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Proximate composition, antinutrients and some functional properties of a potential infant food made from wheat and groundnut

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Abstract

The study evaluated the proximate composition, anti-nutrients, some sensory and functional properties of a potential infant food made from wheat and groundnut. The proximate composition was determined by AOAC standard methods, phytate determination was by UV-spectrophotometer and oxalate levels by permanganate titration method. Percent moisture, ash, protein, fat and fibre contents in the formulated food were 8.56 %, 1.88 %, 18.45 %, 31.22 % and 2.49 % respectively. These were found to be higher than their corresponding values in Nestle Cerelac namely; 5.18 %, 1.20 %, 15.23 %, 9.47 % and 2.27 % respectively and as such, the formulation is likely to provide more nutrients to the growing infant and a better allowance for nutrient losses associated with food processing/preparation than Nestle Cerelac. However, the carbohydrate content of the formulated food (37.40 %) was considerably less than that of Nestle Cerelac (66.65 %) and is also well below the recommended level for carbohydrate in infant food (65 %). Also, the fat content of the formulated food (31.22%) significantly exceeded the level found in Nestle Cerelac (9.47 %) and the set recommended level for fat in infant food (10 %). Phytate and oxalate contents of the formulated food were found to be 2.90 % and 1.03 % respectively and as such are well below their established safe permissible limits of 0 - 5%. The water absorption capacity, swelling index, loosed and packed bulk densities of the formulated food were 6.71, 23.52, 4.42 g/L and 13.70 g/L respectively, implying that more of the formulated food can be constituted in little water and yet give the desired nutrient density. Sensory evaluation revealed that whereas the appearance and texture of the formulated food were more preferred than those of Nestle Cerelac, its taste and flavour were only slightly less preferred than those of Nestle Cerelac.

Keywords: Infant food, formulated food, proximate analysis, infant formula

1. Introduction

Breast feeding remains the ideal form of infant feeding between the ages of 0-6 months [1,2]. However, exclusive breast feeding is not without its attendant challenges which make it increasingly difficult for nursing mothers to breast feed for longer than nine months. In many West African countries, exclusive breast feeding is usually advised as it is adequate for up to six months of age but thereafter becomes increasingly insufficient in meeting the nutritional needs of the growing infant [1,2]. This is because from ages 6 months and above, the child undergoes rapid growth, physiological maturation and development. This situation necessitates the introduction of other foods to the infant to complement breast milk [1]. However, lack of properly formulated infant foods in developing countries, have been reported to be one of the major contributing factor to high rates of infant mortality arising from infant malnutrition [3]. Also, the high costs of proprietary infant formula make them unaffordable to low-income households. In addition, most complementary foods for infants are based on high starch cereals like maize, sorghum and millet with poor nutritional values due to poor processing and the fact that lysine is limiting in cereals hence are in their native uncomplemented forms, unable to meet infant nutritional needs [4]. A review of infant food formulation studies reveal that a nutritionally adequate infant food might be one with a 13:7 Cereal-Legume blend proportion as some of the most successful cereal Legume blend formulations were those in which the cereal-legume blend proportions approximated 13:7 [1,5,6,7,8]. This study is aimed at assessing some nutrient, anti-nutrient, functional and sensory properties of a potential infant formula made from wheat and groundnut using a 13:7 cereal-legume blend. This study will thus provide knowledge of the suitability of the formulated diet as a potential low-cost formula for infants.

2. Materials and method

2.1 Sample procurement and Infant food formulation

Three (3) kilograms each of wheat and Groundnut grains were procured from Wurukum Market in Makurdi, Benue State, Nigeria and 2g of each was separately characterised by proximate analysis as described hereafter. Two and a half kilogram (2.5kg) each of the wheat and groundnut grains were separately cleaned and processed into fine flour following the sequence shown in Figure 1 and 2. The fine flours obtained were then used to formulate the infant food

