Asian Food Science Journal

Volume 23, Issue 2, Page 1-12, 2024; Article no.AFSJ.112808
ISSN: 2581-7752

Blends of Wheat, Mango Kernel and Orange Pomace Flours: Chemical and Functional Properties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2024/v23i2696

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:
https://www.sdiarticle5.com/review-history/112808

Original Research Article

Received: 07/12/2023
Accepted: 12/02/2024
Published: 17/02/2024

ABSTRACT

The study set out to produce composite flour from wheat, mango kernel and orange pomace. Mango kernel and orange pomace were processed into flours and mixed with wheat flour at different proportions of WF:MKF:OPF as follows (100:0:0-A, 60:10:30-B, 60:20:20-C, 60:30:10-D, 60:40:0-E and 60:0:40-F). The flours produced were analyzed for functional properties, anti-nutrient, and proximate. The functional properties of flours ranged as follows; bulk density (0.41-0.85 g/cm^3), swelling capacity (1.26-1.47 g/mL), oil absorption capacity (1.16-3.80 g/L), water absorption capacity (1.70-5.80 mL/g), and foaming capacity (0.05-2.50 %). The gelatinization temperature ranged from 62.50-88.50^{o}C while the least gelation concentration ranged from 6.30-8.87 %. The anti-nutritional properties of phytates, oxalate and tannin were as follows; 0.00-0.04 %, 0.08-0.35 %, 0.04-0.08 % for flours. The Proximate composition ranged from 5.58 -10.89 % moisture, 6.34-14.12 % protein, 1.06-1.82% fats, 0.24-0.66 % fiber, 1.42-5.01% ash, 71.77-85.37% carbohydrates and 337.90-376.39 kcal/100g

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energy for flour samples. This research indicates that orange pomace at 10 % and mango kernel at 30 % flour blends could serve as functional and nutritional ingredients in foods with 60 % wheat respectively.

Keywords: Functional ingredients; mango kernel; orange pomace; composite flour.

1. INTRODUCTION

“Waste produced from the processing of fruits and vegetables is in the form of pomace, peels, and seeds amounting to about 25 – 30 % and is grossly underutilized” [1]. “However, these by-products are important sources of sugars, minerals, organic acids, fiber, phytochemicals (such as flavonoids and carotenoids), and phenolic compounds that have a wide range of nutritional sensory qualities” Claudia et al, (2014).

Many fruits including Mango (*Mangifera indica*) and oranges (*Citrus sinensis*) are only consumed in part with the fleshy portions of eaten raw processed into juice while the peels, seeds and pomace are often thrown away. During orange juice production for instance, only around half of the fresh orange weight is transformed into juice Matouk et al, [2]. “generating huge amounts of residues (peel, pulp, seeds) known as orange pomace which is rich in nutrients and fiber”. “During the processing of ripe mango, its peel and seed are generated as waste, which is approximately 40-50 % of the total fruit weight” Ashoush and Gadallah, [1]. This high volume of waste is in most cases, spread on soil in areas adjacent to the production site for use as raw material in animal feeds, decay and waste away or just burnt away. The latter method of waste handling significantly contributes to environmental pollution with its attendant health hazards.

“Interestingly, these by-products from both mango kernel and orange pomace can be used to add value to wheat as composite flour for quality improvement. Composite flours are a mixture of flours from tubers rich in starch (e.g. cassava, yam, sweet potato) and/or protein rich flours (e.g. soy, peanut) and /or cereals (e.g. maize, rice, millet, buckwheat), with or without wheat flour.” In another words, “A flour made by blending or mixing varying proportions of more than one non-wheat flour with or without wheat flour and used for the production leavened or unleavened baked or snack products that are traditionally made from wheat flour and increase the essential nutrients in the human diet is called composite flour” (Suresh et al, 2015).

Wheat flour is the most important ingredient in baked goods owing to its one-of-a-kind ability to build a coherent gluten network when mixed with water Egwujeh et al., [3] but is limited by its high cost, as the climatic conditions and soil type in Nigeria are not conducive for its cultivation Falola & Oloyede, [4]. Substituting flours from other crops and fruits such as orange and mango (especially the parts that constitute wastes), for wheat flour will increase the nutritional composition of the snack, making it more appealing, affordable, and beneficial to the population's health.

The increased number of studies to improve the ways to extract maximum value from food by-products, add them back into foods, and reduce their environmental impact represents a key strategy. Furthermore, it is in agreement with the Food and Agriculture Organization of the United Nations [5] recommendations, “to prevent food waste, to reduce its economic and environmental impact, but finding new uses for food products that end up being discarded”

This work is therefore intended to produce and assess the quality of composite flour from wheat, mango kernel and orange pomace flour.

