CHEMICAL COMPOSITION OF FINGER MILLET (*Eleusine coracana*) FLOUR

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S. S. Audu[1*], A. A. Ehanwo[1], M. O. Aremu[2], B. W. Tukura[1], A. I. Ambo[1], A. Usman[1]
[1]Department of Chemistry, Nasarawa State University PMB 1022, Keffi, Nigeria
[2]Department of Chemical Sciences, Federal University Wukari, PMB 1020, Taraba State, Nigeria
*Corresponding author: saratusteve@yahoo.com

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Abstract: The chemical composition of finger millet (*Eleusine coracana*) flour was studied for its nutrients with respect to proximate, mineral and amino acid compositions. Chemical composition of the finger millet flour was determined using standard analytical methods. The result of the proximate composition indicated that the finger millet flour contained considerable amount of crude protein (8.42 ± 0.05), crude fat (7.94 ± 0.06), carbohydrate (73.32 ± 0.23), ash (2.51 ± 0.11), crude fibre (2.51 ± 0.06), and moisture (5.58 ± 0.21) while the mineral composition showed that it contained Ca (70.89), Na (19.95), Mg (16.42), K (9.95), Mn (9.95), Cu (4.73), Cr (9.83), Fe (0.74), Zn (0.45) P (60.80) mg/100g and Pb was not at detectable range of AAS. Amino acid analysis revealed that leucine was 10.65 g/100g crude protein which constituted the highest essential amino acid (EAA) while glutamic acid (17.21 g/100g cp) was the most concentrated AA. Finger millet flour has a balance content of minerals and essential amino acids, though supplementation may be required for Leu, Met + Cys (TSAA) and valine. Hence the flour can be used for human and animal nutritio.

Keywords: *Eleusine coracana*, proximate, mineral, amino acid

Introduction

The continuous increase in population growth, inadequate supply of protein and the harsh economic situation make it necessary to explore the possibilities of using new plant resources in order to meet the growing need of food, clothes and housing for human and animal populations (Becker, 1986; Eknayake *et al*., 1999). Most developing countries including Nigeria depend on plant based foods as the more staple food for the supply of energy and protein, this account in parts for protein deficiency which prevail among the populace as recognized by Food and Agricultural Organization (FAO) (Elegbe, 1998).

Finger millet (*Eleusine coracana*), typically a tropical crop, belongs to the group of minor cereals. It is originally a nature to Ethiopian highlands, and mainly consumed in India and Africa (Andrea *et al*., 1999). It is also an important staple food because of its excellent storage properties, and nutritive value, resistance to disease and tolerance to soil moisture stress. Its nutritive value which is higher than that of rice and equal to that of wheat places it high among other cereals. It contains the highest amount of calcium among all the food grains (Ihekoronye *et al*., 1985) and also a good source of other micronutrients like potassium, zinc, phosphorus and iron (Ramachandra *et al*., 1977). Apart from minerals such as calcium, phosphorus and iron, finger millet contains appreciable quantity of vitamin B-Complex, thiamine and riboflavin (Barbeau and Hilu, 1993). Finger millet has amino acid methionine which is lacking in the diets of hundreds of millions of the poor who lived on starch staple food such as cassava, plantain, polished rice and maize meal (Barbeau and Hilu, 1993). Epidemiological reports indicate that regular consumption of finger millet reduces incidences of diabetes mellitus, cardiovascular disease, duodenal ulcer and other gastro intestinal tract related disorders. It supports immune system and removes free radical from the body and also helps to prevent and treat cancer. More so, it is an important antioxidant in plants, animals, fungi and some bacteria and Achaea. It is capable of preventing damage to important cellular components caused by reactive oxygen (Andrea *et al*., 1999).

This research was undertaken to determine the proximate, mineral and amino acid compositions of finger millet (*Eleusine coracana)* flour grown in Plateau State, Nigeria in order to supplement, contradict and/or add to existing data in the literature.

Materials and Methods

Materials

The finger millet seeds were purchased from Katako Market in Jos metropolis. Then they were taken for identification at the Herbarium of the Botany Unit, University of Jos, Nigeria. Stones and unwanted materials were handpicked. The sample was then washed, Oven dried at a temperature of 45°C. It was later ground, filtered with a sieve of 2 mm mesh to fine powder, then kept in a polythene bag for analyses.

Proximate analysis

The proximate analysis of the sample for moisture, crude protein, crude fibre, ash, carbohydrate and fat were carried out in triplicates according to the method of Association of Official Analytical chemists (AOAC, 1995). Nitrogen was determined by the micro Kjeldahl method as described by Pearson (1976) and the percentage nitrogen was converted to crude protein by multiplying by 6.25. The carbohydrate content was determined by difference.

