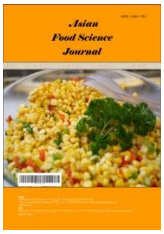

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Chemical and Functional Properties of Composite Flours Made from Fermented Yellow Maize, Bambara Groundnut, and Mango Fruit for 'Ogi' Production

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Authors' contributions

This work was carried out in collaboration among all authors. Author SJB conducted the experiment and collected the data and analyzed them. Authors JKI and AD contributed in supervision of the experiment. Author NBB contributed in paper formatting, helped to check the English, grammar and also processing process during submission to the journal. All authors read and approved the final manuscript.

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ABSTRACT

The study examined the chemical and functional properties of composite flours based on maize, Bambara groundnut, and mango for possible use as complementary food. Flours were prepared from yellow maize variety, Bambara groundnut and mango pulp and blended in the ratios 100/0/0, 90/5/5, 85/10/5, 75/20/5, 70/25/5 and 65/30/5 labelled as samples A, B, C, D, E and F respectively. Standard methods were used to evaluate the composite flours and the control for functional properties, and chemical properties. Analysis showed an increase in the moisture content, proteins (19.28% in sample A to 23.81 % in sample F), lipids, carbohydrate. Crude fibre content ranged from 2.97% in Sample F to 1.91% in Sample A. Ash content generally increased from 1,62% in sample A to 2.58% in sample F.

Phosphorus, Calcium and Potassium showed an increasing trend as follows; (154 mg/100 g in sample A to 186.86 mg/100 g in sample F), (392.67 mg/100 gin sample a to 399.94 mg/100 g in sample F), (183.56 mg/100 g in Sample A to 192.02 mg/100 g in Sample F) respectively.

Provitamin A and ascorbate showed significant increase in the composite flours than the control. All anti-nutrient compositions in the samples were within tolerable levels

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There was no significant difference in the swelling indices of the different flour blends; the highest water absorption capacities were seen in sample F (1.36 g/ml) while the lowest was seen in the control sample A (1.15 g/ml). Water absorption capacity therefore showed an increasing trend with increasing substitution of maize flour with BG flour and mango powder. Results showed that supplementing Yellow maize flour with Bambara groundnut flour and mango powder considerably improved the protein content of the flour, hence they can find useful application for ogi production.

Keywords: Yellow maize; bambara groundnut; mango powder; Ogi.

1. INTRODUCTION

Protein, energy, and micronutrient malnutrition are the commonest forms of childhood malnutrition in Nigeria [1]. The present uncertainty in the world food supply and the expected increase in food demand warrant the search for alternative sources of food which will be readily available and affordable for all and sundry by government planners and scientists. In Nigeria, just like in most other developing countries of the world, the infant complementary foods are grossly inadequate nutrient-wise [2]. The traditional complementary foods have usually been made primarily with non-supplemented cereal crops. The complementary foods are inadequately processed and are deficient in some macro and micronutrients [2]. Therefore, adequate and efficient processing as well as judicious blending of the locally available foods could result in improved intake of nutrients to prevent malnutrition. Thus, the use of a multi-mix or composite flour might help to ensure nutrition security in infants and young children.

Maize (*Zea mays*) is a major staple food in the developing world and ranks second to wheat among the world’s cereal crops in terms of production [3]. Maize protein varies in common varieties from about 8 to 11 percent of the kernel weight. Maize contains high levels of dietary fibre (12.19%) but is low in 'trace minerals and ascorbate. Legumes are rich not only in proteins, but in other nutrients such as starch and fat [4]. Bambara groundnut (BG), (*Vigna subterranea* L.) is an important source of affordable protein in the diets especially in regions where animal protein is comparatively expensive. The crop is richer in essential amino acids than other legumes and has a higher protein score (80%) than soya bean (74%) and cowpea (64%) [5]. However, like other legumes, BG lacks sulphur containing amino acids [6,7]. In some way, the blending of Bambara groundnut with a staple food, such as maize, which contains higher levels of cysteine and methionine, is and should be a recommended nutritional strategy [8]. Fruits are valuable sources of vitamins and minerals [9]. They could provide significant quantities of micronutrients when blended with maize diets. Mango (*Magnifera indica*) belong to the genius Angifera, consisting of numerous species of tropical fruiting trees in the flowering plant family, Anacardiaceae. It is cultivated and distributed widely for use as fruits, juice, flavor, color, and fragrance [10]. Mangoes are tropical fruits rich in beta-carotene and vitamin C. The values for mango pulp are 0.20 mg/100 g beta-carotene and 300 mg/100 g vitamin C on fresh weight basis [8]. Maize, Bambara groundnut, and mango are readily available foods in sub-Saharan Africa, and they have good nutritional attributes. Supplementing the traditional maize complementary food 'ogi' with Bambara groundnut and mango (Julie variety) pulp could improve the nutrient composition of the complementary food. The protein is relatively fair in the sulphur-containing amino acids, methionine, and cysteine but low in lysine and very low in tryptophan [7].The focus of this study was therefore to evaluate the quality of pap (ogi) produced from yellow maize, Bambara groundnut and Julie mango powder.

