



Processing Effects on Physicochemical and Proximate Composition of Finger Millet (*Eleusine coracana*)

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ABSTRACT

African millet is a cereal crop with tiny seed. The study was aimed at determining the effect of processing methods on the proximate, phytochemical, and mineral composition of finger millets. Grains were collected, roasted and another portion fermented, after which physicochemical, proximate, and mineral analysis were carried out using the methods of Association of Analytical Communities. Findings from the result showed that terpenoids, tannins, steroids, and saponin were present in fermented millet, while only alkaloids, terpenoids, and tannin were the only phytochemicals present in roasted millet. Bulk density of fermented millet was $1158 \pm 16.51 \text{ kg/m}^3$ and significantly different from roasted and unprocessed millets with $993.6 \pm 11.44 \text{ kg/m}^3$ and $1146.80 \pm 16.04 \text{ kg/m}^3$. DPPH activity and Foaming Capacity in fermented millet were 26.40 % and 1.96 % respectively and significantly different from values obtained in roasted and unprocessed millet that both had 31.80 % (DPPH activity) and (5.88 %) foaming capacity. Fermented millet had higher carbohydrate (78.46 %), crude fibre (8.48 %), and energy (327.96 Kcal/100 g), while roasted millet had higher crude protein (6.53 %) and moisture (11.25 %). Manganese was the highest mineral obtained from unprocessed millets (18.1 %) and whose value was higher than those of the processed millets. Roasted millet recorded highest values for phosphorus (0.35 %), potassium (0.44 %), magnesium (0.13 %), zinc (25.5 %), and iron (74.9 %). Processing of millets helped release more nutrients and metabolites into the food products, though fermented millet would be recommended as an energy laden food source, rich in various phytochemicals of health benefitting nature.

INTRODUCTION

African finger millet (*Eleusine coracana*) is an annual crop belonging to the family Poaceae (Gramineae) which is grown in the arid areas of Africa and Asia. It is a cereal crop with small seeded grain but not a true caryopsis. Its pericarp (glumes) is not fused with the testa, thus the pericarp can easily be removed by rubbing or soaking in water, and other times by threshing (McDonough, *et al.*, 1986). It possesses a white endosperm and the kernel can be spherical, globular, or oval, in shape with diameter between 1 to 1.8 mm. Finger millet is consumed as food and feed in addition to its current usage as forage as a result of its potential benefits to give higher sustaining power, lower glycaemic response (Chethan and Melleshi, 2007).

To improve digestibility, palatability and shelf life, the cereal is subjected to different processing method and condition such as milling, boiling, roasting, and germination. The millet is used as whole flour mostly for traditional food preparation and can be consumed raw after soaking and sprouting in form of salads. Popped, malted, and fermented products (such as noodles, biscuit, muffins, vermicelli, pasta, halwa, bread, papad (Krishnan *et al.*, 2011; Gull *et al.*, 2015). It is known as the poor man's food because of its 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. It is a good source of Magnesium, Manganese and phosphorus, and has been reported to have anti-diabetic, antimicrobial, cataractogenetic properties which results from the presence of compounds it contains (Chethan *et al.*, 2008; Xu *et al.*, 2011; Banerjee *et al.*, 2012; Chaturvedi *et al.*, 2008).

Bioavailability of some nutrients in food supplements is limited by the presence of anti-nutrients such as tannins, phytates, oxalates, cyanides and saponins (Gibbs-Russell *et al.*, 1989); and processing methods such as boiling, soaking, roasting, and fermenting reduces the anti-nutrient content of such food thus, enhancing biological availability of the nutrients.

The challenge of food scarcity and protection, high cost of antimicrobials, and the need to source for readily available and cheap sources of antimicrobials necessitated this study. The study aims to ascertain the effect of processing methods on the proximate, phytochemical, and mineral composition of finger millet varieties found in Kano State, Nigeria.

