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Evaluation of flour blends made from high quality protein maize and soursop seed flours

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ABSTRACT: This study aimed to evaluate the nutritional properties of flour blends made from high quality protein maize and soursop seeds flour. The flour blends were formulated as MQS (100% Quality protein maize), MPM (90% quality protein maize + 10% soursop seeds flour), MMM (82.5% quality protein maize + 17.5% soursop seeds flour), MSM (75% quality protein maize + 25% soursop seeds flour) and MFM (67.5% quality protein maize + 32.5% soursop seeds flour). Proximate composition, functional properties, vitamin composition, mineral content and phytochemical properties of the flour blends were evaluated using standard analytical methods. The proximate composition result of the flour blends showed that moisture content, ash, crude protein, crude fat, crude fibre and carbohydrate values were within the range of 9.88-14.66, 1.97-5.62, 9.97-14.49, 5.14-8.89, 3.23-8.24 and carbohydrate 62.78-79.71% respectively. Water absorption capacity, oil absorption capacity, solubility, swelling capacity, gelation capacity and bulk density values were within the range of 107.44-116.78, 97.98-102.85, 9.97-17.67, 41.89-49.67, 0.73-3.27% and 0.88-5.79 g/ml respectively. Vitamins A, B1, B2 and B3 values were within the range of 5.55-8.45, 0.77-2.93, 0.36-4.78 and 1.87-5.49 mg/100 g. Calcium, magnesium, iron, zinc and copper values were within the range of 45.5553.67, 123.78-128.93, 7.67-15.78, 4.86-14.57 and 1.68-4.88 mg/100 g while phytochemical values: total phenolic, total flavonoids, tannin and phytate values were within the range of 95.55-109.55 mgGAE/100 g, 5.08-14.13, 13.58-18.24 and 87.35-92.89 mg/100 g respectively. Flour blends from MFM had the highest moisture (14.66%), ash (5.62%), crude protein (14.49%), crude fat (8.89%) and crude fibre (8.24%) while MQS had the highest carbohydrate (79.71%). Flour blends from MFM had the optimum functional and phytochemical properties, mineral content and vitamin contents. The study therefore inferred that supplementation of quality protein maize with soursop seeds flour, especially at 32.5% soursop seed flour supplementation, could offer consumers acceptable indigenous snacks of improved nutritional qualities.

Keywords: Quality protein maize, soursop seeds, flour blends, phytochemicals, proximate composition, mineral content, functional properties.

INTRODUCTION

Quality protein maize (QPM) has recently attracted much attention from the international market because of their high content of essential amino acids such as lysine, tryptophan and threonine (Chukwuma *et al.*, 2016). Soursop seeds have been reported to contain significant nutrients including protein, fat, crude fibre, minerals such as potassium, sodium, calcium, iron, zinc, copper and magnesium (Fasakin *et al.*, 2008).

Soursop (*Annonamuricata*) originates from South America and the Antilles; however, wild soursop is thought to have originated from Africa. Four *Annona* species known as bearers of edible fruits are custard apple (*A. reticulata*), sugar apple (*A. squamosa*), cherimoya (*A. cherimola*), and soursop (*A. muricata*), which originated from South America. Many seeds have gained importance due to their potential to lower cholesterol, delay human ageing, and prevent cancer (Tiencheu *et al.*, 2021). The fresh fruit of soursop is a favourite on the market due to its pleasant and sweet taste, but the sensitive characteristics of the fruit lead to the production of the pulp as the most

economically attractive commercial form. The pulp yield of soursop varies from 46.8 – 85.85%. Nutritionally, soursop seeds have been reported to nutritionally contain 18.43% protein, 14.99% fat, 14.83% fibre, and 32.36% carbohydrate (Odunayo, 2020). Anti-nutritionally, soursop seeds possess 390.20 mg/100 g cyanides, 0.66 mg/100 g oxalates, 263.40 mg/100 g phytates and 8.41 mg/100 g tannins (Nwakife *et al.*, 2021).

Therefore, the purpose of this study was to evaluate the effect of soursop seed and quality protein maize flour blends on the nutritional quality of the composite flours

MATERIALS AND METHODS

Quality protein maize (QPM) was obtained from the International Institute of Tropical Agriculture (IITA) in Ibadan, Oyo State, Nigeria while soursop fruits were obtained from a local fruits vendor in Ijagbo, Oyun Local Government Kwara State, Nigeria. The equipment required for the successful conduct of this study was made available for usage at the Food Processing Laboratory of the Food Technology Department in Federal Polytechnic Offa Kwara State.

Preparation of quality protein maize (QPM) flour

Quality protein maize (QPM) flour was prepared as described by Lawrence (2022), with modification. QPM was thoroughly cleaned by picking out all broken kernels together with other foreign particles and then sorted to obtain the wholesome ones. The known weight of maize kernels was washed. The QPM were spread on the trays and oven-dried at 50 °C until constant dryness and ground into flour using an attrition mill. The flour blends were passed through a 60 µm mesh size sieve. It was then packaged in an air-tight polyethylene bag, stored in a plastic container with a lid and kept in a freezer until needed for use for further processing. See Figure 1.

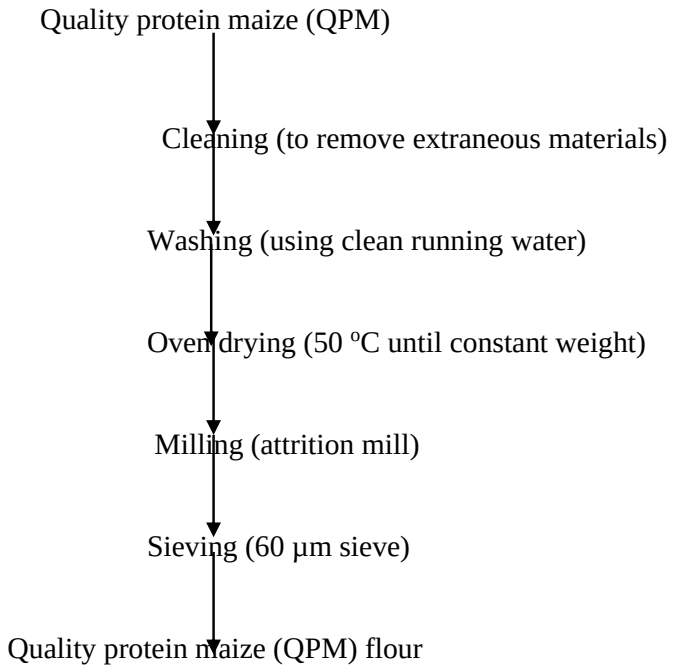

Figure 1. Flow chart for the preparation of QPM flour (**Source**: Lawrence, 2022: modified).

