Introduction

Acha (Digitariaeexcissilis) is a cereal grain in the family of gramineae and commonly referred to as fonio or hungry rice (Alamu, 2001. Ayo and Nkama 2006). The major traditional foods from the grain are; thick (tuwo) and thin (kunu), porridge, steamed product (brabu sco or couscous) and alcoholic beverages (Jideani and Akingbala, 1993). Acha grains may be boiled like rice; flour from acha may be fortified with other cereals flour especially for the production of porridge or pudding (Ayo and Nkama, 2003; Ayo and Nkama 2006). Acha grain can also be milled into flour to produce biscuit and bread with desirable qualities (Ayo and Nkama, 2003; Alain et al., 2007).

Acha can be classified based on the color and sizes of the grain. Acha is also one of the most nutritious of all grains; its protein content is higher than that of maize and first (Ayo and Nkama, 2003; Jideani and Akingbala, 1993; Ogbona and Abdulkadir 2008). The consumption of cereal based foods like biscuit has triggered the need for nutritional improvement of the nutrient content of the eacha-moringa flour blend. Moringa oleifera tree is widely cultivated due to its high adaptability to environmental conditions (Teixira et al., 2014). It’s considered as one of the most useful trees in the world because almost all parts of this plant can be used as in food, in medicines and for industrial purposes (Anvar et al., 2007). In many countries, there are huge efforts to spread the use and cultivation of M. oleifera, since it is a significant source of fats, proteins, beta-carotene, vitamin C, iron, potassium, and other nutrients with low toxicity of seeds and leaves (Saini et al., 2014).

Moringa plant have drawn much attention and have been studied for its various biological activities, including antiinflammatory (Churmark et al., 2008), immune-boosting (Miyoshi et al., 2004), antiviral (Khalkafalla et al., 2010), antioxidant and antimicrobial (Kumar et al., 2013; Lister and Wilson 2001; Kumar et al., 2013) properties and tumor suppressive effects in skin papillomagenesis, hepatocarcinoma cancer, colon cancer, and myeloma (Khalkafalla et al., 2010; Budda et al., 2011; Bharali et al., 2007; Brunelli et al., 2015).

Pinto et al. (Pinta et al., 2015) demonstrated that vegetable proteins are less susceptible to in vivo digestion than animal proteins. The low content of sulfur containing amino acids, compact structure, presence of non-protein components (dietary fiber, tannins, phytic acid) and antiphysiological proteins (protease inhibitors, lectins) can affect digestion. Teixeira et al. (2004) found that whole leaf flour contained 28.7% crude protein, 7.1% fat, 10.9% ashes, 44.4% carbohydrate and 3.0 mg 100 g

Abstract: The research investigated into the effects of added moringa seed powder on the phytochemical, oligosaccharide, in-vitro starch/protein digestibility and the elemental content of acha-moringa flour blend. The moringa seed flour was substituted (5, 10, 15, 20 and 25%) into acha flour to produce flour blends. The flour blends and the control (100% acha flour) were analysed for phytochemicals (tannin, HCN, saponin, phytate, flavonoid, steroid, phenol), oligosaccharides (raffinose and stachyose), starch/protein in vitro digestibility, elemental (calcium, phosphorous, magnesium, iron, zinc) and vitamins (vit. A, C and B12). The phytochemical result showed increase in phenol (2.67 mg/g to 3.15 mg/g), sternd (0.35 to 0.52 mg/g) and flavonoid (0.83 to 1.01 mg/g), but decrease in saponin (2.96-1.98 mg/g) with increase in the added moringa paste (5-25%). The antinutrient result show increase in tannin (0.86 to 1.28 mg/g), cyanoegenic glycoside (HNCN) (2.72 to 3.03 mg/g), alkaloid (1.23 to 1.49 mg/g), alkaloid (1.23-1.43mg/g), but decrease in phytate (1.63- 1.06 mg/g) with increase in the added moringa paste. The in-vitro-protein digestibility increased from 75.70±0.14 – 82.90±0.18 while the in-vitro-starch digestibility decreases from 68.60±0.14 – 62.03±0.04% with increase in the added moringa flour paste (0-25%). The starchose and raffinose values of the acha-moringa seed flour blends ranges from 0.51±0.01 - 0.66±0.04 and 0.36±0.03-0.41±1%, respectively. The calcium, magnesium, phosphorous, zinc and iron content of the acha –moringa flour blend ranged from 18.62±0.08-20.29±1.9, 28.9±0.9-30.95±0.8, 35.29±0.8- 42.34±2, 0.72±0.3-1.08± 0.06 and 0.84±0.8b 1.39± 0.5mg/100g, respectively with addition of moringa flour at 5, 10, 15, 20 and 25%. The effects of added moringa seed flour were generally significant, p<0.05, and positive on the assessed qualities consequently improving the nutrient content of the eacha-moringa flour blend.

