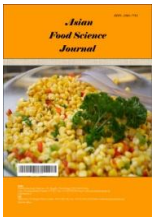

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# Nutritional Composition, Microbiological Quality and Sensory Properties of *Kunu-zaki* Produced from Millet and Tigernut Blend

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author KMAA designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author ARO wrote the protocol and together with author OCA managed the analyses of the study. Author ARO managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** To investigate the effect of supplementation of *kunu-zaki* with milk on its nutritional and microbiological qualities and overall acceptability.
**Place and Duration of Study:** Department of Science Laboratory Technology, Faculty of Applied Sciences, Rufus Giwa Polytechnic, Owo, between April, 2019 and July, 2019.
**Methodology:** The two (2) *Kunu-zaki* blends were produced by traditional fermentation method, thereafter, they were screened for the presence of microorganisms using pour plate method while colonial characteristics and biochemical tests (Sugar utilization, catalase, coagulase, oxidase) were done to confirm the identity of the organisms. The proximate composition (moisture, protein, lipid, ash, fibre and carbohydrate) of the samples were assayed using standard procedures. The sensory properties of the *Kunu-zaki* were assessed using a trained panel. Data were analyzed statistically using SPSS version 17.0 and the means separated using Duncan Multiple Range Test.
**Results:** Coliforms and *Enterobacteriacea* were not found in the enriched and control *Kunu-zaki* samples. However, the highest total heterophilic bacterial count ($107x10^3$ cfu/ml) and lactic acid

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bacterial count (131 x$10^3$ cfu/ml) were found in sample B while the least counts were found in the control sample with 92 x$10^3$ cfu/ml and 122 x$10^3$ cfu/ml total bacterial and lactic acid bacterial counts respectively. Further, the highest fungal count was found in control sample (67 x$10^3$ sfu/ml) while the least count were observed on sample B (52 x$10^3$ sfu/ml). The control sample had the lowest pH 4.65 while sample C had the highest pH of 5.95. Also, the TTA ranged between 0.57% I sample C and 0.83% in control sample. A total of six (6) bacteria and six (6) fungi were isolated from the freshly prepared *kunu-zaki*-tigernut milk blends, they were *Bacillus subtilis*, *Bacillus licheniformis*, *Micrococcus luteus*, *Lactobacillus acidophilus*, *Lactobacillus plantarum*, *Streptococcus* species, *Geotrichum candidum*, *Saccharomyces cerevisiae*, *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium* and *Penicillium* species. The crude protein, moisture content and fat of the enriched *Kunu-zaki* were significantly ($p \leq 0.05$) higher than the control sample. Also, there was a reduction in fibre, ash and carbohydrate content of the enriched *Kunu-zaki* product compared with the control sample. The enriched *Kunu-zaki* samples had higher level of potassium, magnesium and phosphorus than the control *Kunu-zaki* while they had lower calcium and sodium concentrations. *Kunu-zaki*-tigernut milk blends had comparable rating to the control in appearance and aroma but had a higher rating for taste and overall acceptability.
**Conclusion:** The enrichment of *Kunu-zaki* with tigernut milk had significant elevating effect on the nutrition and sensory properties of the *Kunu-zaki* and its overall acceptability.

*Keywords: Kunu-zaki; enrichment; nutritional composition; microbial quality; sensory properties.*

## 1. INTRODUCTION

*Kunu-zaki* is a non-alcoholic indigenous beverage drink that is commonly used for refreshment in several places in Nigeria [1]. It is reported as an appetizer, food complement and refresher to quench thirst [2]. It is milky cream in appearance and are consumed within few hours of its production [2]. It can be prepared from several independent plants including sorghum (*Sorghum bicolor*), millet (*Penisetum typhoides*), maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum aesstivum*) and acha (*Digitalis exilis*) [3]. *Kunu-zaki* is rich nutritionally, therefore many Nigerians who could not afford milk extensively consume this drink especially in the rural areas especially among the students population in higher institution [4]. Amusa and Ashaye [5] reported the nutritional content of Kunu drink are.3hou1 – 3.63% (protein), 3.55 – 3.63% (fat), 1.16 – 1.21% (ash), 82.92 – 83.55% (carbohydrate). According to Amusa and Odunbaku [6], food is a vital ingredient for the nourishment of life especially in plants and animals. Hence, all fruits, vegetables, cereals, drinks and juices or dairy products are foods. They are known to be associated with some microorganisms [7].

