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AMINO ACIDS PROFILE, FUNCTIONAL AND SENSORY PROPERTIES OF INFANT COMPLEMENTARY GRUEL PRODUCED FROM RICE AND DEFATTED BAMBARANUT FLOUR MEAL

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ABSTRACT

Background: The type of complementary food a child is fed should consider the energy and nutrient quality of the meal to meet the child's growth requirement.

Objective: To determine amino acid profile, functional and sensory properties of infant complementary gruel produced from rice and defatted bambaranut flour meal.

Materials and methods: Rice and defatted bambaranut composite flour meal was made into blends of various proportions 90:10%, 80:20%, 70:30% and 60:40%. The amino acid profile, functional and sensory properties of the blends were analyzed.

Results: Essential amino acids such as leucine(6.34g/100g-7.30g/100g), lysine (4.64g/100g-5.10g/100g), isoleucine(3.48g/100g-3.70g/100g), phenylalanine (3.22g/100g-3.91g/100g),tryptophan(0.81g/100g-0.90g/100g), valine(3.31g/100g-4.10g/100g),methionine(2.10g/100g-2.36g/100g),histidine (2.10g/100g-2.26g/100g) and threonine (3.12g/100g-3.22g/100g) were detected; while non-essential acids such as Proline (3.10g/100g-3.30g/100g), arginine (5.02g/100g-6.38g/100g),tyrosine(2,12g/100g-3.30g/100g), cysteine (1.01g/100g-1.34g/100g), alanine(4.03g/100g-4.46g/100g), glutamic acid (11.12g/100g-13.20g/100g), glycine(3.19g/100g-4.20g/100g), serine(2.57g/100g-3.30g/100g), and aspartic acid (7.70g/100g-8.30g/100g) were also detected. The functional properties evaluated were bulk density which ranged from 0.54g/ml -0.58g/ml; water absorption capacity 141.40g/ml-180.56g/ml; oil absorption capacity 166.32g/ml-128.21g/ml; swelling capacity 12.09g/ml-18.70g/ml; foam capacity 3.18g/ml-6.20g/ml; least gelation 3.80g/ml-7.62g/ml.

Conclusion: The samples were acceptable to the panelists (nursing mothers); although sample rice based contained 10% defatted bambaranut infant complementary gruel with highest average mean score of 7.93 was most preferred.

Keywords: *Amino acid, complementary gruel, rice flour, bambaranut.*

INTRODUCTION

Despite abundant global food supplies, widespread malnutrition persists in many developing countries. The World Health Organization (WHO) and UNICEF have been concerned about this trend, particularly Protein Energy Malnutrition (PEM) and micro-nutrient deficiencies (hidden hunger) among infants, children and pregnant women. The United Nations System Standing Committee on Nutrition (SCN) pointed out that malnutrition is directly and indirectly associated with more than 50% of all childhood mortality and also a major contributor to disease in developing world (1).

Major international and national efforts towards addressing these problems include nutritional supplementation, fortification of staple foods and modification of traditional diets to meet specific requirements. The promotion and support of exclusive breastfeeding, access to and the initiation of nutritious complementary foods between ages 6-24 months remain essential components of achieving optimal nutrition and malnutrition control programs for infants and children (1, 2). Failure to achieve these components predisposes the infant to malnutrition, growth retardation, infection and increased risk of mortality.

Complementary foods are formulated food mixtures meant to be fed along with breast milk for infants above 6months until completely weaned off breast milk (3). Weaning is the process of gradual withdrawal of breast-milk which is no longer sufficient to meet the nutritional requirements of infants and introduction of other foods and liquids known as complementary foods, to complement the breast-milk and gradual introduction to family diets (4, 5, 6, and 7). Thus, in a weaning process there is always need to introduce soft, easily swallowed and digestible foods to supplement the infants feeding early in life. Complementary feeding is instituted according to country-specific infant feeding guidelines. Most families depend on locally formulated diets to feed infant and young children. The locally formulated foods (pap and porridges etc.) are low in protein and high in anti-nutritional factors that reduce the bio-availability of some micro-nutrient, poor processing and cooking methods also contribute substantially to loss of micro-nutrients, leading to micro-nutrient deficiency disorders in infants fed with these foods (4, 6).

