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Formulation and Nutritional Evaluation of Complementary Foods Prepared from Maize, Sorghum, Groundnut, Crayfish, and Beans

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Abstract

The aim of this study was to develop local, readily available, cheap, nutritious and easy to prepare complementary food (CFs) for infants and young children (IYC) and serve as panacea to reduce malnutrition in Nigeria. An experimental study and cross-sectional survey were conducted in Ijebu-Ode Local Government Area, Ogun State, Nigeria. Sorghum (*Sorghum bicolor*), maize (*Zea mays*), beans (*Vigna unguiculata*), groundnut (*Arachis hypogae*) and crayfish (Scientific name) were obtained from a local market in Ijebu-Ode, Nigeria. The cereals were manually cleaned and processed into flour using standardized fermentation and germination methods. Sensory evaluation was conducted among twenty-one randomly selected mothers of IYC. With AOAC, proximate analysis results of the CFs showed that moisture content ranged from 4.00±1.79% for samples 1 (Germinated maize, beans groundnut and crayfish; 70:10:10:10) to 9.12% for sample 10 (fermented sorghum, beans groundnut and crayfish ; 70:10:10:10). The crude protein content ranged from 17.84±1.12% for samples 16 (Maize and sorghum, beans groundnut and crayfish; 70:10:10:10) to 25.63 ±0.89% for sample 6 (fermented maize, beans groundnut and crayfish; 50:30:10:10). Sensory evaluation of the best six complementary foods with the highest protein contents was conducted. In terms of colour and overall acceptability, sample 10 was most acceptable and was not significantly ($p \leq 0.05$) different from others, sing Duncan Multiple Range Test. The protein content of the complementary foods increased as the content of both legumes increased with crayfish content as being constant. Complementary foods prepared from sorghum, groundnut and crayfish is most acceptable, and therefore it is recommended.

Keywords: Complementary food, Malnutrition, Proximate analyses, Sensory analyses

INTRODUCTION

One of the most important physiological phenomena that go on in infants is growth and development. The period of transition from exclusive breastfeeding to family food,, referred to as complementary feeding, covers a child from 6-23 months of age, and is a vulnerable period (FAO, 2011) From birth to about six months of age, nature has provided the mothers' breast milk with nutrients that meet the nutritional demand of the infant for good growth and development, hence the promotion of Exclusive Breast Feeding (EBF) by nutritionists, paediatricians and World

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Health Organisation (WHO). However, beyond six months of age, the nutritional requirements of the infants increase to the extent that they can no longer be met by the breast milk alone hence the need for the introduction of complementary foods. This is the period that is often referred to as "weaning" and also the period when the problem of malnutrition among the infants often manifests due principally, to inadequate consumption of foods of good nutrient content. In many developing countries, however, traditional complementary food gruels are based on starchy staple foods, such as wheat, rice, maize or sorghum, that produce viscous porridges that are difficult for infants to consume. Consequently, the gruels are often over-diluted to reduce their viscosity which invariably reduces their energy density. Arising from the over-dilution and reduction in nutrient density, the infants are unable to consume enough quantity due to their small gastric capacities, hence they become malnourished.

RELATED WORKS

Malnutrition among children in Nigeria

The Nigeria Demographic and Health Survey (NDHS) study carried out in 2005 and reported in 2010, still confirmed the high prevalence of malnutrition in Nigeria. The result of the NDHS indicates that 41% of children under five years are stunted and 23% are severely stunted; 14% of children under five are wasted. Nationally, 23% of children under five are underweight and 90% are severely underweight. There is therefore the need to carry out research into how to reduce the high prevalence of malnutrition especially undernutrition in Nigeria through the production of locally available nutritious complementary foods. Although, WHO recommends that infants be exclusively breastfed for the first 6 months of life (WHO, 2020), after 6 months, breast milk alone will no longer be sufficient both in terms of quantity and quality to meet the nutritional requirements of the child especially for energy and micronutrients notably zinc, iron and vitamin A (UNICEF, 2009). Also, at the age of six month and above a child is undergoing rapid growth, physiological maturation and development making breast milk not sufficient to meet the nutritional needs of infant. This calls for the introduction of nutritious complementary foods which are also called weaning foods. Various international efforts are being made since long back for alleviating vitamin A deficiency and thereby combating night blindness.

