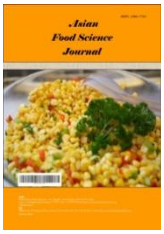

Asian Food Science Journal

21(6): 1-11, 2022; Article no.AFSJ.85849
ISSN: 2581-7752

Preparation and Quality Evaluation of Biscuits from Mango Seed Kernel-Acha Flour Blends

Ibrahim Abdul-Alim Gambo [a*], Ayo Jerome Adekunle [a] and Bessong Sarah [a]

[a] *Department of Food Science and Technology, Federal University Wukari, Nigeria.*

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/2022/v21i630431

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/85849

Original Research Article

Received 10 February 2022
Accepted 13 April 2022
Published 28 April 2022

ABSTRACT

Production and quality evaluation of biscuits from mango seed kernel-Acha flour blend were studied. The biscuits were formulated with 0, 5, 10, 15, 20, 25 and 50% of mango seed kernel (*magnifera indica)* flour with acha flour. The biscuits were prepared from the flour blends with other ingredient (fat, salt, baking powder and sugar) and evaluated for chemical composition, physical and sensory properties. The moisture, ash, protein and carbohydrate content decreased from 14.79-9.03, 2.37-2.17, 16.85-15.5 and 58.08-56.70, while the fat and fibre content increased from 5.67-8.99 and 0.40-0.90 respectively with increased in the level of mango seed kernel flour addition. Minerals and vitamins content result indicated increasing level of potassium, magnesium, vitamin A and vitamin K (256.31-486.43, 11.26-12.35, 0.01-0.07 and 0.02-0.51mg/g) respectively with increased in mango seed kernel flour. While decreased level of calcium and vitamin C were 1.10-0.66 and 1.65-1.27 with increased mango seed kernel flour addition. Physical properties result indicated a decreased in the weight, height diameters, thickness and break strength 24.95-21.90, 3.15 - 2.85, 5.25 - 4.85, 1.15 - 0.75 and 1.45-0.30 respectively, spread ratio and volume 5.25-6.25 and 21.66-22.91 of the biscuit sample increased with increased in mango seed kernel flour addition. In sensory evaluation, biscuits containing 10% mango kernel flour had the highest sensory score for all sensory attribute. The biscuit blends were generally accepted up to 15% but most preferred and accepted blend biscuits is that of the 100% acha and 100% wheat flour. The mango seed kernel incorporation had significant effect and could contribute to the improvement of the flour blend biscuits.

Keywords: Quality; biscuit; mango seed kernel; acha flour.

**Corresponding author: Email: ibrahimag@fuwukari.edu.ng;*

1. INTRODUCTION

Mangoes are juicy stone fruits (drupes) that grow on a variety of tropical trees in the genus Mangifera, and are cultivated primarily for their delicious fruit [1]. The majority of these species found as wild mangoes in nature. The *Anacardiaceae* family includes the genus. *Magnifera indica* is one of the most frequently cultivated fruits in the tropics, with a global distribution. Other *Magnifera* species, such as horse mango (*Magnifera foetida*), are grown on a more regional scale.

The seed %age of different mango types varies from 9% to 23% of the fruit weight, with the kernel content ranging from 45.7 % to 72.8 % [2]. Moisture (5.9%), Ash (2.43%), crude protein (5.20%), carbohydrates (76.14%), and crude fibre (0.49%) are all contained in the mango seed kernel's proximate composition. Seed kernel's physical characteristics Depending on the cultivar, mango seeds are a single flat oblong seed with a fibrous or hairy surface. A thin lining covers a single embryo, 4-7 cm long, 3-4 cm wide, and 1 cm thick, inside the 1-2 mm thick seed coat. The kernel of the mango seed is encased in a tough covering. The significance of the seed kernel Potassium, magnesium, phosphorus, calcium, and salt are abundant in mango seed kernels [2]. The current situation is Nigerian lying in the midst of abundant nutrient rich crops but suffering from malnutrition with high rate of importation, this partly stimulated investigation into alternative available crops. The abundant mango seed kernel in Nigeria is grossly underutilized and constitutes great %age of waste. The abundance and annual growth of Acha with its high nutrient content calls for its processing and to reduce its wastage, as well as enriching the same.

According to [3], *Digitaria exilis*, also known as fundi in some parts of Africa, is a grass species with English common names such as white *fonio*, *fonio* millet, hungry rice, or acha rice. It is the most important species among a broad range of wild and domesticated animals. Although the grains are small, they have the potential to improve nutrition, increase food security, promote rural development, and assist land sustainability. Despite its valuable properties and extensive production, fonio has received little attention in terms of research and development, which is why it's frequently called an underutilized crop. The Chemical composition of acha grains have been reported to contain about, 6.9% crude protein, fat content 2.10%, carbohydrates content 87.4%, crude fibre content of acha is lower 1.02%, moisture content 8.6%, Ash content 1.5% and minerals ash 2.44% [4].