Different approaches have been adopted to combat the problem particularly of "hidden hunger" in Nigeria and most developing countries; these include food based approaches like diet diversity, food fortification and bio-fortification.

Kennedy *et al*., (8) further suggested that food fortification and bio-fortification could be the most cost effective.

Bambaranut (*Voandzeia subterranean*) is a legume that is generally grown in West and Central Africa, although bambaranut is grown extensively in Nigeria, it is one of the under-utilized legumes in the country, it is a rich source of protein (20%-25%), it is high in essential amino acid "methionine" than other legumes and contains 6-12% lipid. The seeds are locally eaten in a number of ways, in eastern Nigeria the seeds are milled into flour and used as a major ingredient in "okpa" production, while in northern part, it is boiled and eaten with cereals and grains or roasted and flavored with salt and eaten as a snack, in western part.

Rice (*Oryza sativa*) is a cereal grain, it is the most widely consumed staple food for a large part of the world's human population; it contains vitamins and minerals. The starch of rice is a mixture of amylase and amylopectin. The vitamins of rice are thiamine (B1), riboflavin (B2), pyridoxine (B6), pantothenic acid, Nicotinic acid, Inositol, Choline and Biotin. Minerals found in rice include calcium, phosphorous and iron (9). Specifically, this work evaluated the protein quality, functional and organoleptic properties of infant complementary food from indigenous foodstuffs.

MATERIALS AND METHOD

Procurement of Materials

Bambaranut (*Voandzeia subterranean*) bean, Parboiled rice (*Oryza sativa*) grains and other ingredients such as milk flavor powder, sugar, anti-caking agent, vanilla flavor were purchased from a Relief market extension, Owerri, Imo state.

Sample Preparation

Preparation of Rice Flour meal

The method of Okaka*et al.,* (10) was used (Figure 1). White rice grains were sorted manually to remove extraneous foreign materials. The rice grains were par-boiled for 15min, and dried at 78°C in cabinet dryer until ≤ 10% moisture was obtained. The dried rice grains were milled into fine flour meal particles using hammer mill. The meal was sieved by passing through a 120µm aperture sieve and then packaged in a sterile plastic container.

Defatted Bambaranut Flour meal

Bambaranut meal was prepared using the method described by Okaka*et al.,* (10) (Figure 2). The seeds were sorted for stones and other physical defects, soaked for 12hr and rubbed severely with the palm to remove the seed coat. Dehulled seeds were blanched at 65°C for 35min in a stainless steel bowland oven dried at 85°C. The dried seeds were milled using a hammer mill and sieved through a 120µm sieve aperture into flour meal. The flour was defatted by slurring the sample in an organic solvent (hexane) using soxhlet apparatus. After extraction, solvent was recovered through rotary evaporator. The residue was collected and the solvent was evaporated under the sun. It was then packaged in an airtight polyethylene bag.

Formulation of Rice- Bambaranut Infant Complementary Gruel

Rice based infant complementary gruel was prepared by mixing the main raw materials rice and defatted bambaranut flour meal at different formulation proportions as described in Table 1. Other ingredients were made constant through the blends and homogenized using warring blender; then packaged in an air-tight polyethylene bags for further use.

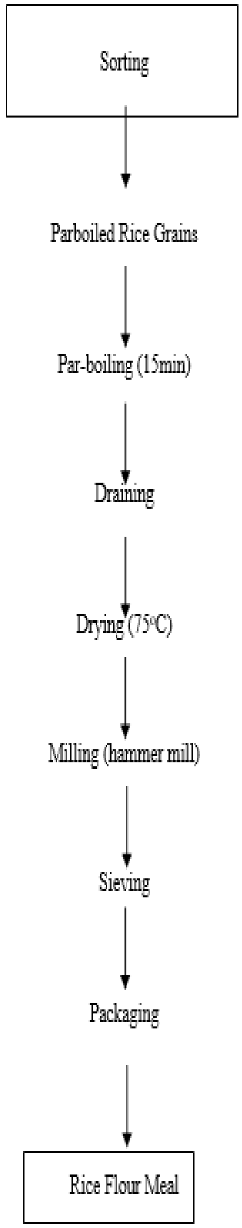

Figure1: Flowchart for the production of Rice flour

Figure 2: Flowchart for production of Defatted Bambaranut Flour Meal

Table 1: Formulation of Rice- Bambaranut infant Complementary Gruel

Samples	**A**	**B**	**C**	**D**
Proportion of Formula	90:10	80:20	70:30	60:40
Rice flour meal	180	160	140	120
De-fatted BFM	20	40	60	80
Sugar	15	15	15	15
Milk Flavor(%)	1.5	1.5	1.5	1.5
Vanila (%)	1.5	1.5	1.5	1.5
Anti caking agent	0.25	0.25	0.25	0.25