Breastfeeding and Complementary feeding practices

Among three different approaches, namely supplementation program through distribution of vitamin A capsules; fortification of common foods with micronutrients and improvement of dietary quality through diversification of foods, the third one is an important food complementary based approach in achieving and maintaining adequate intake of micronutrient rich foods in the context of an adequate total diet (World Health Organization, (WHO), 2020, Lutter & Rivera, 2003) stated that 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. Malnutrition, specifically under nutrition, is a serious medical condition marked by a deficiency of energy, essential proteins, fats, vitamins, and minerals in a diet. It is especially burdensome and dangerous for young, growing children. There are currently 195 million children less than five years of age affected by malnutrition; 90 percent of them live in Sub-Saharan Africa and South Asia. This is an ongoing medical emergency with devastating communal and economic consequences and urgent action is required (Black *et al*., 2010). Evidence for specific interventions that might improve maternal and child nutritional status include breastfeeding, complementary feeding, and provision of food supplements, micronutrient interventions, supportive nutrition strategies, and large-scale nutrition program (Black *et al.*, 2008). Poor feeding practices and shortfall in food intake are the most important direct factors responsible for malnutrition and illness among children in Nigeria (Solomon, 2005). Breast milk alone is no longer sufficient to meet the nutritional requirements of infants and therefore, food is needed (Alelign *et al.*, 2020).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 (Zlotkin, *et al.*, 2010). According to Codex Alimentarius Commission CAC (2018), complementary foods should be of appropriate nutritional quality and energy to balance the nutrients obtained from breast milk for infants and family foods for younger children. This study therefore was aimed at formulation and nutritional evaluation of complementary foods prepared from maize, sorghum, groundnut, crayfish, and beans

METHODOLOGY

Sample collection

All the food samples, yellow maize, sorghum, beans, groundnut and white crayfish were purchased from Oke-Aje market at Ijebu-Ode, Ogun, Nigeria. Maize and sorghum flours were prepared from both fermented and germinated grains adopting Papageorgiou's (2020) method.

Preparation of complementary foods

The complementary foods were prepared from the composite flours of yellow maize (*Zea mays*); beans (*Vigna unguiculata*); groundnut (*Arachis hypogaca*) with red skin; and white crayfish (*Procambarus acutus*) and then compared with 100% fermented maize flour as sample A, and 100% fermented sorghum flour as sample B. For the fermentation process, the cereal grains were handpicked and winnowed to remove the dirty and bad ones. Thereafter, they were soaked in excess cold clean tap water at 270C for 72 hours at room temperature after which they were washed and drained. They were thereafter wet milled using local commercial mill and sieved with the household sieve of about 280µm. The husks were discarded while the filtrate was allowed to settle for about 8 hours and the paste was recovered using a muslin cloth and squeezed to further remove the water. The paste was then dried on an improvised heated clean aluminium surface at a room temperature of 70oC for four hours and thereafter dried milled and sieved to obtain the dried corn flour (ogi).

For the germination process, the cereal grains were cleaned as described earlier and then steeped in clean cold tap water at 270C for 12 hours. They were, thereafter, spread on a local sieve of 280µm (150 mesh) for 48 hours after allowing for sprouting (germination). The sprouted grains were then cleaned again in water, drained and wet-milled with commercial mill. The same processes of obtaining the dried flour described earlier for the fermentation process were then followed. Groundnut flour was obtained using the method described by Onimawo & Offurum (2015). The groundnut seeds were cleaned by handpicking and winnowing and then soaked cold tap water at 270C for about 8 hours to remove the testa and the seeds were dried on an open aluminium trough at 70oC for 4 hours. The dried seeds were then dried-milled and sieved to obtain the flour. The cowpea seeds were soaked in cold clean tap water of 270C for 10 minutes after which they were robbed between the palms to remove the testa. They were then boiled for 20 minutes and drained. The drained seeds were then dried on hot clean aluminium trough at 70oC for 4 hours, dried milled and sieved to obtain the cowpea flour. Dried crayfish were thoroughly cleaned by handpicking and winnowing to remove the dirt and detached fins, blended with a household blender and sieved to obtain the flour. The various blends were obtained as; cereal grains varying from 70: 60:50% while the cowpea varied from 10:20: 30%., both the groundnut and crayfish flour constituted 10% of the various blends. A total of 18 different blends were finally produced (Table 1).

