



## **Quality Evaluation of Maize Akamu as Affected by Dehulling, Partial Germination and Oil Seed Supplementation**

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### **Authors' contributions**

*The work was a joint collaboration among all colleagues. Author AGI designed the study, prepared the first manuscript draft and statistically evaluate the data. Authors AP and AGI processed the materials, carried out the physicochemical analysis. Author AHN carried out microbial analysis and conducted sensory evaluation of the food products. Authors AGI, AP and AHN separately went through the final manuscript draft and grey areas sorted out.*

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### **ABSTRACT**

Akamu, a starchy cereal-based lactic acid fermented gruel consumed in West Africa was prepared using different processing methods: use of dehulled (D) maize grains, use of partially germinated (PG) maize grains (36-48h) and blends: PG and soybean (S) (90:10), D and S (90:10) and D and Melon (M) seed (90:10). Soaking, wet-milling, wet-sieving, sedimentation (24h), decanting, dewatering were involved and the traditional maize akamu served as the control. The seven different samples were subjected to physicochemical microbiological and sensory evaluations. Crude protein (4.70-10.33%), crude fat (4.12-14.30%), total ash (0.26-0.88 %%), crude fibre (1.51-2.77%) contents were higher in oil seed treated akamu and the carbohydrate contents (<74.41%) were the lowest. The akamu made of dehulled(D) maize had poorer proximate composition. Dominant elements in all the akamu were Phosphorous and Potassium and surprisingly, Zinc

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(1.98mg/100g), Iron (7.33 mg/g) and potassium (106.83 mg/g) in the akamu made with dehulled maize and calcium higher in the control (14.21mg/100g) and partially germinated (14.71mg/100g) akamu. Low water activity in the dried akamu ensured satisfactory low bacterial and fungal counts ( $<10^3$ cfu/g). The control (U) and D akamu possessed better functional and sensory properties; water absorption capacity, swelling power and pH of the different akamu varied significantly: 7.40—8.10 ml/g, 2.74-5.73 g/g, and 5.41-7.42 g/g respectively. Short period of germination (<48 h) did not affect negatively the proximate composition, sensory, water absorption capacity and swelling power of the PG, PG+U, PG+S akamu(s). The control (U) and D akamu were adjudged to possess better sensory properties especially U akamu with scores slightly greater than 8 on a 9-point hedonic scale, but the superior nutritive value of oil seed treated akamu(s) were masked by poorer sensory attributes. It is concluded that akamu made from PG maize or its blends with undehulled maize or soybean were better alternatives to traditional akamu which is nutritionally inferior although it possessed excellent sensory and functional properties.

*Keywords: Maize akamu; dehulled maize; oilseed meal; germination; fermentation.*

## 1. INTRODUCTION

Akamu also called “ogi” is the fore-most cereal-based starchy weaning or breakfast meal in Nigeria and its production and consumption remain undeterred by modernity, and has continued to play dominant role in the nutrition of resource-poor Nigerians even in the urban areas, providing the nutritional needs of infants, older people and convalescing adults. Maize is the grain of choice for akamu preparation in Southern Nigeria due to its availability over coarse cereals such as millets, sorghum, acha which are commonly grown in drier areas of Northern Nigeria, however similar common preparation method is utilized involving wet-milling and wet-sieving of a steeped grain, then decanting the water from starchy sediment, further dewatering reduced the water content, sun-drying is rarely carried out so as to avoid the development of unsavory sensory attributes, therefore secondary fermentation continues to take place until a batch is finished. Akamu gruel is prepared by pouring hot water onto the akamu slurry with continuous stirring until it is gelatinized to the consistency level desired by the consumer. Addition of sugar to sweeten and milk to enrich before consumption is the practice by the well-to-do in the society. The importance of this gruel as a complimentary food in the rural Nigeria cannot be overstressed, therefore fortification of akamu has continued to be the subject of research study such as Akinrele and Edwards [1], soy-ogi; Egunlety and Syarief [2] ogi with temp; Amingo and Akingbala [3] okra seed flour treated ogi; Fasoyiro and Arowora [4] ogi with pepeon pea; Arise et al. [5] ogi with moringa seed flour; Inyang and Effiong [6] ogi fortified with periwinkle meat flour. This may not be unconnected with ravaging menace of infant child malnutrition in

Nigeria with high mortality and morbidity manifesting in stunting, high susceptibility to infectious diseases and poor brain development in formative years [7]. Nutritional value of akamu is low, a starchy meal stripped off of available protein, fibre, minerals and vitamins through unit operations such as soaking, wet-sieving and decanting [3]. Although dehulling of seeds help reduce anti-nutritional factors that affect sensory properties and digestibility of the food product but it is done at the expense of nutritional completeness because the hulls are home to some mineral elements, health-giving phytochemicals and dietary fibre. Soaking and sieving also further reduce the quality and quantity of protein in a protein deficient grain with low level of lysine, an essential amino acid. According to McIntosh and Topping [8], pulses are valuable nutritional resource providing high quality lysine-rich protein (2-3 times greater than in cereals) for human diet in addition to non-nutrient phytochemicals, the focus of research with regard to heart diseases and cancer prevention. Duranti and Guis [9] have noted that legumes provide 20-33% of the dietary proteins to humans. Soybeans is the foremost oil seed in terms of scale of production, a major industrial raw material and a good resource for fabrication of functional foods and complementation of cereal- and tuber-based diet common in low-income peoples in less developed countries of the world. Melon seed (*Citrullus Colocynthis* Schrad, Syn *Citrullus lanatus*) on the other hand is a monoecious herb of the curcubitaceae family known to thrive in different climates especially the tropical environment and produces an inedible fruit within which are embedded oil and protein-rich seeds, a common snack either cooked or roasted and the fermented paste of the shelled seeds called “ogiri” is a good soup