Reference sample-Nutribon rice cereal, BNF-Bambara Flour Meal.

Determination of Amino Acid Profile
Amino acid analysis was carried out according to the method as described by Sparkman *et al.*, (11).

Determination of Tryptophan
Tryptophan is a difficult amino acid to determine in proteins and peptides because it chemically decomposes during acid hydrolysis. It should be noted that tryptophan is destroyed by 6N HCL during hydrolysis. Antioxidants such as thioglycolic acid or dodecanethiol have been used to 6 N hydrochloric acid (HCl) to preserve tryptophan. Alkaline hydrolysis has also been studied and was shown to produce higher tryptophan recovery than acid hydrolysis. The addition of phenol has also been reported. Alkaline hydrolysis was improved by using sodium hydroxide (NaOH) instead of barium hydroxide to prevent problems with both precipitation and adsorption of tryptophan.

Determination
The tryptophan in the known sample was hydrolyzed with 4.2 M Sodium hydroxide. The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

De-fatting of sample
A known weight of the dried sample was weighed into extraction thimble and the fat was extracted with chloroform/methanol (2:1 mixture) using soxhlet extraction apparatus as described by AOAC (12), the extraction lasted for 15hrs.

Nitrogen determination
A small amount (200mg) of ground sample was weighed, wrapped in whatman filter paper (No.1) and put in the Kjeldhal digestion flask. Concentrated sulphuric acid (10ml) was added. Catalyst mixture (0.5g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ration of 10:5:1 was added into the flask to facilitate digestion. Four pieces of anti-bumping granules were added.

The flask was then put in Kjeldhal digestion apparatus for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100ml in standard volumetric flask. Aliquot (10ml) of the diluted solution with 10ml of 45% sodium hydroxide was put into the Markham distillation apparatus and distilled into 10ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70ml of distillate was collected. The distillate was then titrated with standardize 0.01N hydrochloric acid to grey coloured end point, the percentage nitrogen in the original sample was calculated using the formula:

$$\text{Percentage Nitrogen} = \frac{(a - b) \times 0.01 \times 14 \times V \times 100}{W \times C}$$

Where:

a	=	Titre value of the digested sample
b	=	Titre value of blank sample
v	=	Volume after dilution (100ml)
w	=	Weight of dried sample (mg)
c	=	Aliquot of the sample used (10ml)
14	=	Nitrogen constant in mg

Hydrolysis of the sample
A known weight of the defatted sample was weighed into glass ampoule. 10ml of 4.2M NaOH was added and oxygen was expelled by passing nitrogen into the ampoule. The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at $105^0C \pm 5^0C$ for 4 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. The filtrate was neutralized to pH 7.0 and evaporated to dryness at 40^0C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of borate buffer (pH 9.0) and store in plastic specimen bottles, which were kept in the freezer.

Loading of the Hydrolysate into TSM analyzer
The amount loaded was 60 microlitre. This was dispended into the cartridge of the analyzer. The period of an analysis lasted for 45 minutes.

Functional Properties Determination
Functional properties which include bulk density, water absorption capacity, oil absorption capacity, foaming capacity, swelling index and gelation concentration were determined using standard methods described by Onwuka (13).

Sensory Evaluation
Sensory evaluation was carried out using twenty Nursing mothers during their post-natal visit at from Ohaji Health Center Mgbirichi. The samples of the complementary gruel produced prior to presentation to the panelists was re-constituted using 50g of each sample (rice-defatted bambaranut flour), 100ml of boiled water was added and stirred to gelatinize and presented in identical serving plates to the nursing mothers. The subjects were enlightened and counsel on the procedure and were subsequently presented with the test food samples. A 9-point hedonic scale (14) was used to obtain response for colour, taste, aroma mouth-feel and overall acceptability. The interviewer (researcher) assisted the respondents (nursing mothers) who could not write or understand English language properly.

