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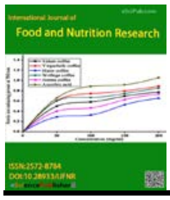

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Effect of Pasteurisation on the Proximate Composition, Mineral and Sensory Properties of Fresh and Dry Tiger Nuts, and Their Milk Extracts

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ABSTRACT

The proximate, mineral and sensory properties of pasteurised and unpasteurised fresh and dry yellow tiger nuts and their milk extract were evaluated. Milk from samples of fresh and dry tiger nuts were extracted separately by wet milling and expression before pasteurisation. The moisture, protein, fat, ash, crude fibre, carbohydrate and energy content of the tiger nuts varied from 14.36 - 47.98%, 5.54 – 6.85%, 1.31 – 1.97%, 5.28 – 4.60%, 26.09 - 24.60%, and 296.72 – 434.00 KJ/g respectively. The total sugar content was 9.82 - 11.85% for pasteurised tiger nuts and 10.09 - 12.64% for unpasteurised nuts while reducing sugar ranged from 3.06 - 4.82 and 3.67 - 5.01% respectively, for pasteurised and unpasteurised tiger nuts. Cu, Fe, Zn, Ca, Mg and K content ranged from 0.09 - 0.13, 11.00 - 13.74, 0.05 - 0.06, 1692.94 - 1921.99, 265.12 - 794.57 and 1048.34 - 1181.67 mg/100g respectively. The moisture, protein, fat, ash, crude fibre, carbohydrate and energy values of the milk extract varied from 76.93 - 81.92%, 9.84 - 11.41%, 3.09 - 5.01%, 0.01 - 0.03%, 0.01 - 0.11%, 2.74 - 7.16% and 373.22 - 488.68 KJ/g respectively. Total sugar content was 9.63 - 11.64 and 10.81– 12.23% respectively, for the pasteurized and unpasteurized milk while the reducing sugar ranged from 3.42 - 4.13 and 4.14 - 4.49 %. Cu, Fe, Zn, Ca, Mg and K content varied from 0.02 - 0.03, 3.67 - 4.34, 0.02 - 0.03, 606.98 - 669.32, 86.88 - 289.71 and 349.45 - 393.89 mg/100g respectively. Dry tiger nut and its milk had significantly ($P \leq 0.05$) higher proximate, sugar and mineral contents. Pasteurization significantly ($P < 0.05$) increased the ash, moisture, carbohydrate, Cu, Fe and Mg with decrease in fat, protein and sugar contents of the milk. This study has revealed that pasteurization contributed to significant increase in nutrient content of the tiger nuts and its milk.

Keywords:
Tiger nut, milk, pasteurisation, proximate composition, mineral, sensory properties.

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1. Introduction

Tiger nut (*Cyperus esculentus*), is an emerging grass- like plant belonging to the family *Cyperaceae* and the order, *Commelinalis* [1]. Tiger nuts *(Cyperus esculentus*) have long been recognized for their health benefits as they are rich in fibre, protein and natural sugars, minerals (phosphorus, potassium), and vitamins E and C [2], [3]. It is a popular plant in Nigeria and known by different names by different ethnic groups. In the Eastern and Southern parts of Nigeria, it is known as “aki-Hausa” or “ofio” while it is commonly called “aya” and “mumu” in the Northern and Western parts respectively. Three varieties (Black, brown and yellow) are cultivated in the country and among these, only two varieties (yellow and brown) are readily available in the market. The yellow variety is preferred to all other varieties because of its inherent properties like its bigger size and attractive colour. The yellow variety also yields more protein and possess less anti-nutritional factors especially polyphenols [4]. Tigernut produces high quality oil of up to about 25.5% content and 8% of protein [3]. Tiger Nut (*Cyperus esculentus*) is a plant species with the potentials of ensuring and promoting healthy living among humans [5]. In Nigeria, tiger nut is available in fresh, semi-dried and dried forms in the markets where it is sold locally and consumed even un-processed. The utilization of tiger nut is highly limited in spite of the fact that tiger nut is cultivated widely in the Northern part of the country [6]. This could probably be attributed to ignorance on the nutritional status of the plant and the plant products. Nutritionally, the protein in tiger nut is of high biological value considering its many essential amino acids content that satisfy amino acid need of adults [7], [8]. Tiger nut is also an excellent source of some useful minerals (iron, calcium phosphorus, potassium, sodium, magnesium, zinc and traces of copper) and vitamin E that are essential for body growth and development [9]. Tiger nuts and its products are rich in carbohydrates, mono-, di-, and polysaccharides and have excellent fat composition similar to olive oil [10], [11]. Tiger nut is a functional food, with nutraceutical benefits. It helps to prevent heart problems, thrombosis and activate blood circulation [12], treating urinary tract and bacterial infection and assist in reducing the risk of colon cancer [3], control blood pressure due to its high in Arginine content [13], [14].