2. MATERIALS AND METHODS

Yellow maize, (*Zea mays* I.) grains, Bambara groundnut seeds (*Vigna subterranea* L.) and Mango (*Magnifera indica* L.) pulps was used for the study. They were purchased from the Wurukum market Makurdi in Benue State of Nigeria. All reagents used were of analytical grade.

2.1 Flour Preparation

2.1.1 Preparation of dehydrated maize Ogi

Yellow maize was sorted and cleaned to remove broken grains and foreign objects. It was then steeped in deionized water in a ratio of 1:3 (w/v) (grain to water). The steeped grains were allowed to ferment in a bell jar at room temperature (27-28°C) for 48 hours. After fermentation, the water was drained. The fermented grains were wet milled in a commercial maize mill and filtered through a cheese cloth with excess water. The slurry obtained was left to sediment. The water was decanted, and the paste obtained was dried in the sun (3 days). The dried paste was milled into flour in a maize mill (model corona - 2N, England) and stored in a refrigerator at 4°C after sieving (150 µm) [11].

2.1.2 Preparation of bambara groundnut flour

Dry Bambara groundnut seeds were cleaned and sorted to remove extraneous material. The seeds were then be spread evenly on an oven tray and toasted in an electric oven at140 °C for 10 min. It was then ground to a fine powder using a hammer mill and final sieved using a 150 µm mesh sieve. It was finally be stored in a refrigerator at 4°C until used. [5],

2.1.3 Preparation of mango powder

Ripe mango fruits (2 kg) were cleaned. The mango pulps were scrapped out of the fruits using a fruit knife. The fruit pulps were cut into small slices of 5mm thickness and dried using an oven at 50°C for 36 h. All the dried samples of maize ogi, Bambara groundnuts, mango and pawpaw were separately milled in a laboratory hammer mill (Model ED-5, Thomas Willey, England to fine flours (1 mm mesh) [12].

2.2 Flour Blend Formulation

Flour blend formulation was done as shown on Table 1.

2.3 Analytical Methods

2.3.1 Functional properties

The functional properties of Bulk density, Water Absorption Capacity, Gelatinization Temperature, Foam Capacity, Swelling Index were carried out as described by previous research [13]

2.3.2 Proximate composition

The proximate analysis of the fermented maize flour and the blends were determined by the official methods of AOAC [14]. Carbohydrate was determined by difference (100 - the sum of the content of protein, fat, ash, and moisture). Energy was calculated using Attwater factor (fat x 9 + carbohydrate x 4 + protein x 4 kcal/100 g).

2.3.3 Mineral composition determination

Four macro (Ca, Na, K, Mg) and four trace minerals (Fe, Cu, Mn, and Zn) were each determined by Atomic Absorption Spectrophotometer (AAS). The optimum range for each of the elements was prepared and all the operational instruction for setting up the instrument for the analysis of specific element was strictly followed. The ash residue of each sample was digested with 5 mL of concentrated nitric acid, filtered and thereafter transferred to 100 mL volumetric flask and diluted with distilled water to 100 mL, stored at room temperature for AAS analysis [14].