MATERIALS AND METHODS

a) Procurement of finger millet

Commercially available finger millet was purchased from the Kano State Central Market and was identified at the Herbarium unit of the Department of Biological Sciences, Ahmadu Bello University, Zaria with a voucher No 24356.

b) Processing of finger millet

i) Roasting

The finger millet (*Eleusine coracana*) is sorted by hand picking then washed to remove foreign materials after which the grains were rinsed and allowed to dry. After drying, the grains were roasted for 10 – 15 min (in an open pan using firewood)

ii) Fermentation: Fermentation was done by soaking the seed in clean water and covering with a sack for 24 h and then sun-dried.

c) Physicochemical Properties

i) Bulk density: Bulk density was carried out according to the modified methods of Mariotti *et al.*, (2006).

ii) True density

The true density (kg/m³) was determined by the liquid displacement method using a top loading balance. A total of 100 g of grains were immersed in graduated beaker containing distilled water. The amount of water displacement was recorded according to the methods of Karababa and Coşkuner (2013).

$$P_t = \frac{30g}{V_2 - V_1}$$

Where: Pt = true density, V₁ = initial volume and V₂= final volume.

iii) Porosity

It was calculated using Equation from the true density and bulk density using method of Varnamkhasti *et al.* (2008).

iv) Water absorption capacity

One gram finger millet flour was transferred into weighing 50 mL centrifuge tubes in triplicate to which 10 mL distilled water was added, stirred and incubated in water bath at 30 °C for 30 min. The centrifuge tubes were centrifuged at 3000 rpm for 15 min using a Model T-8BL Laby™ centrifuge (Laboratory Instruments, Ambala Cantt India). The supernatants were discarded and the residues weighed. Two different weights of the centrifuge tubes gave water absorbance.

v) Determination of dispersibility

This was carried out using the methods of Olapade *et al.* (2014). A total of 10 g of the flour sample was weighed into 100 mL measuring cylinder and distilled water was added. The set up was stirred vigorously and allowed to stand for 3 h. The volume of settled particle was recorded and subtracted from 100. Percentage Dispersibility = 100 – volume of settled particles

d) Proximate Composition

Estimations were made of nitrogen (as an index of crude protein), water, fat, ash and crude fibre. When the total was subtracted from 100% the difference was termed carbohydrate by difference. Determination of the moisture content, ash and crude fat followed the method of AOAC (2005). Crude fibre determination was done following the method of Pearson (1981). Estimation of nitrogen content was by the Kjeldahl method multiplied by 6.25, the nitrogen – protein factor to convert to crude protein.

i) Moisture Content

The moisture content was determined using procedure described by AOAC (2005). The moisture content of each samples were determined by weighing 5 g of the sample into aluminium moisture can. The sample was then dried to constant weight at 105 °C.

$$\frac{\text{weight of can} - \text{weight of empty can}}{\text{weight of sample}} \times 100$$

ii) Crude Protein

Crude protein content was measured following the procedure below: Two (2) g of sample was weighed and place in 600 mL Philip's conical flask, after which 1 g of pure scale pepsin dissolved in 490 mL distilled water and was added to sample. Ten (10) millilitres 25% HCl (by weight) was added and place in a beaker and incubated at 38 °C. After 24 h, 10 mL HCl was further added, stirred well and returned to the incubator. After another 24 h the sample was filtered and washed until free from acid. The filter paper and residue were transferred to Kjeldahl flask, and nitrogen content determined using the formula below:

Percentage digestibility crude protein = total crude protein - % crude protein in filter paper residue.

iii) Ash Content

Two grams of samples was weighed in well incinerated crucibles and then ashed in a muffle furnace at 600 °C for 3 h. The ash content was calculated as:

$$\frac{\text{weight of crucible} + \text{ash} - \text{weight of empty crucible}}{\text{weight of sample}} \times 100$$

iv) Crude Fibre

Two grams of the sample was transferred into 1 L conical flask. One hundred millimetres of sulphuric

acid (0.255 mol/L) it was heated to boiling and then introduced into the conical flask containing the sample. The contents were then boiled for 30 min, ensuring that the level of the acid was maintained by the addition of distilled water. After 30 min, the contents were then filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly until its washing was no longer acidic to litmus. The residue was then transferred into a conical flask. One hundred millilitres of sodium hydroxide (0.313 mol/L) was then brought to boil and then introduced into the conical flask containing the sample. The contents were then boiled for 30 min, ensuring that the level of the acid was maintained by the addition of distilled water. After 30 min, the contents were filtered through a muslin cloth held in the funnel. The residue was rinsed thoroughly until its washing was no longer alkali. The residue was then introduced into an already dried crucible and ashed at 600 °C ± 200 °C.

