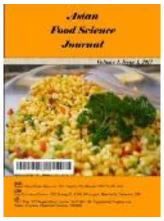

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Effect of Added Moringa Seed Paste on the Quality of Acha -moringa Flour Blends

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAA designed the study, wrote the protocol and first draft of the manuscript, managed the literature searches. Authors OEA performed the statistical analysis and AAO managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The research is aimed at investigating the effect of added moringa seed paste on the proximate, mineral, vitamin composition, functional properties of the acha-moringa flour blend. Moringa paste was substituted into acha flour at 5, 10, 15, 20 and 25% (w/w) to produce acha-moringa flour blends, coded AB1, AB2, AB3, AB4, AB5, and AB6, respectively. The proximate, minerals, vitamins, functional and pasting properties varied with mark significant differences (p = 0.05). The proximate composition- moisture, ash, protein, fats, fibre increased from 8.23 to 9.23, 1.05 to 1.53, 3.38 to 4.61, 1.88 to 2.87, and 2.43 to 3.14 %. Minerals contents increased at the inclusion of moringa seed paste (0-25%) in acha flour blends with Ca, Mg, P, Zn, Fe, from 18.61 to 20.29, 28.67 to 30.95, 30.61 to 42.34, 0.66 to 1.08 and 0.76 to 1.39 mg/100g. Respectively Similarly, the vitamins content significantly increased (p = 0.05) with the inclusion of moringa seed paste (0-25%). The vitamin A, C and B_{12} increased from 2.51 to 3.56; 3.61 to 5.50, 14 to .39 mg/100 g, respectively. Bulk density, water absorption capacity and forming capacity decreases from 0.75 to 0.64 (g/cm^3), 1.57 to 1.10 (cm^3/g), and 15.80 to 10.63 (%) respectively; while, there were increase

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in emulsification and oil absorption capacity (38.58 to 54.21 (%) and 2.58 to 3.05 (cm^3/g), respectively, at p = 0.05). The pasting properties showed a significant decrease, p = 0.05, with decrease in peak viscosity, trough, break down, final viscosity, set back, pasting temperature, from 2919.00 to 1499.50; 1388.50 to 822.50; 1530.59 to 677.00, 3527.00 to 2197.50; 2138.50 to 1375.00 RVU, 77.43 to 71.25°C; respectively, but increased the pasting time from 5.13 to 5.53 min with increase in the moringa paste (0-25%). The added moringa seed paste had proven to improve the mineral, vitamins, functional and pasting qualities of acha cereal flour which had been underutilised industrially in Nigeria. Acha –moringa seed flour blend could be a nutritious meal for diabetes, and other health challenged individual.

Keywords: Moringa paste; acha; flour blends; biscuit; quality.

1. INTRODUCTION

The consumption of cereal foods such as biscuits and bread has become very popular in Nigeria; especially among children. Most of these foods are, however, of reduced sources of a protein[1]. The main problem facing the bakery industry in Nigeria is the total dependence on importation of wheat for sustenance. Nigeria has an unfavourable climatic condition for wheat cultivation, but suitable for other cereal (sorghum, maize, millet, *acha)*; legumes (soybean, groundnut, Bambara nut, cowpeas) and vegetable [2]. Therefore any effort made to substitute part of the wheat flour with other available flours such as sorghum, millet; *acha* will enhance the reduction in cost of production.

Acha (*Digitaria exilis*) commonly referred to as *fonio, finni and* hungry rice [3], is probably one of the oldest Africa cereals [4] and classified as one of the lost crops of Africa. *Acha* crops are exceptionally tolerant to a wide variety of climatic and other growth conditions, particularly drought and poor soil [4]. The grains are widely produced in the area of their growth (Bauchi, Plateau, Kaduna States of Nigeria) and are consumed as stable foods. Acha grains are processed and consumed as light porridge (e.g. *tuwo, kunun, gote*), thick porridge (e.g. *masa*) and whole grains in soup [5,6]. *Acha* is reported to have a high pentosan (3.3%), hence high water absorption capacity that could be utilised in baked goods [7] and uniquely rich in methionine and cystine [4] and relatively evoke low sugar on consumption [8] an advantage for people with diabetes. Several research efforts have been made to produce confections from acha [1,9], however, like many other cereals, acha are deficient in some essential amino acids, such as lysine. Cream coloured acha contain about 8.7% protein and in some black acha samples, may be up to 11.8%, which is high in leucine (19.8%), methionine and cysteine (of about 7%) and valine (5.5%) of the essential amino acids [10,11]. The dried seed of Moringa contains digestible protein (20-26%), 8-11% ash (potassium 1600-2200 mg, magnesium 800-1800 mg, phosphorous 200-600 mg, iron 18-28 mg) and vitamins(vit. A -4000-8000 mg, vit, C 15-100 mg) [12,13].