2.3.4 Vitamin composition

L-Ascorbic Acid analysis (Vitamin C): Ascorbic acid was determined by titration using Standard indophenol solution [15]. Indophenol solution was prepared by dissolving 0.05 g of 2, 6-dichloro indophenol in water and diluted to 100 mL. Titration was done with the indophenol's solution till a faint pink colour persists for 15 seconds

β-carotene analysis: An extraction method used by Kaspar KL et al. [16] was adopted in this study with modification. One gram of flour blend (< 2 mm) was first dispersed with 2 mL distilled water in a 50 mL centrifuge tube and mixed thoroughly. Then, 7.5 ml acetone (0.1 % #BHT in ethanol) was added and vortexed (mini vortexer, Fisher Scientific, CA). The resulting slurry was cold saponified by adding 1.2 mL of 40% methanolic KOH solution (MeOH) and left to stand in the dark for 16 h at 4°C. A 7.5 mL solvent mixture (hexane/ethyl acetate, (1:1, v/v) was added and vortexed for 1 min, followed by adding 10 mL of 10% Na2SO4 and vortexing for 1 min. The solution was allowed to stand in the dark for 1 h until the organic layer was separated. The upper organic layer was collected and transferred to a small tube and centrifuged at 600 g for 8 min (DYNAC Centrifuge, Becton Dickenson, MD). Two mL of supernatant was dried under nitrogen (Analytical Nitrogen Evaporator, Organomation Assoc., Inc. Berlin, MA) for analysis of carotenoids by HPLC. All extraction procedures were performed under dimmed light. The dried extract was reconstituted in mobile phase (mixture of acetonitrile, methanol and chloroform, 47:47:6; v/v/v), and analyzed using HPLC. The HPLC system consisted of a Waters 2690 separation module and a Waters 996 photodiode array detector (Waters Corp, Mild, MA) was used to separate the β-carotene. The flow rate was 1 mL/min with an injection volume of 10 µl. Duplicate samples were analyzed for each treatment and the mean values were reported.

Vitamins E, B1, B3, B6, were evaluated as described by AOAC [14]. For each flour sample, 3g of were mixed with 5ml of Hexane and 200ml of HPLC grade water. The mixture was homogenized (12000 rpm), centrifuged (3500 x g) for 30 minutes followed by sequential filtration through Whatman filter paper and 0.45 micrometer membrane. Then 15 µl of supernatant was into the HPLC equipped with a UV detector set at 254 nm. The peaks of the vitamins in the samples were calculated in relation to peaks of standard vitamins.

2.3.5 Determination of antinutrients

Alkaloids and saponins were quantified by the gravimetric method as reported Fahal EM et al. [17,18]. For phytate determination, 0.2g of the sample was weighed into 250mL conical flask. It was soaked in 100 mL of 20% concentrated HCl for 3 h. The sample was then filtered. 50 mL of the filtrate was placed in a 250mL beaker and 100mL distilled water added to the sample. Then 10mL of 0.3% ammonium thiocyanate solution was added as indicator and titrated with standard iron (III) chloride solution which contained 0.00195 g iron per 1 ml [19]. Oxalate was determined as described [20]. 2.5 g of the sample was extracted with dilute HCl, 5 ml of concentrated ammonia and precipitated with $CaCl_2$ as calcium oxalate. The precipitate was washed with 20 mL of 25% H2SO4 and dissolved in hot water before titrating with 0.05 N KMnO4 to determine the concentration of oxalate. Tannins were determined using the Burn method [20]. 5 g of the dried sample was treated with 50 mL methanol and kept for 24 hours before filtration. 5 mL of freshly prepared vanalin hydrochloric acid was added and the solution was allowed to stand for 20 min for color development. The absorbance was measured at 550 nm using spectronic 20 and the machine value was used in calculating the tannin content.

2.4 Preparation of Porridges

The method described by Akpapunam et al. [21] was used Porridges were prepared from both the composite flours and the flours from the maize traditional complementary food - "Ogi". One hundred grams of each flour was mixed with 550 ml of deionized water. The slurry was heated in a thermostatically controlled water bath (Thermostirrer 95, Gallenkamp, England) set at 75^0C for 15 min. Two grams of granulated sugar was added to the porridge. The porridges were kept separately in thermos flasks to maintain the serving temperature of 40°C.

2.5 Sensory Evaluation

The sensory evaluation will be performed as described by Iwe MO et al. [22]. A 20-member panel of mothers who regularly use commercial weaning foods was randomly selected to perform the organoleptic test. The evaluation was based on a 9-point hedonic scale quality with 9 representing “liked extremely” and 1 representing “disliked extremely”. The panelists consisted of 20 mothers who regularly use commercial weaning foods. The porridges were presented to each of the panelist in a Thermos flask (20 mL of sample), coded as in the hedonic scale. Each panelist evaluated the porridges for, colour, taste, texture, and general acceptability.

