18.06±2.09a	18.76±2.89a	14.40±1.02c
Crude Fat	11.89±1.75c	12.83±2.09b	13.53±2.11ab	14.76±3.83a	3.21±0.08d
Crude Fibre	3.66±0.90b	3.87±0.66ab	4.00±0.12a	4.11±0.08a	3.66±0.06b
Sugars	5.66±0.21b	5.43±0.11b	5.09±0.77c	5.16±1.09bc	16.65±1.99a
Starch	51.77±2.18a	47.00±1.98b	44.98±2.09b	44.93±2.11b	54.35±3.81a
Total Carbohydrate	57.43±3.87b	52.43±2.16bc	50.06±2.81c	50.09±3.99c	71.09±5.64a
Energy (Kcal)	406.05±6.88a	389.02±5.43b	397.48±9.87ab	408.24±8.88a	400.55±16.02a
Calcium (mg)	291.32±9.43bc	300.32±9.32b	281.55±12.91c	312.33±11.21b	401.81±4.44a
Iron (mg)	6.16±1.11c	7.38±2.83a	6.99±2.10b	7.61±2.11a	3.77±1.29d
Zinc (mg)	3.08±2.10a	2.44±1.73b	3.08±1.32a	2.78±0.43ab	1.81±1.11d
Copper (mg)	0.88±0.02a	0.76±0.01ab	0.45±0.01c	0.89±0.01a	0.44±0.01c
Selenium (mg)	0.44±0.02b	0.38±0.01b	0.54±0.06a	0.46±0.01b	0.30±0.11bc
Vitamin C (mg)	10.66±1.10bc	11.99±1.78b	14.67±2.09a	15.82±2.78a	10.22±0.78c
Total carotenoids (µg/100g)	1291.38±34.01c	1717.09±9.09b	1832.43±23.65a	1862.65±32.98a	912.65±21.54d

Means with the same letter (superscripts) in the row are not significantly different at P>0.05.

but significantly ($p<0.05$) lower in copper and selenium compared to the composites. The vitamin C and total carotenoids contents were lower in the control sample than in the different blends.

Amounts of nutrients in 65g of blends are shown in Table 2. From this table, the amounts of protein, fat, fiber that can be provided by 65g of the composite blends are 11.11-12.19g, 7.73-9.60g, 2.38-2.67g respectively, was close to the RDA for protein, fat and fiber while the control sample was far below the RDA. The energy, iron, calcium and zinc in 65g of the diets were below their RDAs. Table 3 shows the functional properties of the complementary blends. There were no significant differences ($p>0.05$) in the bulk density (0.49 – 0.66 g/ml), swelling power (6.87 – 8.66 %), solubility (15.98 -17.32 %) and dispersibility (72.11 – 79.36 %) of the composite blends and the control. There were significant differences ($p<0.05$) in the water absorption capacity (120 - 130 mL/100g) among the blends and the control.

The pasting properties of the complementary blends are shown in Table 4. The pasting properties of the formulated blends and the control sample showed significant differences ($p<0.05$) in some of the parameters. Peak viscosity during heating ranged from 65.75 RVU for sample B to 79.50 RVU for sample D, the trough viscosity ranged from 34.03 RVU for sample B to 46.01 RVU for sample D, and the breakdown viscosity ranged from 28.54 RVU to 33.50 RVU for A and D, respectively. The final viscosity ranged from 42.33 RVU to 59.58 RVU, the set back ranged from 8.33 RVU to 13.83 RVU in sample B and C, respectively. The peak time ranged from 3.87 minutes for sample B to 4.23 minutes for sample C. The pasting temperature ranged between 73.76 to 75.10^{0}C with sample C recording the highest gelatinization temperature with the control sample having the lowest pasting temperature.

Table 5 shows the sensory scores associated with porridges made from the composite flours and Cerelac a commercial complementary food. The mean sensory scores of the control porridge and those of the composite flours differed significantly ($p<0.05$) in their sensory parameters. The values obtained for colour ranged from 4.33 to 4.90, which was lower than the panelists score (7.21) for the control sample. The taste of sample D was least preferred by the panelists compared to the control sample. In terms of flavor, there was significant difference ($p<0.05$) between the control sample and the formulated complementary porridges. Texture of all samples except the control had no significant difference ($p>0.05$). Control sample was most generally accepted by the panelists.