Consequently, efforts are made to improve its nutritional quality through the incorporation of protein from plant sources.

Moringa olifera, a tropical, multipurpose tree has grown from being practically unknown, even unheard of, to be a new and promising nutritional and economic resource for developing countries. The leaves, which are smooth to grow and rich in proteins, vitamins and minerals are becoming widely used in projects for fighting against malnutrition [14]. Almost every part of the moringa plant has nutritional value:- dried seed, leaf powder and extracted seed oil can be added to any meal as a dietary supplement. The focus of this study is to investigate effects of added moringa seed paste on the quality of acha-moringa flour blends.

2. MATERIALS AND METHODS

2.1 Materials

Acha (*Digitaria exilis*) and *Moringa oleifera* grains were purchased from Central Market, Jos, Nigeria.

2.2 Methods

2.2.1 Preparation of acha flour

Acha flour was produced as reported by Ayo et al.,[9] method. The grains were manually cleaned by handpicking the chaff, de-stoned by sedimentation (washing in tap water using local calabash), dried at 45°C in a hot air cabinet dryer

(APV- machine Dryer) for 8 hours, milled (attrition milling machine -Lister Inc England). The flour was sieved (60 mesh size), vacuum packaged (Phlico Vacum sealer, Hongkong) in polyethylene and kept in refrigerator (4°C) for analysis.

2.2.2 Preparation of moringa flour

Moringa seed was washed (in tap water), dried in hot air dryer (at 50-55°C) for 5hrs, milled (attrition milling machine -Lister Inc England), sieved (60 mesh size), dried (at 50°C for 30 mins) and vacuum packed in polyethene. The flour was kept at refrigerated temperature (4-6°C) to prevent spoilage particularly rancidity until usage.

2.2.3 Preparation of acha and moringa flour blends

Moringa seed flour was substituted into acha flour at 5, 10, 15, 20 and 25% to produce flour blends and were thoroughly mixed (using Kewood blender) to obtain homogenous blends. Also 100% acha flour was weighed as the control sample.

2.4 Sample Analyses

The proximate composition (moisture, ash, fat, protein, fiber and carbohydrate) were determined as reported by AOAC [11]. Functional properties (water absorption capacity, oil absorption capacity, emulsion capacity and bulk density) were determined as reported by Narayama and Naesinga [15] and Vitamin A, B_{12} and C were determined according to Bruno [16] and AOAC [12] methods. Phytochemicals (saponnins, tanin, HCN, alkaloid,phytate, steroil, phenol and flavonoids) content were determined as reported by Krishnaiah et al., [17], Bohm and Kocipal [18], Obadoni and Ochuk [19]. The Invitro-protein (pepsin) digestibility, invitro-carbohydrate digestibility, raffinose and starchyose contents of moringa seed–*acha biscuits* were determined as reported by Aboubaear et al. [20] method. Pasting characteristics of blends were determined according to Brabender visco-amylograph (Newport Scientific Pty Ltd. Warrie-wood NSW, Australia) method. Flour slurry, containing 12% solids was heated from 30 to 95°C at a rate of 2.5°C/min, held at 95°C for 15 minutes, and cooled at the same rate to 50°C [21]. The pasting performance was automatically recorded on the graduated sheet of the amylogram. The peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time and pasting temperature were read off the amylograph.

All experiments were performed in triplicate. The statistical analysis were carried out using the Statistical Package for the Social Scientists (SPSS) version 23.0. Data obtained were subjected to one-way analysis of variance at significance difference level of 5%, while the means were separated according to Duncan's multiple range test.

3. RESULTS AND DISCUSSION

The proximate composition of the acha–moringa flour blends are shown in Table 1. The moisture , ash, protein, fats, fibre content of the flour blends increased from 8.23±.01 to 9.23±.11, 1.05±.01 to 1.53±.05, 3.38±.03 to 4.61±.08, 1.88±.04 to 2.87±.13, and 2.43±.02 to 3.14±.14%. The relatively increase in the proximate composition as generally observed in all the assessed flour blends could be due to the inherent nutrients in moringa seed flour which agreed with former works [22,21].