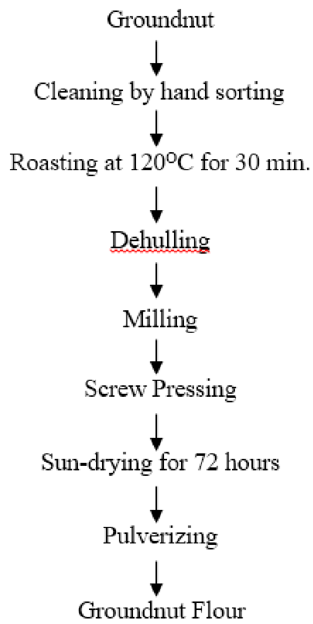

Fig 1: Flow chart for production of Groundnut flour

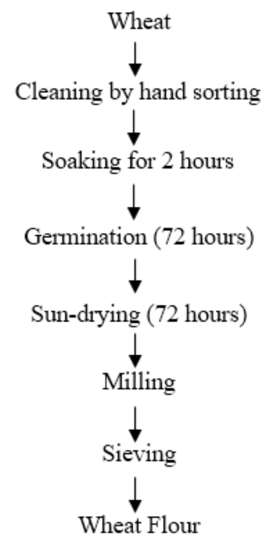

Fig 2: Flow chart for production of Wheat flour

The formulated infant food was obtained by blending both wheat and groundnut flours using material balance method in a 13:7 blend proportion as shown below:

Infant food (100%) = 65% Wheat Flour + 35% Groundnut Flour

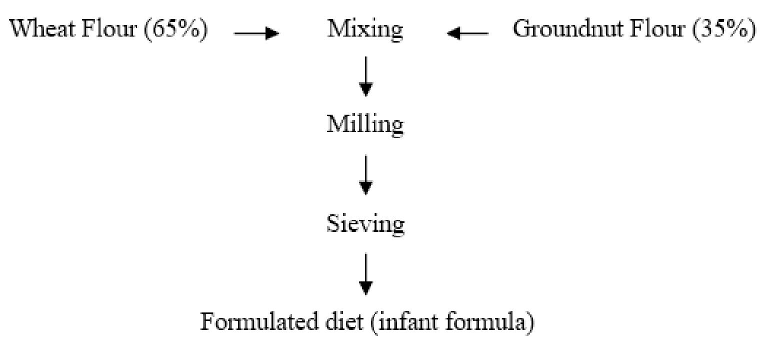

Fig 3: Flow chart for production of formulated

2.2 Characterization of formulated infant food

2.2.2 Proximate analysis

Moisture content, ash content, crude protein, crude fat, crude fibre and nitrogen free extract were determined for both the unprocessed wheat and groundnut grains as well as the formulated infant food obtained from blending their respective flours. Proximate analysis was carried out by standard analytical methods prescribed by AOAC [9].

2.2.3 Antinutrient content: Phytate and Oxalate determination

The Oberlease spectrophotometer method described by Ojinnaka [4] was used, 2g of sample was dispersed in 50 mL 2N HCl, agitated for 30 minutes, and allowed to stand for 20 min before being filtered. 1mL $Fe(NH_4)SO_4$ was then added seperately to 0.5 mL of the filtrate and 0.5 mL sodium phytate standard. Both tubes were then stoppered, and their content boiled in a bath for 30 minutes before cooling with ice to 25 ºC. The addition of Bipyrimidine reagent gave colored solutions whose absorbances at 519 nm was used to calculate the phytate content in the sample.

In the determination of Oxalate, the permanganate titration method described by Ojinnaka[4] was used. A 2g sample was dissolved in 100 mL distilled water with addition of 5 mL 6N HCl. This was then digested by boiling for 1 hour, cooled, filtered and the pH adjusted to 4.5 before reheating to 90 ºC. When cooled, ferrous iron precipitate was removed by filtration reheated to 90ºC with addition of 10 mL $CaCl_2$, cooled and refrigerated at 5 ºC for 6hrs.

The solution was then filtered and the precipitate dissolved in 10 mL 20 % H_2SO_4 and made up to 100 mL with distilled water. The solution was then titrated against 0.05M $KMnO_4$ solution to a faint pink color and the oxalate content calculated from the relationship that:1 mL of 0.05M $KMnO_4$ solution corresponds to 0.00225 g oxalate [4].