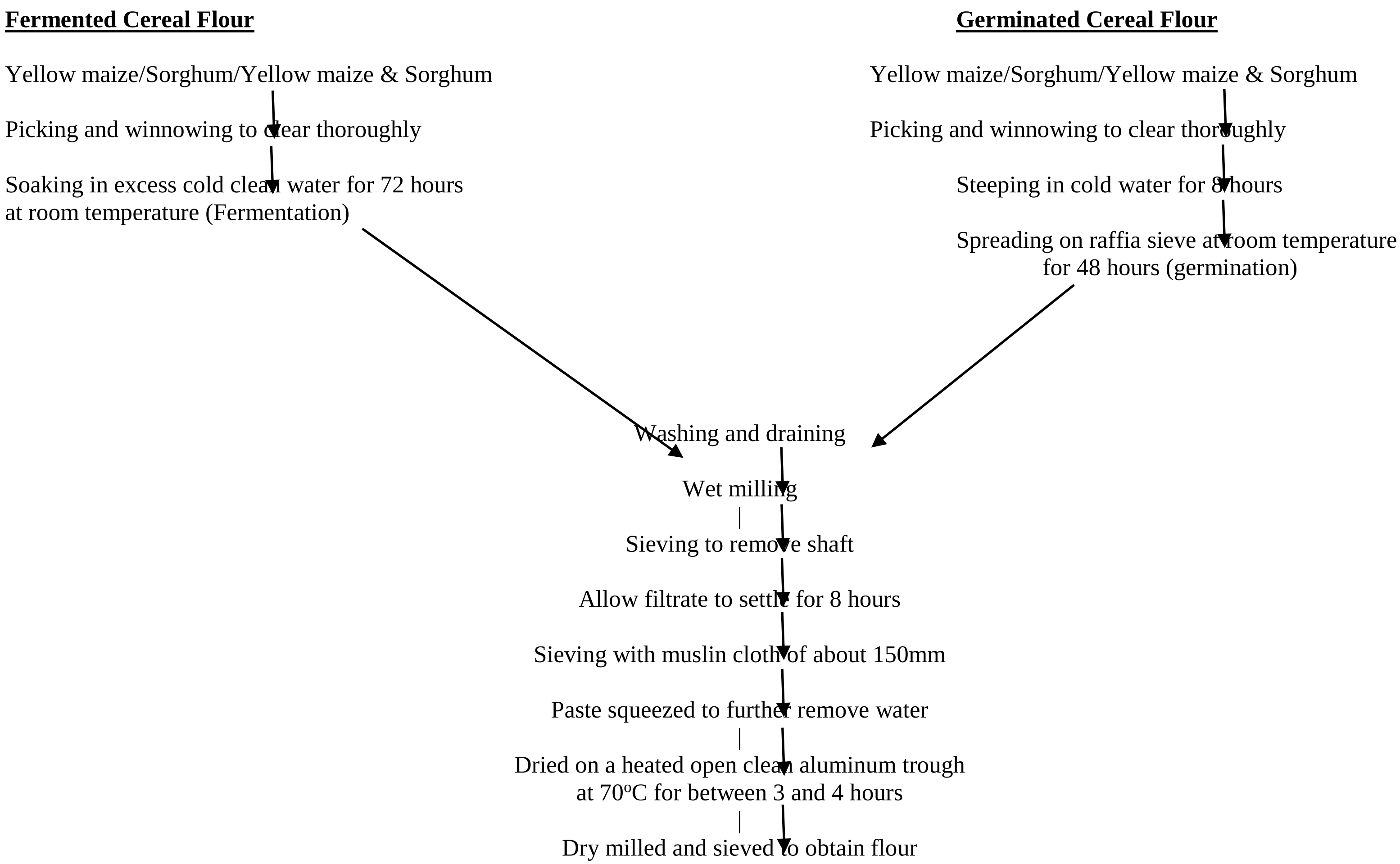

Figure 1. Flowchart for the Production of Fermented and Germinated Cereal Flour (Papageorgiu, 2020).

Cowpea Seeds
↓
Picking and winnowing to clean thoroughly
↓
Washing
↓
Soaking in cold clean water for 10 minutes to remove seed coat (husk)
↓
Boiled in water for 20 minutes
↓
Draining
↓
Spread on heated aluminum tray and dried at 70^{o}Cfor 3 hours
↓
Dry milling and sieving to obtain flour

Figure 2. Flowchart for processing cowpea flour.

Groundnut Seeds
↓
Picking and winnowing to clean
↓
Soaking for 8 hours to remove testa
↓
Drying on aluminum trough at 70^{o}C for 4 hours
↓
Dry milling and sieving
↓
Groundnut flour

Figure 3. Flowchart for processing groundnut flour.

