



## Nutritional and sensory evaluation of processed finger millet (*Eleusine coracana*) Food (Koko)

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### Abstract

Gruel is a thinner sort of porridge, however depending on the choice of consistency, it is commonly sipped rather than eaten. This study investigates the nutritional composition and organoleptic properties of gruel made from processed finger millet. Four samples were produced from finger millet seeds, based on processing methods. Sample A (unprocessed), B (Roasted), C (Germinated) and D (Fermented). The samples were subjected to proximate analysis, sensory evaluation, anti-nutritional properties, minerals composition, amino acid profile and dietary fibre according to AOAC. The result for proximate analysis revealed that the fermented sample yields significantly higher moisture content ( $91.25 \pm 0.12\%$ ) while the roasted sample had the least moisture content ( $85.99 \pm 0.02\%$ ). Furthermore, a higher value for ash ( $3.39 \pm 0.05^a$ ), protein ( $8.19 \pm 0.06^b$ ) was recorded in the fermented sample while germinated sample ( $0.81 \pm 0.01^b$ ) had the highest fat content with the highest carbohydrate ( $87.89 \pm 1.21^a$ ) been recorded in the whole sample. Furthermore, the anti-nutrient evaluation of the sample shows that the unprocessed sample had the highest anti-nutritional content except phenol, which is higher in the fermented ( $82.60^c \pm 1.00^d$ ) sample. For the mineral composition, the roasted sample had magnesium ( $8.00^a \pm 1.10$ ), the highest value of phosphorus ( $8.00^a \pm 0.30$ ) was recorded in the fermented sample, germinated ( $12.00^a \pm 1.20$ ) has the highest calcium content, while higher value was recorded for iron ( $10.00^a \pm 1.20$ ), potassium ( $9.10^a \pm 1.50$ ), and Manganese ( $8.00^{cb} \pm 1.30$ ) in the unprocessed sample. The fermented samples had a higher value for essential and non-essential amino acids. Likewise, unprocessed samples had the highest total dietary fibre ( $17.30^b \pm 0.50$ ), and insoluble fibre ( $16.00^b \pm 0.30$ ) while the soluble ( $1.90^a \pm 0.20$ ) was recorded in the germinated sample. Consumer acceptability test shows that the roasted sample had the highest ranking compared to other parameters evaluated and also ranked highest ( $8.50 \pm 1.40^c$ ) for general acceptability. Therefore, processing methods decreases the anti-nutrient content, lowers the carbohydrate content, increases the amino acids and mineral elements concentration and improves the sensory attributes and general acceptability of food sample.

**Keywords:** gruel, nutritional and organoleptic properties

### Introduction

Gruel is a type of porridge that is thinner; although depending on the consistency chosen, it is frequently sipped rather than eaten. Gruel has historically been a diet of both Westerners and Africans, particularly among the low socio-economic class. Gruel can be prepared from a variety of grains / cereals, including millets, hemp, barley, or, in dire circumstances, chestnut flour or a less bitter acorn from some oaks. Esan, *et al* (2014) [10].

In Nigeria, it is commonly known as Pap, Akamu or Koko/kunu in Hausa and Ogi in Yoruba mostly made from fermented millet, Corn, and Sorghum. This variety and the processing methods may vary from region to region even though in recent times, millet pap which is simply the Hausa version can be found in Northern Nigeria and is now, widely accepted by most Nigerians. Abdalla, *et al* (1998) [2]. It is usually consumed as breakfast alongside moimoi, fried yam and bean cake (Akara/Kosai) and sometimes drunk as a refreshing drink at any time of the day, especially at bedtime. Enriched gruel with ground nuts, soybeans and other types of legumes has been used as convenient food for the sick, complementary and weaning for children. Cereals such as Ground Oats, Wheat, Rye, and Rice are also used by heating or boiling in water or milk. Abulude, F.O. (2005) [3]. Local foods are indigenous foods that can be found in a rural setting or community, most of which are processed minimally and in season, locally produced, available and affordable which are different from region to region and

most often specific to a location. Singh P., and Raghuvanshi, R.S (2012) [22]. Although a healthy and adequate diet is recommended, the specific details may vary depending on an individual's personal needs and goals (Especially for people at risk for metabolic diseases).

