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Nutritional composition and functional properties of maize – soya bean composite flour

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Abstract

The functional properties, proximate, mineral and anti-nutritional composition of maize/soya bean composite flour blends were investigated. The maize flour (MF) was blend with soya bean flour (SF) in the ratios of 90:10,80:20, 70:30, 60:40 and 50:50 (MF: SF) respectively. The flour blends were analyzed using Standard methods. The range in functional properties of the blends were, bulk density, (0.90 ±0.09 - 0.94 ±0.12g/mL), swelling capacity, (1.79 ±1.68 - 2.29 ±1.22%), pH (5.18 ±0.29 - 6.76 ± 0.48) and water absorption capacity (11.96 ±0.18 - 16.22 ±0.11%). The proximate composition of blend shows that the protein content of the samples increased steadily with increased substitution with soya bean flour 79.13 ±0.10 % in 90:10 and 63.66 ±0.34 % in 50:50 sample ratios while carbohydrate and fiber decreased, fat, and ash increased with increase in soya bean flour addition. The mineral composition of the blends also showed that potassium, phosphorous, iron, zinc and magnesium was increasing, while the anti-nutrient gradually decreased as shown in the following ranges, phytate (0.36 ± 0.01- 1.23 ± 0.01 mg/100g), oxalate (0.10 ± 0.01-0.31 ± 0.01 mg/100g.) and tannin (0.02 ± 0.01- 0.18 ± 0.00 mg/100g) respectively. The study showed that the nutritional value and functional properties of maize flour can be drastically improved by supplementing the flour with adequately processed Soya bean flour. Swelling capacity, water absorption capacity, pH, protein, ash, phosphorus, potassium, calcium, iron, zinc and magnesium contents of the composite blends increased significantly with increased supplementation with soya bean flour. Compositing maize and soya bean flour has resulted in decreased anti-nutrient content of the composite flour samples. Soya beans can effectively be used in locally formulated weaning foods as an acceptable protein supplements. The processes, parameters and formulation developed through this study has successfully produced a high protein energy weaning food with acceptable functional characteristic as well as excellent nutritional quality.

Keywords: Anti-nutritional; Proximate Composition; Minerals; Cereals; Legumes; Flour blends

1 Introduction

Composite flour is a mixture of different flours from cereal, legume or root crops that is created to satisfy specific functional characteristics and nutrient composition. It could be a mixture of wheat flour (usually more than 80%) with other flours such as maize, rice, sorghum etc. (usually less than 20%). The use of composite flour based on wheat and other cereals including minor millets in bakery products is becoming popular because of the economic and nutritional advantages of composite flour [1]. Cereals and legumes have played a significant role in reducing the problem of malnutrition throughout the world. These are rich sources of carbohydrates, lipids and protein therefore they are used as major ingredient in preparation of starch and protein-based food formulation. Various cereals and legumes flours

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differ in their biochemical composition, molecular structure, conformation of food components and show diverse functional properties [2, 3].

The variation in functional properties is attributed to the relative proportion of carbohydrates, lipids and protein in different flours. Functional properties of flours are also changed by processing conditions such as extraction, isolation, drying, milling, blending, baking, cooking and fermentation [4, 5, 6]. Protein solubility, swelling capacity, water holding capacity, gelling abilities and foaming properties are intrinsic physicochemical properties of flours based on the relative strength of hydrophilic and hydrophobic groups of starch and protein. Proteins containing comparatively greater number of polar amino acids show high hydrophilic strength while the hydrophobic character of protein is based on exposure of non-polar amino acids [2]. Ionic strength, pH, temperature and radiations cause denaturation of protein molecules and affect the functional properties of flour. The variation in functional properties further leads to the change in quality of food products [7, 8]. Bulk density of flour depends on the structural arrangement of carbohydrates and other polymers present in flour [9].

