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Nutrient composition, functional and organoleptic properties of complementary food formulated from sorghum, walnut and ginger

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Abstract In developing countries, particularly sub-Saharan Africa, infant complementary foods are grossly inadequate, complementary foods were formulated. Sorghum, walnut and ginger were processed into flour separately and were then blended in ratios 100:0:0(SWG1); 80:15:5(SWG2); 70:25:5(SWG3); 60:35:5(SWG4) and 50:45:5(SWG5). The proximate, functional and sensory properties of processed flour were determined. The result indicates that the protein content increases as walnut proportion of the samples increased. The protein content of the resulting flour increased significantly from 6.52 to 10.21%, with a corresponding decrease in the carbohydrate content from 85.23 to 77.22%; the moisture content(flour) ranged from 6.30 to 9.01%; fat content from 1.67 to 2.28%; ash content from 0.05 to 0.11%; crude fibre from 0.27 to 0.3%; carbohydrate from 85.23 to 77.22%. The levels of the antinutrients were lower in the complementary foods than the control samples. The water absorption capacity, bulk density and swelling index were lower in fermented complementary blends than the control samples. There exists significant difference ($P < 0.005$) among the samples analyzed. Sensory evaluation conducted on the porridge showed a significant difference ($p < 0.05$) in color and odour. Sample blend SWG 3(70:25:5) was most generally accepted among the samples. The nutritional and textural qualities of sorghum flour were improved with the addition of walnut and ginger flour. A sample with 25% walnut and 5% ginger is more acceptable. Processing of sorghum into flour and porridge will encourage the use and utilization of the sorghum in other forms. Fortification of sorghum with walnut and ginger flour makes the food more nutritious thereby alleviating the problem of malnutrition especially in children.

Key words: Sorghum, Walnut, Ginger, Fortification, proximate analysis, sensory properties

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Introduction

In developing countries, particularly sub-Saharan Africa, inadequate intake of protein has led to various forms of malnutrition in both children and adults. This is because breakfast meals for both adults and infants are based on local staple diet made from cereals, legumes, roots, and cassava and potatoes tubers. It has been reported that in developing countries, protein malnutrition persists as a principal health problem among children below the age of five in Nigeria (UNICEF, 1996). However, results from previous studies note that most cereals are limited in essential amino acids such as threonine and tryptophan even though rich in lysine (Anglani, 1998; Perez-Consesa *et al*., 2002; Mensa-Wilmot *et al*., 2001; Nnam, 2001; Onweluzo and Nnamuchi, 2009), while most oil seeds and legumes are rich in essential amino acid particularly the Sulphur amino acids (Radha *et al*., 2007; Kanu *et al*., 2007a, b). Thus a combination of such food stuffs will improve the nutritional value of the resulting blend that will make it better compared to the individual components alone (Mensa-Wilmot *et al*., 2001).

In Nigeria, an extensive work has been done in an effort to formulate various breakfast and infant cereal meals by combining the available local cereals and legumes (Mensa-Wilmot *et al*., 2001; Egounlety, 2002; Kanu *et al*., 2007c). The suitability of cereals, oil seed and legumes blend meals for human consumption has been extensively reviewed (Kulkani *et al*., 1991; Radha *et al*., 2007) and many countries have reported success in those formulations (Anglani, 1998; Kanu *et al*., 2007c). In Sierra Leone, however, with all the attempts made, no appropriate blend had ever been formulated that meets the nutritional requirements of the old age. Thus, this research is an attempt to formulate a cereal-based porridge meal with additional constituents such as walnut and ginger in various proportions for infants. Sorghum is locally produced and abundantly available. They have been reported for their suitability in food formulations (Kulkani *et al*., 1991; Choi and Sohn, 1997). Sorghum is a popular grain in many areas of Africa. Sorghum grains serve as an ingredient for many unique indigenous foods and beverages. Fermented sorghum porridge is an important staple food items for people of the West African sub-region and are also important weaning foods for infants and convalescents due to its high calorie and some other mineral elements. Food preparation methods generally differ from region to region. A porridge or stiff paste, a basic diet in most of east Africa, is prepared by adding pounded flour to hot water. In Ethiopia and Sudan sorghum flour may be made into a flat cake or the grain may be popped or boiled whole. In West Africa, sorghum is used to prepare many foods. In Nigeria, particularly in the northern region, it is utilized mainly in the preparation of *tuwo*-thick dough prepared by mixing sorghum flour in hot water and allowing the paste to cool and gelatinize which is then eaten with soup. *Akamu*, *koko* or *pap* is prepared by soaking the grains in cold water, milling and filtering through a cloth and the expressed mass is reconstituted in cold water after which boiling water is added to it. Sorghum beer is very popular. It may be drunk as *burukutu* – an alcoholic gruel; or as *pito* when the sediment is removed. In most parts of Asia, particularly India, sorghum grain is ground, made into dough and baked as flat unleavened bread. Walnut has been extensively investigated and reported to possess many health benefits to humans particularly for its quality oil (Abou- Gharbia *et al*., 2000). Similar sentiments are held for ginger peas as well. As far as our knowledge is concerned based on literature review, no attempts have ever been made to combine the above food stuffs to obtain a blend that could be As far as our knowledge is concerned based on literature review, no attempts have ever been made to combine the above food stuffs to obtain a blend that could be used as a cereal-based porridge meal for the aged. Thus, the objective of this work is to evaluate the effect of sorghum and walnut variation on functional properties and acceptability of breakfast meal.