Table 1. Composition of formulated complementary foods.

Cereal	%	Beans Flour (%)	Groundnut Flour (%)	Crayfish Flour (%)	Sample Number
Germinated Maize	70	10	10	10	1
	60	20	10	10	2
	50	30	10	10	3
Fermented Maize	70	10	10	10	4
	60	20	10	10	5
	50	30	10	10	6
Germinated Sorghum	70	10	10	10	7
	60	20	10	10	8
	50	30	10	10	9
Fermented Sorghum	70	10	10	10	10
	60	20	10	10	11
	50	30	10	10	12
Maize & Sorghum mixed in ratio 1:1 (Germinated)	70	10	10	10	13
	60	20	10	10	14
	50	30	10	10	15
Maize & Sorghum mixed in ratio 1:1 (Fermented)	70	10	10	10	16
	60	20	10	10	17
	50	30	10	10	18

Preparation of the Gruel

The gruels were prepared in the presence of the mothers at the clinic, using the method the mothers were familiar with. The gruel was dissolved in a little quantity of clean, cold water at 27^0C, poured gradually into boiling water about 3 times the volume of the dissolved gruel and thereafter stirred until a gruel of desired consistency was obtained. Portions were then served into small plates for mothers to assess and give their responses.

Sensory Evaluation

Sensory attributes of the gruels was carried out using 21 un-trained panelists consisting mothers of infant and young children attending the postnatal clinic at the Ogun State General Hospital, Ijebu-Ode. They were randomly selected and their consent was sought prior to participation in the evaluation exercise. Prior to commencement of the exercise, respondents were trained to rinse their mouths after tasting each sample of the complementary food to avoid overlapping effect on taste.

The respondents rated their preference for color, taste, texture, flavor, appearance, consistency and overall acceptability of gruels from the 16 experimental samples using the standardized. Validated and approved hedonic ratings (1 = disliked extremely to 9 = liked extremely).

DATA ANALYSES

Proximate analysis of the complementary foods

Moisture (AOAC method 950.46B), ash (AOAC method 920.153), crude protein (AOAC method 955.04) contents were determined according to Association of Official Analytical Chemists procedures (AOAC 2012). Carbohydrate levels were calculated by the equation: % carbohydrates = 100% − (% moisture + % protein + % ash + % lipid), while energy values were estimated using the formula: energy value (kcal/100g) = 4 × protein (%) + 9 × lipid (%) + 4 × carbohydrate (%). Crude fiber content of flour were determined by trichloroacetic acid method as described by Entwisted *et al*. (1949).

Sensory analysis

The data was subjected to analysis of variance (ANOVA) using the IBM SPSS statistics version 23 and the differences between significant mean values were separated at ($P \leq 0.05$) probability level using Duncan Multiple Range Test.

Ethical Consideration

Ethical approval was sought from the Research Committee of the Directorate of Education, Research and External Relations (DEER) of Tai Solarin University of

Education. Permission was also obtained from the authorities in charge of the Ogun State General Hospital, Ijebu-Ode to involve the mothers attending the postnatal clinic in the study. Also consent of the mothers was sought after explaining the objectives of the study to them, and none of the respondents was forced to participate in the study as this was in accordance with the Helsinki declaration.

RESULTS

The results of the proximate analysis of the processed flours are presented in Table 2. The moisture content of the processed flour ranged from 7.84 ± 1.35 g/100g for germinated maze to 11.16 ± 7.5 g/100g for boiled beans. The crude protein content ranged from 10.73 ± 1.3 g/100g for fermented maize to 31.45 ± 7.2 g/100g groundnut. The fat content ranged from 2.22 ± 0.12 g/100g germinated beans to 47.83± 3.1 g/100g for groundnut. The ash content ranged from 0.61 ± 0.70 g/100g for FS to 13.70 ± 0.5 g/100g crayfish. While the carbohydrate content ranged from 16.95±2.82 g/100g in groundnut to 80.36±3.39 g/100g in fermented sorghum.

Table 2. Proximate composition of the processed flours (g/100g).

