Journal of Agriculture, Environmental Resources and Management
www.saerem.com
ISSN2245-1800(paper) ISSN 2245-2943(online)
6(6)1-800:**December.**.2024; pp50-55

Evaluation of Nutritional Properties of Complementary Food Produced From Selected Spices, Bambara Nut and Maize Blends

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Abstract

This study was carried out to investigate the nutritional composition and sensory qualities of complementary food produced from blends of Maize, Bambara groundnut and selected spices. Flours were produced from maize, Bambara groundnut, ginger and turmeric using traditional methods. The complementary food blends were formulated by mixing maize flour, Bambara nut flour, ginger powder and turmeric powder in the ratios of 100:0:0:0, 85:10:5:0, 70:20:10:0, 85:10:0:5 and 70:20:0:10 to obtain samples AAA, BBB, CCC, DDD and EEE respectively. These blends were evaluated for their nutritive value using standard methods. Sensory evaluation was also carried out to assess the acceptability of the blends. Results obtained showed that some significant difference (p<0.05) existed in their quality parameters. The proximate analysis showed that the samples contained 15.02 – 20.27% moisture, 4.53-6.82% ash, 7.23 – 7.68% protein, 3.15 – 3.58% fat, 0.11 – 9.76% crude fiber and 55.50 – 60.21% carbohydrates. The overall acceptability results showed that sample AAA (7.50) was the most preferred after the control sample (7.88) in the attributes assessed closely followed by samples BBB (7.08) while sample EEE (5.82) was the least accepted. It was therefore concluded that Bambara nut, ginger and turmeric could be potential cheap sources of alternative supplements to whole maize flour in the production of complementary foods. The findings of this study when implemented could alternatively replace most commercial complementary food products, and as such play a key role in the diets of infants in Nigeria and in the world at large.

Keywords: *complementary food, bambara nut, maize, spices.*

Introduction: Complementary foods are any nutrient containing foods or liquids other than breast milk given to young children during the period of complementary feeding (6–24 months) (Folorunso, Ayetigbo and Afolabi, 2018). According to Ujioghene, Izuwa and Akenzua, (2021), complementary food are also known as infant foods and are mostly produced from plant products which includes cereals (such as wheat, maize and rice), roots and tubers (such as cassava, yam and potatoes), legumes (such as soybeans, cowpeas, bambara groundnuts) and several others. Ojinnaka, Ebinyasi, Ihemeje and Okorie, (2013) stated that complementary foods are generally introduced between the ages of six months to three years old as breastfeeding is discontinued. Complementary food can be made by using one or a combination of more than one plant product. It comes in different forms (such as porridge and pap) depending on the location, culture and the staple foods that are available (Bolarinwa, Olajide, Oke and Olaniyan, 2016). In Africa, complementary food comes in the form of fermented grains or roots, cooked and mashed into a fine porridge while in Nigerian, the main weaning diet is a cereal pap made from maize, millet, sorghum. Their mode of preparations has not been optimized to provide the required nutrients. Hence, consumption of these starchy gruels which are inadequate in protein, energy, essential amino acids, and micronutrients has been the major cause of nutrient-related illnesses, weak immunological response, and retarded body growth in infants (James, Akosu, Maina, Baba, Nwokocha, Amuga, Audu, Yemmy and Omeiza, 2018). However, nutritionists and food scientists at individual and organizational levels have been working toward the provision of nutritious, cheap, and readily available dietary supplements for young children in the developing world. Ingredients used for such formulations are derived from dietary staples available and affordable in the region of interest.

Maize (*Zea mays*) is a staple food for about 50% of the sub-saharan African population (Olaniyan, 2015). It is the most widely grown cereal in the world and ranks third among major cereal crops after wheat and rice (Farnia, Mansouri, Farnia and Branch, 2014). It is predominantly composed of starch (60 - 75%), and is an excellent source of vitamins (including fat soluble vitamin E) and minerals. However the protein content of maize is very low constituting only about 9 - 12% when compared with other grains (Otunola, Sunny-Roberts, Adejuyitan and Famakinwa, 2012).