2.3 Determination of functional properties
2.3.1 Determination of Swelling index (SI)
This was determined using the method reported by Ukpabi and Ndumle [4]. Ten gram of the formulated food was dispersed into a 100 mL measuring cylinder, levelled and 40 mL of distilled water was added to the sample in the cylinder to make up the initial volume recorded as (V_1) and allowed to stand for 1 hour. The final volume (V_2) was then recorded after swelling occurred and the swelling index calculated as the ratio of the final volume to the initial volume [4].

2.3.2 Determination of Water Absorption Capacity (WAC)
This was determined as the weight of the water absorbed and held by one gram of the sample [4]. One gram (1g) of the formulated food was placed in a pre-weighed test tube and 10 mL of distilled water was added to the tube with thorough shaking. The mixture was then allowed to stand for 30 min at room temperature and later centrifuged at 3500 rpm for 30 min. The supernatant was decanted and the residue in the test tube inverted over an absorbent paper and left to drain completely before the tube and its content were weighed. The weight of water absorbed and held by the sample was obtained by subtracting the weight of the dry sample and empty test tube from the final weight of the tube and moist sample. The determination was done in triplicate and the mean value recorded.

2.3.3 Determination of Bulk Density (B.D.)
The method described by Onwuka was used [4]. A 10 g sample of the formulated food was weighed into a clean 100 mL cylinder and the volume recorded. The bottom of the cylinder was then tapped repeatedly on a padded table until no further reduction was seen in volume. The new volume was recorded as the packed volume. The bulk density was calculated for both the loose and packed version by dividing the weight of the sample by its volume [4]. For both loose and packed versions, the measurement was repeated thrice and the mean value recorded.

2.4 Sensory Evaluation
The sensory properties of both formulated infant food and Nestle Cerelac were scored by a panel of 20 untrained judges after labelling them as samples A and B respectively to prevent compromising their true identities. The Visual-organoleptic method described by Ahima [1] and Okoye *et al.* [10] was used, in which 77g sample was constituted in 100 mL cold H_2O with addition of 80 mL boiling H_2O and cooked for 20 minutes to give the gruel that was served. Appearance, aroma, taste, after-taste, colour and overall acceptability were scored using a 5-point hedonic scale with 5 being like extremely and 1 being dislike extremely. The mean score of corresponding sensory attributes of both formulated food and Nestle Cerelac were statistically compared by T-test for presence of significant difference.

2.5 Statistical Analysis
From the data obtained the mean values and standard deviations were calculated. The significant differences between the means were tested using T-test.

3. Results and discussion

Table 1: Proximate composition of Wheat and Groundnut

Proximate parameter	**Wheat**	**Groundnut**
Moisture	10.58 ±0.66	5.69 ± 0.30
Ash	2.59 ± 0.30	2.67 ± 0.35
Crude protein	12.43 ± 1.37	30.38 ± 0.64
Crude Fat	2.58 ± 0.41	48.61 ± 1.24
Crude Fibre	2.56 ± 0.50	2.37± 0.29
Carbohydrate (C.H.O)	69.26 ± 0.94	10.28 ± 1.83
Total	100.00	100.00

The proximate composition of feed materials used in formulating the infant food is as shown in Table 1. The result show that whereas crude fat and crude protein are clearly limiting in wheat (2.58 % and 12.43% respectively) and much below the levels found in Nestle Cerelac (9.4% and 15.5% respectively) as well as the Protein advisory group (PAG) recommended levels for infant food (10% and 20% respectively) [1], groundnuts on the other hand adequately complements wheat in fat and protein as its fat and protein content (48.61 % and 30.38% respectively) well exceed the amounts in Nestle Cerelac earlier stated as well as the recommended levels set for infant food by the PAG. Also Table 1 show that groundnuts is limiting in carbohyrate (10.28%) as this is far below the level in Nestle Cerelac (66.65%) but this is adequately compensated by the carbohydrate level in wheat (69.24%). However with regard to ash content and fibre, both wheat and groundnut are comparable.