Sample	Moisture	Crude Protein	Fat	Ash	Carbohydrate
GM	9.70±0.42	10.60±0.91	5.48±0.73	1.33±0.18	72.89±1.04
FM	7.84±1.35	10.73±1.33	4.56±0.37	0.72±0.09	76.14±2.96
GS	10.23±8.71	10.09±1.04	3.01±0.01	1.41±0.24	75.25±9.50
FS	9.67±4.65	7.63±1.78	3.28±2.16	0.61±0.70	80.36±3.39
GB	10.4±4.65	24.96±1.22	2.22±0.12	3.53±0.39	58.87±5.35
BB	11.16±7.54	23.03±0.72	4.09±3.12	2.59±0.54	59.06±3.14
CF	10.63±0.60	22.54±5.09	3.69±0.51	13.70±0.58	49.44±0.81
GN	1.67±1.40	31.45±7.21	47.83±3.17	2.09±0.24	16.95±2.82
FMS	9.61±1.99	11.80±1.44	4.54±0.95	1.37±0.28	72.68±1.22
GMS	8.24±0.85	11.51±1.10	5.98±0.95	1.37±0.28	72.85±0.95

Values are mean ± standard deviation of duplicate analyses**.**

Key:

GM: Germinated Maize, BB: Boiled Beans, GS: Germinated Sorghum, GN: Groundnut: GB: Germinated Beans, GMS: Germinated Maize and Sorghum, CF: Crayfish, FMS: Fermented Maize and Sorghum: FM: Fermented Maize, FS: Fermented Sorghum

Table 3 describes the mineral content of the processed samples. The calcium content ranged from110.00 mg/100g in germinated maize to 12855.5 mg/100g in crayfish; the phosphorus content ranged from149.26 mg/100g in fermented maize to 1264 mg/100g in crayfish. The potassium content ranged from 417.54 mg/100g in fermented maize to 1666.62 mg/100g in crayfish. The magnesium content ranged from 36.05 mg/100g in fermented maize to 346.84 mg/100g in crayfish, while the sodium content ranged from 4.99mg/100g germinated maize to 137.42 mg/100g in crayfish. The iron content ranged from 4.85mg/100g in germinated beans to 44.24mg/100g in germinated maize.

Table 3. Mineral composition of the processed flours (mg/100g).

Sample	Ca	P	K	Mg	Na	Fe
GM	110.00±14.14	302.34±3.31	557.27±201.83	107.79±11.02	5.53±3.92	44.24±3067
FM	157.00±94.75	149.26±15.18	106.73±61.18	36.05±5.57	5.04±2.19	20.34±299
GS	112.50±31.82	294.13±64.85	421.26±97.20	120.15±0.21	5.51±3.52	13.84±799
FS	165.50±6.36	162.82±4.00	141.55±26.09	60.43±28.89	5.47±3.14	26.07±13.85
GB	404.50±204.35	315.79±22.33	1634.60±105.50	160.26±0.37	9.48±7.67	4.85±4.03
BB	383.00±131.52	279.64±13.63	994.04±262.97	100.83±15.32	8.36±5.71	5.85±2.51
CF	1285.50±1491.58	1264.32±6.82	1664.62±19.67	346.84±188.30	137.42±176.54	16.82±3.48
GN	310.50±13.44	347.67±17.43	768.12±101.64	159.70±0.41	7.64±3.05	6.21±3.12
FMS	120.5±85.56	250.73±27.25	416.54±188.74	98.91±26.74	5.23±4.26	44.94±9.09
GMS	137.50±67.18	301.82±2.57	554.44±205.85	121.87±30.93	4.99±3.95	29.96±27.52

Values are mean ± standard deviation of duplicate analyses**.**
Key:
GM: Germinated Maize, BB: Boiled Beans, GS: Germinated Sorghum, GN: Groundnut: GB: Germinated Beans, GMS: Germinated Maize and Sorghum, CF: Crayfish, FMS: Fermented Maize and Sorghum: FM: Fermented Maize, FS: Fermented Sorghum

The results of the proximate analysis of the formulated CFs are presented in Table 4. The moisture content ranged from 4.00 ± 1.79% for Sample 1 to 9.12 ± 1.79% for sample 10. The crude protein content ranged from 17.84 ± 1.12% for sample 16 to 25.63 ± 2.89% for sample 6. The fat content ranged from 6.77 ± 0.89% for sample 14 to 11.42± 2.68% for sample 6. The ash content ranged from 2.12 ± 0.40% for sample 4 to 4.46 ± 1.21% for sample 3. The crude fibre content ranged from 1.64 ± 0.36% to 4.63 ± 2.89% for sample 15. While the carbohydrate content ranged from 52.45±8.89% in sample 9 to 62.44±5.08% in sample 17. It is worthy of note that all the CFs were of significantly higher protein content than two controls (samples A and B) i.e. fermented maize and sorghum ($p<0.05$).