Maize grain can be consumed fresh by boiling or roasting. It may also be traditionally processed by wet or dry milling into a variety of food products such as pap, solid gel, mashed maize, kokoro, popcorn etc. (Olanipekun, Olapede, Suleiman and Ojo, 2015). Among these products from maize, pap is the one of the most popular because of its use as a complementary food. But just as with other mainly maize-based food products, prolonged consumption of this food is associated with protein deficient nutritional status like protein-energy malnutrition (PEM) and kwashiorkor in children (Arise, Akintayo, Dauda and Adeleke, 2019). Fortification of pap with a cheap protein-rich food material like bambara groundnut can be a way out.

Bambara groundnut (*Vigna subterranea*) is among the legumes that are widely cultivated in Nigeria and it is underutilized. It has not been adequately exploited, as human food because of constraints like hard to cook phenomenon, strong beany flavour, presence of anti-nutrients and poor dehulling and milling characteristics (Ewuola, Ibironke and Fashakin, 2015). Arise, Amonsou and Ijabadeniyi (2015) noted that the seed makes a complete food, as it contains sufficient quantities of protein, carbohydrate and fat. Its seeds contain about 15 - 27% protein, which is high in lysine (6.5 – 6.8%) and a reasonable amount of methionine (1.8%) normally found limiting in legumes (Arise, Alashi, Nwachukwu, Malomo, Aluko and Amosou, 2017). In addition, bambara groundnut is known to contain 63% carbohydrates, 18% oil and the fatty acid content is predominantly linoleic, palmitic and linolenic acids (Ewuola *et al.,* 2015). According to Murevanhema and Jideani (2013), bambara nuts contain a number of beneficial minerals that are required in food products, such as potassium, calcium, sodium, iron and magnesium. The seeds have been reported to contain some anti-nutrients which can be reduced or removed by different processing methods (Arise *et al.,* 2019).

Recently, interest in the use of indigenous spices including ginger and turmeric in formulation of food products had grown rapidly because of the increasing consumer's awareness on functional foods. Ginger and turmeric are spices whose beneficial roles in treating serious medical conditions such as allergy, constipation, diabetic wounds, inflammation, excessive blood clothing and sinusitis in addition to treating minor illnesses such as cough, cold and runny nose have been reported (Oragwu and Maduekwe, 2021). These spices are rich in vitamins, minerals and also contain bioactive ingredients which are responsible for their acclaimed beneficial effects (Adebayo-Oyetoro, Olatidoye, Ogundipe, Akande and Isaiah, 2012; Oragwu and Maduekwe, 2021). Despite the beneficial aspects of plants as sources of local complementary foods, a few problems are often associated with their products. Some these problems include high cost of commercial products, low nutrient composition and short shelf life of the locally formulated complementary food. Thus, combination of maize, bambara nut and spices (ginger and turmeric) in formulation of complementary foods, will not only improve its nutrient composition but is also expected to extend its shelf life since ginger and turmeric have been reported to possess some antimicrobial properties (Oragwu and Maduekwe, 2021). This study therefore, seek to investigate the feasibility of producing acceptable and nutritionally improved complementary food from blends maize, bambara nut and spices. The aim of this study was to evaluate the nutritional and sensory quality of complementary food from maize, bambara nut, ginger and turmeric. The specific objectives of the study include: To produce flours from maize and bambara nut.; To produce ginger and turmeric powder.; formulate complementary foods from the blends of these flours and powders.; To determine the proximate composition and energy values of these products; To evaluate the sensory acceptability of the products.