Preparation of soursop seeds flour

Soursop seed flour was prepared as described by Onyechi *et al.* (2014). Matured soursop fruits were sorted from a selection of several mature fruits of Soursop. The fruit's maturity was determined by its dark green skin with smooth numerous fleshy spines. The soursop fruits were washed and cut vertically into two halves; the seeds were carefully extracted from the fruit and sun-dried until constant weight. Then the seeds were milled using an attrition mill and sieved using a 60 µm mesh size sieve to obtain soursop seeds flour. See Figure 2

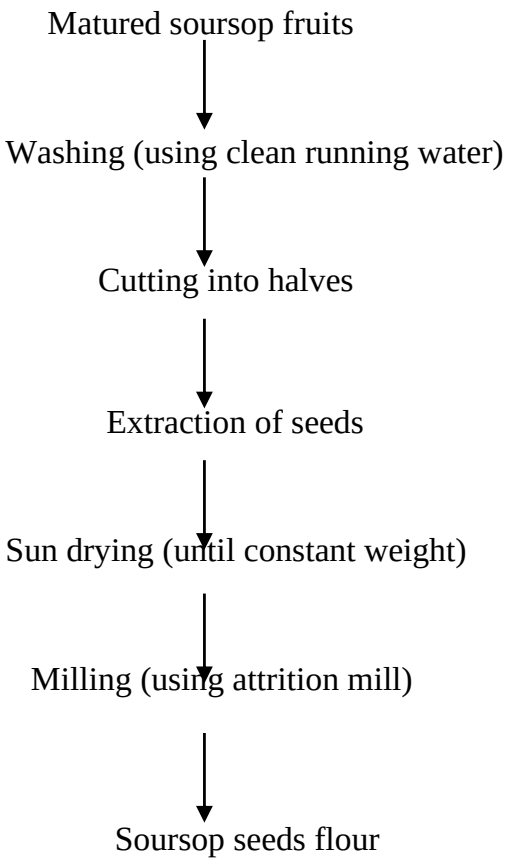

Figure 2. Flow chart for the preparation of soursop seeds flour (**Source**: Onyechi *et al.*, 2014).

Composite flour preparation

Quality protein maize and soursop flours were prepared by

blending them. The composite flour of quality protein maize-soursop seed (90:10, 82.5:17.5, 75:25 and 67.5:32.5 respectively) and 100:0 was used as control (Adebayo, *et al*., 2024).

Procedure for analysis

Proximate composition of flour blends

The proximate composition of flour blends was analyzed according to the official method of analysis described by the Association of Official and Analytical Chemists (AOAC, 2012).

Moisture content: The moisture content was determined by the method described by AOAC (2012), which is the use of the air-over method. The sterile petri dish was weighed and the weight was recorded as W_1. Two grams (2 g) of the sample was then weighed into the petri dish and the weight was taken as W_2. The sample was dried at 105°C for 3 h and transferred into a desiccator, cooled for an hour and then weighed until constant weight was attained.

$$\%\text{Moisture content} = \frac{\text{W3} - \text{W1}}{\text{W2} - \text{W1}} \text{ x } 100$$

Where: W_1 is the weight of the petri dish; W_2 is the weight of the petri dish and sample; W_3 is the weight of the petri dish and sample after drying.

Crude protein: The protein content was determined using a Micro-kjedhal method (AOAC, 2012) which involves wet digestion, distillation, and titration. The protein content was determined by weighing a known gram of sample into a boiling tube that contained 25 ml concentrated sulfuric acid and one catalyst tablet containing 5 g K_2SO_4, 0.15g $CuSO_4$ and 0.15 g TiO_2. Tubes were heated at low temperatures for digestion to occur. The digest was diluted with 100 ml distilled water, 10 ml of 40% NaOH, and 5 ml $Na_2S_2O_3$, anti-bumping agent was added, and then the sample was diluted with 10 ml of boric acid. The NH_4 content in the distillate was determined by titrating with 0.1 N standard HCl using a 25 ml burette. A blank was prepared without the sample. The protein value obtained was multiplied by a conversion factor, and the result was expressed as the amount of crude protein.

$$\%\text{ crude protein} = \frac{\text{AV} - \text{TV x 0.1N Hcl x 0.014 x F}}{\text{weight of sample}} \; x\; 100$$

Where: AV = Actual value, TV = Titre value, F = conversion factor.

Crude fat: Crude fat was determined by the method described by AOAC (2012). Crude fat was determined by using a soxhlet apparatus. Approximately 3 g of the sample was put into a thimble and extracted with n-hexane for about 6 hours. The solvent was removed from the extracted oil by evaporation. The oil was further dried in a hot-air oven at 100°C for 30 minutes to remove residual organic solvent and moisture. This was cooled in desiccators and weighed. The quantity of the oil was expressed as a percentage of the original sample used.
Calculation:

$$\%\text{ Crude fat} = \frac{\text{W4} - \text{W3}}{\text{W2} - \text{W1}} \; x\; 100$$

Where: W_1 is the weight of the thimble; W_2 is the weight of the thimble and sample; W_3 is the weight of the round bottom flask; W_4 is the weight of the round bottom flask and the residual oil.

Total ash content: The total ash content was determined by using the procedure of AOAC (2012). About 2 g of the sample was weighed into a clean crucible weighed W (and together as W_2). The crucible was then placed in a muffle furnace chamber at 600°C until the sample turned into ashes. The crucible was removed from the furnace, cooled in desiccators and allowed to cool to room temperature and reweighed as W_3.

$$\%\text{Ash} = \frac{\text{W3} - \text{W1}}{\text{W2} - \text{W1}} \; x\; 100$$

Where: W_1 is the weight of the crucible; W_2 is the weight of the crucible and sample before drying; W_3 is the weight of the crucible and sample after drying

Crude fibre content: Crude fibre was determined using a method described by AOAC (2012). Two grams (2 g) of the sample was weighed (W_1) which was extracted with n-hexane. This was transferred into a 1 litre flask. Sulphuric acid (1.25% of 200 ml) was added and the flask was placed on a hot plate and boiled for 30 min. The content was filtered and the residue was washed with 70 ml of distilled water. The residue was removed and 200 ml of boiling 1.25% sodium hydroxide (NaOH) was added and boiled for 30 min. The content was filtered and the residue was washed with distilled water. The residue was then transferred to a dish and dried at 130°C for 30 minutes cooled in desiccators and weighed (W_2). This will then ignited at 600°C, cooled and reweighed (W_3).

$$\%\text{ Crude fibre} = \frac{\text{W2} - \text{W3}}{\text{W2} - \text{W1}} \; x\; 100$$

Where: W_1 is the sample weight; W_2 is the sample weighed with the dish after drying; W_3 is the sample weighed with the dish after being ignited

Carbohydrate content (by difference): Carbohydrate content was determined by subtracting the value of the analyzed components, i.e. moisture content, protein, crude fat, ash content, and crude fibre. 100 - % (crude protein + total ash + crude fibre + crude fat + moisture content)

Functional properties of flour blends

Bulk density (BD): Bulk density was determined by the method described by Ade *et al*. (2012). 5 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped on the laboratory bench manually until a constant volume was obtained. The bulk density (g /ml) was calculated as the weight of flour (g) divided by flour volume (ml).

$$\text{Bulk density} = \frac{\text{weight of sample (g)}}{\text{volume of sample (ml)}}$$

Water Absorption Capacity (WAC): Water absorption capacity was determined by the method described by Ade *et al*. (2012). Ten millilitres of distilled water was added to 1 g of each sample in beakers. The suspension was stirred for 5 mins. The suspension obtained was thereafter centrifuged (Bosch Model No TDL-5, Germany) at 1415 RCF rpm for 30 minutes and the supernatant was measured in a 10 ml graduated cylinder. The density of water was taken as 1.0 g/cm^3. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant.

