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Chemical Composition, Nutrient Adequacy and Organoleptic Qualities of Infant Complementary Food Mixes Made from Combination of *Digitaria exilis*, *Sesamum indicum* and *Glycine max*

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Abstract: The best nourishment for infants at birth is breast milk. As from six months of age, the child's energy and nutrient requirements increase more than breast milk contains. To fill this gap, other foods are introduced to complement breast milk. Foods given to children to augment energy/nutrient content of breast milk are called complementary foods. This study evaluated the chemical composition, nutrient adequacy and organoleptic qualities of complementary food mixes made from *Digitaria exilis*, *Sesamum indicum* and *Glycine max*. *Digitaria exilis* was fermented and sundried; *Sesamum indicum* roasted and *Glycine max* boiled, fermented and sundried before milling separately into flour and subsequently combined at different ratios to produce *Digitaria exilis*$_{70}$ and *Sesamum indicum*$_{30}$ ($D_{70}S_{30}$); *Digitaria exilis*$_{70}$ and *Glyxine max*$_{30}$ ($D_{70}G_{30}$); *Digitaria exilis*$_{70}$ *Sesamum indicum*$_{15}$ *Glyxine max*$_{15}$ ($D_{70}S_{15}G_{15}$); *Digitaria exilis*$_{70}$ *Sesamum indicum*$_{20}$ *Glyxine max*$_{10}$ ($D_{70}S_{20}G_{10}$) and *Digitaria exilis*$_{70}$, *Glyxine max*$_{20}$ and *Sesamum indicum*$_{10}$ ($D_{70}G_{20}S_{10}$). Formulated flour mixes and gruels produced were chemically and organoleptically assessed, respectively using standard procedures. A commercial product served as control. Means were compared statistically. $D_{70}G_{30}$ mix had more protein (19.26%), folate (108.71 mg) and lowest zinc (3.24 mg) than others. The mixes had above 400 kcal energy, 11.3 to 13.01 mg iron and 190.28 to 198.34mg calcium. Protein, iron, zinc and folate in most of the mixes met 50-100% RNI for the under-fives. The $D_{70}G_{30}$, $D_{70}S_{15}G_{15}$, $D_{70}S_{20}G_{10}$ and $D_{70}G_{30}$ had highest colour (6.80), texture (7.90), flavor (6.50) and general acceptability (6.70) ratings, respectively. The $D_{70}G_{30}$ had the best nutritional and general acceptability attributes for complementary feeding.

Key words: Oil seeds, cereals, mixes, adequacy, acceptability

INTRODUCTION

Optimal breast-feeding will not ward off malnutrition if the child is not fed adequate quantities of good quality complementary foods after 6 months of age (WHO, 2005). Growth faltering often seen in under-fives during the period of complementary feeding, remains a major public health problem in poor resource settings. According to WHO (2011) estimates, two out of five children under the age of five in developing countries are stunted and a large proportion of them are in addition deficient in one or more micronutrients. UNICEF (2011) report showed that malnutrition is a contributory cause of more than half (53%) of under-fives death in Nigeria. The prevalence of under-five malnutrition in Nigeria was 27.2% in 2002, 25.7% in 2004, 26.7% (under-weight) in 2008 and 41.0% (stunting) in 2008 (World Bank, 2008). About 18% wasting, 61.1% stunting and 32% underweight were reported in Nasarawa, Nigeria (Awogbenja *et al*., 2012) while in another study in Zaria, northwestern Nigeria, 7% wasting, 31% stunting and 29% underweight were reported (Sufiyan *et al*., 2012). Another study by Ibeanu *et al*. (2013) observed 19% wasting, 86% stunting and 21% underweight in Anambra state, southeast Nigeria. It is obvious therefore, that stunting (chronic malnutrition), wasting (acute malnutrition) and underweight (chronic or acute or a combination of both) of under-fives are abound in Nigeria. One of the proven actions to prevent under-five malnutrition is exclusive breast-feeding for 6 months followed by adequate complementary feeding after 6 months of age (UNICEF, 2011). Optimal breast and complementary feeding practices can save the lives of 1.5 million children under five every year (WHO, 2010), while optimal complementary feeding alone can prevent an estimated 6% of under-five deaths (WHO, 2011).

