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NUTRITIONAL AND ANTINUTRITIONAL ASSESSMENTS OF NIGERIAN FINGER MILLET *(ELEUSINE CORACANA)*

Chemistry

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ABSTRACT

Eleusine coracana (finger millet) grain was evaluated with the aim of providing information that will guide the effective use of the plant nutrition as alternative food source. The proximate composition revealed moisture content (12.03 ± 0.06 %), ash content (3.00 ± 0.1 %), crude protein (7.81 ± 0.02 %), crude fibre (6.10 ± 0.1 %), crude lipid (1.30 ± 0.2 %), carbohydrate (69.76 ± 0.2 %) and energy value (321.98 ± 0.01 kcal/100g). The following minerals were present potassium (22923 ± 1907µg/g), sodium (729 ± 37 µg/g), copper (10 ± 0.5 µg/g), calcium (23 ± 0.6 µg/g), and magnesium (17 ± 5. µg/g), zinc (3 ± 0.7 µg/g), manganese (88 ± 1.0 µg/g), iron (38 ± 2.3 µg/g), phosphorus (226 ± 0.1 µg/g), cadmium (0.398 ± 0.02 µg/g) and chromium (0.429 ± 0.3 µg/g). It has the following vitamins content vitamin A (0.13 ± 0.18 µg/g), vitamin C (35.21 ± 0.15 µg/g), vitamin E (244.46 ± 1.14 µg/g), and vitamin B_2 (0.25 ± 0.02 µg/g). *Eleusine coracana* also has the following anti-nutritional factors tannins (0.09 ± 0.01µg/g), cyanide (0.027 ± 0.03 µg/g), phytate (2.33 ± 0.06 µg/g) oxalate (0.00068 ± 0.0003 µg/g) and nitrate (0.95 ± 0.1 µg/g). It contains both essential and non-essential amino acid including the rare ones that cannot be found in some cereal like tryptophan methionine, glumatic acid and threonine. These results revealed that the grain of *Eleusine coracana* (finger millet) contained essential nutrients which compete favorably well with those of other grains.

KEYWORDS

Nutritional, antinutritional, finger millet, eleusine, proximate and minerals analyses

1.0 INTRODUCTION

Nutritional well being is a sustainable force for health and development and maximization of human potential. The nutritional status of a community has therefore been recognized as an important indicator of national development (Singh and Raghuvanshi, 2012). In other words, malnutrition is an impediment in national development and hence assumes the status of national problem. For solving the problem of deep-rooted food insecurity and malnutrition, dietary quality should be taken into consideration (Singh and Raghuvanshi, 2012). Diversification of food production must be encouraged both at national and household level in tandem with increasing yields. Growing of traditional food crops suitable for the area is one of the possible potential successful approaches for improving household food security (Singh and Raghuvanshi, 2012)

Millet is a collective term referring to a number of small seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions (Baker, 1996). These are distributed in about 10 genera and 20 species in all (Lupien, 1990). The millets include five genera of the *Panacea* family (*Panicum, Setaria, Echinochloa, Pennesetum and Eleusine*). The most important cultivated species are: Proso millet *(Panicum miliaceum)*, Foxtail millet *(Setaria italica)*, Japanese barnyard millet *(Echinochloa frumentacea)*, Finger millet *(Eleusine coracana)* and Koda millet *(Paspalum scrobiculatum)*

1.1 *Eleusine coracana*

E. coracana is an annual plant grown as a cereal in warm temperate regions of the world from Africa to Asia and also in Australia. It is called *tamba* in Hausa (Nigeria), finger millet, *African* millet, *koracan* (England); "*ragi*" (India); *Susu* (Korea); *fingerhirse* (Germany); *wimbi* (Kenya); *pwana* by Birom and *vuruh* (Zuru). (Diane *et al.,* 2003). Finger millet is of the scientific classification of the order of *poales*, family of *Poaceae*, sub family of *Chloridoideae*, genus of *eleusine* and species of *E. coracana.* (BSBI List, 2007).

E. coracana can grow in almost all types of soil and climatic conditions including alkaline soils with pH as high as 11 and at an altitude of 2500 m from sea level, with average annual rainfall ranging from 800-1200 mm. It is known as the poor man food because of long sustenance as it can be stored safely for many years without infestation by insects and pests. This property makes it a very necessary famine reserve food (Gull *et al.,* 2015).

MATERIALS AND METHOD

Sample Collection and Preparation

The sample grain was collected from Birnin-Yauri town, Ngaski Local Government area of Kebbi state, Nigeria. It was identified as *Eleusine coracana* at Usmanu Danfodiyo University Herbarium laboratory at the Department of Biological Sciences Usmanu Danfodiyo University Sokoto. The voucher identification number is UDUH/ANS/0166.