Two pericarp colors, white and brown, have been seen in *Digitaria exilis* and *Digitaria iburua*, respectively. The *Digitaria iburua* specie with the brown pericarp color is typically chosen among customers, especially for creating *kunuzaki* (a local beverage drink) [5],[6]. Acha grains, with a diameter of 500 to 700μm, are among the smallest and lightest cereals in terms of size and weight [7]. Because of the small size of the kernel, grinding acha before cooking is typically unnecessary *Digitaria iburua* had substantially larger size kernels than *Digitaria exilis*, according to the kernel size distribution and sample weight [4]. The average kernel appeared to be slightly larger than 710μm m and slightly less than 500μm m in diameter [6].

The crop is an important part of cooking in West Africa [8]. *Digitaria exilis* is a grain traditionally used for porridges and steamed cooked food. The species is known to have high carbohydrate and protein levels [9]. When compared to other cereals like wheat, rice, and maize, *Digitaria exilis* has higher protein levels due to its high content of important amino acids like methionine [10]. These qualities show that *Digitaria exilis* could be a good source of food and if the right characters are selected for it could turn into a useful crop [8]. The relative high level of hydrophobic residues in polamin protein fraction of acha is a potential that could be exploited as bio-plastic films and coatings for food [11]. This is with the idea that grains proteins have a critical role in defining end-use quality, especially for human nutrition and food processing [12]. The aim objective of this study was to determine the chemical composition, physical and sensory properties of mango kernel-acha flour blends biscuit

2. MATERIALS AND METHODS

2.1 Materials

Mango fruits (*Magnifera indica)* were purchased from Wukari new market in Taraba, while Acha grains (*Digiteria exillis*) were purchased from a local market in Kaduna State, Nigeria. Baking powder, baking fat, sugar (Dangote) and salt were also purchased from Wukari new market in Taraba State.

2.2 Preparation of Raw Materials

2.2.1 Mango kernel flour preparation

Mango seeds were cleaned and dried for 6 h in hot air at 60°C. Kernels were carefully separated from stone with a stainless-steel knife, then dried for 4 h in a hot air oven at 50°C and stored in airtight containers. To soften the hard kernels, they were steeped in water for 6-7 h. Soaking boosted the weight of the kernels to 166.4% of their original weight (500 g), as well as reducing anti-nutrient elements. Soaked kernels were cut into 5-10mm thick pieces, blanched for 2 minutes, then dried for 5 h in a hot air oven at 60°C. According to [13], the dried kernels were processed (attrition mill), sieved, and packaged in a polyethylene container.

2.2.2 Acha flour preparation

The acha flour was made according to the procedures [14]. The acha grains were manually cleaned (by handpicking chaff and dust) and stones were removed by washing them in clean water (sedimentation). The cleaned and stone-free grains were oven dried for 3 h at 45°C, processed in an attrition mill (model R175A), sieved (0.3-micron aperture), packaged in polyethylene, and stored at room temperature.

2.2.3 Composite Flour Preparation

Blends of mango kernel and acha flours were made according to the directions provided by [7]. Flour blends containing diverse proportions of mango kernel flour (0-50 %) were made by uniformly blending mango kernel and acha flour at various ratios (5:95, 10:90, 15:85, 20:80, 25:75, and 50:50), respectively, while a control of 100% wheat was utilized.

2.2.4 Preparation of biscuit

The creaming procedure described by [15] was used to make the biscuits. 100 % mango kernel-acha composite flour, 60% fat, 40% sugar, 0.6% salt, and baking powder were required (1.5). To make a creamy mixture, the sugar and fat were combined together in a mixer before adding the flour and other dry components. The ingredients were then thoroughly mixed to form a hard, homogeneous dough. The dough was kneaded by hand on a smooth, clean surface for around 5 minutes. On a wooden board, the dough was thinly flattened with a rolling pin to a consistent thickness of 2 mm and cut into desired shapes of similar dimensions (with a biscuit cutter). Cut out biscuit dough pieces were placed on a greased baking tray and baked in an oven (160°C) for 17 minutes to make mango kernel-acha biscuits. After baking at 35-370°C, the biscuits were quickly cooled, sealed in polyethylene bags, and stored at room temperature until chemical analysis and sensory evaluation. Wheat biscuits were created with dough made completely of wheat flour (100%) and baked in the same manner as the control wheat biscuits.

2.3 Analytical Methods

2.3.1 Proximate analysis

Moisture, crude protein, ash, crude fat, and proximate analysis of samples were all tested on the flours and the most appropriate biscuit. The flour was tested for carbohydrate content and crude fibre:

2.3.2 Determination of moisture content

The moisture content of the mango seed kernel-acha flour blend was determined as described by [16],[17] methods. A 2.0gram sample was carefully weighed into a glass crucible that had already been dried and weighed. It was then dried for 18 hours at 50°C in a thermostatically controlled forced convection oven (Gallenkamp, England). The glass crucibles were taken out of the oven and placed in desiccators to cool before being weighed. Moisture content was calculated as a %age based on the differential.

$$\%Moisture = \frac{weight\ of\ dish + undried\ sample - initial\ weight\ of\ empty\ dish}{weight\ of\ dish +\ undried\ sample - weight\ of\ dish + dried\ sample} \times 100$$