Traditional complementary foods in ultra-poor communities of Nigeria are made from cereals and starchy roots and tubers. These have been shown to be monotonous, bulky and low in energy and nutrient densities (Ibeanu, 2009). Low nutrient quality of these traditional complementary foods and inadequate feeding practices predispose under-five children in to malnutrition, poor health, growth and development. Mothers who cannot afford animal based complementary foods or enrich/fortify plant based ones, face the dilemma of raising malnourished children.

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Cereals and legumes have been shown to have nutrient potentials that complement one another in general (Fernandez *et al*., 2002) and have amino acid pattern that can compare to that of animal. Studies have showed that combining different Nigerian staple cereals and legumes produced complementary foods that had more energy and nutrients than the traditional *og*i gruels (Ibeanu, 2009; Nwamarah and Amadi, 2009).

Maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum* spp.), soybean (*Glycine max*) and peanuts (*Arachis hypogea*) are combined and used for complementary feeding in Nigeria. Other cereals and legumes such as hungry rice *(Digitaria exilis*) and benne seed (*Sesamum indicum*) are also cheap sources of plant protein but are under exploited and not commonly used in infant feeding. Hungry rice is one of the nutritious grains in the world (Thiam, 2008). It is particularly rich in many essential amino acids (National Academy of Science, 2006). Benne seed is an oil legume that is rich in micronutrients and phytochemicals (Bedigian, 2003). The potentials of these under-utilized staples to produce multi mixes for use in complementary feeding could be exploited as nutritionally alternative to the monotonous maize or millet gruel. This study evaluated the chemical composition, nutrient adequacy, organoleptic attributes and acceptability of infant complementary multi mixes made from hungry rice, benne seed and soybean.

MATERIALS AND METHODS

Preparation and formulation of multi-mixes: Hungry rice (*Digitaria exilis*), benne seed (*Sesamum indicum*), soybean (*Glyxine max)* were the cereal and legumes, respectively used for the study. Hungry rice was washed, soaked in water (1: 3 ratio) and fermented for 48 h (with the water changed every 24 h) and sundried. Benne (sesame) seeds were handpicked and washed, sundried and roasted at 80°C for 10 min or until the seeds turned golden in colour. Soybean seeds were also handpicked, washed and boiled at 100°C for 60 min, dehulled, soaked in water (1: 3 ratio), fermented for 24 h and sundried. The dried seeds were roasted at 80°C for 10 min. All the treated seeds were milled separately into flour, stored in air tight container and refrigerated until used.

The flours were combined based on their crude nitrogen (N) concentration. Altogether, there were 5 multi-mixes, each derived 70% of its protein from cereal (hungry rice) and 30% from legume and or oil seed (soybean and benne seed). The multi-mixes formulated namely *Digitaria exilis*$_{70}$ and *Sesamum indicum*$_{30}$ ($D_{70}S_{30}$); *Digitaria exilis*$_{70}$ and *Glyxine max*$_{30}$ ($D_{70}G_{30}$); *Digitaria exilis*$_{70}$ *Sesamum indicum*$_{15}$ *Glyxine max*$_{15}$ ($D_{70}S_{15}G_{15}$); *Digitaria exilis*$_{70}$ *Sesamum indicum*$_{20}$ *Glyxine max*$_{10}$ ($D_{70}S_{20}G_{10}$) and *Digitaria exilis*$_{70}$, *Glyxine max*$_{20}$ and *Sesamum indicum*$_{10}$ ($D_{70}G_{20}S_{10}$) were analyzed for energy and nutrients before being used to produce gruels.

The gruels as well as that made from a proprietary maize-soybean based complementary food which served as a control were also analyzed for energy and nutrients. All the analyses were done in triplicate using standard procedures. The adequacy of the gruels was calculated by expressing nutrient content of the daily portion size (1000 mL of gruels to be consumed in four meals of 250 mls each) to be fed a child who still consuming average amount of breast milk as percentage of the recommended nutrient intake.

Organoleptic assessment of gruels made from multi-mixes: A standard recipe was developed and used to prepare the gruels from the formulated multi-mixes. The control was prepared according to the manufacture's instruction.