$$\frac{\text{final weight of crucible} - \text{initial weight of crucible}}{\text{weight of sample}} \times 100$$

e) Mineral Content

Mineral analysis was carried out on samples digested with hydrochloric acid. Total iron (AOAC – 944.02) were analysed by colorimetric method using α bipyridyl method (AOAC 2005). Total phosphorous was analysed colorimetrically using methods of Tausky and Shorr, (1953), while the total calcium was analysed using method of Raghuramulu, (1983).

f) Statistical Analysis

Data was analysed by (Analysis of Variance) ANOVA using SPSS 20.0 software. Values were calculated per 100 g of flour. All analysis was carried in 3 replicates. The results are presented as means ± SD. The means separated using turkey's test. Level of significance was set at P ≤ 0.05. Correlation coefficients between mineral and anti-nutrient content as well as between % tannins and dietary fibre fractions of finger millet was determined.

RESULTS

a) Phytochemical constituents of processed finger millet

Based on the type of processing, terpenoids and tannins were the only constituent present in the millet after the two treatment methods (Table 1). Alkaloids was not found in fermented millet, while flavonoids, steroids, and saponin were absent in roasted millet.

Table 1: Phytochemical constituents of fermented and roasted finger millet.

Type of phytochemical	Fermented millet	Roasted millet
Alkaloids	-	+
Flavonoids	+	-
Terpenoids	+	+
Steroids	+	-
Tannins	+	+
Saponins	+	-

b) Effects of processing on the physicochemical parameters of finger millet

Bulk density of fermented millet recorded the highest value of $1158 \pm 16.51 \text{ kg/m}^3$, while roasted millet obtained $993.6 \pm 11.44 \text{ kg/m}^3$ (Table 2). The values

were significantly different from each other. Foam stability and foaming capacity recorded no significant variation in values between the treatment methods as shown in Table 2, but the foaming capacity value of 5.88 % obtained for unprocessed millet was significantly different from values obtained for the processed millets.

Table 2: Physicochemical properties of processed and unprocessed finger millets

Parameter	Fermented millet	Roasted millet	Unprocessed millet
Bulk density (kg/m^3)	$1158^a \pm 16.51$	$993.6^c \pm 11.44$	$1146.80^b \pm 16.04$
True density (kg/m^3)	$1613.4^a \pm 48.02$	$1515.6^b \pm 34.88$	$1515.8^b \pm 35.33$
Porosity (%)	$28.25^b \pm 2.47$	$32.41^a \pm 5.40$	$24.31^c \pm 2.10$
Dispersibility (%)	$92.03^a \pm 0.38$	$84.73^c \pm 0.64$	$87.37^b \pm 0.15$
DPPH Activity (%)	26.40 % ^b	31.80 % ^a	31.80 % ^a
FC (%)	1.96 ± 0.00^b	1.96 ± 0.00^b	5.88 ± 0.00^a
FS (ml)	0.97 ± 0.01^a	0.98 ± 0.00^a	0.98 ± 0.00^a

Key: FC - Foaming Capacity; FS - Foam Stability

c) Proximate composition of processed finger millet

As shown in Table 3, proximate compositional values after the different treatments were administered showed that crude protein obtained 6.46 % in

fermented grains, while the value was 6.53 % in roasted millet; carbohydrate had 78.46 % and 77.29 % in fermented and roasted millets respectively. Energy content showed that fermented millet would give 327.96 Kcal/100 g higher than 323.07 Kcal/100 g found in roasted millet.

