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Chemical Properties of Mango Kernel and Seed and Production of Biscuit From Wheat-mango Kernel Flour Blends

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ABSTRACT

Mango seed and kernel are regarded as waste and have been underutilized in the food industry. This study investigated the physicochemical and antioxidant properties of mango kernel and seed flour. In addition, mango kernel flour was employed as composite flour for biscuit production. Proximate composition of mango seed and kernel include; protein (3.58%-10.48%), fat (10.01%-18.00%), crude fibre (2.48%-2.63%) and carbohydrate (64.57%-75.80%). The result of functional properties of flour from mango seed revealed that the seed possessed oil (2.80 g/ml) and water absorption capacities (4.00g/ml) that were significantly higher than that of the kernel. However, the mineral analysis showed that mango kernel had values that were significantly higher than that of the seed in calcium (896.40 mg/100g: 4122.45 mg/100g), potassium (540.50 mg/100g: 376.27 mg/100g) and magnesium (814.53 mg/100g: 474.44 mg/100g). Antioxidant activities exhibited by mango kernel were significantly higher when compared to that of mango seed in the ability to scavenge 1,1-diphenyl-2-picrylhydrazyl (98.10%; 74.70%), ferric reducing properties(72.18 mg/100g; 52.65 mg/100g), flavonoid content (42.36 mg/100g; 19.01 mg/100g) and phenol (1222.13 mg/100g; 512.33 mg/100g). The proximate composition of the biscuits produced using wheat flour and mango kernel flour in different ratios;95%:5%, 90%:10% and 85%:15% revealed that biscuits from composite flour had protein content that were significantly higher than that of 100% wheat flour (control). Sensory results showed that biscuits from wheat- mango kernel flour were scored above average for overall acceptability.

Keywords: antioxidant activity; biscuit; mango seed and kernel; physicochemical property

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INTRODUCTION

Mango (*Mangifera indica*) is utilized for many purposes such as the young fruits whose tegument have not yet hardened, are used in Asiatic countries as a vegetable, fresh or pickled. In Latin American countries, slightly unripe pulp is eaten with some salt. Ripened fruits are eaten fresh everywhere, to make juice or marmalade, also dried and made into candy. Mango seed kernel is a nutritional promising seed because of its high levels of carbohydrate and oil. Kaura *et al*. (2004) found that amylose content of mango kernel starch was observed to be lower than those of corn and potato starches. Mango seed is very rich in vitamins, some minerals, glutamate, methionine, arginine, phenylalanine/tyrosine while lysine is the limiting amino acid (Fowomola, 2010). Mango seed is richer in vitamins than cassava (Okigbe, 1980). The presence of antioxidant vitamins C, E and A suggests that mango seed could be used as an alternative source of these vitamins.

Several studies have shown that mango seed kernels contain various phenolic compounds and can be a good source of natural antioxidants (Puravankara *et al*., 2000; Abdalla *et al*., 2007). In addition, polyphenols from mango seed kernels were found to contain tannins, gallic acid, coumarin, ellagic acid, vanillin, mangiferin, ferulic acid, cinammic acid (Arogba, 1997). Composite flours from plant sources have been employed in the production of bread, biscuits or cookies (Olagunju and Ifesan, 2013; Nwosu *et al*., 2014; Ifesan *et al*., 2015).

Considerable amounts of mango seeds are discarded as waste and they account for 35%–55% of the fruit depending on the variety (Bhalerao *et al*., 1989). Furthermore, when discarded they constitute nuisance to the society and also a source of pollution. Research reports on proximate, mineral composition of mango seed is documented (Fowomola, 2010). However, there is dearth of literature on the use of mango seed or kernel in confectionery industry. Therefore we carried out this work to investigate the chemical composition of mango seed and kernel and the acceptability of wheat-mango kernel biscuits.

MATERIALS AND METHOD

Sources of Materials

Ripe mangoes *(Mangifera indica)* were purchased from the local market in Akure, Ondo State, Nigeria. All other reagents used were of analytical grade.