Materials and Methods: Source of Material: Maize grains, turmeric and ginger, will be purchased from Eke Ekwuluobia market, Anambra State while bambara groundnut will be purchased from a local market in Enugu State. All the raw materials will be packaged in a clean bag and taken to the Food Processing Laboratory of Department of Food Technology, Federal Polytechnic Oko, Anambra State, Nigeria; for further processing. All chemicals to be used will be of analytical grade.

Processing of Fermented Maize: Fermented maize will be produced following the methods described in the study of Folorunso, Ayetigbo and Afolabi (2018) with slight modification. Two kilograms of yellow maize will be cleaned by hand picking to remove dirt, stones and unwanted materials. It will then be steeped in clean water for 48hrs in a plastic container with covers. The water will be decanted after 48hrs and the maize washed 3 times in water to reduce fermenting odour after which it will be wet-milled using grinding machine. The milled slurry will be sieved using muslin cloth, which separates the pomace from the filtrate. The filtrate will be allowed to settle after which the clear filtrate will be decanted while the residue will be bagged to further remove any remaining water. The residue which is the pap will be dried for 48hours in a cabinet drier at 50ºC. The dry fermented maize powder will be packaged in an airtight container prior to further use.

Maize Grains
↓
Sorting
↓
Washing
↓
Steeping
↓
Fermentation (48hrs)
↓
Washing
↓
Milling
↓
Sieving
↓
Settling
↓
Decanting
↓
Drying (50ºC, 48hrs)
↓
Fermented maize powder

Fig. 1: Flow chart for the production of fermented maize powder.

Processing of Bambara Groundnut Flour: This will be done according to the method described by Ujiroghene *et al.* (2021) with slight modification. Bambara groundnut seeds will be sorted and washed to remove stones and other extraneous materials. The bambara groundnut seeds will be steeped in tap water at 28°C for a period of 72hrs to loosen the seed coat. The kernels will be dehulled using traditional pestle and mortar. After dehulling, the grains will be washed and the hulls removed. The grains will be dried in a cabinet drier at 100°C for 10hrs and the dried kernels will be winnowed to remove the remaining lighter materials. The dehulled bambara groundnut kernels will be milled into flour using hammer mill, after which it will be sieved to obtain finer flours. The flour will be packaged in an airtight container prior to further use.

Bambara Groundnut
↓
Sorting and Cleaning
↓
Washing
↓
Soaking (28ºC, 72hrs)
↓
Dehulling
↓
Washing
↓
Drying (100ºC, 10hrs)
↓
Winnowing
↓
Milling
↓
Sieving
↓
Bambara Groundnut Flour

Fig. 2: Flow chart for the processing of bambara groundnut flour.

Processing of Ginger and Turmeric Powder

The method described by Oragwu and Maduekwe (2021) will be used in the production of ginger and turmeric powder with slight modification. The rhizomes of ginger and turmeric will be carefully washed with clean water. They will then be peeled and steamed for 10 minutes to remove the raw odour. It will later be dried in the cabinet dryer at a temperature of 65 ºC for 48hrs. The dried rhizomes will be polished to remove rough surface by handpicking before it will be finally milled into powder, sieved and packaged prior to further use.

Ginger and Turmeric
↓
Washing
↓
Peeling
↓
Slicing
↓
Drying (65ºC; 48hrs)
↓
Milling
↓
Sieving
↓
Ginger and Turmeric Powder

Fig.3: Flow chart for the production of ginger and turmeric powder.

Formulation of Complementary Food Blends: The experimental work will be conducted using different levels of blending ratios as shown in the Table 1 below to obtain complementary foods. Whole (100%) fermented maize powder will serve as the control.

Table 1: Formulation of Complementary Foods

S/N	Maize Flour	Bambaranut Flour	Ginger Powder	Turmeric powder
1.	100	0	0	0

2.	85	10	5	0
3.	70	20	10	0
6.	85	10	0	5
7.	70	20	0	10

Proximate Analysis: The proximate analysis of the complementary food samples will be carried out using the analytical methods of AOAC (2012).