Keywords: Quality, phytochemicals, anti-nutritional, digestibility, oligosaccharides, acha-moringa flour blend
Comparative Analysis of Acha-Moringa Flour Blend

Iron. The protein profile revealed levels of 3.1% albumin, 0.3% globulins, 2.2% prolamin, 3.5% glutenin and 70.1% insoluble proteins. Otherwise, the most recent investigations reported that a flocculating protein (6.5 kDa, IEP pH 10) from the seeds of *M. oleifera* was isolated and purified. Amino acid analysis and sequencing showed high contents of glutamine, arginine and proline, and a total of 60 residues (Freire et al., 2015; Kwambwa et al., 2015; Gusschmidt et al., 1995 and Pavanikumar et al., 2014).

In general, there are low concentrations of antinutritional factors in the plant, although the seeds possess glucosinolates (65.5 μmol/g dry matter), phytates (41 g/kg) and hemagglutination activity while the leaves have appreciable amounts of saponins (80 g/kg), besides low quantity of phytates (21 g/kg) and tannins (12 g/kg), hypotensive activity, strong antioxidant activity and chelating property against arsenic toxicity (Arabshahi et al., 2007; Ghasi et al., 2000; Mehta et al., 2003; Santos et al., 2009). This research work aimed at evaluating the phytochemical, anti-nutrient, starch/protein digestibility, elemental and oligosaccharide composition of Acha-moringa flour blend.

Materials and Methods

**Material and material preparation**

*Moringa oleiferal* was obtained from Wuakri Main market, Nigeria. The hulls of moringa seeds were removed manually milled (attrition mill) and passed through a sieve of 0.35 mm aperture to produce the moringa flour. The acha grains were washed, destoned (sedimentation method) and dry-milled (attrition mill), and pass through a sieve aperture of 0.35 mm to produce acha flour. The moringa seed flour was substituted into acha flour at 5, 10, 15, 20 and 25%, while 100% acha flour served as control or standard. A Kenwood mixer was used for mixing samples at speed 6 for 3 min to achieve uniform blending.

**Determination of bioactive and anti-nutritional composition of acha-moringa flour blends**

**Determination of alkaloid**

Determination of alkaloid was made by the method described by Oluwole et al., (2013). The alkaloid content was determined gravimetrically. Five grams of the sample was weighed and dispensed in 10% acetic acid solution in ethanol to form a ratio of 1:10 (10%). The mixture was allowed to stand for 4 h at 28°C. It was later filtered via Whiteman No. 42 grade of filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation and treated with drop wise addition of concentrated aqueous NH₄OH until the alkaloid was precipitated. The alkaloid precipitated was received in a weighed filter paper, washed with 1% ammonia solution, and dried in the oven at 80°C. Alkaloid content was calculated and expressed as a percentage of the weight of sample analyzed.

**Determination of saponins**

The spectrophotometric method was used for saponin analysis as described by Oluwole et al., (2013). One gram of the flour sample was weighed into a 250-mL beaker and 100 mL isobutyl alcohol was added. The mixture was shaken on a UDY shaker (UDY Corporation, Fort Collins, CO) for 5 h to ensure uniform mixing. The mixture was filtered through a Whatman No. 1 filter paper into a 100-mL beaker and 20 mL of 40% saturated solution of magnesium carbonate was added. The mixture obtained was further filtered through a Whatman No. 1 filter paper to obtain a clear colorless solution. One milliliter of the colorless solution was homogenized into a 50-mL volumetric flask and 2 mL of 5% FeCl₃ solution was added and made up to mark with distilled water and allowed to stand for 30 min for blood red color to develop. Standard saponin solutions (0–10 ppm) were prepared from saponin stock solution and treated with 2 mL of 5% FeCl₃ solution as done for experimental samples. The absorbance of the sample as well as standard saponin solutions were read after color development on a 21D spectrophotometer (Milton Roy, Houston, TX) at a wavelength of 380 nm. The percentage saponin was also calculated.