Maize (*Zea mays* L.) is the most important cereal in the world after wheat and rice with regard to cultivation. In sub-Saharan Africa maize is a staple food for an estimated 50% of the population. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. More than 40 different ways of consuming maize had been recorded in many countries in Africa [10]. Africans consume maize as a starchy base in a wide variety of porridges, pastes, grits, and beer. Green maize (fresh on the cob) is eaten parched, baked, roasted or boiled with or without salt and plays an important role in filling the hunger gap after the dry season [6]. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products [11].

Maize as a cereal contain Vitamins such as vitamin C, vitamin E, Vitamin K, Vitamin B1(thiamine), vitamin B2 (niacin), Vitamin B3 (Riboflavin), vitamin B5 (panthothenic acid) vitamin B6 (pyridedoxine) folic acid, selenium, N-P-coumaryl tryptamine and N-ferrulyl tryptamine. Potassium which is the major mineral present in maize has good significance in human diet [12]. Maize germ contains about 45-50 % of oil that is used in cooking salads and is obtain from wet milling process [13]. The oil contains 14 % of saturated fatty acids (SFAs) 30 % monounsaturated fatty acids (MUFAs) and 56% Polyunsaturated Fatty acids (PUFAs). The refined maize oil contains linoleic acids (54 – 60 %), oleic acid (25-31 %) palmitic acid (11-13 %), stearic acids (2-3%), linolenic acid and (1 %), [14]. Maize is an essential source of various major phytochemicals such as carotenoids compounds, phenolic compound and phytosterols [15, 16, 17].

Legumes or pulses are edible fruits or seeds of pod bearing plants. Their seeds are put to a myriad of uses, both nutritional and industrial, and in some parts of the developing countries they are the principal source of protein for humans. Legumes have high protein content in the range of 20-40%; about twice that of cereals and several times that in root tubers [18, 19]. The common legumes in Nigeria include, Cowpea (*Vigna unguiculata),* Soybeans (Soya beans) (*Glycine max*), Pigeon pea (*Cajanus cajan*), Groundnuts (*Arachis hypogea)* and African yam bean (*Sphenostylis stenocarpa*) [20]. Legume and cereal proteins are nutritionally complementary, depending on the contents of the second limiting amino acids, i.e., threonine in cereals and tryptophan in legumes. Hence, the need for blending legumes with cereals in food product development. Therefore, a combination of such food stuffs will improve the nutritional value of the resulting blend compared to the individual components alone.

However, consumption of proteins from plant sources (legumes) is encouraged in order to diversify their utilization [21]. Combination of legumes and grains provide biologically high quality, readily available and cheaper protein that contains all essential amino acids in proper proportion, and their amino acids complement each other [22]. Soybean (*Glycine max*) is a better source of quality protein that is superior to all other plant foods because it has good balance of the essential amino acids and it contains a reasonable amount of methionine. This can be a good supplement for crops that are rich in carbohydrate. Soybean has been reported to have equal or higher lysine content and most of other essential amino acids, this corresponds to the WHO/FAO recommendation [23].

Protein deficiency is a major dietary problem facing underdeveloped and developing countries. The deficit is due the deficiency in the macro nutrients. Protein energy malnutrition affects children who do not consume enough calories of protein. Complementing maize with soybean has been recognized to have vast genetic and health potentials, especially in reducing malnutrition among Africans; much research has been carried on cereals and legumes, however these crops has not received adequate research attention, thereby limiting its contribution to food security and preventing potential food crisis. Increasing the use of crops is one of the better ways to reduce nutritional, environmental and financial vulnerability in times of change. Over the years, some conditions have negatively influenced the productivity and acceptability of maize and soya bean among cultivators, consumers, and research scientists. Intervention programs have not led to serious improvements. There is an urgent need to look inwards for solutions, especially for these crops (cereals and legumes) since they are commonly and mostly consumed. There is need to promote the utilization and consumption of these crops. It is against this background that this study was conducted to evaluate the nutritional properties of maize-soybean composite flour blends. Therefore, the objective of this study was to evaluate the nutritional composition, anti-nutrients and functional properties of maize-soybean composite flour.

2 Materials and Methods

2.1 Materials

Maize and soybean for the study were purchased from modern Market in Makurdi metropolis, Benue State, Nigeria. White corn variety of maize were used because, it is widely grown in Benue State and is commonly used for human consumption.