The finger millet seeds sample were sun-dried for couple of days after harvesting, then the talk were de-husked using mortar. The grain sample were winnowed to remove the chaff and ground into powder form, and then preserved into sample bottle for analysis.

EXPERIMENTAL

Determination of Moisture Content

Procedure: Moisture content was determined by drying 2 g of the grain sample to a constant weight in a crucible at 105 ºC (AOAC 2000). The moisture content was calculated using the equation:

$$\text{Moisture contest (\%)} = \frac{\text{loss in weight}}{\text{Weight of the sample}} \times 100$$

Determination of Ash Content

Procedure: The sample 2 g was ash at 600 ºC in a muffle furnace, until constant weight was obtained. The ash content was calculated as:

$$\text{Ash content (\%)} = \frac{\text{weight of ash}}{\text{Weight of dry sample}} \times 100$$

Determination of Crude Protein

The crude protein of the sample was determined using the micro-Kjeldhal method as described by Kirk and Sawyer (1991)

Determination of Crude Lipid Content

Crude lipids were analyzed by exhaustively extracting 2 g sample in hexane solution using soxhlet apparatus The powdered sample 2 g was added into a thimble and inserted into a thimble holder which was suspended over 100 cm^3 of hexane measured into a previously dried and weighed round –bottom flask and this was assembled together with the thimble holder and its contents. The Quick fit condenser was connected to the Soxhlet extractor and refluxed for 16 hours at low heat on a heating mantle. The flask was later removed and the solvent evaporated in a steam bath. The flask containing the crude lipid was then heated at 105 ºC in an oven for 30 min, cooled in a desiccators and the weight of the collected crude lipid was calculated and expressed as percentage crude lipid (AOAC 2000):

Crude lipid (%) = $\frac{\text{Weight of oil extracted}}{\text{Weight of sample}}$ x 100

Determination of Crude Fibre Content

The principle of the method is based on loss of crude fibre when ignited after being digested with acid and base under specific conditions.

The powdered sample 2 g was placed in a 250 cm^3 conical flask. 100 cm^3 of 1.25 % sulphuric acid (H_2SO_4) and 10% sodium hydroxide (NaOH) solution were added and then heated on a hot plate for 30 min. The content was then filtered after which the residue was washed with boiling water until the washing was not acidic by testing with litmus paper.

The flask was reconnected to the condenser and boiled for another 30 min with NaOH. The content was also filtered through a linen cloth and the residue obtained was transferred into a dried and weighed porcelain crucible and then dried at 105 °C for 3 hr and reweighed. The crucible and its content were then ignited in an electric furnace at 600 °C for 30 min, cooled and then reweighed (AOAC 2000). The loss on weight was reported as percentage fibre as in the equation 2.10.

Crude fibre (%) = $\frac{\text{loss in weight on ignition}}{\text{Weight of the sample}}$ x 100

Determination of Available Carbohydrate

The percentage carbohydrate were determined by difference from the percentage (ash content, crude protein, crude fibre and crude fat) and subtracted from 100 % moisture free samples (AOAC 2000).

A. Carbohydrate (%) = 100 – (Ash + Protein+ Lipids+ Fibre+ Moisture)

Determination of Calorific Value

The calorific value was calculated using the Atwater factors of 4, 9, and 4 for protein, fat and carbohydrate respectively. (Onyeike *et al*., 1995).

Atomic Absorption Spectrophotometery (AAS)

Sample Digestion: 5 cm^3 of 100ppm nitric acid (HNO_3) was added to 2 g of sample in a beaker and stirred. Then 4cm^3 of 1.0M Perchloric acid ($HClO_4$) were added and slightly stirred. It was heated on a hot plate and a strong effervescence was produced. When the brown fumes were less dense, the solution was allowed to cool. A slightly yellow dissolution a small white solid quantity in suspension still remained. The solution was filtered and diluted up to 50 cm^3 of distilled water. Jones *et al*., (1991). Thus, the metallic elements: Zn, Mn. Fe, Cu, Ca, Mg, Cd, and Cr were analysed using AAS...