Tiger nut is a good source of vegetable milk. Although, Soybean has received very high research attention among vegetable milk and more research is still being designed to improve the quality of soymilk [15]. Tiger nut milk is now being given attention as a locally available underutilized tuber in milk production. The physical, chemical and sensory characteristics of the tiger nut milk beverage have been found to depend on factors, such as the variety of tuber and procedure for beverage production [2], [16]. Pasteurization is one of the most important processes in milk production and in the food industry due to its important in food preservation and shelf life extension. There are many physical methods used in pasteurization such as raising temperatures, decreasing of temperatures suddenly, drying and irradiation [17]. Heating of the tiger nut milk beverage above 72°C has been reported to result in changes in the physical and organoleptic characteristics due to the gelatinization of the starch [13]. The need for adequate information on the influence of pasteurisation on the nutrient and sensory quality of this all important beverage engendered the objective of this study, to evaluate the effect of pasteurization on the proximate composition, mineral and sensory properties of fresh and dry tiger nuts and their milk extract.

2. Materials and Methods

2.1 Tiger nut samples

The yellow variety of fresh and dry tiger nuts used for this study was sourced from the fruit market in D/Line, Port Harcourt, Rivers State, Nigeria.

Sample preparation

The tiger nuts after sorting to remove foreign matters, sand, broken and bad nuts were washed with tap water. Before milk extraction, about 1 kg of the dry nuts was soaked with 5 litres of tap water for 48 h. Thereafter, the nuts were washed again with clean tap water.

2.2 Extraction of milk from the fresh and dry tiger Nuts

Tiger nut milk was extracted according to the method described by Udeozor and Awonorin, [18], with some modifications as shown in Figure 1. About 1kg of the cleaned tiger nut was blended five times for 5min each into slurry with 2 L of potable water in a Kenwood blender (Model BL440, UK). The milk from the slurry was extracted using muslin cloth. Half portion of the milk extract was pasteurized at 72ºC for 10mins, allowed to cool to a constant temperature of 25ºC, the second half was unpasteurized. The freshly extracted milk samples were thereafter used for further analysis.

2.3 Proximate Analysis

The moisture, ash, protein, fat, crude fibre and carbohydrate contents were determined using the standard method of AOAC [19]. Energy was obtained using the at-water factor of 37 KJ/g for fat and 17 KJ/g for protein and carbohydrate

2.4 Sugar Determination

Determination of sugar (total, reducing and non-reducing sugar) was carried out using Lane and Eynon method as described by James [20]. For the fresh and dry tiger nuts, 5g of the slurry of each was used while 5 mL of the extracted milk was used for the evaluation of the sugar content. Briefly, the samples were measured into a beaker and 100ml of warm water was added. The solution was stirred until all the soluble matters were dissolved and filtered through wattman filter paper into a 250 volumetric flask. This solution was used for titration to obtain the reducing sugars. For the total sugar estimation, 100ml of the prepared solution was pipetted into a conical flask; 10ml of dilute HCL was added and boiled for 5mins. It was allowed to cool and the solution was neutralized with 10% NaOH and made up to volume in a 250 volumetric flask. The solution was used for titration against Fehling's solution. The reading was taken and the sugars calculated as follows:

% Reducing Sugars = $(F \times D) / (T \times W \times 10)$

% Total Sugars = $(F \times D \times 2.5) / (T \times W \times 10)$

Where:

F = 4.95 mg glucose (Glucose factor for 1 ml of Fehling's solution as the milk was extracted from tuber not an animal source)

D = 250 ml dilution

T = Titre

W= Weight of sample

Non-reducing sugar was estimated as the difference between total sugar content and reducing sugar content

2.5 Mineral Determination

Calcium (Ca), Copper (Cu), Iron (Fe), Magnesium (Mg), Potassium (K) and Zinc (Zn) content of the tiger nuts and the tiger nut milk were analysed according to the standard method of AOAC [19], using Atomic Absorption spectrophotometer (AAS) (Hitachi Z-5300, polarized Zeaman, Hitachi Ltd, Japan). The light source was Hollow cathode lamp of each element, using acetylene and air combinations, under the following conditions: air pressure of 0.3Mpa, air flow rate of 6.5L/min, acetylene pressure of 0.09Mpa and a flow rate of 1.7 L/min was used.

2.6 Sensory Evaluation

A panel of 25 panelists consisting of staff and students randomly chosen from the department of Food Science and Technology, Rivers State University, Port Harcourt were used for evaluation of the sensory attributes of the pasteurized and unpasteurized Tigernut milk. They were asked to assess the samples based on the following attributes: appearance, colour, flavour, taste and overall acceptability. Panelists rating were based on a 9-point hedonic scale with the degree of likeness of the product attribute express as: 1 - dislike extremely, 2 - dislike very much, 3 - dislike moderately, 4 - dislike slightly, 5 - neither like nor dislike, 6 - like slightly, 7 - like moderately, 8 - like very much and 9 - like extremely [21].

2.7 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA): general linear model (GLM) using IBM SPSS (Release 2015) software for windows version 23.0, (Amrmonk, Ny: IBM Corp). Statistical differences were established at ($P \leq 0.05$).