Statistical Analysis
Data was analyzed according to a completely randomized design with duplicate replicates. Data was subjected to variance analyses (ANOVA) and differences between means were evaluated by turkey's multiple range tests using SPSS statistic programme, version 20.0 USA Inc.

RESULTS
Table 2 present the essential amino acids profile of infant complementary gruel samples. There was significant difference ($p<0.05$) on the values of nine essential amino acids content of the gruel samples. Lucine content of the complementary gruel increased from 6.34 in sample A (90:10% of rice-defatted bambaranut flour meal) to 7.30 of sample D (90:10% of rice-defatted bambaranut flour meal). Other amino acids increases as defatted bambaranut flour meal increased; lysine increased from 4.64 to 5.10, phenylalanine 3.22 to 3.91, tryptophan 0.81 to 0.90, valine 3.31 to 4.10, methionine 2.10 to 2.36, histidine 2.10 to 2.26 and threonine 3.22 to 3.12 while on the contrary isoleucine decreased gradually from 3.70 to 3.48.

Non-essential amino acids profile (Table 3) showed that proline, arginine, tyrosine, cystine, alanine, glutamic acid, glycine, serine and aspartic acid were found on the rice-defatted bambaranut complementary gruel samples. The values among the samples were not the same but significant ($p<0.05$). Proline content ranged from 3.10 to 3.30, arginine 5.02 to 6.38, tyrosine 2.12 to 3.30, cystine 1.01 to 1.34, alanine 4.03 to 4.46, glutamic acid 11.12, glycine 3.19 to 4.20, serine 2.57 to 3.30 and aspartic 7.70 to 8.30.

Table 2 Essential Amino Acids (g/100g) Profile of rice-defatted bambaranut complementary infant gruel

Samples	A	B	C	D	Chemical score (%)	LSD	R-AA FAO/WHO	R-AA FAO/WHO
Leucine	$6.34^{d}\pm0.02$	$6.78^{c}\pm0.01$	$6.99^{b}\pm0.01$	$7.30^{a}\pm0.01$	91.51	0.1369	86	6.6
Lysine	$4.64^{d}\pm0.01$	$4.84^{c}\pm0.01$	$4.99^{b}\pm0.01$	$5.10^{a}\pm0.01$	89.57	0.0707	70	5.8
Isoleucine	$3.70^{a}\pm0.00$	$3.61^{b}\pm0.01$	$3.59^{b}\pm0.01$	$3.48^{c}\pm0.01$	93.15	0.0612	54	2.8
Phenylalanine	$3.22^{d}\pm0.01$	$3.38^{c}\pm0.01$	$3.80^{b}\pm0.01$	$3.91^{a}\pm0.01$	95.80	0.0935	93	2.8
Tryptophan	$0.81^{c}\pm0.01$	$0.85^{b}\pm0.01$	$0.83^{bc}\pm0.01$	$0.90^{a}\pm0.00$	94.71	0.0866	17	1.1
Valine	$3.31^{d}\pm0.01$	$3.69^{c}\pm0.01$	$3.83^{b}\pm0.01$	$4.10^{a}\pm0.01$	93.79	0.0935	66	3.5
Methionine	$2.10^{d}\pm0.00$	$2.20^{c}\pm0.01$	$2.30^{b}\pm0.01$	$2.36^{a}\pm0.01$	95.86	0.0866	57	2.2
Histidine	$2.0^{c}\pm0.00$	$2.18^{b}\pm0.01$	$2.21^{ab}\pm0.01$	$2.26^{a}\pm0.02$	89.72	0.01323	22	1.9
Threonine	$3.22^{a}\pm0.01$	$3.17^{b}\pm0.01$	$3.16^{bc}\pm0.01$	$3.12^{c}\pm0.01$	93.15	0.0935	47	3.4

Key: Sample A= 90:10% of rice and defatted bambaranut flour meal.
Sample B= 80:20% of rice and defatted bambaranut flour meal.
Sample C= 70:30% of rice and defatted bambaranut flour meal.
Sample D= 60:40% of rice and defatted bambaranut flour meal
R-AA = Reference Amino Acid

