Nutrient Composition and Functional Properties of Fonio (*Digetaria exilis*) and Amaranth (*Amaranthus cruentus*) Flour Blends

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Authors' contributions

This work was carried out in collaboration between both authors. Author JAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author OE managed the literature searches and carry out the analysis. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

This study investigated the nutrient composition and functional properties of flour blend of acha and amaranth grains. The amaranth flour was substituted into acha flour at 5, 10, 15, and 20% and to produce acha-amaranth flour blend. The chemical composition and functional properties of the flour blend were determined. The protein, crude fibre, fat and ash content ranged from 7.66 - 12.93, 0.44 - 0.59, 0.15 - 1.01, and 0.11 - 0.96% with increase in added amaranth grain flour (0-20%). The moisture content and carbohydrate ranged from 12.46 – 11.7, 77.41 - 4.33% and decreased with increasing added amaranth flour. The potassium, magnesium, phosphorus, vitamin B_3, vitamin E and vitamin B_6 content ranged from 0.09 - 0.14, 0.06 - 0.12, 0.19 - 0.34.14 - 0.24, 0.39 - 0.75 and 0.54- 0.69 mg/100 g increase with increasing in amaranth flour. The bulk density, swelling capacity ranged from 0.79 - 0.76 g/cm3 and 295.00 -275.00 ml/g, respectively with increases in added amaranth flour. The water absorption capacity, oil absorption capacity and foaming capacity ranged from 120.00 – 145.00, 110.00 – 135.00, 0.06 - 0.09, ml/g, respectively,

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with increasing acha substitution using amaranth flour. the 20% amaranth flour addition had the highest values of protein, fat, ash and crude fiber at 7.66 - 12.93, 0.44 - 0.59, 0.15 - 1.01, and 0.11 - 0.96% respectively. Amaranth incorporation had significant effects and contributed to the improvement of the flour blend.

1. INTRODUCTION

1.1 Background of the Study

Acha (*Digitaria exillis*) is a cereal grain in the family of gramineae and commonly referred to as fonio or hungry rice [1]. Compared to starches like *D. Iburua* and *Eleusine coracana, D. exilis* has more branched molecules. Acha does not contain any glutenin or gladines proteins which are the constituents of gluten, making it suitable for people with gluten intolerance [2]. Acha has a high water absorption capacity a property that could be linked to an appreciable amount of pentosan. The high water absorption capacity of acha could be utilized in baked goods [3].

The major traditional foods from acha include: thick (Tuwo) and thin (Gwete and kunu) porridge (eaten with of stew and vegetables), steamed product (burabusko) and alcoholic beverages [4]. It could be boiled like rice (achajollof) and is also used in the form of "couscous" in some countries in West Africa [4]. Acha is known to be easy to digest and is traditionally recommended for children, old people [2]. Acha grain can also be grounded into flour to produce biscuit [3]. Acha is also one of the most nutritious of all grains. Its seed is rich in methionine and cystine, they are vital to human health and deficient to today's major cereals. Like wheat, rice, maize, sorghum, barley and rye [5].

The recent finding of the unique property of acha flour in relatively lowering the blood glucose level [2] and the subsequent reducing the diabetic arises in the affected has made the same an attractive research focus in the recent times.

The Amaranth(*Amaranthus cruentus*), commonly known as (Alehu), spinach and green leave is known to be a very nutritious pseudocereal with exceptionally high protein content as compared to the true cereals. Amaranth plants are classified as pseudocereals that are grown for their edible starchy seeds, but they are not in the same botanical family as true cereals such as wheat and rice. Amaranth species that are still used as grain are *Amaranthus caudatus* L, *Amaranthus cruentus* L, and *Amaranthus hypochondriacus* L. A seed of grain amaranth is on average composed of 13.1 to 21.0% of crude protein; 5.6 to 10.9% of crude fat; 48 to 69% of starch; 3.1 to 5.0% (14.2%) of dietary fibre and 2.5 to 4.4% of ash [6]. It is a terrific source of minerals like calcium, magnesium, and copper, a good source of zinc, potassium, and phosphorus. It helps to build strong bones and a muscle, aid hydration, boost energy, and is vital in thousands of processes.