Table 3: Proximate composition of processed finger millets

Parameter	Fermented millet	Roasted millet
Crude fat (%)	2.23	2.18
Crude protein (%)	6.46	6.53
Total ash (%)	2.84	2.76
Carbohydrates (%)	78.46	77.29
Crude fibre (%)	8.48	6.53
Moisture (%)	9.91	11.25
Energy (Kcal/100 g)	327.96	323.07

d) Mineral composition of differently treated finger millet

Fermentation of millet led to reduced values of Magnesium, Manganese, and Zinc as shown in Table

4. Calcium, phosphorus, potassium, and iron contents increased in fermented millet from 0.01 to 0.33 %, 0.15 to 0.24 %, 0.21 to 0.43 %, and 33.1 to 46.0 % respectively.

Table 4: Processing effect on the mineral constituent of finger millet

Processing method	Ca	P	K	Na	Mg	Fe	Mn	Zn
	Percentage (%)							
Fermented millet	0.33	0.24	0.43	0.02	0.11	46.0	7.5	15.0
Roasted millet	0.01	0.35	0.44	0.01	0.13	74.9	18.0	25.5
Unprocessed millet	0.01	0.15	0.21	0.01	0.12	33.1	18.1	18.1

DISCUSSION

Absence of saponin in roasted finger millet might be attributed to the processing method adopted in the preparation. Roasting of cereals, pulses and oilseeds which is usually by dry frying had been reported to remove from processed food anti-nutritional or toxic compounds such as giotrogenic agents, cyanogenic glycosides, alkaloids and saponins and increase storage life of such food product (Gopaldas *et al.*, 1982; Huffman and Martin, 1994). Venkateswaran and Vijayalakshmi (2010) reported that fermented finger millet showed reduction in phytic acid and tannin contents by 88.8% and 90.1%, respectively, with an increase of 61.5% minerals, reducing sugars and soluble proteins.

Phytate, an anti-nutrient stores elemental phosphorous and myoinositol; and forms crystals which are excreted in urine when it combines with divalent metallic ions like Calcium and Iron (Adesuyi *et al.*, 2012).

The absence of flavonoids and steroid could be predicated on the roasting method employed as the fermented finger millet showed these metabolites were in the millet

Polyphenols are a large and diverse class of compounds, many of which occur naturally in a range of foods plants phenolics (hydroxy benzenes) especially polyphenols (containing two or more phenolic groups) which are ubiquitous in plants foods consumed by human and animals and one of the widest groups of a dietary supplements marketed worldwide (Ferguson, 2001). The main polyphenols in cereals are phenolic acids and tannins, while flavonoids are present in small quantities (Rao and Muralikri Shna, 2002). Although these compounds play no known direct role in nutrition, many of them have antioxidant properties which aids proper functioning of body cells. Antioxidants respond to death resulting from oxidative stress on cells and adjoining tissues integrity by scavenging reactive free radicals capable which causes cell death and tissue damage which inadvertently result in cancer, emphysema, cirrhosis, atherosclerosis, and arthritis (Shahidi and Wanasundara, 1992).

Other activities of the metabolites include anti-estrogenic, anti-carcinogenic and anti-inflammatory, antiviral effects and platelet aggregation inhibitory activities that might potentially be beneficial in preventing or minimizing the incidence of diseases (Ferguson, 2001). Millet grains are rich in phenolic acids, tannins, and phytate that act as "antinutrients" (Thompson, 1993). Antinutrients reduce the risk of

colon and breast cancer in animals (Graf and Eaton, 1990). Terpenoids has been reported to confer antioxidant, antimicrobial, antifungal, antiviral, antihyperglycemic, antiinflammatory, and antiparasitic activities. Phenols and flavonoids in Phenolic compounds are antimicrobial in nature especially against Gram-positive bacteria where result is dependent on concentration (Tiwari *et al.*, 2009).