Materials and methods

Materials

Sorghum, walnut and ginger were all purchased from a local market at Mile 2 in Lagos State.

Sample Preparation

The fermented sorghum flour was produced by soaking sorghum grains in water for 48hours. The softened kernel was milled and sieved to remove the germs and hulls. Water was added to the product, which is almost pure starch, and this mixture is allowed to ferment anaerobically for 72hours. The fermented meal was then pressed to produce the fermented cake. The cake was then dried and milled to produce the fermented sorghum flour. The walnut was washed to remove adhering contaminations and then cooked for 30 minutes to aid deshelling process in sulphited water. The deshelled walnut was size reduced to increase surface area and then blanched by adding into boiling water, then removing the container from the heat and allowing standing for 2 minutes before draining. This helps to reduce the tannin content of the walnut.

Preparation of the blends

Different samples were prepared by combining 80%, 70%, 60% and 50% fermented sorghum powder, 15%, 25%, 35% and 45% walnut powder with a constant 5% of Ginger powder (Table 1).

Table 1. Blends of Sorghum, walnut and ginger used in breakfast meal production

Code	Sorghum	Wall nut	Ginger
SWG1 (100%Sorghum)	100%	-	-
SWG2 (80% Sorghum: 15% walnut: 5% ginger)	80	15	5
SWG 3 (70% Sorghum: 25% walnut: 5% ginger)	70	25	5
SWG 4 (60% Sorghum: 35% walnut: 5% ginger)	60	35	5
SWG 5 (50% Sorghum: 45% walnut: 5% ginger)	50	45	5

Moisture content determination

5grammes of sample was weighed into a Petri-dish of known weight. The weighed sample was put into an oven pre-set at 110^{o}C for 3hrs. The sample was removed and cooled in a dessicator to room temperature and the weight was determined after which it was returned into the oven at 110^{o}C for 30 minutes until constant weight was obtained: AOAC (2004).

Ash content determination

5grammes of sample was weighed into a previously ignited and cooled silica dish. The dish was ignited gently first and then at 600^{0}C for 3 hours in a muffle furnace. The dish and its content were cooled in a dessicator and reweighed; the weight of the residue was recorded as ash content.

Crude fat determination

Crude fat was determined by the method of AOAC (2004). This was determined using a Soxtec System HT2 fat extractor. Crude fat was extracted from the sample with hexane, and the solvent evaporated off to get the fat. The difference between the initial and final weight of the extraction cup was recorded as the crude fat content.

Crude protein determination

Crude protein was determined by Kjeldahl method using Kjeltec TM model

2300, as described in Foss Analytical manual, AB, (2003). The method involved digestion of the sample at 420^0C for 1hr to liberate the organically bound nitrogen in the form of ammonium sulphate. The ammonia in the digest ammonium sulphate was then distilled off into a boric and receiver solution, and then titrated with standard hydrochloric acid. A conversion factor of 6.25 was used to convert from total nitrogen to percentage crude protein (AOAC, 2004).