Grain amaranth has been shown to exhibit antioxidant activity and this has been attributed to its content of polyphenols, anthocyanins, flavonoids and tocopherols [7,8]. Phenolic content of grain amaranth varies between species and may be affected by environmental conditions [8]. The antioxidant activity of phenolics is associated with inhibition of lipid peroxidation [9].

Amaranth grain can be used in the production of flour which can be used in the baking of various types of bread, such as chapatti and tortilla, but not yeast bread. In addition to the common application of barley malt, beer can also be produced from amaranth. Amaranth grain could be a good source of vegetable oil and alcoholic beverage [10]. Composite flours have been used extensively and successfully in many developing countries in the production of baked foods. In this work, the use of composite flour is to enhance the nutritional and health characteristics of baked products.

Amaranth flour has been investigated in the formulation of bread, films, and gluten-free products. Amaranth flour can be used up to 15% in the production of amaranth–wheat composite bread without affecting physical and sensory qualities [11]. Also, amaranth flour could improve the quality of protein of the bread of particular significance to children.

A major problem facing developing countries like Nigeria today is malnutrition which has

contributed to infant mortality, poor physical and intellectual development in the infant and low resistance to diseases. The abundance of amaranth with its high nutrient content calls for it's processing to reduce its wastage and could be used as a fortifying or enriched food product with relatively low nutrient. Lack of information has sealed the potential of amaranth.

Amaranth flour could be incorporated into acha flour to improve nutrition while increasing its utilization in baking industries. The objective of this work is to determine the nutrient composition and functional properties of acha-amaranth grain flour blends

2. MATERIALS AND METHODS

2.1 Materials

Acha grains (D. *exilis*) were purchased from Jos central market Nigeria and cream coloured cultivar of amaranth grain (*Amaranthus caudatus)* were purchased from Wukari New Market, Taraba State, Nigeria.

2.2 Methods

2.2.1 Preparation of acha flour

Acha grains were sorted manually, washed (using tap water) to remove tiny stones and dust as well as foreign materials (by decanting them as they float on top of the water), drained, oven-dried (at 60°C), milled (Attrition mill-model no. 0712098) and sieved (0.3 µm aperture size). The flour was packaged in a polyethene bag and stored at 5°C as acha flour.

2.2.2 Preparation of amaranth flour

Amaranth grains were sorted manually and then washed (potable water) to remove stones, strew

and dust as well as foreign materials (by decanting them as they float on top of the water), drained, oven-dried (at 40°C), milled (Attrition mill-model no. 0712098) and sieved (0.3 µm aperture size). The flour was packaged in a polyethene bag and stored at 5°C as amaranth flour.

2.2.3 Production of fonio (*D. exilis*) and amaranth (*Amaranthus cruentus*) flour blends

Composite Preparation: Acha and amaranth flours were blended at different proportions at (100:0; 95:5; .90:10; 85:15, 80:20 and 100:0%) respectively in order to prepare the composite flours. 100% acha flour served as control (Table 1). The blends were thoroughly mixed using Kenwood Blender and packed in a polyethene container.

2.3 Analytical Methods

2.3.1 Determination of chemical composition of acha-amaranth blend flour

Fonio (*D. exilis*) and Amaranth (*Amaranthus cruentus*) flour blends were analysed for moisture, crude protein, crude fat, ash, crude fibre and carbohydrate contents.

2.3.2 Determination of moisture content

The Moisture Content was determined using the procedure described by AOAC [12]. The five gram of the sample was weighed into an aluminium moisture can. The sample was then dried to constant weight at 105±2°C. The moisture content was calculated as:

% Moisture content =

$$\frac{(Weight\,of\,can + samle) - (Weight\,of\,empty\,can) \times 100}{Weight\,of\,sample}$$

