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Research Paper

Studies on the evaluation of the nutritional quality, chemical composition and rheological characteristics of a cereal fortified with legume as a weaning food blend

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Abstract. Cereal and legume weaning food blends were prepared in a mixed ratio 60:20:10:10 from fermented maize/roasted cowpea, roasted Bambara nut, and roasted groundnut, respectively. Each cereal and legume seeds were evaluated for their nutritional qualities. The maize used in this experiment were white maize of local variety and improved quality of yellow maize. Standard methods were used for the parameters analysed. The results revealed that, the protein content (13.73 ± 0.01) of the weaning food blends from yellow maize is similarly close to the recommended daily intake for infants (0 month to 1 year) compared to the blend prepared from white maize. The low moisture contents (4.04 ± 0.10) exhibited by the two weaning food blends might give a good storage stability. The zinc and iron levels of the two weaning food blends were comparable to the commercial weaning food of Cerelac® and Frisogold®, though the levels of calcium, potassium, phosphorus and sodium were low. Heat processing of the grains resulted in low levels of phytic acid and higher *in vitro* protein digestibility of the weaning food blends respectively. The predominant micro-organisms isolated during the production of "kamu" with the two varieties were (*Saccharomyces cerevisae, Lactobacillus plantarum* and *Streptococcus lactis).* Results on sensory evaluation showed that there were no significant difference ($p > 0.05$) in the acceptability of the weaning food blends, even though the yellow maize used in this study is superior to the white maize in some of the given parameters analyzed.

Keywords: Fermentation, Yellow Maize, White Maize, Chemical composition and Sensory evaluation.

INTRODUCTION

In Africa, weaning is a period of transition for the infant during which its diet changes in terms of consistency and source. The child is gradually weaned into a semi solid food which is generally described to be digestible, having high energy density and low bulk (Onweluzo and Nwabugwu, 2009).

The weaning process may be gradual, lasting for months until the infant is finally introduced to the family diet. On the other hand, in abrupt weaning, the infant is introduced directly into the family menu. This later option creates a problem, as the child may not be able to eat enough of the adult diet to meet his or her nutritional need (Onofiok and Nnanyelugo, 1998).

Protein - energy malnutrition is a major health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants, as well as very low resistance to disease and consequently stifles development. Protein - energy malnutrition generally occurs during the crucial transitional phase when children were weaned from liquid to semi-solid or fully adult foods (Amankwah et al., 2009). Poverty and poor feeding practices have been attributed as the major factors responsible for this nutritional problem (Oluwole, 2008).

Traditional weaning foods in Nigeria consists of monocereal grains prepared from either maize, millet or sorghum referred to as "*Ogi* or *Akamu*", which is of poor nutritional value due to deficiency in some of the essential amino acids such as lysine and tryptophan. Our locally available cereals when subjected to some thermal processing techniques can be supplemented with legumes (rich in essential amino acids) which are a good potential source of protein for weaning food in children due to its high digestibility and acceptability to children (Modu et al., 2010).

MATERIALS AND METHODS

Sources of white and yellow maize, cowpea, bambara nut and groundnut

The yellow and white maize, cowpea, dry bambara nut and groundnut were obtained from local market of Maiduguri, Nigeria. The cereals and the legumes were assessed by a seed breeder in the Lake Chad Research Institute Maiduguri, Nigeria and a Botanist (plant taxonomist) from Department of Biological Science, University of Maiduguri, Nigeria.

Preparation of akamu

Akamu was prepared according to the method as described by Akingbala et al. (1981).

Preparation of bambara nut

One hundred (100 g) of dry bambara nut was cleaned of dirt, roasted and milled into a fine powder after which it was sieved using a sieve as described by Theodore et al. (2007).

Preparation of groundnut

One hundred (100 g) of groundnut was cleaned of dirt, roasted and dehulled. The dehulled groundnut was milled as described by Davies (2009).

Formulation of the weaning meals

Weaning meals was formulated using yellow maize and white maize, cowpea, bambara nut and ground nut respectively in a 60:20:10:10 ratio, that is, 60 yellow maize: 20 cowpea: 10 bambara nut: 10 groundnuts, and 60 white maize: 20 cowpea: 10 bambara nut: 10 groundnuts.