Oil Absorption Capacity (OAC): Oil absorption capacity was determined by the method described by Ade *et al*. (2012). Ten millilitres of soybean oil were added to 1g of each sample in beakers and allowed to stand at ambient temperature (30°C) for 30 min, then thereafter centrifuged (Bosch Model No TDL-5, Germany) at 1415 RCF for 30 minutes and the supernatant was measured in a 10 ml graduated cylinder. Oil absorbed was calculated as the difference between the initial volume of oil added to the sample and the volume of the supernatant.

Emulsion capacity (EC): The emulsion capacity of the samples was determined by the method described by Adebowale *et al*. (2015). One (1 g) gram of sample, 10 ml of distilled water and 10 ml of soybean oil were prepared in a calibrated centrifuged tube. The emulsion was centrifuged at 448 RCF for 5 minutes and the ratio of the height of the emulsion layer to the total height of the mixture was calculated as emulsion capacity in percentage.

Least Gelation Concentration (LGC): Gelation concentration was determined by the method described by Ade *et al*. (2012). Test tubes containing suspension of 2-20% w/v of samples prepared in 5ml distilled water were heated for 1hr in boiling water followed by cooling in ice and further cooling for 2 hours at 30°C. The least gelation concentration was the one at which the sample did not fall or slip when the test tube was inverted.

Vitamin composition determination of flour blends

Vitamin A: Vitamin A was determined as described by Chukwuma *et al*. (2016). Two (2) g of each sample was weighed into a flat bottom reflux flask. 10 ml of distilled water was added and shaken carefully to form a paste. 25 ml of alcoholic KOH solution was added and a reflux condenser was attached. The above mixture was heated in a boiling water bath for 1 hour with frequent shaking. The mixture was cooled rapidly and 30 ml of water was added. The hydrolysate obtained was transferred into a separatory funnel. The solution was extracted three times with 250 ml quantities of chloroform. Two (2) g anhydrous Na_2SO_4 was added to the extract to remove any traces of water. The mixture was then filtered into a 100 ml volumetric flask and made up to mark with chloroform. Standard solution of ß-carotene Vitamin A of range 0 – 50 µg/ml with chloroform by dissolving 0.003 g of standard ß-carotene in 100 ml of chloroform. The above gradients of different standard solutions prepared were determined with reference to their Absorbances from which the average gradient was taken to calculate Vitamin A (ß-carotene in µg/100 g). Absorbances of the sample and standards were read on the Spectrophotometer (Metrohm Spectronic 21D Model) at a wavelength of 328 nm. Calculations:

$$\text{Vitamin A (µg/100 g)} = \frac{\text{Absorbance of sample x Dilution factor}}{\text{Wt. of sample}}$$

Thiamine (Vitamin B_1): Thiamine content was determined as described by Thomas *et al*. (2020). The thiamine content of the samples was determined by weighing 1 g of the sample into a 100 ml volumetric flask with the addition of 50 ml of 0.1M H_2SO_4 and boiled in a boiling water bath with frequent shaking for 30 minutes. Five millilitres (5 ml) of 2.5 M sodium acetate solution was added and the flask was set in cold water to cool contents below 50 ^{0}C. The flask was stoppered and kept at 45-50°C for 2 hours and thereafter made up to the 100 ml mark. The mixture was filtered through a No. 42 Whatman filter paper, discarding the first 10 ml. Ten millilitres (10 ml) was pipetted from the remaining filtrate into a 50 ml volumetric flask, and 5 ml of acid potassium chloride solution was added with thorough shaking. Standard thiamine solutions were prepared and treated the same way. The absorbance of the samples as well as that of standards was read on a fluorescent UV Spectrophotometer (Cecil A20 Model, USA) at 285 nm.

Riboflavin (Vitamin B_2): Riboflavin content was determined as described by Thomas *et al*. (2020). One (1 g) gramme of each sample was weighed into a 250 ml volumetric flask. 5 ml of 1M HCl was added, followed by the addition of 5 ml of dichloroethene. The mixture was shaken and 90 ml of deionized water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 minutes to extract all the riboflavin. The mixture was then cooled and made up to volume with de-ionized water. It was then filtered, discarding the first 20 ml of the aliquot. Two millilitres (2 ml) of the filtrate obtained was pipetted into another 250 ml volumetric flask

and made up to mark with de-ionized water. Samples were read on the fluorescent spectrophotometer at a wavelength of 460 nm. Standard solutions of riboflavin were prepared and readings were taken at 460 nm. The sample riboflavin was obtained through calculation.

Niacin (Vitamin B_3): Five (5 g) gram of sample was extracted with 100 ml of distilled water and 5 ml of this solution was drawn into a 100 ml volumetric flask and made up to the mark with distilled water. Standard solutions of niacin were prepared and the absorbance of the sample and standard solutions was measured at a wavelength of 385 nm on a spectrophotometer, and niacin concentration of the sample was estimated (Thomas *et al*., 2020).

Pantothenic acid (Vitamin B_5): Pantothenic acid content of the sample was determined by extracting 1 g of the sample with distilled water, filtered and 5ml of aliquot of the sample filtrate thoroughly mixed with 5ml of 12% KBr and 10 ml of $KMnO_4$ solutions. The mixture was warmed in a boiling water bath for 10 minutes, cooled in ice for 5 minutes and 20% freshly prepared H_2SO_3 solution was added dropwise to obtain a colourless solution. To the colourless solution, 10 ml of 2, 4 - dinitrophenyl hydrazine (5 g/l) was added and mixed thoroughly. The mixture was then heated on a steam bath for 15 minutes and cooled to room temperature to obtain a yellow precipitate. The precipitate was dried for 30 minutes in an oven at 100°C and dissolved in a hot pyridine solution with thorough mixing to form a homogenous suspension. The suspension was filtered through a Whatman No 42 filter paper into a 50 ml volumetric flask and made up to mark with pyridine solution. To this solution was added 50 ml distilled water, followed by adding 5 ml of 5M NaOH solution. The absorbance of the sample and standard solutions of panthothenic acid were read on a spectronic 21D spectrophotometer at 570 nm, and sample content was calculated in µg /100 g of sample (Thomas *et al.,* 2020).