Table 1. Proximate composition of acha-amaranth flour blends

Acha flour (%)	Amaranth flour	Wheat flour	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Crude fibre (%)	Carbohydrate (%)
100	0 0	-	14.84±.01[a]	0.11±.01[e]	0.21±.00[e]	7.66±.00[d]	0.44±.00[d]	77.41±.01[a]
95	5 0	-	14.67±.00[b]	0.11±.01[e]	0.24±.00[d]	7.02±.01[e]	0.44±.00[d]	76.90±.02[b]
90	10 0	-	14.19±.01[c]	0.54±.00[c]	0.27±.01[c]	7.67±.01[d]	0.44±.00[d]	76.72±.02[c]
85	15 0	-	13.53±.01[d]	0.86±.01[b]	0.82±.01[b]	8.33±.00[c]	0.47±.01[c]	76.27±.01[d]
80	200	-	12.46±.00[e]	0.96±.00[a]	1.01±.00[a]	8.99±.00[b]	0.50±.01[b]	74.33±.01[f]
0	0	100	11.75±.01[f]	0.35±.01[d]	0.15±.01[f]	12.93±.00[a]	0.59±.00[a]	75.82±.01[e]

Average means scores with the same superscript alphabet in the same column are not significantly different,
p=0.05

2.3.3 Determination of crude protein content

The macro Kjeldahl method as described by the AOAC [12] method was used. Ten gram of the sample was weighed into a conical flask (250 ml), 0.8 g of the catalyst (potassium sulphate) was poured into the conical flask and 5 ml of sulphuric acid and three glass beads (anti bumps) were dropped inside the conical flask and swirled. The mixture was heated on the Kjeldahl apparatus for 2-3 hours at 100°C until it turned bluish-white.

The digest' was allowed to cool in the air and diluted with 10ml distilled water. This was distilled using Markham distillation apparatus where 100 ml conical flask containing 5 ml of boric and 2-3 drops of the mixed indicator was attached. The 5 ml of the digest was introduced into the body of the apparatus and followed by l0m1 of 40-45% sodium hydroxide solution. The distillate collected as ammonium sulphate which was titrated against 0.1 M hydrochloric acid. A blank titration was carried out using distilled water instead of the distilled. Percentage nitrogen was calculated using the formula:

$$\% \text{ Nitrogen} = \frac{Titre\,value - Blank \times 0.0014g \times 100 \times 25}{Weight\,of\,sample \times 5ml}$$

2.3.4 Determination of crude fat content

Fatwas extracted using Soxhlet extractor with hexane and quantified gravimetrically. One gram of sample was weighed into an extraction thimble and then put on hold with grease-free cotton. Before extraction commenced the round bottom cans was dried, cooled and weighed. The thimble was placed in the extraction chamber and 80 ml hexane was added to extract the fat. The extraction was carried out at 135°C for 1 hour 40 minutes after which the fat collected at the bottom of the cans cooled in a desiccator [12].

$$Fat = \frac{Weight\,of\,fat \times 100}{Weight\,of\,sample}$$

2.3.5 Determination of ash content

The ash content was determined by the AOAC [12] method. Two grams of the sample was weighed into a dried pre-weighed porcelain crucible. The sample was transferred into a preheated muffle furnace (carbolite Bamford S30 2AU) and heated at 550°C for 2 h. The ash was removed and cooled in a desiccator and weighed. The percentage of ash was calculated as:

$$\%\text{Ash} = \frac{Weight\,of\,Ash}{Weight\,of\,original\,food} \times 100$$

2.3.6 Determination of crude fibre content

The crude fibre was determined using the method described by the AOAC [12] method. 2 g of the samples were weighed into 500 ml beaker and in 200 ml WI t) 1 & 30 minutes. 11 weight suspension was filtered using a white filter pipa and rinsed with hot water to obtain a filtrate. The residue obtained was transferred into a crucible and placed in an oven for 40 other 30 minutes. The dried residue was cooled in a desiccator and weighed. Percentage crude fibre was calculated using the formula:

$$\% \text{ Crude fibre} = \frac{Loss\,in\,weight\,after\,incineration}{Weight\,of\,original\,food} \times 100$$

2.3.7 Determination of carbohydrates content

Carbohydrate was calculated by difference as described by Ihekoroye and Ngoddy, (1985):

%Carbohydrate=100 - (%Moisture + %Fat + %Protein + %Ash + %Cruder fibre).