Determination of chemical composition

Chemical analysis was carried out on the maize, cowpea, bambara nut, groundnut and their blend according to the methods of AOAC (2000). The total energy value was determined according to the method of Mohgoub, 1999, using the following formula:

Total energy (Kcal/100g) = [(% available carbohydrates × 4) + (% protein × 4) + (% fat × 9)]

Determination of mineral elements

Atomic absorption spectrophotometer (AAS) (Model AA 6800 series Shimazo corp) was used for the determination of Ca, P, K, Fe, Zn and Mg. Two grams (2 g) of sample was weighed into a crucible and incinerated at 600°C for 2 h in a muffle furnace. The ashed sample was transferred into 100 ml volumetric flask and 100 ml of distilled water was added into it and readings were taken on the AAS.

Determination of protein *in vitro* digestibility

In vitro protein digestibility was determined following the procedure of Nills (1979). One milliliter (1 ml) of 11% trypsin was introduced into 3 test tubes and 1 ml of 0.1 NaCl was added and allowed to stand to equilibrate. 1 ml of akamu or composite mixture was added to all the test tubes (labeled as digestibility at 1 h and 6 h). The reaction in each of the test tube was stopped with 5 ml of neutralized formalin at 60 min and 6 h. The content of the test tube was then filtered using filter paper. The filter paper was dried in an oven at 108°C for 3 h. The nitrogen of the undigested sample was determined by the Kjedahl method.

$$\%\ \textit{in vitro}\ \text{protein digestibility} = \frac{CP_1 - CP_2}{CP_1} \times 100$$

Where:
CP_1 = Total protein of unprocessed grain
CP_2 = Total protein after digestion with trypsin

Determination of phytic acid

Phytic acid was determined following the procedure of Davies and Reid (1979). One gram (1 g) of sample was extracted in 40 ml of 0.5 M nitric acid for 1 h. The sample was filtered and 5 ml of 0.08 M ferric chloride was added. It was then boiled for 20 min and then filtered. The free iron (Fe^{3-}) remaining in the solution was then determined calorimetrically by adding 2 ml of 0.005 M ammonium thiocyanate and the iron-binding capacities of the extracts was determined by difference. The results were then expressed in terms of mg Fe bound g^{-1} sample extracted.

Determination of hot paste viscosity

The hot paste viscosity of samples was determined using Brookfield viscometer Rv model (Brookfield engineering laboratories Stoughton, USA) at 4, 10 and 20 rpm. Appropriate spindles were used for viscosity determination. The readings obtained were multiplied by appropriate factors based on the spindle used as described by Nkama et al. (2001). Slurries were heated in a water bath at 100°C with constant stirring (1 g of sample in 100 ml of water) for about 30 min and finally cooled at room temperature and then the viscosity was measured.

Microbiological analysis

Microbial analysis was determined following the procedure of Harrigan and McCaine (1976). Appropriate dilution of samples was enumerated for bacterial counts and yeasts using nutrient agar, MacConkey agar, sabourraud dextrose agar and blood agar base (Harrigan and McCaine, 1976). Inoculated plates were incubated at appropriate time and temperature combinations. Colonies of respective microbial types appearing in inoculated plates were counted and expressed as colony forming units (cfu/g). Colonies of bacteria and yeasts were isolated and subcultured to obtain pure cultures.

Sensory evaluation

A 10% (w/v) of the weaning food blends was cooked (using heat) and its quality was evaluated by members of panel consisting of 21 mothers (untrained) drawn from an antenatal clinic in Maiduguri. They were selected at random to grade the samples (improved and local) for colour, odour, taste, texture and overall acceptability based on a 9 point hedonic scale as modified by Williams (1982).

Statistical analysis

All determination was carried out in triplicate. The data collected was subjected to analysis of variance (ANOVA) and Duncan multiple range test (DMRT) was used to test any significant difference ($p < 0.05$).