2. MATERIALS AND METHODS

2.1 Sourcing and Preparation of Raw Materials

Orange and mango fruits were obtained from Yakua’s citrus farm and Gbakorun’s mango farm both in Gboko Local Government, Benue State, Nigeria.

Orange pomace and mango kernel flours were produced as shown Figs 1 and 2. Wheat, orange pomace and mango kernel flour were formulated to obtain six samples as shown in Table1.

2.2 Determination of Functional, Proximate and Antinutritional Properties of the Flours

Functional properties such as bulk density, water absorption capacity, foaming capacity, oil absorption capacity, swelling capacity, gelatinization temperature and least gelation concentration of the flours and their blends were determined according to the method described by Onwuka, [9].

Moisture, fat, crude fiber], protein was determined according to standard methods AOAC, [2005]. Total carbohydrate content was calculated using the following formula.

% carbohydrate =100 - (moisture + Ash + Crude Protein + Crude fat + Crude fibre)   (1)

The energy value was determined using the attwater factor viz.

Energy value (kcal/100g) = 9× % fat + 4 × % protein + 4 × % carbohydrate   (2)

Oxalates and tannin content were determined respectively using the methods according to Krishnaiah et al. [10].

Phytate concentration by the method of Young and Greaves with slight modification was used AOAC, [11].

$$\text{Phytates Acid} = \frac{titre\ value \times 0.00195 \times 1.19 \times 100}{sample\ mass\ (g)} \quad (3)$$

2.3 Statistical Analysis

Statistical Package for Social Science (SPSS) Version 26 computer software was used to analyze the data. All experiments were conducted in triplicates and reported as mean ± standard deviation. Analysis of variance (one-way ANOVA) was used to ascertain any significant differences in the treatments; differences were considered at 95% ($p<0.05$) significant level. The Duncan Multiple Range Tests (DMRT) was used to separate means.

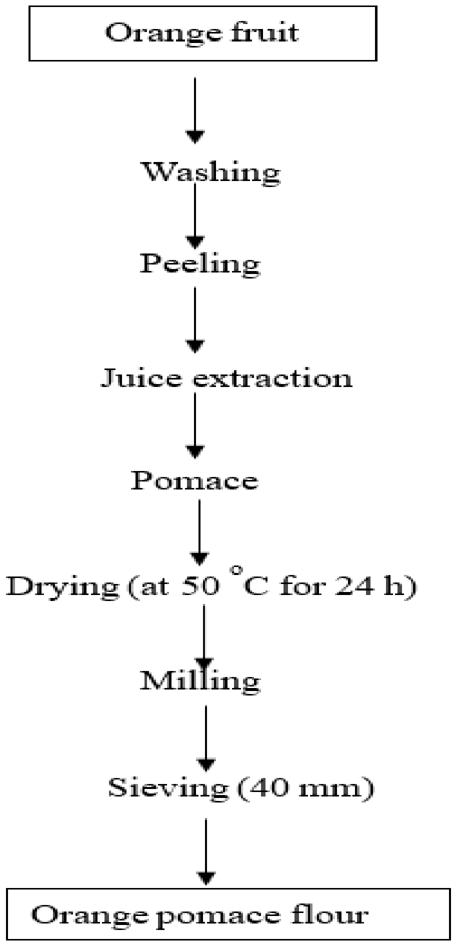

Fig. 1. Flow diagram for the production of orange pomace flour Ogo et al., [6]