Analysis of Phosphorus

Principle: The principle of this method is based on the reaction between phosphorus and ammonium molybdate to form a hetero-polyphosphomolybdate complex. The complex was then reduced with tin (II) chloride solution to form a blue purple complex (molybdenum blue), the intensity of which was measured at 810 nm wavelength. The absorbance measured was directly proportional to the concentration of phosphorus in the sample (James 1995)

% P. = $\frac{\text{Conc. (ppm) x Vol. of the solution } (cm^3)}{\text{Aliquot } (cm^3) \text{ x sample weight (g)}}$ x 100

Determination of Vitamin C

Exactly 10 cm^3 of 95 % ethanol was added to 1.00 g of the sample and was left overnight to extract. 1 cm^3 of the extract was measured in to centrifugal test tube together with 1 cm^3 of phosphotungstate reagent which was mix thoroughly and left for 30 minutes. The test tube was centrifuged at 700 rpm and the whole of the separated supernatant was collected with a pipette - the supernatant was the test sample for spectrophotometric measurements. Another standard sample was prepared as above using 1 cm^3 of phosphotungstate reagent with the extract, without centrifugation. The absorbencies of the test sample A_x and of the standard sample A_s were both measured at 700 nm against the mixture PR: 50 mM solution of oxalic acid = 1:1 (v/v) as a reference sample. The concentration C_x of vitamin C (µM) in the extract was calculated using the formula below

$$C_x = \frac{A_x}{A_s} \times C_s$$

Where

C_s = concentration of the standard solution, C_x = concentration of vitamin C,

A_x = absorbance of the test sample and A_s = Absorbance of standard sample

Determination of vitamin E

Exactly 10cm^3 of 95 % ethanol was added to 1 g of the sample and was left overnight to extract. 0.5 cm^3 of the extract was measured in to test tube 1 (centrifugal) with a tight stopper together with 0.5 cm^3 of anhydrous ethanol and the plugged test tube was shock vigorously for 1 minute. 3 cm^3 of xylene was added and the test tube was plugged again, shock vigorously for another 1 minute. The tube was centrifuged at 150 rpm to separate the extract. 0.25 cm^3 of solution of bathophenanthroline was added into another test-tube II. 1.5 cm^3 of the extract (upper layer) was collected and transferred into the test-tube II then the content was mixed. 0.25 cm^3 of $FeCl_3$ was added to the tube II then 0.25 cm^3 H_3PO_4 solution was added and mixed again, this way a test sample was obtained for spectrophotometric measurement.

To prepare a standard sample, 0.5 cm^3 of the extract was taken in a test tube and 0.5 cm^3 α-tocopherol with 5 cm^3 of deionized water were added to the extract. The sample was not centrifuged. The absorbance values of the test sample A_x and of the standard sample A_s were both measured at 539 nm against the blank test. The concentration, C_x of vitamin E (µM) in the extract was calculated, using formula 2.14 below.

$$C_x = \frac{A_x}{A_s} \times C_s$$

Where: C_s = conc. of standard solution, A_x = absorbance of the test sample and

A_s = absorbance of standard solution

Determination of Vitamin A

Exactly 10cm^3 of 95 % ethanol was added to 1 g of the sample and was left overnight to extract. 1 cm^3 of the extract was added into the test tube I (centrifugal) with a tight stopper and 1 cm^3 of KOH solution was added, the tube was plugged then shaken vigorously for 1 minute. The tube was heated in a water bath at 60^{0}C for 20 minutes and it was cooled down in cold water. 1 cm^3 of xylene was added, plugged and shaken vigorously for 1 minute. The tube was then centrifuged at 150 rpm. The whole of the separated extract (upper layer) was collected then transferred to another test tube II. The absorbance A_1 of the extract was measured at 335 nm against xylene and the extract in the test tube II was exposed to the UV light for 30 minutes then the absorbance A_2 was measured. The concentration C_x of vitamin A (µM) in the analyzed liquid was calculated using the formula below

$C_x = (A_1 - A_2) \times 22.23$

Where 22.23 is the multiplier received on basis of the absorption coefficient of 1 % solution of vitamin A (as the retinol form) in xylene at 335 nm in a 1 cm cuvette.

Determination of Riboflavin

Exactly 2 g of sample was taken into a conical flask. 50 cm^3 of 0.2M HCl was added and boiled in a water bath for one hour. It was cooled and the pH was adjusted to 6.0 using NaOH. The pH was further lowered to 4.5 using 1M HCl. This was filtered into 100 cm^3 measuring flask and made to volume. Three tubes were marked 1, 2 and 3. 1 cm^3 of glacial acetic acid was added to each tube and mixed thoroughly. Then 0.5 cm^3 of 3 % $KMnO_4$ solution was added to the tubes. The tubes were kept for two minutes after which 0.5 cm^3 of 3 % H_2O_2 was added and mixed well. Then the absorbance values were measured at 525nm.

