Article

Effects of Processing Treatments on the Chemical Composition of Tiger Nut (*Cyperus esculentus*) Milk Products

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Abstract: Tiger nut (*Cyperus esculentus*) is an edible perennial grass-like plant that has long been recognized for its health benefits as it is rich in fiber, protein, vitamins, minerals and natural sugars. It can be eaten raw, roasted or made into a refreshing milk which is very nutritive and healthy for consumption. There were several efforts to mass-produce the locally prepared tiger nut milk in our locality, but the fact that it has a shorter shelf-life, brings about a hindrance. The main objective of the present study is to unveil the cause for the easily spoilage of tiger nut milk and device ways to promote its production using different treatments. Tiger nut milk products were prepared using different methods; water soaked tiger nut milk (WSTM), toasted tiger nut milk (TTM), methanol soaked tiger nut milk (MSTM), and the pasteurised tiger nut milk (PTM). Each of these milk proucts prepared was divided into two portions; the first portion is treated with an antibiotic preservative, Nisin and the second portion was left untreated. The two portions were further divided into two; one stored at refrigerating temperature and the other at room temperature, making four different treatments per mixture and a total of 16 samples. These samples were subjected to proximate analysis; protein, fat, moisture, ash and carbohydrate. The chemical composition of the samples was significantly ($P < 0.05$) affected by processing treatment. All the samples had high moisture content, and a considerable amount of fat. The preservative treated samples that received pasteurized treatment were found to stay more than a week with fair quality. Findings from the study shows that the chemical characteristics of the various milk products were significantly affected by the different processing treatments.

Keywords: Nisin, water soaked tiger nut milk (WSTM), toasted tiger nut milk (TTM), methanol soaked tiger nut milk (MSTM), and the pasteurised tiger nut milk (PTM)

1. Introduction

Milk is an important source of nutrients and serve as a source of food for infants, growing children and adults [1]. It is the primary source of nutrients for infant mammals before they are able to digest other types of food. The high cost of milk in developing countries has led to the development of alternative source of milk from plant materials [2]. A protein-rich drink can be produced from locally available plant foods at an affordable price in place of animal protein which is scarce and expensive, and could play an important role to reduce protein malnutrition.

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Plant milk has been consumed for centuries in various cultures, both as a regular drink (such as the Spanish horchata) and as a substitute for dairy milk. The most popular varieties are soy milk, almond milk, rice milk and coconut milk. Their protein content varies. It contains no lactose or cholesterol, and is usually sold with added calcium and vitamins, especially B_{12}. Only soybean has been extensively investigated while other oil seeds and tubers such as tigernut, have not been studied comprehensively. Little research attention has been given to bambaranut [3], baobab [1], peanut [4], melon seed [5] and tiger nut milk [6] as sources of vegetable milk.

Tiger nut, an under-utilized crop, was reported to be high in dietary fibre content, which could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetes and gastrointestinal diseases [7]. It has 5.8% moisture, rich in protein (7%) [8] and carbohydrates such as reducing sugar (7.4%), soluble polysaccharide (7.4%) and starch (86.4%) [9]. Tiger nut is also rich in mineral elements such as sodium, calcium, potassium, magnesium, zinc and traces of copper [10]. According to Ojobe and Tempo [11], the protein in tiger nut is of high biological value considering the many essential amino acids it contains. These amino acids are higher than those proposed in the standard by the FAO/WHO [12, 13] and satisfy amino acid need of adults [14].

Tiger nuts are a rich source of nourishment, and remain a significant source of food for both the poor and the wealthy throughout Northwest Africa. They are a good sources of oleic acid (a monounsaturated fat also found in olive oil and avocado), and which is associated with increased HDL (good) cholesterol levels.

Tiger nuts can be processed into varieties of milk products like water soaked tiger nut milk, toasted tiger nut milk, methanol soaked tiger nut milk and the pasteurised tiger nut milk. Tiger nut milk can be used by special people having milk allergies such as galactosemia and lactose intolerance.

The tiger nut milk is a stimulating vegetable drink prepared mainly with tiger nut, water and sugar. It's milk can serve as a good alternative to cow milk with a natural sweetened taste [15].The milk is said to be rich in minerals, like phosphorus, calcium and magnesium, iron and in vitamin C and E which are vital for body growth and development. It does not contain lactose or gluten; this makes it a suitable choice for people who are not able to tolerate gluten (celiac patients) and also for the lactose-intolerant who stay away from cow milk and other dairy products [16].

Due to its content of some digestive enzymes like catalase, lipase, and amylase, tiger nut milk could be recommended for people with problems of digestion, flatulence and diarrhea [17].

The ability to keep the milk for a long period of time has been a major drawback as it easily got spoiled. The aim of the research is therefore, to determine the effect of various processing treatments on the chemical composition of the tigernut milk.

2. Materials and Methods

Fresh tigernuts (*Cyperus esculentus*) and spices were obtained from Rimi market in Kano State, Nigeria. The tigernut was authenticated in the Department of Plant Biology, Bayero University Kano with the accession number BUKHAN 0367 by Baha'uddeen Sa'id Adam. The spices used

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include ginger *(Zingiber officinate*) and cloves (*Eugenia coryphée*). The chemical preservative used was Nisin, then vanilla flavor and sugar.