**Determination of tannin content**

Tannin content of the flour samples was determined using the methods described by Swain (1979) and Oluwole et al. (2013). The sample (0.2 g) was measured into a 50-mL beaker; 20 mL of 50% methanol was added, covered with homogenizer, placed in a water bath at 77–80°C for 1 h, and the contents stirred with a glass rod to prevent lumping. The mixture was filtered using a double-layered Whitman No. 1 filter paper into a 100-mL volumetric flask using 50% methanol to rinse. This was made up to mark with distilled water and thoroughly mixed. One milliliter of the sample extract was homogenized into a 50-mL volumetric flask, and 20 mL distilled water, 2.5 mL Folin-Denis reagent, and 10 mL of 17% NaCO₃ were added and mixed. The mixture was made up to mark with distilled water, thoroughly mixed, and allowed to stand for 20 min when bluish-green coloration developed. Standard tannic acid solutions in the range of 0–10 ppm were treated similarly as the 1 mL sample above. The absorbance of the tannic acid standard solutions as well as samples was read after color development on a 21D spectrophotometer at a wavelength of 760 nm. Percentage tannin was calculated.

**Determination of phytic acid**

An indirect colorimetric method of Wheeler and Ferrel (1971) and modified by Oluwole et al. (2013) was used for phytate determination. This method depends on an iron to phosphorus ratio of 4:6. A quantity of 5 g of the test sample was extracted with 3% trichloro acetic acid. The phytate was precipitated as ferric phytate and converted to ferric hydroxide and soluble sodium phytate by adding sodium hydroxide. The precipitate was dissolved in hot 3.2 N HNO₃ and the color read immediately at 480 nm. The standard solution was prepared from Fe(NO₃)₃, and the iron content was extrapolated from a Fe(NO₃)₃ standard curve. The phytate concentration was calculated from the iron results assuming a 4:6 iron: phosphorus molecular ratio.

**Determination of oxalate content**

Oxalate was determined by AOAC (2005) method. One gram of the sample was weighed in a 100-mL conical flask. Seventy-five milliliters of 3 mol/L H₂SO₄ was added and the solution was stirred intermittently with a magnetic stirrer for about 1 h and then filtered using Whiteman No. 1 filter paper. The sample filtrate (extract) (25 mL) was collected and titrated against hot (80–90°C) 0.1 N KMnO₄ solution to the point when a faint pink color appeared that persisted for at least 30 sec. The concentration of oxalate in each sample was obtained from the calculation: 1 mL 0.1 permanganate = 0.006303 g oxalate

**Determination of steroids**

The Steroids were determined by the method described by Okeke and Elekwa (2003).

**Total carotenoids determination**

According to Yuan et al. (2009), 5 g of each defatted moringa Ethanol-Petroleum Concentrate were extracted with a mixture of acetone and petroleum ether (1:1, v/v) repeatedly using the mortar and pestle until a colorless residue was obtained. The upper obtained collected and combined with crude extracts after washed for several times with water. The extracts were made up to a known volume with petroleum ether. Total carotenoids content was determined by recording the absorbance at 451 nm with a spectrophotometer. Total carotenoids were calculated and expressed as mg g⁻¹ dw.
**Flavonoids determination**
The total flavonoids content of moringa EPC were determined according to the method of Mohdaly et al. (2012). A 0.5 ml aliquot of 2% AlCl₃ ethanolic solution was added to 0.5 ml of the extracts and mixed well. After keeping for 1 h at room temperature, the absorbance at 420 nm was measured. A yellow color indicates the presence of flavonoids. The total flavonoids content were expressed as mg quercetin equivalent (QE) per 100 g dw.