*Kunu-zaki* has been reported to be processed by following different technological process such as steeping the whole grains for 6-24 hours, wet milling with spices and sweep potato, gelatinization of about three-quarter of the mixture in hot water, pitching with about one-quarter fresh (ungelled) part of the mixture. Thereafter, the drink is ready for consumption after 6 – 24 hours of fermentation [8,1].

Food fortification is the addition of micronutrients to processed foods. In many situations, this strategy can lead to relatively rapid improvements in the micronutrient status of a population. It has been observed that, food fortification can be a very cost-effective to public health intervention. However, an obvious requirement is that the fortified food(s) needs to be consumed in adequate amounts by a large proportion of the target individuals in a population [9]. It is also necessary to have access to, and to use, fortificants that are well absorbed yet do not affect the sensory properties of foods [10].

Tigernuts and its products are rich in carbohydrates, mono-, di-, and polysaccharides. They contain relatively high levels of protein, oleic acid (monounsaturated fatty acid which has a bigger resistance to chemical decomposition) and fat. Tigernuts have excellent nutritional quality with a fat composition similar to olive oil and rich mineral content, especially phosphorus and potassium. Tigernut oil has a mild, pleasant flavour and is considered as food oil similar but superior in quality to olive oil. The polyunsaturated fatty acid content (linoleic acid & linolenic acid) is enough to cover daily minimum needs of about 10 g and the oil has high content of Vitamin E (alpha-tocopherol) and

thus higher oxidative stability than other oils, due to its content of polyunsaturated fatty acids and gamma-tocopherol [11].

Microbial spoilage of food is of great concern since food present nearly ideal conditions for the survival and growth of many types of microorganisms. Bacteria and fungi (yeasts and molds) are the principal types of microorganisms that cause food spoilage and food-borne illnesses. The primary sources of microbial contamination are soil, air, water and the processing machinery or utensils. Every culture on earth, through written or oral tradition has relied on the vast variety of natural chemicals found in healing plants for their therapeutic and preservative properties. Such plants can be put into culinary or medicinal use [12]. Therefore, this research was undertaken to assess the microbiological quality, proximate composition and sensory property of kunu produced from millet and tiger nut blend.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Sample

Tigernut (yellow type), millet samples, other ingredients such as sugar were purchased from Shasha market in Akure, Ondo state, Nigeria in May 2019. They were taken to the laboratory immediately for further analyses.

### 2.2 Sterilization Procedure

The glass wares, such as conical flask, beaker, test-tubes etc. were duly washed thoroughly with detergent using brush. They were subsequently rinsed in large quantity of clean water and dried in a drying cabinet and then sterilized in hot air oven for 30 mins at holding temperature of 180°C. Inoculating wire loop used were sterilized by flaming with a spirit lamp until red hot and then allowed to cool before using. The surfaces of the workbench were sterilized by wiping with cotton wool soaked in 75% alcohol before and after each working period.

### 2.3 Media Used

The media used for this work include Nutrient Agar (Oxoid, Uk) for isolation of total bacteria, Eosin Methylene Blue agar (Oxoid, Uk) for isolation of coliforms, De Mann Rogosa Soy agar for the isolation of Lactic acid bacteria, MacConkey agar (Oxoid, Uk) for isolation of the *Enterobactericeae* and Potato dextrose agar (Oxoid, Uk) for isolation of fungi. They were prepared strictly according to the manufacturer's specifications and then autoclaved at 121ºC for 15 mins.

### 2.4 Production of Tigernut Milk

Fresh 500 g of tigernuts were soaked in two changes of clean water for 12 hours. The soaked tigernuts were washed in two changes of water, drained, blended into paste in electric blender and slurred. Two thousand and five hundred (2500 ml) of distilled water was used all together during the blending and slurring process. The slurry was filtered with the aid of a clean damp muslin cloth and the filtrate obtained was transferred into sterilized plastic bottles, corked and stored in the freezer prior to analysis. Fig. 1 shows the processes involved in tigernut milk production.