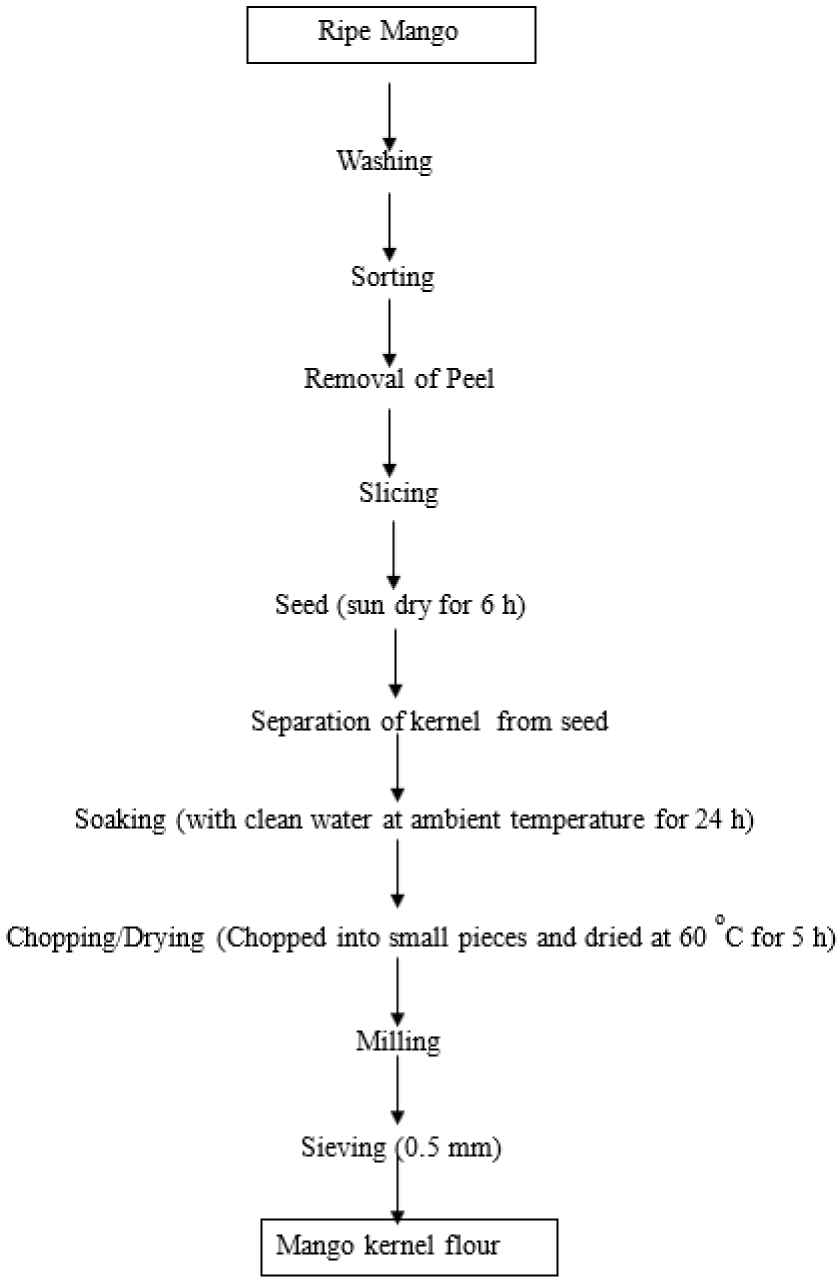

Fig. 2. Flow diagram for the production of Mango Kernel Flour Dakare et al, [7]

Table 1. Flour blend formulation

Sample	Wheat (%)	Orange Pomace (%)	Mango kernel (%)
A	100	0	0
B	60	30	10
C	60	20	20
D	60	10	30
E	60	0	40
F	60	40	0

Source: (Elechi-Jasper et al., [8]

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Wheat, Orange Pomace and Mango Kernel Flour and their Blends

These properties are usually determined by the organoleptic, physical, and chemical properties of the food such as protein content, carbohydrate content, fiber and fat content Juliana & Zhengxing, [12]. Table 2 presents the functional properties of the composite flours.

Water absorption capacity (WAC) is the ability of flour to absorb or retain water. This ability is a very important property for all flours in food preparations. WAC of study flours ranged from 1.76 mg/L (sample A) to 5.80 mg/L (sample E). There was a significant increase (p<0.5) in WAC of flour samples from sample A to E as the level of MKF increased. WAC is a critical function of protein for various food products like dough and biscuits baking [13]. Proteins, fibers and carbohydrates are the major chemical compositions that enhance the water absorption capacities of flours they contain hydrophilic parts such as polar or charged side chains. Therefore, the increase in the WAC of the flour is due to the increase in the protein and fiber content of the flour as it is being substituted with MKF and OPF. A similar trend was observed by Abiodun et al., [14] who used composite flours of wheat, enriched with bambara.

The bulk density (BD) of the flours ranged from 0.47 g/mL (sample C) to 0.85 g/mL (sample E). The bulk density of flour is the mass of many particles of flour material divided by the total volume they occupy. It is also a measure of the heaviness of a flour sample. The BD of a flour is one of the parameters used to determine its s requirements and is a function of the particle size and moisture content of flours Oladele & Aina, [15]. Sample C had the lowest BD while sample E had the highest BD. These results are higher than 0.58-0.61 g/ml as was reported by Legesse & Emire, [16]. This could be due to the fact that as wheat flour was being substituted with MKF and OPF, it led to an increase in the heaviness of the flour at sample E with the highest substitution with 40% MKF.