Table 3 Non Essential Amino Acids (g/100g) Profile of Rice-defatted Bambaranut Complementary Infant Gruel

Samples	A	B	C	D	Chemical score (%)	LSD	R-AA FAO/WHO	R-AA FAO/WHO
Proline	$3.30^{a}\pm0.01$	$3.26^{a}\pm0.01$	$3.20^{b}\pm0.01$	$3.10^{c}\pm0.01$	-	0.1118	-	-
Arginine	$5.02^{d}\pm0.01$	$5.20^{c}\pm0.01$	$6.02^{b}\pm0.01$	$6.38^{a}\pm0.01$	-	0.0935	-	2.0
Tyrosine	$2.12^{d}\pm0.01$	$2.30^{c}\pm0.01$	$3.01^{b}\pm0.01$	$3.30^{a}\pm0.01$	96.45	0.1275	93	-
Cystine	$1.01^{d}\pm0.00$	1.10c±0.01	$1.30^{b}\pm0.01$	$1.34^{a}\pm0.01$	97.65	0.1225	57	-
Alanine	$4.46^{a}\pm0.01$	$4.33^{b}\pm0.01$	$4.22^{c}\pm0.01$	$4.03^{d}\pm0.01$	-	0.935	-	-
Glutamic Acid	$11.12^{d}\pm0.01$	$12.58^{c}\pm0.01$	$13.00^{b}\pm0.01$	$13.20^{a}\pm0.01$	-	0.1118	-	-
Glycine	$3.19^{d}\pm0.01$	$3.71^{c}\pm0.01$	$3.90^{b}\pm0.01$	$4.20^{a}\pm0.01$	-	0.1275	-	-
Serine	$2.57^{d}\pm0.01$	$3.00^{c}\pm0.01$	$3.09^{b}\pm0.01$	$3.30^{a}\pm0.01$	-	0.1118	-	-
Aspartic acid	$8.30^{a}\pm0.01$	$7.70^{c}\pm0.01$	$7.87^{b}\pm0.01$	$8.26^{a}\pm0.01$	-	0.1118	-	-

Key: Sample A= 90:10% of rice and defatted bambaranut flour meal.
Sample B= 80:20% of rice and defatted bambaranut flour meal.
Sample C= 70:30% of rice and defatted bambaranut flour meal.
Sample D= 60:40% of rice and defatted bambaranut flour meal
R-AA = Reference Amino Acid

Results on functional properties of rice- defatted bambaranut infant complementary gruel (Table 4) shown that the bulk density was between 0.54g/mL of sample D and 0.60g/mL while water absorption ranged from 141.40% to 180.56%, oil water absorption decreased from 128.21% to 116.32%, swelling capacity ranged from 12.09% to 18.70%, foam capacity was between 3.18% and 6.20% but the least gelation concentration decreased from 7.62 of sample A to 3.80 of sample D.

Table 4: Functional Properties of Infant Complementary Gruel

Samples	**A**	**B**	**C**	**D**	**LSD**
Bulk Density (g/cm^3)	0.60^{a}±0.00	0.56^{b}±0.00	0.55^{c}±0.00	0.54^{d}±0.00	0.0180
WAC (%)	180.56^{a}±0.02	172.03^{b}±0.03	150.65^{c}±0.02	141.40^{d}±0.02	0.2318
OAC (%)	128.21^{a}±0.02	125.13^{b}±0.02	120.03^{c}±0.02	116.32^{d}±0.02	0.2121
Swelling Capacity (%)	18.70^{a}±0.02	17.21^{b}±0.01	15.13^{c}±0.02	12.09^{d}±0.02	0.1969
Foam Capacity (%)	3.18^{d}±0.02	5.02^{c}±0.01	5.80^{b}±0.01	6.20^{a}±0.03	0.2031
Least Gelation Concentration	7.62^{a}±0.01	5.87^{b}±0.02	4.09^{c}±0.04	3.80^{d}±0.01	0.2291