Calculation:

Riboflavin content = x/y-x * 1/w

x = (absorbance of sample 1) – (absorbance of sample blank)

y = (absorbance of sample + standard tube 2) – (absorbance of sample + standard blank)

W = weight of the sample

Determination of Phytate

The phytate was determined through phytic acid determination using the procedure described by Lucas *et al*., (2000).

Procedure

2 g of the sample was taken in to 250 cm^3 conical flask. 2% HCl was

used to soak the sample for 3 hours then the content was filtered using double layer filter paper. The filtrate was placed into 250 cm^3 beaker and 10 cm^3 of distilled water was added, 10 cm^3 of 0.3 % NH_4SCN solution was also added and titrated with 1.95mg/cm^3 iron II chloride solution and the end point was signified by brownish yellow coloration that persisted for 5 minutes. Phytin – phosphorus 1 cm^3 Fe is equal to 1.19 mg phytin phosphorus was determined and phytate content was calculated by multiplying value of phytin- phosphorus by 3.55 (Lucas *et a*l.,2000).

Determination of cyanide

The sample (5.00g) were added into 50 cm^3 of distilled water in a corked conical flask and allowed to stand overnight. The mixture was filtered using Whatman filter paper. 1 cm^3 of the filtrate was put in a test tube and 4 cm^3 of the alkaline picrate was added to the filtrate. The test tube was then incubated in a water bath at 95 ^{0}C for 5minutes. The contest in the test tube was cooled and its absorbance was measured at 490 nm again a blank reagent. The amount of cyanide was then extrapolated from a standard calibration curve (AOAC, 1990)

Determination of Tannins

The powdered sample (2 g) was put into a 100 cm^3 conical flask and 50 cm^3 of distilled water added. The flask was then heated to boiling for 1hour, filtered hot and the filtrate collected in a 50 cm^3 conical flask. The residue was washed several times and the combined solution made to the volume with distilled water.

To 0, 1, 2, 3, 4 and 5 cm^3 of the standard tannic acid and 10 cm^3 of the sample solution in a 50 cm^3 volumetric flask, 2.5 cm^3 Folin-Denis reagents and 10 cm^3 of Na_2CO_3 solution were added and made to volume with distilled water. The flask was allowed to stand for 20 minutes after which absorbance were measured at 760 nm. The calibration curve was plotted (using standard tannic acid) from which the concentration of tannic acid (ppm) in the sample was extrapolated and tannins content in the sample was calculated (Allen *et. al,* 1974)

Determination of Nitrate

The method reported by IITA (1988) was followed for the nitrate analysis.

Nitrate was determined by weighing 2 g of the powdered sample into a 15-cm^3 centrifuge tube and 10 cm^3 of distilled water were added. The content was incubated in water bath at 45 ºC for 1 hour, the content was cooled and centrifuge at 3000 rpm for 15 minutes. Similarly, 0.2 cm^3 of the extract was put into another 20 cm^3 volumetric flask. To the flasks, 0.8 cm^3 of 5 % (w/v) salicylic acid, sulphuric acid reagent was added and mixed thoroughly. The content was allowed to stand for 20 minutes and followed by the addition of 2M NaOH solution. The content was then cooled at room temperature and its absorbance was measured at 410 nm. The calibration curve was plotted from which the concentration of nitrate (ppm) in the sample was extrapolated and nitrate content in the sample was calculated as below (IITA, 1988):

$$NO^{3-}(mg/100g) = \frac{\text{conc. (ppm) x solution volume } (cm^3)}{\text{Aliquot } (cm^3) \text{ x sample weight}} \times 100$$

Determination of Oxalate

Oxalate was determined using the method described by Krishna and Ranjhan (1980), Oxalate was precipitated as calcium oxalate; the concentration was determined by titration with potassium permanganate.

$$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Procedure: 1 g of the sample was added to 75 cm^3 of 15 % H_2SO_4 and the solution was intermittently stirred with magnetic stirrer for 1hour then the solution was filtered. Then 25 cm^3 of the filtrate was collected and titrated against 0.1 M $KMnO_4$ solution until a faint pink color appeared and persisted for 30seconds. 1 cm^3 of 0.1M of $KMnO_4$ = 4.50mg of oxalic acid

Determination of Amino Acid Profile

The Amino Acid profile was determined using methods described by Benitez (1989). The sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 4 g of the sample was put in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 2006).

Hydrolysis of the sample for amino acid analysis

A known weight of the defatted sample was taken into glass ampoule. 7 cm^3 of 6M HCl was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g. methionine and cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105±5^{0}C for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. It should be noted that tryptophan is destroyed by 6M HCl during hydrolysis.

