Advances in Food Science and Technology Vol. 1 (7), pp. 088-094, July, 2013. Available online at www.internationalscholarsjournals.org

Full Length Research paper

Complementary food gruels Nutrient composition formulated from soybeans, groundnut and malted cereals for use in North-western Nigeria

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Accepted 05 June, 2013

Prevalence of malnutrition in children in North-western Nigeria is high due to poor complementary feeding practices. An attempt was made to formulate low-cost, nutritive complementary foods using malted maize, millet and sorghum with groundnut and soyabean. Nutrient qualities of gruel of the formulations thus prepared were evaluated. The ash content ranged from 1.03 ± 0.01 to 2.54 ± 0.35 g/100 g with the crude protein ranging from 6.37 ± 0.23 to 7.88 ± 0.28 g/100 g. Levels of lysine (4.80 to 6.87 g/100 g protein) and methionine (1.25 to 3.33 g/100 g protein) in most formulated complementary foods were higher than the international reference values of 4.2 and 2.2 for lysine and methionine, respectively. Percentage *in- vitro* protein digestibility of the formulations (75 to 82%) is comparable to that of the commonly used complementary foods (72 to 82%) in the zone. Zinc content ranged from 74.15 to 107.85 ppm and Iron content was between 177.10 and 476.64 ppm. Phytates (0.01 to 0.34 mg/100 g), tannins (16 to 37 mg/100 g) and free cyanide (0.16 to 0.99 mg/100 g). Levels of microbial contamination in the formulated were lower when compared to that reported in commonly used complementary foods in North Western Nigeria. There was no presence of *Samonella* and *Shigella* in all the samples while also no *Staphylococcus* spp and *Escherichia coli* in some of the samples. Sensory evaluation found the formulated complementary foods preparations to have good acceptability. There is improvement in the nutrient quality of the formulated complementary foods with good acceptability comparable to that commonly used in the zone.

Key words: Complementary foods, malted cereals, soyabean, groundnut, formulated blends, nutrient composition.

INTRODUCTION

Adoption of recommended breastfeeding and complementary feeding practices and access to the appropriate quality and quantity of foods are essential components of optimal nutrition for infants and young children (Lutter and Rivera, 2003). Complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children under 5 years of age worldwide (Daelmans and Saadeh, 2003). Many factors contribute to the vulnerability of children during the complementary feeding period. The complementary foods are often of low nutritional quality and given in insufficient amounts. When given too early or too frequently, they displace breast milk (Villapando, 2000; WHO, 2002).

Data available on the regional prevalence of diarrhea, under nutrition and under 5 mortality in Nigeria showed a strong interaction among these three factors, with each of them far more prevalent in northern than southern part of Nigeria (UNICEF, 2001). Prevalence of malnutrition in children in North western Nigeria is high due to early introduction of complementary foods and high levels of microbial contamination (Anigo et al., 2007, 2008). Poor feeding practices and shortfall in food intake are the most important direct factors responsible for malnutrition and illness amongst children in Nigeria (Solomon, 2005). The high cost of fortified nutritious proprietary complementary foods is always beyond the reach of most Nigerian

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Table 1. Formulated complementary food blends.

Code	Blend	Ratio (w/w %)
MGBSG	Malted guinea corn: Boiled soybeans: Roasted groundnut	60:20:20
MGRSG	Malted guinea corn: Roasted soybeans: Roasted groundnut	60:20:20
MLBSG	Malted millet: Boiled soybeans: Roasted groundnut	60:20:20
MLRSG	Malted millet: Roasted soybeans: Roasted groundnut	60:20:20
MMBSG	Malted maize: Boiled soybeans: Roasted groundnut	60:20:20
MMRSG	Malted maize: Roasted soybeans: Roasted groundnut	60:20:20

families; hence many depend on inadequately processed traditional foods consisting mainly of unsupplemented cereal porridges made from maize, sorghum and millet (Nnam, 2002).

The global strategy for infant and young child feeding states that, infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health, and thereafter, receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to two years or beyond (WHO, 2002). Improved complementary feeding and breastfeeding practices with reduced morbidity are essential to achieving the Millennium Development Goals (MDGs) for child survival and prevention of malnutrition (Lutter, 2003). Complementary feeding improvement should be of highest priority for nutrition of infant and young children because of its crucial role in preventing mortality and enhancing children development (Lutter and Dewey, 2003).