The functional properties of acha-moringa flour blend are shown in Fig. 2. Functional characteristics could help to evaluate and possibly predict properties of proteins, fat, fibre and carbohydrates inherent in the food and as well predict their possible replacement conventionally. The bulk density of acha flour decreased significantly ($p<0.05$) with increasing level of acha flour, which agreed with the finding of Iwe et al. [23]) who reported reduction in bulk density of rice flour supplemented with African yam bean. Lower bulk density of the acha-moringa flour blends compared to 100% acha flour could be as result of reduction in carbohydrate content which has been reported to have high bulk density [24]. Emulsion capacity of the acha-moringa flour blend decreased (54.21-35.58%) with addition of moringa flour. Reduction in emulsion capacity with increasing concentration of moringa flour could be due to higher protein content of the blends which might caused reduction in surface tension [25]. Partial replacement of acha flour with moringa flour resulted to significant ($p<0.05$) reduction in water absorption capacity with values ranging from 1.57 ml/g in 100% acha flour to 1.10 ml/g in the blend that contained 25% of moringa flour. The observed result could be due to reduction in the crystalinity of the starch component consequent to blending moringa flour thereby reducing its water binding ability as pointed out by Badifu and

Akubor [26], that water holding capacity of food systems is dependent on the water binding capacities of their constituents. Significant increase ($p<0.05$) from 2.58 ml/g in 100% acha flour to 3.05 ml/g in the blend that contained 25% moringa flour were recorded for oil absorption capacity which could be attributed to entrapment of oil by the non-polar side chains of protein [27] in moringa flour.

The in-vitro protein digestibility, in-vitro carbohydrate digestibility, starchyose and raffinose contents are presented in Table 2. The level of inclusion of moringa flour in acha flour had significant ($p<0.05$) effect on these parameters. In-vitro protein digestibility increased significantly ($p<0.05$) from 75.7 to 82.90% with increase in the percentage (0 to 25%) of added moringa seed flour. The increase could be due to the relative high protein content of moringa seed flour. The observation in this work agreed with that of Singh and Singh [28] that observed increase in protein digestibility of wheat flour fortified with peanut meal(which contain relatively higher protein content). On the other hand, the in-vitro carbohydrate digestibility of acha-moringa flour blend decreased (68.5 to 62.63%) significantly ($p<0.05$) with increasing level (0 to 25%) of moringa flour. This might be due to relatively lower carbohydrate content of moringa seed flour inclusion. The poor starch digestibility values of the flour blend as observed in the work agreed with former observations of Chinma et al.,[21]. This quality may be an advantage of acha –moringa flour blends in the production of functional food particularly for groups with special calorie and glycemic requirements such as obesity or diabetic people.

Table 1. Effect of added moringa on the digestibility, starchyose and raffinose contents of acha –moringa composite flour

Moringa (%)	Acha flour (%)	In-vitro protein digestibility	In-vitro carbohydrate digestibility	Starchyose	Raffinose
0	100	75.70 ± .14e	68.60± .14a	0.46± .09b	o.35± .01b
5	95	76.73 ± .09d	65.79± .12b	0.51± .01b	0.36± .03b
10	90	78.58 ± .12c	64.69± .27c	0.52± .04b	0.34± .04b
15	85	79.82 ± .03b	63.51± .11d	0.59± .01ab	0.37± .03ab
20	80	82.71 ± .16a	63.24± .49d	0.59± .08ab	0.38± .03ab
25	75	82.90 ± .18a	62.63± .04e	0.66± .04a	0.41 ± .01a

Values are means ± standard error of three determinations. Means in the same column with different superscripts are significantly different (p< 0.05)