DISCUSSION

Complementary foods formulated in this study compared favourably with the commercial formula used as control (Cerelac) and the proximate composition showed that the moisture values compared well with values obtained by Alabi (1999); Solomon (2005); Asma *et al*. (2006); Onabanjo *et al.* (2008). The similarity could be attributed to the choice of food components or materials and the preparation methods adopted. High moisture content in foods has been shown to encourage microbial growth (Temple *et al*., 1996). The low residual moisture content of the blend is advantageous in that microbial load is reduced and storage life is enhanced and prolonged. The exceptionally high levels of protein noticed in the composite blends

Table 2: Amounts of Nutrient in 65 g of the Multi-mix Blends prepared from sorghum, sesame, carrot and crayfish flours

Nutrients (%DM)	*RDA (6-11 months)	A	B	C	D	Control
Moisture		3.11	2.87	3.30	2.72	2.72
Ash		2.63	2.66	2.74	3.13	2.59
Crude Protein	13-14g	11.26	11.11	11.74	12.19	9.36
Crude Fat	10-25g	7.73	8.34	8.79	9.60	2.09
Crude Fibre	15-20g	2.38	2.52	2.60	2.67	2.38
Sugars		3.68	3.53	3.31	3.35	10.82
Starch		33.65	30.55	29.24	29.20	35.33
Total Carbohydrate		37.33	34.08	32.54	32.56	46.21
Energy (Kcal)	650kcal	263.93	252.86	258.36	265.36	260.36
Calcium (mg)	270mg	189.39	195.21	183.01	203.01	261.18
Iron (mg)	9.0mg	4.00	4.80	4.54	4.95	2.45
Zinc (mg)	4.1mg	2.02	1.59	2.02	1.81	1.17
Copper (mg)		0.57	0.49	0.29	0.58	0.29
Selenium (mg)		0.29	0.25	0.35	0.30	0.20
Vitamin C (mg)		6.93	7.79	9.54	10.28	6.64
Total carotenoids (μg/100g)		839.40	1116.11	1191.08	1210.72	593.22

*FAO/WHO (2002)

Table 3: Functional Properties of complementary foods prepared from sorghum, sesame, carrot and crayfish flours per 100 g dry weight

Functional properties	A	B	C	D	Control
Bulk density (g/ml)	0.62a	0.66a	0.65a	0.56a	0.49a
Water absorption capacity (mL/100g)	130a	126a	132a	129a	120b
Swelling power (%)	8.66a	7.99a	7.87a	8.09a	6.87a
Solubility (%)	17.32a	16.02a	16.34a	15.98a	16.67a
Dispersibility (%)	74.33a	78.32a	74.38a	79.36a	72.11a

Means with the same letter (superscripts) in the same row are not significantly different at p>0.05.

Table 4: Pasting Properties of complementary foods prepared from sorghum, sesame, carrot and crayfish flours per 100 g dry weight

Sample	Peak (RVU)	Trough (RVU	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peaktime (mins)	Pasting Temp (0C)
A	68.54b	39.96a	28.54a	50.17b	10.21b	3.90b	75.03a
B	65.75b	34.03b	31.75a	42.33c	8.33b	3.87b	74.23a
C	74.38a	45.66a	28.70a	59.50a	13.83a	4.23a	75.10a
D	79.50a	46.01a	33.50a	59.58a	13.58a	4.07ab	75.08a
Control	67.89b	41.84a	26.05a	47.60b	15.65a	3.88b	73.76a

Means with the same letter (superscripts) in the same column are not significantly different at p>0.05.

