EFFECT OF ADDED DEFATTED *MORINGA* SEED FLOUR ON THE QUALITY OF *ACHA* BASED BISCUIT

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Abstract: This study evaluated the effect of added defatted *moringa* seed on the quality of *acha* based biscuits. The Defatted *Moringa* Seed Flour was substituted into *acha* flour at 5, 10, 15, 20, and 25 % to produce acha and Defatted Moringa Seed Flour blends with 100% *acha* and wheat as controls. Chemical (proximate, minerals, vitamins) composition was determined (AOAC, 2016), physical and sensory properties of the biscuits were evaluated (Chinma *et al*., 2022). Moisture, fat, and protein contents increased from 8.57-8.87, 19.91-20.38, and 14.45-26.79%, fibre, ash and carbohydrates contents decreased from 3.12-2.99, 2.33-2.04, and 51.63-38.94% with increase of the flour. Vitamin A, B_1 and B_6 contents increased from 1.24-1.83, 0.42-0.94, and 0.82-1.48mg/100g with increase of the flour. Calcium, phosphorus and potassium contents increased from 37.54-47.54, 8.90-9.26, and 39.54-51.28mg/100g with increase of the flour. Water absorption, swelling, and foaming capacity increased from 1.70-1.95ml/g, 5.92-17.00%, and 5.27-5.82g/g while the emulsifying capacity, oil absorption capacity, and bulk density decreased from 43.99-37.79%, 0.90-0.50%, and 0.87-0.66g/ml with increase of the flour. Sensory studies revealed a poor acceptance of the biscuits, while the sample containing 5% Defatted *Moringa* Seed Flour was the most preferred. Conclusively, this study showed that the use of defatted *moringa* seed and *acha* flour blends improved the protein, minerals, vitamins, and phytochemicals content of the biscuits.

Keywords: *Acha-moringa* flour blend, addition, defatted, effect and quality

Introduction

Biscuits are flour based products that are edible. They are regarded as a form of confectionery dried to very low moisture content. The simplest form of biscuit is a mixture of flour (wheat flour), water, fat, sugar and other ingredients which are mixed together into a dough which is rested for a period, passed between rollers to make a sheet; the sheet is then stamped out, baked cooled and packaged (Ayo *et al.,* 2022a). They are commonly ready-to-consume, low cost and convenient meal products that are eaten by every age group in several countries. Biscuits can be eaten with tea or soft drinks, and they can be used as weaning foods for infants (Adegbanke *et al.*, 2020). Biscuits are popular due to their ready-to-consume nature, inexpensive, different savour and instant energy supply potential needed for activity which is more important (Ogo *et al*., 2021).

Wheat is the most preferred cereal for biscuits and other baked products due to its unique rheological properties. The superiority of wheat over other cereals is due to the presence of gluten which inherently imparts all the essential qualities to their products (Oyet and Chibor 2020). The importation of wheat flour has led to high cost of production of baked products, hence locally cultivated and available cereals crops could be an alternative in Nigeria (Ayo *et al*., 2022b). Protein quality of wheat is inferior to that of most cereals like acha, sorghum and this has resulted in a number of efforts to supplement wheat flour with other protein rich flour (Aderinola *et al*., 2020).Biscuits are high in carbohydrates, fat, and calories but low in protein, fiber, vitamins, and minerals (Farzana *et al*., 2022). Biscuit is known to generally contain fat (18.5%), carbohydrate (78.23%), ash (1.0%), protein (7.1%) and salt (0.85%). The nutritional value of biscuits varies with the type of cereal used (Ayo *et al*., 2022).

Moringa oleifera is a plant which is distributed in many tropical and subtropical countries. The whole plant, including seeds, leaves, stems, and roots, is rich in nutrients and can be used for food (Kachangoon *et al.,* 2022). *Moringa oleifera* seeds have an important nutritional value, with high levels of proteins, lipids and carbohydrates (Kachangoon *et al.,* 2022). *Moringa* seeds are a rich source of protein which contains 32–62.8% of protein, depending upon extraction procedure (Saa *et al*., 2019). One of the major nutritional challenges in developing countries and especially Nigeria is malnutrition which is due to inadequate consumption of protein. A potential and convenient means to reduce this challenge is to supplement baked products such as biscuits with protein since they are commonly consumed among people especially by children (Aderinola *et al*., 2020). Moringa seeds contain high protein content (~52%) with all the essential amino acids and could act as a potential source of functional protein isolate (Jain *et al.*, 2019). Owing to the balanced amino acid composition, *Moringa* seed protein isolate (MPI) could be used as an alternative to other protein sources for application in human foods. The total essential and non-essential, charged, aromatic, and *sulphur* containing amino acid profile of *Moringa* protein isolates makes them a suitable choice of protein for adults, children, and animals. The high cysteine and methionine (43.6 g/kg protein) contents of *Moringa* seed protein are close to those of chicken eggs and cow and human milk (Owon *et al.*, 2021). It is also reported to improve the quality of food products along with additional health benefits. Recent findings have demonstrated that *Moringa* seeds, their extracts, protein, and peptide fractions have a high nutritional profile and bioactive compounds that can be employed for application in the nutraceutical, pharmaceutical, and functional food industry (Kumar *et al*., 2022).

Acha (*Digitaria exillis*) is a cereal grain in the family of gramineae and commonly referred to as acha or hungry rice. *Acha* is mostly consumed whole; perhaps because of its small size (Ayo *et al*., 2022b). *Acha* is an important source of antioxidant phenolics, dietary fiber and cholesterol-lowering waxes and capable of helping diabetic patients in West Africa (Deriu *et al.,* 2022). Despite its low agronomic yield potential. *Acha* is gaining importance as a crop and food ingredient due to its superior nutritional characteristics compared with other cereals, the increased market interest in traditional food, and its suitability to be grown in tough conditions, such as in arid soil (Deriu *et al.,* 2022). *Acha* flour has been mixed with other ingredients to improve the nutritional and textural quality of different food products such as malts, beverages, sourdough, bread, puddings, crackers, breakfast cereals, and biscuits (Zhu 2020). *Acha* has a high content of calcium and iron, compared to the other cereals indicated in the food composition table of Mali. Potassium and magnesium appear to be the major mineral elements in *acha* grains (Zhu, 2020). The protein content of *acha* is like that found in white rice although it has higher sulphur amino acid content (methionine and cysteine). *Acha* has a high pentosan content, which gives it the capacity to absorb water to produce a very viscous solution, an attribute known for good baking operation (Deriu *et al.,* 2022). It contains 7-9% crude protein. Its protein is high in methionine and cysteine, two important amino acids almost deficient in wheat, rice, barley and rye. Investigation carried out on the *Acha* grain reveals that the *Acha* grain contains 6.5% crude protein (Ayo *et al*., 2022). *Acha* is a nutrient-dense grain that is rich in dietary fiber, B-vitamins, minerals and essential amino acids such as Leucine, lysine, methionine, phenylalanine and others (Ayo *et al*., 2022).