Table 1. Flour blends formulation for complementary food from yellow maize, Bambara groundnut and mango flours

Flour sample	Yellow maize ogi (%)	Bambara groundnut flour (%)	Mango flour (%)
A	100	0	0
B	90	5	5
C	85	10	5
D	75	20	5
E	70	25	5
F	65	30	5

Table 2. Functional properties of flour blends

Sample	Swelling index	Bulk density (g/L)	Water absorption capacity (g/mL)	Foaming capacity (g/mL)	Gelatinization temperature (°C)
A	1.07± 0.00	0.54[a] ± 0.01	1.15[a]± 0.01	15.00[b]± 0.02	72.05[b] ± 0.00
B	1.00± 0.00	1.75[c]± 0.00	1.20[ab]± 0.00	10.00[a] ± 0.01	70.50[a] ± 0.50
C	1.04 ± 0.01	0.58[b] ± 0.01	1.20[ab] ±0.00	10.00[a] ± 0.01	70.00[a] ± 0.00
D	1.04 ±0.00	1.75[c] ± 0.00	1.20[ab] ± 0.00	10.00[a] ± 0.02	70.00[a] ± 0.00
E	1.03 ± 0.01	1.75[c] ± 0.00	1.05[a] ± 0.00	10.00[a] ± 0.01	70.00[a] ± 0.00
F	0.07 ± 0.01	0.54[a] ± 0.00	1.36[b] ± 0.01	10.00[a] ± 0.00	70.00[a] ± 0.00
LSD		0	0.18	0	0.73

Values are mean±SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least significant difference

2.6 Statistical Analysis

All analyses were done in triplicates and results were expressed as mean ± standard deviation (SD). The data obtained from the various experiments were recorded during the study and were subjected to Analysis of Variance (ANOVA). The significant difference between the means was tested against the critical difference at 5 % level of significance. Separation of means was carried out using Fischer's LSD test.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Flour Blends

The results for the functional properties of the flour blends are shown in Table 2. There was no significant difference in the swelling indices of the different flour blends. These findings were contrary to those observed by Okafor M et al. [23], who showed that swelling index increased with increasing substitution of wheat flour. The difference observed may be due to processing methods adopted. The ability of food materials to absorb fluid and expand its molecular size is referred to as swelling index. The swelling capacity of a flour is the extent to which it increases in volume in relation to its initial volume when soaked in water [24]. It is a quality criterion for good formulations. Swelling power is the ability to increase in volume when foamed [25,26]. The effect of their swelling index will be reflected on the texture of food prepared from such flours. Samples B, D and E had the highest bulk densities 1.75g/L while sample A and F showed the lowest Bulk densities of 0.54 g/L. These results contradict a previous study [27] which reported that bulk density increased with increasing substitution with a high protein flour. High bulk density is important and more desirable in terms of packaging and transport of food materials as it reduces the costs of these operations in the food industry [28]. The bulk density of flours is affected by the moisture contents [27] and gives an idea of the packaging needs involved. The highest water absorption capacities were seen in sample F 1.36 g/mL while the lowest was seen in the control sample A, 1.15 g/mL. Water absorption capacity therefore showed an increasing trend with increasing substitution of maize flour with BG flour and mango powder. Water absorption capacity showed an increasing trend from the control (100 % wheat flour) to the samples with higher levels of substitution. These results were different from that obtained from previous work carried out by Shittu TA et al. [29]. The water absorption capacity is an indication that a particular sample would be useful in food system for bakery product [30]. WAC is the ability of food products to incorporate water within its structural matrix and is very important functional trait in foods such as sausages, custard, and baking dough [31]. It also refers to water retained by a food product following filtration and application of mild pressure of centrifugation [32]. WAC of flour or powder is a function of the number and nature of the hydrophilic constituents and to some extent, on pH and nature of the proteins. Foaming capacity on the other hand was greatly reduced with substitution as the value dropped sharply from 15.00g/mL in sample A to10.oog/mL in the rest of the substituted flour samples. The foam stability refers to the ability of protein to stabilize against the gravitational and mechanical stresses [31]. The decrease in foam capacity could be due to the reduction in carbohydrate content with increasing substitution. A similar drop was observed in gelatinization temperature from 72.05°C in sample A to 70°C in the rest of the substituted samples. The temperature at which gelatinization of starch takes place is known as the gelatinization temperature [28]. Gelatinization temperature is influenced by the amount of loose starch granules available in the sample.