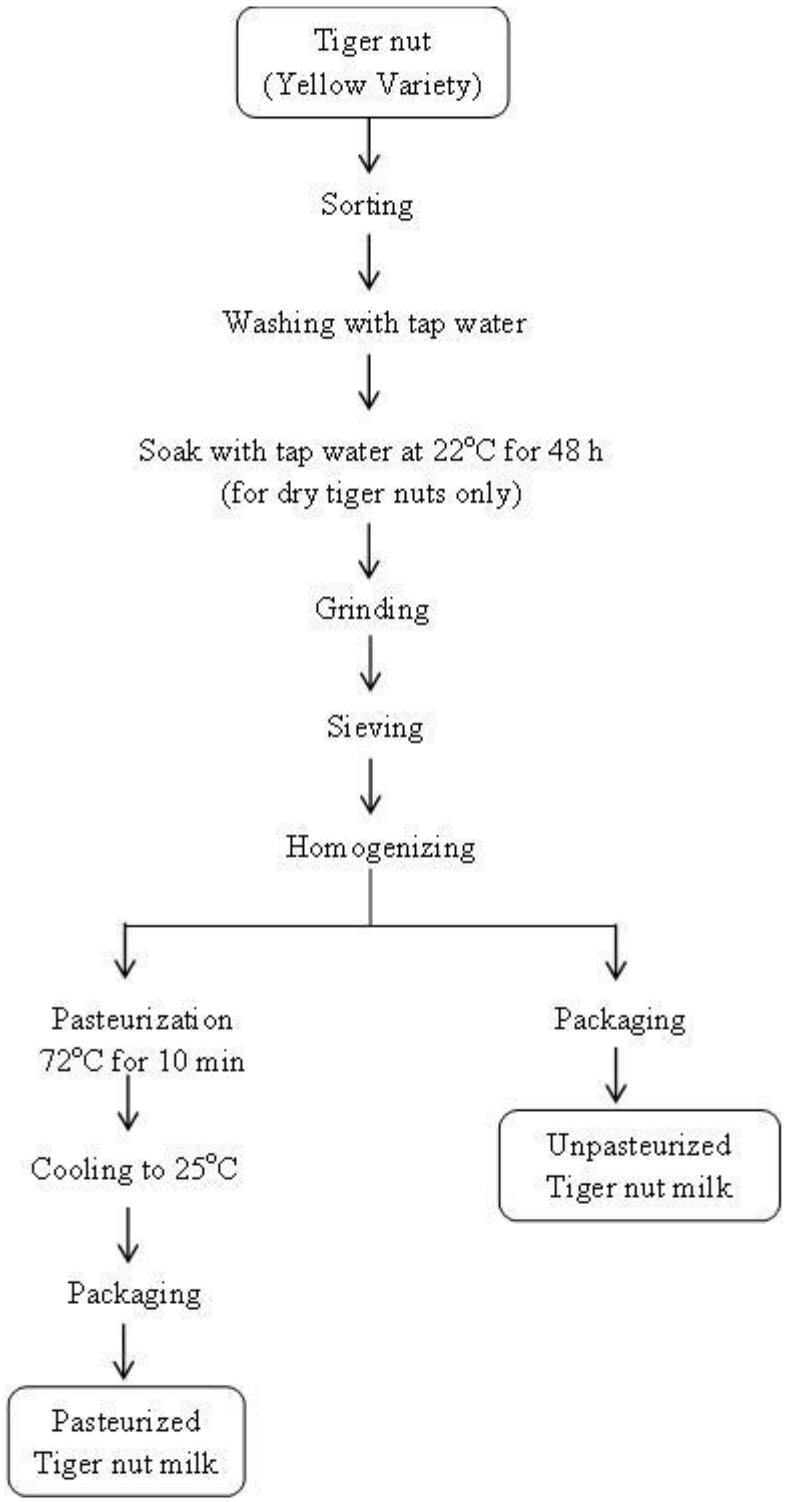

Figure 1: The flow chart for production of tiger nut milk

3. Results

3.1 Proximate Composition

3.1.1 Proximate composition and Sugar Content of pasteurised and unpasteurised fresh and dry Tiger nuts

The proximate composition of the pasteurised and unpasteurised fresh and dry tiger nuts are shown in Table 1.

Table 1: Proximate composition (%) of pasteurized and unpasteurised fresh and dry tiger nuts

Sample	Moisture	Fat	Ash	Fibre	Protein	Carbohydrate	Energy(KJ/g)
F_{UN}	46.09±0.44^{b}	5.28±0.20^{a}	1.38±0.06^{b}	16.22±0.11^{a}	6.43±0.16^{b}	24.60±0.53^{d}	319.48^{c}
F_{PN}	47.98±0.87^{a}	4.60±0.08^{b}	1.31±0.02^{b}	14.50±0.16^{b}	5.54±0.24^{c}	26.09±0.97^{c}	296.72^{d}
D_{UN}	14.36±0.43^{d}	4.68±0.15^{b}	1.97±0.18^{a}	13.77±0.33^{c}	6.85±0.19^{a}	58.36±0.86^{a}	434.00^{a}
D_{PN}	39.96±0.98^{c}	5.04±0.36^{a}	1.76±0.20^{a}	14.37±0.53^{b}	6.57±0.23^{b}	32.25±0.88^{b}	341.76^{b}

Values with the same superscript in the same column are not significantly (p<0.05) different. N = 4 ± SD F_{UN} = Unpasteurized fresh tiger nut; F_{PN} = Pasteurized fresh tiger nut; D_{UN} = Unpasteurized dry tiger nut; D_{PN} = Pasteurized dry tiger nut