Minerals analysis

The sample was analyzed using computer controlled atomic absorption spectrometer (AAS Model 969). Sodium and potassium were determined using a flame photometer (Model 405, Corning UK). All determinations were done in triplicate and mineral content was reported in mg/100 g sample.

Determination of amino acid profile

The powdered sample was defatted and hydrolyzed. The amino acids were quantitatively measured by the procedure of Spackman (1958) using automatic amino acid analyzer (Technicon Sequential Multi-Sample Analyzer, TSM).

Estimation of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P-PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo (2000)

$$p\text{Im} = \sum_{i=1}^{n=1} pliXi$$

Where pIm = the isoelectric point of the mixture of amino acid

pI_i = the isoelectric point of the ith amino acids in the mixture

X_i = the mass or mole fraction of the amino acids in the mixture

The quality of dietary protein was measured by finding the ratio of available amino acids in the protein concentrate compared with needs expressed as a ratio (FAO, 1970). Amino acid score (AMSS) was then estimated by applying the FAO/WHO formula (1991).

$$\text{AMSS} = \frac{\text{mg of amino acid in 1g of test protein}}{\text{mg of amino acid in 1g reference protein}} \text{ X } \frac{100}{1}$$

The predicted protein efficiency ratio (P – PER) of the sample was calculated from their amino acid composition based on the equation developed by Alsmeyer *et al.* (1974) as follows:

P-PER = 0.468 + 0.454 (Leu) - 0.105 (Tyr).

Results and Discussion

The result of the proximate composition of finger millet flour is presented in Table 1. The moisture content (5.58 ± 0.20) obtained is lower when compared to values for *Garnoderma spp* {10.20 ± 0.20} and *Omphalotus olearlus* (11.10 ± 0.20) (Aremu *et al.*, 2006a). However, this value is higher than those for some plant foods, rare cowpea (1.8%), cranberry bean (1.7%), Kersting's groundnut (1.7%) (Aremu *et al*, 2006b). But in close agreement with those reported for *Luffa cylindrica* (5.8%), fluted pumpkin seeds (5.02%) (Olaofe *et al*., 1994). The low moisture content indicates a long shelf life for the cereal flour.

The crude fat (7.94 ± 0.06) is higher when compared with the reported values for bambara groundnut (4.15%) (Adeyeye and Adamu, 2005). However, the value obtained is lower when compared to values for *Vigna subterranea* (24.1 ± 0.02), *Kerstingiella geocarpa* (21.4 ± 0.10) and *Phaseolus coccineus* (30.4 ± 0.05) (Aremu *et al*., 2006b). The result indicated that *Eleusine coracana* cannot be grouped under oil rich plant foods.

The ash content (2.51 ± 0.11) is considerably higher than those values reported for different types of millet (1.3 - 1.8%) (Rao, 1994). It is however lower when compared with the reported values for varieties of some Nigerian underutilized legume flours such as Bambara groundnut (4.30 ± 0.13) Kersting's groundnut (3.20 ± 0.05) and cowpea (3.60 ± 0.02). This suggests that the finger millet flour could probably provide essential, valuable and useful minerals needed for good development of the body.

The crude protein content is (8.42 ± 0.05) which is lower when compared with those of protein rich foods such as soyabean, cowpeas, Kersting's groundnut, pigeon peas, Bambara groundnut (Aremu *et al*., 2006b) and some soil seeds. Species of *Cucurbitaceae* (33.13-33.25%), gourd seeds (23.7-30.8) (Olaefe *et al*., 1994). Finger millet could therefore be used as an alternative source of protein in diets/protein supplement especially in nations like Nigeria where the majority of the populace live on starchy food and cereals.

The crude fibre (2.51 ± 0.06) is in close agreement with the values reported for *Luffa cylindrica* (2.5 ± 0.40) (Fagbemi and Oshodi, 1991), cowpea (2.4%) and gourd seed (2.8%) (Akintayo *et al*., 2002), but lower than that reported for soya bean (4.28%). This suggests that finger millet could provide additional dietary fibre in the diet. The carbohydrate content of (73.32 ± 0.23 kg/100g) is higher than reported values for *Luffa cylindrica* seeds (13.6%), *Ganderma Spp* (0.3 ± 2.0), *Omphalotus* (50.6 ± 1.0) (Gyar and Ogbonna, 2006). However, the value is lower when compared with cowpea (28.3 ± 0.2) but in close agreement with value for Kersting's groundnut (73.9 ± 0.15). This indicates that, it could serve as a good source of energy.