2.4 Determination of Functional Properties

2.4.1 Water absorption capacity

The water absorption capacity was determined using the method described by Onwuka, (2005). Ten millilitres (10 ml) of distilled water was added to 1g of cha-amaranth composite flour sample in a weighed centrifuge tube. The tube was agitated on a vortex mixer for 2 min and then centrifuged at 4000 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water were removed and then weighed. Water absorption capacity was expressed as the weight of water bound by 100g of dried flour.

2.4.2 Oil absorption capacity

The oil absorption capacity was determined using the method described by Onwuka, [13]. One gram (1 g) of acha-amaranth composite flour sample was mixed with 10ml of refined vegetable oil and allowed to stand at ambient temperature for 30 min. it was then centrifuged for 30 min at 2000 rpm. The oil and adhering drops of oil was decanted and discarded. Oil absorption capacity was expressed as per cent oil bound per gram flour.

2.4.3 Bulk density

The bulk density was determined using the method described by Onwuka, [13]. Fifty grams (50 g) of ach-amaranth composite flour sample was poured into a 100ml measuring cylinder. The cylinder was tapped fifty (50) times on a laboratory bench to constant volume. The volume of the sample was recorded.

$$\text{Bulk density (g/cm}^3\text{)} = \frac{weight\ of\ the\ sample}{volume\ of\ the\ sample\ after\ tapping}$$

2.4.4 Foaming capacity

The foaming capacity and stability were determined using the method described by Onwuka, [13]. Two grams (2 g) of acha-amaranth composite flour sample was added to 50 ml of distilled water at 30 ± 2°C in a 100 ml graduated cylinder. The suspension was mixed and shaken manually for 5 min to foam. The volume of foam at second after whipping was expressed as foaming capacity using the formula;

$$\text{Foam capacity} = \frac{volume\ of\ foam\ after\ whipping}{volume\ of\ mixture} \times 100$$

The volume of foam was recorded at different time intervals (5, 10, 15 and 20 seconds) after whipping to determine the foam stability as per cent of the initial foam volume.

2.4.5 Swelling capacity

The swelling capacity was determined using the method described by Olapade et al. [14]. One gram (1 g) of acha-amaranth composite flour sample was mixed with 10 ml of water in a weighed centrifuge tube. The tube was heated in a water bath at 85°C for 15 min and then centrifuged at 2000 rpm for 30 min. The clear supernatant was decanted and discarded. The adhering drops of water were removed and then weighed. Swelling capacity was expressed as per cent swelled per gram flour.

2.5 Determination of Mineral Composition

The mineral contents of the samples were evaluated using the methods described by Adedeye et al. [15]. One gram of dried sample was digested with 2.5 ml of 0.03N hydrochloric acid (HCl). The digest was boiled for 5 minutes, allowed to cool to room temperature and transferred to 50 ml volumetric flask and made up to the mark with distilled water. The resulting digest was filtered with ashless Whatman No. 1

filter paper. The filtrate from each sample was analyzed for mineral (phosphorus, magnesium and Iron) contents using Atomic Absorption Spectrophotometer (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Nowalk, Connecticut, USA) using standard wavelengths. The real values were extrapolated from the respective standard curves. Values obtained were adjusted for HCl-extractability for the respective ions. All determinations were performed in duplicates.

2.5.1 Determination of phosphorous content

Determination of phosphorus was done according to the method of AOAC [12]. Twenty-five grams (25 g) of ammonium molybdate and 1.25 g of ammonium metavanadate were added to 300 ml of distilled water, warmed to dissolve, cooled and made up to 500ml with water. Concentrated HCl (215 ml) was diluted to 500 ml with water and mixed with ammonium molybdate-ammonium metavanadate reagent. The phosphorous stock was prepared by dissolving 0.879 g of dried phosphorous dihydrogen orthophosphate (dried at 105°C for one hour) with water and 1ml of conc. HCl added. It was diluted to 200ml with the first reagent, and 2ml of toluene was added to give 1 mg/ml. The working standard was prepared by measuring 2 ml of phosphorous to 0, 2, 4, 6, 8, and 10 ml of standard phosphorous solution into six 200-ml volumetric flasks and diluted to mark with water. Each phosphorous standard solution (5 ml) was pipetted into a 500-ml graduated flask. Molybdate mixture (10 ml) was added and diluted to the mark with water. It was allowed to stand for 15 minutes for colour development, and the absorbance measured at 400 nm against blank. A calibration curve relating absorbance to mg of phosphorous was used to read the phosphorus content of the sample solution in mg/ml and the number of phosphorous equivalent to the absorbance of the sample blank determined was calculated.