Table 2: Comparison of Proximate Composition of Formulated Infant food and Proprietary Formula (Nestle cerelac)

S/N	**Feed Component**	**Formulated food**	**Nestle Cerelac**	**Critical value of t at p=0.05 and d.f =4**	**Calculated value of t at p =0.05 and d.f =4**	**Presence of significant difference**
1.	Moisture	8.56 ± 0.40	5.18 ±0.05	2.7764	11. 887	Yes
2.	Ash	1.88 ± 0.19	1.20 ± 0.00	2.7764	5.086	Yes
3.	Protein	18.45 ± 0.66	15.23±0.23	2.7764	6.548	Yes
4.	Fat	31.22 ± 0.95	9.47 ± 0.47	2.7764	29.15	Yes
5.	Fiber	2.49 ± 0.18	2.27 ± 0.57	2.7764	0.5228	No
6.	C.H.O	37.40 ± 1.72	66.65±0.58	2.7764	22.90	Yes

Table 2 show the proximate composition of the formulated infant food and that of Nestle Cerelac (wheat with milk variant) as well as their statistical comparison using T-test. This shows that overall; moisture, ash, protein, fat and fibre contents in the formulated food (8.56%, 1.88%, 18.45%, 31.22%, and 2.49% respectively) are higher than their corresponding values in Nestle Cerelac (5.18%, 1.20%, 15.23%, 9.47% and 2.27% respectively) and as such, it is more likely to provide a beter allowance for nutrient losses that may be associated with any food processing strategy that may be employed before the food get to its ready-to-eat stage. However, the carbohydrate content of the formulated food (37.40%) fall far below the carbohydrate content of Nestle Cerelac (66.65%) and is also well below the recommended level for carbohydrate in infant food set by PAG (65%) [11]. It is also observed that, because the groundnut used in the feed formulation is undefated the fat content of the formulated food far exceed the level found in Nestle Cerelac and the set recommended levels for fat in infant food by PAG (10%). This observation raises concerns as to the bioavailability of dietary energy for infants fed with the formulated diet as the low carbohydrate levels would imply a low amount of readily available sugar for basal metabolic activities that enable growth and development. However recent findings have shown that infants depend on fat for 50% of their energy needs [12] thus making the high fat content somewhat of an advantage. The T-test analysis perfomed at $P>0.05$ and a degree of freedom of 4 show that, there is a significant difference between the levels of moisture, ash, protein, fat and carbohydrate present in the formulated infant food when compared with the proprietary formula as the calculated value of t for each proximate parameter is greater than the corresponding critical value of t for the parameter in question as shown in Table 2. The exception however is with the fibre content of the formulated versus proprietary food where the calculated value of t (0.5228) is far less than the critical value of t (2.7764) and as such there is no significant difference between the fibre contents of both formulated and prorietary food.

Since the levels of moisture, ash and protein in the formulated food are higher than those of Nestle Cerelac, it implies that: As relate to moisture, the formulated food is likely to have a shorter shelf life than the proprietary food given that the higher the moisture in a food material, the more susceptible it will be to spoilage by food degrading microbes [13]. As relate to ash, the formulated food is more likely to be richer in nutrient minerals than the proprietary food and as relate to protein, the formulated food can be expected to have a greater positive impact on tissue repair and body building compared to the proprietary food.

Table 3: Phytate and Oxalate contents of formulated Infant food

S/N	Phytate level (%)	Oxalate level (%)
1.	2.12	1.32
2.	3.69	0.98
3.	2.91	0.79
Mean ± S.D	2.90 ± 0.78	1.03 ± 0.26

Table 3 shows that the mean phytate and oxalate contents of the formulated food are 2.90% and 1.03% respectively. These levels are well below the established safe permissible limits of 0 - 5% for phytates and oxalates in foods [14] and as such it is expected that there would be no significant loss of calcium and other divalent nutrient minerals in infants fed with the formulated food.