Vitamin E (Tocopherol): Vitamin E was determined as described by Chukwuma *et al*. (2016). 1 g of sample was weighed into a 250 ml conical flask filtered with a reflux condenser. 10 ml of absolute alcohol and 20 ml of IM alcoholic Sulphuric acid were added. The condenser and flask were wrapped in aluminium foil and refluxed for 45 minutes and cooled for 15 min. 50 ml of distilled water was added to the mixture and transferred to a 250 ml separating funnel covered with aluminium foil. The unsaponifiable matters in the mixture were extracted with 5 x 30 ml dimethyl ether. The combined extracts were washed free of acid and dry evaporated at a low temperature and the residues obtained were immediately dissolved in 10 ml absolute alcohol. Aliquots of solutions of the sample and standards (0.3-3.0 mg vitamin E) were transferred to a 20ml volumetric flask, 5ml Absolute Alcohol added, followed by a careful addition of 1 ml conc. HNO_3. The flasks were placed on a water bath at 90 °C for exactly 3 minutes from the time the alcohol began to boil. Cool rapidly under running water and adjust to volume with absolute alcohol. Measure the Absorbance at 470 nm against a blank containing 5ml absolute alcohol and 1ml conc. HNO_3 was treated in a similar manner.

$$\text{Vitamin E } (\mu g/100\ g) = \frac{\text{Absorbances of sample x gradient factor x Dil. Factor}}{\text{Wt. of sample}}$$

Ascorbic acid (vitamin C): Ascorbic acid in the samples was determined by titrating the aqueous extract of each sample with solution of 2, 6 - dichlorophenol-indophenol dye to a faint pink end point (Thomas *et al.,* 2020).

Mineral composition of the flour blends

Mineral analyses were determined using the standard illustrated by Coțovanu *et al*. (2022). The analysis of the sample involved two stages: the mineralization of the sample and the metal dosage by spectrophotometry. During mineralization, the organic matter in the sample (5.00 ± 0.001 g) was destroyed by carbonization and combustion in the calciner, with the temperature gradually increasing from 250 °C to 450 °C, up to 900 °C, for 8 h. A total of 5 mL HCl 6 mol/L (STAS 13013/1-91) was added to the ash obtained, and then the acid was evaporated using a sand bath. The residue was dissolved with 730 µL HNO_3 69% and brought to the mark (50 mL) with deionized water. As a control sample, deionized water was used following the same procedure as for the analyzed sample. The spectrophotometric determination involved the following steps: activating the cathode lamp corresponding to the elements (Ca, Fe and Zn), adjusting the operational parameters, activating and adjusting the flame, and establishing the curve standard by absorbing four working standard solutions of different concentrations. In the flame system used, the nebulizer and the atomizer play a decisive role: the nebulizer aspirates a liquid sample with a controlled flow and the atomizer creates a fine aerosol and mixes the aerosol with the oxidizing gas. The mineral elements are expressed as mg/100 g of flour and were calculated with Equation below:

$$E = C \cdot F \cdot VM$$

Where: E = mineral element concentration, mg/100 g; C = the concentration measured on the calibration curve, mg/L; F = dilution factor; V = sample volume, mL; M = sample mass taken in the analysis, g.

Phytochemical content of flour blends

Carotenoids

Total carotenoid concentration was quantified according to

Rodriguez-Amaya and Kimura (2004). Briefly, 1 g fresh sample was homogenized in 20 mL acetone and the supernatant was decanted. This process was repeated until attaining complete removal of all pigments. The sample was filtered and washed with 30 mL acetone, the acetone evaporated and the dry sample dissolved in 60 mL petroleum ether. The resulting solution was filtered, transferred quantitatively to a 100 mL volumetric flask, and volume completed with petroleum ether. Of this solution, 2 mL was placed in a test tube with 8 mL petroleum ether. Absorbance was read at 475 nm (Thermospectronic Genesis 10 uv, Madison, Wi, USA) and concentration was calculated with a β-carotene curve.

Alkaloids

This was determined by the method of Tiwari *et al*. (2011). 5 g of sample (w_0) was weighed into a conical flask and 200 ml of 10% acetic acid in ethanol was added. The flask was shaken and left to stand for 4 h. The content was filtered and the filtrate evaporated to about a quarter of its original volume. A few drops of ammonium hydroxide were added to precipitate (ppt) the alkaloid. The ppt was trapped by filtering through a previously weighed filter paper (W_1). The filter paper was dried at 60°C and the final weight was recorded as W_2

$$\text{The percentage (\%)alkaloid } = \frac{(W_2 - W_1)}{W_o} x\ 100$$

Flavonoids

This was estimated by the method of Mahajan and Badujar, (2008). 1 g of the sample was weighed into a conical flask and 50 ml of 80% methanol was added. The flask was placed on a hot plate at a low temperature for 30 min accompanied by shaking. After 30 min, the mixture was cooled and filtered into a volumetric flask and made up to mark with 80% methanol. 3 ml of the filtrate was taken into a test tube and 0.1 ml of 10% aluminium chloride, and 0.1 ml sodium potassium tartrate was added followed by the addition of 3 ml of distilled water. The test tube was shaken and absorbance read at 415 nm with a uv visible spectrophotometer using 80% methanol as blank. The flavonoid content was computed by extrapolating the absorbances obtained down the concentration a six of a routing standard obtained from the same procedure or an existing rutin standard graph obtained from the same procedure.

Total phenol content

Total phenol content was determined as described by Khasanah *et al*. (2023). Phenol was extracted by adding 10 ml of ethanol to 1 g of sample in a conical flask. The flask was cocked and shaken vigorously for 30 min and filtered. The filtrate was used for the total phenol assay. 1.00 ml of the ethanolic extract was taken into a tube and 0.5 ml 2 N Folin – Ciocalteu reagent, 1.5 ml 7% sodium carbonate were added and made up to 10 ml with water. The mixture was shaken properly and left for 90 minutes for colour development after which the absorbance was read at 765 nm using a uv visible spectrophotometer. The phenol content was obtained by extrapolating the absorbances obtained down the concentration a six of a tannic acid standard graph obtained from similar procedure or an existing tannic acid standard graph obtained from similar procedure. The phenol content was reported in mg/kg TAE.

Tannin

This was determined according to the method described by Yusuf (2019). About 0.5 g of each sample was mixed with about 2 ml of water and heated on a water bath. The mixture was filtered and about 1 ml of 10% FeCb solution was added to the filtrate. A blue-black solution indicated the presence of tannins.

Steroids

This was carried out by the addition of 4 ml of acetic anhydride to 1 g of each of the crude extracts (separately) with further addition of H_2SO_4 (2 ml). The presence of steroids was indicated by the change of colour from violet to blue or green (Yusuf, 2019).