Moisture content of the tiger nuts increased with pasteurization from 46.09 to 47.98% for the fresh nuts and 14.36 to 39.96% for the dry nuts. The unpasteurized dry tiger nuts had significantly (p≤0.05) the least moisture content. The ash content varied from 1.31 – 1.97%. The ash content of the dry tiger nut was significantly higher than the fresh tiger nuts. Pasteurization had no significant (p≤0.05) effect on the ash content of the tiger nuts. Pasteurization resulted in decrease in crude fibre content of the fresh tiger nuts from 16.22 to 14.50%, while an increase was observed for the dry tiger nuts (from 13.77 to 14.37%). There was no significant (p≤0.05) difference in the fibre content of the pasteurized tiger nuts. The fresh tiger nuts had significantly (p≤0.05) the highest content of crude fibre. The protein content of the tiger nuts varied significantly (p≤0.05) from 5.54 – 6.43% and 6.57 – 6.85% respectively, for the fresh and dry tiger nuts. The dry unpasteurized tiger nuts had significantly (p≤0.05) the highest protein content while the pasteurized fresh nuts had significantly (p≤0.05) the least. The protein content decreased with pasteurization. Pasteurization resulted in increase in fat content of the dry tiger nuts from 4.68 – 5.04% while a decrease was observed for the fresh tiger nuts (5.28 – 4.60%). For the dry tiger nuts, pasteurization resulted in increase in carbohydrate content (from 32.25 to 58.36%) while a decrease was observed for the fresh tiger nuts (from 26.09 to 24.60%). The dry tiger nuts had significantly (P≤0.05) the highest content of carbohydrate. The energy content varied significantly (P≤0.05) from 296.72 – 434.00 KJ/g. The dry tiger nut had significantly (P≤0.05) higher energy content than the fresh tiger nut. Pasteurised samples had significantly (P≤0.05) lower energy value.

Figure 2, showed the sugar content of the pasteurized and unpasteurised fresh and dry tiger nuts. Total sugar for the fresh tiger nut varied from 9.82 -10.09% and 11.85 – 12.64% for the dry tiger nut. The reducing sugar for the fresh tiger nut varied from 3.06 – 3.67% and 4.42 – 5.01% for the dry tiger nut. The non-reducing sugar content was 5.55 – 6.13% and 6.17 -6.49% for the fresh and dry tiger nut respectively. The dry tiger nut had significantly (p≤0.05) higher sugar content than the fresh tiger nut in both pasteurized and unpasteurized samples.

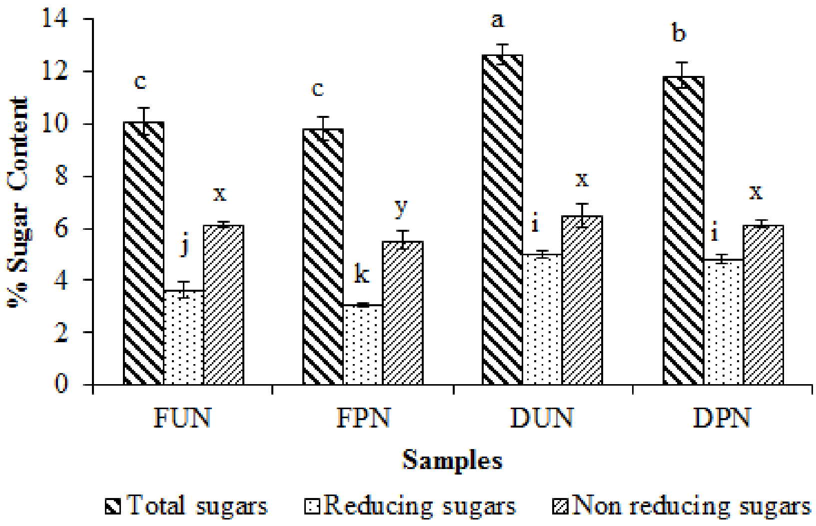

Figure 2. The sugar content of pasteurized and unpasteurised fresh and dry tiger nuts

Values with the same letters for each sugar type are not significantly (p<0.05) different. N = 4 ± SD

F_{UN} = Unpasteurized fresh tiger nut; F_{PN} = Pasteurized fresh tiger nut; D_{UN} = Unpasteurized dry tiger nut; D_{PN} = Pasteurized dry tiger nut

3.1.2 Proximate composition and Sugar Content of Milk Extracted from Fresh and Dry Tiger Nut

The proximate composition of the pasteurized and unpasteurized milk extracted from fresh and dry tiger nuts are shown in Table 2. Moisture varied from 76.93 – 81.92%. Pasteurization had no significant (P≤0.05) effect on the moisture content of the milk extracted from the fresh tiger nut. Milk from the dry tiger nut had significantly (P≤0.05) the least moisture content. The total solid content ranged from 18.08 – 19.29 % and 18.74 - 23.07% for the milk from the fresh and dry tiger nuts respectively. The values did not vary significantly (P≤0.05) except for the unpasteurized milk from dry tiger nut that had significantly (P≤0.05) the highest amount of total solid. The unpasteurised tiger nut milk had significantly (P≤0.05) higher fat content of 4.85 and 5.01% respectively, for the milk from the fresh and dry tiger nut. The protein, ash and the fibre contents varied significantly (P≤0.05) among the samples and a decrease was observed in the pasteurised samples. Protein varied from 9.84 – 11.03% for milk from the fresh tiger nut and 10.03 – 11.41 % for milk from the dry tiger. Ash ranged from 0.01 - 0.03% for milk from the fresh tiger nut and 0.04 - 0.11% for milk from the dry tiger nut while fibre content was between 0.01 – 0.02% and 0.02 - 0.03% respectively, for the milk from the fresh and dry tiger nut. Pasteurization resulted in significant (P≤0.05) decrease in carbohydrate content of the fresh tiger nuts from 7.16 to 4.91%, while an increase was observed for the dry tiger nuts from 2.74 to 5.57%. The energy values for the unpasteurised milk samples were significantly (P≤0.05) higher than the pasteurised samples.