Mean score with different letters on the same column are significant ($p \leq 0.5$).
Key: Sample A= 90:10% of rice and defatted bambaranut flour meal.
Sample B= 80:20% of rice and defatted bambaranut flour meal.
Sample C= 70:30% of rice and defatted bambaranut flour meal.
Sample D= 60:40% of rice and defatted bambaranut flour meal
WAC = Water Absorption Capacity
OAC = Oil Absorption Capacity

Sensory properties of complementary gruel samples (Table 5) showed significant different ($p<0.05$) among the average mean scores. Mean scores for colour of the samples ranged from 5.27 to 7.65, taste 5.73 to 7.42, aroma 6.40 to 7.89, mouth-feel 5.12 to 6.85 and overall acceptability was between 5.87 of sample C and 8.02 of reference sample E.

Table 5 Sensory properties of Complementary infant gruel from rice-defatted bambaranut flour

Samples	**A**	**B**	**C**	**D**	**E**	**LSD**
Colour	7.64^{a}	7.13^{ab}	6.00^{bc}	5.27^{c}	7.65^{a}	0.54
Taste	7.36^{a}	7.00^{a}	5.73^{a}	6.20^{a}	7.42^{a}	0.66
Aroma	7.50^{b}	6.81^{c}	6.40^{d}	6.47^{d}	7.89^{a}	0.12
Mouth-feel	6.86^{a}	6.63^{a}	5.87^{a}	5.12^{a}	6.85^{a}	0.65
Overall acceptability	7.93^{a}	7.38^{ab}	5.87^{b}	6.13^{b}	8.02^{a}	0.59

Mean score with different letters on the same column are significant ($p \leq 0.05$)
Key: Sample A= 90%: 10% of rice and defatted bambaranut flour
Sample B= 80%: 20% of rice and defatted bambaranut flour
Sample C= 70%: 30% of rice and defatted bambaranut flour
Sample D= 60%: 40% of rice and defatted bambaranut flour
Sample E = Reference sample = Nutribon rice cereal

DISCUSSION

Amino Acid Profile of Infant Complementary Gruel

Table 2 shows the amino acid profile of the infant complementary gruel blends from Rice- Defatted bambaranut flour meal. All the essential amino acids as well as non- essential amino acids were found. Most of the essential amino acids increased as the proportion of the defatted bambaranut flour meal increased, except for Isoleucine and threonine which decreased. The essential amino acids are regarded as the obligatory amino acids which cannot be produced in the body at needed level but must be supplied through food (4). Essential amino acid evaluated ranged as follows; leucine 6.34-7.30g/100g was higher than FAO/WHO/UNU (15) reference values, lysine 4.64-5.10g/100g which is lower than 5.8g/100g recommended for infants (4.7); phenylalanine 3.22-3.91g/100g,this range was higher than FAO/WHO/UNU reference values of 2.8g/100g; tryptophan 0.81-0.90g/100g which was slightly lower than the reference value which implies that higher incorporation of defatted bambaranut meal may be required above level used in this work. Valine ranged from 3.31-4.10g/100g which is within the range of the reference values of FAO/WHO/UNU (15); methionine 2.10-2.36g/100g was higher than the reference value. In each case, sample A (10% defatted bambaranut flour meal) had the lowest values while sample D (40% defatted bambaranut flour) had the highest values. Isoleucine ranged from 3.48-3.70g/100g in sample D and sample A respectively was higher than 2.8g/100g reference value, threonine ranged from 3.12-3.22g/100g also for sample D and sample A respectively but lower than FAO/WHO/UNU (15) reference value. This result agrees with previous reports by Anigo*et al*., (4).

The results tend to agree with the statement that the high protein content of legumes increases the protein content of cereal based complementary foods and supplements the deficiency of amino-acid (16). Non- essential amino acids also increased with increased proportion of defatted bambaranut flour, except for Alanine and Proline, while Aspartic acid did not follow any defined order. From the study, it was observed that the calculated chemical scores was higher than the reference amino acid because the reference amino acid is from an animal source.

Functional Properties of the Infant Complementary Gruel

The result of the functional properties of complementary infant gruel from Rice-Defatted bambaranut flour is shown in table 4. All the functional properties evaluated decreased with an increase in the proportion of the defatted bambaranut flour, except for foam capacity which increased when proportions of defatted bambaranut increased from 10% to 40%.