RESULTS AND DISCUSSION

The proximate composition result of quality protein maize (QPM) and soursop seeds flour blends are depicted in Table 1. The moisture contents of the flour blends varied significantly ($p<0.05$) from 9.88 to 14.66% with flour from sample MFM having the highest moisture content (14.66%) while the least moisture content (9.88%) was observed in flour from 100% quality protein maize (sample MQS). Significantly ($p<0.05$), increase in moisture contents of the flour blends was observed with increased soursop seeds flour supplementation. The moisture contents of the flour blends are in line with the recommended level of 10 – 15% for moisture contents of flour-based food products (Agbamafle, 2019; Sogo-Temi *et al.*, 2023). The flour blends could therefore have low spoilage microbial proliferation potentials, thus, a pointer to longer shelf stability. The findings of the current study are in line with 12.75 – 16.62% for moisture contents of from maize, rice, millet fortified with soybean and tiger nut studied by Lawrence (2022), 9.08 – 10.95% for moisture

Table 1. Proximate composition of quality protein maize (QPM) and soursop seeds flour blends.

Proximate composition (%)	MQS	MPM	MMM	MSM	MFM
Moisture	9.88±0.01^{e}	10.12±0.01^{d}	10.52±0.02^{c}	12.99±0.01^{b}	14.66±0.00^{a}
Total Ash	1.97±0.01^{e}	2.26±0.01^{d}	2.52±0.02^{c}	3.79±0.01^{b}	5.62±0.02^{a}
Crude Protein	9.97±0.01^{e}	10.07±0.03^{d}	11.89±0.01^{c}	13.99±0.01^{b}	14.49±0.01^{a}
Crude Fat	5.14±0.02^{e}	5.78±0.02^{d}	5.92±0.01^{c}	6.46±0.02^{b}	8.89±0.01^{a}
Crude Fibre	3.23±0.02^{e}	5.77±0.01^{d}	6.06±0.02^{c}	6.97±0.02^{b}	8.24±0.01^{a}
Carbohydrate	79.71±0.02^{a}	76.13±0.03^{b}	73.63±0.05^{c}	68.81±0.02^{d}	62.78±0.04^{e}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at $p<0.05$. Key: MQS = 100% Quality protein maize, MPM = 90% quality protein maize + 10% soursop seeds flour, MMM = 82.5% quality protein maize + 17.5% soursop seeds flour, MSM = 75% quality protein maize + 25% soursop seeds flour, MFM = 67.5% quality protein maize + 32.5% soursop seeds flour.

contents of croissants from wheat-fermented Bambara flour blends by Arise *et al.* (2020) and 11.70 – 13.28% for moisture contents of wheat-bambara groundnut flour blends studied by Barakat (2021).

Ash content is an estimate of the total mineral content in a given quantity of food substance (Kumsa and Haile, 2020). The total ash contents of the flour blends ranged from 1.97 to 5.62% with flour supplemented with 32.5% soursop seeds flour (sample MFM) having the best total ash content (5.62%) while the lowest total ash content (1.97%) was observed in sample MQS (100% Quality protein maize). There were significant variations at a 95% confidence level between the total ash contents of the flour blends. The result showed a significant ($p<0.05$) increase in total ash contents of the flour blends at varying levels of soursop seeds flour supplementation. Ash is an index of minerals in foods; hence, flour supplemented with 32.5% soursop seeds flour (sample MFM) could offer the most minerals than other flour blends. This is indicative of the mineral content potentials in soursop fruit that can act as inorganic co-factors (Iheanacho and Udebuani, 2009; Osei *et al.*, 2023). The results are comparable to 2.05 – 3.06% for ash contents of acha-mushroom flour blends studied by Ayo *et al.* (2018), 0.82 – 2.81% for ash contents of maize-cassava-soybean composites researched by Igbua *et al*. (2018) and 0.82 – 2.97% reported for ash contents of lafun-pigeon pea flour blends researched by Bolaji *et al.* (2021).

Proteins are essential nitrogenous compounds needed by both man and animal for growth, development and repair of damaged tissues, they do so by providing crucial body nutrients, maintaining body fluid balance and contributing to body immune function and enzyme formation (Nwakife *et al.*, 2021). The crude protein contents of the flour blends varied significantly ($p<0.05$) from 9.97 to 14.49% with flour from sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the best crude protein content (14.49%) while the lowest value (9.97%) was observed in flour from 100% quality protein maize flour (sample MQS). An increase in crude protein contents of the flour blends was observed, significantly ($p<0.05$), with an increase in soursop seeds flour inclusion. An inherent crude protein content of 18.43% in soursop seeds has been reported in soursop seeds (Odunayo, 2020); thus, a pointer to the increase in protein contents observed in the flour blends. The results of the current study are comparable to 7.30 – 9.77% for protein contents of yellow maize, soybeans and jack bean flour blends studied by Meka *et al.* (2019), 8.01 – 14.16% for protein contents of wheat-tiger nut flour blends researched by Senya *et al.* (2021) but lower than 16.32 – 28.34% for protein contents of soybean-wheat flour blends studied by Awuchi (2019).

The mean score values for the crude fat contents of the flour blends varied from 5.14 to 8.89% with flour from sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the best crude fat content (8.89%) while the lowest crude fat content (5.14%) was observed in MQS (100% quality protein maize). There were significant variations at a 95% confidence level between the crude fat contents of the flour blends. Increase in soursop seeds flour, significantly ($p<0.05$), were observed with increase in soursop seeds flour addition. This is attributed to the high fat contents 37.54% inherent in soursop seeds (Osei *et al*., 2023). The findings of the current work are in line with the findings of other workers; 6.29 – 9.52% for fat contents of yellow maize, soybeans and jackfruit seed flour blends studied by Meka *et al.* (2019), 6.07 – 11.30% for lipid contents of aerial yam-soybean flour blends studied by Umoh (2020) but lower than 17.22 – 17.84% for fat contents of acha-mushroom flour blends by Ayo *et al.* (2018). Fat is essential component of tissues and a veritable source for fat soluble vitamins (A, D, E and K). It is able to supply thrice the amount of energy required by the body. It also plays a role in determining the shelf-life of foods (Ayo *et al*., 2018).

Dietary fibre is imperative for human digestive health and proper bowel motility. It also assists to full the stomach for extended time, improves blood sugar and cholesterol levels and helps in ameliorating diseases including bowel cancer, diabetes and heart disease (Iwanegbe *et al.*, 2019). The crude fibre contents of the flour blends ranged from 3.23 to 8.24% with flour from sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having

Table 2. Functional properties of quality protein maize (QPM) and soursop seeds flour blends.