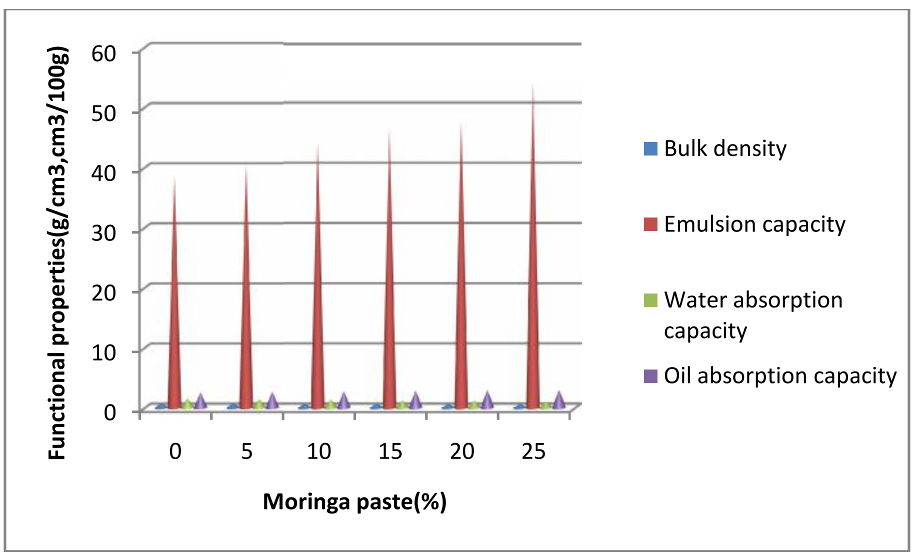

Fig. 1. Effect of added moringa pasteon the functional properties of acha –moringa composite flour

Table 2. Effect of added moringa on the pasting quality of acha –moringa composite flour

Acha flour (%)	Moringa seed paste(%)	Peak viscosity (RVU)	Trough (RVU)	Break down (RVU)	Final viscosity (RVU)	Set back (RVU)	Pasting time (min)	Pasting temperature (°C)
100	0	2919.00± 49.50a	1388.50 ± 26.16a	1530.50± 23.33a	3527.00 ± 16.97a	2138.50 ± 9.19a	5.13 ± .00c	77.43 ± .04a
95	5	2591.00± 69.30b	1376.00± 36.77a	1215.00± 32.53b	3403.00±65.05ab	2027.00±28.28b	5.47 ± .00b	77.50±.00a
90	10	2546.50± 54.45b	1338.00 ± 25.46a	1208.50± 28.99b	3290.00± 70.71b	1952.00±45.25b	5.53 ± .00ab	78.28 ± .11a
85	15	2200.50± 98.29c	1196.0b0 ±56.57b	1004.50± 41.72c	2950.50 ± 86.97c	1754.50±30.41c	5.60 ± .00a	78.33±.04a
80	20	1836.00± 2.83d	994.50 ± 6.36c	841.50± 9.19d	2559.50± 41.72d	1565.00±48.08d	5.63 ±.05a	78.70± .57a
75	25	1499.50 ± 98.29e	822.50± 41.72d	677.00 ± 56.57e	2197.50 ± 65.76e	1375.00±24.04e	5.53± .09ab	71.25±.90a

Values are means ± standard error of three determinations. Means in the same column with different superscripts are significantly different ($p< 0.05$)

Table 3. Effect of added moringa paste on the proximate composition of acha- moringa flour blend(%)

Acha flour(%)	Moringa paste(%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
100	0	8.23 ± .01e	1.05 ± .01c	3.38 ±.03f	1.88 ±.04d	2.43 ± .02b	85.47 ± .09a
95	5	8.43 ±.04de	1.11 ± .05c	3.89 ± .04e	2.01 ±.04d	2.76 ± .14b	84.57± .08b
90	10	8.62 ±.06cd	1.24 ± .02b	4.09±.04d	2.29 ±.06c	2.86 ± .17a	83.77±.06c
85	15	8.82 ±.03bc	1.31 ±.08b	4.28 ± .03c	2.41±.02c	2.91± .19a	83.19± .06d
80	20	8.83 ±.16b	1.48± .04a	4.46 ±.06b	2.57±.02b	3.13±.16a	82.68±.16e
75	25	9.23±.11a	1.53 ± .05a	4.61 ± .06a	2.87± .13a	3.14±.14a	81.77± .245f