A is 100 % Maize, B is 90 % maize, 5% BG 5% mango powder, C is 85 % maize, 10 % BG, 5 % mango powder, D is 75 % maize, 20 % BG, 5 % mango powder, E is 70 % maize, 25 % BG, 5 % mango powder, F is 65 % maize, 30 % BG, 5 % mango powder

3.2 Proximate Composition of Flour Blends

The results for proximate composition are shown in Table 3. The significance of determining the moisture content of food products helps a lot to know about the food product's characteristics, including its physical appearance, texture, taste and weight, in addition to the food product's shelf-life/stability, freshness and resistance to bacterial contamination [33,34]. Moisture content in dried foods should be ≤12% for prolong shelf-life and storage stability [34]. The highest moisture content was registered in sample B7.95% whereas the lowest moisture content was registered in sample D 7.01%.Proetein content of the flour samples increased consistently from 19.28% in sample A to 23.81% in sample F. Protein is very essential for body building and repair of worn out body tissues, in addition, its presence in peppered food product will help reduce the problem of protein-energy malnutrition for all ages in a population suffering this challenge [35]. These results agree with those found in previous studies carried out by Ocheme OB et al. [36]. This could largely be because of the addition of protein rich Bambara Groundnut. On the other hand, fat content decreased from 14.12% in sample A to 13,16% in sample F. Fat is essential component of tissues and a veritable source for fat soluble vitamins (A, D, E and K). It can supply thrice the amount of energy required by the body [37]. Dietary fibre intake has been reported to be associated with many health benefits. Consumers with high intakes of dietary fibre have significantly lower risk for developing coronary heart disease, stroke, hypertension, diabetes, obesity, and gastrointestinal diseases. High fibre intakes lower blood pressure, serum cholesterol levels, improves glycaemia and insulin sensitivity in non-diabetic and diabetic individuals. Fibre significantly enhances weight loss and ameliorates gastrointestinal disorders including gastroesophageal reflux disease, duodenal ulcer, diverticulitis, constipation, and haemorrhoids as well as the enhancement of immune function [38]. Fibre in diet cause fat reduction and maintain proper peristaltic movement of the intestinal tract to prevent constipation [39]. The lowest value for crude fibre was registered in sample A 1.91%. Sample F showed the highest crude fibre content 2.97%. Ash content showed an increasing trend from 1,62% in sample A to 2.58% in sample F. Ash content gives an indication of the mineral contents of a food sample [40]. Carbohydrates provide the major source of the most easily available energy in the diet. The Institute of Medicine recommends that we should consume between 45–65% of total calories which should come from carbohydrates [41]. Carbohydrate content decreased steadily from 55.91%in sample a to 50.25% in sample F. Most of the energy in a diet comes from carbohydrates. Total calorific value or energy value also decreased from 428.82 Kcal/100 g in sample a to 414.62 Kcal/100 g in sample F. The high caloric value of the blends is noteworthy (416.62 to 428.82 Kcal/100 g). It is an indication that the Ogi produced from the blends would be a good source of energy.

3.3 Vitamin Contents of Flour Blends

The results for vitamin contents are shown in Table 4. Vitamins are organic molecules that are essential micronutrients that the body needs in small quantities for the proper functioning of its metabolism. Vitamins are defined as relatively low-molecular- weight compounds that humans, and for that matter, any living organisms that depend on organic matter as a source of nutrients, require in small quantities for normal metabolism. With few exceptions, humans cannot synthesize most vitamins and need to obtain them from food and supplements. Insufficient levels of vitamins result in deficiency diseases, for example, scurvy and pellagra, which are due to the lack of ascorbic acid and niacin, respectively. Essential nutrients cannot be synthesized in the body and therefore must be obtained through diet. Pro-vitamin A (beta carotene) values increased significantly from1.35 ug/100g in sample A and the highest value was registered in sample E 3.88 ug/100g. This is supported by an early study by Ibidapo OP et al. [42]. The beta carotene content in mango powder will significantly add to the composition of carotene in the Yellow Maize Bambara Groundnut and mango flour blend. This makes the product a good source of vitamin A, as it is a vitamin A precursor. Ibidapo OP et al. [42] also support this claim. Vitamin B1 (Thymine) content increased from0.85 mg/100g in sample A to 0.91 mg/100g in sample D. The WHO safe level recommendation of thiamine is 0.3 – 0.7 mg/day [43]. This indicates that the samples could meet the nutrient intake recommendation for children from 4 months to 6 years of age. The highest value for vitamin E was registered in sample E 0.91 mg/100 g. Vitamin E is an antioxidant that helps scavenge free radicals that could cause cancer.