2.2 Production of Maize, Soybean and Composite Maize-Soya bean Flour

The maize flour was produced according to method described by [24], while soya bean flour was produced according to method described in [25]. The production of maize-soya bean composite flour was produced with slight modification as described in [24].

2.3 Flour Blend Formulation

The maize flour was blended with soya bean flour in the ratios of 100:0, 80:20, 70:30, 60:40, and 50:50 to produce maize and soya bean composite flours. The composite flours produced were packaged individually in an airtight plastic container for analysis.

Table 1 Blend Formulation for Maize-soybean Composite Flour

Sample	Maize (%)	Soya bean (%)
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40
F	50	50

Key: A (100 % Maize flour+0 % Soybean flour); B (90 %Maize flour + 10 % Soya bean flour); C (80 % Maize flour + 20 % Soybean); D (70 % Maize flour + 30 % Soya bean flour);E (60 % Maize flour+ 40 % Soybean flour); F (50 % Maize flour + 50 % Soya bean flour)

2.4 Physical, Chemical and Functional Composition of Composite Flour

Bulk Density Determination Bulk density was determined for each of the formulated samples using the method described by Onwuka, [26]. The pH of the food samples was measured with a Mettler Delta 350 pH meter using the method described by Onwuka [26]. The moisture content was determined by air-oven method as described in [27]. The protein content of the composite flour blends would be determined using the micro-Kjeldahl methods. Fat content of composite flour blends was estimated using solvent Petroleum ether (Soxhlet). Total Dietary Fiber would be determined following [28]. The amount of carbohydrates was calculated by difference. The values refer to "Total carbohydrate by difference" that is, the sum of the figures for moisture (%), protein (%), fat (%), and ash (%) are subtracted from 100. The total ash content of a substance is the percentage of inorganic residue remaining after the organic matter has been ignited. The total energy was determined by the method described by Kanu *et al*. [29]. The swelling capacity was determined by the method described by Onwuka [26]. Water absorption capacity (WAC) and the fat absorption capacities (FAC) of the formulated samples were determined using the method described by Onwuka [26].

2.5 Mineral Determination

The determination of calcium, Potassium, Magnesium, Phosphorus, Iron, Zinc and Zinc was done following Association of Official Analytical Chemists, AOAC, [28].

2.6 Determination of Anti-nutritional Factors

The phytate determination was evaluated as described by Thompson and Erdman [30]. Tannin was determined by the method described by AOAC. The titration method described in AOAC, [28] was used for the determination of oxalate in the composite flour blends.

2.7 Data Analysis

The data obtained were analyzed using Special Package for Social Science (SPSS, version 20) to detect significant differences ($p < 0.05$) among the sample means.

3 Results and Discussion

Table 2 shows the result of the physicochemical and functional properties of maize-soybean composite flour. The functional properties of flour are those that directly determine their end uses. The swelling power of granules reflects the extent of the associative forces within the granules [31]. It has been established that the composition and nature of macromolecules (protein, fat, and carbohydrates) in food materials often affect their functionality [32]. The bulk density of the composite ranges from (0.90-0.94 g/mL) the bulk decrease with increasing level of soya bean flour. There was no significant difference between the samples. The values obtained in this study are lower than the values (0.92-0.97 g/mL) reported by Okoye *et al*., [33] for cornstarch/soya bean flour blends. It is also higher than the value (0.60-0.67g/mL) recorded by Bolarinwa *et al*. [34] The decrease in the bulk density in this study indicates lesser packaging requirement with increasing level of soya bean flour supplementation (Table 2).

The swelling capacity of the samples ranged from 1.79-2.29 %. The values are also higher than the values (1.21-1.27 %) reported by Bolarinwa *et al*. [34]. The variation in the swelling capacity of the blends could be attributed to differences in the amylase and amylopectin contents of their starch [9]. The excellent swelling capacity of the composite flours suggests that they may be useful in the preparation of sauces, bread, soups and gravies (Table 2).