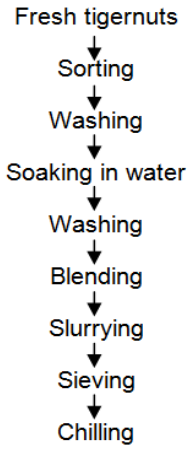
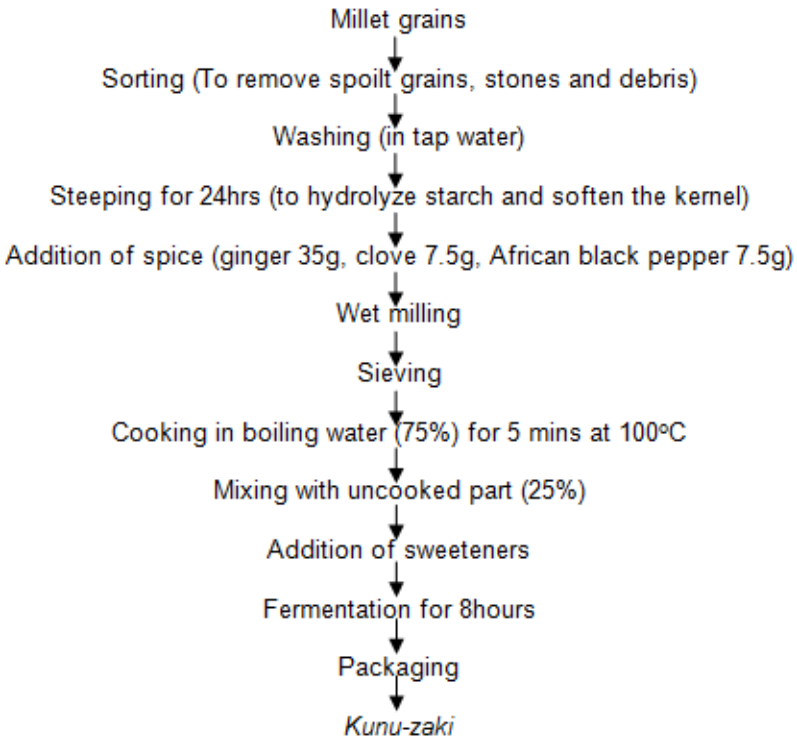



**Fig. 1. Flowchart for the production of tigernut milk**

### 2.5 Production of *Kunu-zaki* Samples

Two hundred and fifty grams (250 g) of millet grains were steeped in 500 ml of distilled water in an airtight plastic container for 24hours (primary fermentation). Thereafter, the grain was washed and mixed with spices (ginger 35 g, clove 7.5 g, African black pepper 7.5 g); the mixture were wet-milled and sieved. The resultant slurry was divided into two parts (3:1). The larger part was cooked by adding boiling water (100°C) and allowed to cool to about 50°C after which the uncooked part was added to the cool cooked part and then homogenized. Sweeteners were added to taste during the mixing, and then the mixture was allowed to ferment (secondary fermentation) for 8 hours after which it was packaged [12].




**Flowchart for the production of *kunu-zaki***

## 2.6 Preparation of *Kunu-zaki*-tigernut Milk Blends

Different blends of *Kunu-zaki* and tigernut milk blends were prepared as follows:

A: 1000 ml of *Kunu-zaki* 0% tigernut milk

B: 850 ml of *Kunu-zaki* + 150 ml of tigernut milk 15% tigernut milk

C: 700 ml of *Kunu-zaki* + 300 ml of tigernut milk 30% tigernut milk

## 2.7 Microbiological Analyses

Nine ml of distilled water was pipette into 5 clean test tubes each, they were covered with cotton wool and aluminum foil, and then they were autoclaved at 121°C for 20 mins. The sample was macerated in a beaker, 1g of the macerated sample was weighed into a sterile test tube containing 9 ml of distilled water was added to make 1:9 of sample water ratio i.e. $10^{-1}$. The mixture was shaken well to suspend the propagules then a sterile pipette was used to measure 1m from the supernatant into another test tube containing 9 ml sterile distilled water. The mixture was shaken to homogenize this makes $10^{-2}$. This was done in sequential order until the last test tube $10^{-5}$ [12].