2.5.2 Determination of potassium content

Phenanthroline method as described in AOAC [12] was used for the determination of potassium content. Phenanthroline solution was prepared by dissolving 100mg I,10-phenanthroline molybdate in 100 ml distilled water by stirring and heating to 80°C. Hydroxylamine solution was prepared by dissolving 10 g in 100 ml of distilled water, while ammonium acetate buffer solution was prepared by dissolving 250 g in 150 ml

distilled water. 5ml of the digested sample put into a test-tube. Then, 3 ml of phenanthroline solution and 2 ml of HCl were added.

Hydroxylamine solution (1 ml) was added to the mixture and boiled in a steam bath at 600°C for 2 minutes. Then, 9 ml of ammonium acetate buffer solution was added and 35 ml diluted to 50 ml with water. The absorbance was taken at 510 nm. The calibration curve was prepared by pipetting 2, 4, 6, 8 and 10 ml standard iron solution into 100 ml volumetric flasks to prepare a solution of known concentrations. The curve obtained was used to read off the value of potassium.

2.5.3 Determination of magnesium content

Determination of magnesium content was done according to the method of AOAC [12]. Ashed (2 ml) sample was transferred into 3 test tubes and 3ml of water added. 2 ml of 10% sodium tungstate, and 2 ml of 0.67N sulfuric acid were added, centrifuged for 5 minutes. 5 ml of the supernatant was taken added 1 ml water, 1 ml of 0.05% titan yellow, and 1 ml of 0.1% gum ghatti. 2 ml of 10% sodium hydroxide was added and the absorbance taken at 520 nm against a blank.

2.6 Determination of Vitamin

Thiamin, riboflavin and niacin were determined as described in the method by AOAC [12] using HPLC (Shimadzu, Japan) PE series 400 liquid chromatograph fitted with a photo-diode array detector, a C18 stainless steel column (ODS 250 mm x 4.0 mm) at 35°C oven temperature.

2.7 Statistical Analysis

All the experiments were conducted in duplicates in a completely randomized design. The data were analyzed by analysis of variance using Statistical Package for Science (SPSS) software version 17.0, 2007. Means where significantly different were separated by the least significant difference (LSD) test. Significance was accepted at p=0.05.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Acha-amaranth Flour Blends

The proximate composition of the acha-amaranth composite flour evaluated is presented in Table

1. The protein, crude fibre, fat and ash content of acha-amaranth flour blend increased from 7.66 - 12.93, 0.44 -0.59, 0.15 -1.01, and 0.11-0.96% while moisture content, and carbohydrate decreased from 12.46- 11.75%, 77.41 - 4.33, respectively.

The effect of adding amaranth to acha are significant, p>0.05. The 80:20% acha-amaranth sample had the highest value for protein (12.93%), crude fibre (0.59%), fat (1.01%), ash (0.96%) while the 100:0% acha-amaranth sample had the highest value for moisture (12.46%) and carbohydrate (4.33%). The decrease in moisture content could be due to the relative increase in the fibre content of the added amaranth flour. Fibres can absorb moisture. The moisture contents of the acha-amaranth blend flours were low which make them suitable for long-time storage. The growth and proliferation of food spoilage microorganisms are hindered at low moisture levels [16]. The moisture content is slightly above (10%) that observed by Ade-Omowaye [16] which they find to be suitable for good keeping quality of the flour.