**Determination of total phenolic compounds**
The Folin-Ciocalteu assay, adapted from Ramful et al. (2011) was used for the determination of total phenolics present in the citrus fruit extracts. To 0.25 mL of diluted extract, 3.5 mL of distilled water was added followed by 0.25 mL of Folin-Ciocalteuragent (Merck). A blank was prepared using 0.25 mL of 80% methanol instead of plant extract. After 3 min, 1 mL of 20% sodium carbonate was added. Tube contents were vortexed before being incubated for 40 min in a water-bath set at 40°C. The absorbance of the blue coloration formed was read at 685 nm against the blank standard. Total phenolic were calculated with respect to gallic acid standard curve (concentration range: 0-12 µg mL⁻¹). Results are expressed in mg of gallic acid 100 g⁻¹ of plant material.

**Determination of starchyose and raffinose**
The high performance liquid chromatography (HPLC) method for Sugar analysis was used for the determination of raffinose and starchyose (BabuValiyodan et al., 2015)

**Mineral determination**
AOAC (2005) methods were used to determine the mineral compositions of the samples. One gram of sample was digested with nitric/perchloric/sulfuric acid mixture in the ratio 9:2:1, respectively, and filtered. The filtrate was made up to mark in a 5-mL volumetric flask. The standard curve for respective mineral was prepared from known standards and corresponding values of minerals in the samples estimated. Values of sodium and potassium were determined using a Flame photometer (Sherwood Flame Photometer 410; Sherwood Scientific Ltd., Cambridge, U.K.) using NaCl and KCl as the standard (AOAC 2005), while phosphorus was determined using the Vanado-molybdate method.

**Determination of starch/protein digestibility of the blends**
The in vitro protein digestibility of the samples were determined using the procedure described by Mertz et al. (1984) and Aboubacar et al., (2001) while in vitro starch digestibility were determined as described by Shekib et al. (1988) and Chinnam et al. (2012)

**Determination of oligosaccharides (raffinose and stachyose)**
Raffinose and starchyose were determined by the methods of Matella et al. (2005) and Siddiqiet al. (2006).

**Quantitative analysis of the vitamins**
To measure the Vitamin C contents of the samples Gholamreza et al. (2015) method was used. The experimental methods described by Gholamreza et al. (2015) were used to measure the Vitamin A contents of the sample.

**Determination of hydrogen cyanide**
Titrimetric method (AOAC, 2005) was used. The titration procedure using silver nitrate with p-dimethylamino-benzalrhodanine indicator was used.

**Statistical analysis**
Data was analyzed using analysis of variance. Duncan multiple range test was used to determine significant difference among the various samples in triplicate. Data were analyzed using the software statistical package for social science (SPSS) version 11.00 SPSS inc., Chicago, IL, USA at the 0.05 confidence level.

**Results and Discussion**

**Phytochemical composition of acha-moringa flour blend**
The results of the phytochemical composition of moringa seed-acha flour blend are shown in Table 1. The result showed increase in phenol (2.67 to 3.15 mg/100g), steroids (0.35 to 0.52 mg/100g) and flavonoid (0.83 to 1.01 mg/100g), but decrease in saponin (2.96-1.98 mg/100g) with increase in the added moringa paste (0-25%). The effects were significant, p < 0.05. The increase in the value of the phytochemical with addition of moringa could be due to the relative high value of the same in the moringa seed flour (Barakat and Ghazal 2016; Melesse et al., 2013). Moringa has been found to be a good source of polyphenols and antioxidants (Melesse et al., 2013). Phytochemicals such as vanillin, omega fatty acids, carotenoids, ascorbates, tocopherols, beta-sitosterol, moringine, kaempferol and quercetin have been reported in its flowers, roots, fruits, and seeds (Mishra et al., 2011; Kowalski 2010). The increase in the phytochemical values of moringa flour blend could be due to the relatively high phenolic values (10.17± 2.894 mg/100g) as earlier reported (Sulaiman and Fazilah, 2015; Singh et al., 2009; GowardhanSingh, 2013). However, the relatively low value observed in the work could be due environmental factors such as light, germination, degree of ripeness, variety, processing and storage, genetic factors can influence levels (Ahn et al., 1989). The trace quantities of flavonoid compounds indicate that the sample could act as immune enhancers, hormone modulators, antioxidant, anti-clothing and anti-inflammatory Okwu and Omomadomo (2005). They have been reported to be a potential contender to combat free radicals, which are harmful to our body and food systems (Nagai et al., 2003). The saponin values (1.98-2.94 mg/100g) observed in the work is relatively higher than the value (0.5 mg/100g) observed by Price et al. (1987), however, the decrease in the saponin values with increase in the added moringa flour could be due to its low saponin content of moringa. Saponins are generally characterized by their bitter taste, their ability to foam in aqueous solution, causing nausea, vomiting and their ability to hemolyse red blood cells (Jansman et al., 1998). Similarly, the saponin content of acha-moringa flour blends (1.98-2.94 mg/100g) were lower than that (5.20 mg/100 g) observed by Seena (2008). The lowering of the saponin value with addition of moringa flour could be an advantage over the deleterious effects of the same.