One of the major constraints in biscuits production is the dependence of wheat flour for its production and importation of wheat which has led to the high cost of baked products (Ayo *et al*., 2022b). It also contains high gluten which has prompted to some gluten illness such as celiac disease, gluten ataxia thus there is a need for an alternative cereal. The alternative use of locally available but underutilized cereals crops such as acha is relatively poor both in quantity and quality in terms of nutrient. *Moringa oleifera* seeds, a good source of protein which could be used to improve the quality of the product contains high content of fat which could lead to rancidity of product.

Materials and Methods

Materials

Acha grains (*Digitaria exilis*) was purchased from Wukari New Market, Taraba State. *Moringa oleifera* seeds, margarine (Simas), baking powder (omega), granulated sugar (Golden penny), ethanol (99%) and salt (Uncle palm salt) was purchased from Wukari New Market, Taraba state.

Methods of preparation

Preparation of acha flour

Acha grains (*Digitaria exilis*) was sorted manually and washed using portable water to remove tiny stones, dust and dried using the oven dryer at 50℃ for 6hours. It was milled using a attrition mill, sieved through a 0.3 mm mesh, packaged in a polyethylene bag and stored at 5℃ (Olagunju *et al.,* 2020).

Preparation of Defatted Moringa seed flour

The method described by Darshana *et al.* (2020), with slight modification was used in defatting. *Moringa oleifera* seeds was dehulled manually, picked, washed with portable water and drained. It was spread thinly on the oven dryer tray, oven dried at 50°C for 4hours, milled and sieved through 0.4mm sieve mesh. The *moringa* seed flour was then defatted with ethanol until the fat content reduces below 0.5%. The defatted flour was air-dried at ambient temperature (28-32°C) for 24 hours. It was then milled, sieved through a 0.2 mm mesh sieve and stored for further analysis.

Production of defatted Moringa seed-acha flour blend biscuits

The method described by Oyet and Chibor, (2020) was used to produce the biscuits with slight modifications in the formulation. The sugar and baking fat were creamed using a Kenwood mixer at medium speed until light and fluffy, followed by salt, baking powder and lastly water. The mixture was thoroughly mixed into consistent paste. The paste was filled and pressed out into predetermined size and shape using a piping bag. The dough was arranged in pre-oiled trays and baked in a preheated laboratory oven operating at 160ºC for 20-30min. After baking, the hot biscuits were removed from the oven and allowed to cool. It was then packaged in a polyethylene bag of appropriate thickness and permeability using an impulse sealing machine prior to further analysis. It is shown below in the recipe for the blend biscuit (Table 1)

Table 1: Recipe formulation for composite blend biscuit

Ingredients	A	B	C	D	E	F	G
Wheat	100	0	0	0	0	0	0
flour (g)	0	100	95	90	85	80	75
Acha (g)	0	0	5	10	15	20	25
DMSF(g)	30	30	30	30	30	30	30
Margarine	20	20	20	20	20	20	20
(g)	1	1	1	1	1	1	1
Sugar (g)	1	1	1	1	1	1	1
Salt (g)	15	15	15	15	15	15	15
Baking							
powder (g)							
Water (g)							

Source: (Oyet and Chibor, 2020)
DMSF: Defatted *Moringa* seed flour

Analytical method

Determination of the functional properties of Moringa seed-acha blend flour

Water absorption capacity and oil holding capacity were determined according to the method described by Ayo and Kajo (2016). Bulk densities and swelling capacity of the samples were determined using the procedure outline by Ayo *et al.* (2018b). The foam capacity was determined using the method described by Chandra *et al.* (2015). Emulsifying capacity was determined using the method described by Ayo and Kajo, (2016) with slight modifications, 1g of the flour sample was blended with 10ml distilled water at room temperature for 30seconds in a warring blender at 1600rpm. 10ml of vegetable oil was gradually added after complete dispersion with continued blending for another 30seconds, and then transferred into a centrifuge tube at 2000rpm for 5minutes. The volume of oil separated from the sample after centrifugation was read directly from the tube. Emulsion capacity is expressed as the amount of oil emulsified and held per gram of sample.

Pasting property of flour blends

The pasting properties were determined using Rapid Visco Analyser (RVA). 3.5 g of the flour sample was weighed and dispensed into the test canister, 25 ml of distilled water was added, mixed thoroughly and analysed using the RVA using the manufacturer recommended parameters (Ayo *et al.,* 2018b).

Determination of chemical composition of blend biscuits

Proximate analysis of blend biscuits

The method described in AOAC (2015) was used to analyze the proximate composition of samples for moisture, ash, fibre, crude fat, protein, while the carbohydrate content was calculated by subtracting the sum of the valve of the nutrient from 100.

Determination of minerals composition of blend biscuits

The phosphorus content was determined using the method described by AOAC (2016).

Potassium and calcium contents were determined by the method described by Ayo *et al*. (2021).

Determination of vitamins composition of blend biscuits

Vitamin A content was determined using the method described by AOAC (2016). The method described in AOAC (2015) was used to analyze the vitamin B_6 content. Vitamin B_1 was determined by HPLC as described by Ayo *et al.* (2023). 2 g of fresh sample was weighed into 50 mL polypropylene tube and 30 mL of 3% metaphosphoric acid was added and homogenized using a homogenizer. The mixture was sonicated in an ultrasonic bath for 5 mins, vortexed and centrifuged at 845×g for 5 mins, filtered, (0.25 μm membrane) and separated using chromatography. The mobile phase composition consisted of 0.3 mM potassium dihydrogen phosphate in 0.35% (v/v) phosphoric acid at a flow rate of 0.2 mL/ min at ambient temperature. Injections of 20 μL were performed with a total run time of 12 mins. Data were extracted at a wavelength of 242 nm; compound identification was based on matching of the retention times with pure ascorbic acid.

Determination of anti-nutrient and phytochemical contents of blend biscuits

Determination of phytate content

Phytate content (mg/100 g) was determined by the method described by Hawa *et al.* (2018). The method described by Ayo *et al.* (2023) was adopted to determine the total phenolic, total flavonoid and carotenoid content of the samples.