The crude fibre increased with increase in added amaranth flour. This could be due to the presence of high dietary fibre content in amaranth grain [17]. Accurately measuring the fibre content of foods is critical to making a sound benefit claim, whether it is a nutrient claim, structure-function claim, or health claim [18]. Dietary fibre is reported to prevent colonic cancer, appendicitis arteriosclerosis, diverticulosis and haemorrhoid [19]. Lund et al. [20] reported that dietary fibre with high water absorption capacity would prevent dehydration and shrinkage of product structures. Flours with such fibres would be useful in baked products such as biscuits and bread where the fibres could reduce the loss of moisture with extended product shelf life.

Incorporation of fibre contributes to the improvement of sensory properties and texture shelf life of foods due to its functional properties such as fat mimetic, thickening, water holding capacity, gel-forming ability, and ant staling properties [21]. Fibre has been added into food products as a partial replacement for fat, flour, and/sugar and to improve water and oxidative stability and oil retention [22,23].

Ash content indicates the presence of mineral matter in food. Increase in ash content indicates that samples with a high percentage of ash could

be good sources of minerals. The findings concerning the increase in the carbohydrate content in this work agreed with that of McWatters et al. [24].   High carbohydrate contents could be an indication of good sources of energy.

3.2 Mineral Composition of Acha-amaranth Flour Blends

The mineral content of acha amaranth blend four is shown in Table 2 Potassium, magnesium and phosphorus of Fonio (*D. exilis*) and Amaranth (*Amaranthus cruentus*) flour blends increased from 0.09 - 0.14, 0.06- 0.12, and 0.19 - 0.34 respectively, with increase in the added amaranth flour.

The 100% acha flour had the least value of potassium (0.09), magnesium (0.06) and phosphorous(0.19). The potassium, magnesium and phosphorous content of the blend flour where increase by 75%, 100% and 78% comparative to that of acha flour. The effects of amaranth increase was therefore significant and agreed with the works of Cruz et al. [25,17]. The improved acha- amaranth blend flour compared favourably with the wheat flour with 0.20 mg/100 g (Potassium), 0.08 mg/100 g (magnesium) and 0.43 mg/100 g (phosphorous). The increase in potassium, magnesium and phosphorous content shows that Fonio (*D. exilis*) and Amaranth (*Amaranthus cruentus*) flour blends should be recommended at the bakery industry.

Magnesium is present in the mitochondria and other enzymes important in energy transfer [26]. Magnesium in an activator of enzyme systems which maintains electrical potential in nerves [26].

3.3 Vitamin Composition of Acha-amaranth Flour Blends

The result of vitamin content of Fonio (*D. exilis*) and Amaranth (*Amaranthus cruentus*) flour blends is shown in Table 3. Vitamin B_3 vitamin B_6 and vitamin E increases from 0.14 - 0.24, 0.39 - 0.75 and 0.54- 0.69 mg/100 g, respectively.

The effect of adding amaranth to acha on the vitamin B and E are very significant (p=0.050. The 80:20% acha-amaranth sample had the highest value for vitamin B_3 (0.24%), vitamin B_6 (0.75%), vitamin and E (0.69%). The vitamin B_3, vitamin E and vitamin B_6 content of the blend flour increased by 84%, 27% and 92% comparative to that of acha flour. The effects of added amaranth flour agreed with the works of Cruz et al. (2011) and (Bruni et al. 2001). The improved acha- amaranth blend flour can compare favourably with the wheat flour with 0.22 mg/100 g (vitamin B_3), 0.08 mg/100 g (vitamin E) and 0.69 mg/100 g (Vitamin B_6). The increase in potassium, magnesium and phosphorous content shows that Fonio (D. exilis) and Amaranth (*Amaranthus cruentus*) flour blends should be recommended at the bakery industry.