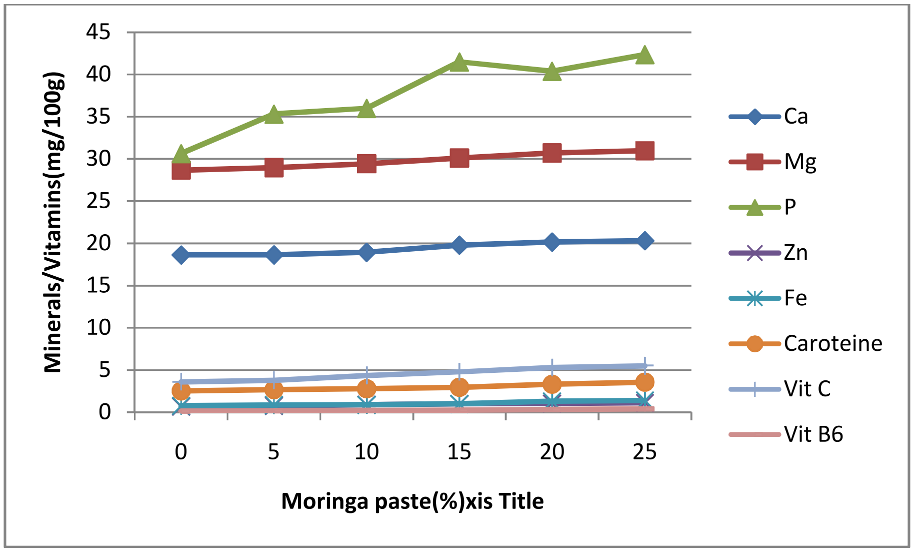

Fig. 2. Effect of added moringa paste on the minerals and vitamin composition of acha-moringa composite flour

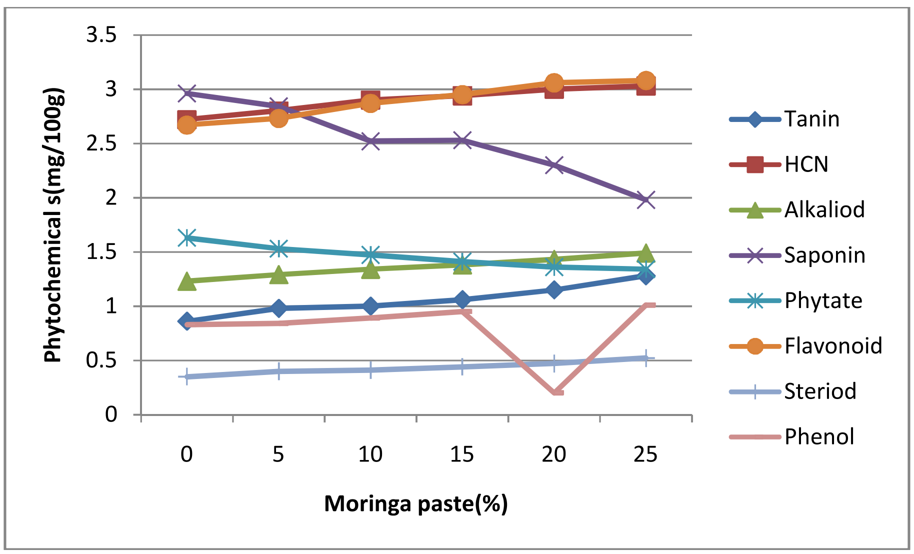

Fig. 3. Effect of added moringa psteon the phytochemical composistion of acha-moringa flours

The starchose and raffinnose content of the acha-moringa flour blends increased from 0.45 to 0.66 and 0.35 to 0.41% respectively, with increase in the percentage of moringa seed flour inclusion. However, increase was only significant at above 10% added moringa seed flour. The use of acha-moringa flour blend at less than 10% moringa seed flour could be said to reduce the tendency of flatulence caused by starchose as earlier reported [29].

The mineral and vitamin contents of acha-moringa flour blend are shown in Fig.2. The level of moringa seed inclusion had significant ($p<0.05$) effect on assessed minerals and vitamins.

The Ca, Mg, P and Zn content of the acha-moringa flour blend increased from 18.61±0.12 to 20.29±0.19, 28.67±0.16 to 30.95±0.08, 30.61±0.58 to 42.34±0.2, 0.66 ±0.04 to 1.08±0.06 and 0.76±0.01 to 1.39±0.05 mg/100 g, respectively with increase (0–25%) in the percentage of added moringa seed flour. The increase in calcium, magnesium, iron and vitamin C as observed in this work agreed with early works in enrichment of food products with moringa [22,30,31,32].

Increase in calcium could help the body to building strong bones and teeth, clots blood, and aid the body in release of hormones and other chemicals, and maintaining normal heart beat, and magnesium have been identified in regulation of blood glucose levels and aid in the production of energy and protein [33]. Zinc and iron have been identified with improved functionality of the body's defensive (immune) system and oxygen-carrying proteins of the hemoglobin and myoglobin found in red blood cells and myoglobin is found in muscles [34].

The phosphorous ratio (Ca/P) ratios is an indices for bone formation and the values observed in this work (0.479-0.527 mg/100 g) though relatively low but fall within the recommended value (<1) for diets, particularly for hypertensive patients. Therefore, the observed values for the acha-moringa seed flour blends in this study is suitable for people who are of risk to high blood pressure and could also be of nutritional benefit, particularly for children and the aged who need higher intakes of calcium and phosphorus for bone formation and maintenance [22,30].