Recipe ingredients:

1: 100 g of multi-mix flour
2: 100 mL of cold water
3: 800 mL of boiling water

Method:

1: Add 100 mL of cold water to 100 g multi-mixes in a pot and stir to make paste
2: Add 800 mL of boiling water to the paste and stir
3: Cook on low heat for 10 min while stirring occasionally
4: Leave porridge to cool to 40°C and serve

A nine-point Hedonic scale was used to evaluate the sensory attributes of the gruels by 30 judges made up of mothers and women of childbearing age. The gruels were coded, labeled and displayed in plastic containers with lids and scored by the judges for colour, flavour/taste, texture and general acceptability. Evaluation protocol which included rinsing of mouth and testing spoons after each testing was fully explained to them.

Data analysis: The Statistical Package for Social Sciences (SPSS) version 17 was used to analyze the data collected which were expressed as means and percentages. One way analysis of Variance (ANOVA) and Duncan's multiple range tests were used to separate/compare means at significance level $p<0.05$.

RESULTS

Nutrient composition of the multi-mix flours and the control as consumed is shown in Table 1. The $D_{70}S_{30}$ had the highest energy (450.9 kcal) followed by $D_{70}S_{20}G_{10}$ (433.4 kcal). $D_{70}G_{30}$ had the least (403.2 kcal) energy value. All the multi-mixes had significantly ($p<0.05$) higher energy than the control (398.0 kcal). The protein

Table 1: Nutrient composition of the formulated multi-mixes and the control/100 g

Samples	$D_{70}S_{30}$	$D_{70}G_{30}$	$D_{70}S_{15}G_{15}$	$D_{70}S_{20}G_{10}$	$D_{70}S_{10}G_{20}$	*Control
Energy (kcal)	450.9±0.02^{a}	403.2±0.04^{b}	422.8±0.06^{b}	433.4±0.03^{a}	410.8±0.06^{b}	398.0^{c}
Moisture (%)	5.0±0.21^{a}	4.9±0.35^{a}	4.9±0.07^{a}	4.9±0.03^{a}	4.9±0.03^{a}	2.5^{b}
Protein (%)	15.4±0.04^{b}	19.3±0.02^{a}	17.2±0.01^{a}	16.9±0.01^{a}	18.1±0.01^{a}	15.0^{b}
Fat (%)	17.9±0.01^{a}	8.7±0.02^{b}	12.2±0.02^{a}	14.7±0.01^{a}	9.8±0.04^{b}	9.0^{b}
Fibre (%)	1.3±0.02^{b}	1.9±0.02^{b}	1.4±0.03^{b}	1.3±0.02^{b}	1.3±0.01^{b}	7.0^{a}
CHO (%)	57.1±0.02^{b}	62.1±0.02^{a}	61.0±0.01^{a}	58.1±0.02^{b}	62.3±0.01^{a}	64.2^{a}
Folate (µg)	94.3±0.00^{c}	108.7±0.00^{a}	101.5±0.00^{b}	99.1±0.00^{b}	103.9±0.00^{b}	80.0^{d}
Retinol (µg)	41.6±0.01^{b}	40.8±0.02^{b}	44.5±0.02^{b}	41.3±0.02^{b}	44.0±0.02^{b}	450.0^{a}
Ascorbate (µg)	2.3±0.02^{b}	4.4±0.01^{b}	3.0±0.01^{b}	3.0±0.01^{b}	3.2±0.01^{b}	50.0^{a}
Iron (mg)	13.0±0.02^{a}	11.3±0.03^{a}	12.2±0.04^{a}	12.5±0.02^{a}	11.9±0.03^{a}	10.0^{a}
Calcium (mg)	198.3±0.02^{b}	190.3±0.01^{b}	194.3±0.02^{b}	195.7±0.03^{b}	193.0±0.01	390.0^{a}
Zinc (mg)	7.3±0.01^{a}	3.2±0.02^{b}	6.0±0.02^{a}	7.3±0.02^{a}	4.2±0.01^{b}	6.0^{a}

Means with different superscript on the same column are significantly different ($p<0.0$)