Vitamin B6 (Pyridoxine) content was lowest in sample A 0.22 mg/100 g and highest in sample E 0.32 mg/100 g. This indicates that the pyridoxine content of the flour blends increased with increasing substitution. Lack of this vitamin B6 leads to Dandruff-like eruptions, pink eye, and Epilepsy [44]. Vitamin C ascorbic acid increased from 4.38 in sample a to 4.93 in sample F. Vitamin C is good for the prevention of scurvy and it also acts as an antioxidant ridding the boy of harmful free radicals [45].

3.4 Mineral Contents of Flour Blends

The results for mineral contents are shown in Table 5. Minerals are a group of essential nutrients which serve a variety of important metabolic functions and are parts of molecules such as haemoglobin, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA) [46]. Calcium plays significant roles in blood clothing, bone and teeth development and muscle contraction in humans [47]. There was no significant difference in Calcium content and Iron content of the flour samples. Iron is an important component of haemoglobin which is an oxygen–carrying pigment in the blood [48]. Magnesium content reduced from 269.36mg/100g in sample A to266.43 mg/100 g in sample F. This result is supported by [48]. Phosphorus content on the other hand increased from 154 mg/100 g in sample a to 186.86mg/100g in sample F. Potassium content also showed an increasing trend from 392.67 mg/100 g in sample a to 399.94 mg/100 g in sample F. Potassium is very essential in blood clothing and muscle contraction [40]. These findings are in line with those of [40]. Sodium content increased significantly from 2.39mg/100g to 6,59mg/100g in sample F. however, all the samples are below the upper level of sodium intake for children as the acceptable range for sodium recommended intake in United Kingdom is 210–700 mg/day for children between the age of 0 month to 6 years [43].

3.5 Antinutritional Factors of the Flour Blends

Results of antinutrients are found on Table 6. Anti-nutrients are natural or synthetic compounds that interfere with the absorption of nutrients [49] in the body. They could both be harmful and helpful to the body. Generally, all anti-nutrient compositions in the samples are within tolerable levels. Sample D had the highest alkaloid levels 4.76% while sample E had the lowest value 1.99%. Alkaloids are a class of naturally occurring organic compounds that mostly contain basic nitrogen atoms [50]. This group of compounds includes related compounds with neutral and even weakly acidic properties. Some synthetic compounds of similar structure also belong to the class of alkaloid. Alkaloid is seen as bye-products of plant metabolism, and they also act as protein reservoirs [51]. Alkaloids play important role in defence systems against pathogens and animals. Saponin content reduced from 14.60 % in the control sample to 11.00% in the most substituted sample. Saponins are naturally occurring plant glycosides that are generally found in plant. They possess soap-like qualities and produce lather when mixed with water. Occurring in a wide variety of herbs, spices vegetables and fruits, saponins are chemical compounds with significant functions. Studies have shown that saponin has several health benefits, including its ability to reduce cholesterol levels, inhibiting diseases causing bacteria; hence saponin is classified as a phytochemical [52]. Saponin is not toxic to humans but lethal to fish and other cold-blooded animals and have been used to kill snails that harbour bilharzia parasite [53]. Saponins can be bitter in taste and throat-irritating activity but, they contain some properties that are said to have the capacity to reduce heart diseases in humans. There have been reports that the presence of tannins in high proportion can cause browning or other pigmentation problems in both fresh food and processed products and that it can provoke an astringent reaction in the mouth and make the food unpalatable [13]. Tannins reduced from 17% in the control sample and sample B registered the lowest tannin content value 15.00%. Oxalates are naturally occurring substance found in plants and in humans. Study had shown that oxalates in large amounts bind with calcium forming calcium oxalate, which is insoluble and not absorbed by the body [54]. Oxalates are considered poisonous at high concentration, but harmless when present in small amounts [55]. Highest oxalate contents were found in sample B and F 0.11% while the lowest value 0.05% was in sample D. There was no significant difference in the phytate contents of the flour samples.