Sensory Evaluation: This sensory evaluation will be performed using the method of Iwe (2002). A panel of 20 students (male and female) of Federal polytechnic Oko, Anambra State will be used for the sensory evaluation of the complementary food. The different blends of the product will be evaluated by panelists after it was reconstituted in warm water for colour, taste, texture, flavour and general acceptability. The scoring will be based on a 9 Point Hedonic Scale ranging from 1 (extremely dislike) to 9 (extremely like) and 5 (neither like nor dislike). The samples will be presented in identical containers coded with 3 digit random numbers with each sample having a different number. The samples will be presented all at once.

Statistical Analysis: All measurements will be carried out in triplicate. The data generated will be analyzed using statistical program SPSS (version 22.0) and significant difference will be compared by Analysis of Variance test (ANOVA) following Duncan's multiple range tests at the significance level of 5%.

Results and Discussion: Proximate composition of complementary food produced from maize, bambara groundnut and selected spices. The results of the proximate composition of the complementary food produced from maize, bambara groundnut and selected spices are shown in Table 2. The percentage moisture composition of the samples ranged from 15.02 – 20.27%. Sample EEE recorded the highest moisture content and is significant different ($p < 0.05$) from other samples. Statistically, no significant difference ($p>0.05$) was observed in the moisture contents of samples AAA, BBB and CCC which had values of 15.69%, 15.61% and 15.02% respectively. This is an indication that the blending ratios did not affect the moisture content of these samples. The percentage moisture obtained in this study is higher compared to 6.30 – 9.01% and 1.49 – 3.80% reported by Adebayo-Oyetoro *et al.* (2012) and Uche (2020) for complementary food produced from sorghum-walnut-ginger and maize-pigeon pea blends respectively. In a similar study, Folorunso *et al.* (2018) also reported lower moisture content ranging from 5.80 – 10.10% for complementary food formulated from maize, soybeans, ginger and turmeric. The higher moisture content observed in the present study could be attributed to the variety, agronomic or environmental condition of the raw materials utilized in this study. Differences in the processing and drying methods adopted may also have contributed to the varied results. The moisture content recorded in all samples were above the acceptable limits 10% for moisture in weaning foods as reported in the study of Adebayo-Oyetoro *et al.* (2012). Low moisture content is desirable for extending the shelf-life of food products, while high moisture contents in food products encourages microbial growth and subsequent spoilage. Thus, the high moisture content observed in the present study is undesirable as it may lead to early spoilage of the complementary food.

Table 2: Proximate composition (%) of complementary food produced from maize, bambara groundnut and selected spices.

Sample	Moisture	Ash	Protein	Fat	Fibre	CHO
AAA	$15.69^{c}\pm0.3$	$6.53^{bc}\pm0.0$	$7.27^{bc}\pm0.3$	$3.48^{b}\pm0.0$	$8.39^{b}\pm0.1$	$58.64^{b}\pm0.20$
BBB	$15.61^{c}\pm0.5$	$6.58^{ab}\pm0.0$	$7.24^{bc}\pm0.1$	$3.68^{a}\pm0.1$	$9.76^{a}\pm0.2$	$56.59^{c}\pm0.47$
CCC	$15.02^{c}\pm0.0$	$6.30^{c}\pm0.26$	$7.68^{a}\pm0.03$	$3.27^{c}\pm0.1$	$7.53^{d}\pm0.2$	$60.21^{a}\pm0.40$
DDD	$19.36^{b}\pm0.4$	$6.82^{a}\pm0.18$	$7.47^{ab}\pm0.0$	$3.15^{c}\pm0.1$	$7.69^{d}\pm0.1$	$55.50^{d}\pm0.71$
EEE	$20.27^{a}\pm0.6$	$4.53^{d}\pm0.06$	$7.23^{c}\pm0.06$	$3.58^{a}\pm0.2$	$8.06^{c}\pm0.1$	$56.33^{cd}\pm0.51$