$D_{70}S_{30}$: $Acha_{70}$/benne $seed_{30}$
$D_{70}G_{30}$: $Acha_{70}$/$soybean_{30}$ flours
$D_{70}S_{15}G_{15}$: $Acha_{70}$/benne $seed_{15}$/$soybean_{15}$ flour
$D_{70}S_{20}G_{10}$: $Acha_{70}$/benne $seed_{20}$/$soybean_{10}$ flour
$D_{70}S_{10}G_{20}$: $Acha_{70}$/benne $seed_{10}$ /$soybean_{20}$
*Control: Manufacturer's values

Table 2: Phytochemical and anti-nutrient composition of the formulated multi-mixes

	$D_{70}S_{30}$	$D_{70}G_{30}$	D_{70} $S_{15}G_{15}$	$D_{70}S_{20}G_{10}$	$D_{70}S_{10}G_{20}$
Phytochemical					
Saponin (mg)	2.0^{a}	0.8^{b}	1.4^{a}	1.6^{a}	1.2^{b}
Flavonoid (mg)	11.1^{a}	10.6^{a}	11.3^{a}	11.3^{a}	11.4^{a}
Tannin (mg)	0.4^{a}	0.7^{a}	0.6^{a}	0.5^{a}	0.6^{a}
Anti-nutrient					
Phytate (mg)	2.7^{a}	2.3^{a}	2.5^{a}	2.7^{a}	2.4^{a}
Oxalate (mg)	1.8^{a}	1.7^{a}	1.8^{a}	1.7^{a}	1.8^{a}
Haemagglutinin (mg)	Trace	0.2^{a}	0.1^{a}	0.1^{a}	0.1^{a}

Means with different superscript on the same column are significantly different ($p<0.05$)

$D_{70}S_{30}$: Hungry $rice_{70}$/benne $seed_{30}$
$D_{70}G_{30}$: Hungry $rice_{70}$/$soybean_{30}$
$D_{70}S_{15}G_{15}$: Hungry $rice_{70}$/benne $seed_{15}$/$soybean_{15}$
$D_{70}S_{20}G_{10}$: Hungry $rice_{70}$/benne $seed_{20}$/$soybean_{10}$
D_{70} $S_{10}G_{20}$: Hungry $rice_{70}$/benne $seed_{10}$/$soybean_{20}$

content of all the blends except for the $D_{70}S_{30}$ (15.4%) was significantly higher than that of the control (15.0%). $D_{70}S_{15}G_{15}$ (17.2%), $D_{70}S_{20}G_{10}$ (16.9%) and $D_{70}S_{10}G_{20}$ (18.1%) had comparable protein values. The control had significantly higher fibre (7.0%) content relative to the mixes. The $D_{70}S_{30}$ had more fat (17.9%) followed by $D_{70}S_{20}G_{10}$ (14.7%). All the multi-mixes, except the $D_{70}G_{30}$ (8.7%) and the $D_{70}S_{10}G_{20}$ (9.8%) contained significantly ($p<0.05$) more fat than the control (9.0%). Carbohydrate in the mixes ranged from 57.1% in $D_{70}S_{30}$ to 62.3% in $D_{70}S_{10}G_{20}$.

The $D_{70}G_{30}$ had the highest and least contents of folate and retinol, respectively. All the blends had significantly ($p<0.05$) more folate than the control (80.0 µg) while the control had more retinol (450.0 µg). The control also had more ascorbate content than the mixes. The iron values of the mixes and the control were similar. Calcium was higher in $D_{70}S_{30}$ (198.3 mg) than the rest of the samples and all their values were lower ($p<0.05$) than that of the control (390.0 mg). The zinc content of the $D_{70}G_{30}$ (3.2 mg) and the $D_{70}S_{10}G_{20}$ (4.2 mg) were significantly lower than the other mixes and the control (6.0 mg).

Table 2 shows that saponin in $D_{70}S_{30}$ (2.0 mg), D_{70} $S_{15}G_{15}$ (1.4 mg) and $D_{70}S_{20}G_{10}$ (1.6 mg) was similar and significantly higher than that in $D_{70}G_{30}$ (0.8 mg) and $D_{70}S_{10}G_{20}$ (1.2 mg). Flavonoid and tannin in all the mixes were the same. Traces of haemagglutinin were found in $D_{70}S_{30}$ while the others contained about 0.2 mg. Less than 2.0 and 3.0 mg of oxalate and phytate, respectively were found in all the mixes.