The values of phenol of the ach-moringa flour blend increased from 2.73-3.15 mg/100g with increase in the added moringa flour (5-25%), and the increase was significant, p<0.5. The increase could be due to the relatively high level of phenol (2.900 ± 0.002 mg) inherent in moringa flour as observed by Sulaimanand Fazilah (2015). Phenol have been observed as antioxidant suppress ROS formation either by inhibition of enzymes or by chelating trace elements involved in free radical generation, scavenging ROS; and protection of antioxidant defenses, anti-radicale generation, scavenging ROS; and protection of antioxidant defenses, anti-inflammatory, and anti-hypertensive properties (Singh et al., 2009; Ayinde et al., 2007; Li-Weber 2009; Shashank and Abhay, 2013).

<table>
<thead>
<tr>
<th>Table 1: Phytochemical composition of acha-moringa flour blend</th>
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<tr>
<td>Moringa (%)</td>
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Plant sterols, also called phytosterols, found in plants, are clinically shown to lower LDL cholesterol as part of a heart-healthy diet. Clinical studies suggest that plant sterols can reduce cholesterol by 8–15% (Kowalski, 2010). Plant sterols

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have been observed to be Generally Recognized as Safe in a variety of food and beverage applications (Kowalski, 2010; Harborne, 1998).

**Anti-nutrient composition of acha –morinda flour blend**

The result of the anti-nutrient compounds is shown in Table 2. The results showed increase in tannin ranging from (0.86 to 1.28 mg/100g), cyanogenic glycoside (HCN) (2.72 to 3.03 mg/100g), alkaloid (1.23 to 1.49 mg/100g), alkaloid (1.23- 1.43 mg/100g), but decrease in phytate (1.63 - 1.06 mg/100g), with increase in the added morinda paste. The increase in the tannin value of the blends agreed with findings of Sulaiman and Fazilah (2015) that moringa seed contain 0.890 ± 0.020 mg/100g of tannin. Satinder et al. (2011), reported lower value of tannin for wheat bran, rice bran, oat bran and the value reported by Okwu and Ndu (2006) is lower than the value reported for this work. Tannin contents of the acha-moringa flour blends (0.98 - 1.28 mg/100g) were lower than those reported for groundnut seeds (450.00 mg/100 g: Fasoyiro et al., 2008), sorghum grains (280.00 mg/100 g: Elemo et al., 2001), and Cajanuscajan (550.00 mg/100 g: Ayodele and Kigbu, 2005).

Tannins have been reported to speed up the rate of healing in enlarged mucous membrane, to be quick in curing of wounds and to possess astringent properties. The presence of tannin in the flour will support their use in treating hemorrhoid, varicose ulcers, frostbite, burns in herbal medicine and wound (Okwu and Okwu, 2004).

Phytic acid has a strong ability to chelate multivalent metal ions, specially zinc, calcium, iron and as with protein residue. The binding can result in very insoluble salts with poor bioavailability of minerals (Zhou and Erdman, 1995). They reduce the bioavailability and digestibility of nutrients by forming complexes with minerals, protein, digestive enzymes and amino acids mainly lysine, methionine, arginine and histidine (Bird 1991; Saunders et al., 1986).