Functional properties (%)	MQS	MPM	MMM	MSM	MFM
Water absorption capacity (%)	107.44±0.01^{e}	109.97±0.04^{d}	111.86±0.01^{c}	113.22±0.00^{b}	116.78±0.01^{a}
Oil Absorption capacity (%)	97.98±0.02^{e}	98.16±0.07^{d}	99.77±0.01^{c}	100.47±0.02^{b}	102.85±0.06^{a}
Solubility (%)	9.97±0.01^{e}	11.45±0.02^{d}	13.55±0.30^{c}	15.78±0.02^{b}	17.67±0.01^{a}
Swelling Capacity (%)	49.67±0.02^{a}	47.78±0.02^{b}	45.92±0.01^{c}	43.46±0.02^{d}	41.89±0.01^{e}
Gelation capacity (%)	0.73±0.02^{e}	0.97±0.01^{d}	1.06±0.02^{c}	2.67±0.02^{b}	3.27±0.70^{a}
Bulk density (g/ml)	0.88±0.01^{e}	1.12±0.01^{d}	2.24±0.01^{c}	3.76±0.00^{b}	5.79±0.01^{a}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at $p<0.05$. Key: MQS = 100% Quality protein maize, MPM = 90% quality protein maize + 10% soursop seeds flour, MMM = 82.5% quality protein maize + 17.5% soursop seeds flour, MSM = 75% quality protein maize + 25% soursop seeds flour, MFM = 67.5% quality protein maize + 32.5% soursop seeds flour.

the highest crude fibre content (8.24%) while the least crude fibre content (3.23%) was observed in sample MQS (100% Quality protein maize). Significantly ($p<0.05$), the result showed increase in crude fibre contents of the flour blends with increase in soursop seeds flour inclusion. Except for MQS, the crude fibre contents of the soursop seeds flour-enriched flour blends are not in conformity with the recommended crude fibre (≤5%) contents of foods by Codex standard (Gemede, 2020). The values are higher than 0.91 – 2.80% reported for crude fibre contents of flour blends from unripe plantain, soybean and ginger studied by Iwanegbe *et al.* (2019) but in line with 3.83 – 7.94% for crude fibre contents of fermented millet, sesame and moringa seeds flour blends studied by Disseka *et al.* (2018).

The carbohydrate contents of the flour blends differed significantly ($p<0.05$) from 62.78 to 79.71% with sample MQS (100% Quality protein maize) having the highest carbohydrate content (79.71%) while the least value (62.78%) was observed in flour incorporated with 32.5% soursop seeds flour (sample MFM). Significantly ($p<0.05$), the result showed decrease in carbohydrate contents of the flour blends with increased soursop seeds flour addition. This could be attributed to the inherent crude protein content of 18.43% in soursop seeds have been reported in soursop seeds which may have reduced the carbohydrate contents (Odunayo, 2020). Similar findings have been reported for the reduction in carbohydrate contents 65.07 – 69.02% of wheat-soursop flour blends granola studied by Deedam *et al*. (2020). The results are in consonance with 72.87 – 74.56% for carbohydrate contents of wheat, ripe and unripe plantain flours by Vivienne *et al.* (2015), 66.64 – 83.69% for carbohydrate contents of plantain-watermelon rind composites by Adegunwa *et al.* (2020) and 57.03 – 62.50% for carbohydrate contents of wheat, banana and pigeon pea composite flour blends studied by Adejumo *et al.* (2020). The high carbohydrate contents of the composite flours in this study are of advantage as they will provide the energy needed to do work (Sogo-Temi *et al.*, 2023).

The functional properties result of protein maize and soursop seeds flour blends are shown in Table 2. Functional properties are the essential physicochemical properties of foods that reflect the complex interactions between the structures, molecular conformation, compositions, and physicochemical properties of food components with the nature of the environment and conditions in which these are measured and associated (Suresh and Samsher, 2013; Siddiq *et al*., 2020).

The water absorption capacity of the flour blends varied significantly ($p<0.05$) from 107.44 to 116.78% with sample D (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest water absorption capacity (116.78%) while the least value (107.44%) was observed in 100% Quality protein maize (sample MQS). There was significant ($p<0.05$) increase in the water absorption capacity of the flour blends with an increased in soursop seeds four supplementation. The findings of the current study are lower than 3.25 – 4.50% for water absorption capacity of tapioca-moringa seeds flour blends by Olanrewaju *et al.* (2023), 158 – 183% reported for water absorption capacity of wheat-acha-pigeon pea flour blends studied by Adeyanju *et al.* (2018) and 125 – 170.5 g/100 g for water absorption capacity of tapioca-soy flour blends by Otegbayo *et al.* (2013).

Oil absorption capacity (OAC) is the ability of the flour to absorb and retain oil and reflects the emulsifying capacity of the flour thus it will contribute to the flavour that gives mouth feel and increases the soft texture to the mouth (Oulaï *et al*., 2014; Zainol *et al.*, 2020). The oil absorption capacity of the flour blends differed significantly at a 95% confidence level from 97.98 to 102.85%. Sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) had the highest oil absorption capacity (102.85%) while the least oil absorption capacity (97.98%) was observed in sample MQS (100% Quality protein maize). Increase in the oil absorption capacity of the flour blends, significantly ($p<0.05$), were observed with increased in soursop seeds flour addition. The findings of the current study are lower than 191.20 – 206.80% for the oil absorption capacity of millet-sesame-moringa seeds flour blends studied by Disseka *et al.* (2018).

Solubility is an index of protein functionality such as denaturation and its potential applications (Omueti *et al.*,

2009). The solubility of the flour blends varied from 9.97 to 17.67% with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest solubility (17.67%) while the least value for solubility (9.97%) was observed in 100% quality protein maize (sample MQS). There were significant differences ($p<0.05$) between the solubility of the flour blends with increase solubility values directly related to increased levels of soursop seeds flour inclusion. The findings of the current study are comparable to 16.16 – 20.23% reported for the solubility index of yam-soy flour blends by Olu *et al.* (2012), 12.86 – 21.04% for the solubility index of whole wheat-sweet potato-based composite flour by Chiedu *et al.* (2023).

The swelling capacity of the flour blends differed significantly ($p<0.05$) from 97.98 to 102.85%. Sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) had the highest oil absorption capacity (102.85%) while the least oil absorption capacity (97.98%) was observed in sample MQS (100% Quality protein maize). Increase in oil absorption capacity of the flour blends, significantly ($p<0.05$), were observed with increased soursop seeds flour addition. This is not in tandem with the findings of Ahemen *et al.* (2018) whose study reported increase in swelling capacity of 1.13 – 1.34% of wheat-tigernut-defatted sesame composite flour with increased tiger nut flour supplementation.

The least gelation concentration (LGC) expresses the quantity of flour needed per volume to obtain a gel (Agume *et al.*, 2017). The gelation capacity of the flour blends varied significantly ($p<0.05$) from 0.73 to 3.27% with flour sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest gelation capacity (3.27%) while the least gelation capacity (0.73%) was observed in sample MQS (100% Quality protein maize). Increase in gelation capacity of the flour blends, significantly ($p<0.05$), were observed with increase in soursop seeds flour addition. The findings of the current study are lower than 6 – 12% reported for least gelation capacity of sorghum-cocoa powder *ogi* flour studied by Odunlade *et al*. (2016). The low level of least gelation capacity is however desirable since low least gelation concentration will lead to increase in viscosity (Omobolanle *et al.*, 2014).