The adequacy of the gruels made from the formulated multi-mixes is presented in Table 3. The protein, folate and iron content of all the gruels met more than half of the required nutrient intake of a child consuming average amounts of breast milk. The ranges were 118.0-142.7% for protein, 68.6-71.6% folate and 87.1-267.7% iron. About half of the calcium requirement by met by formulated gruels. Fat was adequate in only $D_{70}S_{30}$ and $D_{70}S_{20}G_{10}$. The energy content of all the formulated gruels was however, less than 50% of the requirement.

Table 4 presents the sensory and acceptability tests of the gruels made from the formulated complementary mixes and the control. There were variations in the colour of the gruels. The control had the highest (7.9) colour rating which was significantly ($p<0.05$) higher than those of the gruels made from the formulated mixes. The $D_{70}G_{30}$ (6.8), D_{70} $S_{15}G_{15}$ (6.1), D_{70} $S_{20}G_{10}$ (6.3) and $D_{70}S_{10}G_{20}$ (6.6) had comparable colour ratings; $D_{70}S_{30}$ was rated least (4.6). The control had the least (6.1) texture rating which was significantly ($p<0.05$) lower

Table 3: Nutrient content of 1000 mL of gruel made from the formulated mixes expressed as percentage of RNI

Nutrient	143 g $D_{70}S_{30}$ = 1000 mL gruel	125 g $D_{70}G_{301}$ = 1000 mL gruel	125 g $D_{70}S_{15}G_{15}$ = 1000 mL gruel	132 g $D_{70}S_{20}G_{10}$ = 1000 mL gruel	125 g D_{70} $S_{10}G_{20}$ = 1000 mL gruel
Energy (kcal)	483.9	385.8	383.8	429.3	362.4
RNI (kcal)	1300	1300	1300	1300	1300
RNI met of (%)	37.2	29.7	29.5	33.0	27.9
Protein (g)	20.6	22.8	20.2	19.7	18.9
RNI	16	16	16	16	16
RNI met of (%)	128.8	142.7	126.3	122.9	118.0
Fat (g)	25.6	10.8	15.3	19.5	13.6
RNI	40.0	40.0	40.0	40.0	40.0
RNI met of (%)	64.0	27.1	38.2	48.7	33.9
Retinol (µg)	59.5	51.1	55.7	54.5	55.0
RNI	400.0	400	400	400	400
RNI met of (%)	14.9	12.8	13.9	13.6	13.8
Ascorbate (mg)	2.0	2.9	3.7	3.0	3.5
RNI	30	30	30	30	30
RNI met of (%)	6.7	9.4	12.4	10.0	11.8
Folate (µg)	112.1	114.5	109.7	111.4	113.4
RNI	160	160	160	160	160
RNI met of (%)	70.1	71.6	68.6	69.6	70.9
Calcium	284.4	231.6	241.6	254.3	237.8
RNI	500	500	500	500	500
RNI met of (%)	56.9	46.3	48.3	50.9	47.6
Iron	10.2	7.9	6.1	18.4	15.0
RNI	7.0	7.0	7.0	7.0	7.0
RNI met of (%)	145.7	112.6	87.1	262.7	214.9
Zinc	10.4	3.2	7.6	8.3	5.2
RNI	4.1	4.1	4.1	4.1	4.1
RNI met of (%)	253.7	78.8	185.4	203.4	127.6

$D_{70}S_{30}$: Hungry $rice_{70}$/benne $seed_{30}$
$D_{70}G_{30}$: Hungry $rice_{70}$/$soybean_{30}$
$D_{70}S_{15}G_{15}$: Hungry $rice_{70}$/benne $seed_{15}$/$soybean_{15}$
$D_{70}S_{20}G_{10}$: Hungry $rice_{70}$/benne $seed_{20}$/$soybean_{10}$
D_{70} $S_{10}G_{20}$: Hungry $rice_{70}$/benne $seed_{10}$/$soybean_{20}$
1000 mL gruel is to be consumed in 4 meals of 250 mls per meal

Table 4: Sensory and acceptability test of the gruels from formulated complementary mixes