RESULTS

Chemical composition

Table 1 represents the proximate composition of the raw and processed white maize, yellow maize, cowpea, bambara nut and groundnut. A significant difference ($p < 0.05$) was shown in the protein content between the raw and processed values of the white maize, yellow maize, cowpea, bambara nut and groundnut. The moisture contents of the raw and processed white maize, yellow maize, cowpea, bambara nut and groundnut showed significant differences ($p < 0.05$) with the raw maize grains having higher values. The carbohydrate and the energy contents of the raw and processed white maize and yellow maize did not show any significant differences ($p > 0.05$). The low moisture (yellow maize 4.04 ± 1.10 and white maize 3.66 ± 0.57) content observed indicates that the weaning food blends will have a good shelf life. Because food spoilage micro-organism strive where the moisture content of a food is high, this is in agreement with similar reports of Ene-Obong and Carnovate (1992). The increase in protein content of the two varieties of maize could be as a result of improvement in the protein quality of the maize during fermentation. This finding is consistent with earlier reports of Modu et al. (2010) and Laminu et al. (2011). An increase in the carbohydrate content was noticed in the “kamu” produced from the two varieties of maize and the pattern is similar with the reports of Modu et al. (2010). The protein content of the weaning food blend favourably compared with the recommended daily allowance of infants from 0 month to 1 year (protein is 14 g/kg). Therefore, the results showed that there was substantial increase in the protein after blending of the “kamu” prepared from two varieties of maize, with cowpea, bambara nut and groundnut. Similar findings were also reported by Modu et al. (2010), Nkama et al. (2001), Mbata et al. (2009), Amankwah (2009) and Essien et al., (2010) in a related work, where an increase in protein content was observed.

Table 2 shows the proximate composition of the weaning food blends as compared with commercial weaning foods. The moisture (4.04 ± 0.01) and ash (1.36 ± 0.47) content of the yellow maize blend shows higher values than that of the white maize blend. A significant difference ($p < 0.05$) was shown in the protein contents of the prepared weaning food blends. Weaning food blend prepared from yellow maize, cowpea, bambara nut and groundnut showed a higher value than the weaning food blend prepared from white maize, cowpea, bambara nut and groundnut. The protein content of the two prepared weaning foods blends when compared with commercial weaning food blends (Cerelac® and Frisogold®) showed lower values. The carbohydrate contents of the two prepared weaning foods blends are lower compared to the commercial weaning foods Cerelac® and Frisogold®.

Mineral elements

Table 3 shows the mineral element composition of raw and processed white maize, yellow maize, cowpea, bambara nut and ground nut. A significant decrease (p <

Table 1. Proximate composition of raw and processed white maize, yellow maize, cowpea, bambara nut and groundnut.

Parameter	White maize		Yellow maize		Cowpea		Bambara nut		Groundnut	
	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed
Dry matter (%)	94.80±0.10[a]	95.70±0.10[b]	94.20±0.10[a]	97.13±0.15[c]	96.20±0.10[d]	94.10±0.10[a]	95.20±0.10[b]	94.80±0.10[a]	95.60±0.10[b]	97.66±0.57[c]
Moisture content (%)	5.16±0.11[a]	4.33±0.11[b]	5.80±0.10[a]	2.86±0.15[c]	5.86±0.10[d]	3.80±0.11[a]	5.20±0.10[b]	4.80±0.10[a]	4.40±0.10[b]	2.66±0.57[d]
Crude protein (%)	6.46±0.01[a]	7.80±0.01[b]	7.34±0.01[b]	8.32±0.01[c]	17.06±0.01[d]	18.81±0.01[e]	12.58±0.02[f]	15.73±0.02[g]	19.07±0.02[h]	22.82±0.02[i]
EE or Fat (%)	2.06±0.05[a]	2.90±0.10[b]	2.06±0.11[a]	2.03±0.05[a]	3.93±0.05[c]	2.33±0.57[a]	3.90±0.10[c]	3.03±0.15[d]	4.33±0.57[e]	7.66±0.57[f]
Crude fibre (%)	7.00±1.00[a]	7.00±1.00[a]	5.66±0.57[b]	7.10±0.10[a]	17.66±0.57[c]	12.00±1.00[d]	25.00±1.00[e]	17.66±0.57[c]	24.33±1.52[f]	25.00±1.00[e]
Ash (%)	1.33±0.57[a]	1.06±0.05[a]	2.03±0.05[b]	1.06±0.11[a]	1.33±0.57[a]	1.06±0.05[a]	1.10±0.10[a]	1.10±0.10[a]	4.33±0.57[d]	3.66±0.57[c]
Carbohydrate (%)	81.97±1.61[a]	83.23±0.46[a]	80.41±0.60[a]	83.54±0.14[a]	60.74±0.53[b]	61.26±0.10[b]	48.16±3.25[c]	59.71±0.60[d]	47.89±2.20[c]	45.52±1.17[e]
Energy (kcal/100g)	78.39±0.03[a]	76.98±5.54[a]	78.57±0.71[a]	81.47±0.16[a]	56.46±0.59[c]	58.62±0.50[c]	52.67±1.16[d]	57.03±0.10[e]	43.22±2.78[f]	38.18±1.75[g]

Values are recorded as means ± S.D of three determinations. Values in the same row with different superscript are significantly different ($p < 0.05$).