*Values are means ± standard deviation. Means with the same superscript in the same column are not significantly different ($p<0.05$). **Keys: AAA =** 100:0:0:0 Maize-Bambara groundnut-Ginger-Turmeric; **BBB =** 85:10:5:0 Maize-Bambara groundnut-Ginger-Turmeric; **CCC =** 70:20:10:0 Maize-Bambara groundnut-Ginger-Turmeric; **DDD =** 85:10:0:5 Maize-Bambara groundnut-Ginger-Turmeric; **EEE =** 70:20:0:10 Maize-Bambara groundnut-Ginger-Turmeric

The results of the ash content also showed that there were some significant differences ($p < 0.05$) among all samples. Sample DDD recorded the highest value of ash content (6.82%) while EEE was lowest with a value of 4.53%. This is not in agreement with the ranged of values (0.23 – 0.57% and 1.06 – 1.36%) reported by Ojinnaka *et al.* (2013) for soybean-cocoyam complementary food and Bintu *et al.* (2016) for maize-cowpea-bambara groundnut weaning food respectively. The varied results may be attributed to the differences in the composition of raw materials used. The ash content is an indication of the amount of minerals in a food sample. It is the inorganic residue remaining after the removal of water and organic matter by heating in the presence of oxidizing agent (Folorunso *et al.*, 2018). Evidence has shown that addition of food ingredients brings about an improvement of the nutritive value of food (Wokeh *et al.*, 2017). The high ash content of sample DDD suggests that it will provide more minerals in the complementary food than the other samples. Consequently, an individual feeding on a food with high ash content would not be mineral deficient.

The protein content of the formulated complementary foods ranged from 7.23% to 7.68% with sample EEE having the least value while sample CCC had the highest value. Some significant differences ($p<0.05$) existed among the samples. There were little observable effects of inclusion of both bambara groundnut and the selected spices on the protein content of the complementary food. This observation is contrary to the findings of Awolu and Olokunsusi (2017) as well as the findings of Ujiroghene *et al.* (2021) who noted that incorporation of bambara groundnut flour in complementary food drastically improved the protein content of the products with their respective values ranging from 33.73 – 40.83% and 19.90 – 32.13%. Bambara groundnut being a leguminous seed rich in protein (15 - 27%) (Arise *et al.,* 2017); is expected to improve the protein content of the product, however, the reason for the low protein content obtained in study could not be explain but may probably be due to experimental error as well as influence of processing methods used. Considering this, the result for protein obtained in the present study still fell within this range; indicating that it will be fit to be used as weaning food. The capacity of dietary protein to support maintenance and growth of body tissues is dependent on the quantity and proportion of essential amino acids contained in the protein hence when vegetable source proteins regarded as incomplete proteins as in cereals and legumes are mixed, protein complementation improves the biological value of such foods (Adenuga, 2010).

The fat content of the formulated complementary food ranged from 3.15 – 3.68% with sample BBB having the highest value (3.68%) while sample DDD had the least value (3.15%). The results in Table 4.1 showed that no significant difference ($p>0.05$) existed between samples CCC (3.27%) and DDD (3.15%) as well as sample BBB (3.68%) and EEE (3.58%) but the significantly differed ($p<0.05$) from that of sample AAA (3.48%). The fat contents obtained in this study are similar to 3.66% reported by Bintu *et al.* (2016) for white maize-cowpea-bambara groundnut weaning food; higher than 1.22 – 1.93% reported by Ojinnaka *et al.* (2013) for soybean-cocoyam complementary food and lower than 5.91 – 8.25% reported by Uche (2020) for maize-pigeon pea complementary food. The variations in these results could be due to differences in the composition of raw materials used. Ujiroghene *et al.* (2021) stated that fat contributes to energy value of food as well as provide essential fatty acid for efficient neurological, immunological and functional developments in infants. However, high levels of fat in food products could lead to rancidity in foods and development of unpleasant compounds (Folorunso *et al.*, 2018). The low fat content obtained in this study is advantageous because it will contribute to shelf stability of the product.