African finger millet (*Eleusine coracana*) belongs to the family Poaceae (Gramineae is an annual plant which is cultivated in the arid areas of Africa and Asia. It is called Tamba in Hausa, Oka in Yoruba and Igbo. The millet has several health benefits due to its phytochemical composition such as phenolic compounds, some of which are effective inhibitors of pancreatic amylase and intestinal- glucosidase. Singh P., and Raghuvanshi R.S (2012) [22]. It is also a rich source of mineral elements and Amino acids especially methionine which are not found in most cereals. Shobana S. (2006) [20]. Traditionally, finger millet food preparations are known for having a low glycemic response and higher satiety scores compared with other cereal foods and are usually recommended for diabetic management and control. Singh P., and Raghuvanshi R.S (2012) [22]. Therefore, there is a need to assess the suitable processing methods of Finger millet that would retain its health benefits and nutrient composition.

Processing according to a study has been proven to influence the nutritional and health potentials of foods. Although, it also has other advantages such as flavour enhancement, improves colour, taste, and aroma, extended shelf life and most importantly increases nutritional content

of food materials. Saleh, *et al* (2013)<sup>[19]</sup>. Furthermore, the roasting of grains leads to the denaturation of proteins, thus improving their digestibility. Fermentation also converts starch complexes to enhance other nutrients while germination increases different vitamins content in cereals and legumes such as tocopherol, riboflavins (Vitamin B2) and niacin (Vitamin B3). Tizazu, S. (2010)<sup>[23]</sup>

This work aims to determine the effect of processing (roasting, fermentation and germination) on organoleptic characteristics and nutrient composition of finger millet (*Eleusine coracana*) flour.

## Methodology

### Materials and sources

Finger millet commonly called *Tamba* in Hausa was purchased from the Central Market, Kaduna and was identified at the Herbarium unit of the Department of Biological Sciences, Ahmadu Bello University, Zaria.

### Experimental design and experimental samples

Gruel was produced from finger millet; samples based on processing methods are: Sample A (unprocessed), B (Roasted), C (Germinated) and D (Fermented). The gruel samples were subjected to proximate, amino acids, mineral elements, anti-nutrients and sensory properties.

The results obtained were further subjected to statistical analysis (ANOVA) for effect of processing methods.

### Sample preparation

sample A (roasting at 110°C for 20 minutes), sample B (germination for 12h at room temperature), sample C (fermentation for 48 hours), and sample D (whole finger millet).

## Chemical analysis

### Proximate analysis

The sample was analyzed for moisture, ash, crude protein, fat, fibre and available carbohydrate according to the method recommended by the Association of Official Analytical Chemists (2000).

### Sensory evaluation

The sensory evaluation was carried out according to Indrani, *et al* (2010)<sup>[12]</sup>. The acceptability of the products was carried out by 20 semi-trained panellists.

### Mineral element determination

Phosphorus (P), Iron (Fe), Calcium (Ca), Magnesium (Mg), Manganese (Mn), and Potassium (K) were determined by Atomic Absorption Spectrometry (AAS); while Sodium (Na) and Potassium (K) was determined by flame photometry according to the method of AOAC (2013)<sup>[6]</sup>.

### Anti-nutrients Determination

Phytate was determined using the method of Maga (1983)<sup>[13]</sup>, and cyanide content was determined according to the method of AOAC (2000)<sup>[4]</sup>. Alkaloid was determined by the gravimetric method of Harbone (1980). Oxalate was determined using the method of Oke (1969)<sup>[16]</sup>, and Tannin content was estimated according to the method described by Makkar and Becker (1993)<sup>[14]</sup>. Saponin was determined using the gravimetric method of AOAC (2000)<sup>[4]</sup> employing the use of a Soxhlet extractor and two different organic solvents.

## Determination of amino acids profile

The amino acid profile in the known sample was determined using methods described by Benitez (1989)<sup>[8]</sup>.

## Dietary fibre determination

### Total dietary fibre determination

The crude fibre was determined by the AOAC (2000)<sup>[4]</sup> method. Samples were defatted and gelatinized in the presence of heat-stable alpha-amylase, and then enzymatically digested with protease and amyl glucosidase to remove digestible protein and starch.