Table 4: Functional properties of formulated potential infant food

S/N	Water Absorption Capacity	Swelling Index	Bulk Density(g/L)	
			Loosed	Packed
1.	6.71	23.08	4.34	13.70
2.	7.10	24.10	4.80	13.50
3.	6.50	23.40	4.14	13.90
Mean ± S.D	6.77 ± 0.30	23.52 ± 0.52	4.42 ± 0.33	13.70 ± 0.20

Table 4 shows that the Water absorption capacity (WAC) of the formulated infant food is 6.71. This value is high compared with reported values in literature and will be expected to cause food swelling during preparation into gruel depending on the values of other functional properties [4]. The swelling index was found to be 23.52 and similar values in literature are adjuged as high[4] and because WAC and swelling index ultimately determine the consistency of the formular during preparation into gruel, the implication is that the resulting gruel which otherwise should hold large amounts of water during gruel preparation and as such become excessively voluminous and hence have a low energy and nutrient density, will instead be expected to give a more nutrient-dense food for infants fed on the formulated food because the food have most of its energy/calories in its high fat content even if a small amount of it is consumed [12].

The loosed and packed bulk densities of the formulated food are 4.42 g/L and 13.70 g/L respectively. These are the lowest attainable density without compression and the highest attainable density upon compression respectively indicating that a significant difference exist between both. The implication is that more of the formulated food can be constituted in small amount of water yet giving the desired energy nutrient density.

Table 5: Comparative mean scores of sensory Parameters of formulated and proprietary infant food

Sensory Parameter	Sample A	Sample B	T-critical at p=0.05 and d.f of 38	T-calculated at p=0.05 and d.f of 38	Existence of significant difference
Appearance	4.55± 0.66	4.50± 0.67	2.0244	0.2318	No
Taste	4.25± 0.54	4.45± 0.97	2.0244	0.7852	No
Flavour	3.75 ±0.89	4.45 ±0.74	2.0244	2.6365	Yes
Texture	4.85 ±0.36	4.10 ±0.77	2.0244	3.8461	Yes
General Acceptability	4.45 ± 0.05	4.40 ±0.73	2.0244	0.2464	No

Table 5 comparatively show the mean scores of sensory Parameters of both formulated and proprietary infant food as assigned by the panel of judges. The sensory scores show that, whereas the appearance and texture of the formulated food (sample A) are more prefered than those of the proprietary food (sample B), the taste and flavour of the formulated diet were just slightly less preferred than those of the proprietary formula, but this is only because the latter contained skimmed milk whereas the former did not and hence the more appealing flavour of the latter. Most judges suggested that the taste and flavour of the formulated infant food be enhanced if it must completely rival the proprietary formula. A t-test comparison of the corresponding mean scores of sensory parameters of both proprietary and formulated infant foods ($p>0.05$) at 38 d.f show that the observed differences between the mean scores are only marginal and are not significantly different except with regard to flavour and texture. The T-test analysis also show that in general, the acceptability of the formulated food is comparable to that of the proprietary food as the calculated value of t (0.2464) is less than the critical value of t (2.0244) meaning there is no significant difference between their general acceptabilities.

4. Conclusion

The formulated infant food was found to be protein-rich and fat energy-dense with acceptable sensory attributes. However it was found that, the taste and flavour must be improved upon if the formulated infant food must strongly rival already-existing popular proprietary infant formula in the market as opinned by most of the judges.

The study also found that with respect to moisture, ash, protein and fibre compositions, the formulated food was comparable to the proprietary formular (Nestle Cerelac) and mostly complies with the proximate composition guidelines for infant food by the PAG. However exceptions were found with respect to carbohydrate and fat compositions where their levels in the formulated food (37.40 % and 31.22 % respectively) were significantly lower and higher respectively than their respective values in the proprietary formula (66.65 % and 9.47 %) respectively. Also, the aforementioned carbohydrate content in the formulated food is much lower than the set range by the PAG (65- 67%) but the diet have a much higher fat content (31%) than the set recommended range by PAG (9-10%). Thus, implying that if fed to infant, more of the energy from the formulated food will be supplied from fat than from carbohydrate. Also,the oxalate and phytate levels in the formulated food (1.03 % and 2.90 %) are within acceptable limits (0-5 % respectively) for infant food and have favourable indices for the functional properties studied as the indices obtained suggested an infant diet that is nutrient and energy-dense for infant.

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