The oil absorption capacity (OAC) of the flours ranged from 1.16 g/L (sample A) to 3.80 g/L (sample E). OAC is the ability of the fat in flour to bind to the non-polar side chain of proteins. The Oil absorption capacity is an essential functional property that contributes to enhancing mouth feel while retaining the food products' flavor [17]. Significant difference was observed between the composite flour samples and the control sample A. This could be due to the protein content in MKF and OPF as the level of substitution varies. The higher the amount of heat treatment given to a protein, the more hydrophobic the protein becomes, as a result of a higher number of hydrophobic groups exposed through the unfolding of the protein molecules Hasmadi et al., [18]. This could further explain the significant increase (p<0.05) in the OAC of the flours with increase substitution of MKF and OPF. The results of this study agree with those of Chandra et al., [19] and Kaushal et al., [20].

The swelling capacity (SC) of the flours ranged from 1.26 % (sample A) to 1.47 % (sample B), with sample A having the least while sample B had the highest swelling capacity. Different substitution levels with MKF and OPF witnessed a significant variation within the samples (p<0.05) from sample A to sample C. There was a significant (p<0.05) decrease in the swelling capacity between the control sample A and the composite flour samples (B to F). The SC of a flour is a function of the size of particles, types of variety (like the presence of starch) and types of processing methods or unit operations involved in the flour production. The results show a significant increase (p<0.05) in SC from sample A to sample F. This could be due to an enhancement in the flour's ability to absorb water and swell as it reflects the extent of associative forces in the starch granules Godswill et al., [21].

The foaming capacity (FC) of the flours ranged from 0.05 (sample B, C and D) to 2.50 % (sample A). Proteins are mainly responsible for foaming Zhu et al., [22]. Foaming capacity and stability generally depend on the interfacial film formed by the proteins, which maintains the suspension of air bubbles and slows down the coalescence rate Cousminer, [23]. This study recorded a significant increase (p<0.05) in the foaming capacity as the substitution with MKF and OPF varied increased from sample B to sample F. This could be due to the increase in protein content of the flours as MKF and OPF concentration increased. A similar trend was reported by Aburime et al., [24] and Chandra et al., [19].

Gelatinization temperature ranged from 62.50 ºC to 88.50 ºC with sample C having the least gelatinization temperature and Sample A flour having the highest. The temperature reduced with a reduction in MKF flour among the samples. The results were higher than the 65.40 ^{o}C to 71.55 ^{o}C reported by Jimoh, [25]. Gelatinization temperature is the temperature at which the gelatinization of starch takes place. The gelatinization temperature of starch depends on the plant type and amount of water present, pH, salt concentration and types, sugar, protein, and fat in the recipe. Starch gelatinization improves and increases the availability of starch for hydrolysis by amylase. Gelatinization of starch is often used in cooking in food industries to ease starch digestibility and also to thicken/bind water in sauce, soup etc. Awuchi et al, [26].

Least gelation concentration (LGC) measures the minimum amount of flour needed to form a gel in a measured volume of water. It varies from flour to flour depending on the relative ratios of their structural constituents like protein, carbohydrates, and lipids Oladele & Aina, [15]. LGC which varied from 6.30 to 8.87 % increased as the percentage inclusion of MKF and OPF increased. The increasing concentration of protein enhances the interaction among the binding forces which in turn increases the gelling ability of the flour Awuchi, et al, [26]. It was observed that the higher the LGC, the higher the quantity of flour needed to form a gel and the lower the LGC the better the gelling ability of the flour.

3.2 Proximate Composition of the Flours and their Blends

Table 4 displays the proximate composition results for wheat, orange pomace and mango kernel flours, along with their various blends.

The moisture content ranged from 5.58 % (sample A) to 10.89 % in sample E for flours as shown in table 3. For individual flours, orange pomace had 10.73 % while mango kernel had 8.87 %. “There was a significant increase ($p<0.05$) in the moisture content with increasing incorporation of MKF and as the level of OPF reduced” [27] “Moisture content indicates the shelf-stability of a product; such that, the lower the moisture content, the better the shelf stability of such products” Dong et al., [27].

The ash content which is indicative of the level of mineral content of a food material significantly increased ($p < 0.05$) from 3.08 - 3.19 % as substitution with orange pomace and mango kernel flours was made in samples B - F with E 5.01 % having the highest compared to A of 1.42 %. These results which are in agreement with those of Das et al., [28] suggest that the blends of orange pomace 2.47 % and mango kernel 2.61 % must have been responsible for the improved mineral content in the various flour blends in contrast to the sample made from wheat flour alone.

“The substitution of MKF and OPF in wheat resulted to an increase in the fat content from 1.06-1.25 %. The flour blend with 20% MKF (sample E) had the highest fat content while the control sample (sample A) recorded the least. This increase in the fat content differed significantly ($p<0.05$) among all the blended samples. The increase in the fat content could be due to the substitution effect as a result of the fat content in the MKF and OPF” as reported by Khule et al. [29].