Table 3. Proximate composition of flour blends

Sample	Moisture content (%)	Protein content (%)	Fat content (%)	Crude fibre (%)	Ash content (%)	Carbohydrates (%)	Total calorific value (Kcal)
A	7.16[b] ± 0.01	19.28[a] ± 0.15	14.12[a] ± 0.01	1.91[a] ± 0.01	1.62[a] ± 0.01	55.91 ±0.87	428.82 ± 4.03
B	7.95[d] ± 0.02	19.88[a] ± 0.02	13.82[a] ±0.51	2.02[b] ± 0.01	1.85[b] ± 0.04	54.49[d] ±0.54	421.92[b] ± 2.57
C	7.21[c] ±0.01	21.79[b] ± 0.54	13.23[a] ± 0.04	2.12[c] ± 0.02	1.88[bc] ± 0.01	54.26[d] ±0.05	421.23[b] ± 0.28
D	7.01[a] ±0.01	22.11[b] ± 0.01	13.28[a] ± 0.15	2.51[d] ± 0.08	1.85[b] ± 0.02	53.26[c] ± 0.27	420.29[b] ± 0.37
E	7.28[c] ± 0.06	22.93[b] ± 0.06	13.90[a] ±0.01	2.68[d] ± 0.01	1.91[c] ± 0.01	51.31[b]± 0.03	422.02[b] ± 0.23
F	7.23[c] ± 0.04	23.81[bc] ± 0.09	13.16[a] ± 0.07	2.97[e] ± 0.01	2.58[d] ± 0.03	50.25[a] ± 0.02	414.62[a] 0.41
LSD	0.07	1.56	4.17	0.08	0.05	1.04	5.63

Values are mean ± SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least significant difference

Table 4. Vitamin contents of flour blends

Sample	Pro-vitamin A (b-carotene) (µg/100g	Vitamin B1(mg/100g)	Vitamin E(mg/100g)	Vitamin B6(mg/100g)	Vitamin C(mg/100g)
A	1.35[a] ± 0.03	0.85[a] ± 0.03	0.87[a] ± 0.02	0.22[a] ± 0.01	4.38[a] ± 0.01
B	1.37[a] ± 0.01	0.86[a] ± 0.02	0.88[a] ± 0.00	0.24[a]± 0.01	4.63[a] ± 0.04
C	2.97[b] ± 0.01	0.88[a] ± 0.01	0.88[a] ± 0.00	0.28[b] ± 0.02	4.87[b] ± 0.01
D	3.15[c] ± 0.02	0.91[b] ± 0.01	0.88[a] ± 0.01	0.28[b] ± 0.03	4.61[a] ± 0.01
E	3.88[d]± 0.01	0.89[a] ± 0.00	0.91[a] ± 0.01	0.32[c]± 0.01	4.76[a]± 0.27
F	3.87[d]± 0.01	0.89[a] ± 0.02	0.90[a] ± 0.01	0.31[bc] ± 0.01	4.93[b] ±0.06
LSD	0.04	0.05	0.04	0.04	0.39

Values are mean ± SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least significant difference

Table 5. Mineral contents of flour blends (mg/100g)

Sample	Calcium	Iron	Magnesium	Phosphorus	Potassium	Sodium
A	183.56[a] ± 4.60	12.09[a] ±0.47	269.36[b] ± 0.48	154.21[a] ± 0.78	392.67[a] ± 0.62	2.39[a] ± 0.06
B	186 28[a] ± 2.95	11.70[a] ±0.29	268.00[a] ±0.33	165.94[b]± 0.95	392.89[a] ± 0.94	2.94[b] ± 0.05
C	189.66[a] ±1.49	11.82[a] ± 0.16	268.55[a] ± 0.21	166.44[b]± 0.11	397.78[b] ± 1.45	3.93[c] ± 0.05
D	191.66[a] ± 0.01	12.09[a] ± 0.04	268.47[a]± 0.58	175.52[c]± 3.59	399.55[c] ± 0.44	4.71[d] ± 0.02
E	191.91[a] ± 0.03	12.16[a] ± 0.60	267.48[a]± 0.03	180.99[d] ± 1.01	399.93[c] ± 0.05	5.73[e] ± 0.07
F	192.02[a] ± 0.03	12.83[a] ± 0.06	266.43[a]± 0.35	186.86[e]± 1.86	399.94[c] ± 0.05	6.59[f] ± 0.19
LSD	9.55	3.00	2.82	4.22	1.69	0.21