condiment in Southern Nigeria (ref). Sprouting of seeds is an ancient practice that leads to increased solubility and availability of nutrients, reduced bulk density making it possible to produce nutrient dense free –flowing gruel, instead of bulky stuff with low dietary energy. Steeping, fermentation Sprouting and legume flour supplementation have been utilized by many researchers to produce akamu with better functional and sensory properties as well as the reduction of anti-nutritients. According to Thoy et al. [10] germination improves the protein and dietary fibre, reduces the phytate and tannin contents thereby ensuring mineral availability. Bau et al. [11] reported that increased metabolic activity due to imbibition of water by quiescent seeds leads to protein synthesis and increased activity of hydrolytic enzymes that ensures the solubility of both nutrient and anti-nutrients. Therefore the focus of this present study was to evaluate the effects of seed dehulling, sprouting and oil-seed supplementation on the functional, chemical and sensory properties of akamu.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Raw Materials

Maize (flint, white), shelled melon seeds, soybeans were purchased at the Maiduguri Monday market Borno State, northeast Nigeria and conveyed to the Department of Food Science and Technology (Food Processing Laboratory) of university of Maiduguri.

### 2.2 Preparation of the Variously Treated Akamu Samples

Traditional methods of akamu preparation in Nigeria was used as describe by Ijabadeniyi [12] to prepare the variously treated akamu, which involved dry cleaning, steeping (16h), wet milling in a disc attrition mill, wet-sieving using amount of water twice the volume of wet slurry, 24 h sedimentation, dewatering in a cotton sack and finally oven drying (70°C 10 h) and packaged in a low density polythene bags prior to analysis. Dehulling was done using local mills after conditioning. Sorted and cleaned maize seeds were soaked in tap water(1:3 w/v) for 24h after which soaked seeds were placed on tray lined with hot water washed jute bag and allowed to sprout, water was sprinkled morning and evening until the appearance of rootlets(<48 h). Germinated maize grains were used to produce

akamu alone and separately mixed with unde-hulled maize, with dehulled parboiled soybean, also with parboiled shelled melon seeds (egusi) and produced akamu. Dehulled maize grains were used to produce akamu alone and then mixed with parboiled dehulled soybeans to produce akamu. The control was akamu from unde-hulled maize grains. All akamu(s) were produced using the traditional method of akamu preparation as earlier stated. Seven formulations were obtained code-named:

- I. U (100%) = Undehulled maize akamu
- II. D (100%) = Dehulled maize akamu
- III. PG (100%) = Partially germinated (<48 h sprouting)
- IV. PG+U (50:50) = Partially germinated (<48 h sprouting) and Undehulled maize akamu
- V. PG+S (90:10) = Soybean supplemented partially germinated maize akamu
- VI. D+S (90:10) = Soybean supplemented dehulled maize akamu
- VII. D+M (90:10) = Melon seed meal supplemented dehulled maize akamu

The flow diagrams are shown in Figs. 1-7.

### 2.3 Physicochemical Analysis

#### 2.3.1 pH of the variously treated dried akamu samples

The filtrate of 10% suspension of each of the raw akamu sample was taken using a pH meter (Jenway 3330, UK) previously standardized using phosphate buffer 4.0 and 7.0 (AOAC, 2012).

#### 2.3.2 Water Absorption Capacity (WAC) of the variously treated dried akamu samples

The method described by Onwuka [13] was used to determine WAC, it involved adding 10 ml distilled water to 1g sample, allowed to stand for 30min, then centrifuged at 3500rpm 15 min, the volume of free water (supernatant) was directly read from the graduated centrifuge tube.

#### 2.3.3 Swelling power of the variously treated dried akamu samples

The method described by Leach et al. [14] was adopted, it involved the addition of 10 ml distilled water to 1 g of sample, mixed and heated at 80°C, 30 min after it was centrifuged 1000 rpm

for 15min, the supernatant was decanted and the weight of the paste divided by the weight of the sample was reported as swelling power (g/g).

## 2.4 Proximate Composition of the Differently Treated Dried Akamu

Proximate composition of akamu was determined according to the procedures outlined by AOAC [15]. Moisture contents were obtained by drying at 105°C, 1h in an air oven; crude protein (%N×6.25) was determined using micro-Kjeldahl procedure; crude fat by solvent extraction (petroleum ether, boiling point 60-80°C) of a weighed sample in Soxhlet apparatus, total ash by ashing in a muffle furnace at 550°C, 5 h and the carbohydrate contents were estimated by 'difference'.