Percentage fiber for individual flours ranged from 0.24 % in wheat, 4.07 % in orange pomace and 3.14 % mango kernel. The fiber content for supplemented flours increased significantly from 0.32 % in sample B to 0.66 % in sample E. Crude fiber content of this study were comparable to results of (Das et al., [28].

“The protein content of the flour samples varies significantly with sample A having the least (6.34 %) while the highest was observed in sample F (15.19 %). There was a significant increase ($p<0.05$) in the protein content as the level of incorporation of MKF increased” [27]. This increase in protein content could be justified since the OPF also contains significant protein content of 8.1 %. This tallies with other studies demonstrating that OPF contains significant protein content which can and has been harnessed for food product development [30].

The addition of blends of orange pomace and mango kernel flours decreased the carbohydrate content from about 85.37 % in sample A to 68.51 % in sample E. The increase in the proportion of mango kernel brought about a decrease in the carbohydrate content of the flour samples [31-33].

Interestingly too, the energy content of the flour blend samples ranged from 347.87 kcal in sample F to 376.39 kcal in the control sample (A). There was significant difference ($p<0.05$) in the energy content of the flour samples as the proportion of MKF and OPF increased [34,35].

Table 2. Functional properties of the flours

Sample	BD (g/mL)	WAC (mL/g)	FC (%)	OAC (mL/g)	SC (mL/g)	GT (ºC)	LGC (%)
A	0.70^{c}±0.00	1.70^{a}±0.00	2.50^{e}±0.00	1.16^{a}±0.01	1.26^{b}±0.00	88.50^{f}±0.50	6.30^{a}±0.00
B	0.77^{d}±0.00	4.55^{c}±0.05	0.05^{a}±0.00	2.55^{b}±0.05	1.47^{f}±0.00	63.00^{a}±0.00	8.73^{ef}±0.15
C	0.41^{a}±0.00	5.05^{e}±0.05	0.05^{a}±0.00	2.70^{c}±0.00	1.20^{a}±0.00	62.50^{a}±0.50	8.50^{cd}±0.00
D	0.63^{b}±0.00	4.75^{d}±0.05	0.05^{a}±0.00	3.55^{d}±0.05	1.36^{d}±0.00	64.50^{b}±0.50	8.63^{de}±0.06
E	0.85^{e}±0.05	5.80^{f}±0.10	0.12^{b}±0.01	3.80^{e}±0.00	1.42^{e}±0.00	66.00^{c}±1.00	8.13^{b}±0.12
F	0.79^{d}±0.02	4.55^{c}±0.15	0.54^{d}±0.01	2.62^{bc}±0.11	1.32^{c}±0.03	64.25^{b}±0.25	8.87^{f}±0.06
MKF	0.69^{c}±0.00	5.15^{e}±0.15	0.15^{c}±0.01	4.05^{f}±0.05	1.61^{g}±0.00	85.00^{d}±0.00	8.40^{c}±0.10
OPF	0.67^{c}±0.00	4.15^{b}±0.05	0.05^{a}±0.00	3.85^{e}±0.05	1.74^{h}±0.00	86.50^{e}±0.50	9.70^{g}±0.10

Values within the same column with different superscripts are significantly different at $p<0.05$.

KEY

A: 100% Wheat
B: 60%Wheat flour, 10%MKF, 30%OPF
C: 60%Wheat flour, 20%MKF, 20%OPF
D: 60%Wheat flour, 30%MKF, 10%OPF
E: 60%Wheat flour, 40%MKF, 0%OPF
F: 60%Wheat flour, 0%MKF, 40%OPF
MKF: Mango Kernel Flour
OPF: Orange Pomace Flour

BD: Bulk density
WAC: Water absorption capacity
FC: Foaming capacity
OAC: Oil absorption capacity
SC: Swelling capacity
GT: Gelatinization temperature
LGC: Least gelation concentration