The hydrogen cyanide value of the acha-moringa flour blend were very low (2.9 -30 mg/100g) and insignificant to the upper safe level 50-200 mg/100g or 100-200 ppm (Public Health England, 2014). It could therefore be said that the blends are safe for consumption and free from ill effects of hydrogen cyanides such as: non-specific CNS symptoms, muscular and neurological effects, tachypnea and tachycardia, include seizures, a rapid loss of consciousness, cardio respiratory depression and collapse, pulmonary oedema and death (Public Health England, 2014; Shanthakumari et al., 2009).

The increase in the phytochemical values as observed in this work agreed with observation of Soetan (2008) that addition of moringa seed flour influenced the phytochemical compositions of the blend flour and subsequently that of the processed food materials. Comparatively, the alkaloid content of acha-moringa seed flour blends (1.29-1.49 mg/100g) were lower than that of the upper limit of 60 mg/100 g recommended for a safe feed (McDonald et al., 1995).

It is evident that anti-nutrients and phytochemicals have both adverse and beneficial effects in humans (Solasdoye and Chukwuma, 2012). For example, phytic acid, lectins, phenolic compounds and tannins, saponins, enzyme inhibitors, cyanogenic glycosides, and glucosinolates reduce the bioavailability of certain nutrients and impair growth in children (Elemo et al., 2001; Dingyam et al., 2003). On the contrary, when phytic acid, lectins, and phenolic compounds and saponins were used at low levels, they exhibited hypoglycemic, hypocholesterolemic and anticancer properties (Yoon et al., 1983; Sidhu and Oakenful 1986; Thompson et al., 1988; Jariwalla et al., 1990; Oakenfull and Sidhu, 1990).

### In-vitro protein and In-vitro carbohydrate digestibility of Acha-moringa flour blend

The result of the in-vitro protein and in-vitro starch digestibility are shown in Fig. 1. The in-vitro protein digestibility increased from 75.70±0.14 – 82.90±0.18% while the in-vitro starch digestibility decreases from 68.60±0.14 – 62.03±0.04% with increase in the added moringa flour (0-25%). The in-vitro starch digestibility values obtained in this study is relatively higher than 26.43-57.25% for tigernut-pigeon pea blend reported by Chinma et al. (2011), 32.68-53.12% for unripe plantain-defatted sesame flour blend biscuits (Chinma et al., 2012; Zebib et al., 2015) and 36.08-52.36% reported by Jishaand (2011) for whey-protein concentrate-cassava flour biscuits. The decrease in the in-vitro starch digestibility of the flour blend as the level of moringa seed paste increased in the blend may be attributed to the increased crude fiber content which could caused a reduction in the starch digestibility by trapping starch granules within a viscous protein-fiber-starch net work (Chinma et al., 2011; Chinma et al., 2012). The presence of protein bodies around starch granules (due tin increased protein content) as observed by Chinma et al. (2012) may restrict granule swelling and starch gelatinization and hence, reduce the susceptibility to enzymatic attack (Aarath et al., 2003), thereby reducing in-vitro starch digestibility of acha-moringa flour blend.

<table>
<thead>
<tr>
<th>Moringa (mg/100g)</th>
<th>Acha (mg/100g)</th>
<th>Tannin (mg/100g)</th>
<th>HCN (mg/100g)</th>
<th>Phytate (mg/100g)</th>
<th>Alkaloid (mg/100g)</th>
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<tr>
<td>0</td>
<td>100</td>
<td>0.86±0.01c</td>
<td>2.72±0.06d</td>
<td>1.63±0.03a</td>
<td>1.23±0.04d</td>
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<td>5</td>
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<td>2.80±0.14c</td>
<td>1.53±0.08ab</td>
<td>1.29±0.04cd</td>
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<td>90</td>
<td>1.00±0.03abc</td>
<td>2.90±0.06bc</td>
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<td>1.34±0.06bc</td>
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<td>15</td>
<td>85</td>
<td>1.06±0.03ab</td>
<td>2.94±0.06abc</td>
<td>1.41±0.04cd</td>
<td>1.38±0.03abc</td>
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<tr>
<td>20</td>
<td>80</td>
<td>1.15±0.04a</td>
<td>3.00±0.03ab</td>
<td>1.36±0.06cd</td>
<td>1.43±0.01ab</td>
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<td>25</td>
<td>75</td>
<td>1.28±0.03a</td>
<td>3.0±0.02a</td>
<td>1.34±0.02d</td>
<td>1.49±0.07a</td>
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increase in the added moringa paste (5-25%). The effect of the added moringa paste on the in-vitro protein digestibility of the flour blend is significant, p<0.05. The increase in the in-vitro protein digestibility of the blend flour could be due to the increase in the protein content inherent in the added moringa seed paste.