Bulk density is a measure of pack per volume of the flour meal. In this study, the result obtained ranged from 0.54g/cm^3 to 0.58g/cm^3 for sample D (40% defatted bambaranut flour) and sample A (10% defatted bambaranut flour) respectively which falls in the same range for results reported for sorghum (0.61g/cm^3),pearl millet (0.59g/cm^3), and maize (0.60g/cm^3), (18). Bulk density promotes digestibility of the infant formula, especially among children with immature digestive system (19).

Swelling capacity is used to determine the amount of water that the formula will absorb and the degree of swelling within a given time and temperature. Sample D which contained 60-40% of rice-defatted bambaranut flour meal, had the lowest swelling capacity of 12.09g/cm^3 while sample A (with 10% inclusion of defatted bambaranut flour) had the highest value of 18.70g/cm^3. Low swelling capacity is an advantage in complementary feeding as it increases the nutrient density of the food, and the child is able to consume more in order to meet the nutrient requirement (18).

Gelation is the ability of starch to absorb moisture and swell. The least gelation ranged from 3.80g/cm^3 to 7.62g/cm^3 for sample D(with 40% defatted bambaranut flour meal) and A(10% defatted bambaranut flour) respectively. Infant formula with high gelation requires less heat during preparation (20).

Foam capacity ranged from 3.18g/cm^3 to 6.20g/cm^3 for sample A(with 10% defatted bambaranut flour meal) and sample D (with 40% defatted bambaranut flour meal) respectively. High foam capacity in infant diet is not desirable; however, preparation at reduced pressure minimizes its formation. High water absorption capacity (WAC) is desirable in infant formula for the improvements of mouth-feel and viscosity reduction in food products. In this study, water absorption capacity ranged from 141.40g/cm^3 to 180.56g/cm^3 for sample D (40% defatted bambaranut flour meal) and sample A (10% defatted bambaranut flour) respectively. Oil absorption capacity (OAC) in the blended flour might be due to the thickness of interfacial bi-layer model of protein to protein interaction. Sample A had the highest OAC of 128.21g/cm^3, while sample D had the lowest value of 116.32g/cm^3. The reduced value of OAC in sample D might be due to collapse of the flour blend proteins thereby increasing the contact between protein molecules leading to coalescence and thus reduce stability of the samples.

Sensory Properties of Infant Complementary Gruel

The mean scores for sensory properties of infant complementary gruel were presented in Table 4. The colour of the samples ranged from 7.64 to 5.27. The sample containing 10 and 20% defatted bambaranut flour respectively had the best colour when compared with other samples. The aroma of the samples showed that there was significant difference ($p \leq 0.05$) ranging from 7.50 to 6.47, which implies that the beany flavor of the bambaranut may have caused the significant difference in the aroma. The mouth-feel of the samples ranged from 6.86 to 5.12 and the taste of the samples showed that there was no significant difference in the taste, the samples containing 10 and 20% defatted bambaranut flour respectively had the best taste when compared with other samples. Sample A (90:10% of rice and defatted bambaranut flour meal) most preferred sample by the nursing mothers in terms of colour, taste, aroma and mouth-feel. Sample A was most preferred in overall acceptability with a mean score of 7.93 followed by sample B (80:20% of rice and defatted bambaranut flour meal) with 7.38 mean score. However sample E (commercial rice based complementary) food have 8.02 highest mean score for overall acceptability but the mean score was not different significantly ($p < 0.05$) when compared.

CONCLUSION

This study concluded formulation of infant complementary gruel from rice and defatted bambaranut increased the amino acids, functional and sensory properties. In this study attempt have been made to formulate ainfant complementary gruel that will be of higher protein quality and nutritive value and easily affordable. The results showed that acceptable low cost and highly nutritious infant complementary gruel could be produced from blends of rice and defatted bambaranut flour meal. The results implies that this product is rich in essential amino acids, such as valine, leucine and isoleucine which are responsible for the substrates for gluconeogenesis, phenylalanine which is needed for the production of a pigment called melanin that contributes to eye, hair and skin colour and tryptophan that is a precursor for the synthesis of serotonin and aspartame and glutamate serve as ammonia transporters to the liver and kidney for urea synthesis.

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