The water absorption capacity of the samples ranged from (11.92-16.22 %). The water absorption capacity increases significantly ($p \leq 0.05$) with increase in soybean flour substitution (Table 2). The increase in water absorption capacity may assure product cohesiveness. The values obtain in this study are higher than the values (1.71-1.97 %) observed in Bolarinwa *et al*., [13] report. The variation in water absorption of the samples could be due to the destruction of the matrix of macromolecules which have the ability to entrap large amount of water during processing [4].

The pH value of maize soya bean composite flour ranges from (5.18-6.76 %). The pH values of the composite flour in this study increase significantly with increase in soybean flour (Table 2). This shows that acidity decreases with increasing soybean flour substitution and the composite flour is not acidic. The flour can therefore be used to produce acceptable products for people suffering from stomach or pectic ulcer. The pH values (5.18-6.76) of the composite flour are similar to the pH values (5.60 - 6.7) reported by Adenekan and Oyewole [35]. It is also similar to the pH values (5.50-6.33 %) reported by Bolarinwa *et al.* [34].

Table 2 Physicochemical and Functional Properties of Maize-Soya bean Composite Flour

Sample	**Bulk D. (g/mL)**	**Swe. Cap. (%)**	**pH**	**Wac (%)**
A (100:00)	$0.94^a \pm 0.12$	$1.79^f \pm 0.33$	$5.18^f \pm 0.29$	$1.75^f \pm 0.11$
B (90:10)	$0.92^a \pm 0.11$	$1.86^e \pm 0.45$	$5.56^e \pm 0.33$	$1.83^e \pm 0.12$
C (80:20)	$0.90^a \pm 0.09$	$1.94^d \pm 0.74$	$5.86^d \pm 0.36$	$1.92^d \pm 0.16$
D (70:30)	$0.92^a \pm 0.10$	$2.01^c \pm 0.42$	$6.14^c \pm 0.62$	$1.98^c \pm 0.19$
E (60:40)	$0.93^a \pm 0.11$	$2.23^b \pm 0.33$	$6.63^b \pm 0.68$	$2.07^b \pm 0.10$
F (50:50)	$0.92^a \pm 0.08$	$2.29^a \pm 0.51$	$6.76^a \pm 0.48$	$2. 18^a \pm 0.22$

Values are mean ± standard deviation of duplicate determination; Mean in the column with the same superscript are not significantly different at P< 0.05. **Key:** Bulk D= Bulk Density; Swe. Cap=Swelling Capacity; Wac=Water Absorption Capacity;A (100% Maize flour+0% Soya bean flour); B (90%Maize flour + 10% Soya bean flour); C (80%Maize flour + 20% Soya bean); D (70% maize flour + 30% Soya bean flour); E (60% maize flour+ 40% Soya bean flour) and F (50% Maize flour + 50% Soya bean flour)

3.1 Proximate Composition of Maize-Soya bean Flour Blends

The result of proximate composition of maize-soya bean flour blends is presented in Table 3. The moisture contents of maize/soya bean flours were between (8.28 - 10.60 %), while the moisture content of the blends increased as the proportion of soybean flour increased. The moisture content of maize–soya bean composite flours blends is below 13 % and was comparable with the reports on moisture contents of kidney bean/wheat flour blends and moisture contents above 14 % are likely to affect the storage stability of products [36]. Flour Fortification Initiative [37] Reported 11.2 % moisture content of cornmeal, degermed unenriched and enriched flour. Low moisture content of products suggests good keeping quality [38]. The moisture content in this study was higher than the moisture content value (5.66-7.00) reported by Bolarinwa *et al*. [34]. However, it is lower than the moisture content value (28-37 %) of wheat and soya bean composite flour for the production of bread reported by Jahangir *et al*. [39].