Table 4. Proximate composition of the formulated complementary foods and the control samples (g/100g).

Sample Number	Moisture	Crude Protein	Fat	Ash	Crude fibre	Carbohydrate
A	7.84±1.35	10.73±1.33	4.56±0.37	0.73±0.09	-	76.14±2.96
B	9.67±0.10	7.63±1.73	3.28±2.16	0.61±0.70	-	80.36±3.39
1.	7.41±0.82	19.7±0.29	10.29±0.44	3.03±0.66	2.16±0.33	57.32±3.85..
2.	6.73±2.01	20.35±0.74	8.47±0.74	3.50±1.08	2.13±0.51	58.82±2.81
3.	7.70±1.96	23.68±0.84	8.09±0.86	4.46±1.21	2.54±0.96	53.53±4.36
4.	7.21±2.17	18.48±0.34	9.06±0.16	2.12±0.40	1.93±0.79	61.20±2.22
5.	4.87±2.75	19.15±2.53	9.54±1.06	2.97±1.04	1.69±0.34	61.78±6.02
6.	4.00±1.79	25.63±2.89	11.42±2.66	3.94±1.61	2.16±0.57	52.85±4.87
7.	5.24±2.76	20.25±0.12	7.96±0.29	3.85±0.39	2.15±1.08	60.55±4.50
8.	7.53±0.18	20.71±0.02	9.66±1.72	4.30±1.49	2.06±0.33	55.74±3.74
9.	6.64±6.30	24.70±1.67	9.67±1.66	4.31±0.62	2.23±0.31	52.45±8.89
10.	9.12±1.79	21.50±1.03	7.80±1.46	3.31±0.70	5.18±3.87	53.09±3.37
11.	8.64±0.86	22.31±2.19	7.52±1.71	3.94±0.09	3.94±2.05	53.65±3.09
12.	8.49±1.30	19.26±0.14	7.23±0.45	3.13±1.41	4.00±2.86	57.89±1.26
13.	6.13±1.24	18.15±0.08	8.44±0.36	3.50±0.96	3.29±1.66	60.49±0.80
14.	5.30±1.62	20.38±0.96	6.77±0.89	3.36±1.19	2.23±0.90	61.96±3.23
15.	6.68±1.58	21.05±2.08	6.87±0.89	4.23±1.42	4.63±2.89	56.54±1.32
16.	7.24±3.73	17.84±1.12	7.57±1.04	3.26±1.16	4.53±2.95	59.56±5.4
17.	7.65±2.24	18.42±0.62	6.97±0.48	2.88±0.61	1.64±0.36	62.44±5.08
18.	6.35±2.83	22.11±3.07	10.66±1.19	3.38±0.14	1.83±0.56	55.67±5.70

Values are mean ± standard deviation of duplicate analyses.

Controls Key
Sample A - fermented maize
Sample B - fermented sorghum

Table 5 describes the mineral content of the CFs. The calcium content ranged from 0.41% in sample 17 (Maize and sorghum, beans groundnut and crayfish; 60:20:10:10) to 2.83% in sample 15 (Maize and sorghum, beans groundnut and crayfish; 50:30:10:10); the magnesium content ranged from 0.04% in sample 4(fermented maize, beans groundnut and crayfish; 70:10:10:10) to 0.13% in sample 8(Germinated sorghum, beans groundnut and crayfish; 60:20:10:10). The potassium content ranged from 0.24% in sample 4 to 1.04% in sample 15. The phosphorus content ranged from 0.23% in sample 4 to 0.05% in sample 3(Germinated maize, beans groundnut and crayfish; 50:30:10:10), while the sodium content ranged from 89.16ppm in sample 17 to 186.43ppm in sample 6. With respect to the micronutrient composition, the manganese content ranged from 11.9ppm in sample 1 to 27.07ppm for sample 15. The iron content ranged from 41.85ppm in sample 1(fermented maize, beans groundnut and crayfish; 70:10:10:10) to 397.26ppm in sample 2(Germinated maize, beans groundnut and crayfish; 60:20:10:10); the copper content ranged from 0.71ppm in samples 1 and 2 to 2.38ppm in sample 8, while the zinc content ranged from 11.17ppm in sample 3 to 23.16ppm in sample 7. (Germinated sorghum, beans groundnut and crayfish; 70:10:10:10)

Table 5. Mineral content of the complementary foods (mg/100g).