Physical properties of the blend biscuits

Weight: Weight of biscuits was measured as the average value of three individual biscuit with digital weighing balance (Chinma *et al*., 2022).

Thickness and diameter: The thickness and diameter of the biscuits was measured with a vernier calliper in two perpendicular directions (Chinma *et al.,* 2022).

Volume: The volume of the biscuits is defined as the area of the biscuits multiplied by the thickness (Yachita *et al.,* 2023). It is calculated using the formula;

Volume=$d^2\pi T/4$

Where T=average thickness of biscuits (cm)

d=diameter of biscuits (cm)

Spread ratio: The spread ratio of the biscuit was determined by dividing biscuit diameter by the thickness (Chinma *et al.,* 2020)

Break Strength: Biscuit of known thickness was placed centrally between two parallel metal bars (3cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit as described by Ayo and Kajo (2016).

Sensory evaluation of MSPI-Acha biscuits

The sensory evaluation of the samples was carried out for consumer acceptance and preference using 20 randomly selected semi trained judges (students and staff of the Department of Food Science and Technology, Federal University Wukari, Nigeria). Nine points Hedonic scale (1 and 9 representing "extremely dislike" and "extremely like"), respectively was used for the preference test. Qualities to be assessed include colour (crust and crumb), odour, taste, texture (crumb and crust) and general acceptance. Coded samples of the same size and temperature (30ºC) was served in a coloured(white) plate of the same size to judges in each panel cupboard under the fluorescent light; only one sensory attribute was tested at one sitting. Unless otherwise maintained all the measurement was made in triplicate and the values represented the average of the three measurements (Ayo *et al.,* 2018b)

Statistical analysis

The results obtained from the various analyses were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0. Means where separated with Duncan Multiple Range Test (DMRT) at 5% level of significance ($p \leq 0.05$).

Results and Discussion

Functional properties of Defatted Moringa seed-Acha flour blends

The functional properties of defatted *moringa* seed-*acha* flour blends are presented in Table 2. The Water absorption capacity (WAC) of the flour blends increased from 1.65 to 1.95ml/g with increase in defatted *Moringa* seed. The highest value was recorded in 75:25% flour blends (75% *acha* and 25% *Moringa*) and the lowest value was recorded in 100% wheat. This agreed with the work of Bello *et al.* (2020) who recorded similar increase with added *Moringa* flour. The capability of food materials to absorb water to a large extent is associated to its protein content (Kiin-Kabiri *et al.,* 2015). High water absorption capacity is also attributed to loose structure of starch polymers while low value indicates the compactness of the structure. It also refers to the ability of protein matrix, such as protein particles, protein gels to absorb and retain water against gravity.

Water absorption capacity is a desirable trait in foods such as custards, sausages and dough because these are supposed to imbibe water without dissolution of protein, thereby attaining body thickening and viscosity (Oyet and Chibor, 2020).

The packed bulk density of the flour blends decreased from 0.96 to 0.66g/ml with increase in defatted *moringa* seed (0 to 25%). The highest value was recorded in 100% *acha* with 0.96 which was higher than the value in the bulk density of Ayo *et al.* (2022a) while the lowest value recorded in 100% wheat was similar to his work. The loose bulk density decreased from 0.72 to 0.59g/ml with increase in defatted *moringa* seed flour (0—25%). Bulk density provides information on the capacity of the required packaging material. The higher the bulk density of the flour, the denser the packaging material required for packaging. High bulk density of flours suggests their suitability for application in food preparations whereas low bulk density would be useful in the formulation of complementary foods (Awuchi *et al.,* 2019).

The foaming capacity of the blend flour increased significantly (p<0.05) from 2.96 to 17.00% with increase in defatted *moringa* seed flour (0-25%). This agrees with the work of Ayo *et al.* (2018b). The highest value was recorded in 75:25% flour blends (75% *acha* and 25% defatted *moringa* seed) and lowest value was recorded in 100:0 (100% *acha)*. The increase in foam capacity can be attributed to the increase values of protein with added defatted *moringa* seed.The foaming capacity of flours is mainly related to proteins, which form a continuous, cohesive film around the air bubbles in the foam.

The oil absorption capacity decreased significantly (p<0.05) from 1.15 to 0.50ml/g with increase in defatted *moringa* flour (0-25%).The ability of flours to bind with oil makes them useful in food applications where optimal oil absorption is desired, making flours to have potential functional applications in foods such as production of pastries, sausage. The oil absorption capacity also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation (Awuchi *et al.,* 2019).

The emulsifying capacity of the flour blends decreased with no significant different from 43.99 to 37.79% with increase in defatted *Moringa* seed flour. This agrees with work of Ayo *et al.* (2018a) which recorded similar decrease in flour blend of *Acha-Moringa* seed flour.The emulsifying capacity, also called emulsion capacity (EC), of foods is associated with the amount of oil, non-polar amino acids residues on the surface of protein, water, and other components in the food. An increased number of non-polar amino acids residues on the surface of protein will reduce the energy barrier to adsorptions which depends on the protein structure (Awuchi *et al.,* 2019).The swelling capacity of flour blends increased significantly (p<0.05) from 4.91 to 5.81 with increase in addition of defatted *moringa* seed flour (0-25%). The highest value was recorded in 75:25% flour blend (75% *acha* and 25% defatted *moringa* seed flour blend) and lowest was recorded in 100% wheat. This is in line with Bello *et al.* (2020) work who also recorded similar increase

Sample	Water absorption capacity (ml/g)	Bulk density (g/ml)	Loose bulk density (g/ml)	Foam Capacity (%)	Oil absorption capacity (ml/g)	Emulsifying Capacity (%)	Swelling Capacity (g/g)
A	1.15^{a}±0.07	0.65^{c}±0.03	0.54^{d}±0.02	4.00^{bc}±2.83	1.20^{a}±0.28	41.42^{a}±0.35	4.67^{d}±0.03
B	1.65^{b}±0.07	0.96^{a}±0.06	0.72^{ab}±0.07	2.96^{c}±1.36	1.15^{a}±0.07	43.91^{a}±0.76	4.91^{d}±0.11
C	1.70^{b}±0.14	0.87^{ab}±0.06	0.74^{a}±0.04	5.92^{bc}±2.72	0.90^{ab}±0.14	43.99^{a}±0.82	5.27^{c}±0.12
D	1.80^{ab}±0.28	0.77^{bc}±0.08	0.63^{c}±0.00	6.77^{bc}±4.03	0.80^{ab}±0.28	43.93^{a}±1.51	5.35^{bc}±0.06
E	1.90^{ab}±0.14	0.72^{bc}±0.07	0.65^{bc}±0.03	10.67^{ab}±1.23	0.65^{b}±0.07	41.93^{a}±1.06	5.51^{abc}±0.06
F	1.90^{ab}±0.14	0.72^{bc}±0.07	0.61^{cd}±0.03	16.66^{a}±0.93	0.60^{b}±0.00	43.13^{a}±2.65	5.65^{ab}±0.16
G	1.95^{ab}±0.07	0.66^{c}±0.07	0.59^{cd}±0.00	17.00^{a}±4.24	0.50^{b}±0.14	37.79^{b}±0.82	5.82^{a}±0.27