### 2.7.1 Isolation of microorganism

The pour plate method was adopted for the culturing of the organisms. One (1) ml of the aliquot of $10^{-3}$ were dropped in pre-labeled separate sterile petri dishes in duplicates, 20 ml of molten agar at 45°C was poured on it and the petri dishes were swirled to homogenize. The plates were allowed to solidify on working bench and then they were incubated inverted in incubator at 35°C for 18 to 24 hours for nutrient agar, EMB and MacConkey agar plates while MRSA plates were incubated anaerobically for 48hrs. Fungal plates were incubated at room temperature for 3 to 7 days. The colonies were counted after incubation and discrete colonies were sub-cultured on nutrient agar slant for further identification [12].

### 2.7.2 Characterization of isolates

The cultural and morphological characteristics of the colonies were observed based on the criteria of Berger's Manual of Determinative Bacteriology. These include the following; shape

of the colonies, the elevation, the edge, optical characteristics and pigmentation. Biochemical characterization of the isolates was done including Gram staining reaction, sugar fermentation, catalase, coagulase and oxidase tests [7].

### 2.7.3 Identification of fungi

Pure cultures of fungi isolates were characterized and identified based on the morphological characteristics of the organisms and confirmed by comparing them with the characteristics given in fungi data base. The morphological characteristic of the moulds were based on the size, colour and aerial mycelia growth [13].

## 2.8 Proximate Composition

This was done according to the methods of AOAC [14].

### 2.8.1 Moisture content

The moisture content was determined by using oven-drying method. Clean and dry Petri-dishes were weighed by using meter balance and their respective weights were recorded (W1). Five g of the sample was weighed into pre-weighed dry dishes (W2) spreading as much as possible. The dishes containing the sample were transferred into the oven maintained at 105°C and dried for 3 hours. After three hours they were transferred to the desiccators to cool and then weighed. This process was continued until a constant weight (W3) was taken to be the percentage moisture content

> % moisture = [(loss in weight due to drying (W2 –W3) / Weight of sample taken (W2 – W1) x (100 / 1)]

### 2.8.2 Ash content determination

One gram of the sample was weighed into clean dried pre-weighed crucibles with lid (W1). The organic matter was burnt off using flame (lid removed) until the sample became charred. The crucibles were then transferred to the muffle furnace set at 550°C (lid removed). Ashing was continued until a light grey of white ash was obtained. The crucibles were then cooled in desiccators and weighed (W2)

$$\% \text{ Ash} = \frac{W2 - W1 \times 100}{W1}$$

### 2.8.3 Fat content

Cleaned and dried thimbles were weighed as (W1) and 5g oven dried sample was added and re-weighed (W2). Round bottom flask was filled with petroleum ether (40 - 60°C) up to ¾ of the flask. Soxhlet extractor was fixed with a reflux condenser and adjusted the heat source so that the solvent boils gently, the sample(s) were put inside the thimble and inserted into the soxhlet apparatus and extraction under reflux was carried out with petroleum ether (40–60°C). After the barrel of the extractor is empty, the condenser was removed and the thimble was removed, taken into the oven at 100°C for one hour and later cooled in the desiccators and weighed again (W3).

> % Fat = [(Weight loss of sample (extracted fat) (W2 – W3) / Original weight of the sample (W2 – W1) x (100 / 1)]

### 2.8.4 Protein content

Kjeldahl nitrogen method was employed for the determination of protein content of the sample, 1.0 g of the sample was weighed into the digestion flask. Kjeldahl catalyst (5 selenium tablets) was added to the sample. 20 ml of concentrated $H_2SO_4$ was added to sample and then fixed for 8 hours in the digestion unit (450°C) of the Kjeldahl apparatus in fume cupboard. The digest, pure yellow after cooling changed into a colourless liquid that was transferred into 100 ml volumetric flask and made up to mark with distilled water. About 20 ml of 4% boric acid solution was pipette into conical flask. A drop of methyl red was added to the flask as indicator. The sample was thereafter diluted with 75 ml of distilled water. 10 ml of the digest was made alkaline with 20 ml of NaOH (20%) and distilled. The steam exit of the distillatory was closed and the change of colour of boric acid solution to green was timed. The mixture was distilled for 15 min (AOAC, 1984). The filtrate was then titrated against 0.1 N HCl. The protein content was calculated from the relationship:

> Total protein = [(Titre × Normality of Acid × 0.014 / Sample weight) x (100 / 1)]