### 2.4.1 Mineral composition of the differently treated dried akamu

Minerals were determined according to the method of AOAC [15]. Five grams of each sample was dry-ashed, and each ash was dissolved in 20ml dilute hydrochloric acid and filtered with Whatman No. 4, the filtrate was made up to 100ml with de-ionized water in a standard flask. Aliquots of the filtrate were used to assay Phosphorous using Vanado-Molybdate colorimetric method. Calcium, Iron and Zinc were determined using atomic absorption Spectrophotometer (Perkin Elmer Model, Lamber35). Potassium contents were determined using a Flame Photometer (Model

405 Corning, UK). Concentrations of mineral elements

### 2.4.2 Microbiological status of the differently processed akamu samples

Standard procedures as described by APHA [16] were used to evaluate the microbiological status of different akamu. Akamu samples were serially diluted with 0.1% peptone water, 1ml of 10<sup>4</sup> and 10<sup>5</sup> dilutions were pour plated on duplicate plates, on nutrient agar for total mesophilic aerobic bacteria count incubated at 37°C for 48 h; on antibiotic treated potato dextrose agar incubated at room temperature 4-5 days for mould/yeast count; on McConkey at 37°C 48 h for coliform count. Plates without samples were equally treated that served as control. Viable colonies were counted using Gallenkamp colony digital counter.

## 2.5 Sensory Evaluation of the Various Treated Akamu Samples

Coded disposable cups were filled with equal amounts of warm akamu porridge (20% w/v) and presented to 15-member semi-trained panel consisting of ten females and five males, students and staff of the Department of Food Science and Technology, University of Maiduguri. They were instructed to evaluate the color, consistency, taste, aroma, texture and overall acceptability of the samples on a 9-point hedonic scale where 1 represents extremely disliked, 5= neither liked nor disliked, 9 = extremely liked using the control as the reference point.

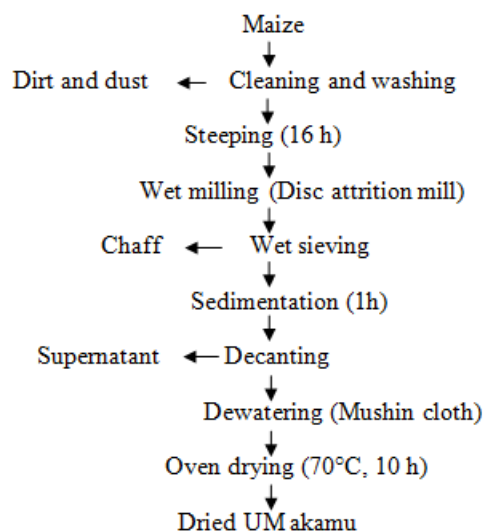


Fig. 1. Flow diagram for the preparation of Undehulled Maize (UM) akamu

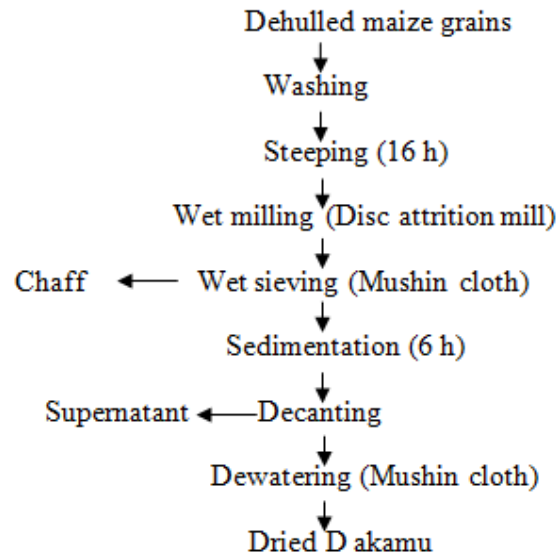


Fig. 2. Flow diagram for the preparation of Dehulled Maize (DM) akamu

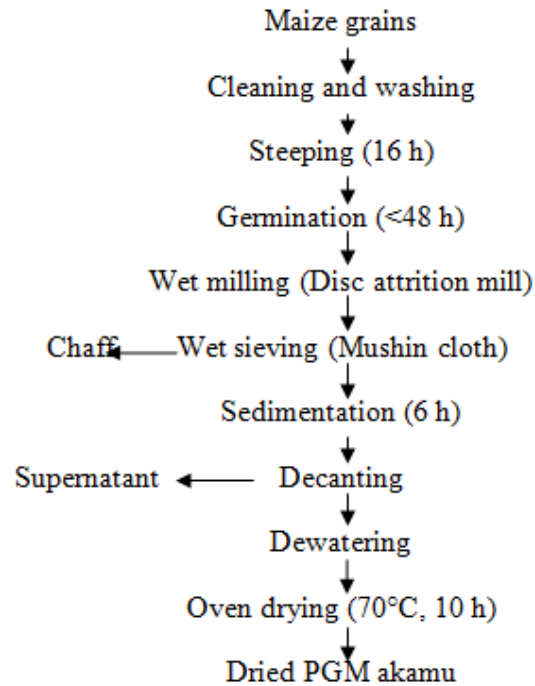


Fig. 3. Flow diagram for the preparation of partial germinated maize akamu

## 2.6 Statistical Analysis

Procedures were replicated and the data generated were subjected to one-way analysis of variance, the treatment means were separated using Duncan's multiple range test and

significance was accepted at 95% confidence level limit ( $p < 0.05$ ). Statistical Package for Social Science (SPSS) Version 20 was the software used for statistical analysis. Results were represented as mean  $\pm$  SE ( $n=3$ ).