Table 2: Functional properties of defatted *Moringa* seed-*acha* flour blends

Sample	Peak viscosity (centipoise)	Trough (centipoise)	Break down (centipoise)	Final viscosity (centipoise)	Setback (centipoise)	Peak time (mins.)	Pasting temperature (^{0}C)
A	131.39^{e}±0.07	110.32^{a}±0.94	51.54^{c}±0.43	155.61^{a}±1.18	47.68^{f}±0.20	5.04^{g}±0.01	86.69^{d}±0.20
B	168.89^{a}±0.07	97.76^{a}±0.30	55.42^{a}±0.01	112.49^{g}±0.98	67.49^{a}±0.08	7.73^{a}±0.01	89.64^{a}±0.13
C	167.89^{b}±0.10	97.95^{d}±0.02	53.55^{b}±0.02	114.54^{f}±0.02	62.39^{b}±0.07	7.72^{b}±0.01	89.64^{a}±0.02
D	161.39^{c}±0.08	99.24^{d}±0.04	53.07^{b}±0.02	121.44^{e}±0.01	61.83^{c}±0.02	7.71^{c}±0.01	89.23^{b}±0.02
E	156.91^{d}±0.10	101.76^{c}±0.01	51.14^{d}±0.12	125.55^{d}±0.16	56.60^{d}±0.24	7.62^{d}±0.02	88.24^{b}±0.02
F	151.44^{d}±0.01	104.44^{b}±0.14	46.54^{d}±0.01	128.65^{c}±0.01	52.39^{d}±0.08	7.54^{e}±0.02	88.04^{c}±0.04
G	151.04^{d}±0.01	104.85^{b}±0.00	46.18^{e}±0.04	134.53^{b}±0.16	52.22±0.02	7.46^{f}±0.02	88.06^{c}±0.04

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different (p<0.05).
A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSFF=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour

Pasting properties of Defatted *Moringa* seed-*Acha* flour blends

The results of the pasting properties of the defatted *Moringa* seed-*acha* flour blends are shown in Table 3. The peak viscosity decreased significantly (p<0.05) from 167.89 to 151.04 with increase in defatted *Moringa* seed flour (5-25%). The results show that the highest value was recorded in 100% *acha* and the lowest value was recorded in 100% wheat. The decrease in the peak viscosity could be attributed to the increase in protein content which added Defatted *Moringa* seed flour and low level of carbohydrates.

The trough viscosity increased significantly (p<0.05) from 97.95 to 104.85 with increase in defatted *moringa* seed flour (5-25%). The highest value of trough was recorded in 100% wheat and lowest value recorded in 100% *acha*. There was no significant difference between 95:5% and 90:10% flour blends and also between 80:20% and 75:25% flour blends. Trough thickness measures the smallest capacity of the paste to resist collapse during the period of cooling (Ayo *et al.*, 2018b).

The breakdown decreased from 53.55 to 46.18 with increase in defatted *moringa* seed flour (5-25%). The highest value was recorded in 100% *acha* and lowest value was recorded in 75% *acha* with 25% defatted *Moringa* seed flour. Breakdown viscosity reflects the stability of the paste during processing. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress during. The high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross-linking properties (Ayo *et al.*, 2022a).

The final viscosity increased significantly (p<0.05) from 114.54 to 134.53 with increase in defatted *moringa* seed flour (5-25%) with the highest value recorded in 100% wheat flour and lowest value was recorded in 100% *acha* flour. The increase could be attributed to the increase in protein content with increasing levels of defatted *Moringa* seed flour.

The setback decreased significantly (p<0.05) from 62.39 to 52.22 with increase in defatted *Moringa* seed flour. The highest value was recorded in 100% *acha* and lowest was recorded in 100% wheat flour. Higher set back values are synonymous with reduced dough digestibility while lower setback during the cooling of the paste indicates a lower tendency for retro gradation (Ayo *et al.*, 2018b)

The peak time decreased significantly (p<0.05) from 7.72 to 7.46 minutes with added defatted *Moringa* seed flour. The highest value was recorded in 100% *acha* and lowest value was recorded in 100% wheat. The pasting temperature ranged from 89.64℃ to 88.06℃ with increase in defatted *Moringa* seed flour. Pasting time is a measure of the cooking time. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starches. Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability (Ayo *et al.*, 2022).

Table 3: Pasting properties of defatted *Moringa* seed-*acha* flour blends

Sample	Calcium (mg/100g)	Phosphorus (mg/100g)	Potassium (mg/100g)
A	$34.78^{b} \pm 0.01$	$8.41^{g} \pm 0.02$	$41.63^{d} \pm 0.42$
B	$25.63^{a} \pm 0.27$	$8.76^{f} \pm 0.10$	$31.94^{f} \pm 0.71$
C	$37.54^{c} \pm 0.01$	$8.90^{e} \pm 0.04$	$39.54^{e} \pm 0.00$
D	$39.47^{d} \pm 0.04$	$8.99^{d} \pm 0.05$	$40.91^{e} \pm 0.03$
E	$41.39^{e} \pm 0.08$	$9.06^{b} \pm 0.06$	$42.28^{c} \pm 0.08$
F	$44.47^{f} \pm 0.04$	$9.01^{c} \pm 0.04$	$46.78^{b} \pm 0.08$
G	$47.54^{a} \pm 0.16$	$9.26^{a} \pm 0.04$	$51.28^{a} \pm 0.08$

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different (p<0.05). A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF, E=85%AF,15%DMSF F=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour.