Production of Mango kernel and seed flour

The mangoes were sorted, washed and both the peel and the pulp were manually removed from the mango using knife. The kernels were broken open manually and the seeds were removed. Both the mango seed and mango kernel were individually rinsed with water, oven dried at 50ºC and then milled into fine flour. The flours were kept in air tight plastic containers at room temperature during the analyses.

Determination of proximate analysis of flour from mango seed, kernel and wheat-mango kernel biscuit

The method of AOAC (2005) was used to determine the percentages of moisture contents, protein, crude fibre, fat and carbohydrate in the flours and biscuit.

Determination of functional properties of mango seed and kernel flours

Bulk density was estimated as described by Monterio and Prakash (1994). Water and oil absorption capacities of flours were measured using centrifugation method (AOAC 2005). Dispersibillity of mango seed and kernel flour was determined following AOAC (2005). About 15 g of the flour sample was measured into a 1000 ml measuring cylinder, 90 ml of water was added and the solution was allowed to stand for 3 h. The final volume after 3 h was determined. Dispersibility was determined by subtracting the final volume from 100%.

Determination of mineral content of mango seed and kernel flour

The dry ashing technique as described by Oshodi and Fagbemi (1992) was used for the determination of mineral composition (calcium, potassium, magnesium, iron and sodium) of mango seed and kernel flour.

Determination of phytochemical and antioxidant properties of mango seed and kernel

flours

Determination of tannin content: About 0.2 g of flour sample was weighed into a 50 ml sample bottle. Ten milliliter of 70% aqueous acetone was added and properly covered. The bottles were placed in an ice bath shaker for 2 h at 30 ^{0}C. Each solution was then centrifuged and the supernatant stored in ice. About 0.5 ml of Folin Ciocateau reagent was added to both sample and standard (tannic acid solution) followed by 2.5 ml of 20% Na_2CO_3 the solutions were vortex and allowed to incubate for 40 min at room temperature. Absorbance was read at 725 nm against a reagent blank concentration of the same solution from where a standard tannic acid curve was prepared (Makkar and Goodchild, 1996).

Determination of phytate content: Phytate content of sample was determined according to the method of Wheeler and Ferrell (1971). Four grams of sample was soaked in 100 ml of 2% HCl for 3 h and then filter through a No 1 What man filter paper. About 25 ml was taken out of the filtrate and placed in a conical flask and 5 ml of 0.3% of ammonium thiocyanate solution was added as indicator. After which 53.5 ml distilled water was added to give it the proper acidity and this was titrated against 0.00566g per milliliter of standard iron (III) chloride solution that contain about 0.00195 g of iron per ml until a brownish yellow coloration persist for 5min.

Determination of oxalate content: Oxalate was determined by the method of Day and Underwood (1986). One gram of flour sample was soaked in 75 ml of 1.5N H_2SO_4 for an hour and then filtered through a No 1 Whatman filter paper. About 25 ml was taken out of the filtrate and placed inside a conical flask and this was titrated hot (80-90^{o}C) against 0.1M $KMnO_4$ until a pink color that persisted for 15 s was obtained.

Water Extract Preparation: Five gram of mango seed and kernel flour were individually blended with 25 ml distilled water and allowed to stand at room temperature for about 24 h. Aqueous extract was obtained by filtering the mixture using a Whatman No 1 filter paper and the supernatant was used for antioxidant assays.

Determination of Total phenolic contentof mango seed and kernel flour: The total phenol content of the extract was determined using the method reported by Singleton *et al*. (1999). Appropriate dilutions of the extracts were oxidized with 2.5 ml of 10% Follin-Coicalteau's reagent (v/v) and neutralised by 2.0 ml of 7.5% sodium carbonate. The reaction mixture was incubated for 40 mins at 45 ^{o}C and the absorbance was read at 765 nm in the spectrophotometer. The total phenol content was subsequently calculated.

Determination of Total Flavonoid content mango seed and kernel flour: The total flavonoid content of the extracts were determined using a slightly modified method reported by Bao *et al*. (2005). Briefly, 0.5 ml appropriately diluted sample was mixed with 0.5 ml methanol, 50 **µl of 10% $AlCl_3$**, 50 **µl of 1M potassium acetate**, 1.4 ml water, and allowed to incubate at room temperature for 30mins.The absorbance of the reaction mixture was subsequently measured at 415 nm.