The crude protein content of maize flour was the least with value of 8.48 %, while the blends with soya bean flour substitutions had higher protein contents value of 16.81 % (Table 3). This showed that the addition of soya bean flour resulted in increased protein content of the composite flours. This observation is due to a reflection of the superior nutritional properties of soya bean flour over maize flour and it demonstrated their mutual supplementation effect. The protein values were lower when compared to the protein content value 22.76 %, from blends of maize/soya bean reported by Edema *et al*. [40]. The increase in the protein content of the composite flour could be attributed to high protein content of soya bean [41]. The protein value (8-11 %) in this study is comparable to what was reported for wheat and soybean composite flour for production of bread. [39]. High crude protein of the maize-soya bean flour signifies that the composite flour can serve as cheap source of protein to African populace. Products from the flour would have the potential of solving the problem of protein-energy malnutrition.

The fat content of the blends increased as the proportion of soy bean flour increased. The fat content of the composite ranged from 2.05-5.63 % (Table 3). This is lower when compared with the value (4.09-9.14) previously reported [40]. Soya bean is an oil seed, which has been reported to be a leading source of edible oils and fats. It is also a rich source of essential fatty acids [42]. The increase in the fat content could imply good energy levels of the blend containing soya bean flour. The fat content of the flour was slightly high because soybean flour used was un-defatted. The fat content (2.05-5.63 %) of the maize-soya bean flour obtained in this study followed the trend reported in similar study [43].

The ash content of the samples increased significantly ($p \leq 0.05$) with increased level of soya bean inclusion in the blends (Table 3). The increased ash content of the samples is an indication that they are good sources of minerals [41]. Soya bean seeds have been reported to contain an appreciable quantity of minerals [44]. The ash content of a food material could be used as an index of mineral constituents of the food [45]. Legumes have been reported to be good sources of ash. The ash content (1.28-2.637 %) of the composite flour reported in this study is similar to the ash content (2.9%) of composite flour produced from maize-soy flour [40]. It is also similar to the ash content values (1.39-2.73) composite of maize and African yam bean [43].

Fiber has been credited for promotion of increased excretion of bile acids, sterols and fat which have been implicated in the etiology of certain ailments in humans [20]. The fiber content of the maize-soya bean composite flour varied from 0.93 - 1.86 % (Table 3). These values are lower than the fiber content values (3.50-5.00 %) of composite wheat-soya bean composite flour for production of bread [39]. However, it is similar to fiber values (0.22-1.48 %) recorded in previous study [20]. The decrease in the fiber content of the blend could be as a result of dehulling soybean to increase protein.

The carbohydrate content of the maize flour was the highest, while the blends had lower carbohydrate contents as soya bean flour increases. The carbohydrate content in this study ranged from 64.33-79.91 % (Table 3). This signified that the addition of soya bean flour resulted in the decrease of the carbohydrate content of the blends. The same trend was reported when compositing wheat and soya bean for bread production [39]. The range of value in this study is similar to the value of carbohydrate reported in similar study [34].

The energy contents of maize-soya bean composite flours blends ranged from 372.01- 375.76 Kcal (Table 3). This is an indication that the blends of the composite flour would be a good source of energy. The energy content in this study is in the range of energy content value (245-285 Kcal) of wheat and soya bean composite flour for bread [39]. The variation in the energy content of the samples could be due to differences in their protein and carbohydrate contents [20].