Chemical composition of defatted Moringa seed flour Acha flour blend biscuits

Proximate composition of defatted Moringa seed-Acha flour blend biscuits

The proximate composition of defatted *Moringa* seed-*Acha* flour blend biscuits is presented in Table 4

The moisture content of the blend biscuits increased significantly ($p<0.05$) from 8.57 to 8.87% with increase in defatted *moringa* seed flour (5-25%). The highest value was recorded for 100% wheat and lowest was recorded for 100% *acha*. These values are in accordance with the work of Ayo *et al.* (2018a) who recorded similar increase in moisture with increase in *moringa* seed flour levels. The lower the moisture contents of a product, the better the shelf stability of such product because low moisture ensures shelf stability in dried products. Thus, low moisture content in confectionaries such as biscuit is an advantage as it will bring about reduction in microbial spoilage and prolonged storage shelf life if stored inside appropriate packaging materials under good environmental condition (Ayo *et al.,* 2022a).

The fat content of the blend biscuits increased significantly ($p<0.05$) from 19.91 to 20.38% with increase in added defatted *moringa* seed flour (5-25%). The increase in fat content with added defatted *moringa* seed flour is attributed to the high fat content of 38.67% in *moringa* seed as reported by Gopalakrishnan *et al*. (2016). Fats are sources of essential fatty acids, an important dietary requirement for infants and children.

The fiber content of the blend biscuits decreased significantly ($p<0.05$) from 3.12 to 2.99% with increase in added defatted *moringa* seed flour (5-25%). The highest value was recorded in 100% *acha* and lowest value was recorded in 100% wheat. The fiber content decreased with added defatted *moringa* seed flour which could be attributed to the lower fiber level in the added defatted *moringa* seed flour. This agrees with the work of Ayo *et al.* (2011) for biscuits produced with acha and cowpea flour.

The ash content of the blend biscuits decreased significantly ($p<0.05$) from 2.33 to 2.04% with increase in added defatted *moringa* seed flour (5-25%). This is lower than the results of Ayo *et al.,* (2011) in biscuits produced with acha and cowpea. This Ash content indicates the presence of mineral matter in food. Ash residue is generally taken to be a measure of the mineral content of the original food and which is generally small (Ayo *et al.,* 2022a).

The protein content increased significantly ($p<0.05$) from 14.45 to 26.79% with increase in added defatted *moringa* seed flour (5-25%). The highest value was recorded in 75% *acha* with 25% defatted *moringa* seed flour and lowest recorded in *acha.* The protein content recorded in this study is higher than that of Orafa *et al.* (2023) which ranged from 7.715 to 13.89% for biscuits produced from *acha* and defatted melon seed. The protein content increased with added defatted *moringa* seed due to the high protein content in defatted *moringa* seed of 35.97% as reported by Gopalakrishnan *et al*. (2016). This shows that biscuits produced from *acha* and defatted *moringa* seed are good source of protein.

The carbohydrates content decreased significantly ($p<0.05$) from 51.63 to 38.94% with increase in added defatted *moringa* seed flour (5-25%). The decrease in the carbohydrates can be attributed to the low level of carbohydrates in the defatted *moringa* seed flour. The highest value was recorded in 100% wheat and the lowest value was recorded in 75% *acha* with 25% defatted *moringa* seed flour.

Table 4: Proximate composition of defatted *Moringa* seed-*acha* flour blends biscuits

Sample	Moisture (%)	Fat (%)	Fiber (%)	Ash (%)	Protein (%)	Carbohydrates (%)
A	$8.92^{a} \pm 0.01$	$17.91^{e} \pm 0.11$	$1.82^{e} \pm 0.01$	$2.03^{e} \pm 0.03$	$11.74^{f} \pm 0.12$	$57.67^{a} \pm 0.12$
B	$8.43^{d} \pm 0.02$	$19.54^{d} \pm 0.16$	$3.13^{a} \pm 0.02$	$2.36^{a} \pm 0.02$	$9.69^{g} \pm 0.04$	$56.86^{b} \pm 0.09$
C	$8.57^{c} \pm 0.01$	$19.91^{b} \pm 0.07$	$3.12^{a} \pm 0.00$	$2.33^{a} \pm 0.02$	$14.45^{e} \pm 0.15$	$51.63^{c} \pm 0.25$
D	$8.70^{b} \pm 0.03$	$19.88^{c} \pm 0.01$	$3.09^{ab} \pm 0.01$	$2.23^{b} \pm 0.01$	$17.19^{d} \pm 0.05$	$48.93^{d} \pm 0.01$
E	$8.82^{a} \pm 0.08$	$19.84^{c} \pm 0.06$	$3.05^{c} \pm 0.02$	$2.13^{c} \pm 0.02$	$19.92^{c} \pm 0.06$	$46.24^{e} \pm 0.25$
F	$8.85^{a} \pm 0.05$	$20.11^{b} \pm 0.07$	$3.02^{b} \pm 0.03$	$2.09^{d} \pm 0.01$	$23.36^{b} \pm 0.07$	$42.58^{f} \pm 0.23$
G	$8.87^{a} \pm 0.01$	$20.38^{a} \pm 0.07$	$2.99^{b} \pm 0.03$	$2.04^{e} \pm 0.02$	$26.79^{a} \pm 0.08$	$38.94^{g} \pm 0.18$

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different ($p<0.05$).
A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSFF=80%AF:20%DMSF,G =75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour

Mineral composition of defatted *Moringa* seed-*acha* flour blend biscuits

The mineral composition of the defatted *Moringa* seed-*acha* flour blend biscuits is presented in Table 5. The calcium content of the blend biscuits increased significantly ($p<0.05$) from 37.54 to 47.54mg/100g with increase in added defatted *moringa* seed flour (5-25%). The calcium content of the blend biscuits increased with added defatted *moringa* seed flour due to the high level of calcium in the *moringa* seed flour of 76.85mg/100g as reported by El-Massry *et al,* (2013). Calcium is important for normal nerve and muscle action, blood clotting, heart function, cell metabolism and also strengthens the bones and teeth in combination with phosphorus (Bakare *et al*., 2020).

The potassium content of the blend biscuits increased significantly (p<0.05) from 39.54 to 51.28mg/100g with increase in added defatted *moringa* seed (5-25%). The highest value was recorded in 75% *acha* with 25% defatted *moringa* seed and lowest value was recorded for 100% *acha*. There was no significant difference between 5% and 10% blends. The increase in potassium content of the blend biscuits with added defatted *moringa* seed flour is due to the high level of potassium in the *moringa* seed of about 64.24mg/100g as reported by El-Massry *et al.*, (2013). This is higher than the results of Adegbanke *et al.*, (2020) for biscuits produced with wheat and Bambara groundnut flour.