2.3.3 Determination of ash content

A 2.0-gram sample was carefully weighed into a pre-ignited and previously weighed crucible, then heated for two hours at 600°C in a muffle furnace (Gallenkamp, England). After ashing, the crucibles were cooled in a furnace to below 200°C for 20 minutes before being desiccated to room temperature. The crucibles and their contents were weighed and the ash content expressed as a %age [17].

$$\%Ash(\text{dry basis}) = \frac{weight\ of\ ash}{weight\ of\ original\ samples} \times 100$$

2.3.4 Determination of crude fat content

A two (2.0) gram of sample was transferred into a paper thimble plugged at the opening with glass wool to evenly distribute the solvent as it drops on the sample during extraction and placed into a thimble holder. The sample packet was inserted in the soxhlet extraction device' butt tubes. The extraction flask was baked for about 5 minutes at 110°C before being cooled and weighed. The fat was removed for 2-3 hours using petroleum ether and mild heating. The extraction flask was taken apart and set aside to cool. The ether was evaporated using steam or a water bath until there was no more ether odor. The extraction flask and its extract were then recorded after cooling to room temperature [17].

$$\%Crude\ fat = \frac{wt\ of\ the\ flask\ and\ oil\ extracted - wt\ of\ the\ empty\ exttration\ flask}{weght\ of\ sample} \times 100$$

2.3.5 Determination of protein contents

The samples' protein content was evaluated using the [17] method. One kjeldahl catalyst tablet, 10ml of conc. H2SO4, and half (0.5) gram of finely ground materials were weighed into a digestion flask, along with one kjeldahl catalyst tablet, and digested for 4 hours until a clear solution was formed. The digest was cooled before being transferred to a 100ml volumetric flask and topped up with distilled water to the desired volume. 20 mL of boric acid, 5 drops of indicator, and 75 mL of distilled water were poured into a conical flask. 10 mL of digest was dispensed into a Kjedahl distillation flask, the conical and distillation flask were secured in place, and 20 mL of 2% NaOH was put into the digest through the glass funnel. When the boric acid solution and indicator turned green, the steam exit was closed and the timing began. After a 15-minute distillation, the distillate was titrated with 0.05NHCl.

$$\%Total\ Nitrogen = Titre\ value \times Atomic\ mass\ of\ Nitrogen \times Normality\ of\ HCl\ used \times 4$$

Therefore, the crude protein content is determined by multiplying %Nitrogen by a constant factor of 6.25 i.e., %crude protein = %N x 6.25.

2.3.6 Determination of crude fibre content

The crude fibre determination sample was transferred to a digestion flask. The flask was filled with 200mL of boiling sulphuric acid (H2SO4) solution and an anti-foaming agent (asbestos), then attached to a digestion flask with a condenser and heated. The sample was boiled for 30 minutes, allowing the entire sample to be fully wetted while preventing any of it from remaining on the flask's walls and out of touch with the solvent. The flask was removed after 30 minutes and the contents strained through linen cloth in a funnel before being washed with boiling water until the washings were no longer acidic. With 200 mL of boiling sodium hydroxide (NaOH) solution, the asbestos sample was rinsed back into the flask. The condenser was rejoined to the flask, and the mixture was boiled for 30 minutes. The content was filtered once more through linen cloth in a funnel and carefully rinsed with hot water before being treated with 15ml of 95% ethanol. In an oven at 110°C, the residue was put into previously dried and weighed porcelain and baked to a constant weight. It was then weighed after cooling in a desiccator. The crucible and its contents were fired at 550°C for 30 minutes until the carbonaceous materials was consumed in a muffle furnace. After cooling in a desiccator, it was weighed [17].

$$\%Crude\ fibre = \frac{wt\ of\ sample\ before\ incineration - wt\ of\ sample\ after\ incineration}{weight\ of\ original\ sample} \times 100$$

2.3.7 Determination of carbohydrate content

The nitrogen free method described by [17] was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameters as:

Nitrogen free extract (NFE) %age carbohydrate

$$(NFE) = 100 - (m + p + F + A + F_2)$$

Where - M= moisture, P= protein, F_1= fat, A= ash, F_2= crude fibre

2.4 Determination of Mineral Content

2.4.1 Determination of potassium and calcium

Potassium was determined by flame photometry as described by [18], and calcium by the EDTA titration method [19].

2.4.2 Determination of magnesium content

Magnesium concentration was determined using the method of [17]. 2 g of ash was put to 3 test tubes with 3 ml of water, 2 ml of 10% sodium tungstate, and 2 ml of 0.67N sulphuric acid, centrifuged for 5 minutes. 1ml of water, 1ml of 0.5 % titan yellow, and 1ml of 0.1 % gum ghatti were added to 5ml of supernatant. The absorbance was measured at 520nm against a blank after 2ml of 10% sodium hydroxide was applied.

2.5 Determination of Vitamins

2.5.1 Determination of vitamin C, Vitamin A (β-carotene) and Vitamin K

The Barakat titrimetric method was used to determine the ascorbic acid concentration of the samples. By bleaching for 5 minutes, twenty (20g) grams of the materials were homogenized in 100ml EDTA/TCA extraction solution. The method described by [20] was used to determine the vitamin A content of the samples. The concentration of vitamin K was determined using the HPLC method with fluorescence detection reported by [21].