Table 3 Proximate Compositions of Maize-Soya bean Flour Blends

Sample	M.C (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Cab. (%)	En. (Kcal)
A(100:00)	$8.28^{e} \pm 0.28$	$8.48^{f} \pm 1.18$	$2.05^{f} \pm 0.04$	$1.28^{f} \pm 0.05$	$1.86^{f} \pm 0.08$	$79.91^{a} \pm 0.10$	372.01^{f}
B (90:10)	$8.66^{d} \pm 0.18$	$10.63^{e} \pm 0.16$	$2.89^{e} \pm 0.02$	$1.33^{e} \pm 0.05$	$1.67^{e} \pm 0.07$	$76.49^{b} \pm 0.90$	374.49^{e}
C (80:20)	$8.77^{c} \pm 0.99$	$12.81^{d} \pm 0.28$	$3.64^{d} \pm 0.04$	$1.84^{d} \pm 0.11$	$1.43^{d} \pm 0.34$	$72.94^{c} \pm 0.39$	375.76^{a}
D (70:30)	$9.53^{b} \pm 0.35$	$13.87^{c} \pm 0.64$	$4.28^{c} \pm 0,04$	$2.05^{c} \pm 0.20$	$1.18^{c} \pm 0.14$	$70.27^{d} \pm 0.17$	375.08^{c}
E (60:40)	$10.08^{a} \pm 0.09$	$14.96^{b} \pm 0.86$	$4.86^{b} \pm 0.02$	$2.31^{b} \pm 0.16$	$1.06^{b} \pm 0.10$	$67.79^{e} \pm 0.66$	$374. 74^{d}$
F (50:50)	$10.60^{a} \pm 0.22$	$16.81^{a} \pm 0.92$	$5.63^{a} \pm 0.02$	$2.63^{a} \pm 0.20$	$0.93^{a} \pm 0.02$	$64.33^{f} \pm 0.34$	375.23^{b}

Values are mean ± standard deviation of duplicate determination; Mean in the column with the same superscript are not significantly different at P< 0.05. **Key**: M.C.: Moisture content; Cab.: Carbohydrate, En., Energy; A (100 % Maize flour+0 % Soya bean flour); B (90 %Maize flour + 10 % Soya bean flour); C (80 % Maize flour + 20 % Soya bean); D (70 % Maize flour + 30 % Soya bean flour);E (60 % Maize flour+ 40 % Soya bean flour); F (50 % Maize flour + 50 % Soya bean flour)

3.2 Mineral Composition of Maize-Soya bean Flour Blends (mg/100g).

The result of the mineral composition of maize-soya bean flour blends is shown in Table 4**.** The calcium contents of maize-soya bean flours varied from 9.32-14.02 mg/100g, and the calcium content of the blends increased significantly ($p \leq 0.05$) with increased supplementation with soybean flour (Table 4). The maize-soya bean composite flour values are higher when compared with the calcium content (0.093-0.119 mg/100 g) of malted sorghum-soya flour reported by Bolarinwa *et al*. [34] and calcium content value (0.49-0.74 mg) reported by Idowu. Calcium plays significant roles in blood clothing and muscle contraction in humans [46]. Also, Calcium is necessary for optimal growth and development of infant and young children.

The phosphorus content of maize flour was the least, while that of the blends increased with increasing substitution with soya bean flour. The phosphorous content in this study ranged from 2.84-4.24 mg (Table 4). The phosphorous values recorded in this study are lower when compared with the phosphorous content value (168-180 mg) of malted sorghum-soya reported by Bolarinwa et al. [34]. This showed that soy bean flour had higher content of phosphorus. This is in agreement with the report that soya bean is a good source of phosphorus [47]. Phosphorus helps in the formation of Adenosine Triphosphate (ATP) in the body [48].

The potassium content of the blends increased significantly ($p \leq 0.05$) with increased level of soya bean flour in the blends. The potassium content of the composite flour in this study ranged from 2.18-3.82mg (Table 4). This is higher than the potassium content value (0.56-1.41mg) of maize and African yam bean composite flour reported by Idowu. The result, however, indicates that soya beans are good source of potassium. Potassium is very essential in blood clothing and muscle contraction [43].

The iron content of the samples ranged from 1.98-3.08 mg/100g with the blends containing 10 and 50% soya bean flour having the least and highest values, respectively (Table 4). This is higher when compared with the iron content value (0.144-0.188mg) of malted sorghum-soy [34]. However, the iron content in this study is lower than the iron content value (31.84-38.07) reported by Idowu. This is in line with the report that soybean has a good source of iron [49]. Iron is an important component of hemoglobin which is an oxygen–carrying pigment in the blood. When foods with iron are eaten, it is absorbed into proteins and helps these proteins intake, carry, and release oxygen throughout the body. An iron deficiency called iron-deficiency anemia is very common around the world, especially for women and children in developing nations. Symptoms of iron deficiency take years to develop and include fatigue, weakness, and shortness of breath [20].