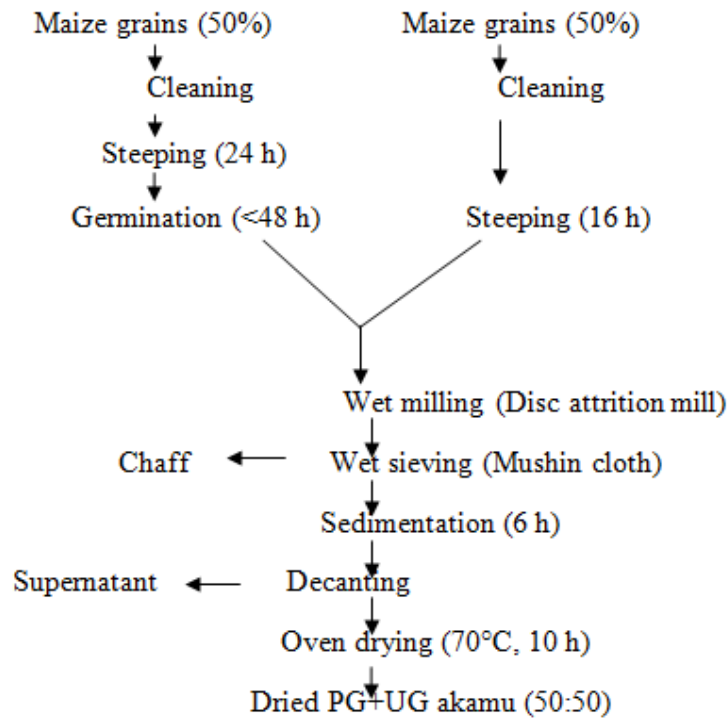


Fig. 4. Flow diagram for the preparation of the Partially Germinated (PG) and Ungerminated (UG) akamu

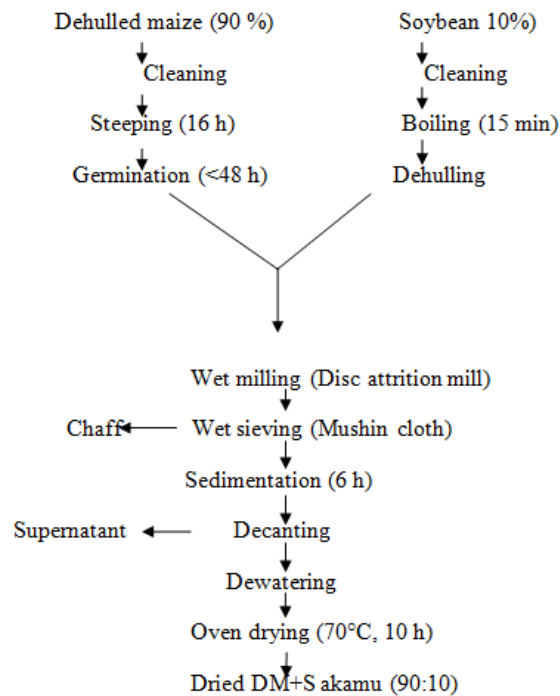


Fig. 5. Flow diagram for the preparation of Dehulled Maize (DM) +Soybean (S) akamu

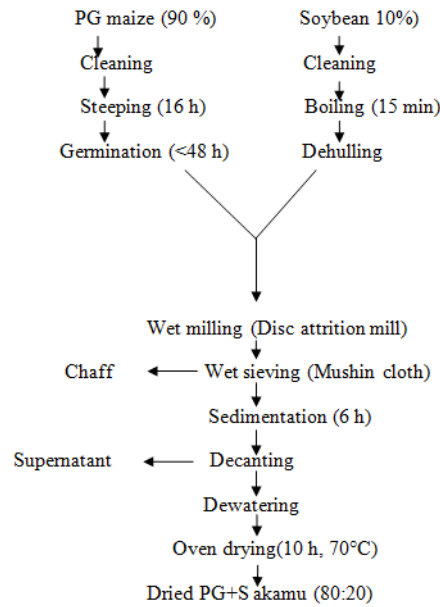


Fig. 6. Flow diagram for the preparation of Partial Germinated Maize (PGM) +soybean (S) akamu

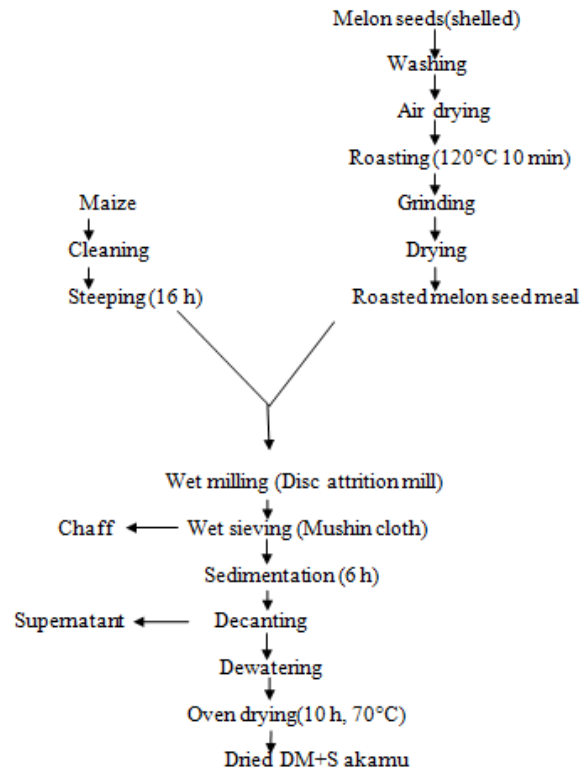


Fig. 7. Flow diagram for the preparation of Dehulled Maize (DM) + Melon Seed (M)