Over 70% of dietary protein in developing countries is supplied by cereals that are relatively poor sources of protein (Glover, 1976). Formulation and development of nutritious weaning foods from local and readily available raw materials has received a lot of attention in many developing countries (Plahar and Annan, 1994). Several blends using legumes singly or in combination have been evaluated (Ekpenyong et al., 1977; Plahar et al., 1983; Sefa-Dede, 1984) . Legumes are largely replacing milk and other sources of animal protein, which are expensive and not readily available, as suitable substitutes for high-quality protein (Plahar and Annan, 1994). Therefore, appropriate processing and blending of locally available food commodities are been carried out by a number of researchers in Nigeria (Solomon, 2005) Table 1. The present study is a contribution to addressing the prevalence of malnutrition in children in North Western Nigeria through formulation of more nutritious complementary foods using locally available components.

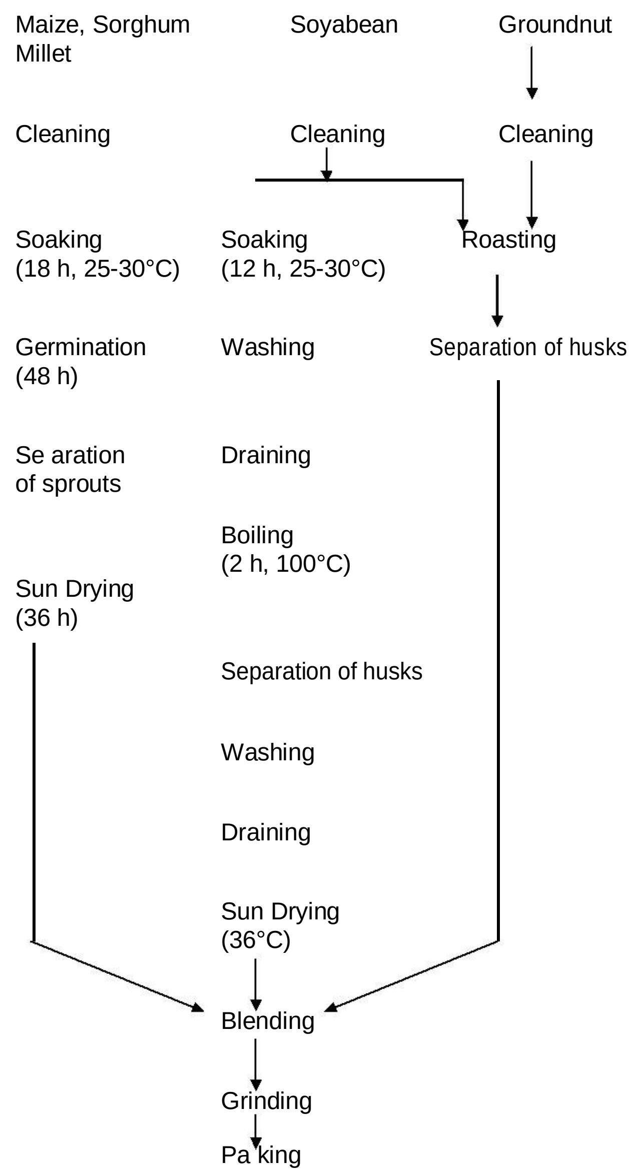

Figure 1. Flow chart for preparation of formulated complementary food blends.

MATERIALS AND METHODS

Cereal grain (guinea corn, *Sorghum bicolor*; maize, *Zea mays* and millet, *Pennisetum glaucum*), groundnuts and soyabean used for this work were purchased from Samaru market in Zaria, Kaduna state. All the grains and legumes samples were manually cleaned by removing manually the ones that were mouldy or broken. The grains were malted as described by Kulkarni et al. (1991) for cereals modified with no addition of sodium benzoate as shown in Figure 1. The grains were watered twice daily and non-germinated ones removed.

Table 2. Proximate composition of formulated complementary foods (g/100 g dry matter).