Determination of ferric reducing properties (FRAP) mango seed and kernel flour: The reducing property of the extracts were determined by assesing the ability of the extract to reduce $FeCl_3$ solution as described by Oyaizu (1986). A 2.5 ml aliquot was mixed with 2.5 ml of 200 Mm sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide. The mixture was incubated at 50 ^{o}C for 20 min, and then 2.5 ml of 10% trichloroacetic acid was added. This mixture was centrifuged at 650 rpm for 10 min.Then 5 ml supernatant was mixed with an equal volume of water and 1 ml of 0.1% ferric chloride. The absorbance was measured at 700 nm and ferric reducing antioxidant property was calculated.

Determination of 1,1-diphenyl-2-picrylhydrazyl(DPPH) free radical scavenging activity: The free radical scavenging ability of the extracts against DPPH free radical was evaluated as described by Gyamfi *et al* .(1999). An appropriate dilution of the extracts (1 ml) was mixed with 1 ml of 0.4 mM methanolic solution containing DPPH radicals, the reaction mixture was left in the dark for 30 mins and the absorbance was taken at 517 nm.

Composite Flour Formulation

Three composite flour blends were formulated and were prepared by mixing varying proportions of wheat flour and mango kernel flour as

Table 1: Formulation for the wheat-mango kernel composite flour

Composite flour	Wheat flour (WF) (%)	Mango kernel (MK) flour (100%)
Wheat flour (WF)	100	0
95%WF:5%MK	95	5
90%WF:10%MK	90	10
85%WF:15%MK	85	15

Table 2: Proximate composition (%) of mango kernel and seed flour

Parameters	Mango kernel flour	Mango seed flour
Moisture	3.33 ± 0.76^{b}	6.33 ± 0.29^{a}
Protein	10.48 ± 0.20^{a}	3.58 ± 0.76^{b}
Fat	18.00 ± 2.00^{a}	10.01 ± 2.00^{b}
Crude fibre	2.48 ± 0.10^{b}	2.63 ± 0.08^{a}
Ash	1.14 ± 0.02^{b}	1.65 ± 0.02^{a}
Carbohydrate	64.57 ± 1.63^{b}	75.80 ± 1.92^{a}

Values with different superscripts along rows are statistically significant $p\leq0.05$

Table 3: Functional properties of mango kernel and seed flour

Properties	Mango kernel flour	Mango seed flour
Oil absorption capacity (g/ml)	1.20 ± 0.10^{b}	2.80 ± 0.10^{a}
Water absorption capacity (g/ml)	2.60 ± 0.21^{b}	4.00 ± 0.11^{a}
Bulk density (g/ml)	2.55 ± 0.05^{a}	1.55 ± 0.12^{b}
Dispersibility (%)	40.49 ± 0.60^{b}	59.00 ± 1.01^{a}

Values with different superscripts along rows are statistically significant $p\leq0.05$

Table 4: Mineral composition (mg/100g) of mango kernel and seed flour

Mineral	Mango kernel flour	Mango seed flour
Calcium	896.40 ± 0.53^{b}	4122.45 ± 0.39^{a}
Potassium	540.50 ± 0.50^{a}	376.27 ± 0.25^{b}
Magnesium	814.53 ± 0.50^{a}	474.44 ± 0.52^{b}
Iron	70.33 ± 1.53^{b}	294.30 ± 0.10^{a}
Sodium	102.15 ± 0.13^{b}	344.14 ± 0.13^{a}

Values with different superscripts along rows are statistically significant $p\leq0.05$

shown in Table 1.