Table 1: Proximate composition of finger millet (*Eleusine coracana*) flour

Characteristic	Values[a] (g/100g)
Moisture	5.58±0.21
Crude fat	7.94±0.06
Ash content	2.51±0.11
Crude protein	8.42±0.05
Crude fibre	2.51±0.06
Carbohydrate	73.32±0.23

[a]Values are mean ± standard deviation of triplicate determinations; [b]Calculated metabolisable energy (kJ/100g sample) (protein x 17 + fat x 37 + carbohydrate x 17); NA = Not available

Table 2: Mineral composition of finger millet (*Eleusine coracana*) flour (mg/100g sample)

Mineral	Composition
Ca	70.89
Na	19.95
Mg	16.42
K	9.95
Mn	9.95
Cu	4.73
Cr	9.83
Fe	0.74
Zn	0.45
Pb	ND
P	60.80
Na/K	1.60
Ca/P	1.17
Ca/Mg	4.31

ND = Not detected

Finger millet (*Eleusine coracana*) flour contained significant amount of important minerals (Table 2). The calcium concentration (70.89 ± 0.62 mg/100 g) dry weight was the highest followed in descending order by phosphorus (6.80 ± 0.65 mg/100g), sodium (19.95 ± 0.46 mg/100g), magnesium (16.42± 0.52 mg/100g), potassium (12.50 ± 0.35 mg/100 g), manganese (9.95 ± 0.25 mg/100 g), chromium (9.83 ± 0.20 mg/100g), copper (4.73 ± 0.13 mg/100g), iron (0.74 ± 0.04 mg/100 g), and zinc (0.45 ± 0.01 mg/100g). Lead was not at the detectable range of AAS.

The most important mineral was calcium (70.89 ± 0.62 mg/100g). This present observation is not in agreement with the report of other researchers (Olaofe *et al*., 1991; Fagbemi and Oshodi, 1991; Audu and Aremu, 2011a) who have reported that potassium is the most abundant mineral in agricultural products. The presence of phosphorus, magnesium in conjunction with calcium would make *Eleusine coracana* suitable for bone formation in children since their deficiencies (P, Mg and Ca) can lead to abnormal bone development (Aletor and Aladetimi, 1989). Potassium helps in the synthesis of amino acids and proteins (Malik and Strivastava, 1982). Sodium and potassium are required to maintain the osmotic balance of the blood fluids, pH of the body and have control of glucose absorption (Fleck, 1976). The ratio of Na/K in the body is great concern for the prevention of high blood pressure. Na/K ratio less than one is recommended for humans. The ratio of Na/K was 1.60 in which is slightly above the recommended amount, hence might promote high blood pressure. Food is considered "good" if the Ca/P ratio is above one and "poor" if it is less than 0.5. Ca/P ratio above two helps to increase the absorption of calcium in the small intestine. The result of Ca/P is 1.2. It is above one and so *Eleusine coracana* is good. The Ca/Mg ratio (4.31) is higher than the recommended value (1.0).

The result of amino acid composition in the finger millet (*Eleusine coracana*) flour is shown in Table 3. Glutamic acid (17.21 g/100g crude protein), followed by aspartic acid (6.92 g/100g cp) had the highest concentration among the group of amino acids (AA). Together, they made up 24.13 g/100g cp. Similar observation has been reported by Olaofe *et al.* (1994) on legume flours. Leucine (10.65 g/100g cp) was the most concentrated essential amino acids, then valine (5.00 g/100g cp), phenylalanine (4.90 g/100g cp) and arginine (4.17 g/100g cp). The least concentrated essential amino acid was methiocine (1.82 g/100g cp), histidine (2.07 g/100g cp) and lysine (2.15 g/100g cp). The value for leucine (10.65 g/100 cp) in this report is higher than reported values for protein concentrated for some Nigerian legumes. Lima bean (7.45 g/100g cp), pigeon pea (8.40 g/100 cp) and African yam bean (7.45 g/100g cp) (Oshodi *et al.*, 1998). However, lower when compared with reported values for *Vigna subternanea* (66.8 g/100g cp), *Kerstingiella geocarpa* (70.19 g/100g cp) and *Phaseolus coccineus* (59.1 g/100g cp) (Aremu *et al.*, 2006b). Methionine content (1.82 g/100g cp) in finger millet (*Eleusine coracana*) is found to be higher than that of soyabean (0.9 g/100 g cp) (Akintayo *et al.*, 2002) and lower than bambara groundnut (2.0 g/100g cp). Tryptophan was not determined. The calculated isoelectric point (pI) was 4.83. It is useful in predicting the pI for protein in order to enhance quick precipitation of protein isolate from biological sample (Olaofe and Akintayo, 2000). The predicted protein efficiency ratio (P-PER) is one of the quality parameters used for protein evaluation (FAO/WHO, 1991). The P-PER (4.31) in this report is higher than reported P-PER values of some legume flours/concentrates. *Phaseolus coccineus* (1.91) (Robinson, 1975), and *Prosopis africana* (2.3) (Aremu *et al.*, 2017). It can be said that finger millet *Eleusine coracana* sample satisfied FAO requirement. The evaluation based on classification is shown in Table 4. The total amino acids, TAA (87.28 g/100g cp) in this study is higher than reported values for plants foods which ranged from (39.3 – 76.5 g/100g cp) (Olaofe *et al.*, 1994; Akobundu et al., 1982; Aremu *et al.*, 2006c). The total sulphur amino acid (TSAA) was 3.8 g/100g cp, which is lower than the 5.8 g/100g recommended for infants (Salunkhe and Kadam, 1989). The essential aromatic amino acid (EArAA) (4.9 g/100g cp) is higher than reported values for *Luffa cyndrica* kernel (3.25 g/100g cp) (Olaofe *et al.*, 1994). The value is lower than the range suggested for ideal infant protein (6.8 – 11.8 g/100g).