Sample	Calcium (mg/100g)	Phosphorus (mg/100g)	Potassium (mg/100g)
A	$34.78^{b} \pm 0.01$	$8.41^{g} \pm 0.02$	$41.63^{d} \pm 0.42$
B	$25.63^{a} \pm 0.27$	$8.76^{f} \pm 0.10$	$31.94^{f} \pm 0.71$
C	$37.54^{c} \pm 0.01$	$8.90^{e} \pm 0.04$	$39.54^{e} \pm 0.00$
D	$39.47^{d} \pm 0.04$	$8.99^{d} \pm 0.05$	$40.91^{e} \pm 0.03$
E	$41.39^{e} \pm 0.08$	$9.06^{b} \pm 0.06$	$42.28^{c} \pm 0.08$
F	$44.47^{f} \pm 0.04$	$9.01^{c} \pm 0.04$	$46.78^{b} \pm 0.08$
G	$47.54^{a} \pm 0.16$	$9.26^{a} \pm 0.04$	$51.28^{a} \pm 0.08$

The phosphorus content of the blend biscuits increased significantly (p<0.05) from 8.90 to 9.26mg/100g with increase in added defatted *moringa* seed flour (5-25%). The increase in the phosphorus content of the blend biscuits with added defatted *Moringa* seed flour could be attributed to the high level of phosphorus in the defatted *moringa* seed. The highest value recorded was in 75% *acha* with 25% defatted *moringa* seed and lowest value was in 100% wheat. This shows that the blend biscuits are good sources of phosphorus. Phosphorus is the second most abundant mineral in the body after calcium. In form of various phosphates, phosphorus performs a wide variety of essential functions including liberation and utilization of energy from food (Ayo *et al.,* 2022a).

Table 5: Mineral composition of defatted *Moringa* seed-*acha* flour blend biscuit

Sample	Carotenoids (mg/100g)	Flavonoids (mg/100g)	Phenols (mg/100g)	Phytate (mg/100g)
A	$0.77^{g} \pm 0.02$	$0.76^{g} \pm 0.03$	$7.63^{g} \pm 0.03$	$0.35^{g} \pm 0.03$
B	$1.83^{f} \pm 0.02$	$0.85^{f} \pm 0.00$	$11.58^{f} \pm 0.50$	$1.24^{f} \pm 0.02$
C	$2.02^{e} \pm 0.14$	$0.96^{e} \pm 0\ 02$	$14.53^{e} \pm 0.29$	$1.64^{e} \pm 0.01$
D	$2.17^{d} \pm 0.01$	$1.05^{d} \pm 0.01$	$17.43^{d} \pm 0.21$	$1.88^{d} \pm 0.01$
E	$2.30^{c} \pm 0.03$	$1.13^{c} \pm 0.01$	$20.32^{c} \pm 0.13$	$2.13^{c} \pm 0.02$
F	$2.37^{b} \pm 0.02$	$1.19^{b} \pm 0.02$	$22.30^{b} \pm 0.04$	$2.25^{b} \pm 0.01$
G	$2.42^{a} \pm 0.01$	$1.24^{a} \pm 0.03$	$24.28^{a} \pm 0.05$	$2.37^{a} \pm 0.02$

*Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different (p<0.05). A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSF F=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=Wheat flour, AF=*Acha *flour and DMSF=defatted Moringa seed flour*

Vitamins composition of defatted Moringa seed-acha flour blend biscuits

The vitamins composition of defatted *Moringa* seed-*acha* flour blend biscuits is presented in Table 6. The vitamin A content of the blend biscuits increased significantly (p<0.05) from 1.24 to 1.83mg/100g with increase in added defatted *moringa* seed flour. The increase in vitamins content of the blend biscuits with added defatted *moringa* seed flour is due to the high level of vitamin A present in it. Vitamin A is a vital micronutrient naturally present in many foods and it is important for maintaining a healthy immune system, for growth and development of the body and also for reproduction (Gilbert, 2013).

The vitamin B_1 content of the blend biscuits increased significantly ($p<0.05$) from 0.42 to 0.94mg/100g with increase in added defatted *moringa* seed flour (5-25%). The increase in vitamin B_1 content of the blend biscuits with added defatted *moringa* seed flour could be attributed to the high level of vitamin B_1 content present in the seeds. The highest value was recorded in 75% *acha* with 25% defatted *moringa* seed flour and lowest value was recorded in 100% wheat.

The vitamin B_6 content of the blend biscuits increased significantly ($p<0.05$) from 0.82 to 1.48mg/100g with increase in added defatted *moringa* seed flour (5-25%). The vitamin B_6 content of blend biscuits was significantly higher than the control (100% wheat) and also 100% *acha* due to the high level of vitamin B_6 content present in the seeds. This is lower than the results of Makanjuola and Adebowale (2020) for biscuits produced from wheat and cocoyam.

Table 6: Vitamin composition of defatted *Moringa* seed-*acha* flour blend biscuits

Sample	Water absorption capacity (ml/g)	Bulk density (g/ml)	Loose bulk density (g/ml)	Foam Capacity (%)	Oil absorption capacity (ml/g)	Emulsifying Capacity (%)
A	$1.15^{a}\pm0.07$	$0.65^{c}\pm0.03$	$0.54^{d}\pm0.02$	$4.00^{bc}\pm2.83$	$1.20^{a}\pm0.28$	$41.42^{a}\pm0.35$
B	$1.65^{b}\pm0.07$	$0.96^{a}\pm0.06$	$0.72^{ab}\pm0.07$	$2.96^{c}\pm1.36$	$1.15^{a}\pm0.07$	$43.91^{a}\pm0.76$
C	$1.70^{b}\pm0.14$	$0.87^{ab}\pm0.06$	$0.74^{a}\pm0.04$	$5.92^{bc}\pm2.72$	$0.90^{ab}\pm0.14$	$43.99^{a}\pm0.82$
D	$1.80^{ab}\pm0.28$	$0.77^{bc}\pm0.08$	$0.63^{c}\pm0.00$	$6.77^{bc}\pm4.03$	$0.80^{ab}\pm0.28$	$43.93^{a}\pm1.51$
E	$1.90^{ab}\pm0.14$	$0.72^{bc}\pm0.07$	$0.65^{bc}\pm0.03$	$10.67^{ab}\pm1.23$	$0.65^{b}\pm0.07$	$41.93^{a}\pm1.06$
F	$1.90^{ab}\pm0.14$	$0.72^{bc}\pm0.07$	$0.61^{cd}\pm0.03$	$16.66^{a}\pm0.93$	$0.60^{b}\pm0.00$	$43.13^{a}\pm2.65$
G	$1.95^{ab}\pm0.07$	$0.66^{c}\pm0.07$	$0.59^{cd}\pm0.00$	$17.00^{a}\pm4.24$	$0.50^{b}\pm0.14$	$37.79^{b}\pm0.82$