Proximate composition	MGRSG	MGBSG	MLRSG	MLBSG	MMRSG	MMBSG
Dry matter	14.39 ± 1.43[ab]	13.29 ± 0.01[b]	13.59 ± 0.01[b]	11.05 ± 0.01[c]	13.26 ± 0.71[b]	15.68 ± 0.08[a]
Ash	2.28 ± 0.19[a]	1.11 ± 0.04[c]	2.69 ± 0.96[a]	1.30 ± 0.09[b]	2.54 ± 0.35[a]	1.03 ± 0.01[d]
Crude fat	1.09 ± 0.04[d]	1.24 ± 0.02[c]	2.06 ± 0.16[ab]	1.61 ± 0.40[bc]	1.05 ± 0.17[d]	1.99 ± 0.28[ab]
Crude protein	7.88 ± 0.28[a]	6.76 ± 0.61[b]	6.37 ± 0.23[c]	7.25 ± 0.05[b]	7.20 ± 0.41[a]	7.44 ± 0.22[a]
Crude fibre	1.21 ± 0.01[c]	1.02 ± 0.02[d]	1.74 ± 0.02[a]	0.99 ± 0.03[d]	0.87 ± 0.01[e]	1.54 ± 0.10[b]
Total carbohydrate	88.75 ± 0.28[c]	90.89 ± 0.57[a]	88.88 ± 1.04[bc]	89.84 ± 0.51[b]	89.21 ± 0.58[bc]	89.54 ± 0.10[b]

Values in the same row with different superscripts are significantly different ($p < 0.05$). MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans.

Groundnut and a part of soyabean were roasted separately while another batch of soyabean was steeped, washed with tap water and boiled (Figure 1) . Each formulated blend milled using hammer mill and were mixed thoroughly mistral homogenizer into smooth homogenous powder and then stored in airtight containers at room temperature (25 - 30^{o}C) until used. Ready-to-eat gruel of each formulated complementary foods was made by mixing flour in cold water at concentrations of 20% and then poured into boiling water (200 ml) with the addition of 20 g of flour, stirred and allowed to remain heated for 15 min to form thick gruel, after which samples were taken for analyses.

Chemical analyses

Samples and standard solutions were prepared according to the procedures of the AOAC (1990).The proximate composition of the formulated complementary food samples were determined as described by AOAC (1990). Total carbohydrate was determined by difference. Amino acid profile was determined using the method described by Spackman et al. (1958). Samples were digested in a solution by the acid digestion method (Allen, 1974). Mineral element (Na, K, Ca, Mg, P, Mn, Fe and Zn) concentrations were determined using Atomic Absorption Spectrophotometer (Hitachi, model 180-80). Phosphorus was determined spectrophotometrically by the vanadomolybdate method (AOAC, 1990). Phytic acid was determined by method of Wheeler and Ferrel (1971), tannin by the vanillin-HCl (Earp et al., 1981) and cyanide content by method of Ikediobi et al. (1980). *In-vitro* protein digestibility determined as described by Mertz et al. (1984).

Microbiological and sensory analysis

All microbiological analyses were carried out based on procedures recommended in the International Commission on Microbiological Specification for Foods (1996). Appropriate serial dilutions of the formulated complementary foods were carried out and 0.1 ml of the selected dilution was spread on triplicate plates using sterile glass spreader. This technique was used for the enumeration of Total Aerobic Count, *Escherichia coli* counts, *Staphylococcal* counts, *Salmonella and Shigella* counts, and Fungi and Molds counts on Nutrient Agar, Eosin Methylene Agar, Salmonella and Shigella Agar, and Sabourand Glucose Agar. Media used were prepared according to the manufacturers instructions and all cultures were incubated at 37°C for 24 h.

Sensory evaluation of the ready-to-eat formulated complement-tary foods was carried out on the taste, appearance, aroma, texture, colour and overall acceptability by a 14 semi-trained adult panelists which includes mothers with children age 6 to 24 months and postgraduate students in Ahmadu Bello University, Zaria using a 9-piont hedonic scale (Williams, 1982) which range between 1 (dislike extremely) and 9 (like extremely). The range method of statistical analysis was applied for the test of the significance to find the preferences.

Statistical analyses

Results were expressed as mean ± standard deviation. The difference between groups of each parameter was determined using the t-test and statistical significance was claimed at $P < 0.05$.