Table 2. Chemical composition of the weaning food blend compared with commercial weaning foods.

Parameter	White maize/ cowpea/bambara nut/ groundnut	Yellow maize/ cowpea/bambara nut/groundnut	Commercial weaning foods	
	60:20:10:10*	60:20:10:10**	Cerelac ®1 (maize)	Frisogold ®2 (wheat)
Dry matter (%)	96.00 ± 1.00[a]	96.26 ± 1.06[a]	ND	ND
Moisture content (%)	3.66 ± 0.57[a]	4.04 ± 1.10[a]	ND	2.0
Crude protein (%)	11.54 ± 0.01[a]	13.73 ± 0.01[b]	15	15.5
EE or Fat (%)	3.66 ± 0.57[a]	1.50 ± 0.50[b]	10	7.3
Crude fibre (%)	12.00 ± 1.00[a]	10.66 ± 0.57[a]	2.0	1.7
Ash (%)	1.06 ± 0.11[a]	1.36 ± 0.47[a]	3.0	ND
Carbohydrate (%)	71.46 ± 0.01[a]	70.23 ± 0.46[a]	65	71.0
Energy (Kcal/100g)	67.80 ± 0.57[a]	68.39 ± 0.75[a]	410	415

Values are recorded as mean ± SD of three determinations. Values in the same raw with different superscript are significantly different ($p < 0.05$)
* 60 parts of white maize, 20 parts of cowpea, 10 parts of bambara nut and 10 parts of groundnut.
** 60 parts of yellow maize, 20 parts of cowpea, 10 parts of bambara nut and 10 parts of groundnut.
1. Cerelac (Maize); 2. Frisogold (wheat). ND – Not determined.

0.05) was observed in the levels of calcium, phosphorus and zinc of the raw and processed white maize and yellow maize. The level of sodium of the raw and processed white maize and yellow maize also showed a significant decrease. The level of iron in the raw and processed white maize and yellow maize increased significantly ($p < 0.05$). The raw and processed cowpea, bambara nut and groundnut showed a significant decrease ($p < 0.05$) in the levels of sodium, calcium and zinc. However, the level of iron was found to significantly increase in the raw and processed legumes.

Mineral element composition of the weaning food blend

The mineral element composition of the weaning food blends was also presented in Table 3. The levels of iron and zinc compared favourably

Table 3. Mineral element composition of the weaning food blends compared with commercial weaning foods.

Mineral element (ppm)	White maize/ cowpea/bambara nut/ groundnut	yellow maize/ cowpea/bambara nut/groundnut	Commercial weaning foods	
	60:20:10:10*	60:20:10:10**	Cerelac ®1 100g/g (maize)	Frisogold ®2 100g/g (wheat)
Sodium	36.60 ± 0.00^a	81.45 ± 0.00^b	145	120
Potassium	2.26 ± 1.00^a	1.36 ± 0.15^a	635	495
Calcium	51.28 ± 0.01^a	44.66 ± 0.01^b	600	350
Magnesium	1.87 ± 1.15^a	5.20 ± 0.23^a	ND	39
Phosphorus	9.04 ± 0.03^a	17.52 ± 0.01^b	400	330
Iron	8.41 ± 0.01^a	6.01 ± 0.01^b	7.5	ND
Zinc	2.14 ± 0.01^a	7.28 ± 0.01^b	5.0	1.7

Values are recorded as mean ± S.D of three determinations. Values in the same raw with different superscripts are significantly different ($p < 0.05$). * 60 parts of white maize, 20 parts of cowpea, 10 parts bamabara nut and 10 parts of groundnut. ** 60 parts of yellow maize, 20 parts of cowpea, 10 parts of bambara nut and 10 parts of groundnut.