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different (p<0.05). A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSF F=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=+Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour

Phytochemicals composition of defatted Moringa seed-acha flour blends biscuits

The phytochemical composition of the defatted *moringa* seed-*acha* flour biscuits is presented in Table 7. The carotenoids content of the blend biscuits increased significantly ($p<0.05$) from 2.02 to 2.42mg/100g with increase in added defatted *moringa* seed flour (5-25%). The increase in the carotenoids content of the blend biscuits with added defatted *moringa* seed flour could be due to the high level of carotenoids present in *moringa* seed of about 9.57mg/100g as reported by El-Massry *et al.* (2013).

The flavonoids content of the blend biscuits increased significantly ($p<0.05$) from 0.96 to 1.24mg/100g with increase in added defatted *moringa* seed flour (5-25%). The increase in flavonoids content of the blend biscuits with added defatted *moringa* seed is attributed to the high level of flavonoids present in *moringa* seed. The highest value was recorded in 75% *acha* with 25% defatted *moringa* seed flour and lowest value was recorded in 100% wheat. Flavonoids have antioxidant properties that play protective role against the development of cardiovascular diseases, atherosclerosis, hypertension, ischemia/reperfusion injury, diabetes

Table 7: Phytochemicals composition of defatted *Moringa* seed-*acha* blend biscuits

Sample	Peak viscosity (centipoise)	Trough (centipoise)	Break down (centipoise)	Final viscosity (centipoise)	Setback (centipoise)	Peak time (mins.)	Pasting temperature (^{0}C)
A	$131.39^{e}\pm0.07$	$110.32^{a}\pm0.94$	$51.54^{c}\pm0.43$	$155.61^{a}\pm1.18$	$47.68^{f}\pm0.20$	$5.04^{g}\pm0.01$	$86.69^{d}\pm0.20$
B	$168.89^{a}\pm0.07$	$97.76^{a}\pm0.30$	$55.42^{a}\pm0.01$	$112.49^{g}\pm0.98$	$67.49^{a}\pm0.08$	$7.73^{a}\pm0.01$	$89.64^{a}\pm0.13$
C	$167.89^{b}\pm0.10$	$97.95^{d}\pm0.02$	$53.55^{b}\pm0.02$	$114.54^{f}\pm0.02$	$62.39^{b}\pm0.07$	$7.72^{b}\pm0.01$	$89.64^{a}\pm0.02$
D	$161.39^{c}\pm0.08$	$99.24^{d}\pm0.04$	$53.07^{b}\pm0.02$	$121.44^{e}\pm0.01$	$61.83^{c}\pm0.02$	$7.71^{c}\pm0.01$	$89.23^{b}\pm0.02$
E	$156.91^{d}\pm0.10$	$101.76^{c}\pm0.01$	$51.14^{d}\pm0.12$	$125.55^{d}\pm0.16$	$56.60^{d}\pm0.24$	$7.62^{d}\pm0.02$	$88.24^{b}\pm0.02$
F	$151.44^{d}\pm0.01$	$104.44^{b}\pm0.14$	$46.54^{d}\pm0.01$	$128.65^{c}\pm0.01$	$52.39^{d}\pm0.08$	$7.54^{e}\pm0.02$	$88.04^{c}\pm0.04$
G	$151.04^{d}\pm0.01$	$104.85^{b}\pm0.00$	$46.18^{e}\pm0.04$	$134.53^{b}\pm0.16$	52.22 ± 0.02	$7.46^{f}\pm0.02$	$88.06^{c}\pm0.04$

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different $p<0.05$.
.A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSF, F=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour mellitus, neurodegenerative diseases (Alzheimer's diseases and Parkinson's diseases), rheumatoid, arthritis and ageing (Ayo *et al.*, 2022a)

The phenol content of the blend biscuits increased significantly ($p<0.05$) from 14.53 to 24.28mg/100g with increase in added defatted *moringa* seed flour (5-25%). The increase of the phenol content of the blend biscuits with added defatted *moringa* seed flour can be traced to the high level of phenols present in *moringa* seed of 22.43mg/100g as reported by Do Nascimento *et al.* (2017).

The phytates content of the blend biscuits increased significantly ($p<0.05$) from 1.64 to 2.37mg/100g with increase in defatted *moringa* seed flour. Phytates lowers the blood glucose response of diabetes patients by reducing the rate of starch digestion and slowing gastric emptying *(Gemede et al., 2014)*. This is higher than results of Ayo *et al.* (2022a) for biscuits produced with acha and tangerine peel.

Physical properties of defatted Moringa seed-acha flour blend biscuits

The physical properties of defatted *Moringa* seed flour-*acha* flour blend biscuits is presented in Table 8. The thickness of the blend biscuits increased significantly ($p<0.05$) from 0.22 to 0.39cm with increase in defatted *moringa* seed flour. The thickness of the blend biscuits was relatively lower than that of 100% wheat. The higher the thickness of biscuits the higher its ability to withstand stress (Ubbor *et al.*, 2022). The differences in biscuits could be attributed to the differences in thickness of dough rolled out during processing. The diameter of the blend biscuits increased significantly ($p<0.05$) from 3.87 to 4.12 with increase in defatted *Moringa* seed flour. The diameter determines the quality of flour used in baking (Bala *et al.,* 2015). This is lower than the diameter values of Ubbor *et al.* (2022) ranging from 4.49 to 5.23 for cookies produced from wheat, *acha* and orange flesh sweet potatoes. The volume of the blend biscuits increased from 2.65 to 5.01cm^3 with increase in added defatted *moringa* seed flour. There was no significance between 10, 15 and 20% blends. The weight of the blend biscuits increased significantly ($p<0.05$) from 6.53 to 7.98g with increase in added defatted *Moringa* seed flour. This is higher than the results of Ayo *et al.* (2022b) for biscuits produced from annealed cassava starch and *acha* flour. The break strength of the blend biscuits decreased from 1325.00 to 912.50g with increase in added defatted *moringa* seed flour. The reduction in break strength with increase in added defatted *moringa* seed flour could be due to the dilution in carbohydrates content of the composite biscuits. The breaking strength refers to the force required to break biscuits and is dependent on the interaction between protein and starch hydrogen bonds.