Values are mean ± SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least significant difference

Table 6. Antinutrient composition of Flour blends (%)

Sample	Alkaloids	Saponin	Tannins	Oxalates	Phytates
A	3.32^{b} ± 0.01	14.60^{d} ± 0.02	17.00^{c} ± 0.00	0.07^{b} ± 0.00	0.06 ± 0.00
B	4.05^{c} ± 0.01	14.60^{d} ± 0.05	15.00^{a} ± 0.01	0.11^{c} ± 0.01	0.11 ± 0.00
C	$3.35^{\mathbf{b}}$ ± 0.02	11.28^{b} ± 0.05	15.00^{a} ± 0.01	0.07^{b} ±0.01	0.07 ± 0.00
D	4.76^{e}± 0.08	12.09^{c} ± 0.03	15.61^{b}± 0.01	0.05^{a} ± 0.00	0.07 ± 0.01
E	1.99^{a} ± 0.01	13.67^{d} ± 0.01	15.05^{a} ± 0.01	0.07b ± 0.00	0.07 ±0.01
F	4.58^{d} ± 0.02	11.00^{a} ± 0.00	15.63^{b} ±0.01	0.11^{c} ± 0.02	0.08 ± 0.01
LSD	0.1	0.07	0.11	0	0

Values are mean ± SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least Significant Difference

Table 7. Sensory properties of pap (Ogi) made from flour blends

Sample	Appearance	Taste	Flavour	Consistency	General acceptability
A	7.15^{d}±1.76	6.80^{d}± 1.72	6.05^{b} ± 1.66	6.90 ^{e}± 1.48	6.70^{d} ± 1.64
B	6.80^{cd}±1.72	6.20^{a} ± 1.57	6.20^{b} ±1.86	6.80^{d} ± 1.36	6.35^{c} ± 1.71
C	6.60^{c} ± 1.85	6.60^{c} ± 1.20	6.15^{b} ±1.52	6.98^{f} ± 0.99	6.85^{e} ± 1.39
D	6.03^{c} ± 1.64	6.45_{b} ± 1.43	5.50^{a} ± 1.75	6.75^{c}± 1.58	6.05^{a} ±1.56
E	5.80^{b} ±1.89	6.20^{a} ± 1.60	5.85^{a} ± 1.96	6.50^{b} ±1.83	6.20^{b} ± 1.47
F	5.10^{a} ±1.87	5.95^{a} ± 1.59	5.80^{a} ± 1.78	6.20^{a}± 1.69	6.35^{c} ± 1.53
LSD	0.45	0.13	0.35	0.03	0.02

Values are mean ± SD of 3 replicates. Means within columns with the same superscript were not significantly different p>0.05 LSD = Least Significant Difference

3.6 Sensory Properties of Gruel or "Ogi" Made from Flour Blends

The results for the sensory evaluation of gruels made from the different flour blends are shown in Table 7. The control sample A had the best scores for appearance, taste flavour consistency. That notwithstanding, all the other gruel samples had scores above 5. For the substituted samples sample B registered the highest score for appearance 6.8, sample C registered the highest score for taste 6.6.sample B for flavour 6.2 sample C for consistency 6.98 and sample C again for general acceptability .6.85. The lowest scores in all the parameters were registered in sample F. Sample C compared favourably with the control sample A in scores for appearance taste flavour consistency and general acceptability.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Nutritious and acceptable complementary food (ogi) can be prepared from yellow maize, Bambara groundnut and mango flour blends. It is evident from the presented results that the composite flour blends would be suitable for production of an acceptable 'ogi' but the blend with 85:10:5 ratio is much preferable as it compared favourably with the control sample in terms of general acceptability. This is because it displayed better chemical and functional properties compared to the control and other samples.

4.2 Recommendations

From these conclusions the following recommendations are suggested:

i. Packaging and storage stability of the composite flours should be researched on in order to effectively commercialize yellow maize Bambara groundnut and mango composite flour.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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