Samples	Colour	Texture	Flavour	General acceptability
$D_{70}S_{30}$	4.6±2.80[a]	7.5±2.98[a]	5.3±3.11[a]	4.9±2.11[a]
$D_{70}G_{30}$	6.8±2.73[b]	7.6±3.38[a]	5.9±2.55[a]	6.7±2.89[b]
D_{70} $S_{15}G_{15}$	6.1±2.77[b]	7.9±2.75[a]	5.7±3.10[a]	5.8±2.48[c]
D_{70} $S_{20}G_{10}$	6.3±2.26[b]	7.2±2.89[a]	6.5±3.27[a]	6.6±2.48[b]
$D_{70}S_{10}G_{20}$	6.6±2.81[b]	7.1±2.76[a]	6.1±2.27[a]	5.7±2.41[c]
Control	7.9±1.71[c]	6.1±2.74[b]	6.6±3.20[a]	7.3±1.92[b]

Means with different superscript on the same column are significantly different from each other ($p<0.05$)
$D_{70}S_{30}$: Hungry $rice_{70}$/benne $seed_{30}$
$D_{70}G_{30}$: Hungry $rice_{70}$/$soybean_{30}$
$D_{70}S_{15}G_{15}$: Hungry $rice_{70}$/benne $seed_{15}$/$soybean_{15}$
$D_{70}S_{20}G_{10}$: Hungry $rice_{70}$/benne $seed_{20}$/$soybean_{10}$
D_{70} $S_{10}G_{20}$: Hungry $rice_{70}$/benne $seed_{10}$/$soybean_{20}$

than those of the mixes. All the gruels from the formulated multi-mixes had comparable texture values ($p>0.05$). The control had the highest flavour rating (6.6) relative to the other the samples, however, these differences were not significant ($p>0.05$). The control also had the highest general acceptability rating of 7.3 followed by $D_{70}G_{30}$ (6.7), D_{70} $S_{20}G_{10}$ (6.6), D_{70} $S_{15}G_{15}$ (5.8) and $D_{70}S_{10}G_{20}$ (5.7). The least accepted gruel was the $D_{70}S_{30}$ (4.9).

DISCUSSION

The flours of the formulated multi-mixes had higher carbohydrate, protein and fat and energy contents than the control. This is a positive attribute because low energy dense foods tend to limit total energy intake and utilization of other nutrients (Solomon, 2005). This finding was similar to that of Makinde and Ladipo (2012). They reported that the protein and energy contents of sorghum, benne seed and soybean based complementary food were higher than the control (maize/soybean) they used. The high protein content of the flours was expected because soybean and benne seed used in the supplementation of hungry rice were leguminous oil seeds which are rich in protein (Thiam, 2008 and National Academy of Science, 2006). Many researchers observed that when Nigerian staple cereals were supplemented with legumes for infant complementary feeding, their protein values were comparable and cheaper than protein from complementary foods of animal origin (Ibeanu, 2009;

Nwamarah and Amadi, 2009; Obizoba, 1989). Again, the fat content of the flours was relatively higher than the control. This could be attributed to the inclusion of oil dense benne seed and soybean in the mixes (Makinde and Ladipo, 2012). The inclusion of the plant oil was recommended in foods meant for infants and children to increase the energy density of such foods as well as help in the transporting fat soluble vitamins (FAO/WHO, 1998). In addition, benne seed oil contains sesamolin and sesamol antioxidants believed to promote cell integrity and healthy body tissue in the presence of oxidizing compounds (Makinde and Ladipo, 2012). Carbohydrate was also more in the formulated multi-mixes than in the control. This could be a function of the ratio (70%) of cereal in the mixes.

The crude fibre content of all the multi-mixes was lower than the recommended 5 g/100 g (FAO/WHO/UNU, 1985). This observation could be attributed to the dehulling of some of the base grains. However, dehulling of pulses, legumes, oil seeds and certain cereals used in infant complementary food, was recommended by FAO/WHO Food Standards Programme (2012) to decrease and if possible, eliminate phytate, tannins and other phenolic materials, which can lower the protein digestibility, amino acid bioavailability and mineral absorption. Also low fibre content in complementary food reduces bulkiness of the food and encourages high digestibility and absorption of nutrients such as proteins and minerals (Ijarotimi *et al*., 2012).