Table 3. Proximate composition of flour blends

Sample	MC %	Ash %	Lipids %	Fiber %	Protein %	CHO %	Energy Kcal/100g
A	$5.58^{a}\pm0.03$	$1.42^{a}\pm0.00$	$1.06^{f}\pm0.01$	$0.24^{a}\pm0.00$	$6.34^{a}\pm0.01$	$85.37^{h}\pm0.03$	$376.39^{h}\pm0.02$
B	$9.73^{c}\pm0.06$	$3.08^{b}\pm0.00$	$1.27^{c}\pm0.00$	$0.32^{b}\pm0.01$	$6.70^{b}\pm0.31$	$79.91^{f}\pm0.32$	$348.83^{g}\pm0.05$
C	$9.66^{c}\pm0.09$	$4.53^{d}\pm0.00$	$1.20^{b}\pm0.00$	$0.50^{d}\pm0.00$	$11.32^{c}\pm0.04$	$73.77^{e}\pm0.05$	$342.23^{e}\pm0.33$
D	$9.87^{d}\pm0.04$	$4.74^{e}\pm0.00$	$1.41^{d}\pm0.00$	$0.55^{e}\pm0.01$	$12.65^{d}\pm0.00$	$71.77^{d}\pm0.03$	$341.36^{d}\pm0.08$
E	$10.89^{f}\pm0.02$	$5.01^{f}\pm0.00$	$1.82^{e}\pm0.06$	$0.66^{f}\pm0.00$	$14.12^{e}\pm0.01$	$68.51^{c}\pm0.08$	$337.90^{c}\pm0.20$
F	$9.76^{cd}\pm0.05$	$3.19^{c}\pm0.02$	$1.25^{bc}\pm0.00$	$0.40^{c}\pm0.01$	$15.19^{a}\pm0.04$	$80.22^{g}\pm0.12$	$347.87^{f}\pm0.32$
MKF	$8.87^{b}\pm0.17$	$2.61^{h}\pm0.06$	$13.18^{g}\pm0.05$	$3.14^{h}\pm0.03$	$9.17^{f}\pm0.10$	$63.03^{a}\pm0.04$	$325.14^{a}\pm0.10$
OPF	$10.73^{e}\pm0.03$	$2.47^{g}\pm0.00$	$1.55^{a}\pm0.00$	$4.07^{g}\pm0.00$	$8.1^{g}\pm0.00$	$66.15^{b}\pm0.03$	$328.24^{b}\pm0.13$

Values within the same column with different superscripts are significantly different at $p<0.05$.

KEY
A: 100% Wheat
B: 60%Wheat flour, 10%MKF, and 30% OPF
C: 60%Wheat flour, 20%MKF, 20%OPF
D: 60%Wheat flour, 30%MKF, 10%OPF
E: 60%Wheat flour, 40%MKF, 0%OPF
F: 60%Wheat flour, 0%MKF, 40%OPF
MKF: Mango Kernel Flour

CHO: carbohydrate
MC: moisture content.
OPF: Orange Pomace Flour

Table 4. Antinutritional composition of flour blends

Sample	Tannins	Oxalates	Phytates
A	$0.04^{a}\pm0.00$	$0.08^{a}\pm0.01$	$0.04^{f}\pm0.00$
B	$0.06^{b}\pm0.00$	$0.21^{b}\pm0.00$	$0.00^{a}\pm0.00$
C	$0.06^{bc}\pm0.00$	$0.27^{d}\pm0.00$	$0.01^{c}\pm0.00$
D	$0.07^{bc}\pm0.00$	$0.27^{d}\pm0.00$	$0.01^{c}\pm0.00$
E	$0.08^{c}\pm0.00$	$0.35^{e}\pm0.01$	$0.01^{c}\pm0.00$
F	$0.07^{bc}\pm0.00$	$0.25^{c}\pm0.00$	$0.00^{b}\pm0.00$
MKF	$0.76^{d}\pm0.02$	$0.97^{g}\pm0.00$	$0.03^{e}\pm0.00$
OPF	$0.84^{e}\pm0.00$	$0.57^{f}\pm0.00$	$0.01^{d}\pm0.00$

Values within the same column with different superscripts are significantly different at $p<0.05$.

KEY
A: 100% Wheat
B: 60%Wheat flour, 10%MKF, 30%OPF
C: 60%Wheat flour, 20%MKF, 20%OPF
D: 60%Wheat flour, 30%MKF, 10%OPF
E: 60%Wheat flour, 40%MKF, 0%OPF
F: 60%Wheat flour, 0%MKF, 40%OPF
MKF: Mango Kernel Flour
OPF: Orange Pomace Flour

3.3 Anti-nutrient content of the Flours and their Blends

The antinutrient content in the composite flours is presented in Table 3.

The phytate content of the flours ranged from 0.00 to 0.04 % as the level of incorporation of MKF increased. When bound to minerals (calcium, iron, magnesium, and zinc), as well as proteins, phytic acid is recognized for its capacity to diminish their accessibility and impair the solubility and functionality of the proteins [36].

The oxalate content of orange pomace flour 0.57 mg/100g and that of mango kernel flour 0.97 mg/100g. The oxalate content of wheat 0.08 mg/100g was far below 35-270 mg/100g for grains. The oxalate content increased significantly ($p<0.05$) for samples with increase of mango kernel flour. The oxalate contents ranged from 0.08 to 0.27 %. There was significant increase in the contents as level of incorporation mango kernel flour increased [37].