RESULTS

Table 2 showed result of proximate analyses of the formulated complementary foods. MMBSG (15.68 ± 0.08%) had significantly higher ($p < 0.05$) dry matter contents which is comparable to MGRSG (14.39 ± 1.43%). MMBSG had significantly ($p < 0.05$) lower ash content (1.03 ± 0.01%) while comparable higher values of crude protein were recorded for MGRSG (7.88 ± 0.28%), MMBSG (7.44 ± 0.22%) and MMRSG (7.20 ± 0.41%). Crude fat contents of MGRSG (1.09 ± 0.04%) and MMRSG (1.05 ± 0.17%) were significantly ($p < 0.05$) lower while MGBSG (90.89 ± 0.57%) significantly higher ($p < 0.05$) in total carbohydrate content. Pattern of variation of the non-essential and essential amino acids concentrations indicates that MLRSG was higher compared to the other formulated complementary foods (Table 3) . Table 4 showed no significant difference ($p > 0.05$) in the *in-vitro* protein digestibility of all the formulated complementary foods and commonly used plain cereal pap (KDLP, KBGP) as control. Mineral element concentrations showed that MLRSG which had significantly ($p < 0.05$) higher ash content (Table 2), recorded significantly ($p < 0.05$) higher with comparable values for some of the mineral elements especially K, Ca and P (Table 5). The result also indicates that sodium, manganese and iron contents were significantly ($p < 0.05$) higher in MGBSG while significantly ($p < 0.05$) lower values of calcium and phosphorus contents were observed in MGRSG and MMBSG respectively. There were significant differences ($p < 0.05$) in magnesium content of MGBSG (146.91 mg/100 g) and MMBSG

Table 3. Amino acids composition of formulated complementary foods (g/100g protein).

Amino acids	MGBSG	MGRSG	MLBSG	MLRSG	MMBSG	MMRSG
Aspartate	9.25	6.51	10.03	9.81	8.17	7.21
Serine	2.75	2.48	2.18	3.08	2.86	2.00
Glutamate	14.30	13.11	15.19	18.85	12.52	11.15
Proline	1.91	2.54	2.86	3.61	2.97	1.80
Glycine	3.89	4.03	4.49	7.36	3.65	3.59
Alanine	3.98	2.50	3.97	5.67	4.45	3.29
Cystine	1.19	1.12	1.38	1.65	1.37	1.09
Tyrosine	3.22	2.89	3.22	3.54	3.22	3.06
Lysine	5.14	4.80	5.74	6.87	6.01	5.26
Histidine	2.38	2.16	2.63	3.38	2.32	2.56
Arginine	5.45	4.50	5.61	6.63	6.13	4.96
Threonine	2.77	3.02	3.02	3.24	2.49	2.20
Valine	3.39	2.73	3.25	4.15	2.64	3.00
Methionine	1.25	2.48	2.68	3.33	1.87	1.34
Isoleucine	3.35	3.28	3.56	4.04	3.04	2.50
Leucine	5.72	6.03	6.97	7.19	5.65	4.99
Phenylalanine	4.23	4.39	4.56	5.41	4.05	3.59

MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans.

Table 4. Percentage *in-vitro* protein digestibility of formulated complementary foods.

Complementary foods	% *in-vitro* digestibility
MGRSG	82.12 ± 6.35^{a}
MGBSG	79.23 ± 3.10^{a}
MLRSG	75.27 ± 2.70^{a}
MLBSG	80.68 ± 6.40^{a}
MMRSG	76.88 ± 2.16^{a}
MMBSG	77.24 ± 3.83^{a}
KBGP	82.17 ± 3.12^{a}
KDLP	72.51 ± 6.98^{a}

Values with different superscripts are significantly different (p<0.05). KBGP = Guinea corn pap. KDLP = Millet pap. MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans.

(107.56 mg/100 g) and also in the zinc content of MGRSG (7.42 mg/100 g) and MMRSG (10.79 mg/100 g).

Levels of antinutrient (Table 6) in the formulated complementary foods revealed that MGRSG (0.34 ± 0.02 mg/100 g) and MLBSG (37.42 ± 9.46 mg/100 g) had significantly higher ($p < 0.05$) phytate and tannin concentrations respectively. Significantly ($p < 0.05$) higher free cyanide contents were recorded in MGBSG (0.84 ± 0.13 mg/100 g) and MLBSG (0.99 ± 0.13 mg/100 g). Presented in Table 7 are the mean counts of organisms in the formulated complementary foods with significantly ($p < 0.05$) higher total aerobic count of

Table 5. Mineral element concentration in formulated complementary foods (mg/100 g dry matter).