2.6 Determination of Physical Properties

2.6.1 Height, weight, diameter, thickness of the biscuits

Six well-formed biscuits were measured for the height of three rows and a column, as specified by [14]. Weighing the mango seed-acha composite biscuit on an electronic weighing balance (Mettler PF160 Balance, Switzerland) determined its weight, using venire calipers, the diameter and thickness of the mango seed-acha composite biscuit were measured [14].

2.6.2 Breaking strength and spread ratio

The method provided by was used to determine the break strength of mango seed-acha composite biscuits and bread [22]. A 0.4cm x 5-20mm biscuit sample was placed in the middle of two parallel metal bars (3cm apart) and weights were applied until the biscuit was fully formed. The biscuit's break strength was determined by the least weight that caused the biscuit to break. The spread ratio was computed using the approach outlined above in [14]. Four well-formed biscuits and bread were measured in length and height of three rows and columns, respectively. The spread ratio was determined by dividing the diameter by the height. Using the formula $V = \pi r^2 h$, the volume of the acha-mango seed composite biscuit was calculated [14].

2.7 Sensory Evaluation

Twenty untrained panel members were randomly selected from (Department of Food Science and Technology Federal University Wukari, Nigeria) based on their acquaintance with the mango seed-acha biscuits for sensory evaluation. The biscuits were placed in white plastic plates separated by compartment and placed in the sensory laboratory, suitably coded (ABP, BPF, AJD, BAF, ACP, BXF, ADB, and BPG) and of the same size and temperature (29±3C). The coded samples were to be evaluated for color, crispiness, scent, taste, texture, and general acceptability by the panel lists. To avoid influencing other panel lists, the panelists rinsed their lips with bottled water after tasting each sample and were not allowed to make any comments throughout the evaluation. A nine-point Hedonic scale was used as a questionnaire, with one (1) signifying "very detest" and nine (9) representing "highly like." Taste, odor, texture, after-mouth feel, flavor, and general acceptance were the criteria evaluated, as reported by [7].

2.8 Statistical Analysis

In a completely randomized approach, all of the analysis were done in duplicate. Statistical Package for Social Science (SPSS) software version 23 was used to do analysis of variance on the data. The least significant difference

(LSD) test was used to distinguish the means that were substantially different. At $p<0.05$, significance was accepted.

3. RESULT AND DISCUSSION

3.1 Proximate Composition of Mango Seed Kernel -Acha Flour Blend

The chemical composition result is shown in table 1 below. Moisture content, Ash content, fat content, protein fibre content, and carbohydrate content ranged from 14.97 to 9.03, 2.37 to 1.57, 5.67 to 8.99, 16.85 to 14.80, 0.40 to 0.90, 58.08 to 54.82, with up to 50% acha substitution utilizing mango The carbohydrate content dropped as the mango kernel flour content increased, ranging from 58.08 to 54. The moisture level reduced with increased mango kernel flour, which could be owing to the high fibre content in it, and this is an advantage for maintaining product quality because it will not allow microorganisms, biochemical, or enzymatic processes, which is consistent with the findings [23]. The ash contents of the 100% acha, 5, 10, 15, 20, 25, and 50% mango kernel-acha blend were 2.37, 2.32, 2.30, 2.25, 2.20, 2.17, and 1.57, respectively. With increasing acha substitution utilizing mango kernel flour, the fat content increased from 5.67 to 8.99. High levels of linoleic and oleic acids, notably palmitic acid, have been recorded in Acha grains [9]. This research backs up the assumption that mango kernels are nutrient-dense and high in protein. The significant effect of mango kernel addition is the increased fat content reached at 25% mango kernel substitution. The drop in protein content with increased mango kernel flour could be attributable to the processing method's influence, which is consistent with the fundamental principles of [24]. The protein amount dropped from 16.85 to 14.80 grams.

The 5, 10, 15, 20, 25, and 50% mango kernel-acha flour blends had crude fibre content of 0.55, 0.60, 0.70, 0.75, 0.85, and 0.90, respectively, and increased in mango kernel flour addition despite the abundant supply of it in acha reported [25]. This could be because fruits have a high fibre content, as described by [26]. However, as the amount of mango kernel flour was increased from 58.08 to 54.82, the carbohydrate content decreased. The high carbohydrate content of 100% acha (58.08) is comparable to [27],[28]. This could be related to the production of composite flour and nutritional decrease prior to processing.

3.2 Mineral Content of Mango Seed Kernel-Acha Flour Blend Biscuits

Table 2 shows the results of the mineral content of mango seed kernel-acha. With an increase in mango seed kernel, the potassium and magnesium of mango seed kernel-acha flour bends. With increased mango seed kernel flour addition, the potassium content of the (0-50%) mango seed kernel-acha flour blends increased from 256.31 to 486.43mg/100g respectively. With increasing im mango seed kernel flour, the magnesium content of the (0-50%) mango seed kernel-acha flour blends increased from 11.26 to 12.35mg/100g. Potassium (256.31mg/100g) and magnesium (11.26 mg/100g) were the lowest in the 100% acha flour, whereas potassium (486.43 mg/100g) and magnesium (12.35 mg/100g) were the highest in the 50% substitution. Increased mango seed kernel flour resulted in a decrease in calcium. As a result, the impacts of the mango kernel increase were significant, and they correspond with the findings of [25]. Potassium is a necessary ingredient for the production of amino acids and proteins. Magnesium is an important mineral for enzyme activity and for maintaining the body's acid-alkaline equilibrium.