Table 2. Mineral content acha-amaranth flour blends

Flour Acha flour (%)	Blend		Potassium (Mg/100 g)	Magnesium (Mg/100 g)	Phosphorous (Mg/100 g)
	Amaranth flour (%)	Wheat flour (%)			
100	0	0	0.08±.00[f]	0.06±.00[d]	0.19±.00[f]
95	5	0	0.09±.00[e]	0.08±.00[c]	0.23±.01[e]
90	10	0	0.10±.01[d]	0.10±.01[b]	0.28±.00[d]
85	15	0	0.11±.00[c]	0.10±.00[b]	0.33±.01[c]
80	20	0	0.14±.00[b]	0.12±.00[a]	0.34±.01[b]
0	0	100	0.20±.00[a]	0.08±.01[c]	0.43±.00[a]

Average means scores with the same superscript alphabet in the same column are not significantly different, p=0.05

Table 3. Vitamin content of acha-amaranth flour blends

Flour Acha flour (%)	Blend		Vitamin B_3 (Mg/100 g)	Vitamin E (Mg/100 g)	Vitamin B_6 (Mg/100 g)
	Amaranth Flour (%)	Wheat flour (%)			
100	0	0	0.13±.01[d]	0.54±.01[f]	0.39±.01[f]
95	5	0	0.14±.01[d]	0.58±.01[d]	0.41±.01[e]
90	10	0	0.19±.00[c]	0.59±.00[c]	0.47±.01[d]
85	15	0	0.21±.00[b]	0.64±.00[b]	0.61±.00[c]
80	20	0	0.24±.01[a]	0.69±.00[a]	0.75±.01[a]
0	0	100	0.22±.01[b]	0.56±.00[e]	0.69±.00[b]

Average means scores with the same superscript alphabet in the same column are not significantly different, p=0.05

Table 4. Functional properties of acha-amaranth flour blends

Acha flour (%)	Amaranths flour (%)	wheat flour(%)	Water absorption (ml/g)	Oil absorption (ml/g)	Bulk density (g/cm³)	Foaming capacity (ml/g)	Swelling capacity (ml/g)
100	0	0	120.00±14.14[a]	110.00±28.28[a]	0.79 ±0.02[a]	0.06± 0.00[c]	295.00±7.07[a]
95	5	0	125.00±21.21[a]	130.00±14.14[a]	0.79 ±0.00[a]	0.07±0.01[bc]	280.00±0.00[a]
90	10	0	131.25±8.84[a]	130.00±42.43[a]	0.78 ±0.00[ab]	0.08±0.01[bc]	275.00 ±7.07[a]
85	15	0	145.00±7.07[a]	131.25±8.84[a]	0.77 ±0.02[ab]	0.09±0.01[b]	275.00±7.07[a]
80	20	0	145.00±35.36[a]	135.00±21.21[a]	0.76 ±0.00[b]	0.09±0.01[b]	275.00±21.21[a]
0	0	100	65.00±21.21[b]	115.00±21.21[a]	0.68 ±0.01[c]	0.15±0.00[a]	270.00±14.14[a]

Average means scores with the same superscript alphabet in the same column are not significantly different, p=0.05

3.4 Functional Properties of Acha-amaranth Flour Blends

The result of functional assessment of the acha flour blend is shown in Table 4. The bulk density, swelling capacity decreased from 0.79 - 0.76, 295.00 -275.00% respectively with increase in added amaranth flour (5-20%). The water absorption capacity, oil absorption capacity and foaming capacity increased from 120.00 – 145.00, 110.00 – 135.00,0.06 - 0.09, ml/g, respectively, with increase in added amaranth flour(5-20%). The 80:20% acha-amaranth samples had the highest value for foaming capacity, water absorption, and oil absorption and lowest value for swelling capacities and bulk density. The results agreed with the reported values for starch foodstuff by Onuh and Abdulsalam [27].

Bulk density is significant in package design, storage and transport of foodstuff [28]. This revealed that bulk density depends on the particle size and moisture content of flours. The high bulk density of flour could suggest their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods [28]. Water absorption capacity defines the ability of a product to associate with water under conditions where water is limited [29]. The highest water absorption capacity of the 80:20% acha-amaranth samples could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in this flour.

The water and oil binding capacity of protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity [29] which agreed with the findings in this work.

4. CONCLUSION

The addition of amaranth flour has proven to improve the chemical/nutrient composition to acha based flour. Acha-amaranth flour blend product could there add value to food products and increase the varieties of good table for human consumption.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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