Fibre is an indigestible component of plant material, known to be important for the improvement of roughage as well as the contribution of healthy condition of the intestine. The fibre content of the products ranged from 7.53% in sample CCC to 9.76% in sample BBB. There was significant difference ($p<0.05$) in the crude fibre composition of the samples except for samples CCC and DDD which were statistically the same ($p>0.05$). These values are higher than 0.26 – 0.81% reported for maize, bambara groundnut and cowpea complementary food (Ewuola *et al.*, 2015). Variation in the raw materials used could be the reason for contradicting results obtained. According to the report of Ujiroghene *et al.* (2021), fibre content of infant cereals should be at a range of 0.3% to 2.5%. Overall, the result of this study showed that the fibre content of the samples exceeded the required quantity for infants. In as much as dietary fibre helps to regulate bowel movement, softens faeces and increase faecal bulk hence preventing constipation, when in excess, it may decrease appetite in infants and young children (Abeshu, 2016).

There was significant difference ($p<0.05$) in the carbohydrate content of the products. Carbohydrate content of the complementary foods ranged from 55.50% to 60.21%. Sample DDD had the lowest carbohydrate content (55.50%) while the CCC had the highest value (60.21%). There was no definite trend for the percentage carbohydrate obtained in this study as the level of substitution of maize flour with bambara groundnut, ginger and turmeric increased. This is not in line with the reports of Folorunso *et al.* (2018) who observed that the carbohydrate content of maize complementary food decreased from 77.30 – 41.71% as the level of inclusion of soybean powder increased. The relatively high carbohydrate content of the formulated complementary foods indicates that the food will provide infants with the required calorie.

Sensory qualities of complementary food produced from maize, bambara groundnut and selected spices.

The sensory properties of the complementary foods produced from maize, bambara groundnut and selected spices are presented in Table 3. The mean score for the colour of the formulated complementary foods ranged from 5.65 – 8.50 with the control sample (AAA) having the highest score while the sample containing 70% maize, 20% bambara groundnut and 10% turmeric powder (EEE) had the least value. Although some significant differences ($p<0.05$) existed amongst the samples, the acceptability of the colour of the complementary food decreased with the increasing substitution of maize powder with bambara groundnut, ginger and turmeric. The panelists however, rated the colour of the samples containing both 5% and 10% turmeric powder lower probably because of their bright yellow colour as they were all familiar with the creamy colour associated with complementary food produced from maize grains. This is contrary to the observation of Folorunso *et al.* (2018) who reported that the panelist preferred complementary food containing turmeric powder when compared to other samples. This variation may be attributed to the different perceptions of the panelists.

Flavour is an integral part of taste and general acceptance of drinks before it is put in the mouth. It is therefore an important parameter when testing acceptability of complementary foods blends (Folorunso *et al.*, 2018). Results of sensory evaluation indicated that the flavour of the formulations slightly varied significantly ($p<0.05$) from each other. Their mean scores ranged from 5.20 in sample EEE to 7.85 in the control sample (AAA). As observed for colour of the products, the flavour the turmeric spiced complementary foods were the least accepted. The sensations of taste and smell are functions of flavor which is a complex of sensations. It is the flavor of a food that ultimately determines its acceptance or rejection, even though its appearance evokes the initial response (Iwe, 2007).

Table 3: Sensory qualities of complementary food produced from maize, bambara groundnut and selected spices.