There were more folate, zinc and iron in all the multi-mixes than in the control. The high zinc and iron values could be attributed to the presence of benne seed which was reported by Gernah *et al*. (2012) and Bedigian (2004) as a good source of zinc and iron. The high mineral values observed in this study agreed with the report of Solomon (2005) that enrichment of cereals with benne seed improved mineral content of the food products relative to other leguminous seeds. The values of retinol and ascorbate were low in the formulated multi-mixes relative to the control probably because the base ingredients were poor sources of the vitamins and the mixes were not fortified as is the practice with proprietary products (Solomon, 2005).

The values of flavonoid and tannins observed in this study were lower than the safe levels (20-70 mg/day and 150-200 mg/day, respectively) reported in studies by Beecher (2003) and Schiavone *et al*. (2007). The low values of flavonoid might be due fermentation and production of other flavonoid-based compounds while that of tannins could also be associated with microbial fermentation that increased levels of tannic acid. Low levels of these phytochemicals meant that absorption of minerals such as iron in the formulated mixes might not be inhibited (Afsana, 2003). Also the values of phytate and oxalate in the multi-mixes were lower than that reported as safe (<301 mg/100 g and 80-120 mg/day, respectively) in other studies (Schlemmer *et al*., 2009). The observation meant that divalent minerals (calcium, iron and zinc) would be more bio-available when gruels made from the mixes are consumed (Brown *et al*., 1998). The haemagglutinin content (trace -0.2 HU/mg) of the mixes were lower than the safe level of <25 HU/mg. It was therefore, unlikely that the mixes would pose toxicity problem when consumed.

According to Brown *et al*. (1998) complementary foods should provide approximately 50-70% of total daily requirement for energy, 20-45% protein, 5-30% retinol, 60% calcium, 100% iron and 85% zinc. All the gruels made from the formulated mixes met the protein, retinol, iron and zinc requirements for a complementary food. Protein, iron and zinc were particularly very high (over 100%). This was an added advantage because plant based foods generally have low bio-availability, therefore, when excess is consumed one is certain that at least the required quantity could be absorbed. The gruels contained appreciable quantities of folate and ascorbate although they are not nutrients of importance in complementary food. This is because breast milk is high in these vitamins in well-nourished mothers. Calcium value in the gruels with low proportion of benne seed flour was slightly lower than recommendation. This could be improved by increasing the ratio of benne seed or addition of ground fish bone as recommended by Nnam and Nwachukwu (2007). The energy and fat in the formulated gruels however, were inadequate. This according to Nnam and Nwachukwu (2007) could be increased by adding a small amount of red palm oil. This also would increase the pro retinol content of the food. The low (<40 g) fat values of the gruels could be due to the high proportion (70%) of hungry rice to the oil seeds. Reversing the cereal-legume ratio used in this study might increase the fat content of the mixes and thus the energy content.

The texture of all the formulated gruels was smoother and creamier and more acceptable relative to the control. This consistency was appropriate for the spoon feeding of infants or young children and in conformity with FAO/WHO Food Standards Programme (2012). recommendations for processed cereal-based complementary foods. The colour of the gruels was a function of treatment which resulted in the milliard enzymatic browning, caramelization of sugar and ascorbic acid oxidation and source of the base cereal (hungry rice). The control however, had higher colour rating of 7.9 as well as higher flavour and general acceptability. The low acceptability of the formulated gruels relative to the control could be attributed to sour/astringent tastes conferred on them due fermentation of hungry rice which was the main component of the multi-mixes and the fact that sugar was not added to the gruels. This was in agreement with the report of Ibeanu (2009) that sugary taste is important in acceptability of infant complementary food. In addition new products are not easily accepted without much advertising.

Conclusion: The study revealed that ready-to-eat infant complementary gruel could be made from blending different proportions of processed hungry rice, benne seed and soybean. The gruels made from the multi-mixes were adequate in some nutrients such as protein, retinol, folate, iron and zinc but inadequate in energy and fat. Increasing the ratio of the benne seed and soybean to the cereal might bring the energy and fat to the level recommended for complementary food. The sensory attributes of the formulated gruels were above average and therefore, have promising acceptability if adequately advertised through nutrition education of mothers and women of childbearing age. Further investigations should be carried out to ascertain the digestibility and bioavailability of the nutrients in the gruels. Also the microbial load and shelf life of the formulated multi-mixes flours should be studied possible use by mothers in ultra-poor communities.

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