> Protein (%) = % Nitrogen x 6.25, Normality of acid (HCL) = 0.1 N, Sample weight = 1.0 g

### 2.8.5 Fibre content

Two (2) grams (W1) of the sample was weighed into one litre conical flask; 200 ml of boiling

1.25% of $H_2SO_4$ was added and boiled gently for 30 mins. The mixture was filtered through muslin cloth and rinsed well with hot distilled water. The sample was scraped back into the flask with spatula and 200 ml of boiling 1.25% NaOH was added and allowed to boil gently for 30mins. It was filtered through muslin cloth and the residue washed thoroughly with hot distilled water and then rinsed once with 10% HCl twice with ethanol and rinsed to drain dry, then the residue was scrapped into a crucible, dried in the oven at 105°C, cooled in a desiccators and weighed (W2). The residue was ashed at 550°C for 90mins in a muffle furnace, cooled and weighed again (W3)

% Fibre = [(W2 – W3 / W1) x (100 / 1)]

#### 2.8.6 Carbohydrate content

Carbohydrate content was determined by subtracting from 100 the sum of the percentage moisture, ash, protein, fat and fibre. The remainder value gives the carbohydrate content of the sample.

% Carbohydrate = 100 - (% Moisture + % Ash + % Fat + % Protein + % Fibre)

### 2.9 Determination of Minerals

The minerals calcium, potassium, sodium, magnesium and phosphorus present in the samples were assayed using the Atomic Absorbance Spectrophotometer (AAS) [15].

### 2.10 Sensory Evaluation

This was done by 10 trained panelists selected randomly from Department of Science Laboratory Technology, Rufus Giwa Polytechnic, Owo, Ondo state. The nine point hedonic scale was used (score "9" having excellent attribute and Score "1" indicating dislike extremely). Samples were coded with random alphabets. The properties evaluated were appearance, taste, aroma and overall acceptability [12].

### 2.11 Statistical Analysis

All data were analyzed by using SPSS version 17. Data were analyzed using one-way analysis of variance (ANOVA), the Duncan's New Multiple Range Test was used to compare means at 95% confidence interval.

## 3. RESULTS AND DISCUSSION

The microbial count on the freshly prepared *kunu-zaki*-tigernut milk blends is shown in Table 1. The table revealed that coliforms and enteric bacteria were not found in the enriched and control *Kunu-zaki* samples. However, the highest total heterophilic bacterial count ($70.00x10^2$ cfu/ml) and lactic acid bacterial count ($131.00 x10^3$ cfu/ml) were found in sample B while the least counts were found in the control sample with $32.00x10^2$ cfu/ml and $122.00 x10^3$ cfu/ml total bacterial and lactic acid bacterial counts respectively. Further, the highest fungal count was found in control sample ($67.00 x10^3$ sfu/ml) while the least count were observed on sample B ($52.00x10^3$ sfu/ml). These results are in agreement with the observation of Akoma et al. [16] who reported similar range in their study. The absence of coliform and *Enterobacteriacea* in the *Kunu-zaki* samples produced in this study is at variance with the report of Akoma et al. [17] who reported coliform contamination of street hawked *kunu-zaki*n samples in Northern Nigeria. The difference may be due to the strict aseptic measures adopted during the sample production in the laboratory. Also, the coliform bacteria in the street hawked *Kunu-zaki* may have been introduced in to the *Kunu-zaki* during dilution with water during production by these producers in order to increase their profit margin. Such dilution of the product with water lowers the quality and increases the risk of contamination with pathogenic organism especially if the water source is of poor quality.

Table 2 shows the pH and total titratable acidity of the freshly prepared *Kunu-zaki*-tigernut milk

**Table 1. Microbial count on the *Kunu-zaki*-tigernut milk blends (x $10^2$ cfu/ml)**

| Sample | Total bacterial count | Lactic acid bacteria | Coliform bacteria | Enterobacteriaceae count | Fungal count |
|---|---|---|---|---|---|
| Sample A | $32.00±0.01^a$ | $122.00±0.01^a$ | - | - | $67.00±0.01^b$ |
| Sample B | $57.00±0.01^b$ | $131.00±0.02^b$ | - | - | $52.00±0.01^a$ |
| Sample C | $70.00±0.15^c$ | $129.00±0.01^b$ | - | - | $58.00±0.01^a$ |