with commercial weaning food Cerelac ® and Frisogold ® while the levels of sodium, potassium, calcium, magnesium and phosphorus were low when compared to the commercial weaning food Cerelac® and Frisogold®. The loss in the levels of the essential minerals such as calcium and zinc could be attributed to the loss in ash content during processing Brou et al., (2008). Also, it was noted that there was an increase in the level of iron in the white maize and yellow maize “kamu” which could be due to the reduction of phytic acid during fermentation, since lactic fermentation changes a diet of low iron bioavailability (Svanberg and Sandberg, 1988). The level of iron and zinc in the weaning food blends compared favourably with the commercial weaning food Cerelac® and Frisogold® and the recommended daily allowance of the infants from 0 month to 1 year (5 mg), similar results were reported by Idowu et al.,(1993) and Modu et al. (2010).

The levels of iron and zinc compared favourably with commercial weaning food Cerelac® and Frisogold® while levels of sodium, calcium, magnesium and phosphorus were low when compared to the commercial weaning foods.

In vitro protein digestibility

Table 4 shows the *in vitro* protein digestibility of raw and processed white maize, yellow maize, cowpea, bambara nut, groundnut and the weaning food blends. The *in vitro* protein digestibility of raw and processed white maize, yellow maize, cowpea, bambara nut and groundnut was found to significantly ($p < 0.05$) increase with time.

Phytic acid

The phytic acid content of the raw and processed white maize and yellow maize of 47.8% was observed for white maize and a percentage decrease of 38.5% was observed for yellow maize (Table 5). White maize showed a higher percentage decrease than yellow maize.

Hot paste viscosity

The hot paste viscosity of the weaning food blends is shown in Table 6. The weaning food blend from white maize and the weaning food blend from yellow maize exhibited high viscosity at shear rate of 50 rpm.

Total bacterial count and microorganisms isolated

The total bacterial count at 24 h for the white maize presented in Table 7 was 232×10^3 which dropped to 216×10^3 cfu/ml by the second day (48 h) and 194×10^3 cfu/ml after third day (72 h). The bacterial count obtained from the slurry after 24 h was 73×10^3 cfu/ml by the time the “kamu” was sun dried to a constant weight, there was a bacterial count of 28×10^3 cfu/ml. The peak of the growth of bacteria was recorded at 24 h.

For the yellow maize the total bacterial count at 24 h was 243×10^3 cfu/ml, which dropped to 219×10^3 cfu/ml by the second day (48 h) and 172×10^3 cfu/ml after 72 h. The bacterial count obtained from the slurry after 24 h was 60×10^3 cfu/ml and when the “kamu” was sun dried to a constant weight it has a bacterial count of 33×10^3 cfu/ml.

The micro-organisms isolated from “kamu” production are shown in Table 8. Throughout the steeping of the white maize, *Bacillus subtilis,* Bacterial species and *Staphylococcus* sp. appeared. *Streptococcus lactic, Saccharomyces cerevisae* and *Lactobacillus plantarum* appeared after 48 days. *Saccharomyces cerevisae*, *Streptococcus lactic* and *L. plantarum* were all present

Table 4. *In-vitro* protein digestibility of raw and processed white maize, yellow maize, cowpea, bambara nut, groundnut and the weaning food blends.

Parameter	White maize		Yellow maize		Cowpea		Bambara nut		Groundnut		Weaning food blends	
	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	White Maize /cowpea/bambara/ground nut 60:20:10:10*	Yellow /cowpea /bambara nut / groundnut 60:20:10:10**
Digestibility at 1 hour (%)	82.27±0.22^a	81.24±0.19^b	87.02±0.12^c	88.76±0.21^d	96.47±0.02^e	96.78±0.02^e	96.01±0.01^e	96.44±0.22^e	96.38±0.55^e	87.37±0.04^e	88.12±0.47^f	95.56±0.06^e
Digestibility at 6 hours (%)	93.24±0.01^a	85.24±0.01^b	91.17±0.80^a	90.92±0.01^c	97.01±0.09^d	99.06±1.58^f	95.34±0.44^d	97.32±0.06^d	97.82±0.08^d	97.37±0.04^d	94.75±0.04^e	96.24±0.03^e

Values are recorded as mean ± SD of three determinations. Values in the same row with different superscripts are significantly different ($p < 0.05$). * 60 parts of white maize, 20 parts of cowpea, 10 parts of bambara nut and 10 parts of groundnut. ** 60 parts of yellow maize, 20 parts of cowpea, 10 parts of bambara nut and 10 parts of groundnut.