Samples	Colour	Flavour	Mouthfeel	Taste	Overall Acceptability
AAA	$8.50^a±0.76$	$7.85^a±0.81$	$8.35^a±0.59$	$7.90^a±0.79$	$8.15^a±0.38$
BBB	$8.10^a±0.79$	$7.50^{ab}±1.1$	$7.10^b±1.07$	$6.65^b±1.09$	$7.34^b±0.66$
CCC	$7.35^b±1.04$	$6.95^b±1.19$	$7.50^b±0.95$	$7.10^b±0.97$	$7.23^b±0.69$
DDD	$6.85^b±1.60$	$6.80^b±1.11$	$7.15^b±0.93$	$6.70^b±1.21$	$6.81^b±0.97$
EEE	$5.65^c±1.50$	$5.20^c±0.74$	$5.40^c±1.90$	$4.50^c±1.70$	$5.16^c±0.62$

*Values are means ± standard deviation. Means with the same superscript in the same column are not significantly different ($p<0.05$). **Keys: AAA =** 100:0:0:0 Maize-Bambara groundnut-Ginger-Turmeric; **BBB =** 85:10:5:0 Maize-Bambara groundnut-Ginger-Turmeric; **CCC =** 70:20:10:0 Maize-Bambara groundnut-Ginger-Turmeric; **DDD =** 85:10:0:5 Maize-Bambara groundnut-Ginger-Turmeric; **EEE =** 70:20:0:10 Maize-Bambara groundnut-Ginger-Turmeric

The mouth feel is very important in a complementary food as it will determine the amount of food an infant would consume since they can only swallow a smooth gruel not a coarse one (Ojinnaka *et al.*, 2013). The mouthfeel of sample AAA (control) was the most accepted with a score of 8.35 and it differed significantly ($p<0.05$) from the rest of the samples. However, no significant difference ($p>0.05$) was observed in the mouthfeel of samples BBB (7.10), CCC (7.50) and DDD (7.15). Their mean scores were significantly higher than that of sample EEE (5.40) which is the least accepted. The panelist noted that all the samples containing either ginger or turmeric powder gave peppery mouthfeel after they were consumed which is a characteristic feature of both ginger and turmeric. This observation is not in line with the reports of Ojinnaka *et al.* (2013) who noted that incorporation of ginger in soy-cocoyam based complementary food did not significantly affect the mouthfeel.

The mean scores for the taste of the formulated complementary food ranged from 4.50 in sample EEE to 7.90 in sample AAA (control). The score for sample AAA (7.90) significantly differed ($p<0.05$) from the rest of the samples. The results in Table 4.2 showed that inclusion of up to 10% turmeric powder in 70:20 maize-bambara groundnut complementary food significantly decreased its acceptability in terms of taste. The overall acceptability scores of the samples in their ascending order are 5.16, 6.81, 7.23, 7.34 and 8.15 for samples EEE, DDD, CCC, BBB and AAA respectively. There was no significant difference ($p>0.05$) in the overall acceptability scores of samples BBB, CCC and DDD but they are significantly ($p<0.05$) higher than that of sample EEE and lower than that of sample AAA (control). This indicates that inclusion of bambara groundnut, ginger and turmeric at up to 20%, 10% and 5% levels respectively did not adversely affect the acceptability of the formulated complementary food.

Conclusion: The study has also shown that nutrient dense complementary food can be produced from blends of maize, bambara groundnut, ginger and turmeric. The results of this study showed that the formulated products are rich source of ash, protein, crude fibre and carbohydrate that nutritionally can improve the nutritional requirements of a child if used as a complementary food. It can therefore be concluded that bambara groundnut, ginger and turmeric could be potential cheap sources of alternative supplements to whole maize flour in the production of complementary foods. Consequently, their formulation could alternatively replace most commercial complementary food products, and as such play a key role in the diets of infants in Nigeria and in the world at large.

Recommendation: The study recommends incorporation of bambara groundnut, ginger and turmeric in formulation of complementary foods since they improved the nutritional properties of the product. This complementary meal is also recommended for adult consumers too.

Further investigations should be done in order to determine the effect of these raw materials on the vitamin, minerals and phytochemical constituents of the product.

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