The filtrate was then evaporated to dryness using rotary evaporator. The residue was dissolved with 5 cm^3 to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

RESULTS AND DISCUSSIONS

Proximate Analysis

The results obtained from proximate analysis are presented in Table 1 below.

The grain show lower moisture content, ash content and lipid content.

Table 1 Result of Proximate composition of E. coracana L grain

Parameter	Composition %
Moisture content	12.03 ± 0.06
Ash content	3.00 ± 0.10
Crude protein	7.81 ± 0.02
Lipids content	1.30 ± 0.20
Crude fibre	6.10 ± 0.10
Carbohydrate content	69.76 ± 0.20
Energy value (kcal/100 g)	321.98 ±0.01

Values are the mean ± standard deviation of triplicate determinations expressed as dry weight of the grain

Minerals:

The grain mineral content was presented in Table 2 and the result shows that the grain is rich in Ca, Mg, K, P, Mn and Fe but low in Na and Zn.

Table 2: Mineral Composition of *E. coracana*

Minerals	Composition (µg/g)
Sodium	729.22±36.51
Potassium	22922.82±1906.77
Phosphorus	226.15±0.41
Calcium	2103.36±0.62
Magnesium	17.43±5.21
Iron	38.32±2.27
Copper	10.26±0.48
Zinc	3.34±0.69
Cadmium	0.39±0.02
Manganese	88.45±1.02
Chromium	0.43±0.29

Values are the mean ± standard deviation of triplicate determinations expressed as dry weight of the grain

Vitamins

The grain vitamin content was presented in Table 3 and the results indicate that the grain contains both water soluble and fat soluble vitamin.

Table 3: Vitamin Composition of E. coracana grain (µg/g)

Parameters	Composition (µg/g)
Vitamin A	0.13±0.18
Vitamin C	35.21±0.15
Vitamin E	244.46±1.14
Riboflavin	0.25±0.02

Values are the mean ± standard deviation of triplicate determinations expressed as dry weight of the grain

Amino acids

The grain amino acid composition was presented in the table 3.4 and the result shows that the grain contains some significant amount of essential amino acid. Some selected essential amino acids were compared with FAO/WHO/UNU reference standard as shown in table 3.4.

Table.4: Amino acids composition of *E. coracana* grain

Amino Acid	Composition (g/100g)	FAO/WHO/UNU (1991) g/100g
Leucine	8.75	6.50
Lysine	3.69	5.50
Isoleucine	4.22	3.00
Phenylalanine	4.97	2.80
Tryptophan	1.68	1.30
Valine	4.88	3.30
Methionine	2.19	2.20
Proline	5.08	-
Arginine	4.30	-
Tyrosine	3.10	4.10
Histidine	1.92	-
Cystine	2.18	1.70
Alanine	4.01	-
Glutamic acid	16.02	-
Glycine	4.01	-
Threonine	3.94	4.00
Serine	4.19	-
Aspartic acid	7.78	-

Anti-nutritional factors

The antinutritional factors result of the sample is presented in Table 5 and the result showed that the fruit has high antinutrient content in the order of Phytate > Nitrate>Tannins >cyanide > oxalate.

Table 5: Anti-nutritional factors of *E. coracana grain*

Anti-nutritional factors	Composition (µg/g)
Tannins	0.09 ± 0.01
Cyanide	0.03 ± 0.01
Phytate	2.33 ± 0.06
Oxalate	0.00136 ± 0.0003
Nitrate	0.95 ± 0.10

All values are the mean of triplicate determinations ± standard deviation

Table 3.6: Anti-nutritional to nutritional molar ratio of *Eleusine coracana grain*

Anti-nutritional to nutritional ratio	Ratio	Critical Value
[Oxalate]/[Ca]	6.50 x 10-7	2.5
[Oxalate]/[Ca+ Mg]	6.44 x 10-7	2.5
[Phytate]/[Ca]	1.11 x 10-3	0.5
[Phytate]/[Fe]	6.0 x 10-2	0.4
[Phytate]/[Zn]	6.9 x 10-1	1.5

Source of critical value: Hassan *et al.,* (2011)

Discussions

Proximate Analysis

Table 3.1 presents proximate composition of the finger millet. The moisture content of E. *coracana* was found out to be 12.03 ± 0.06 % (w/w). This indicates that the grain has a good storage life; hence it can be stored for long term without spoilage. Moisture content is among the most vital and mostly used measurement in the, preservation and storage of food (Onwuka, 2005).

Ash content of 3.00±0.1 % (w/w) was obtained for *E. coracana*. Total ash content is higher in finger millet than in commonly consumed cereal grains and the ash content has been found to range from 1.7 to 4.13 % in finger millet (Singh and Raghuvanshi, 2012).