Table 5. Phytic acid context of raw and processed white maize and yellow maize.

	White maize		Yellow maize	
	Raw	Processed	Raw	Processed
Phytic acid (mg/g)	0.46 ± 0.02^a	0.24 ± 0.02^b	0.36 ± 0.04^c	0.14 ± 0.03^d
Percentage decrease	47.8		38.5	

Values are recorded as means ± SD of three determinations. Values in the same row with different superscript are significantly different ($p < 0.05$).

Table 6. Hot paste viscosity (cp) of the weaning food blends.

Shear rate (rpm)	White maize/cowpea/bambara nut/ groundnut 60:20:10:10*	Yellow maize/ cowpea/bambara nut/groundnut 60:20:10:10**
10	2.82 ± 0.05^a	4.00 ± 0.57^b
20	3.00 ± 0.15^a	4.37 ± 0.57^a
50	4.40 ± 0.54^a	7.20 ± 1.00

Values are recorded as means ± SD of three determinations. Values with different superscript are significantly different ($p < 0.05$). * 60 parts of white maize, 20 parts of cowpea, 10 parts of Bambara nut and 10 parts of groundnut. ** 60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambara nut and 10 parts of groundnut.

after the grain was ground to obtain the slurry. *S. lactic* and *S. cerevisae* appeared after the "kamu" was sun dried to a constant weight.

Almost the same trend was observed for the yellow maize, where *Streptococcus lactic*, lactobacilli, *L. plantarum* and *S. cerevisae* appeared at 24 h of steeping of water. Also *S. cerevisae, lactobacilli* and *L. plantarum* appeared after the "kamu" was sun dried to a constant weight.

Table 7. Total bacterial count and microorganisms isolated.

Sample	Total bacterial count (cfu/ml			
	0 h	24 h	48 h	72 h
White maize				
Steep water	4×10^3	232×10^3	216×10^3	194×10^3
Slurry	-	73×10^3	-	-
Dried 'kamu'	-	28×10^3	-	-
Yellow maize				
Steep water	3×10^3	243×10^3	219×10^3	172×10^3
Slurry	-	60×10^3	-	-
Dried 'kamu'	-	33×10^3	-	-

Table 8. Micro-organisms isolated and identified during production of "akamu".

Sample	0 h	24 h	48 h	72 h
White maize				
Steep water	*Bacillus subtilis, bacterial specie, staphylococcus.*	*Streptococcus lactic, Saccharomyces cerevisae, Lactobacillus plantarum*	*Streptoccocus lactic, Saccharomyces cerevisae, Lactobacillus plantarum*	*Lactobacillus plantarum, Streptococcus lactis, Saccharomyces cerevisae*
Slurry	-	*Saccharomyces cerevisae, Streptococcus lactic, Lactobacillus plantarum.*	-	-
Dried 'kamu'	-	*Streptococcus lactic Saccharomyces cerevisae.*	-	-
Yellow maize				
Steep water	*Bacillus subtilis, Bacterial specie, staphylococcus*	*Streptoccocus lactic, Lactobacillus plantarum*	*Streptococcus lactic, Lactobacillus plantarum, Saccharomyces cerevisae*	*Lactobacillus plantarum, Streptococcus lactic, Sacharomyces cerevisae*
Slurry	-	*Saccharomyces cerevisae, Streptococcus, lactics, Lactobacillus plantarum.*	-	-
Dried "kamu"	-	*Saccharomyces cerevisae, Lactobacillus plantarum, Lactobacilli*	-	-

Sensory evaluation of the weaning food blends

The results obtained from the sensory evaluation of the two weaning food blends were presented in Table 9 and showed no significant differences ($p > 0.05$) in the odour, colour, taste and overall acceptability of the meal.

DISCUSSION

In vitro protein digestibility

Reduction in the level of anti-nutritional factors during the process of fermentation of the white maize, yellow maize and the heat treatment of cowpea, bambara nut and groundnut also helped in increasing the digestibility of the weaning food blends, this is in agreement with reports of Charu and Sehgel (1991), C. A. C (1999), Oria et al. (1995) and Anigo (2010). Fermentation has also been identified to significantly, improve the nutritional value of maize based foods and as well as reduce their anti-nutritional factors (Ariahu, 2009).