Figure 3 showed the sugar content of the pasteurized and unpasteurized milk extracted from fresh and dry tiger nuts. Total sugar content of the pasteurized and unpasteurized milk extracted from fresh and dry tiger nuts varied from 9.63 -10.81% and 11.64 – 12.23% respectively, for the milk extracted from the fresh and dry tiger nut. Pasteurization significantly (P≤0.05) decreased the total sugar content of the milk from the fresh tiger nut. No significant (P≤0.05) difference was observed with the milk extract from the dry tiger nut. The non-reducing sugar followed a similar trend and the values were 4.29 - 5.54% for milk from the fresh tiger nut and 6.65 – 6.92% for milk from the dry tiger nut. The reducing sugar for the milk from the fresh tiger nut varied from 3.42 – 4.14% and 4.13 – 4.49% for the milk from the dry tiger nut.

Table 2: Proximate composition of pasteurized and unpasteurised milk from fresh and dry tiger nuts

Samples	Moisture	Total Solid	Fat	Ash	Fibre	Protein	Carbohydrate	Energy(KJ/g)
F_{UM}	80.71±0.15[a]	19.29±0.15[b]	4.85±0.21[a]	0.01±0.00[d]	0.02±0.00[b]	11.03±0.09[b]	7.16±2.07[a]	488.68[a]
F_{PM}	81.92±0.45[a]	18.08±0.45[b]	3.31±0.14[b]	0.03±0.00[c]	0.01±0.00[c]	9.84±0.15[c]	4.91±0.62[b]	373.22[c]
D_{UM}	76.93±2.00[b]	23.07±2.00[a]	5.01±0.15[a]	0.11±0.01[a]	0.03±0.01[a]	11.41±0.41[a]	2.74±0.55[c]	425.92[b]
D_{PM}	81.26±0.45[a]	18.74±0.45[b]	3.09±0.11[b]	0.04±0.00[b]	0.02±0.00[b]	10.03±0.01[c]	5.57±0.46[ab]	379.53[c]

Values with the same superscript in the same column are not significantly ($p<0.05$) different. N = 4 ± SD F_{UN} = Unpasteurized fresh tiger nut; F_{PN} = Pasteurized fresh tiger nut; D_{UN} = Unpasteurized dry tiger nut; D_{PN} = Pasteurized dry tiger nut

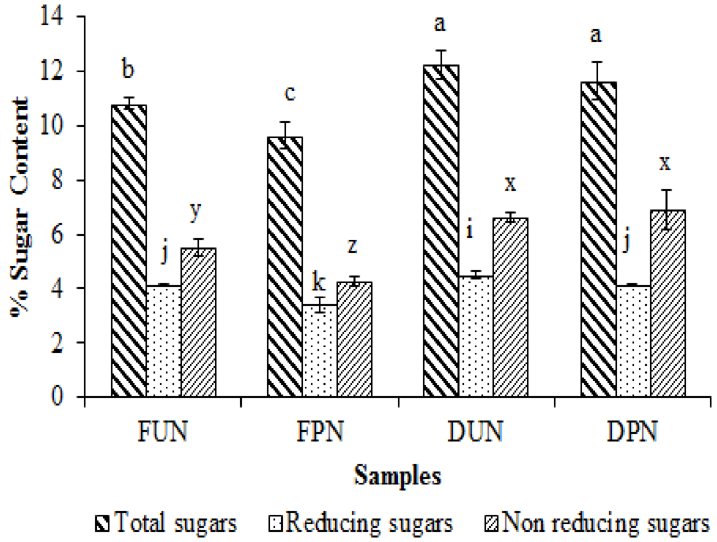

Figure 3. The sugar content of pasteurized and unpasteurised milk extracted from fresh and dry tiger nuts Values with the same letters for each sugar type are not significantly ($p<0.05$) different. N = 4 ± SD F_{UN} = Unpasteurized fresh tiger nut; F_{PN} = Pasteurized fresh tiger nut; D_{UN} = Unpasteurized dry tiger nut; D_{PN} = Pasteurized dry tiger nut

3.2 Mineral Contents

3.2.1 Mineral Content of Fresh and Dry Tiger Nut Tubers (mg/100g)

The micro-mineral (Cu, Fe and Zn) and macro-mineral (Ca, Mg and K) content of the pasteurised and unpasteurised fresh and dry tiger nut are shown in Table 3. The amount of the minerals in the samples varied significantly ($P \leq 0.05$) except for the zinc content. The values for the micro minerals were 0.09 - 0.13, 11.00 - 13.74, 0.05 - 0.06 mg/100g for Cu, Fe and Zn respectively. While the values for the macro minerals were 1692.94 - 1921.99, 265.12 - 794.57 and 1048.34 - 1181.67 mg/100g for Ca, Mg and K respectively.