The addition of moringa flour to the flour blend improve the protein digestibility over the control which confirm that flour blend have better nutritional value than the 100% acha flour. The in-vitro protein digestibility obtained in this work(75.70±0.14 – 82.90±0.18%) is in close agreement with the value (71.20 to 80.0%) reported by El-Adawy (1997) and the value (72.05 to 80.12%) reported by Chinma et al. (2015) for wheat-sesame flour blend and for unripe-plantain-sesame flour blend, but slightly higher than the value (60.20 to 71.57%) reported by Chinma et al., (2011) for tigernut-pigeon pea flour blend.

![Fig. 1: Invitro protein and carbohydrate digestibility of accha-moringa flour blend](image)

**Starchose and raffinose composition of acha –moringa flour blend**

The starchose and raffinose values of the acha-moringa seed flour blends ranges from 0.51± 0.01 - 0.66± 0.04 and 0.36± 0.41 ± 0.11%, respectively, as shown in Fig. 2. The values of stachyose and raffinose in the blend flours and the control (100% acha flour) were relatively low. The presences of starchose and raffinose could be advantageous or discomfort depending on the level or concentration (Siddiq et al., 2006). Raffinose and stachyose are non-digestible short-chain carbohydrates or oligosaccharides. Humans do not have enzymes to digest them, so they pass unchanged to the colon where the normal intestinal bacteria ferment them to gases (methane, carbon dioxide, hydrogen-gases that are responsible for the characteristic features of flatulence, namely nausea, cramps, diarrhea, and the social discomfort associated with the release of rectal gases.), which can cause abdominal bloating (Storey et al., 1998; Matella et al., 2005 and Siddiq et al., 2006). In the large intestine, raffinose and stachyose could act as a soluble dietary fiber, which means they can make stools softer (Matella et al., 2005; Nakakuki, 2002). They could also be used as bulk sweeteners (Siddiq et al., 2006).

**Minerals and vitamin composition of acha-moringa flour blend**

The minerals content as macro-elements (calcium, phosphorus and magnesium) and microelements (iron and zinc) in mg 100 g–1 of acha-moringa flour blend were given in Table 3. The calcium, magnesium, phosphorous, zinc and iron content of the acha–moringa flour blend ranged from 18.62±0.08-20.29 ±19, 28.94 ± 0.09-30.95±.08, 35.29 ± 0.08 -42.34± .2, 0.72± 0.03-1.08 ± 0.06 and 0.84± 0.8b-1.39 ± 0.05 mg/100g, respectively with addition of moringa flour at 5, 10, 15, 20 and 25%. The increase were significantly higher (p<0.05) than the control (100%). The increase in the elemental content with increase in added moringa agreed with findings of Barakat and Ghelal (2016) that the moringa seed flour contain calcium (2016 to 2620 mg/100g), magnesium (322 to 340.6 mg/100g) and phosphorous (1817 to 1845 mg/100g), while Zn was 1.0 mg/100g (w/wt).

The minerals found in M. oleifera could play both a curative and preventive role in combating human disease. For example, Ca is a multifunctional nutrient essential to the body metabolism (Sizer and Whitney, 1999; Freire et al., 2005), and a natural cure for osteoporosis (Howard, 2014). Furthermore, there is strong biological plausibility for the direct impact of Mg intake on cardiovascular disease prevention, insulin sensitivity, and diabetes (Bo and Pisu 2008.), increasing the rate of pregnant female milk production and healing of wounds and functions as an antioxidant as a result of the high zinc content (Rathi et al., 2006), Fe has several essential functions in the body, such as its roles in oxygen transport and oxidative metabolism (Bothwell et al., 1979).