The crude lipid content obtained for *Eleusine coracana* was 1.30 ± 0.2 %(w/w). The crude fat content in finger millet has been reported to range from 1.3 to 1.8 % (Bhatt *et al*., 2003; Singh *et al*., 2003) but Antony *et al.* (1996) have reported a higher percentage of 2.1 % of crude fat. These values differences could be due to regional or variety differences. Lipid provides very good sources of energy and aids in transport of fat soluble vitamins, insulates and protects internal tissues and contributes to important cell processes (Pamela *et al.,* 2005).

The result obtained for crude fibre for finger millet was 6.10 ± 0.1 %(w/w). The crude fibre content obtained is also in agreement with the results reported by Katoch, 1990 (3.7 to 6.00 %). Although crude fibre enhances digestibility, its presence in high level can cause intestinal irritation, lower digestibility and decreased nutrient usage (Oladiji *et al,* 2005).

The crude protein of *Eleusine coracana* obtained was 7.81±0.02 % (w/w). Similar result of protein content of finger millet was reported which ranges between 6 and 8 %, more so low protein content of 5 % and high protein content of 12 % have been reported in different varieties (Hulse *et al.,* 1980). Similarly the value of 10.28 % has also been reported by Bwai *et al* (2014). The recommended dietary allowance (RDA) for protein is 56 g for individual weighing 70kg and 46 g for adult weighing 50 kg (Jones *et al.,* 1985). The plant is a moderate source of protein. According to Pamela *et al.*, (2005), proteins from plant sources have lower quality but their combination with many other sources of protein such as animal protein may result in adequate nutritional value.

The carbohydrate content of *Eleusine coracana* was 69.76±0.06 %. Similar results of 76.43 % and 79.50 % were reported by Bwai *et al.,* (2014) and Singh and Raghuvanshi, (2012) respectively. Considering the high value of the carbohydrate content and when compared with the Recommended Dietary Allowance (RDA) of 130 g the plant is a good source of carbohydrate (Pamela *et al.,* 2005). The major function of carbohydrate is to provide the body with energy. The caloric value of *Eleusine coracana* as shown in Table 3.1 was 378±0.01 kcal/100g, this result is similar to 382.27±0.02 kcal/100g reported for *Eleusine coracana* (Bwai *et al*., 2014).

Mineral Analysis

Table 2 presents the result of mineral element composition of E. *coracana*, in µg/g dry matter. The finger millet is a good source of nutrients especially of calcium, other minerals (Singh & Raghuvanshi, 2012). Singh and Raghuvanshi (2012) reported that the mineral composition of millet grains is highly variable. The genetic factors and environmental conditions prevailing in growing region affect the mineral content of these food grains.

The calcium content of finger millet as shown in table 3.2 was 2103.36 ± 0.62 µg/g which is consistent with Vadivoo *et al.,* (1998) results where the calcium content of 36 genotypes of finger millet ranged from 1620 to 4870 µg/g with mean value of 3200 µg/g. The result also corresponds with that reported by (Khouloud *et al*., 2013) which was observed to be 2120 µg/g. The phosphorous content as shown also in table 3.2 was 226.15 ± 0.41 µg/g. However, Khouloud *et al*., (2013) reported variation of phosphorous content in the range of 27.9 µg/g to 110 µg/g with mean value of 48.5 µg/g. More so, Singh and Srivastava (2006) reported that the finger millet phosphorus content ranged from 1300 to 2950 µg/g with a mean value of 1800 µg/g. This considerable variation might be due to genetic factors and environmental conditions prevailing in growing regions as reported by Singh and Raghuvanshi (2012).

The zinc content of *E. coracana* as shown in Table 3.2 was 3.34 ± 0.69 µg/g; a zinc value of 220 ± 0.01 µg/g was reported by (Bwai *et al.*, 2015). The Dietary reference Intake (DRI) for zinc is 11000 µg (Jone *et al.,* 1985) Thus, the 3.34 µg/g zinc content obtained for this research is lower than the recommended dietary allowance of 11000 µg zinc content. Zinc is essential in the activation of certain enzymes. These include dehydrogenase, alkaline phosphatese and carboxypeptidase. Zinc containing organic compounds is employed as astringent and antifungal agents. It aids wound healing and metabolism of nucleic acid and insulin. Zinc in excess causes anaemia and if deficient in the body can lead to dermatitis (Bwai *et al.*, 2015).