Complementary foods	Na	K	Ca	Mg	P	Mn	Fe	Zn
MGBSG	209.72[a]	381.32[ab]	47.66[a]	146.91[a]	219.98[a]	3.58[a]	47.66[a]	7.88[ab]
MGRSG	170.03[b]	434.95[a]	27.68[b]	123.52[ab]	193.90[a]	1.98[c]	23.73[bc]	7.42[b]
MLBSG	139.86[bc]	319.68[b]	47.95[a]	108.18[ab]	184.4[a]	2.50[bc]	23.98[bc]	9.16[ab]
MLRSG	159.39[bc]	432.90[a]	47.23[a]	122.93[ab]	215.69[a]	1.97[c]	17.71[c]	8.20[ab]
MMBSG	135.08[c]	278.11[ab]	47.68[a]	107.56[b]	148.98[b]	2.98[ab]	19.87[bc]	7.45[ab]
MMRSG	167.23[b]	437.99[a]	39.82[a]	114.43[ab]	172.28[a]	1.99[c]	19.91[bc]	10.79[a]
SEM	14.79	45.56	7.10	13.59	15.73	0.21	3.25	1.31

Values in the same column with different superscripts are significantly different ($p < 0.05$). MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans.

Table 6. Antinutritional factors in formulated complementary foods (mg/100 g).

Antinutrient	MGRSG	MGBSG	MLRSG	MLBSG	MMRSG	MMBSG
Phytates	0.34 ± 0.02[a]	0.12 ± 0.02[b]	0.03 ± 0.00[c]	0.03 ± 0.01[c]	0.01 ± 0.00[c]	0.01 ± 0.00[c]
Tannins	15.57 ± 0.00[b]	15.57 ± 0.00[b]	15.57 ± 0.00[b]	37.42 ± 9.46[a]	15.57 ± 0.00[a]	15.57 ± 8.99[a]
Total cyanide	1.06 ± 0.20[b]	1.85 ± 0.50[a]	1.81 ± 0.35[a]	1.13 ± 0.13[b]	0.22 ± 0.06[d]	0.55 ± 0.03[c]
Free cyanide	0.37 ± 0.12[bc]	0.84 ± 0.13[a]	0.40 ± 0.05[c]	0.99 ± 0.13[a]	0.16 ± 0.05[b]	0.50 ± 0.02[b]
Bound cyanide	0.69 ± 0.29[b]	1.01 ± 0.28[a]	1.41 ± 0.32[a]	0.14 ± 0.03[c]	0.06 ± 0.04[c]	0.08 ± 0.01[c]

Values in the same row with different superscripts are significantly different ($p < 0.05$). MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans.

organism obtained in MGRSG (450.00 ± 45.00 cfu/g) and MLBSG (371.00 ± 90.00 cfu/g) while no growth of *E.coli* in MGRSG, MLRSG and MLBSG. MMRSG (39.33 ± 5.61 cfu/g) had significantly higher ($p < 0.05$) *Staphylococcal* counts while significantly higher ($p < 0.05$) fungi counts were obtained in MGRSG (8.33 ± 3.21 cfu/g) and MMBSG (8.50 ± 0.71 cfu/g). All the formulated complementary foods did not record any growth for *Salmonella* and *Shigella*. Sensory evaluation of the formulated complementary foods showed no significant difference ($p > 0.05$) between the colour, odour and taste compared with commonly used plain cereal pap (Table 8). Overall acceptability rating for the formulated complementary foods was equal ($P > 0.05$) to the plain cereal pap commonly used in North western Nigeria.