### 3. RESULTS AND DISCUSSION

#### 3.1 Proximate Composition (%) of the Differently Processed Dried Akamu Samples

The least moisture content (8.59%) was observed in dehulled (D) maize akamu with 10% melon (M) seed meal (D+M), perhaps due to the higher oil content of 14.30% and D akamu had the highest (10.99%) and the least crude fibre content (1.51%), others had moisture contents that clustered between 9% and 10%, Table 1. This level of moisture contents will ensure storage stability. Ajanaku et al. [17] reported decrease in moisture and increase in protein contents with increased addition of groundnut seeds to ogi. Significant higher content of ash (0.86%) was observed in the PG+U akamu (50:50), a blend of partially germinated (PG) and dehulled (U) maize akamu, expectedly D akamu had the least level of ash (0.26%), crude fibre (1.51%), fat (4.12), and protein (4.78%) indicating the negative effects of producing akamu with dehulled cereal grains. Akamu with higher ash contents were (D+M) (0.78%) and PG+S (0.72%); but among the unsupplemented, PG akamu had the highest ash content either alone or blended with oil seed or dehulled maize.

Fat contents of the variously treated dried akamu ranged from 4.12% in D to 14.30% in melon seed treated akamu, and 10.87% in PG+S akamu, the fat contents of PG akamu (7.13%) was not significantly different from U akamu (7.00%). Addition of soybean as in PG+S further boosted its fat content. Storage of wet akamu cake as currently done by consumers will limit the storage life of akamu through quality deterioration of the fat content. The D akamu had the least level of protein (4.78%), the protein contents of U (5.25%) and PG+U (5.34%) were not significantly different ( $P \geq 0.05$ ). Highest protein was observed in PG+S (10.33%) significantly ( $p < 0.05$ ) higher than in D+M (7.70%) and D+S (7.00%). Oil seeds like soybeans and melon seeds are known cheap sources of high quality oil, protein, fibre and minerals and seed germination further improved the levels of these nutrients as observed in PG+S akamu. Similarly Ojo and Enujiugha [18] had earlier improved the quality of germinated ogi with the addition of ground beans. Iyang and Idoko [19] increased the protein, ash and crude fibre contents of millet ogi with increasing levels of millet malt addition. Both dehulling and wet sieving do limit the nutrient

level of akamu leading to decreased crude protein, crude fat, crude fibre and ash contents. The D akamu had the least level of crude fibre (1.51%) and PG+S akamu the highest (2.77%) significantly higher than that of U akamu (1.96%). Oil seed treated PG akamu or its blends with U had significant high level of crude fibre greater than that of untreated akamu, the same can be said of PG+S akamu with higher level of ash, fat and protein than the untreated.

Oluwalana [20] observed an increase in the level of protein and ash in the sprouted sweet maize flour and a decrease in the fat and fibre which are in line with the findings of this study.

The PG+S (65.88%) and D+M (66.31%) had the least levels of carbohydrate significantly not different and D and U akamu the highest 78.39% and 77.41% respectively also not significantly different. PG, PG+S and D+S akamu had carbohydrate contents which were significantly not different. Akamu with higher contents of fat and protein as in PG+S and D+M had the least carbohydrate contents. Equally, PG+S (402.67kcal) and D+M (424.74kcal) had the highest calorific content due to higher fat content and D akamu had the least calorie (326.73kcal). Olaniran and Ambrose [21] preserved quality protein maize akamu with garlic and ginger, the proximate composition of the untreated is greater than the treated akamu, unlike what was observed in this study. Proximate values reported by Esther et al. [22] for cabinet dried maize ogi are comparable to the values obtained for the control (U100:0) in this study. Adelekan and Oyewole [23] made ogi from different sorghum varieties, higher moisture, ash and protein contents were observed in malted than in the unmalted, the same pattern was observed in this study for PG akamu or its blend. Adelekan and Oyewole [23] reported protein and fat of 18.46% -18.98 and 8.99-9.44 respectively for 30% soybean supplemented ogi from three species of sorghum, smaller range of protein obtained in this study was due to 10% level of supplementation with oil seed meal.

#### 3.2 Physicochemical Properties of the Differently Processed Dried Akamu Samples

The water absorption capacities (WAC) of the variously treated akamu samples varied from 7.40-8.10 g/g, Table 2. Dehulled akamu (U100:0) had the highest WAC significantly different from others, a desirable attribute.



**Table 1. Proximate composition (%) of the differently processed dried akamu samples**

<b>Akamu</b>	<b>Moisture</b>	<b>Ash</b>	<b>Fat</b>	<b>Protein</b>	<b>Crude fibre</b>	<b>CHO</b>	<b>Calorie (kcal/100)</b>
U(100:00)	9.60±1.30 <sup>b</sup>	0.44±0.05 <sup>e</sup>	7.00±0.07 <sup>c</sup>	5.25±0.28 <sup>d</sup>	1.96±0.10 <sup>d</sup>	77.41±0.25 <sup>a</sup>	393.64
D(100:00)	10.99±0.12 <sup>a</sup>	0.26±0.13 <sup>f</sup>	4.12±0.98 <sup>e</sup>	4.78±0.91 <sup>e</sup>	1.51±0.41 <sup>e</sup>	78.39±0.07 <sup>a</sup>	369.76
PG(100:00)	9.64±0.02 <sup>b</sup>	0.68±0.07 <sup>c</sup>	7.13±0.05 <sup>c</sup>	5.25±0.93 <sup>d</sup>	2.41±0.24 <sup>c</sup>	74.65±0.21 <sup>b</sup>	326.73
PG+U (50:50)	10.42±0.22 <sup>a</sup>	0.86±0.08 <sup>a</sup>	6.04±0.94 <sup>d</sup>	5.34±0.98 <sup>d</sup>	2.56±0.39 <sup>b</sup>	74.74±0.39 <sup>b</sup>	374.68
PG+S (90:10)	9.53±0.12 <sup>b</sup>	0.72±0.06 <sup>b</sup>	10.87±0.88 <sup>b</sup>	10.33±0.07 <sup>a</sup>	2.77±0.09 <sup>a</sup>	65.88±1.12 <sup>c</sup>	402.67
D+S (90:10)	9.97±0.09 <sup>b</sup>	0.52±0.04 <sup>d</sup>	5.37±0.12 <sup>de</sup>	7.00±0.99 <sup>c</sup>	2.52±0.11 <sup>b</sup>	74.25±0.51 <sup>b</sup>	373.33
D+M (90:10)	8.59±0.13 <sup>c</sup>	0.78±0.06 <sup>b</sup>	14.30±0.49 <sup>a</sup>	7.70±0.91 <sup>b</sup>	2.42±0.37 <sup>c</sup>	66.31±1.23 <sup>c</sup>	424.74