The manganese content of *E. coracana* as shown in Table 3.2 was 88.45 ± 1.02 µg/g, Bwai *et al.,* (2015) also reported manganese content to be 320 µg/g. The Dietary Reference Intake (DRI) for manganese varies between 2300 µg to 8000 µg (Jones *et al.,* 1985). Certain trace elements such as copper, iron, and manganese constitute essential part of any balanced diet. The content of copper as shown in Table 3.2 was 10.26 ± 0.48 µg/g. The Recommended Dietary Allowance of copper is 900 µg/d. Copper very vital in diet because it is involved in the proper usage of iron (Fe) and especially for the synthesis of cytochrome oxidase, which contains both iron (Fe) and copper (Cu). Excess copper can lead to jaundice (Wilson's disease) (Stoker, 1974).

The potassium content as shown in Table 3.2 was 22922 ± 1906.77 µg/g. This result is similar with the one reported by (Bwai *et al.,* 2015) which was observed to be 14190 µg/g. According to National Research Council (1974), the Recommended Dietary Allowance of potassium is 1875 to 5625 µg/g for adults. Potassium is very vital in regulation of water and electrolyte balance and acid-base balance in the body, as

well as responsible for nerve action and functioning of the muscles. Deficiency of potassium leads to muscle paralysis (Michael, 2007). The sodium content was 729.22 ± 36.51 µg/g, Bwai *et al.*, (2014) also reported a value of 6860 µg/g; likewise Khouloud *et al.,* (2013) reported variation of sodium content in the range of 137.73 to 424.7 µg/g. Sodium is a very important mineral element that aids the transmission of nerve impulses as well as maintenance of osmotic balance of the cells (Bwai *et al.,* 2015). According to National Research Council (1974), the Recommended Daily Allowance for sodium is 11000-33000 µg /g for adults. Deficiency of sodium may lead to dehydration or muscle cramp (Michael, 2007).

The iron content of Eleusine coracana as shown in table 3.2 was 38.32 ± 2.27 µg/g; similar result was obtained by Singh and Srivastava (2006) for iron content of sixteen varieties of finger millet which range from 36.1 to 54.2 µg/g with a mean value of 44.0 µg/g. The recommended dietary allowance by Food and Nutritional Board of iron for man is 8000 µg/d. Iron is very important in the formation of hemoglobin in red blood cells and deficiency of iron leads to anaemia. Base on this value of iron obtained we can say *Eleusine coracana* could be used as dietary source of iron. The chromium content of E. coracana as shown in table 3.2 was 0.43 ± 0.3 µg/g. The recommended dietary allowance of chromium by Food and Nutritional Board is 25 µg /daily. The concentration of cadmium was 0.39 ± 0.02 µg/g. This value is low when compared with the concentration of cadmium (31.0 µg/g) in *Gardenia aqualla* seed (Dangoggo *et al*., 2011).

Analysis of Vitamins

The vitamin A content obtained as shown in Table 3.3 was 0.13 ± 0.18 µg/g. The recommended Dietary allowance by Food and Nutritional Board of vitamin A is 700 µg/d. Vitamin A is very good for the eyes, as well as for a healthy skin. Vitamin C content reported for this research as shown in Table 3.3 was 35.21 ± 0.15 µg/g. This value is low compared with the minimum daily requirement of 100 to 170 µg/g (Food and Nutritional Board, 2002). Vitamin C plays important role in the reduction of iron to ferrous state and facilitates its absorption; it is indispensable in the collagen synthesis. (Elais and Linden, 1999). Vitamin E content as shown in Table 3.3 was 244.46±1.14 µg/g. The daily recommended dietary allowance for a man is 15000 µg/d.

The riboflavin content of finger millet was 0.49 ± 0.02 µg/g. The recommended Dietary allowance for riboflavin 1300 µg/d for riboflavin. Riboflavin is important for normal reproduction, growth, repair and development of body tissues including the skin, hair, nails, connective tissues and immune system, severe riboflavin deficiency is rare and often occurs with other B vitamin deficiencies (Umar *et al.,* 2013)

Analysis of Amino acids

The result of amino acid composition for finger millet grain protein was presented in Table 3.4. The nutritive value of plant protein is assessed by comparing its essential amino acids content with reference standard set by the World Health Organization (FAO/WHO/UNU 1991), based on the amino acid needs of the children aged 2 – 5 years (Abdullah, 2006). Ten essential amino acid were compared with the WHO reference standard, in which six of the essential amino acids namely lysine (8.75 g/100g), isoleucine (4.22 g/100g), phenylalanine (4.92 g/100g), trytophan (1.6 g/100g), valine (4.88 g/100g), and cystine (2.18 g/100g) are slightly higher than the WHO reference standard. More so, four out of the ten essential amino acids namely lysine (3.94 g/100g), methionine (2.19 g/100g), tyrosine (3.10 g/100g) and threonine (3.94 g/100g) are slightly lower than the WHO reference standard.