Sample	Ca	Mg	K	Na	Mn	Fe	Cu	P	Zn
1.	57	7	43	124.9	11.90	41.85	1.55	45	20.17
2	50	11	47	119.61	13.67	53.26	0.71	48	20.55
3	56	10	51	137.52	17.44	397.26	0.71	49	11.17
4	25	4	24	68.01	15.70	236.8	2.41	23	14.24
5	27	5	33	67.46	17.44	134.86	1.55	24	18.72
6	76	9	50	186.43	19.54	152.10	1.56	48	20.12
7	40	11	48	106.58	26.79	199.87	0.71	46	23.26
8	76	13	57	174.26	15.56	216.71	2.38	41	21.42
9	51	10	60	123.49	15.78	184.88	0.72	47	13.83
10	52	6	37	124.88	15.70	236.80	0.71	30	14.33
11	43	5	35	116.76	15.67	200.62	1.55	28	13.87
12	37	5	42	99.69	19.52	237.51	1.56	27	21.47
13	39	8	46	105.99	21.48	257.17	0.72	46	20.96
14	43	10	50	105.88	24.93	273.68	1.73	44	21.71
15	23.8	9	10.4	126.62	27.07	317.73	0.87	48	13.26
16	50	6	53	89.16	21.37	338.83	1.75	26	13.26
17	41	6	31	89.42	25.23	318.30	0.87	30	12.25
18	43	8	35	90.78	25.06	316.16	1.74	30	13.2

The results of the sensory evaluation of the six complementary foods (CFs) with the highest protein contents are presented in Table 6. In terms of colour, sample 6 was most acceptable (7.95) and was more significantly different from the others ($p<0.05$). However, the colour of all the samples was acceptable by the mothers. With respect to the consistency, sample 9 was most acceptable (7.76) but it was not significantly different from all others except control B (fermented sorghum alone). For the taste, the most acceptable was sample 6 (7.62) and it was significantly different from all the other samples. The least acceptable sample with respect to taste was control sample B (5.29) with respect to aroma, the most acceptable was sample 6 with a rating of 7.38 and it was not significantly different from samples 9, 10, 11 and 18. Control sample B was the least acceptable by the panelists (5.62). In terms of the overall acceptability, sample 6 was the most acceptable (7.67) but was not significantly different ($P \leq 0.05$) from samples A (100% fermented maize) 9, 10, 11 and 18.

Table 6. Sensory Scores of the blended complementary foods.

Sample	Colour	Consistency	Taste	Aroma	Overall Acceptability
Sample Contol A)	7.71±1.38^{ab}	7.29±1.65^{b}	6.90±1.37^{bc}	6.29±2.28^{ab}	7.14±0.85^{bc}
Sample B (Control B)	7.00±1.67^{ab}	4.86±2.22^{a}	5.29±1.71^{a}	5.62±2.10 ^{a}	5.67±1.63^{a}
Sample 3	7.33±2.50 ^{ab}	7.00±2.28^{b}	6.11±3.18^{ab}	6.47±2.82^{ab}	6.24±2.77^{ab}
Sample 6	7.95±0.86^{b}	7.57±1.33^{b}	7.62±1.72^{c}	7.38±2.01^{b}	7.67±1.39^{c}
Sample 9	6.48.±2.64^{ab}	7.76±1.34^{b}	7.29±1.82^{bc}	7.26 ±2.15^{b}	7.14±1.77^{bc}
Sample 10	6.29 ±2.53^{a}	7.00±1.48^{b}	6.90±1.58^{bc}	7.10±1.51^{b}	6.95±1.40^{bc}
Sample 11	6.71±2.12^{ab}	6.90±1.51^{b}	7.24±1.67^{bc}	7.10±1.64^{b}	7.00±1.87^{bc}
Sample 18	6.57±2.48^{ab}	6.95±2.11^{b}	6.76±2.30^{bc}	7.10±2.21^{b}	7.00±2.35^{bc}

Key:
Control A: Fermented maize only. Control B: fermented sorghum only
$^{a-bc}$ Mean with similar superscripts in the same column are not significantly different (P>0.05).