Table 5: Mean sensory scores of porridges made from sorghum, sesame, carrot and crayfish flour blends and Cerelac (a commercial complementary food as control)

Samples	Colour	Flavour	Texture	Taste	Overall Acceptability
A	4.90±1.9b	3.87±2.0b	6.03±1.8b	5.55±2.1c	6.33±2.2b
B	4.67±1.7b	4.01±1.6b	5.98±1.1b	5.81±2.2b	5.65±2.1c
C	4.83±1.1b	3.80±1.9b	6.07±1.3b	5.88±2.1b	6.05±1.6b
D	4.33±1.0bc	4.02±0.7b	5.87±1.3b	6.17±1.8b	5.31±1.1c
Cerelac	7.21±2.1a	6.14±1.1a	7.82±1.0a	7.66±2.3a	7.77±2.0a

Means with the same letter (superscripts) in the same column are not significantly different at p>0.05.

could be as a result of the supplementation by both sesame and crayfish. Similar observations were noted by other researchers when sorghum was supplemented with bambara groundnut and sweet potatoes (Nnam, 2001), and when sorghum was supplemented with groundnut and crayfish (Nzeagwu and Nwaejike, 2008). The significant difference ($p<0.05$) between the fiber content of the control and that of the blends could be because of the low fibre content of sorghum which formed the major ingredient of the composite flours. The fat contents of the blends are higher than the recommended 10% for complementary food (FAO/WHO, 1991). This could be due to the addition of sesame, which is an oil seed with high lipid level. The high fat content further increased the energy density of the blends. The significant differences in the energy content of the blends ($p<0.05$) could have resulted from the high carbohydrate content of the raw materials. The Food and Agriculture Organization and the World Health Organization (FAO/WHO, 1998) recommended that foods to be fed to infants and children should be energy-dense ones as low energy foods tend to limit total energy intake and the utilization of other nutrients. However, the total calculated energy values in 65 g of the four local blends fell below the RDA level (FAO/WHO, 2002), thus, that infants may have to consume more quantities of the formulated diets to meet their energy needs.

The higher contents of the mineral noticed in the blends could be attributed to the presence or supplementation effects of a protein source (crayfish) included in their formulations. Crayfish is a good source of iron, and sorghum (a cereal containing non-heme iron) made the iron content of the blends to be high. The significant differences ($p<0.05$) observed between the control and the composites in their calcium content could be attributed to the type of raw materials used as a base especially the cereals. Contrary to what was reported by Nzeagwu and Nwaejike (2008), the calcium contents of the formulated blends observed in the present study were lower than that of the control. However, the total calculated mineral values in 65 g of the four local blends fell below the RDA level. The implication is that these local complementary foods would have to be further fortified with minerals to adequately complement breast milk. Also, notable foods rich in minerals, like vegetables and animal products, could be included as base ingredients in the formulation of the composites flours to further increase the levels of the minerals. With respect to vitamin levels, composite flours showed nutritional superiority probably because of the inclusion of carrot in the formulations. Carrot has been reported as good sources of both vitamin C and provitamin A. Thus it is beneficial effects to use fruits as base ingredients in infant food formulation in order to upgrade the levels of the vitamins and some minerals.

Functional properties determine the application and use of food material for various food products. The bulk density of the blends was comparable to that reported by Asma *et al.* (2006). The formulated complementary blends possess low bulk density, which is an advantage in the preparation of complementary foods. According to Onimawo and Egbekun (1998), high bulk density can limit the caloric and nutrient intake per feed of a child which can resulting in growth faltering. Bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in the food industry

(Karuna *et al*., 1996). Water absorption capacity gives an indication of the amount of water available for gelatinization. Lower absorption is desirable for making thinner gruels. The composite blends had absorption capacities that are between the ranges expected of complementary foods. Swelling power is a factor of ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight/ distribution, degree/length of branching and conformation (Karuna *et al*., 1996).

With the significant differences (p<0.05) in the pasting profile of the different formulations and the control (Cerelac), it must be noted that when starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size, a process called gelatinization and pasting. Peak viscosity, which is the ability of starch to swell freely before their physical breakdown (Sanni *et al*, 2004) is less than 100. Viscosity is an important constraining factor in weaning foods. Low peak viscosity is desirable in infant formulation for low gel strength and elasticity as high peak viscosity is an indication of high starch content (Osungbaro, 1990). It is also related to the water binding capacity of the mixture and is often correlated with the final product quality. The trough, which is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling. There is a significant difference (p<0.05) between the blends and the control. In this study, there was no difference in the breakdown viscosity of the samples analyzed. Breakdown viscosity is an index of the stability of starch (Fernandez and Berry, 1989), The final viscosity is the most commonly used parameter to define the quality of a particular starch -based food sample as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990).