3.3 Vitamin Content of Mango Seed Kernel-Acha Flour Blend Biscuits

Table 3 shows the results of the vitamin content of the mango seed kernel-acha flour combination. With an increase in mango seed kernel flour, the vitamin A content of the 0-50 % mango seed kernel-Acha flour blend increased from 0.01 to 0.07 mg/100g. Any fat-soluble vitamin that is required for normal vision is known as vitamin A. Vitamin K levels increased from 0.02 to 0.55 with the addition of mango kernel flour, which is required for blood coagulation. With an increase in mango seed kernel flour, vitamin C levels fell and ranged from 1.65 to 1.27 mg/100g.

3.4 Physical Properties of Mango Seed Kernel-Acha Flour Blend Biscuits

Table 4 lists the physical characteristics of the biscuit samples. There was a significant difference ($p<0.05$) in the results. The spread ratio of the biscuits ranged from 5.25 to 6.25 mg/100g, with the lowest value in a biscuit made

Table 1. Proximate for mango seed kernel-Acha flour blend biscuits

Materials	Proximate Composition (%)					
Acha: Mango Kernel flour	**Moisture**	**Ash**	**Fat**	**Protein**	**Fibre**	**CHO**
100:0	14.97^{ab}±0.98	2.37^{a}±0.07	5.67^{c}±0.05	16.85^{a}±0.07	0.40^{d}±0.14	58.08^{b}±1.42
95:5	13.93^{b}±0.50	2.32^{a}±0.14	6.69^{b}±0.44	16.60^{a}±0.14	0.55^{cd}±0.07	58.03^{b}±0.06
90:10	12.91^{b}±0.61	2.30^{a}±0.06	7.10^{b}±0.14	16.55^{a}±0.07	0.60^{cd}±0.00	57.16^{b}±0.06
85:15	12.83^{a}±0.16	2.25^{ab}±0.00	7.00^{b}±0.33	7.05^{b}±0.14	0.70^{bc}±0.00	56.65^{b}±0.38
80:20	11.75^{ab}±0.13	2.20^{a}±0.06	6.45^{b}±0.09	15.20^{d}±0.28	0.75^{bc}±0.07	56.58^{b}±0.06
75:25	10.39^{a}±0.21	2.17^{a}±0.08	7.14^{b}±0.03	15.15^{e}±0.07	0.85^{b}±0.07	56.40^{b}±0.31
50:50	9.03^{ab}±0.14	1.57b±0.06	8.99^{a}±0.33	14.80^{e}±0.00	0.90^{b}±0.14	54.82^{c}±0.22
Wheat 100%	10.42^{c}±0.01	1.61^{b}±0.01	3.97^{d}±0.61	10.73^{f}±0.01	1.65^{a}±0.07	71.87^{a}±1.37

Values mean± standard deviation of 2 replicates means within a column with the same superscript were not significantly different (p>0.05); CHO: Aldehyde functional group

Table 2. Minerals content of mango seed kernel-acha flour blend biscuit

Materials	Minerals composition (mg/100)		
Acha: Mango kernel flour	**K**	**Ca**	**Mg**
100:0	256.31^{h}±0.01	1.10^{b}±0.41	11.26^{f}±0.07
95:5	358.33^{g}±0.00	1.11^{a}±0.00	11.37^{d}±0.14
90:10	401.23^{e}±0.00	1.06^{ab}±0.01	11.51^{d}±0.01
85:15	410.73^{d}±0.01	1.00^{c}±0.00	11.70^{c}±0.01
80:20	425.31^{a}±0.01	0.78^{d}±0.01	11.81^{b}±0.01
75:25	468.84^{f}±0.00	0.75^{d}±0.14	11.90^{g}±0.00
50:50	486.43^{c}±0.01	0.66^{e}±0.01	12.35^{e}±0.00
Wheat100%	382.40^{b}±0.00	0.57^{f}±0.00	13.44^{a}±0.01

Values mean± standard deviation of 2 replicates means within a column with the same superscript were not significantly different (p>0.05).

Table 3. Vitamin content of mango seed kernel-acha flour blend biscuits

Materials	Minerals composition (mg/100g)		
Acha: Mango kernel flour	**Vitamin C**	**Vitamin A**	**Vitamin K**
100:0	1.65^{a}±0.01	0.01^{d}±0.00	0.002^{d}±0.00
95:5	1.54^{ab}±0.01	0.02^{c}±0.00	0.003^{c}±0.00
90:10	1.48^{b}±0.01	0.03^{bc}±0.00	0.035^{bc}±0.00
85:15	1.41^{bc}±0.01	0.04^{b}±0.13	0.041^{b}±0.00
80:20	1.37^{c}±0.01	0.05^{ab}±0.00	0.045^{ab}±0.01
75:25	1.31^{cd}±0.01	0.06^{ab}±0.01	0.051^{a} ±0.01
50:50	1.27^{d}±0.01	0.07^{a}±0.13	0.055^{a}±0.13
Wheat100%	1.60^{a}±0.07	0.03^{bc}±0.01	0.003^{c}±0.01

Values mean± standard deviation of 2 replicates means within a column with the same superscript were not significantly different (p>0.05).