DISCUSSION

The aim of this study was to develop local, readily available, cheap, nutritious and easy to prepare CFs for IYC in Nigeria in order to reduce prevalence of malnutrition amongst Nigerian children. The proximate analyses results revealed that the moisture content of the formulated CFs ranged from 1.67-11.16-4g/100g. Sample 1 had the highest moisture content, higher than that reported in the Food Composition Table (FCT) for use in Africa (1.8/100g) (FAO, 1968) and that reported by Bolarinwa, *et al*., 2015. Ogiizu & James (2023) also reported that the moisture content of complementary food prepared from maize, soybean, groundnut and dates (65:25:10:5) has the higher moisture content (65.76%) amongst all other samples of other compositions. Sanni, *et al*., (2006) explained that the lower the moisture content of a product to be stored the better the shelf stability of such products.

Sample 3 has the highest value (13.70g/100g) for ash content and it is higher than that reported in Ogiizu & James (2023). The ash content indicates a rough estimation of the mineral content of product (Adegunwa, *et al*., 2014). The crude protein content ranged from 17.84±1.12% for samples 16, to 25.63 ±0.89% in sample 6, this being a value greater than that reported in the FCT, (23.3g/100g). Apart from control sample B, sample 14 has the highest value for carbohydrate and that was higher than that reported in the FCT (75.4g/100g). The values of carbohydrate reported by Ogizu and James, 2023 was lower than that reported by Gernah *et al*., 2010.

Calcium content ranged between 110.00-12855.50mg/100g, with germinated maize having the lowest value. The result corroborate the study carried out by Compaore in Burkina Faso (Compaore, *et al*., 2011) that showed calcium content in processed flours of sorghum to be higher than those present in that of maize, millet and rice for local complementary feed. The phosphorus content ranged between 149.26-1264.32mg/100g, with 4, 5 and 6 having the lowest values. This value was higher than that present in complementary food formulated from malted cereals, soybeans and groundnut for use in North-west Nigeria by Anigo, *et al*., 2010. Potassium content also ranged from 106.73-16-1664.62mg/100g while magnesium content was in the range of 36.05-346.84mg/100g. These values are commensurate with those obtained by Fasasi, (2009). Findings from the study further revealed that the protein content of the complementary foods (CFs) increased as the quantity of beans and groundnut increases. Since that of the crayfish was constant, the ash and fat content of the CFs were higher than the control samples i.e. 100% fermented maize and 100% sorghum. The nutritional implication of this is to the advantage of the infants as both the mineral elements and energy value of the CFs tends to improve. Although it has been reported that fermentation and germination decrease the protein content of cereals (Abd El-Moneim, *et al*., 2012) the high protein content reported for the CFs in the present study is due to inclusion of the legumes, thus confirming the report that legumes can be used to improve the protein content of cereal gruels (Kebebu et al., 2013; Akinola *et al*., 2014; Onimawo & Offurum, 2015). However, fermentation has been reported to enhance the nutritive value of food by increasing thiamine, nicotinic acid riboflavin content of the resulting. The protein contents of the CFs were higher than those of the traditional fermented maize and sorghum alone. The high protein content of the CFs in this study is an advantage as it will easily meet the protein requirements of the infants with the small quantity consumed and their stomach capacity. As noted by Adebayo-Oyetoro et al. (2013), colour is an important sensory attribute of any food because of its influence on acceptability. The fact that the colour of all the CFs was acceptable to the mothers was therefore of great significance towards their overall acceptability. That all the complementary foods, in spite of their legume composition (10% -30%) in this study were well accepted is in consonance with the findings reported earlier (Happiness, et al., 2010; Onoja, *et al*., 2014, Onimawo & Offurum, 2015 and Ogiizu & James 2023). However, complementary foods containing as high as 70% cowpea had been reported to be of poor acceptability with respect to taste (Abiodun,, *et al*., 2015). Therefore, there is need to be cautious about the level of legume to be included in complementary foods.

CONCLUSION

The formulation and nutritional evaluation of complementary foods prepared from maize, sorghum, groundnut, crayfish, and beans in this study have shown to have a meaningful implication in terms of nutrient composition and organoleptic characteristics. The fact that all the CFs subjected to sensory evaluation was well accepted by the mothers is very interesting and encouraging. This means that with adequate nutrition education, mothers can be encouraged to imbibe the practice of combining various locally available grains, fortified with various options of foods items rich in both animal and plant protein as traditional weaning foods. This in essence will contribute to reduction in the prevalence of malnutrition among infant and young children in Nigeria.

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