*Key: values are mean±SEM, values with different alphabet along the column are significantly different at p≤0.05*

samples. The control sample had the lowest pH 4.65 while sample C had the highest pH of 5.95. Also, the TTA ranged between 0.57% I sample C and 0.83% in control sample. These values were slightly higher than the one reported by Akoma et al. [17] who studied the commercially produced *Kunu-zaki* sold in Niger state, Nigeria. Although, the low pH and acidity observed may be linked with acid production by some bacteria during fermentation which involves the degradation of carbohydrates. Some of the bacteria associated with the fermentation of *Kunu-zaki* are known to be acid producers such as Lactobacillus species and the acetic acid bacteria [18].

**Table 2. The final pH and TTA of the *Kunu-zaki*-tigernut milk blends**

| Parameter | pH | TTA (%) |
|---|---|---|
| Sample A | 4.65±0.01[a] | 0.83±0.10[b] |
| Sample B | 5.76±0.00[b] | 0.61±0.00[a] |
| Sample C | 5.95±0.00[b] | 0.57±0.07[a] |

Table 3 shows the total number of six (6) bacteria and six (6) fungi were isolated from the freshly prepared *kunu-zaki*-tigernut milk blends, they were *Bacillus subtilis*, *Bacillus licheniformis*, *Micrococcus luteus*, *Lactobacillus acidophilus*, *Lactobacillus plantarum*, *Streptococcus* species, *Geotrichum candidum*, *Saccharomyces cerevisiae*, *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium* species and *Penicillum* species. Most of these organisms have been reported by Oranusi et al. [8] to take part in fermentation of various types of cereal products especially *Kunu-zaki* and ogi. And they may have been introduced into the product from the cold uncooked part during the production of the product. These organisms if not removed after production may continue to ferment the product leading to total spoilage of the product as observed by Umaru et al. [1].

The results of the proximate composition of the *Kunu-zaki* samples are presented in Table 4. In the table, the crude protein (%), moisture content (%) and fat (%) of the enriched *Kunu-zaki* were higher than the control sample with higher percentage of these parameters observed with increase in the tigernut milk component. Also, there was a reduction in fibre, ash and carbohydrate content of the enriched *Kunu-zaki* product compared with the control sample. Although, the differences were not significant, they were higher than those reported for commercial *Kunu-zaki* by earlier researchers. The increase in the protein content of the enriched *Kunu-zaki* samples may be due to the higher protein content of the tigernut milk. Also, the increase in moisture content of the enriched *Kunu-zaki* samples may be linked to the volume of water used for the extraction of the tigernut milk. Moreover, the increase in fat content of the enriched *Kunu-zaki* samples may be due to the oil present in the tigernut extract. This has been observed earlier by Osagie and Eka [15]. High fat content of tigernut milk may indicate high values of oil soluble vitamins such as vitamins A, D, E and K [19].

Table 5 shows that the enriched *Kunu-zaki* samples had higher level of potassium, magnesium and phosphorus than the control *Kunu-zaki* while they had lower calcium and sodium concentrations. The richness of the enriched *Kunu-zaki* in essential minerals

**Table 3. Microbial quality of freshly produced *Kunu-zaki*-tigernut milk blends**

| Organism | Sample A | Sample B | Sample C |
|---|---|---|---|
| *Bacillus subtilis* | + | + | + |
| *Bacillus licheniformis* | - | + | + |
| *Micrococcus luteus* | + | + | - |
| *Lactobacillus acidophilus* | + | + | + |
| *Lactobacillus plantarum* | + | + | + |
| *Streptococcus* species | + | + | + |
| *Geotrichum candidum* | + | + | + |
| *Saccharomyces cerevisiae* | + | + | + |
| *Aspergillus niger* | + | + | + |
| *Rhizopus stolonifer* | - | + | + |
| *Fusarium* species | - | + | + |
| *Penicillum* species | - | + | + |