The magnesium content of maize flour was the lowest, while that of the blends increased significantly ($p \leq 0.05$) as the proportion of soya bean flour increased (Table 4). The magnesium content in this studies range from (1.08 - 3.18), and this is adduced to the fact that soya bean is a rich source of magnesium [50]. Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerves [51]. It works with calcium to assist in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions [52]. The decreased level observed in some of the minerals may be associated with the processing techniques.

The zinc content of the blends increased significantly (p≤0.05) with increased supplementation with soya bean flour. Previous study recorded lower values for fortified breakfast cereals as 1.54 ±0.30 mg/kg and 1.64 ±0.4 mg/kg [49]. The range of zinc content (2.25-3.22 mg/100 g) of maize-soya bean flour recorded in this study is higher than the range of zinc content (0.053 and 0.092 mg/100 g) of wheat flour and wheat-soy flour reported by a researcher [53]. Zinc is a component of every living cell and plays a role in hundreds of bodily functions, from assisting in enzyme reactions to blood clotting, and is essential to taste, vision, and wound healing [20]. Zinc acts as an activator of many enzyme systems in humans [2].

Table 4 Mineral Composition of Maize-Soya bean Flour Blends (mg/100g).

Sample	Calcium	Phosphorus	Potassium	Iron	Zinc	Magnesium
A (100:00)	$9.32^{f} \pm 0.62$	$2.84^{f} \pm 0.02$	$2.18^{f} \pm 0.10$	$1.98^{f} \pm 0.08$	$2.25^{f} \pm 0.48$	$1.08^{f} \pm 0.28$
B (90:10)	$10.01^{e} \pm 0.42$	$3.00^{f} \pm 0.01$	$3.38^{e} \pm 0.06$	$2.12^{e} \pm 0.06$	$2.32^{e} \pm 0.03$	$2.27^{e} \pm 0.07$
C (80:20)	$10.25^{d} \pm 0.48$	$3.20^{d} \pm 0.11$	$3.63^{d} \pm 0.01$	$2.52^{d} \pm 0.04$	$2.49^{d} \pm 0.04$	$2.66^{d} \pm 0.14$
D (70:30)	$11.46^{c} \pm 0.19$	$3.52^{c} \pm 0.14$	$3.70^{c} \pm 0.35$	$2.80^{c} \pm 0.03$	$2.65^{c} \pm 0.08$	$2.99^{c} \pm 0.21$
E (60:40)	$12.06^{b} \pm 0.39$	$4.06^{b} \pm 0.09$	$3.74^{b} \pm 0.03$	$2.98^{b} \pm 0.6$	$2.90^{b} \pm 0.34$	$3.10^{b} \pm 0.08$
F (50:50)	$14.04^{a} \pm 0.21$	$4.24^{a} \pm 0.16$	$3.82^{a} \pm 0.57$	$3.08^{a} \pm 0.08$	$3.22^{a} \pm 0.06$	$3.18^{a} \pm 0.17$

Values are mean ± standard deviation of duplicate determination; Mean in the column with the same superscript are not significantly different at P< 0.05. **Key**: A (100 % Maize flour+0 % Soya bean flour); B (90 %Maize flour + 10 % Soya bean flour); C (80 % Maize flour + 20 % Soya bean); D (70 % Maize flour + 30 % Soya bean flour);E (60 % Maize flour+ 40 % Soya bean flour); F (50 % Maize flour + 50 % Soya bean flour)

3.3 Anti-nutritional Composition of Maize-Soya bean Composite Flour (mg/100g)

The result of the anti-nutritional properties of maize-soya bean composite flour is presented in Table 5. The phytate content of the maize, soya bean composite flour ranged from (0.38 - 1.23 mg/100g), this value is lower when compared to the phytate content of malted sorghum-soya flour (25.7-39.4 %) recorded [34]. It is also lower than the phytate content (39.4 %) of raw oat cereal [54]. A gradual decrease of the phytate was observed due to the effect of steeping on the samples [55, 56]. Many dietary fibers contain phytic acid which binds minerals in the digestive tract, which eventually expels the minerals from the body. Some of these minerals are essential for good health, including zinc, iron and calcium. The highest value of phytate was found in the sample containing 100:0 formulations. Legume seeds are known to constitute 1-3 % of phytate and are dependent on species, cultivars and germination of phytate for consumption [57].