### Determination of insoluble dietary fibre

Wet and redistribute the Celite bed in the previously tared crucible, B(b), using ca 3ml H<sub>2</sub>O. Suction was applied to the crucible to draw Celite into an even mat, and enzyme digest was filtered through the crucible into a filtration flask. The beaker was rinsed and the residue was washed twice with 10ml 70°C H<sub>2</sub>O. The combined filtrate and water were transferred into a prepared 600ml beaker, and reserved for determination of soluble dietary fibre, using a vacuum, the residue was washed 2 times each with 15ml portions of 78% ethanol, 95% ethanol, and acetone. (Note: Delay in washing IDF residues with 78% ethanol, 95% ethanol, and acetone may cause inflated IDF values).

### Determination of soluble dietary fibre

Proceed as for insoluble dietary fibre determination through instruction to combine the filtrate and water washings in prepared 600mL tall-form beakers. The beakers were weighed with a combined solution of filtrate and water washings and estimated volumes.

Four volumes of 95% ethanol preheated to 60°C were added, and a portion of 60°C ethanol was used to rinse the filtering flask from IDF determination. Alternatively, the weight of the combined solution of filtrate and water was, washing was adjusted to 80g by the addition of H<sub>2</sub>O, and the addition of 320ml of 95% ethanol and allowed to form a precipitate at room temperature for 1hour.

### Preparation of pap

Finger millet flour (500g) was reconstituted with cold water (350 ml) to a suitable consistency. It would then be reconstituted with hot boiling water (300ml) at 100°C to form gruel (Pap).

## Statistical analysis

Results were presented as mean ± standard deviation except if stated otherwise. Data were analyzed by ANOVA (for effect of processing methods), and differences between means were separated by DMRT, Result with P<0.05 was considered significant. SPSS version 23 was used to carry out the statistical analysis.

## Conclusion

Proximate composition analysis revealed that germination decreases the carbohydrate content of the samples and improves the protein content. The lower fibre content in fermented as shown in Table 1 compared to other samples might be a result of partial solubilization of cellulose and hemicellulose-type material by microbial enzymes according to Shobana *et al* (2013)<sup>[21]</sup>. The increased protein content of germinated and fermented finger seeds respectively including improved amino acid quality

conforms with a study by Saleh *et al* (2013) [19], that fermentation and germination improve the nutritional quality of millets compared to other cereals.

Table 1 indicates that there is a significant difference (P<0.05) in moisture content, protein, fat, and fibre content of Whole from processed (roasted, germinated and fermented) finger millet. The analysis revealed that the fermented sample yielded significantly (P<0.05) higher moisture content (91.25±0.12%) while the roasted sample had the least moisture content (85.99±0.02%).

Ash content was 3.23±0.05%, 3.05±0.02%, and 3.39±0.05% for Pap from roasted, germinated and fermented samples respectively. There is a significant difference (P<0.05) in the protein content of Whole and processed samples. High

protein content was observed in the fermented sample with a value of 8.19±0.06%, while the least (6.80±0.02%) was observed in the germinated sample, fermented samples had the highest protein value in food products including improved amino acids quality conforms with a study of Shobana *et al* (2013) [21], that fermentation and germination improve nutritional quality compared to other cereals. There was a significant difference (P<0.05) in the fat content of Whole and processed (Roasted and fermented) Pap from finger millet. Fibre content was 2.19±0.10%, 2.53±0.11%, 2.19±0.08% and 1.84±0.06% for Whole roasted, germinated and fermented samples.

**Proximate Composition**

**Table 1:** proximate compositions of finger millet gruel

Parameters (%)	Whole	Roasted	Germinated	Fermented
Moisture	90.48±0.24 <sup>b</sup>	85.99±0.02 <sup>a</sup>	90.36±0.30 <sup>b</sup>	91.25±0.12 <sup>b</sup>
Ash	3.15±0.20 <sup>a</sup>	3.23±0.05 <sup>a</sup>	3.05±0.02 <sup>a</sup>	3.39±0.05 <sup>a</sup>
Protein	7.01±0.23 <sup>a</sup>	7.91±0.09 <sup>b</sup>	6.80±0.02 <sup>a</sup>	8.19±0.06 <sup>b</sup>
Fat	0.77±0.01 <sup>b</sup>	0.74±0.02 <sup>a</sup>	0.81±0.01 <sup>b</sup>	0.73±0.02 <sup>a</sup>
Carbohydrate	87.89±1.21 <sup>a</sup>	86.71±0.32 <sup>a</sup>	86.24±0.54 <sup>a</sup>	87.05±1.10 <sup>a</sup>
Fibre	2.19±0.10 <sup>a</sup>	2.53±0.11 <sup>b</sup>	2.19±0.08 <sup>a</sup>	1.84±0.06 <sup>a</sup>

Values are Mean ± SD; Values with different superscripts across the rows by processing methods are significantly different (P<0.05).