With respect to the sensory evaluation of samples the control sample was more accepted by the panelists in all the parameters. This could be due to panelist's familiarity to its taste, flavour and appearance. The fact that the control sample is industrially prepared with additional sweeteners and flavoring could also be an advantage. The panelists scoring in terms of taste of the samples may be due to the similar quantity of crayfish added to the formulations except for sample D that recorded a different score in taste.

CONCLUSION

The use of sorghum, sesame seed, carrot and crayfish in complementary food formulations yields products with improved functional characteristics and high nutritive value. The composite flours formulated showed nutritional superiority over the control in terms of proteins, lipids, ash, crude fibre, Fe, Zn, Cu, Ca, total carotenoids, and vitamin C. There is need for further supplementation of the composite flours with better sources of minerals. The porridges had comparable moderate acceptability with Cerelac. The flavour, texture and colour of all the porridges were liked by the panelists. The addition of carrot improved the total carotenoids and vitamin C contents of the composite flours. Crayfish and sesame are readily available and can be used by mothers to supplement their traditional complementary foods in other to reduce the problem of protein deficiency in children.

REFERENCES

Addo, A.A., Akeredolu, I.A. 2005. Organoleptic and Objective Evaluation of pearl Millet-Conophor Weaning mix; *Nig. J. Nutr. Sci.,* 26(1): 13-18.

Adeyemi, I.A., Idowu, M.A. 1990. The evaluation of pregelatinized maize flour in the development of Maissa, a baked product. *Nigerian Food Journal,* 8: 63-73.

Alabi, M.O. 1999. Nutritional evaluation of formulated cassava (Manihot Esculenta Crantz) leaf based-diets. Ph.D. Thesis, Department of Human Nutrition, University of Ibadan, Ibadan, Nigeria.

Asma, M.A., Babiker, E.F., Tinay, A.H. 2006. Development of weaning food from sorghum supplemented with legumes and oil seeds. *Food and Nutrition Bulletin*; 27(1): 26-34.

A.O.A.C. 2005. *Association of Official Analytical Chemists. Official Methods of Analysis Association of Official Analytical Chemist, Washington D.C.*

Dahiya, S., Kapoor, A.C. 1993. Biological evaluation of protein quality of home processed supplementary foods of pre-school children. *Food Chem*. 48(2): 183.

Dewey, K.G., Brown, K.H. 2002. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food Nutr. Bull*. 24(1): 5–28.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A., Smith, F. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem*., 28: 350-356.

Emiola, L., Delarosa, L.C. 1981. Physico-chemical characteristics of yam starches. *Journal of Food Biochemistry,* 5: 115-130.

FAO/WHO (Food and Agricultural Organization/World Health Organization). 1998. Preparation and use of Food-Based Dietary Guidelines. Report of a Joint FAO/WHO Consultation. WHO Technical Report series 880. Geneva.

FAO/WHO (Food and Agricultural Organization/World Health Organization). 1991. Codex standard for processed cereal-based foods (including guidelines on formulated supplementary foods for older infants and young children). World Health Organization, Geneva, Switzerland.

FAO/WHO (Food and Agricultural Organization/World Health Organization). 2002. Vitamin and mineral requirements in human nutrition. Report of a joint FAO/WHO expert consultation. World Health Organization, Geneva, Switzerland.

Fernandez de Tonella, M.L., Berry, J.W. 1989. Rheological properties of flour and sensory characteristics of bread made from germinated chick peas. *International journal of Food Science and Technology.*

Karuna, D., Noel, G., Dilip, K. 1996. Food and Nutrition Bulletin 17:(2), United Nations University. Tokyo, Japan.

Kulkarni, K.D., Kulkarni, D.N., Ingle, U. M. 1991. Sorghum malt-based weaning formulations preparation, functional properties, and nutritive value. *Food and Nutrition Bulletin,* 13(4): 322 - 327.

Leach, H.W., McCovwen, D.L., Schoch, T. J. 1959. Swelling power and solubility patterns of various starches. Structure of granules. *Cereal Chemistry* 36: 534-544.

Lutter, C.K., Rivera, J. 2003. Nutritional status of infants and young children and characteristics of their diets. *J Nutr.* 133: 2941S–2949S.