Table 3. Mineral content of pasteurised and unpasteurised fresh and dry tiger nut

Samples	Micro minerals (mg/100g)			Macro minerals (mg/100g)		
	Copper (Cu)	Iron (Fe)	Zinc (Zn)*	Calcium (Ca)	Magnesium (Mg)	Potassium (K)
F_{UN}	0.09±0.00[b]	11.00±1.13[b]	0.06±0.02	1692.94±552.25[c]	265.12±26.75[d]	1094.16±99.17[b]
F_{PN}	0.11±0.02[b]	13.74±0.65[a]	0.05±0.00	1921.99±154.33[a]	867.64±10.38[a]	1157.50±112.50[a]
D_{UN}	0.07±0.00[c]	12.08±1.10[ab]	0.06±0.00	1812.47±264.05[b]	410.64±145.27[c]	1048.34±13.34[b]
D_{PN}	0.13±0.01[a]	13.00±0.47[a]	0.06±0.01	1902.93±185.24[a]	794.57±107.26[b]	1181.67±213.34[a]

Values with the same superscript in the same column are not significantly (P≤0.05) different. N = 4 ± SD * Zinc content did not differ significantly (P≤0.05) F_{UN} = Unpasteurized fresh tiger nut; F_{PN} = Pasteurized fresh tiger nut; D_{UN} = Unpasteurized dry tiger nut; D_{PN} = Pasteurized dry tiger nut

3.2.2 Mineral Content of Milk Extracted from Fresh and Dry Tiger Nut (mg/100g)

The micro-mineral (Cu, Fe and Zn) and macro-mineral (Ca, Mg and K) content of the pasteurised and unpasteurised milk extracted from fresh and dry tiger nut are shown in Table 4. The amount of the minerals in the samples varied significantly (P≤0.05) except for the potassium content. The values for the micro minerals were 0.02 - 0.03, 3.67 - 4.34, 0.02 - 0.03 mg/100g for Cu, Fe and Zn respectively. While the values for the macro minerals were 606.98 - 669.32, 86.88 - 289.71 and 349.45 - 393.89 mg/100g for Ca, Mg and K respectively. The pasteurised samples had significantly (P≤0.05) higher amounts of Cu, Fe and Mg while Pasteurization had no significant (P≤0.05) effect on the Zn, Ca and K contents of the milk extract.

3.3 Sensory Evaluation

The assessors' rating of the sensory attributes of the pasteurized and unpasteurised milk extracted from the fresh and dry tiger nuts are shown in Figure 4. The ratings for the sensory attributes evaluated were 7.12 - 7.56 for appearance, 7.00 - 7.32 for colour, 7.16 - 7.64 for flavour, 7.80 – 8.04 for taste and 7.80 - 8.28 for the overall acceptability.

Table 4. Mineral content of milk from fresh and dry tiger Nut (mg/100g)

Samples	Micro minerals (mg/100g)			Macro minerals (mg/100g)		
	Copper (Cu)	Iron (Fe)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Potassium (K)*
F_{UM}	0.03±0.00[b]	3.67±0.38[b]	0.02±0.00[b]	669.32±28.50[a]	88.38±8.92[b]	364.76±33.00
F_{PM}	0.04±0.01[a]	4.58±0.22[a]	0.02±0.01[b]	640.67±51.51[ab]	289.71±3.96[a]	385.83±37.50
D_{UM}	0.02±0.00[c]	4.03±0.37[ab]	0.03±0.00[a]	606.98±90.84[c]	86.88±1.52[b]	349.45±4.45
D_{PM}	0.04±0.00[a]	4.34±0.16[a]	0.02±0.01[b]	634.31±61.75[bc]	264.86±35.76[a]	393.89±71.11

Values are mean ± SD of 4 replications. Means with different superscripts along the same row are significantly different. (p<0.05) F_{UM} = Unpasteurized fresh tiger nut milk; F_{PM} = Pasteurized fresh tiger nut milk; D_{UM} = Unpasteurized dry tiger nut milk; D_{PM} = Pasteurized dry tiger nut milk

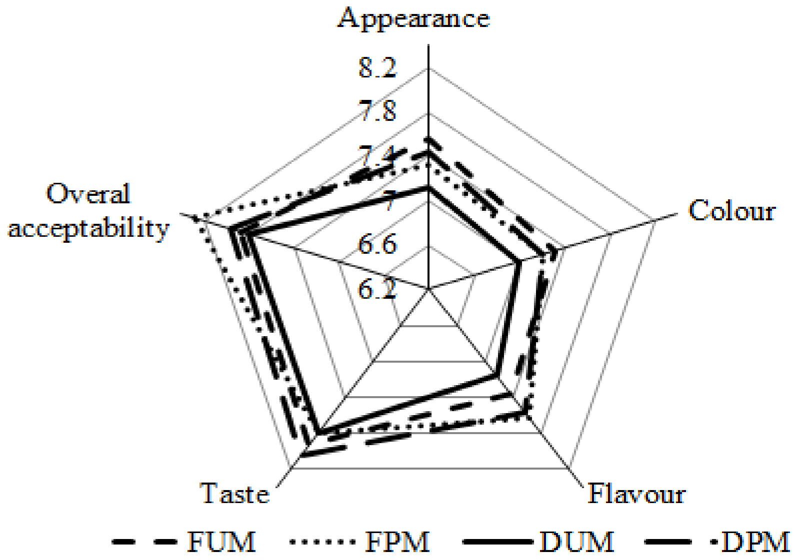

Figure 4. The sensory attributes of the pasteurized and unpasteurised milk extracted from the fresh and dry tiger nuts F_{UM} = Unpasteurized fresh tiger nut milk; F_{PM} = Pasteurized fresh tiger nut milk; D_{UM} = Unpasteurized dry tiger nut milk; D_{PM} = Pasteurized dry tiger nut milk