*Key: += present, -= absent*

**Table 4. Proximate composition of freshly produced *Kunu-zaki*-tigernut milk blends (%)**

| Parameter | Sample A | Sample B | Sample C |
|---|---|---|---|
| Moisture | 74.81±0.00[a] | 78.59±0.00[b] | 82.38±0.01[c] |
| Protein | 1.71±0.03[a] | 1.97±0.04[b] | 2.10±0.00[b] |
| Crude fibre | 0.48±0.01[c] | 0.32±0.12[b] | 0.28±0.01[a] |
| Crude fat | 0.19±0.11[a] | 1.12±1.00[b] | 1.23±0.02[b] |
| Ash | 0.28±0.08[b] | 0.17±0.07[a] | 0.15±0.10[a] |
| Carbohydrate | 22.53±0.00[c] | 17.83±0.00[b] | 13.86±0.15[a] |

**Table 5. Mineral composition of freshly produced kunun-tigernut milk blends (mg/L)**

| Mineral | Sample A | Sample B | Sample C |
|---|---|---|---|
| Calcium | 24.01±0.00[b] | 20.16±0.02[a] | 18.11±1.05[a] |
| Potassium | 319.33±0.15[a] | 377.00±0.18[b] | 430.22±0.05[c] |
| Sodium | 400.20±1.00[a] | 381.17±0.01[a] | 370.00±0.08[a] |
| Magnesium | 230.00±0.10[a] | 249.40±0.02[a] | 280.25±0.11[b] |
| Phosphorus | 245.19±0.07[b] | 377.16±0.00[a] | 570.00±0.18[c] |

**Table 6. Organoleptic properties of freshly produced *Kunu-zaki*-tigernut milk blends**

| Parameter | Sample A | Sample B | Sample C |
|---|---|---|---|
| Appearance | 6.01±0.01[a] | 6.50±0.02[a] | 6.40±0.01[a] |
| Aroma | 7.12±0.04[ab] | 6.67±0.00[a] | 6.18±0.01[a] |
| Taste | 6.20±0.00[a] | 7.50±0.05[b] | 8.67±0.01[c] |
| Overall acceptability | 6.87±0.01[a] | 7.00±0.01[ab] | 8.12±0.01[b] |

*Key: Each data is the mean± standard error of 20 member taste panelist (9-point hedonic scale: 9 = Excellent, 7 = like extremely, 6= like very much, 5 = like slightly, 4 = neither like nor dislike, 3 = dislike slightly, 2 = dislike very much, 1 = dislike extremely)*

such as magnesium, potassium, calcium, sodium and phosphorus suggests that fortification of *Kunu-zaki* with tigernut milk may help to reduce micronutrient deficiency in humans. The *kunu-zaki*-tigernut milk blend could be taken by young and old (children, adolescents, adults, pregnant and lactating mothers) for its high energy and preventive or protective nutrients. These nutrients could significantly contribute to the body's metabolic processes, refreshing the body as well [15]. Magnesium provides bone strength, aids enzyme, nerve and heart functions. Tigernut milk could contribute adequate Mg to the daily need of children. Phosphorus enhances quick release of energy in the body and may combine with calcium for bone and teeth development. Tigernut milk are relatively low in calcium and sodium. Recent studies on blood pressure showed that a diet rich in potassium and magnesium but low in sodium can lead to a decrease in blood pressure within days of beginning a specific diet [20]. Potassium aids nerve impulse transmission and it is a major cation of intracellular fluid. High potassium to low sodium ratio of *kunu-zaki*-tigernut milk therefore, may be imperative in diet formulations for patients with high blood pressure and oedema as well.

In the organoleptic properties evaluation, *Kunu-zaki*-tigernut milk blends had comparable rating to the control in appearance and aroma but had a higher rating for taste and overall acceptability (Table 6). This may be attributed to the level of sugar naturally present in tigernuts. The higher rating of the enriched *Kunu-zaki* samples may be attributed to the better attribute and 'milky' taste of tigernut milk and the difference in the acceptability may be due to the difference in chemical composition as may have been introduced by the tigernut milk in the enriched *Kunu-zaki* sample [21].

## 4. CONCLUSION

From the results obtained in this study, it can be concluded that enrichment of *Kunu-zaki* with tigernut milk significantly enhanced its nutritional properties as shown in the proximate and mineral content results obtained. Also, the enrichment of *Kunu-zaki* with tigernut milk had significant elevating effect on the sensory properties of the

*Kunu-zaki* and its overall acceptability. However, more studies are needed to eliminate the array of microorganisms found in the *Kunu-zaki* to prevent easy spoilage.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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