The vitamin A (β-carotene), vitamins B and C contents of acha-moringa flour blends increased 2.51 to 3.56, 3.61 to 5.50 and from 0.14 to 0.39 mg/100 g , respectively, with increase (0 to 25%) in the percentage of added moringa seed flour. Overall, the concentration of the vitamins increased significantly ($p<0.05$) with increasing level of moringa seed flour. The finding agreed with Olorode et al. [35], that vitamin A content could increase by approximately 15 fold with addition of moringa. The increase in vitamin A could help in forming and maintaining healthy teeth, skeletal and soft tissue, produces the pigments in the retina of the eye and serves as antioxidants protecting cells from damage caused by substances called free radicals [36,37].

Vitamin C is needed for the growth and repair of tissues in all parts of your body, forming an important protein in the formation of skin, tendons, ligaments, and blood vessels [33], while vitamins B_{12} helps regulate levels of the amino acid homocysteine (associated with heart disease) [33,4].

The phytochemical composition of acha-moringa flour blend is shown in Fig.3. Tanin, hydrogen cynide (HCN), alkaloid, saponin, phytate, flavonoid, steroid and phenol increased from 0.86 to 1.28, 2.72 to 3.03, 1.23 to 1.49, 2.96 to 1.98, 1.63 to 1.34, 2.67 to 3.15, 0.35 to 0.52 and 0.83 to 1.01 mg/100 g, respectively, with increase(0 to 25%) in the percentage of added moringa seed flour. The increase were significant, $p< 0.5$). The increase recorded in all the phytonutient evaluated could be attributed to their high concentrations in moringa seed. The quantities of phytochemical compounds observed in the blends could act as immune enhancers, hormone modulators, antioxidant, anti-clothing[18] and anti-inflammatory and could also be a potential contender to combat free radicals, which are harmful to our body and food systems [17,19,21].

The pasting profile of acha-moringa flour blends are shown in Table 3. The pasting properties showed a significant decrease, $p = 0.05$, with decrease in peak viscosity, trough, break down, final viscosity, set back, pasting temperature, from 2919.00±49.50 to 1499.50±98.23, 1388.50±26.16 to 822.50±41.72, 1530.59±23.33 to 677.00±56.57, 3527.00±16.97 to 2197.50± 65.76, 2138.50±9.1 to 1375.00±24.04 RVU and 77.43±.04 to 71.25±9°C, respectively, but increased the pasting time from 5.13±.00 to 5.53±.09 min with increase in the moringa seed flour (0-25%). Significant reduction ($p<0.05$) in peak viscosity with increasing substation with moringa seed flour were observed for all the acha-moringa flour blends. Reduction in peak viscosity could be due to low starch content of the blends. Peak viscosity has been reported to be correlated with water binding capacity of starch which takes place at equilibrium point between swelling which causes an increase in viscosity while rupturing and realignment cause its reduction [38]. Inclusion of moringa seed flour up to 10% did not cause any significant ($p>0.05$) change in trough, however, significant increase ($p<0.05$) was recorded at moringa seed concentration of 15% and above. Breakdown, setback and final viscosities reduced significantly ($p<0.05$) with increasing substitution level of moringa seed flour. Reduction in these parameters with increasing level of moringa seed flour is an indication of the ability of the blends to withstand breakdown during heating and shearing. According to Adebowale et al.,[39], high breakdown viscosity could reduce the ability of flour to withstand heating and shear stress during cooking. Also, peak time reduced with increasing level of moringa seed inclusion in acha flour. Reduction in peak time could be attributed to the buffering effect of protein (from moringa seed flour) on the starch component of the blends. Oluwamukomi et al., [37] and Mazahib et al., [40] also reported higher pasting time in fermented maize (*ogi)* supplemented with soybean flour and bambara groundnut, respectively. There was no significant (p>0.05) difference between the control sample and the blends in terms of pasting temperature.

4. CONCLUSION

The quality effect of added moringa seed paste on acha-moringa flour blends had proven to improve its nutritional, and processing qualities of acha flour. The significant increase in the minerals and vitamins of acha with addition of moringa paste could be an alternative food variety for diabetes and making it desirable in celiac diets. The acceptability of acha-moringa flour blends foods will also be a positive challenge to both acha and moringa farmers and as well in an area of food product developments. The research provides knowledge gap intending to offer suggestions for potential applications of moringa seed flour in foods.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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