Table 4. Physical properties of mango seed kernel-acha flour blend biscuits

Materials			**Physical parameters**				
Acha : mango Kernel flour	**Weight(g)**	**Height (cm)**	**Diameters (cm)**	**Thickness (cm)**	**Break strength (kg)**	**Spread ratio**	**Volume (cm^3)**
100:0	$24.95^{ab}\pm0.21$	$3.15^{a}\pm0.07$	$5.25^{df}\pm0.07$	$1.15^{c}\pm0.14$	$1.45^{b}\pm0.07$	$5.25^{bc}\pm0.07$	$21.66^{c}\pm0.62$
95:5	$24.90^{ab}\pm0.07$	$3.10^{ab}\pm0.14$	$5.20^{df}\pm0.14$	$1.10^{a}\pm0.21$	$1.40^{a}\pm0.07$	$5.15^{b}\pm0.07$	$21.66^{c}\pm0.62$
90:10	$24.85^{b}\pm2.68$	$3.05^{a}\pm0.07$	$5.10^{f}\pm0.14$	$1.05^{bc}\pm0.14$	$1.35^{c}\pm0.14$	$5.85^{c}\pm0.49$	$21.17^{c}\pm0.08$
85:15	$23.80^{ab}\pm1.83$	$2.95^{ab}\pm0.28$	$5.05^{ab}\pm0.14$	$0.95^{ab}\pm0.07$	$0.50^{c}\pm0.14$	$6.00^{a}\pm0.56$	$22.56^{ab}\pm1.20$
80:20	$23.75^{ab}\pm0.84$	$2.90^{ab}\pm0.07$	$5.00^{bc}\pm0.14$	$0.85b^{c}\pm0.14$	$0.45^{c}\pm0.14$	$6.10^{a}\pm0.14$	$22.66^{bc}\pm2.90$
75:25	$22.70^{ab}\pm0.21$	$2.85^{b}\pm0.14$	$4.95^{a}\pm0.14$	$0.80^{bc}\pm0.14$	$0.40^{c}\pm0.14$	$6.20^{a}\pm0.28$	$22.33^{ab}\pm1.30$
50:50	$21.90^{ab}\pm0.77$	$2.80^{ab}\pm0.14$	$4.85^{cd}\pm0.14$	$0.75^{bc}\pm0.07$	$0.30^{c}\pm0.14$	$6.25^{ab}\pm0.21$	$22.91^{bc}\pm2.54$
Wheat 100%	$25.55^{a}\pm0.49$	$3.20^{a}\pm0.14$	$5.80^{ab}\pm0.14$	$1.00^{ab}\pm0.14$	$0.70^{c}\pm0.14$	$5.20^{b}\pm0.14$	$28.80^{a}\pm3.38$

Values mean± standard deviation of 2 replicates means within a column with the same superscript were not significantly different (p>0.0

Table 5. Sensory properties of mango seed kernel-acha flour blend biscuits

Materials			**Sensory Properties**			
Acha: MKF	**Taste**	**Odor**	**Texture**	**After Mouth feel**	**Flavor**	**General acceptability**
100.0	$8.03^{a}\pm0.96$	$7.60^{a}\pm0.90$	$6.97^{a}\pm1.30$	$7.30^{a}\pm1.26$	$6.50^{ab}\pm1.10$	$7.47^{a}\pm0.97$
95:5	$6.9^{be}\pm1.05$	$6.53^{bc}\pm1.55$	$6.30^{ab}\pm1.74$	$6.23^{ab}\pm1.74$	$6.07^{b}\pm1.63$	$6.40^{b}\pm1.67$
90:10	$6.13^{cd}\pm2.34$	$5.90^{cd}\pm2.16$	$6.23^{bc}\pm1.80$	$6.17^{bc}\pm2.05$	$6.67^{ab}\pm1.56$	$6.17^{b}\pm2.18$
85:15	$6.17^{cd}\pm2.02$	$5.73^{cd}\pm1.93$	$5.63^{bc}\pm1.76$	$6.00^{bc}\pm2.18$	$6.90^{a}\pm1.03$	$5.73^{b}\pm1.82$
80:20	$6.00^{cd}\pm1.83$	$5.30^{de}\pm2.42$	$5.40^{bc}\pm2.30$	$5.43^{cd}\pm2.27$	$6.00^{b}\pm1.23$	$5.67^{b}\pm1.82$
75:25	$5.17^{de}\pm2.25$	$4.67^{e}\pm1.79$	$5.03^{c}\pm2.06$	$5.03^{de}\pm1.91$	$5.93^{b}\pm1.63$	$5.53^{b}\pm2.25$
50:50	$4.53^{e}\pm1.70$	$4.63^{e}\pm2.11$	$4.90^{c}\pm2.00$	$4.10^{e}\pm2.23$	$5.90^{b}\pm1.00$	$4.37^{c}\pm2.01$
Wheat 100%	$7.53^{ab}\pm2.05$	$7.13^{ab}\pm2.00$	$6.70^{a}\pm1.84$	$6.70^{a}\pm1.83$	$7.10^{a}\pm1.00$	$7.47^{a}\pm1.70$