The tannin contents ranged from 0.04 to 0.08 % sample A to sample F in flours. Tannins are recognized as anti-nutritional compounds due to their ability to create insoluble complexes with digestive enzymes and hinder the absorption of iron. According to the World Health Organization (WHO), food items with tannin levels below 5 mg per 100 grams are considered safe for human consumption. Consequently, it can be inferred that the tannin content in the wheat, orange pomace flour, and mango kernel flours employed in this research falls within the safe range for consumption.

4. CONCLUSION

This work succeeded in producing flour blends from wheat, orange pomace and mango kernel flours. Sample D (60 % Wheat flour: 30 % mango kernel Flour: 10 % orange pomace Flour) and sample F (60 % Wheat flour: 0 % mango kernel Flour: 40 % orange pomace Flour) were seen to exhibit properties close to those for traditional wheat flour and therefore are recommended for large scale commercial purposes. Substitution of wheat flour with fruit parts (mango kernel and orange pomace) significantly improved the proximate parameters and also better functional properties. The use of these flour blends in suitable proportions in pastry products can potentially enhance dietary quality and minimize post-harvest losses of these fruits as well as reduce the burden on wheat importation and usage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ashoush IS, Gadallah M. Utilization of Mango Peels and Seed Kernels Powders as Sources of Phytochemicals in Biscuit. World Journal of Dairy and Food Sciences. 2011;6(1):35–42.
2. Matouk A. El-Kholy M, Tharwat A. Maximizing the Benefit of Orange Pomace. Journal of Soil Sciences and Agricultural Engineering. 2017;8(9):451-457. DOI:10.21608/jssae.2017.38058
3. Egwujeh SID, Onuh OJ, Yusufu PA, Yakubu A. Evaluation of the Physico-Chemical and Sensory Properties of Biscuit from Wheat and Cricket Flours. Production and Acta Sci. Nutr. Heal. 2017;2(1):03–07.
4. Falola A, Oloyede W. Determinants of Cormmercial Prodution of Wheat: a case study of Bakura Local Government Area, Zamfara State; 2017. Available:https://www.researchgate.net/publication/323698488
5. FAO. Food Wastage Footprint; 2013.
6. Ogo AO, Ajekwe DJ, Enenche DE, Obochi GO. Quality Evaluation of Novel Biscuits Made from Wheat Supplemented with Watermelon Rinds and Orange Pomace Flour Blends. 2021;332–341. Available:https://doi.org/10.4236/fns.2021.123026
7. Dakare MA, Ameh DA, Agbaji AS, Atawodi SE, Anglais AE. Effects of Processing Techniques on the Nutritional and Antinutritional Contents of Mango (*Mangifera indica*) Seed Kernel. 2012; 2:55–59.
8. Elechi Jasper OG, Ene-Obong S, Adamu CS, Nzuta RA, Adejoh BJ. hyyuy. Food and Applied Bioscience Journal. 2022;10(1):1–13.
9. Onwuka GI. Food Analysis and Instrumentation Theory and Practice. Naphthadi prints. A division of Hug Support Nig. Ltd; 2005.
10. Krishnaiah D, Devi T, Bono A, Sarbatly R. Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of

Medicinal Plants Research. 2009;3(2): 067–072.