Cells with different alphabet down the column indicate significance difference between their means at  $p$ -value = 0.05

*D (100:0) = Dehulled maize akamu ; U (100:0) = Undehulled maize akamu; PG (100:0) = Partially germinated maize; PGM+UGM (50:50) = Partially germinated maize + Un-germinated maize; D+S (90:10) = Dehulled maize + soybean; PG+S (80:20) = Partially germinated maize + soybean; D+M (90:10) = Dehulled maize + melon seed akamu*

D, D+S, D+M akamu made with partially germinated maize or its blends had the least WAC, probably due to cleavage of starch polymer by the hydrolytic enzymes mobilized during germination, however significant difference was not observed in the WAC of the dehulled (D) and treated D akamu. The highest swelling power was observed in D akamu (5.73 g/g) perhaps due to lower level of insoluble dietary fibre, next in that order was PG+U akamu (5.29 g/g) and PG (4.83 G/G). Oil seed treated akamu had the least swelling power and the level of swelling was not statistically different ( $P>0.05$ ). Short germination time did not affect the swelling of PG akamu which when further blended with U enhanced the swelling capacity of PG+U. The higher pH were observed in the oil seed treated akamu, 6.13-7.24. Short secondary fermentation (16h) after wet sieving was responsible for slightly acidic nature of the various akamu which varied from 5.41-7.42 g/g. Ajanaku et al. [17] fortified sorghum ogi with increasing level of groundnut seeds, the untreated control had the highest WAC, the pH increased and bulk densities decreased with increasing level of groundnut seed addition, the same scenario was observed in this study with addition of soybean or melon to maize akamu.

### 3.3 Microbiological Status of the Differently Processed Dried Akamu Samples

The low moisture contents of the dried akamu restricted the proliferation of both bacteria and fungi as seen in Table 3 indicating satisfactory level of microbial load ( $<10^4$  cfu/g), worthy of note was the absence of observable growth of coliform in all the samples, Enterobacteriaceae in

general are useful indicators of hygiene, process failure and post-processing contamination of heat processed food (EC Regulation No. 2003/2005) [24]. Akamu is stored in form of dewatered wet cake in ambient condition during which period fermentation continued unabated made possible by microbial invasion including toxicogenic fungi from the environment and food process containers leading to the production of beneficial and harmful substances, such products are sources of food toxicants, a common public health concern often goes unreported. Ezendianfo and Dimefesi [25] reported total bacteria and fungi counts of  $3.0 \times 10^8$ – $7.5 \times 10^8$ ,  $1.8 \times 10^8$ – $3.5 \times 10^8$  and  $0.6 \times 10^8$ – $1.0 \times 10^8$  cfu/g respectively for akamu sold in Nnewi markets Southeast Nigeria, far higher than observed in this study indicating the beneficial effect of keeping akamu in dried form. The same authors isolated micro-organisms such as staphylococcus species, pseudomonas species, *Eucharicha coli* and Klebsiela and Fungi such as *Fausarum spp* and *Aspergus spp* from akamu.

### 3.4 Mineral Profile of the Differently Process Akamu

The levels (mg/100) of mineral elements in the various dried akamu were generally low which implies that the consumption of akamu gruel, a starchy mass will not provide the need mineral elements to meet the Recommended Dietary Allowance (RDA) to the consumers, Table 4. There were significant variations ( $P \leq 0.05$ ) in the mineral contents of the various akamu (mg/100g); Calcium (Ca), Zinc (Zn), Iron (Fe), Phosphorous (P) and Potassium (K) varied respectively from 6.24-14.71, 1.26-1.87, 4.71-7.83, 35.26-120.11 and 38.66-106.83. The increasing order of the