Martorell, R., Schroeder, D.G., Rivera, J. A., Kaplowitz, H.J. 1995. Patterns of linear Italics growth in rural Guatemalar adolescent and children. *J. Nutr.* 125 (Supple). 1060s-1067s.

Nnam, N.M. 2001. Chemical, sensory and rheological properties of porridges from processed sorghum (*Sorghum bicolor*), bambara groundnut (*Vigna subterranean L. Verdc*) and sweet potato (*Ipomoea batatas*) flours. *Plants Fds. Hum. Nutr.*, 56: 251-264.

Nzeagwu, O.C., Nwaejike, N.J. 2008. Nutrient composition, functional and organoleptic properties of complementary foods formulated from sorghum, groundnut and crayfish. *Nigerian Food Journal*, 26(1) ; 13 -20.

Odunmbaku, J.A. 1992. Maize and cowpea weaning food formulations: preparation, chemical analysis and Biological Evaluation of Blends. M.Sc Thesis. Department of Human Nutrition University of Ibadan, Ibadan, Nigeria.

Onabanjo, O.O., Oguntona, C.R.B., Dixon, B.M., Olayiwola, I.O., Oguntona, E.B., Dixon, A.G.O. 2008. Nutritional evaluation of four optimized cassava based complementary foods. *African Journal of Food Science*, 2: 136-142.

Onimawo, A.I., Egbekun, K.M. 1998. Comprehensive Science and Nutrition. Ambik Press Ltd. Benin City, pp 103-208.

Onis, M., Blossner, M. 1997. Global Data Base on child Growth and Malnutrition. Programme of Nutrition (WHO), Geneva P. 447-448.

Osagie, A.U., Eka, O. 1998. Nutritional Quality of Plant Foods. Published by the Post Harvest Research Unit, Department of biochemistry, University of Benin, Benin City, Nigeria. P. 53-81.

Osungbaro, T.O. 1990. Effect of differences in variety and dry milling of maize on textural characteristics of Ogi. *Journal of Food and Agriculture,* 54: 1-11.

Passmore, R., Eastwood, W.A. 1986. Human Nutrition and Dietetics, 8th edn. Churchill: English Language Book Society, P. 15-30.

Rodriguez-Amaya D.B., Kimura, M. 2004. HarvestPlus Handbook for Carotenoid Analysis. HarvestPlus Technical Monograph Series 2, Washington DC and Cali.

Ross, A.S., Walker, C.E., Booth, R.I., Orth, R.A., Wrigley, C.W. 1987. The Rapid Visco Analyzer: A new technique for the estimation of sprout damage. *Cereals Food World,* 32:827–829.

Sanni, L.O., Kosoko, S.B., Adebowale, A.A., Adeoye, R.J. 2004. The Influence of Palm Oil and chemical modification on the pasting and sensory properties of fufu flour. *International Journal of Food Properties,* 7(2): 229 –237.

Solomon, M. 2005. Nutritive value of three potential complementary foods based on cereals and legumes. *African Journal of Food* *and Nutritional Sciences*; 5: 2:1-14.

Sosulski, F.N. 1962. The centrifuge method for determining flour absorptivity in hard red spring wheat. *Cereal Chem.*, 39: 344-349.

Temple, V.J., Badamosi, E.J., Ladeji, O., Solomon, M. 1996. Proximate Chemical Composition of three locally formulated complementary foods. *West Afr. J. Biol. Sci.*, 5:134–143.

Walker, C.E., Ross, A.S., Wrigley, C.W., McMaster, G.J. 1988. Accelerated starch paste characterization with the rapid visco analyzer. *Cereals Food World* 33:491–194.

Watts, B.M., Ylimaki, G.L., Jeffery, L.E., Elias, L.G. 1989. Basic Sensory Methods for Food Evaluation IDRC-277e. The International Development Research Centre, Ottawa, Canada. P. 66-67.

WHO/UNICEF. 1988. Weaning from breast milk to family food. A guide for health and community workers. World Health Organization. Geneva.

Wondimu, A., Malleshi, N.G. 1996. Development of weaning foods based on malted, popped, and roller- dried barley and chicken pea. *Food and Nutrition Bulletin*, 7(2): 169-176.

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