The bulk density (BD) is very critical to evaluate floury products regarding its weight, handling requirement, and the type of packaging materials suitable for storage and transportation of the food materials (Ohizua *et al*., 2017; Oppong *et al.*, 2015). The bulk density of the flour sample ranged from 0.88 to 5.79 g/ml with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest bulk density (5.89 g/ml) while the least bulk density (0.88 g/ml) was observed in sample MQS (100% Quality protein maize). The result showed significant ($p<0.05$) improvements in the bulk density of the flour blends with an increased in soursop seeds flour supplementation. The results are higher than 0.63 – 0.79 g/ml reported for wheat, sweet potato and African yam bean composite flour by Ibrahim and Stephen (2022) but slightly in line with 3.92 – 4.43 g/ml for bulk density of wheat-sweet potato-based composite flour by Chiedu *et al.* (2023). The high bulk densities observed in the study could be attributed to the tight structure of the starch polymer of the composite flour (Ekunseitan *et al.*, 2017). High bulk density of the composite flour in the current study may not be desirable where less quantity is required to meet the nutritional requirements of consumers. Also, this may not aid easy packing and transportation of food products (Aluge *et al.* 2016).

Table 3 depicts the vitamin composition result of quality protein maize (QPM) and soursop seeds flour blends. The vitamin A contents of the flour blends varied significantly ($p<0.05$) from 5.55 to 8.45 mg/100 g with sample MF< (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest vitamin A content (8.45 mg/100 g) while the least vitamin A content (5.55 mg/100 g) was observed in 100% quality protein maize (sample MQS). Increase in soursop seeds flour supplementation, significantly ($p<0.05$), resulted in increase in vitamin A contents of the flour blends. This could be attributed to soursop being a rich source of vitamin A (Olagunju and Sandewa, 2018). The results of the current study are higher than 0.46 – 0.56 µg/100 g reported for provitamin contents of wheat flour-plantain-velvet bean flour blends researched by Adebayo *et al*. (2024). Vitamin A helps to improve vision as it contains β-carotene and prevents xerophthalmia (Rehman *et al.*, 2014; Oluchi *et al.*, 2024).

The mean results for vitamin B1 (thiamin), contents of the flour blends varied significantly ($p<0.05$) from 0.77 to 2.93 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest vitamin B1 content (2.93 mg/100 g) while the lowest vitamin B1 content (0.77 mg/100 g) was observed in sample MQS (100% quality protein maize). Increased in soursop seeds flour supplementation, significantly ($p<0.05$), improved the vitamin B1 contents of the flour blends. The findings of the current study are higher than 0.018 – 0.034 mg/100 g reported for vitamin B1 contents of plantain-tiger nut composite flour blends researched by Adegunwa *et al.* (2020) but slightly in tandem with 0.14 – 1.43 mg/100 g reported for thiamin contents of African yam bean-corn seeds flour blends bread studied by Henry-Unaeze and Amadi (2022). Thiamine is involved in energy release during carbohydrate and fat metabolism (Gropper and Smith, 2009).

The vitamin B2 contents of the flour blends ranged from 0.36 to 4.78 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest vitamin B2 (4.78 mg/100 g) while the lowest vitamin B2 content (0.36 mg/100 g) was observed in sample MQS (100% Quality protein maize). There were significant differences ($p<0.05$) between the vitamin B2 contents of the flour blends. Increased levels of soursop seeds flour supplementation resulted in increase in the vitamin B2 contents of the flour blends. The results are not

Table 3. Vitamin composition of quality protein maize (QPM) and soursop seeds flour blends.

Vitamin composition (mg/100 g)	MQS	MPM	MMM	MSM	MFM
Vitamin A	5.55±0.01^{e}	6.14±0.03^{d}	6.97±0.02^{c}	7.95±0.04^{b}	8.45±0.01^{a}
Vitamin B1	0.77±0.01^{e}	1.08±0.01^{d}	1.88±0.01^{c}	2.07±0.02^{b}	2.93±0.01^{a}
Vitamin B2	0.36±0.03^{e}	0.98±0.01^{d}	2.33±0.00^{c}	3.14±0.04^{b}	4.78±0.01^{a}
Vitamin B3	1.87±0.01^{e}	2.25±0.04^{d}	3.36±0.04^{c}	4.15±0.06^{b}	5.49±0.01^{a}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at p<0.05. Key: MQS = 100% Quality protein maize, MPM = 90% quality protein maize + 10% soursop seeds flour, MMM = 82.5% quality protein maize + 17.5% soursop seeds flour, MSM = 75% quality protein maize + 25% soursop seeds flour, MFM = 67.5% quality protein maize + 32.5% soursop seeds flour.

Table 4. Mineral composition of quality protein maize (QPM) and soursop seeds flour blends.

Mineral composition (mg/100 g)	MQS	MPM	MMM	MSM	MFM
Calcium	45.55±0.01^{e}	46.77±0.01^{d}	48.14±0.04^{c}	50.34±0.01^{b}	53.67±0.01^{a}
Magnesium	123.78±0.02^{e}	124.08±0.01^{d}	125.88±0.01^{c}	126.07±0.02^{b}	128.93±0.01^{a}
Iron	7.67±0.03^{e}	9.98±0.01^{d}	11.33±0.00^{c}	13.14±0.04^{b}	15.78±0.01^{a}
Zinc	4.86±0.02^{e}	7.98±0.02^{d}	9.57±0.01^{c}	12.56±0.01^{b}	14.57±0.03^{a}
Copper	1.68±0.01^{e}	2.14±0.04^{d}	2.88±0.01^{c}	3.15±0.04^{b}	4.88±0.01^{a}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at p<0.05. Key: MQS = 100% Quality protein maize, MPM = 90% quality protein maize + 10% soursop seeds flour, MMM = 82.5% quality protein maize + 17.5% soursop seeds flour, MSM = 75% quality protein maize + 25% soursop seeds flour, MFM = 67.5% quality protein maize + 32.5% soursop seeds flour.

in consonance with 0.67 – 0.79 mg/g reported for vitamin B2 contents of wheat-plantain-velvet bean composite flour blends researched by Adebayo *et al.* (2024).

Vitamin B3 contents of the flour blends varied significantly at a 95% confidence level from 1.87 to 5.49 mg/100 g with flour supplemented with 32.5% soursop seed flour (sample MFM) having the best vitamin B3 content (5.49 mg/100 g) while the lowest vitamin B3 content (1.87 mg/100 g) was observed in sample MQS (100% Quality protein maize). Significantly (p<0.05), increase in vitamin B3 contents of the flour blends were observed with increased soursop seeds flour inclusion. The vitamin B3 content of the flour blends (0.59 – 0.71 mg/100 g) is not in agreement with what was reported for vitamin B3 contents of plantain flake studied by Akinsola *et al.* (2021).