The phosphorous ratio (Ca/P) ratios is an indices for bone formation and the values (0.479-0.527) were relative low and within the recommended (<1) for diets, particularly for hypertensive patients. Therefore, the observed for the acha-moringa seed flour blend in this study is suitable for people who have the risk of 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. It is well known that diets with high value of Ca/P ratio are considered “good,” particularly for growing children who require high intake of calcium and phosphorus for bone and teeth formation (Nieman et al., 1992). Zinc is also important in the healing of wounds and functions as an antioxidant.
The results of the vitamin content of the acha-moringa flour blend and the 100% acha flour is shown in Table 4. The vitamins values for the blends were vitamins A (2.65 ± 0.01–3.56 ± 0.06), vitamin C (3.78 ± 1.36–5.50 ± 0.06) and vitamin B12 (0.17 ± 0.01–0.31 ± 0.05). The vitamins values of the blends were significantly (p<0.05) higher than that of the 100% acha flour (2.51 ± 0.04 for vit.A, 3.61 ± 0.16 for vit.C and 0.14 ± 0.02c for vit.B12).

Table 3: Effect of added moringa on the minerals composition of acha-moringa flour blend

<table>
<thead>
<tr>
<th>Acha: Moringa flour (%)</th>
<th>Ca (mg/100g)</th>
<th>Mg (mg/100g)</th>
<th>P (mg/100g)</th>
<th>Zn (mg/100g)</th>
<th>Fe (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:0</td>
<td>14.6±1</td>
<td>28.6±1</td>
<td>30.6±1</td>
<td>0.66±1</td>
<td>0.76±1</td>
</tr>
<tr>
<td>95:5</td>
<td>18.6±2</td>
<td>28.9±4</td>
<td>35.2±9</td>
<td>0.72±2</td>
<td>0.84±3</td>
</tr>
<tr>
<td>90:10</td>
<td>18.9±2</td>
<td>29.4±3</td>
<td>35.9±8</td>
<td>0.87±1</td>
<td>0.87±2</td>
</tr>
<tr>
<td>85:15</td>
<td>19.7±6</td>
<td>30.0±9</td>
<td>41.4±7</td>
<td>0.96±1</td>
<td>0.97±2</td>
</tr>
<tr>
<td>80:20</td>
<td>36.6±1</td>
<td>30.6±9</td>
<td>40.3±8</td>
<td>1.01±1</td>
<td>1.30±3</td>
</tr>
<tr>
<td>75:25</td>
<td>20.1±3</td>
<td>30.6±9</td>
<td>40.3±8</td>
<td>1.01±1</td>
<td>1.30±3</td>
</tr>
</tbody>
</table>

Table 4: Effect added of moringa on the vitamin composition of acha-moringa flour blend

<table>
<thead>
<tr>
<th>Acha: Moringa flour</th>
<th>Vit A (mg/100g)</th>
<th>Vit C (mg/100g)</th>
<th>Vit B12 (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:0</td>
<td>2.51 ± 0.04</td>
<td>3.61 ± 0.16</td>
<td>0.14 ± 0.02</td>
</tr>
<tr>
<td>95:5</td>
<td>2.65 ± 0.01</td>
<td>3.78 ± 0.13</td>
<td>0.17 ± 0.01</td>
</tr>
<tr>
<td>90:10</td>
<td>2.76 ± 0.02</td>
<td>4.37 ± 0.92</td>
<td>0.2 ± 0.04</td>
</tr>
<tr>
<td>85:15</td>
<td>2.94 ± 0.12</td>
<td>4.78 ± 0.11</td>
<td>0.23 ± 0.04</td>
</tr>
<tr>
<td>80:20</td>
<td>3.13 ± 0.14</td>
<td>5.29 ± 0.06</td>
<td>0.31 ± 0.05</td>
</tr>
<tr>
<td>75:25</td>
<td>3.56 ± 0.06</td>
<td>5.50 ± 0.06</td>
<td>0.39 ± 0.05</td>
</tr>
</tbody>
</table>

Conclusion

The moringa flour was observed to improve the physicochemical (phenol) and nutritional-minerals- Fe, Zn, P3and vitamins- Vits A, B12 and C) potential with improved in-vitro protein digestibility of the acha-moringa flour blend. The relatively low concentrations of anti-nutritional factors (phytate) on addition of moringa flour could be an added advantage in reducing the chelating of minerals such as calcium in the acha-moringa flour blend.

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Comparative Analysis of Acha-Moringa Flour Blend


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