Phytic acid

Reduced level of phytic acid in cereals signifies a better nutritional value. Fermentation process reduced the

Table 9. Sensory evaluation of the weaning food blends.

Parameters	A	B
Colour	8.3 ± 3.21[a]	7.6 ± 2.50[a]
Odour	8.1 ± 3.17[a]	7.2 ± 2.48[a]
Taste	8.6 ± 4.30[a]	7.6 ± 2.56[a]
Texture	8.2 ± 3.01[a]	6.9 ± 2.44[b]
Overall acceptance	8.7 ± 4.0[a]	7.5 ± 2.52[a]

Based on a 9 point hedonic scale.
A – Yellow maize / cowpea / bambara nut / groundnut - 60:20:10:10
B – White maize / cowpea / bambara nut / groundnut – 60:20:10:10

phytic acid. Roasting of legumes also reduced the phytic acid, this is similar with. The Inherent phytase activity on cereals is believed to be activated during fermentation. Sripiya et al. (1997), Neelam and Chauhan (1990) and Mahajan and Chauhan (1987) reported similar findings.

Apparent viscosity

Decrease in apparent viscosity indicates increase in nutrient density. Nkama et al. (2001) made similar observations. Low viscosity weaning diet with a high nutrient content is a desirable characteristic of weaning food (Ariahu et al., 1996). During fermentation of cereals, microbial activity hydrolyses starch granules thereby resulting in reduced viscosity (Chavan and Kadam, 1989). The action of microbial α and β amylases on the maize modify starch structures and results in low viscosity. This therefore leads to a reduction in dietary bulk which is an important factor in the aetiology of protein energy malnutrition (Mbata et al., 2009). The yellow maize prepared weaning food has a higher hot paste viscosity than that of the white maize prepared weaning food.

Micro-organisms Isolated

Lactate bacteria and yeasts were predominant in the fermented samples isolated. In many food and beverages fermentation, a symbolic, relationship between lactate bacteria and yeast is common (Ikemefuna, 1998). It is assumed that the lactate flora provide an acidic condition for the yeast growth while yeast provide sufficient growth factors which enhance growth of lactate flora. The micro-organisms that were predominant were *Saccharomyces cerevisae*, *Lactobacillus plantarum* and *Streptococcus lactics*. This is in agreement with similar findings of Chavan and Kadam (1989), Abegaz et al. (1995), Mbata et al. (2009). Abegaz et al. (2002) Serna-Saldi var and Rooney (1995).

Sensory evaluation of the weaning food blends

The weaning food blends prepared from yellow maize/cowpea/bambara nut/groundnut showed no significant differences ($p > 0.05$) in the acceptability of the weaning food blends. This suggests that any variety of the maize can be used for the preparation of the weaning food blend.

Conclusions

The results obtained indicated the following:

1. The protein content of the weaning food blend from yellow maize is closely similar to the recommended daily intake of infants (0 month to 1 year) 14 food blends and is comparable to commercial weaning foods, Cerelac®, though the level of calcium, potassium, phosphorus and sodium were relatively low.
2. There is an increase *in vitro* protein digestibility in the weaning food blends from the two varieties of maize, and this is as a result of reduction in the level of phytic acid in the raw grains during formation.

The predominant micro-organism (*Saccharamyces cerevisae, Lactobacillus plantarum* and *Streptoccus lactic*) isolated during the production of “kamu” from the two varieties of maize were consistent with the findings of other researchers. The result of the sensory evaluation showed that there was no significant difference ($p > 0.05$) in the acceptability of the weaning food blends.

Thus, cereal/legume blend from yellow maize has been observed to be close to RDA needs of infants of 0 month – 1 year as depicted by the results. The results from the sensory evaluation and microbiological studies have revealed that the weaning food blends were acceptable and safe for feeding infants between 0 month and 1 year of age. However, the weaning food blend from yellow maize was found to be superior to that of white maize.

RECOMMENDATIONS

There is a need to improve on the calcium, potassium, phosphorus and sodium concentrations of the weaning food blends from the two varieties of maize, these minerals are essential for the growing child and this can be achieved by addition of other protein sources like fish and milk to the formulation.

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