Production of biscuits from Wheat Flour and mango kernel flour

Biscuits were produced as described by Olagunju and Ifesan (2013).The raw materials used include flour (wheat and mango kernel flour) (100 g), sugar (10 g), margarine (30 g), salt (2 g), sodium bicarbonate (1 g),water (50 ml), milk (10 g), vanilla flavour (2 ml). These were weighed appropriately and two stage creaming up method was used. All the ingredients except flour were mixed thoroughly in a Kenwood mixer (a 3-speed hand mixer), it was then transferred to a bowl. The flour and sodium bicarbonate was added with continuous mixing for 15 min until smooth dough was obtained. A piece of this dough was cut, placed on a clean platform then rolled out using rolling pin until the desired uniform texture and thickness of 0.44 cm was obtained. Biscuit cutter was used to cut the sheet of the dough into required shapes and sizes. These were transferred on to a greased (with margarine) baking tray. The baking was done at 200ºC and baked for 15 – 20 min. After baking, the hot biscuits were removed from the pan and placed on a clean tray to cool down. The biscuits were then packed after cooling in polyethylene satchets using an impulse sealing machine prior to further analysis.

Physical Characteristics of Biscuit

The weight, diameter, spread ratio and breakability of the baked biscuits were determined as described by Ayo et al. (2007)

Sensory Evaluation

Biscuits made from wheat and mango kernel composite flour were subjected to sensory evaluation using twenty (20) panelists drawn within the University community. Biscuits were evaluated for taste, aroma, crispiness, colour and overall acceptability. The ratings were on a 9-point hedonic scale ranging from 9 (like extremely) to 1 (dislikeextremely) (Solomakos *et al.,* 2005). The control was biscuit made from 100% wheat flour. The mean scores were calculated using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Proximate composition of mango kernel and seed flour

The moisture content of mango seed (6.33%) was higher than that of mango kernel (3.33%) (Table 2). The moisture content of a food is indicative of the dry matter in that food. However, low residual moisture content in flour product is advantageous in that microbial proliferation is reduced and storage life may be prolonged if stored inside appropriate packaging materials under good environmental conditions. Mango kernel flour possessed protein and fat content of 10.48%; 18.00% that were significantly higher than 3.58% and 10.01% of the seed flour, and the ash content from 1.14%-1.65%. The crude fibre (2.48%-2.63%) and very high content of carbohydrate 64.57%-75.80%. Result revealed that mango seed and kernel flour were higher in protein than cassava and plantain (2.63%; 2.30%) and in fibre than wheat flour (0.82%) and cassava flour (1.88%) (Mepha *et al*., 2007; Nwosu *et al*., 2014). The values for proximate composition recorded in this study are within the range previously reported (Kayode *et al*., 2013).

Functional properties of Mango kernel and seed flour

Functional properties are those parameters that determine the application of food material for various food product development. The values of water absorption capacity ranged from 2.60 g/ml – 4.00 g/ml (Table 3). The water absorption capacity of the mango kernel flour was lower than that of mango seed, which may be an indication that the higher fibre content recorded from mango seed flour held more water when compared to the kernel. This observation is in agreement with that reported by Abdalla *et al.* (2007). Dispersibility which is an index of the ease of reconstitution of flour in water is found to be higher in mango seed (59.00%) than the kernel flour (40.49%). However, the values for dispersibility are relatively medium high for flour samples, hence, they will easily reconstitute to give fine consistency dough during mixing (Adebowale *et al.*, 2008). The bulk density of the flour samples were from1.55g/ml-2.55g/ml. The bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, raw material handling and application in wet processing in the food industry (Adebowale *et al*., 2008;

Table 5: Phytochemical and antioxidant (mg/100g) properties of mango kernel and seed flour

Properties	Mango kernel flour	Mango seed flour
Phytate	39.01±1.01[a]	12.73±0.42[b]
Oxalate	3.39±0.18[a]	2.69±0.94[b]
Tannin	816.7±0.12[a]	766.71±0.65[b]
Phenol	1222.13±0.28[a]	512.33±0.15[b]
Flavonoid	42.36±0.11[a]	19.01±0.32[b]
Ferric reducing property (FRAP)	72.18±0.35[a]	52.65±0.62[b]
Free radical scavenging (DPPH)	98.10±0.43[a]	74.70±0.31[b]

Values with different superscripts along rows are statistically significant p≤0.05