The effect of processing methods on the Anti-nutrients composition of finger millet gruel indicates that there is a significant reduction (P<0.05) of phytate, cyanogenic glycosides, alkaloids, oxalate, tannins and saponin in some processed samples (roasted and fermented) while phenols concentration increases in processed samples (roasted, germinated, and fermented).

Table 2 revealed the effect of processing methods on the Anti-nutrients composition of finger millet gruel, the unprocessed sample has a higher content of phytate, cyanogenic glycosides, oxalates, alkaloids, tannins and saponin while germinated has a higher content of phenols (82.60±1.00 m/g). By implication, roasting and fermentation as a processing method result in a significant (P<0.05) reduction of phytate, cyanogenic glycosides, oxalate, and

tannin, comparably, these values are higher than the report of Achimugu, *et al* (2021) [1] on investigation of phytochemicals, anti-nutrients and metallic toxicants composition of tender leaves of Back-eyed bean for food.

Polyphenols are reported to have a higher antioxidant capacity, inhibit amylases (phytate), and slow carbohydrate digestibility, thereby controlling blood sugar levels and preventing the risk of diabetes. Chandrasekara and Shahidi (2012) [9] also reported that the processing of pearl millet grains resulted in a significant increase in phenols and phytate. This conforms to the result obtained in this study. Processing (germination and fermentation) improved the mineral elements concentration such as iron, potassium, calcium, magnesium and manganese.

**Table 2:** Anti – Nutrient Composition of *E. coracana* gruel (Pap)

Anti-Nutrients	Unprocessed	Roasted	Germinated	Fermented
Phytate (mg/100g)	151.39 <sup>d</sup> ±0.73	74.92 <sup>b</sup> ±0.70	79.97 <sup>c</sup> ±0.64	61.28 <sup>a</sup> ±0.73
Cyanogenic glycoside (mg/100g)	0.72 <sup>d</sup> ±0.02	0.40 <sup>b</sup> ±0.01	0.56 <sup>c</sup> ±0.01	0.24 <sup>a</sup> ±0.01
Alkaloids (%)	0.71 <sup>c</sup> ±0.01	0.49 <sup>a</sup> ±0.01	0.64 <sup>b</sup> ±0.01	0.55 <sup>b</sup> ±0.01
Oxalate(mg/100g)	15.68 <sup>d</sup> ±0.33	11.06 <sup>b</sup> ±0.45	13.16 <sup>c</sup> ±0.26	8.29 <sup>a</sup> ±0.33
Tannin (%)	621.11 <sup>c</sup> ±0.06	220.7 <sup>b</sup> ±0.02	210.4 <sup>a</sup> ±0.02	210.5 <sup>a</sup> ±0.02
Saponins (%)	2.09 <sup>c</sup> ±0.08	0.60 <sup>b</sup> ±0.01	0.26 <sup>a</sup> ±0.01	0.32 <sup>a</sup> ±0.01
Phenols (µg)	41.50 <sup>a</sup> ±0.00	44.83 <sup>a</sup> ±0.76	82.60 <sup>c</sup> ±1.00 <sup>d</sup>	52.90 <sup>b</sup> ±1.00

Values are Mean ± SD; Values with a different superscript in the row by processing methods are significantly different (P<0.05).