Sensory evaluation

Porridges were prepared from each of the composite flour. One hundred grams of each flour was homogenized with 500mls deionized water. The slurry was heated slowly with constant stirring for 15mins. I teaspoon of sugar was added to each sample. The porridges were kept separately in thermos flask for sensory evaluation with 20 untrained panelists drawn from Yoruba ethnic group among the staff and students of Department of Food Technology, Yaba College of Technology. They evaluated the samples using a nine point hedonic scale ranging from 1(extremely disliked) to 9 (extremely liked) (Watts *et al.*, 1989). The five porridges were coded appropriately in the hedonic scale. Each judge was given six white plastic cups and teaspoon for use in the sensory evaluation. The judges were provided with clean water to rinse their mouth in between testing of the porridges to avoid carry over effect. Each panelist evaluated the porridges for color, flavour, texture, taste and overall acceptability.

Data analysis

Proximate analysis was carried out in three triplicates while pasting properties was in duplicate. The data were subjected to Analysis of Variance (ANOVA) ($p < 0.05$). Means with significant differences were separated by Turkey test using SPSS 11.0 software.

Results and discussions

Proximate composition: The proximate composition is shown in Table 2. The proximate analysis showed that all the samples were within the normal moisture contents of dried food (flour blends). According to these results there are significant differences ($p<0.05$) in the moisture content of the five formulations. The low moisture observed for the five formulations is a good indicator of their longer shelf life. The moisture content ranged between 6.30 ±0.01% and 9.01 ±0.01% which indicate that the product can be stored for a longer period. This is in line with the findings of Vincent, 2002. It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content. For is this reason, a water content of 10% is generally specified for flours and other related products. It should be pointed out that when these products are allowed to equilibrate for periods of more than one week at 60% relative humidity and at room temperature (25 to 27^0C), moisture content might increase. The ash content ranged from 0.05% to 0.11%. These values are similar to the values reported from the production of legumes-fortified weaning food (Egounlety, 2002) but lower than reported results of Kanu *et al*., 2009 from production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults. Fat content ranged from 1.67% to 2.28%. Fat was significantly different for all the formulations. SWG 5 had the highest fat content followed by SWG 4. From the results the differences were significant ($p<0.05$). Protein content ranged from 6.52% to 10.21%. The protein content for the five formulations was significantly different ($p<0.05$) from each other. SWG 5 has the highest protein content followed by SWG 4. The result of the SWG 5 was significantly lower than the reported results of Egounlety (2002) for the nutritive value of protein-energy legume-fortified weaning for 'ogi' and reported results of Kanu *et al*., 2009 who also studied production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults and the result reported for Binnimix (Kanu *et al*., 2007c). Ashaye *et al.* (2001) reported an increase in protein content (7.28%) and ash (3.58%) when yam flour was substituted with 40% cowpea flour while Achi (1999) reported an increase in protein content from 3.5% in the control (yam flour) to 19.7% for yam flour fortified with 40% soybeans flour. Carbohydrate content varied and decreased with addition of walnut flour. This was in agreement with the findings of Jimoh and Olatidoye (2009) who reported a decrease in carbohydrate content with increase in soybean flour fortification.

Energy was observed to be high for all the five formulations. Significantly higher ($p<0.05$) than the results reported by Mahgoub (1999) and Kulkani *et al*., (1991) who studied sorghum malted-based weaning food formulation: Preparation, functional properties and nutritive value but lower than the results reported by Kanu *et al*.,2009 who also studied production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults.

However, the results corroborated those of Egounlety (2002). Energy content is a parameter used to determine the quality of food especially for formulations designed for adult with high energy requirements. However percentage protein calories were lower than those reported by Mahgoub (1999) however, higher than the required amounts for adult as reported by Robbin-Coker and Jalloh (1975) in infant feeding and protein-calorie malnutrition in

Freetown. According to the Indian Council of medical research, the required optimal protein-calorie requirement for preschool children for India is 7.1% (Mahgoub, 1999). Protein-energy ratio gives the protein content of a food or diet expressed as the proportion of the total energy provided by protein (17KJ, 4kcal/100 g). The average requirement for percent protein is about 7% of total energy intake. Average Western diets provide about 14% for children and half of it for adults (Bender, 2005).