The oxalate content of the maize-soybean composite flour ranged from (0.10-0.31 mg/100g). The highest value was observed in the sample with 100:00 formulations (Table 5). The oxalate levels recorded in this study are lower than the values (4-9 mg/100g) recorded by similar study by Siddhuraju and Becker [42].

The tannin contents of the maize-soya bean composite flour were significantly (p<0.05) low and ranged from (0.02-0.18mg/100g) (Table 5). This is lower when compared with the range of tannin content values (18.9-22.9) of malted sorghum-soya bean composite [34]. Lower tannin content observed in this study could be due to degradation of tannin during steeping and dehulling on the samples. Tannins impart a bitter taste to the grains making them unpalatable and also interfere with protein digestibility [37]. Malting is known to increase polyphenol contents [58] but fermentation reduces them [59]. Decrease in tannin contents could be achieved through soaking, dehulling, fermentation and germination [60]. Tannins are located in the seed coat of the grains and are known to have deleterious effects due to their strong interactions with proteins, with the resulting complexes which are not readily digested by monogastrics. This lowers the protein digestibility and weight [61, 62]. Noteworthy is the fact that processing of legumes is very important so as to reduce the toxic components to the levels that pose no threat to health [31].

Table 5 Anti-nutritional Composition of Maize-soya bean Composite Flour (mg/100g)

Sample	Phytate	Oxalate	Tannin
A (100:00)	$1.23^{a} \pm 0.01$	$0.31^{a} \pm 0.01$	$0.18^{a} \pm 0.0\ 0$
B (90:10)	$1.12^{b} \pm 0.01$	$0.\ 25^{b} \pm 0.01$	$0.13^{b} \pm 0.01$
C (80:20)	$1.00^{c} \pm 0.01$	$0.23^{cb} \pm 0.00$	$0.10^{bc} \pm 0.02$
D (70:30)	$0.89^{d} \pm 0.00$	$0.21^{db} \pm 0.02$	$0.09^{bc} \pm 0.0\ 0$
E (60:40)	$0.53^{e} \pm 0.01$	$0.15^{e\pm}\ 0.01$	$0.06^{cd} \pm 0.01$
F (50:50)	$0.36^{f} \pm 0.00$	$0.10^{f\pm}\ 0.01$	$0.02^{d} \pm 0.01$

Values are mean ± standard deviation of duplicate determination; Mean in the column with the same superscript are not significantly different at P< 0.05. **Key**: A (100 % Maize flour+0 % Soya bean flour); B (90 %Maize flour + 10 % Soya bean flour); C (80 % Maize flour + 20 % Soya bean); D (70 % Maize flour + 30 % Soya bean flour); E (60 % Maize flour+ 40 % Soya bean flour); F (50 % Maize flour + 50 % Soya bean flour)

4 Conclusion

In an attempt to reduce the overdependence on importation of wheat to Nigeria with the attendant high foreign costs, increasing the diverse utilization of available and abundant crops such as soya bean is being explored. The nutritional profile of flour from cereals and legumes is of high health and economic benefit. Soya beans can effectively be used in locally formulated weaning foods as an acceptable protein supplements. The processes, parameters and formulation developed through this study has successfully produced a high protein energy weaning food with acceptable functional characteristic as well as excellent nutritional quality. The study has shown that the nutritional value and functional properties of maize flour can be drastically improved by supplementing the flour with adequately processed Soya bean flour. Swelling capacity, water absorption capacity, pH, protein, ash, phosphorus, potassium, calcium, iron, zinc and magnesium contents of the composite blends increased significantly with increased supplementation with soya bean flour. Compositing maize and soya bean flour result into decreased anti-nutrient content of the composite flour samples.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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