Table 6: Proximate composition (%) of wheat-mango kernel biscuit

Parameters	100%WF	95%WF:5%MK	90%WF:10%MK	85%WF:15%MK
Moisture	6.00±1.00[a]	5.67±3.31[a]	5.23±0.06[a]	4.89±1.27[a]
Ash	2.25±0.02[c]	2.30±0.01[c]	2.36±0.02[b]	2.44±0.01[a]
Crude fibre	1.85±0.01[b]	1.77±0.01[c]	1.96±0.10[a]	1.64±0.01[d]
Protein	9.74±0.01[c]	10.12±0.60[b]	11.76±0.02[a]	11.93±0.13[a]
Fat	3.73±0.02[b]	3.97±0.01[b]	4.40±0.08[a]	4.63±0.01[a]
Carbohydrate	76.43±0.01[a]	76.17±0.01[a]	74.29±0.02[b]	74.47±0.01[b]

Values with different superscripts along rows are statistically significant p≤0.05

WF: wheat flour; MK: mango kernel

Table 7: Physical properties of wheat-mango kernel biscuit

Parameters	100%WF	95%WF:5%MK	90%WF:10%MK	85%WF:15%MK
Diameter (cm)	22.57±0.45[a]	20.53±0.67[b]	22.44±0.09[a]	22.45±0.60[a]
Height (cm)	2.86±0.25[b]	3.00±0.12[ab]	3.29±0.25[a]	2.93±0.37[ab]
Weight (g)	3.81±0.03[b]	3.54±0.01[c]	3.62±0.03[c]	4.46±0.09[a]
Spread ratio	7.94±0.82[a]	6.85±0.06[b]	6.84±0.52[b]	7.65±0.29[ab]

Values with different superscripts along rows are statistically significant p≤0.05

WF: wheat flour; MK: mango kernel

Table 8: Sensory attributes of wheat-mango kernel biscuit

Sensory parameters	100%WF	95%WF:5%MK	90%WF:10%MK	85%WF:15%MK
Taste	7.80±1.14[a]	5.80±2.09[b]	6.00±1.89[b]	5.20±2.39[b]
Colour	7.20±1.14[a]	6.70±0.95[ab]	6.50±0.85[ab]	5.90±1.73[b]
Aroma	7.40±1.65[a]	6.30±1.25[b]	6.60±1.08[b]	6.20±1.10[b]
Overall acceptability	7.70±0.82[a]	6.30±0.95[b]	6.10±1.10[b]	5.60±2.07[c]

Values with different superscripts along rows are statistically significant p≤0.05

WF: wheat flour; MK: mango kernel

Ajanaku *et al.,* 2012). Oil absorbing capacity of mango seed 2.80g/ml is significantly higher than that of mango kernel (1.20g/ml). Oil absorbing capacity (OAC) is an important factor in food rancidity, spoilage and flavour retention capability. The higher the OAC the better the capability of retaining flavour and the higher the chances of it going rancid.

Mineral composition of Mango kernel and seed flour

Table 4 shows that mango seed and kernel are rich in mineral, containing sodium (344.14 mg/100g; 102.15 mg/100g), potassium (376.27 mg/100g; 540.50 mg/100g), calcium (4122.45 mg/100g; 896.40 mg/100g), magnesium (474.44 mg/100g; 814.53 mg/100g), iron (294.30 mg/100g; 70.33 mg/100g). Mango seed is a good source of calcium when compared with that of cassava (Bede, 2010). Mango kernel contains higher calcium and iron than yellow maize (Dakare *et al*., 2010). Potassium and iron are essential nutrients and has important function in blood formation and synthesis of amino acids and proteins (Kittiphoom, 2012).