DISCUSSION

Lack of nutrient-dense complementary foods is one of the common factors accounting for decline in satisfactory growth pattern in children (Lartey et al., 1999). Martins et al. (1992) reported that appropriate number of feeding by children depends on the energy density of the local foods and the usual amount consumed at each feedings. The dry matter contents (Table 2) of the formulated complementary foods when compared with 6.37 to 9.99% reported in plain pap commonly used as complementary foods in North Western Nigeria (Anigo et al., 2009) is an improvement in the nutrient density of the complementary foods which may lead to improved nutrient intake which means more nutrients for same quantity taken and may contribute to solving the problem of malnutrition in the zone. FAO (2001) reported that staple foods such as millet, maize and sorghum are high in starch hence absorbed a lot of water during cooking which make them bulky hence infants need to consume large quantities to get enough energy and nutrients but it is difficult because they have small stomach but the problem is solved if families feed children with weaning foods prepared from germinated cereal flour and enrich bulky foods. Malting reduces viscosity of the foods and hence a child can eat more at a time (Ikujenlola and Fashakin, 2005).

The crude protein values obtained (Table 2) in the formulated complementary foods were lower thanthe 13 to 14 g RDA (Guthrie, 1989) recommended for infants up to one year, however, it may still be able to meet 50% of the RDA but indicates undernutrition which may still lead to nutritional deficiency hence the need to improve on the nutrient density. However, concentrations of crude protein in the formulated complementary foods are higher than 1.38 to3.15 g/100 g reported (Anigo et al., 2009) in commonly used complementary foods in North-western Nigeria. The lysine, leucine and phenylalanine

Table 7. Mean count of organisms (cfu/g) in formulated complementary foods.

Complementary foods	Total aerobic count $\times 10^5$	*E. coli* Count	Staphylococcal	Samonella and Shigella $\times 10^3$	Fungi count
MGRSG	450.00 ± 45.00^{a}	NG	6.00 ± 4.24^{c}	NG	8.33 ± 3.21^{a}
MGBSG	7.00 ± 0.71^{d}	5.50 ± 0.49^{a}	4.33 ± 1.15^{c}	NG	2.00 ± 0.00^{c}
MLRSG	160.50 ± 81.32^{b}	NG	15.00 ± 1.51^{b}	NG	4.00 ± 1.00^{b}
MLBSG	371.00 ± 90.10^{a}	NG	NG	NG	1.50 ± 0.71c
MMRSG	2.50 ± 0.12^{e}	7.00 ± 1.66^{a}	39.33 ± 5.61^{a}	NG	2.50 ± 0.71^{bc}
MMBSG	12.50 ± 3.54^{c}	3.00 ± 0.41^{b}	NG	NG	8.50 ± 0.71^{a}

Values in the same column with different superscripts are significantly different ($p < 0.05$). MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans NG = No growth.

Table 8. Sensory evaluation of formulated complementary foods using the hedonic scale

Blend	Colour	Odour	Taste	Texture	Overall acceptability
MGRSG	6.50 ± 0.76^{a}	5.71 ± 1.48^{a}	6.83 ± 1.07^{a}	6.57 ± 0.90^{ab}	6.43 ± 1.29^{ab}
MGBSG	5.67 ± 1.49^{a}	5.00 ± 1.31^{a}	4.86 ± 1.73^{a}	4.43 ± 1.99^{b}	5.67 ± 0.94^{b}
MLRSG	6.29 ± 1.91^{a}	6.29 ± 1.28^{a}	6.43 ± 1.40^{a}	6.14 ± 1.12^{ab}	6.43 ± 1.18^{ab}
MLBSG	6.71 ± 1.39^{a}	4.14 ± 1.88^{a}	5.71 ± 1.75^{a}	6.71 ± 1.39^{ab}	6.29 ± 0.70^{ab}
MMRSG	7.50 ± 1.38^{a}	6.00 ± 1.51^{a}	6.57 ± 1.50^{a}	6.29 ± 1.83^{ab}	6.57 ± 1.84^{ab}
MMBSG	6.71 ± 1.16^{a}	6.00 ± 0.93^{a}	5.43 ± 1.99^{a}	6.71 ± 1.83^{ab}	6.57 ± 0.73^{ab}
GCP	8.00 ± 1.41^{a}	7.14 ± 1.12^{a}	7.29 ± 0.80^{a}	7.29 ± 1.03^{ab}	7.57 ± 0.73^{a}
LPS	7.67 ± 1.24^{a}	7.00 ± 0.29^{a}	6.57 ± 1.99^{a}	7.57 ± 1.40^{ab}	6.86 ± 2.10^{ab}
GMP	8.14 ± 1.36^{a}	6.29 ± 1.48^{a}	6.14 ± 1.64^{a}	7.33 ± 0.75^{a}	6.71 ± 1.58^{ab}