**Table 2. pH, water absorption capacity and swelling power of the differently processed dried akamu samples**

Akamu	Water absorption capacity (ml/g)	Swelling (g/g)	Power	Bulk density (g/ml)	pH
U (100:00)	8.10±1.47 <sup>a</sup>	3.06±0.59 <sup>d</sup>		0.69±0.01 <sup>a</sup>	5.41±0.32 <sup>d</sup>
D (100:00)	7.80±1.25 <sup>b</sup>	5.73±0.04 <sup>a</sup>		0.65±0.05 <sup>a</sup>	5.66±0.05 <sup>c</sup>
PG (100:00)	7.40±1.30 <sup>b</sup>	4.83±0.02 <sup>c</sup>		0.58±0.03 <sup>b</sup>	5.71±0.04 <sup>c</sup>
PG+U (50:50)	7.50±1.05 <sup>b</sup>	5.29±0.03 <sup>b</sup>		0.62±0.05 <sup>a</sup>	6.32±0.07 <sup>b</sup>
PG+S (90:10)	7.50±1.09 <sup>b</sup>	2.88±0.05 <sup>d</sup>		0.54±0.03 <sup>b</sup>	6.13±0.23 <sup>bc</sup>
D+S (90:10)	7.80±1.28 <sup>b</sup>	2.73±0.01 <sup>d</sup>		0.52±0.02 <sup>b</sup>	6.24±0.19 <sup>b</sup>
D+M (90:10)	7.90±1.46 <sup>ab</sup>	2.74±0.02 <sup>d</sup>		0.54±0.02 <sup>b</sup>	7.24±0.31 <sup>a</sup>

Cells with different alphabet down the column indicate significance difference between their means at  $P$ -value  $< 0.05$

D (100:0) = Dehulled maize akamu; U (100:0) = Undehulled maize akamu;

PG (100:0) = Partially germinated maize; PG+U (50:50) = Partially germinated maize +Ungerminated maize; D+S (90:10) = Dehulled maize soybean; PG+S (80:20) = Partially germinated maize soybean; D+M (90:10) =Dehulled maize + melon seeds meal akamu

**Table 3. Microbiological status of the differently processed dried akamu samples**

Akamu	Total plate count (cfu/g)×10 <sup>2</sup>	Yeast/Mould count (cfu/g)×10 <sup>2</sup>	Total coliform count (cfu/g)
U (100:00)	1.22±14.43 <sup>a</sup>	0.91±9.29 <sup>d</sup>	NG
D (100:00)	1.03±16.24 <sup>c</sup>	1.21±11.24 <sup>c</sup>	NG
PG (100:00)	1.33±17.63 <sup>a</sup>	1.51±6.11 <sup>b</sup>	NG
PG+U (50:50)	0.84±12.25 <sup>c</sup>	1.09±8.26 <sup>d</sup>	NG
PG+S (90:10)	1.23±15.33 <sup>a</sup>	1.57±12.25 <sup>b</sup>	NG
D+S (90:10)	1.17±15.42 <sup>b</sup>	2.07±10.37 <sup>a</sup>	NG
D+M (90:10)	0.98±10.25 <sup>c</sup>	1.01±10.37 <sup>d</sup>	NG

Cells with different alphabet down the column indicate significance difference between their means at  $p$ -value = 0.05.; NG=No growth

*D (100:0) = Dehulled maize akamu ; U (100:0) = Undehulled maize akamu;*

*PG (100:0) = Partially germinated maize; PG+U (50:50) =Partially germinated maize +Ungerminated maize; D+S (90:10) = Dehulled maize + soybean; PG+S (80:20) = Partially germinated maize + soybean; D+M (90:10) =Dehulled maize+melon seed meal akamu*

concentration (mg/100) of the various mineral elements was Zn<Fe<Ca<K<P. Significant higher levels of Ca were observed in Undehulled (U) maize akamu and partially germinated (PG) maize akamu respectively, 14.21 and 14.71 greater than in the soybean and melon seed supplemented akamu. Dehulling decreased calcium level as observed in D (dehulled) akamu, 10.36 and D+S (soybean supplemented dehulled akamu), 6.21. Addition of 10% soybean to D and PG (partially germinated maize) did not enhance the calcium level. Zinc and Iron levels followed similar pattern, lower levels were observed in PG and PG+U(50:50), 1.35 and 1.26 respectively and the levels were enhanced with soybean and melon seed addition to PG akamu indicating that germination reduced the levels of Zinc and Iron but dehulling and oil seed addition increased their concentration in the various akamu. D akamu had the highest level of Zinc (1.98), Iron (7.33) and Potassium (106.83). D+M (Melon seed treated dehulled akamu, 90:10) contained the highest level of Phosphorous (120.11), next was PG+S (98.49), D+S (73.86) and the unsupplemented D akamu the least (35.26) lower than the control (U) akamu indicating further beneficial effect of addition of oil seeds to akamu. Germination also reduced the K contents, 38.66 in PG and 47.28 in PG+U akamu with the lowest values and the highest K was obtained in unsupplemented D akamu (106.83) against 54.14 in the control akamu (U) indicating enhancement of K levels with dehulling of the maize seeds, however the addition of soybean boosted the level (56.25) of K in PG akamu. Iyang and Effiong [6] improved the mineral profile

of ogi with periwinkle flour but the untreated control contained Ca, Zn, and Fe similar to the levels observed in undehulled maize akamu (U) in this study. Abioye et al. [26] reported greater enhancement of mineral profile for Moringa leaf treated ogi. Oluwulana [20] reported significant increase in Ca, Mg, K, and Na with exception of Iron (Fe) in sprouted sweet white and yellow maize flour greater than in the un-sprouted control and at that the reported levels of the minerals are lower than obtained in this study. The levels of minerals reported by Ojo and Enujiugha [18] for ogi produced from blends of germinated maize and ground bean are comparable to levels observed here.