The highest mean result for 1000 sample weight was obtained from fermentation, 775 ± 5.27 g and the lowest mean result for 1000 sample weight was 496.8 ± 5.00 g from unprocessed (data not shown). Fermentation was significantly different ($p < 0.05$) on 1000 sample weight as compared to other samples. The results agreed with the findings of Balasubramanian and Viswanathan (2010) who obtained 185.8 kg at moisture content of 11.1 to 25%. Values of bulk density obtained with fermentation treatment obtaining the highest bulk density and unprocessed grain with the lowest bulk density were in line with the report of Zewdu and Solomon (2007) who got 696 to 840 kg/m³ for millet at a moisture content ranging from 5.6 to 29.60%.

Fermented millet had the highest ($p < 0.05$) true density, followed by roasting, and unprocessed respectively. These results were in line with the findings by Vanrnamkhasti *et al.* (2008) for rough rice, where the mean true density ranged from 1193.38 to 1269.10 kg/m³, respectively. Similar results were obtained by Balasubramanian and Viswanathan (2010) at a moisture content of 11.1 to 25%, and by Jain and Bal (1997) who obtained 1578 to 1623 kg/m³. Zewdu and Solomon (2007) also reported similar results of 1207 to 1361 kg/m³ for millet grain at a moisture content of 5.6 to 29.6%. The mean porosity results for fermented millet was the hughest, while roasted millet had the least. These results agreed with Sangamithra *et al.* (2016) who got 51.30 to 55.83% at a moisture content of 8.7 to 21.7% for maize, Al-Mahasnesh and Rababah (2007) ranging from 45.61 to 46.66% for green wheat, and Zewdu and Solomon (2007) with 38.31 to 42.32% for millet at a moisture content of 5.6 to 29.0%.

Adebowale *et al.* (2012) and Markowski, *et al.* (2013) reported that millet have 59.62% aspect ratio at moisture content of 10% and 47.4% at a moisture content of 9.95% respectively which disagreed with our findings. Our result was in line with the findings of Baryeh (2002) of 78.30 to 80.30% at a moisture content of 5.00 to 22.5%.

The results for bulk density of grains were similar to those reported by Jain and Bal (1997) who studied 3 PM cultivars ranging from 830.0 to 866.1

kg/m³. Goswami et al., (2015) also reported a bulk density ranging from 684.99 to 777.50 kg/m³ on FM grains. Balasubramanian and Viswanathan (2010) obtained the same results ranging from 477.1 to 868.1 kg/m³ at a moisture content of 11.1 to 25%. Fermentation was significantly higher ($p < 0.05$) as compared to other samples. Bulk density is an essential factor that determines the grade and test weight of the grains during drying, storage.

Kamath and Belavady (1980) 3.6% crude fibre in finger millet, while Joshi and Katoch (1990) reported 3.7% crude fibre in finger millet though the two report disagreed with findings in our study that reported high values for the two processing methods compared. Millets possess hypoglycemic effect which is attributed to the high fibre content in it. The health benefits associated with high fibre foods are delayed nutrient absorption, increased fecal bulk, lowering of blood lipids, prevention of colon cancer, barriers of digestion, mobility of intestinal contents, increased faecal transit time and fermentability characteristics (Palasamy et al., 2011).

While sodium and magnesium did not show any significant difference resulting from the processing method employed, fermentation of millet led to reduced Manganese and Zinc content, while it increased the content of calcium, phosphorus, potassium, and iron. Roasting on the other hand increased potassium, phosphorus and zinc contents. Research have shown that Magnesium is associated with reduced risk of heart attack, phosphorus is important for the development of the body tissues and energy metabolism. It is also rich in phytochemicals including phytic acid which is believed to lower cholesterol level and phytate, which is associated with reduced risk of cancer.

CONCLUSION

Finger millet from the report of this study has considerable amount crude fat, crude protein, carbohydrates, moisture and energy which could be used as food supplement especially among the poor population. Roasting and fermenting the grain did not show any significant difference in value of the proximate and mineral composition and so, the study recommends either of the method to improve the shelf-life of the product after processing.

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