11. AOAC. Official Methods of Analysis, 17th ed. Washington; 2010)
12. Juliana KR, Zhengxing C. Effects of processing methods on the physico-functional properties of peanut flour (*Arachis hypogaea* L.). In Biotechnology. 2008;7(2):168–174. Available:https://doi.org/10.3923/biotech.2008.168.174
13. Prajapati R, Chandra S. Samsher CN, Singh GR, Kumar S. Effect of incorporation of flours on the functional properties of composite flours. South Asian Journal of Food Technology and Environment. 2015;1(3 & 4):233–241.
14. Abiodun O, AO, Oladeinde OO, Olatunji FI, Adeyeye SAO. Quality Assessment of Doughnut Prepared from Wheat Flour Enriched with Bambara Nut Flour Quality Assessment of Doughnut Prepared from Wheat Flour Enriched with Bambara Nut Flour. Journal of Culinary Science and Technology. 2017;1–14. Available:https://doi.org/10.1080/15428052.2016.1269708
15. Oladele AK, Aina JO. Chemical composition and functional properties of flour produced from two varieties of tigernut (Cyperus esculentus). African Journal of Biotechnology. 2007;6(21): 2473–2476. Available:https://doi.org/10.5897/AJB2007.000-2391
16. Legesse MB, Emire SA. Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. 2012;3:193–203.
17. Iwe MO, Onyeukwu U, Agiriga AN. Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. Cogent Food and Agriculture. 2016;2(1). Available:https://doi.org/10.1080/23311932.2016.1142409
18. Hasmadi M, Noorfarahzilah M, Noraidah H, Zainol MK, Jahurul MHA. Functional properties of composite flour: A review. Food Research. 2020;4(6):1820–1831. Available:https://doi.org/10.26656/fr.2017.4(6).419
19. Chandra S, Singh S, Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology. 2015;52(6):3681–3688. Available:https://doi.org/10.1007/s13197-014-1427-2
20. Kaushal P, Kumar V, Sharma HK. Comparative study of physicochemical, functional, antinutritional and pasting properties of taro (Colocasia esculenta), rice (Oryza sativa) flour, pigeonpea (Cajanus cajan) flour and their blends. LWT - Food Science and Technology. 2012; 48(1):59–68. Available:https://doi.org/10.1016/j.lwt.2012.02.028
21. Godswill C. Somtochukwu V, Kate C. the Functional Properties of Foods and Flours. International Journal of Advanced Academic Research | Sciences. 2019;5(11):2488–9849.
22. Zhu SM, Lin SL, Ramaswamy SH, Yu Y, Zhang QT. Enhancement of Functional Properties of Rice Bran Proteins by High Pressure Treatment and their Correlation with Surface Hydrophobicity. Food and Bioprocess Technology. 2017;10(2):317-327. Available:http://doi.org/10.1007/s11947-016-1818-7
23. Cousminer J. Culinology: Blending Culinary Arts & Food Science. Research Chefs Association, John Wiley and Sons, Inc; 2017.
24. Aburime LC, Ene-Obong HN, David-Oku E. Functional Properties and Sensory Evaluation of “Chinchin” Bread and Biscuits produced from Composite Flours from African Yam Bean, Orange Fleshed Sweet Potatoes, Plantain, Cocoyam, Maize and Wheat. European Journal of Food Science and Technology. 2020;8(4):46–64.
25. Jimoh MO. Quality Evaluation of Cookies Made from Wheat Flour Fortified with Tiger Nut Flour and Date Palm Fruit. European Journal of Food Science and Technology. 2021;9(3):35–52.
26. Awuchi CG, Igwe VS, Echeta CK. The Functional Properties of Foods and Flours. International Journal of Advanced Academic Research. 2019;5(11).
27. Dong O, Emeh TC, Okorie SU. Evaluation of the Quality of Composite Maize-Wheat Chinchin Enriched with Rhynchophorous phoenicis. Journal of Food Research. 2016;5(4):26. Available:https://doi.org/10.5539/jfr.v5n4p26

28. Das CP, Khan MJ, Rahman MS, Majumder S, Islam MN. Comparison of the physico-chemical and functional properties of mango kernel flour with wheat flour and development of mango kernel flour based composite cakes. NFS Journal. 2019;17:1–7. Available:https://doi.org/10.1016/j.nfs.2019.10.001
29. Khule GD, Khupase SP, Giram KK. Development and quality evaluation of orange pomace fortified biscuits. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):3695–3701.
30. Nagarajaiah SB, Prakash J. Chemical Composition and Bioactivity of Pomace from Selected Fruits. International Journal of Fruit Science. 2016;16(4):423–443. Available:https://doi.org/10.1080/15538362.2016.114343
31. Adeleke RO, Odedeji J. Functional properties of wheat and sweet potato flour blends. Pakistan Journal of Nutrition. 2010;9(6):535–538. Available:https://doi.org/10.3923/pjn.2010.535.538
32. Adeyeye SA, Akingbala JO. Quality characteristics and acceptability of cookies from sweet potato–maize flour blends. Nutrition & Food Science. 2015;45(5):703–715.
33. Adeyeye SA, Akingbala JO. Quality characteristics and acceptability of cookies from sweet potato–maize flour blends. Nutrition & Food Science. 2015;45(5):703–715.
34. Bongjo NB, Ahemen SA, Gbertyo JA, Fulai AMA, Nchung L. Nutritional and Functional Properties of Wheat-Defatted Peanut-Orange Peel Composite Flour. European Journal of Nutrition and Food Safety. 2022;14(12):74-86
35. Chinma C, Gernah D. Physicochemical and Sensory Properties of Cookies Produced from Cassava/Soyabean/Mango Composite Flours. Journal of Food Technology. 2007;5(3):256–260.
36. Tai-Hua M, Sun HN, Ma MM. Sweet Potato Chemistry, Processing and Nutrition; 2019.
37. Bongjo NB, Ahemen SA, Gbertyo JA. Chemical and organoleptic properties of Chinchin produced from flour blends of wheat, defatted peanut and orange peels. J Nutr Health Food Eng. 2023; 13(1):20-6.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/112808