Table 3 shows the effect of processing methods on the mineral composition of finger millet gruel. It reveals that the iron content of Pap from unprocessed seeds had the value of 10.00±1.20mg/100g compared to the product from processed seeds (roasted; 9.05±1.60 and fermented: 9.07±1.60mg/100g) which has no significant difference (p<0.05) except from germinated seeds that had the highest content of iron (13.03±2.20mg/100g) and calcium (12.00±1.20mg/100g), and lowest manganese content with

the value of 2.00±1.20mg/100g). There was no significant difference (p<0.05) in the potassium content of Gruel (Pap) from unprocessed and processed seeds (9.10±1.50, 9.00±1.20, 9.00±2.30 and 9.00±1.40mg/100g). Likewise, the phosphorus content of Gruel (Pap) from roasted and fermented (8.00±100 and 8.00±0.30±g/100g). The analysis also revealed that the magnesium content of Gruel (Pap) from roasted (8.00±1.10mg/100g) and germinated (8.00±1.20mg/100g) seeds show no significant difference (p<0.05).

**Table 3:** Mineral Composition of *E. Coracana* Gruel

Minerals (g/100g)	Whole	Roasted	Germinated	Fermented
Phosphorous	6.00 <sup>a</sup> ±0.60	8.00 <sup>a</sup> ±1.00	6.00 <sup>a</sup> ±1.20	8.00 <sup>a</sup> ±0.30
Iron	10.00 <sup>a</sup> ±1.20	9.05 <sup>a</sup> ±1.60	9.03 <sup>a</sup> ±2.20	9.07 <sup>a</sup> ±1.60
Magnesium	6.00 <sup>a</sup> ±1.30	8.00 <sup>a</sup> ±1.10	8.00 <sup>a</sup> ±1.20	5.00 <sup>a</sup> ±1.40
Potassium	9.10 <sup>a</sup> ±1.50	9.00 <sup>a</sup> ±1.20	9.00 <sup>a</sup> ±2.30	9.00 <sup>a</sup> ±1.40
Calcium	11.00 <sup>a</sup> ±1.40	11.00 <sup>a</sup> ±1.30	12.00 <sup>a</sup> ±1.20	9.00 <sup>a</sup> ±1.10
Manganese	8.00 <sup>cb</sup> ±1.30	6.00 <sup>ab</sup> ±1.20	2.00 <sup>a</sup> ±1.20	5.00 <sup>b</sup> ±1.60

Values are Mean ± SD; Values with a different superscript in the row by processing methods are significantly different (P<0.05)

The result obtained from Amino Acid Profile (table 4a) shows that gruel (pap) from fermented seeds had a higher content of Leucine (9.48±0.44g/100g), Lysine 3.80±0.67g/100g), Isoleucine (4.19±0.10g/100g), Phenylalanine (4.79±0.89g/100g), Tryptophan (1.89±0.01g/100g), and Valine (5.67±0.32g/100g). Methionine ranges from 2.00±0.21g/100g to 2.32±0.06g/100g with the product from, fermented seeds having the highest value. Histidine content of gruel (Pap) from processed (roasted and germinated) finger millet seeds

had no significant difference (p<0.05) except for gruel (Pap) from fermented seeds that had the highest value of 2.17±0.11g/100g. Likewise, the Methionine content was also higher in the product from fermented seeds (2.32±0.06g/100g), while the products from unprocessed seeds recorded the least value of 2.00±0.21g/100g, 7.18±0.11g/100g, 3.42±0.20g/100g, 3.34±1.09g/100g, 3.18±0.51g/100g, 1.57±0.51g/100g, 4.35±0.42g/100g and 1.95±0.22g/100g for Methionine, Leucine, Lysine, Isoleucine, Phenylalanine, Tryptophan, Valine, and Histidine respectively.

**Table 4a:** Essential Amino Acid Composition of *E. Coracana* Gruel

Amino-acid (g/100g)	Unprocessed	Roasted	Germinated	Fermented
Leucine	7.18±0.11	8.49±0.25	9.07±0.43	9.48±0.44
Lysine	3.42±0.20	3.52±0.26	3.71±0.19	3.81±0.67
Isoleucine	3.34±1.09	3.60±0.50	3.89±0.45	4.19±0.10
Phenylalanin	3.18±0.05	4.08±0.15	4.43±0.90	4.79±0.89
Tryptophan	1.57±0.51	1.68±0.91	1.73±0.46	1.89±0.01
Valine	4.35±0.42	4.41±0.33	5.61±0.01	5.67±0.32
Methionine	2.00±0.21	2.19±0.20	2.29±0.30	2.32±0.06
Histidine	1.95±0.22	2.04±0.52	2.04±0.45	2.17±0.11

Values are Mean ± SD; Values with different superscripts across the rows by processing methods are significantly different (P<0.05).