Values mean± standard deviation of 2 replicates means within a column with the same superscript were not significantly different (p>0.05

entirely of wheat flour, indicating that the starches in wheat were very hydrophilic. The spread ratio rose as the amount of mango seed kernel flour in the flour increased. The rise is a result of the flour's binding qualities and the texture of the biscuits. The spread ratio could be affected by the rise in fat content, according to the analysis [29]. The break strength varied from 1.45 to 0.30g.

As the amount of mango seed kernel flour in the biscuit sample increased, the break strength dropped. According to the paper, the decline could be attributable to an increase in the proportion of fats (5.67 to 8.99%) due to the addition of mango kernel flour, diluting the protein and carbohydrate levels, which are the main ingredients responsible for biscuit hardness [30]. Biscuit weights ranged from 24.95 to 21.90g, with the highest value in 100% wheat flour biscuits. With the addition of mango kernel flour, the weight of the biscuits dropped. The drop in weight could be related to an increase in the fat content of the blended mango kernel flour, which is consistent with the findings of the study [14]. The volume rose with increased mango seed kernel flour, ranging from 21.60 to 22.91cm^3. Increased mango kernel flour reduced height, diameter, and thickness from 3.15 to 2.80, 5.25 to 4.85, and 1.15 to 0.75, respectively.

3.5 Sensory Properties of Mango Seed Kernel-Acha Flour Blend Biscuits

Table 5 shows the sensory quality of the acha-mango seed kernel flour blend biscuits. With the addition of mango seed kernel flour, the average mean score for taste, odor, texture, mouth feel, flavor, and general acceptability reduced from 8.03 to 4.53, 7.60 to4.63, 6.97 to 4.90, 7.30 to 410, 6.50 to 5.90, and 7.47 to 4.37, respectively (0-50 %). The effect is statistically significant ($p = 0.05$). It's possible that the decline is attributable to the mango seed kernel's inherent quality. The acceptable mixed biscuit has a %age of 10%. (6.17). Biscuits made with 100 % acha flour and 100% wheat flour are the most popular and well appreciated. Around 15% increased mango seed kernel flour resulted in a decrease in measured metrics.

4. CONCLUSIONS

The addition of mango seed kernel flour to acha flour in the making of biscuits improves the fibre, fat, potassium, magnesium, and vitamin A content of the product, according to the findings of the study. The mango seed kernel acha flour blend biscuits were most acceptable and preferred at 10% substitution of the mango seed kernel flour.

It is recommended that commercializing mango seed kernels can help to reduce environmental pollution caused by by-products of mango processing enterprises, as well as contribute to food security by transforming waste into valuable food items. Mango seed kernel powder, on the other hand, might be used as a source for a variety of baked items and functional food additives. More study is needed in order to improve the baking condition and shelf stability of mango seed kernel-based goods.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ACKNOWLEDGEMENT

The authors are grateful to the department of Food Science and Technology Federal University Wukari, Taraba State for her contribution to this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. OECD-FAO. OECD-FAO Agricultural Outlook 2021–2030 [Internet]. OECD-FAO Agricultural Outlook 2021–2030. 2021. Available:http://dx.doi.org/10.1787/agr-outl-data-%0Ahttp://www.fao.org/documents/card/en/c/cb5332en
2. Fowomola MA. some nutrients and antinutrients contents of mango (Magnifera indica) seed. African J Food Sci. 2010;4(8):472–476.
3. Seema B, David BH, Joanne MH (ret). USDA Database for the Flavonoid Content

of Selected Foods. Nutrient Data Laboratory Beltsville Human Nutrition Research Center Agricultural Research Service U.S. Department of Agriculture; 2013.