Spread ratio of the biscuits increased significantly ($p<0.05$) from 6.20 to 18.53 with increase in defatted *Moringa* seed flour. The blend biscuits had higher spread ratio than the control (100% wheat) which recorded the lowest value of 6.20 for the spread ratio. Spread ratio or diameter is used to determine the quality of flour used in preparing biscuits and the ability of the biscuit to rise. The higher the spread ratio of biscuit the more desirable it is (Aderinola *et al*., 2020). This disagrees with the work of Aderinola *et al.* (2020) who recorded increase in spread ratio ranging 8. 07 to 10.71 for biscuits produced from wheat and *moringa* seed protein concentrate.

Table 8: Physical properties of defatted *Moringa* seed-*acha* flour blend biscuits

Sample	Thickness (cm)	Diameter (cm)	Volume (cm^3)	Weight (g)	Break strength (g)	Spread ratio
A	$0.61^a±0.01$	$3.78_d±0.03$	$6.88^a±0.31$	$6.23^f±0.04$	$2112.5^a±159.10$	$6.20^d ± 0.11$
B	$0.26^d±0.02$	$3.88^{cd}±0.03$	$3.02^d±0.29$	$5.89^g±0.01$	$512.50^d±17.68$	$15.26^b ±1.16$
C	$0.22^d±0.02$	$3.96^{bc}±0.03$	$2.65^d±0.22$	$6.53^e±0.04$	$1325.00^b±141.42$	$18.52^a ±1.96$
D	$0.35^{bc}±0.01$	$3.87^{cd}±0.01$	$4.11^c±0.2$	$6.84^d±0.01$	$1112.50^{bc}±123.74$	11.07^c ±0,40
E	$0.39^b±0.01$	$4.04^{ab}±0.08$	$5.01^b±0.39$	$7.03^c±0.04$	$995.00^c±42.43$	$10.36^c ±0.16$
F	$0.33^c±0.04$	$4.04^{ab}±0.06$	$4.16^c±0.34$	$7.53^b±0.01$	$942.50^c±24.75$	$12.52^{bc} ±1.53$
G	$0.32^b±0.03$	$4.12^a±0.03$	$4.26^c±0.33$	$7.98^a±0.00$	$912.50^c±123.74$	$12.93^{bc} ±1.23$

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different (p<0.05).
A=100%WF,B=100%AF,C=95%AF:5%DMSF,D=90%AF:10%DMSF,E=85%AF,15%DMSFF=80%AF:20%DMSF,G =75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour

Sensory evaluation of defatted Moringa seed-acha flour blend biscuits

The sensory evaluation of defatted *moringa* seed-*acha* flour blend biscuits is presented in Table 9. The average mean scores for colour, texture, taste, and aroma ranged from 7.80-5.50, 8.00-5.30, 8.40-4.05, and 7.80-5.35 from sample A to G. The colour of the blend biscuits decreased from 6.40 to 5.50 with added defatted *moringa* seed and no significance difference between the biscuits with sample c ranking the highest and sample G had the lowest value. The texture of the blend decreased from 6.65 to 5.30 with added defatted *moringa* seed and no significance difference between blends of 15, 20 and 25% with sample C ranking highest and sample G ranking the lowest value. The low values recorded for taste above 10% blend is due to the bitter taste caused by glucosinolates present in the seeds. The aroma of the blend biscuits decreased significantly from 6.70 to 5.30 with added defatted *moringa* seed flour. The overall acceptability decreased significantly from 6.68 to 5.05 with increase in added defatted *moringa* seed flour. The biscuits were all generally acceptable with values higher than average (i.e 5.0) and 5% blend was the most acceptable of the blend biscuits.

Conclusion

Consumable biscuits can be produced from blends of defatted *moringa* seed-*acha* flour. The results from this study showed that addition of defatted *moringa* seed flour to *acha* flour improved the nutritional qualities (protein, fat, minerals, vitamins and phytochemical composition) of the blend biscuits. The water absorption capacity, foaming capacity, and swelling capacity increased with substitution of defatted *moringa* seed whereas the oil absorption, bulk densities, and emulsifying capacity decreased with substitution of defatted *moringa* seed. The blend biscuits were all generally acceptable with 95:5% *acha*: defatted *moringa* seed flour the most preferred.

Table 9: Sensory properties of defatted *Moringa* seed-*acha* flour blend biscuits

Values are presented as means of ± SD. Means with different superscripts within the same column are significantly different

Sample	Colour	Texture	Taste	Aroma	Overall acceptability
A	$7.80^{a}\pm1.51$	$8.00^{a}\pm1.26$	$8.40^{a}\pm0.94$	$7.80^{a}\pm1.4$	$8.00^{a}\pm1.07$
B	$7.80^{a}\pm1.51$	$5.75^{bc}\pm1.8$	$6.55^{b}\pm1.67$	$6.40^{bc}\pm1.79$	$6.28^{bc}\pm1.43$
C	$6.40^{b}\pm1.96$	$6.65^{b}\pm1.57$	$6.95^{b}\pm1.47$	$6.70^{ab}\pm1.72$	$6.68^{b}\pm1.38$
D	$6.10^{b}\pm1.21$	$6.05^{bc}\pm1.54$	$5.90^{bc}\pm1.71$	$5.65^{bc}\pm1.90$	$5.96_{bcd}\pm1.27$
E	$6.00^{b}\pm1.62$	$5.45^{c}\pm1.93$	$4.90^{cd}\pm2.34$	$5.30^{c}\pm2.15$	$5.36_{cd}\pm1.73$
F	$5.75^{b}\pm1.80$	$5.50^{c}\pm1.54$	$4.20^{d}\pm2.04$	$5.40^{bc}\pm1.82$	$5.19_{d}\pm1.39$
G	$5.50^{b}\pm1.67$	$5.30^{c}\pm1.42$	$4.05^{d}\pm2.54$	$5.35^{c}\pm2.48$	$5.05^{d}\pm1.69$

(p<0.05). A=100%WF,B=100%AF,C=95AF:5%DMSF,D=90%AF:10%DMSF, E=85%AF,15%DMSF F=80%AF:20%DMSF, G=75%AF:25%DMSF. WF=Wheat flour,AF=Acha flour and DMSF=defatted Moringa seed flour

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