Table 4b indicated the effect of the processing method on the non-essential Amino Acid content of Gruel (Pap) from finger millet. It shows that fermented gruel samples had a higher content of Proline, Tyrosine, Cystine, Alanine and Glycine (5.38±0.49g/100g, 3.27±0.72g/100g, 2.06±0.02g/100g) 7.73±0.16g/100g and 3.56±0.56g/100g). The result also shows that gruel (pap) from roasted seeds had the highest value of 5.16±0.39g/100g for Arginine content. Likewise, contains the least content of

Cystine(1.80±0.22g/100g), Glutamic Acid (14.99±0.11g/100g) and Glycine (2.99±0.23g/100g). Gruel (pap) from unprocessed seeds had the highest value of 17.18±0.01g/100g for Glutamic Acid content likewise, the least value of 2.75±0.01g/100g and 6.03±0.02g/100g for Tyrosine and Alanine content. The lowest Arginine content is recorded in Gruel (Pap) from germinated seeds with the value of 4.38±0.19g/100g.

**Table 4b:** Non-essential Amino Acid Composition of *E. Coracana* Gruel.

Amino-acid (g/100g)	Unprocessed	Roasted	Germinated	Fermented
Proline	3.96±0.70	4.26±0.32	4.87±0.27	5.38±0.49
Arginine	4.99±0.88	5.16±0.39	4.38±0.19	4.64±0.26
Tyrosine	2.75±0.01	3.09±0.04	3.09±0.49	3.27±0.72
Cystine	1.96±0.12	1.81±0.22	1.93±0.71	2.06±0.02
Alanine	6.03±0.02	6.41±0.17	7.58±0.23	7.73±0.16
Glutamic acid	17.18±0.01	14.99±0.11	15.89±0.14	16.65±0.22
Glycine	3.25±0.41	2.99±0.23	3.39±0.05	3.56±0.56

Values are Mean ± SD; Values with different superscripts across the rows by processing methods are significantly different (P<0.05).

The dietary fibre content of gruel (pap) (table 5) indicated that gruel from unprocessed seeds had the highest value of 17.30±0.50g/100g for total dietary fibre composition compared to roasted (14.10±1.10g/100g), germinated (12.50±0.50g/100g) and product from fermented seeds had the lowest value of 11.20±0.05g/100g. Furthermore, products from germinated seeds recorded higher (1.90±0.30g/100g) soluble dietary fibre content, compared

to products from unprocessed seeds (1.60±0.10g/100g), fermented (1.50±0.03g/100g) and the roasted had the least value of 1.20±0.10g/100g. The result also shows higher (16.00±0.30g/100g) soluble dietary fibre content in gruel (pap) from unprocessed seeds, while products from fermented seeds had the lowest value of 10.00±0.02g/100g. There was no significant reduction of total dietary fibre (TDF) recorded in the gruel samples. This is confirmed by

the study by Pushparaj and Urooji (2011) <sup>[17]</sup>, which reported that processing did not affect total dietary fibre and insoluble dietary fibre (IDF) content. Likewise, in finger millet products (Indian meal), a significant increase in total dietary fibre and insoluble dietary fibre was observed, according to Shobana, *et al* (2006) <sup>[20]</sup>.

Table 6 shows the result of the sensory evaluation carried out on gruel samples prepared from Whole and processed (roasted, germinated and fermented) finger millet.

The result also shows that gruel from roasted finger millet, was significantly ( $P < 0.05$ ) higher in terms of general acceptability, taste, aroma/flavour and texture compared to other samples. Although gruel is from germinated finger millet, due to conversion of starch to sugar makes the gruel less thick and increases insolubility.

The least acceptability of selected foods using flour from unprocessed finger millet seeds in terms of flavour/aroma, texture, general acceptability and especially colour is in conformity with the study by Tizazu, *et al* (2010) <sup>[23]</sup> stated that vision plays a major role in sensory analysis and the appearance of food can have a major effect on its acceptability. Saleh, *et al* (2013) <sup>[19]</sup>.

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