Table 3: Amino acid composition (g/100g crude protein)

Amino acid	Composition
Lysine (Lys)	2.15
Histidine (His)[a]	2.07
Arginine (Arg)[a]	4.17
Aspartic acid	6.92
Threonine (Thr)[a]	3.11
Serine (Ser)	3.75
Glutanic acid (Glu)	17.21
Protein (Pro)	6.58
Glycine (Gly)	3.06
Alanine (Ala)	6.91
Cystine (Cys)	1.99
Valine (Val)[a]	5.00
Methionie (Met)[a]	1.82
Isoleucine (Ile)[a]	3.29
Leucine (Leu)[a]	10.65
Tyrosine (Tyr)	3.70
Phenylalanine (Phe)[a]	4.90
Tryptophan (Try)	ND
Calculated isoelectric point (pI)	4.83
P – PER	4.31

[a]Essential amino acid; ND = Not detected

Table 4: Classification of Amino Acid Composition (g/100g crude protein)

Parameter	Composition
Total amino acids (TAA)	87.28
Total essential amino acid (TEAA)	
With histidine	32.99
Without histidine	30.92
% TEAA	
With histidine	37.79
Without histidine	35.43
Total non – essential amino acids (NEAA)	56.36
% TNEAA	54.57
Essential Aliphatic amino acids (EAAA)	22.05
% EAAA	25.26
Essential Aromatic amino acids (EArAA)	4.90
% EArAA	5.61
Total acidic amino acids (TAAA)	24.13
% TAAA	27.65
Total basic amino acids (TBAA)	8.39
% TBAA	9.61
Total sulphur amino acids (TSAA)	3.81
% TSAA	4.37
% Cystine in TSAA	45.59

Table 5: Amino Acids Scores of Finger Millet *(Eleusine coracana)*

Amino acids	PAAESP[a] (g/100 cp)	EAAC (g/100g cp)	AAS (g/100g cp)
Ile	4.0	3.29	0.82
Leu	7.0	10.65	1.52
Lys	5.5	2.15	0.39
Met + Cys (TSAA)	3.5	3.81	1.09
PHE + Tyr	6.0	13.50	2.25
Thr	4.0	3.11	0.78
Tyr	1.0	ND	NA
Val	5.0	5.00	1.00
Total	36.0	41.51	7.85

[a]**Source:** Belschant *et al*. (1975)
AAC = Amino Acid Composition; PAAESP = Provision Amino Acid (eggs) scoring pattern; EAAC = Essential Amino Acid Composition (Table 4); AAS = Amino Acid Scores

Table 4 also depicts the TAAA (24.13) which was found to be greater than the TBAA (8.39) indicating that the protein is probably acidic in nature (Ogunlade *et al*., 2005; Audu and Aremu, 2011b). The result of amino acid score is displayed in Table 5. The result showed that the first limiting amino acid in finger millet (*Eleusine coracana*) is Lys with value 0.39 followed by Ile (0.82) and Thr (0.78). The present report on limiting amino acid agrees with Bingham (1977) who reported that the essential amino acids most often acting in a limiting capacity is Lys.

Conclusion

This study investigates the proximate, minerals and amino acid composition of finger millet *(Eleusine coracana*). The study has revealed that finger millet cannot be classified as oil – rich flour. However, it has nutritionally valuable minerals (P, K, Mg, Ca, Mn, Na, Cu, Cr, Fe and Zn) and high proportion of essential amino acids (32.99%). Finger millet *(Eleusine coracana)* has a balanced content of essential amino acids with respect to the FAO/WHO (1991) provisional pattern while supplementation may be required in Lys, Ile and Thr.

Conflict of Interest
Authors declare that there are no conflicts of interest.

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