Phytochemical and antioxidant properties of mango kernel and seed flour

The phytochemical composition of mango kernel and seed flour shown on Table 5 revealed that the kernel possessed higher values than the seed. Phytate content (39.01 mg/100g; 12.73mg/100g), oxalate from 2.69 mg/100g-3.39 mg/100g and tannin (816.7 mg/100g; 766.71 mg/100g). The values obtained in this study are higher than those reported by Fowomola (2010) and lower than that of Kayode *et al*. (2013). Tannin form complexes with dietary proteins and carbohydrates, as well as with enzymes (Naurato *et al*., 1999) and reduce the absorption of minerals such as iron and copper (Samman *et al.*, 2001). However, chelation of these metals could sometimes be beneficial as this is one of the mechanisms by which phenolic compounds exert their antioxidant activity (Bravo, 1998). Mango kernel contained higher concentration of flavonoid and phenol (42.36 mg/100g; 1222.13 mg/100g) when compared to the seed (19.01mg/100g; 512.33 mg/100g). Mango kernel has potent antioxidant activity with relatively high phenolic contents (Soong *et al.*, 2004). Mango kernel demonstrated DPPH radical scavenging ability and FRAP of 98.10 mg/100g and 72.18 mg/100g compared to mango seed (74.70 mg/100g; 52.65 mg/100g). The high antioxidant capacity observed in mango kernel is in line with previous reports (Kittiphoom *et al*, 2012; Ashoush and Gadallah, 2011).

Proximate composition and physical properties of wheat-mango kernel biscuit

The result of the proximate composition of the wheat flour, wheat flour (95%) + mango kernel flour (5%), wheat flour (90%) + mango kernel flour (10%), wheat flour (85%) + mango kernel flour (15%) showed that the wheat flour had the highest moisture content of (6.00%) followed by that of wheat flour (95%) + mango kernel flour (5%) (5.67%) while the wheat flour (85%) + mango kernel flour (15%) had the lowest value with 4.89% (Table 6). The decrease in moisture content with increase in level of substitution showed the certainty of prolonging the shelf-life of the product. It was observed that the protein content increased from 9.74 to 11.93% as the amount of mango kernel flour used increased. This result corroborates earlier reports of mango kernel as a good source of protein (Dakare *et al*., 2010). The carbohydrate content of the composite biscuit decreased with increased levels of mango kernel flour in the composite flours. For crude fibre, there is no significant difference p0.05 between control and wheat flour (90%) + mango kernel flour (10%) while there is a significant difference p0.05 between control, wheat flour(95%) + mango kernel flour(5%) and wheat flour (85%) + mango kernel flour (15%). The fat content of the biscuit increased from 3.73% to 4.63%, which increased with increasing composition of mango kernel. It has been reported that mango kernel contain high amount of fat (Dakare *et al.,* 2010). The ash content of the biscuit also increased with increase in composition of mango kernel flour. The control has the highest percentage of carbohydrate followed by wheat flour (95%) + mango kernel flour (5%), wheat flour (90%) + mango kernel flour(10%) then wheat flour (85%) + mango kernel flour (15%).

Data on physical characteristics of biscuit as affected by incorporation of mango kernel flour are presented in Table 7. In general, incorporation of mango kernel flour affected the diameter, thickness and weight of corresponding biscuit. Diameter of the control (100:0 wheat flour) was 22.57

cm while it reduced gradually to 20.53 cm with 95:5 mango kernel flour incorporation. Thickness and spread ratio of control was 2.86 cm and 7.94 for the control respectively, both parameters increased for (95:5) and (85:5) mango kernel flour incorporation. Weight of the control biscuit was 3.81g and increased to 4.46g with incorporation of mango kernel flour. **Sensory Attributes of wheat- mango kernel biscuit**

Table 8 reveals the sensory attributes of biscuit from various blends of wheat flour and mango kernel flour. The addition of mango kernel decreased the mean score of taste (7.80 to 5. 20), colour (7.20-5.90), aroma (7.40 to 6.20) and overall acceptability (7.70-5.60). It was observed that the control was significantly scored higher than those of wheat-mango kernel biscuit. However, biscuits made from 5%-15% mango kernel flour were scored above average.

Conclusion

The physicochemical and phytochemical analyses carried out on mango kernel and seed revealed that they could be good source of balanced food material which could be utilized in food production especially confectionary industry. The utilization of mango kernel flour with wheat to produce biscuit resulted to a biscuit with improved protein content. Further study should be carried out to investigate the ability of the wheat-mango kernel biscuit to serve as a functional food.

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