4. Discussion

4.1 Proximate Composition

4.1.1 Proximate composition and Sugar Content of pasteurised and unpasteurised fresh and dry Tiger nuts

The significantly (P≤0.05) least moisture content of the dry unpasteurized tiger nuts was expected as the essence of the post-harvest drying process was for moisture reduction to extend the keeping quality. The dry tiger nuts readily absorbed moisture during pasteurization which led to significant (p≤0.05) increase in the moisture content of the pasteurized dry tiger nuts. The higher ash, protein and carbohydrate content of the dry tiger nuts can be attributed to the concentration of nutrient after the loss of moisture during the drying process of the tiger nut. This agrees with the finding of Chukwu *et al.,* [22] who reported higher moisture, fat and fibre in fresh tiger nut, and higher content of ash and carbohydrate in dry tiger nut. However, it varied from the finding of Nwaoguikpe *et al.,* [23] where higher carbohydrate in fresh tiger nut and higher fat and fibre content in dry tiger nut was reported. The protein content of the tiger nuts was lower than the values (7.15%) reported by Adgidzi *et al*., [24]. The high moisture content of the fresh tiger nut coupled with the heat pasteurization may have resulted in the increased crude fibre content due to the gelatinisation of starch.

According to a Joint WHO/FAO/UNU Expert Consultation report, for a healthy well-nourished adult the energy requirement is equivalent to the Total Energy Expenditure (TEE), which is the energy spent, on average in a 24-hour period by an individual or a group of individuals. The TEE for an adult male of 20-25 years old with body weight of 70kg involved in vigorous activity is 235 KJ (56 Kcal)/Kg/day and for a female of the same age bracket weighing 57 Kg involved in vigorous activity the TEE is 173 KJ (41Kcal)/kg/day [25]. The energy values of the tiger nuts (319 – 434 KJ/g) are adequate for human requirement in comparison with the requirement. The higher sugar content in the dry samples could be attributed to the concentration of solute after water loss in the dry. Pasteurization significantly (P≤0.05) decreased the reducing and non-reducing sugar content in all the fresh samples, and the total sugar content in the dry sample. The decrease in sugar with pasteurization could be attributed to starch gelatinization and sugar caramelization during the heating process.

4.1.2 Proximate composition and Sugar Content of Milk Extracted from Fresh and Dry Tiger Nut

The moisture content of the extracted milk was significantly (P≤0.05) higher than those of the tiger nuts. This increase in moisture is attributed to the water used in the milk extraction. The other nutrients in the milk samples were also significantly (P≤0.05) lower than that of the tiger nuts. This could be due to losses during the milk extraction process. The significantly (P<0.05) higher content of protein, ash and sugars in the milk extracted from the dry tiger nut was in agreement with the findings of Abubakar *et al.,* [26]. Pasteurization increased ash, moisture and carbohydrate content and decreased the fat, protein and sugar content of tiger nut milk significantly (P<0.05). The decrease in protein could be that heat application (pasteurization) cause the unzipping of the hydrophobic force leading to partial or complete disruption of primary, secondary or tertiary structure of protein molecule. Also whey protein is being denatured during heat treatment [27]. The variation in fibre content could be due to the fact that cooking softens cellulose and encourages loss of digestible plant component causing the cell to separate easily and ease digestion. Decreased in ash content as observed in the study could be as a result of leaching of mineral element during pasteurization [28]. The increased sugar in dry tiger nut milk could be as a result of less moisture content. Also, the reduction in sugar content due to pasteurization could be as a result of gelatinization and caramelization effect of starch and sugar. This result agrees with a previous work reported by Alegría-Toŕan *et al.,* [29]. A comparison of the energy value of the tiger nut milk (373 – 488 KJ/g) with the RDA (235 and 173 KJ/kg/day for an adult male (70Kg body weight) and adult female (57 Kg body weight) showed that the consumption of 100 mL of the tiger nut milk will meet more than 100% of the energy requirement. The sugar content of the extracted milk followed a similar trend with that of the tiger nuts. The milk extract from the dry tiger nut had significantly (P≤0.05) higher content of sugar. This could be due to concentration of solutes in the dry nuts. The pasteurized samples had significantly (P≤0.05) lower content of reducing sugar, attributable to starch gelatinization.

4.2 Mineral Content of Fresh and Dry Tiger Nut Tubers and the Milk Extract

Minerals have diverse functionalities and potentials in the body's metabolism and homeostasis. Its deficiency can result in some common disorders and diseases symptoms [30]. The micro-mineral (Cu, Fe and Zn) and macro-mineral (Ca, Mg and K) content of the pasteurised tiger nut samples were significantly (P≤0.05) higher than the unpasteurised samples for both the fresh and the dry tiger nut. The tiger nut and its milk extract have been shown to contain significant amount of micro and macro minerals. The values obtained were in agreement with the report by Ndubisi, [12] and Nwobosi *et al*., [31].