Table 2. Proximate composition (%) complementary foods from sorghum, walnut and ginger blends

Proximate Composition	**SWG1**	**SWG2**	**SWG3**	**SWG4**	**SWG5**
Protein (%)	6.52±0.01e	7.80±0.01d	8.20±0.00c	9.05±0.05	10.21±0.01
Moisture (%)	6.30±0.01d	7.60±0.01c	7.70±0.01c	8.01±0.01	9.01±0.01
Ash (%)	0.05±0.00	0.06±0.00	0.08±0.00	0.09±0.00	0.11±0.06
Fat (%)	1.67±0.01e	1.72±0.00d	1.81±0.00c	2.10±0.00	2.28±0.00
Crude fibre (%)	0.27±0.00c	0.28±0.01bc	0.29±0.01b	0.31±0.01	0.30±0.01
Carbohydrate (%)	85.23±0.01a	82.63±0.01b	81.92±0.00	80.52±0.00	77.22±0.01
Energy (kcal/100g)	382.03	377.2	376.78	377.18	358.88
% protein calories	6.82	8.3	8.7	9.6	11.4

Means of duplicate determination
SWG1 100% Sorghum
SWG2 80% Sorghum: 15% walnut: 5% ginger
SWG3 70% Sorghum: 25% walnut: 5% ginger
SWG4 60% Sorghum: 35% walnut: 5% ginger
SWG5 50% Sorghum: 45% walnut: 5% ginger

Functional Properties: The results of the functional properties of the samples are shown in Table 3. The water absorption capacity (WAC) and swelling power of the sorghum-walnut and ginger blends decreased progressively as the proportion of walnut increased in the mixture sample.

Carbohydrates have also been reported to influence water absorption capacity of foods (Echendu *et al.,* 2004). The ability of protein to bind water is indicative of its water absorption capacity. The observed variation in water absorption among the flours may be due to different protein concentration, their degree of interaction with water and their conformational characteristics (McWatters *at al*., 2003). On the other hand, McWatters *at al.,* (2003) reported that lower water absorption capacity is due to less availability of polar amino acids in flours. This effect could probably due to lose association of amylose and amylopectin in the native granules of starch and weaker associative forces maintaining the granules structure (Lorenz and Collins, 1990). This result showed that the composite flours had good gelling property. Water absorption capacity is important in bulking and consistency of product as well as in baking applications (Niba *et al.,* 2001). Achi (1999) reported an increase in the water absorption of the yam: soy flour blends with increase level of soy flour substitution. The result of this study is similar to that of Achi1999. This increase is perhaps due to the water binding properties of walnut protein. High swelling capacity has been reported as part of the criteria for a good quality product (Niba et al., 2001). The bulk density of the flour samples ranged from 1.8-0.97(Table 3). Bulk density gives an indication of the relative volume of packaging material required and high bulk density is a good physical attribute when determining the mixing quality of a particulate matter Achinewhu et al., 1998. The bulk density is a reflection of the load the flour samples can carry, if allowed to rest directly on one another. The density of processed products dictate the characteristics of its container or package product density influences the amount and strength of packaging material, texture or mouth feel (Lewis,1992). According to (Basman *et al.*, 2003), higher bulk density is desirable for greater ease of dispersibility of flours. Also, high bulk density limits the caloric and nutrient intake per feed of a child which can result in growth faltering. In contrast, however, low bulk density would be an advantage in the formulation of complementary foods (Ugwu and Ukpabi, 2002). The low bulk density values recorded in this study could therefore be advantageous in the preparation of weaning food formulas. Since SWG_5 had the least bulk density it could be the most suitable for production of complementary foods. According to (McWatters *et al*., 2003), protein has both hydrophilic and hydrophobic properties, and so can interact with water in foods.

Table 3. Functional Properties of sorghum, walnut and ginger blends

Sample	Swelling capacity (%)	Water Absorption capacity (g/g)	Reconstitution index (%)	Water Soluble index (%)	Bulk density (g/cm^3)
SWAG1	2.55	1.20			0.68
SWAG2	67.54±0.07	0.99±0.001	64.54±0.07	2.75±0.01	1.74±0.00
SWAG3	57.65±0.25	0.88±0.002	57.65±0.25	2.22±0.08	1.65±0.003
SWAG4	30.55±0.15	0.88±0.001	40.55±0.15	1.83±0.03	1.82±0.002
SWAG5	25.75±0.15	0.67±0.002	20.75±0.15	1.74±0.00	1.791±0.002

SWG1 100% Sorghum
SWG2 80% Sorghum: 15% walnut: 5% ginger
SWG3 70% Sorghum: 25% walnut: 5% ginger
SWG4 60% Sorghum: 35% walnut: 5% ginger
SWG5 50% Sorghum: 45% walnut: 5% ginger