### 3.5 Sensory Evaluation the Variously Dried Akamu Samples

The control ( U100:0) consistently was the most preferred akamu among the different akamu, possessing better color, texture, taste and therefore greater overall acceptability having sensory scores greater than 8 for each attribute on a 9-point hedonic scale, Table 5. The next in rank terms of preference by the test panelists was D akamu and PG+U. The oil seed treated akamu received the lowest scores of all the attributes tested especially the melon seed treated akamu, however they were not rejected; this could be linked to the usual reluctance by human nature to accept what is new even when the same is adjudged the most nutritive until the taste buds that were trained to like the conventional get used to the new or the modified.

**Table 4. Mineral composition (mg/100g) of the differently processed dried akamu samples**

Sample	Ca (%RDA)	Zn (%RDA)	Fe (%RDA)	P (%RDA)	K (%RDA)
U (100:00)	14.21±0.04 <sup>ab</sup> (1.42)	1.50±0.08 <sup>d</sup> (10)	5.0±0.02 <sup>c</sup> (27.78)	74.65±2.71 <sup>c</sup> (7.47)	54.14±0.29 <sup>c</sup> (1.23)
D (100:00)	10.36±0.11 <sup>c</sup> (1.04)	1.98±0.29 <sup>a</sup> (13.21)	7.33±0.38 <sup>a</sup> (40.72)	35.26±2.00 <sup>f</sup> (3.53)	106.83±0.42 <sup>a</sup> (2.56)
PG (100:00)	14.71±0.09 <sup>a</sup> (1.47)	1.35±0.13 <sup>e</sup> (8.73)	4.82±0.05 <sup>d</sup> (26.72)	58.07±0.13 <sup>d</sup> (5.81)	47.28±1.50 <sup>e</sup> (1.00)
PG+U (50:50)	11.22±0.06 <sup>bc</sup> (1.12)	1.26±0.11 <sup>f</sup> (8.40)	4.71±0.31 <sup>d</sup> (26.11)	53.21±2.57 <sup>e</sup> (5.32)	47.28±1.50 <sup>d</sup> (1.00)
PG+S (90:10)	8.30±0.02 <sup>d</sup> (0.83)	1.73±0.37 <sup>c</sup> (11.53)	6.42±0.37 <sup>b</sup> (35.67)	98.49±1.70 <sup>b</sup> (9.85)	72.61±0.91 <sup>b</sup> (1.55)
D+S (90:10)	6.21±0.21 <sup>e</sup> (0.62)	1.77±0.23 <sup>c</sup> (11.30)	6.44±0.27 <sup>b</sup> (35.77)	73.86±2.71 <sup>c</sup> (7.39)	56.25±0.23 <sup>c</sup> (1.20)
D+M (90:10)	12.21±0.31 <sup>b</sup> (1.22)	1.87±0.14 <sup>b</sup> (12.47)	7.28±0.08 <sup>a</sup> (39.33)	120.11±2.86 <sup>a</sup> (12.01)	52.42±1.15 <sup>cd</sup> (1.12)

Cells with different alphabet down the column indicate significance difference between their means at  $P$ -value < 0.05

DM (100:0) = Dehulled maize akamu; UM (100:0) = Undehulled maize akamu; PGM (100:0) = Partially germinated maize; PGM+UGM (50:50) = Partially germinated maize + Ungerminated maize; DM+S (90:10) = Dehulled maize soybean; PGM+S (80:20) = Partially germinated maize soybean; DM+M (90:10) = Dehulled maize + melon seeds meal akamu

**Table 5. Sensory attributes of the differently treated akamu gruel**

Akamu	Color	Texture	Taste	Overall Acceptability
U (100:00)	8.09±1.03a	8.18±0.07a	8.09±1.05a	8.18±1.25a
D (100:00)	7.36±1.17b	7.82±1.35b	7.18±1.72b	7.55±1.06b
PG (100:00)	6.73±0.71c	7.27±1.03c	7.09±0.98bc	7.55±0.67b
PG+U (50:50)	7.00±0.74bc	7.00±0.98cd	7.00±0.74c	7.18±1.04c
PG+S (90:10)	6.73±0.74c	6.73±0.52d	6.55±0.91d	6.91±0.89d
D+S (90:10)	6.45±0.62de	6.90±0.98d	6.55±0.63d	6.91±0.89d
D+M (90:10)	6.63±0.74d	5.36±0.71e	5.90±0.92e	6.18±0.26e

Cells with different alphabet down the column indicate significance difference between their means at  $p$ -value = 0.05; D (100:0) = Dehulled maize akamu; U (100:0) = Undehulled maize akamu;

PG (100:0) = Partially germinated maize; PG+U (50:50) = Partially germinated maize + Ungerminated maize; D+S (90:10) = Dehulled maize + soybean; PG+S (80:20) = Partially germinated maize + soybean; D+M (90:10) = Dehulled maize + melon seed meal akamu

#### 4. CONCLUSION

Dehulling renders akamu nutritionally inferior, further depreciated by soaking and wet-sieving process. Akamu prepared by traditional process although possessed better sensory and functional properties, yet the nutritive value is far below those of oil-seed treated akamu. Akamu made with partially germinated maize either alone or its blends with undehulled maize or soybean possessed superior nutritive value including higher mineral element profile, functional and sensory properties. Short germination time of less than 48 h is adequate to produce akamu with better nutrient density, further supplementation with oil seed such as

soybean boosted further akamu nutritive value. The more oily melon seed reduced the cherished sensory attributes associated with akamu even at 10% supplementation thereby masking its superior nutritional value. Fortification reduced the water absorption capacities and the swelling power. Storage of wet-akamu cake at ambient conditions is not healthy therefore the adoption of simple and faster drying method for akamu is advocated which ensures safe and storage stable akamu.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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