Calcium in addition with other micro-minerals and protein can help in bone formation with calcium acting as principal contributor. Calcium is important in blood clotting, muscles contraction and in certain enzymes in metabolic processes [32]. The recommended calcium allowance based on North American and European data for an adult male or female above 19 years is 1000 mg/day while the current calcium intake for mature adult male and female is 800 mg/day (FAO/WHO 1998). The value of calcium in the tiger nuts (≥1692 mg/100g) and the milk extract ≤ 669 mg/100g) was calculated to be 169% and 70% of the recommended allowance. These values are also far greater than 260 mg reported as the daily calcium intake from vegetables in African [33]. Hence, tiger nut is a rich source of calcium. Although, over dose of calcium can cause stomach problems for sensitive individuals.

Magnesium is an essential micronutrient needed for nervous system health [34] and for the synthesis of proteins, production of energy and muscle contraction [11]. For an adult male between the ages of 19 and 65 years with assumed body weight of 65 kg, the FAO/WHO, [33] recommended nutrient intake (RNI) for magnesium is 260 mg/day and for a female of the same age bracket weighing 55 kg it is 220mg/day. The level of magnesium obtained in the tiger nut (≥265 mg/100g) and the milk extract (86 – 289 mg/100g) will meet more than 100% of the requirement except for the 86 mg /100g that will meet about 39%. Tiger nut milk therefore is shown to be a rich source of magnesium.

Potassium is needed in fluid balance and regulation of nerve impulse conduction, regular heart beat and cell metabolism. Potassium is important in maintaining electrolyte and chemical balance between the tissue cells and the blood. It plays important part in numerous enzymatic reactions and in physiological processes, such as cardiac rhythm, nervous conduction, and muscular contraction [35].

Copper (Cu) is one of the essential trace elements for humans. It is associated with many enzymes acting as oxidases to achieve the reduction of molecular oxygen. . The medium dietary intake of copper for men is 1.2 - 1.6 mg/day and 1.0 – 1.1 mg/day for female [36]. The copper levels in the tiger nut and the milk will meet ≤8 and ≤2% of the required intakes. The tolerable upper limit for copper is 10mg a value based on protection from liver damage as a critical adverse effect.

Iron (Fe) is essential for the formation of blood cells and an integral part of important enzyme systems in various tissues and its deficiency results in anaemia [37]. RNIs of iron at the least bioavailability level of 5% for an adult male aged 15-17 years weighing 64 kg and a female weighing 56Kg is 12.5 and 20.5mg/day respectively. The amount of iron found in the tiger nuts (≥11 mg/100g) will only meet 53 and 88% of the RNIs for the male anf female respectively will and the milk extract (≤4.58 mg/100g) will meet 22 and 37 % of the RNIs of the female and male respectively. Tiger nut can be said to be a good source of iron.

Zinc is an essential component of a large number (>300) of enzymes involved in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients. It plays vital roles in the maintenance of cell and organ integrity, the immune system and genetic expression. According to the recommendation of FAO/WHO [33], the RNIs of Zinc for an adult male aged 19-65 years weighing 65 kg and a female weighing 55Kg is 4.2 and 3.0 mg/day respectively. The amount of zinc found in the tiger nut (≤ 0.06mg/100g) and its milk extract (≥ 0.02 mg/100g) will meet ≤ 2 % of the RNIs. Although zinc if found in the tiger nut, the amount is insufficient to meet the daily requirement. The decrease in the mineral content of the milk extracted from the tiger nuts can be attributed to losses during the milk extraction process. Though the tiger nut milk is a refreshing drink and adds variety to the product, to get the maximum nutrient, eating of the whole nut is advisable.

4.3 Sensory Evaluation

From the results obtained (Figure 4), the milk extracted from the fresh tiger nut and the dry tiger nut milk did not vary significantly (P>0.05), in the assessors ratings. On a 9 point hedonic scale the ratings (≥ 7 but ≤ 8) for the appearance, colour and flavour signifies that the assessors had moderate likeness for the sensory attributes. While the taste and overall acceptability was liked very much. In general, the milk extracts whether pasteurised or not were acceptable to the assessors. The values obtained were different from the values of 6.85, 5.45, 5.80 and 6.20 for colour, aroma, taste and overall acceptability for fresh tigernut milk as reported by Udeozor, [38]. This may be probable due to the comparison with soy milk which the people are well familiar with.

5. Conclusion

The findings from this work showed that the dry tiger nut and its milk had significantly (P≤0.05) higher proximate, sugar and mineral contents. Pasteurization resulted in significant (P≤0.05) decrease in protein, crude fibre and energy while moisture, fat and mineral content increase significantly (P≤0.05) in the fresh and dry tiger nuts. For the milk extract, pasteurization significantly (P<0.05) increased ash, moisture and carbohydrate with decrease in fat, protein and sugar contents. Pasteurised milk samples had significantly (P≤0.05) higher amounts of Cu, Fe and Mg but no significant (P≤0.05) effect was observed for the Zn, Ca and K contents. Pasteurization in addition to safety contributed to significant increases in nutrient content.

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