The selected mineral composition results of quality protein maize (QPM) and soursop seeds flour blends are presented in Table 4. Calcium contents of the flour blends differed significantly (p<0.05) from 45.55 to 53.67 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest calcium content (53.67 mg/100 g) while the lowest calcium content (45.55 mg/100 g) was observed in 100% quality protein maize (sample MQS). The findings of the current study are lower than 112.40 – 116.49 mg/100 g reported for calcium contents of wheat flour, native/modified starch and *Moringa oleifera* seed flour blends researched by Okereke *et al.* (2021). Calcium, as reported by Weaver and Heaney (2006), is a micronutrient essential to health and wellbeing, which performs diverse biological functions in the human body. It serves as a second messenger for nearly every biological process, stabilizes many proteins and in deficient amounts is associated with many diseases.

The magnesium contents of the flour blends varied significantly (p<0.05) from 123.78 to 128.93 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the best magnesium content (53.67 mg/100 g) while the least magnesium content (123.78 mg/100 g) was observed in sample MFM (100% quality protein maize). The findings of the current study are higher than 50.63 – 56.50 mg/100 g for magnesium contents of whole wheat, sweet potato, defatted peanut and rice bran flour blends studied by Chiedu *et al.* (2023).

The mean results for the iron contents of the flour blends varied from 7.67 to 15.78 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest iron content (15.78 mg/100 g) while the lowest iron content (7.67 mg/100 g) was observed in sample MQS (100% Quality protein maize). The results are higher than 0.60 – 0.88 mg/100 g obtained for iron contents of instant plantain flake enriched with egg parts flour studied by Akinsola *et al.* (2021), 0.25 – 0.67 mg/100 g for iron contents of plantain-tigernut composite flour blends by Adegunwa *et al.* (2020). Iron has several functions in the human body which include; being a constituent of the haemoglobin molecule – 70 %, myoglobin stored in muscles, an activating molecule of several enzymes and found in storage molecules such as ferritin and hemosiderin while iron deficiency anaemia is

Table 5. Phytochemical properties of quality protein maize (QPM) and soursop seeds flour blends.

Phytochemical properties	MQS	MPM	MMM	MSM	MFM
Total Phenolic (mgGAE/100 g)	95.55±0.01^{e}	97.77±0.01^{d}	99.16±0.01^{c}	104.12±0.01^{b}	109.55±0.02^{a}
Total Flavonoid (mg/100 g)	5.08±0.01^{e}	6.88±0.01^{d}	8.68±0.01^{c}	10.07±0.02^{b}	14.13±0.03^{a}
Tannin (mg/100 g)	13.58±0.02^{e}	14.98±0.01^{d}	15.75±0.03^{c}	16.78±0.01^{b}	18.24±0.03^{a}
Phytate (mg/100 g)	87.35±0.01^{e}	88.57±0.03^{d}	89.17±0.01^{c}	90.53±0.02^{b}	92.89±0.01^{a}

Values are mean ± standard deviation of duplicate determinations. Data with different superscripts along the same row are significantly different at p<0.05. Key: MQS = 100% Quality protein maize, MPM = 90% quality protein maize + 10% soursop seeds flour, MMM = 82.5% quality protein maize + 17.5% soursop seeds flour, MSM = 75% quality protein maize + 25% soursop seeds flour, MFM = 67.5% quality protein maize + 32.5% soursop seeds flour.

characterized by small red cells with low haemoglobin.

The phytochemical properties result of quality protein maize and soursop seeds flour blends are presented in Table 5. The total phenolic contents of the flour blends varied significantly (p<0.05) from 95.55 to 109.55 mgGAE/100 g with sample MFM having the highest total phenolic content (109.55 mgGAE/100 g) having the highest total phenolic contents (109.55 mgGAE/100 g) while the least total phenolic content (95.55 mgGAE/100 g) was observed in sample MQS (100% Quality protein maize). The result showed significant (p<0.05) increase in total phenolic contents of the flour blends with increased soursop seeds flour addition. This is beneficial as phenolic compounds have been reported to be highly effective free radical scavengers and antioxidants (Chika *et al.*, 2016). Similar findings have been reported by Hossain *et al.* (2022) whose study reported significant increase in total phenolic contents for biscuits from pumpkin peel, flesh and seeds powders at 15% supplementation.

Total flavonoid contents of the flour blends ranged from 5.08 to 14.13 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest total flavonoid (14.13 mg/100 g) while the least total flavonoid content (5.08 mg/100 g) was observed in sample MQS (100% quality protein maize). Significant (p<0.05) increase in total flavonoid contents of the flour blends were observed with increased quality protein maize supplementation were observed. The results are lower than the 17.0 – 33.74 mg/g reported for total flavonoid contents of wheat-banana-prickly pear biscuits studied by Mahloko *et al.* (2019) but higher than 20.3 – 33.4 µg/g dw reported for total flavonoid contents of buckwheat-amaranth-quinoa bread researched by Chlopicka *et al.* (2012).

Tannin contents of the flour blends differed significantly (p<0.05) from 13.58 to 18.24 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest tannin content (18.24 mg/100 g) while the lowest value for tannin (13.58 mg/100 g) was observed in sample MQS (100% Quality protein maize). The result showed significant (p<0.05) increase in tannin contents of the flour blends with increase in soursop seeds flour inclusion. The results obtained in the current study are higher than 0.02 – 0.03 mg/100 g reported for tannin contents of fermented bambara nut flour by Ola and Opaleye (2019).

Phytate contents of the flour blends differed significantly at a 95% confidence level from 87.35 to 92.35 mg/100 g with sample MFM (67.5% quality protein maize + 32.5% soursop seeds flour) having the highest phytate content (92.35 mg/100 g) while the lowest phytate content (87.35 mg/100 g) was observed in 100% quality protein maize flour (sample MQS). Increase in phytate contents of the flour blends were observed, significantly (p<0.05), with increased soursop seeds flour addition. The findings of the current study are higher than 0.85 – 1.40 mg/100 g reported for phytate contents of African yam bean-cassava flour blends studied by Isaac-Bamgboye *et al.* (2020). Phytate, when at higher concentration, possesses anti-nutritional activities in human diets due to its strong ability to chelate zinc, calcium and iron to form insoluble complexes which are not absorbed, hence, contributing to zinc and iron deficiencies (Isaac-Bamgboye *et al.*, 2020).

Conclusion

The study investigated the effect of soursop seed and quality protein maize flour blends. This shows that supplementation of quality protein maize with soursop seeds flour improved virtually all the parameters analyzed. However, increase in soursop seeds flour inclusion, especially at 32.5% gave the best nutritional and antinutritional values for the flour blends. The need for utilization of quality protein maize with soursop seeds flour blends in food formulations is hereby recommended for the overall health promotion of consumers.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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