Tryptophan is usually the second most deficient amino acid in cereals. However, is not deficient in finger millet. Threonine too was not deficient, in contrast to rice, wheat and sorghum (FAO, 1968). Among millets, finger millet is relatively better balanced in essential amino acids because it contains more lysine, threonine and valine (Ravindran, 1992). Antony *et al.* (1996) reported that finger millet had sulphur containing amino acids (methionine) equal to that of milk.

Anti-nutritional factors

The phytate content of finger millet obtained as shown in Table 3.5 was 2.33 ± 0.06 µg/g (0.0233 %). This value is lower compared to the one reported by (Anthony and Chandra, 1999) which ranges from 6.79 to 6.93 µg/g , the value is also lower when compared to that of wild rice which was reported to be 1.17 ± 02 % (Umar *et al.,* 2013). The problem with phytic acid in food is that it can bind some essential minerals nutrients in the digestive tract and can result in mineral deficiencies (Bello *el al.,* 2008).

Tannin content of finger millet grain as shown in Table 3.5 was 0.09 ± 0.01 µg/g. This value is low compared to 4.0 ± 0.01 and 6.0 ± 0.22 µg/g reported in Sweet and Bitter Cassava (Sarkiyayi and Agar, 2010).

The oxalate concentration as shown in Table 3.5 was 1.36 x 10^{-3}±3.0 x 10^{-4} µg/g. This value is lower compared to the level of oxalate found in wild rice 1.25±0.4 % (Umar *et al*., 2013).

The concentration of nitrate content as shown in Table 3.5 was 0.95±0.1 µg/g. This result is lower compared with 10.32±0.10 µg/g of *P. biglobosa* flower as reported by (Hassan, *at al.,* 2011). Again, the nitrate content observed in this research does not pose harmful effect if ingested.

The Cyanide content as shown in Table 3.5 was 0.03±0.01 µg/g. Hassan*, et al.*, (2011) reported cyanide content of 1.70±0.10 µg/g for *P. biglobosa* flower.

Bioavailability of *E. coracana*

To predict the bioavailability of elements such as calcium, iron and zinc; mineral to antinutrients ratios were calculated and presented in Table 3.6. [Oxalate]/ [Ca] and [Oxalate]/ [Ca + Mg] ratios are below the critical values that will impair calcium bioavailability (Hassan *et al.,* 2008).

Even though it was reported that zinc is the most affected by phytate in animals and humans (Hassan *et al.,* 2008), [Phytate]/ [Zn] ratio was below critical level to interfere with zinc bioavailability (Hassan *et al.,* 2008).

[Phytate]/ [Ca] is also low compared to the critical value known to cause calcium deficiency (Hassan *et al.,* 2008). For adequate iron bioavailability, Mitchikpe *et al*. (2008) argue that [Phytate]/ [Fe] ratio should not exceed 0.4. the ratio for the grain is below the critical value which indicates that the iron in the grain maybe bioavailable.

4.1 CONCLUSION

Form the result of the analysis, *E. coracana* is a rich source of nutrient (carbohydrate, protein, lipid and calorific value), minerals (K, Na, Ca, P and Mn), essential amino acid (lysine, methionine, tyrosine, threonine and tryptophan) and vitamins that has the potentiality of use as a non-conventional food to supplement the nutritional needs of the under-nourished population. The levels of anti-nutrients (tannins, cyanide, phytate, oxalate and nitrate) are all below the toxic level or daily intake. However, it can be concluded that *E. coracana* has what it takes to contribute to the human nutritional requirement.

4.2 Recommendations

From the results of this study the following recommendations are made:

1. Due to the grain high calcium content, it should be integrated in to children and adult diet to help with strong/healthy bones and teeth.
2. To those that want to lose weight finger millet can be a good staple since it contains a rare amino acid called Tryptophan which lowers appetite and helps in keeping weight in control. It gets digested at a slower rate thus keeps one away from in taking excessive calories. Also, fibers present in this give a feeling of fullness thus controls excessive food consumption.
3. Considering the grain richness in amino acids, vitamins and other minerals, finger millet could help in keeping malnutrition at bay.
4. Based on the value obtained for iron content of finger millet in this analysis, eleusine coracana could be use to improve the anaemic condition of a patient
5. Further studies should be carried out on phytochemicals and polyphenols content of the *E. coracana*.

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