4. Chukwu O, Abdul-Kadir AJ. Proximate Chemical Composition of Acha (Digitaria exilis and Digitaria iburua) Grains. J Food Technol. 2008;6(5):214–216.
5. Ibrahim AG, Ayo JA, Joseph HM. Effects of orange-fleshed sweet potato supplementation on the phytochemical composition , physicochemical , and sensory properties of sorghum-based kunu-zaki. Res J Food Sci Nutr. 2022;6(3):22–29.
6. Jideani AI, Akingbala JO. Some physicochemical properties of acha (digitaria exilis stapf) and iburu (Digitaria iburua stapf) grains. J Sci Food Agric. 1993;63(3):369–374.
7. Ayo JA, Gidado F. Physicochemical, Phytochemical and Sensory Evaluation of Acha-Carrot Flours Blend Biscuit. Curr J Appl Sci Technol. 2018;25(5):1–15.
8. Chinwe OU, Ojukwu EO, Jackson BA. ACHA : A Potential Grain as a Food Fortifier. Asian J Agric Food Sci. 2015;03(05):428–435.
9. Jideani A. Digitaria exilis (acha/fonio), Digitaria iburua (iburu/fonio) and Eluesine coracana (tamba/finger millet) Non-conventional cereal grains with potentials. Sci Res Essays. 2012;7(45):3834–3843.
10. Babarinde GO, Adeyanju JA, Ogunleye KY, Adegbola GM, Ebun AA, Wadele D. Nutritional composition of gluten-free flour from blend of fonio (Digitaria iburua) and pigeon pea (Cajanus cajan) and its suitability for breakfast food. J Food Sci Technol [Internet]. Springer India; 2020;57(10):3611–3620.
Available: https://doi.org/10.1007/s13197-020-04393-7
11. Glew RH, Laabes EP, Presley JM, Schulze J, Andrews R, Wang Y-C, Chang Y-C, Chuang L-T. Fatty acid, amino acid, mineral and antioxidant contents of acha (Digitaria exilis) grown on the Jos Plateau, Nigeria. Int J Nutr Metab [Internet]. 2013;5(1):1–8.
Available:http://www.ncbi.nlm.nih.gov/pubmed/26635994%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4666555 PMID: 26635994
12. Erenstein O, Poole N, Donovan J. Role of staple cereals in human nutrition: Separating the wheat from the chaff in the infodemics age. Trends Food Sci Technol. 2022;119:508–513.
13. Lakshmi M, Usha R, Preetha R. Mango (Mangifera indica) Stone Kernel Flour - A Novel Food Ingredient. Malays J Nutr. 2016;22(3):461–467.
14. Ayo JA, Ayo VA, Nkama I, Adewori R. Physiochemical, In-Vitro Digestibility and Organoleptic Evaluation of “Acha” Wheat Biscuit Supplemented with. Niger Food J. 2007;25(1):77–89.
15. Ayo JA, Ojo MO, Popoola CA, Ayo VA, Okpasu A. Production and Quality Evaluation of Acha-tigernut Composite Flour and Biscuits. Asian Food Sci J. 2018;1(3):1–12.
16. Yatnatti S, Vijayalakshmi D, Chandru R. Processing and nutritive value of mango seed kernel flour. Curr Res Nutr Food Sci. 2014;2(3):170–175.
17. AOAC. AOAC: Official Methods of Analysis. Assoc Off Anal Chem. 2019;1:1–771.
18. Rachida C, Laurent N, Christelle V, Sandrine M, Ali K, Thierry G. Determination of Calcium, Magnesium, Sodium, and Potassium in Foodstuffs by Using a Microsampling Flame Atomic Absorption Spectrometric Method After Closed-Vessel Microwave Digestion: Method Validation. J AOAC Int. 2010;93 (6):1888–1896.
19. College of Science. Determination of Calcium Ion Concentration. New Zealand; 2017.
20. Okwu DE. Phytochemicals, Vitamins and Mineral Contents of Two Nigerian Medicinal Plants. Int J Mol Adv Sceinces. 2005;1(4):375–381.
21. Wang LY, Bates CJ, Yan L, Harrington DJ, Shearer MJ, Prentice A. Determination of phylloquinone (vitamin K 1) in plasma and serum by HPLC with fluorescence detection. Clin Chim Acta. 2004;347 (2004):199–207.
22. Ayo JA, Andrew E. Effect of added Bambara groundnut on the quality of acha-date palm based biscuit. Int J Biotechnol Food Sci. 2016;4(3):34–38.
23. Ayo JA. The effect of amaranth grain flour on the quality of bread. Int J Food Prop. 2001;4(2):341–351.
24. Arogba SS. The performance of processed mango (Mangifera indica) kernel flour in a model food system. Bioresour Technol. 1999;70(3):277–281.

25. Cruz J, Béavogui F. Le fonio, une céréale africaine [Internet]. éditions Quae; 2011. Available:http://library.oapen.org/handle/20.500.12657/22805
26. Villanueva-Suárez MJ, Redondo-Cuenca A, Rodríguez-Sevilla MD, De las Heras Martínez M. Characterization of nonstarch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: Comparative study. J Agric Food Chem. 2003;51(20):5950–5955. PMID: 13129300
27. Kuta DD, Kwon-Ndung E, Dachi S, Ukwungwu M, Imolehin ED. Potential role of biotechnology tools for genetic improvement of 'lost crops of Africa': The case of fonio (Digitaria exilis and Digitaria iburua). African J Biotechnol. 2003;2 (12):666–674.
28. Mcwatters KH, Phillips RD, Walker SL, Mccullough SE, Mensa-Wilmot Y, Saalia FK, Hung YC, Patterson SP. Baking performance and consumer acceptability of raw and extruded cowpea flour breads. J Food Qual. 2004;27(5):337–351.
29. Jideani VA, Alamu R, Jideani IA. Preliminary study into the production of non-wheat bread from acha (Digitaria exilis). Nutr Food Sci. 2007;37(6):434–441.
30. Susana EU, Henry ON, Francis SI. Quality evaluation of flour and biscuits produced from wheat and African Yam Bean Tempeh Flours. GSC Biol Pharm Sci. 2021;17(1):124–132.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/85849