Anti-nutritional factor: The results of the antinutritional content the porridges produce from composite flour are shown in table 4. The tannin content level of the samples showed that the sample coded SWAG5 (50% Sorghum: 45% walnut: 5% ginger) has the highest level of (1.01±0.011mg/100g). But compared the level of tannin in the unprocessed walnut as cited by Ekop,2000 which is 2898mg/100g, this level is relatively low and may constitute little significance. Tannins are known to bind to proteins, including digestive enzymes thereby causing decrease in the protein and dry matter digestibility (Rao1994). The level of oxalate was found to vary between 0.03±0.00, 0.05±0.00, 0.10±0.00 and 0.11±0.00 for samples SWG2, SWG3, SWG4 and SWG5 respectively. The lethal dose for concentration of hydrogen cyanide in food materials is 50-60mg as reported by Burn, 1971. The value of hydrogen cyanide is the samples are 0.10±0.00, 0.13±0.00, 0.19±0.00 and 0.34±0.02 which increase in with the increase in the level of substitution with walnut. However, these values obtained were lower than the lethal dose for consumption; this indicated that the respective samples are at a safe level with regard to hydrogen cyanide level.

Table 4. Antinutritional composition of sorghum, walnut and ginger blends

Sample	Tannin (mg/100g)	Oxalate (mg/100g)	HCN (mg/100g)	Phytic Acid (mg/100g)
SWG 1	2.92±0.002	2.20±0.02	5.25±0.02	4.11±0.02
SWG2	0.15±0.002	0.03±0.00	0.02±0.00	0.10±0.00
SWG3	0.17±0.001	0.05±0.00	0.05±0.00	0.13±0.00
SWG4	0.70±0.005	0.10±0.00	0.08±0.05	0.19±0.00
SWG5	1.01±0.011	0.11±0.00	0.08±0.00	0.34±0.02

SWG1 100% Sorghum
SWG2 80% Sorghum: 15% walnut: 5% ginger
SWG3 70% Sorghum: 25% walnut: 5% ginger
SWG4 60% Sorghum: 35% walnut: 5% ginger
SWG5 50% Sorghum: 45% walnut: 5% ginger

Sensory evaluation: Table 5 presents the sensory scores associated with porridges made from the composite flours and the control. The mean sensory scores of the control porridge and those of the composite flour differed significantly (≤0.05) in appearance, taste, flavour, texture and general acceptability. The appearance of the porridges from sample blends was moderately disliked by mothers. However, the control was liked moderately. Colour is an important sensory attribute of any food because of its influence on acceptability. It also shows the suitable raw material used for the preparation, provides information about the formation and quality of the product. The taste, flavours, texture and general acceptability all ranged between dislike slightly and dislike moderately. However, the porridges from all the blends differed significantly (≤0.05) with the control. Sample blend SWG 3(70:25:5) was most generally accepted among the samples. The variation in the proportion of the walnut have resulted in the difference (>0.05) in taste. The control had more acceptability in all the sensory attributes studied. This could be because the familiarity in taste, flavour and colour. This will provide the required protein and energy level will provide basic nutrient for the day's work and eventually ameliorate the problem of malnutrition (Bilsborough, 2006).

Table 5. Mean sensory scores of complementary foods from sorghum, walnut and ginger blends

Parameter	SWG1	SWG2	SWG3	SWG4	SWG5
Colour	2.6a	2.5^a	2.3^a	2.4^a	2.3^a
Texture	3.5^a	3.2^b	3.2^b	3.0^c	3.0^c
Aroma	2.4^a	2.8^a	2.5^a	2.6^a	3.1^a
Taste	3.7^a	3.6^b	3.5^b	3.5^b	3.4^b
Acceptability	3.6^a	3.4^b	3.4^b	3.3^a	3.3^b

Mean with different letters are statistically different ($p \leq 0.05$) according to Duncan's Multiple Range Test.
SWG1 100% Sorghum
SWG2 80% Sorghum: 15% walnut: 5% ginger
SWG3 70% Sorghum: 25% walnut: 5% ginger
SWG4 60% Sorghum: 35% walnut: 5% ginger
SWG5 50% Sorghum: 45% walnut: 5% ginger

Conclusion

The results obtained showed that a blend of fermented sorghum flour, walnut and ginger flour is nutritionally and organoleptically acceptable. Fermented sorghum porridge is an important staple food items for people of the West African sub-region and are also important weaning foods for infants and convalescents due to its high calorie and some other mineral elements. It is high in essential fatty acids, protein and other essential macro and micro minerals, which walnut and ginger have in high value. Therefore a blend of them provide material for maintenance of the body cells and tissue and also aid in promoting good health by preventing certain diseases.

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