Hedonic scale: 1 = Dislike extremely 2 = Dislike very much 3 = Dislike moderately 4 = Dislike slightly 5 = Neither like/dislike 6 = like slightly 7 = Like moderately 8 = Like very much 9 = Like extremely. Values in the same column with different superscripts are significantly different ($p < 0.05$). MGRSG = Malted guinea corn/roasted groundnut/roasted soybeans. MGBSG = Malted guinea corn/roasted groundnut/boiled soybeans. MLRSG = Malted millet/roasted groundnut/roasted soybeans. MLBSG = Malted millet/roasted groundnut/boiled soybeans. MMRSG = Malted maize/roasted groundnut/roasted soybeans. MMBSG = Malted maize/roasted groundnut/boiled soybeans GCP = Guinea corn pap, LPS = Millet pap, GMP = Guinea corn/millet pap.

values (Table 3) for all and methionine values for some of the formulated complementary foods were higher than the international reference values for infants (FAO/WHO, 1998). Percentage *in-vitro* protein digestibility of formulated complementary foods was comparable to those of the commonly used complementary foods in Northwestern Nigeria (Table 4). Protein quality is a measure of the efficiency of utilization of proteins by the body which depends on the amino acid composition, digestibility of the proteins and the biological availability of its amino acids for the synthesis of tissue proteins (Ikujenlola and Fashakin, 2005). There was improvement in concentrations of mineral elements in the formulated complementary foods (Table 5) compare to the commonly used complementary foods in the zone and values obtained for all the mineral elements were higher than RDA for infant up to one year except for calcium and potassium but may also contribute to the overall daily intake of mineral elements. According to FAO/WHO (2001) minerals such as iron and zinc are low in cereals but the addition of legumes can improve the iron content. The body depends on a regular zinc supply provided by the daily diets and improvement of zinc in the diet as obtained in the formulated complementary foods may help decrease the prevalence of stunting in the zone as linear growth was reported (FAO/WHO, 2001) to be affected by zinc supply.

Bioavailability of nutrients in the formulated complementary foods (Table 6) compared to 0.04 to 011 mg/100 g phytates and 0.05 to 0.74 mg/100 g free cyanide reported (Anigo et al., 2009) in commonly used plain pap may also be high due to low levels of phytates which were less than 1% reported to interfere with mineral availability (Erdman, 1979) and free cyanide below 1 mg/100 g safe level reported by FAO/WHO (1998). Phytates strongly inhibit iron absorption in a dose-dependent fashion, though small amounts of phytates have a marked effect (Gillooly, 1983). Germination has been reported (Traore et al., 2004) to reduce the concentration of antinutritional factors like phytates in malted grains hence improves its nutritional quality (Marero et al., 1991). The levels of microbial contamination in the formulated complementary foods were lower (Table 7) when compared to the reported (Anigo et al., 2007) unacceptable levels of Salmonella and Shigella, and predominance of Staphylococcus sp. and fungi detected in most of the commonly used complementary foods in Northwestern Nigeria. Although, satisfactory results were obtained for *Salmonella* and *Shigella* in all and *Staphylococcus* spp and *E. coli* in some of the formulated complementary foods samples, most of them gave unsatisfactory results for total aerobic count. Presence of some organisms in the formulated complementary foods though prepared under laboratory conditions, indicate a level of contamination with pathogens which may have be present prior to processing due to the source of raw materials used.

Sensory quality of some of the formulated complementary foods compare to the commonly used complementary foods in the zone was both liked moderately on the hedonic scale (Table 8). A number of organoleptic features, such as flavour, aroma, appearance and texture, may affect infant's intake of transitional foods (Birch, 1998) which may results in increased consumption (Hofvander and Underwood, 1987) . Feeding infants with improved complementary foods as that formulated in this study for children in the zone may cause improvement in their growth (Lartey et al., 1999).

Conclusion

There is improvement in the nutrient quality of the formulated complementary foods with good acceptability comparable to that commonly used in the zone which can be improve on with the ultimate goal of contributing to the reduction of malnutrition in children in North Western Nigeria.

ACKNOWLEDGEMENT

This study was funded by the University Board of Research, Ahmadu Bello University, Zaria-Nigeria.

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