Preparation of Tigernut Milk

Fresh tubers of tigernut were sorted, washed and rinsed with distilled water then used to produce different milk products as follows:

Water Soaked Tigernut Milk (WSTM):

In this portion, the fresh tigernut was directly soaked in water for 2hours, blended, filtered, sugar and flavor were added. The filtrate was then divided into two portions; one treated with Nisin preservative (2g to 2L of the filtrate) and the other portion was not treated with any preservative. Each of these two portions was again divided into two; one stored at refrigerating temperature and the other one at room temperature, making four different treatments:

- Water soaked tigernut milk + Preservative (2g to 2L of the filtrate) at refrigeration temperature (WSTM+$P_{Ref.T}$).
- Water soaked tigernut milk + Preservative (2g to 2L of the filtrate) at room temperature (WSTM + P_{RT}).
- Water soaked tigernut milk stored at refrigeration temperature ($WSTM_{Ref.T}$).
- Water soaked tigernut milk stored at room temperature ($WSTM_{RT}$).

Toasted Tigernut Milk (TTM):

The fresh tigernut was toasted at 110±5°C for 30minutes in an open pan. It was then blended and mixed; and divided into four portions as done for the first portion.

- Toasted tigernut milk + Preservative (2g to 2L of the filtrate) at refrigeration temperature (TTM+ $P_{Ref.T}$).
- Toasted tigernut milk + Preservative (2g to 2L of the filtrate) at room temperature (TTM + P_{RT}).
- Toasted tigernut milk stored at refrigeration temperature ($TTM_{Ref.T}$).
- Toasted tigernut milk stored at room temperature (TTM_{RT}).

Methanol Soaked Tigernut Milk (MSTM)

In this portion, the tigernut was partly ground and soaked in methanol solution for an hour. It was then removed, dried (so as to allow the methanol to evaporate) and soaked in water (water was changed three times). It was also divided into four portions as above:

- Methanol soaked tigernut milk + Preservative (2g to 2L of the filtrate) at refrigeration tempe rature (MSTM + $P_{Ref.T}$).
- Methanol soaked tigernut milk + Preservative (2g to 2L of the filtrate) at room temperature (MSTM + P_{RT}).
- Methanol soaked tigernut milk stored at refrigeration temperature (MSTM $_{Ref.T}$).
- Methanol soaked tigernut milk stored at room temperature ($MSTM_{RT}$).

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Pasteurized Tigernut Milk (PTM):

Tigernut (2kg) was blended into slurry with water (400 ml). The slurry was pressed using cheese cloth to extract the milk. The extract was pasteurized at 75ºC for 15 min. It was homogenized, bottled when hot and rapidly cooled.

- Pasteurized tigernut milk + Preservative (2g to 2L of the filtrate) at refrigeration temperature (PTM + $P_{Ref.T}$).
- Pasteurized tigernut milk + Preservative (2g to 2L of the filtrate) at room temperature (PTM + P_{RT}).
- Pasteurized tigernut milk stored at refrigeration temperature (PTM $_{Ref.T}$).
- Pasteurized tigernut milk stored at room temperature (PTM_{RT}).

The proximate composition and pH of each sample were analysed at an interval of 4 days.

Chemical Analysis:

Moisture, ash, fat, protein, carbohydrate by difference and pH were determined according to standard methods [18].

Statistical Analysis:

The analyses were performed in triplicates. The mean values and standard deviation were calculated (mean ± SD) using SPSS package16.

3. Results

3.1. Effect of Processing on the Chemical Characteristics of Tigernut Milk Products:

The effects of processing on the chemical characteristics of tigernut milk products are presented on Tables 1-5.

All the samples in table 1 had high moisture content, with TTM+P_{RT} having the highest percentage. Also, TTM+P_{RefT} and PTM+P_{RefT} were significantly different from other samples in terms of their carbohydrate contents. While $WSTM_{RefT}$ and $MSTM_{RT}$ had the highest percentage of protein.

No significant difference existed in almost all the samples in the various parameters after eight (8) days of production. Only PTM+P_{RT} had high percentage of protein (10.7%).

Twelve (12) days after production, all samples had high percentages for moisture content ranging from 71-82%. $WSTM_{RefT}$ and PTM+P_{RT} showed significant difference in their protein contents (10.9%).

In table 4, the percentage fat content of PTM_{RefT} was statistically significant; and $WSTM_{RT}$ and $MSTM_{RT}$ showed significant difference in their percentage moisture content.

Significant difference existed between WSTM+P_{RT} and PTM+P_{RT} and other samples in terms of percentage fat content. While WSTM+P_{RT} and $WSTM_{RT}$ samples had highest moisture content after twenty (20) days of production.

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148 **Table 1. Proximate composition of tigernut milk products obtained from various processing**
149 **treatments after four (4) days of production.**

Treatment Sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
WSTM + $P_{Ref.T}$	78.7 ± 0.2	10.2 ± 0.2	0.5 ± 0.1	2.5 ± 0.1	7.7 ± 0.02
WSTM + P_{RT}	76.5 ± 0.2	9.7 ± 0.2	0.5 ± 0.06	3.2 ± 0.1	9.8 ± 0.01
$WSTM_{Ref.T}$	74.4 ± 0.2	10.2 ± 0.2	0.4 ± 0.1	4.0 ± 0.06	10.9± 0.03*
$WSTM_{RT}$	75.0 ± 0.2	9.2 ± 0.02	0.5 ± 0.1	6.5 ± 0.2	8.7 ± 0.02
TTM + $P_{Ref.T}$	73.5 ± 0.3	14.7 ± 0.1*	0.5 ± 0.2	2.7 ± 0.1	7.7 ± 0.01
TTM + P_{RT}	80.0 ± 0.3	6.3 ± 0.02	0.5 ± 0.1	5.7 ± 0.1	7.7 ± 0.02
$TTM_{Ref.T}$	74.4 ± 0.3	11.4 ± 0.4	0.5 ± 0.1	2.8 ± 0.2	9.8 ± 0.02
TTM_{RT}	78.6 ± 0.3	12.2 ± 0.3	0.4 ± 0.06	3.7 ± 0.2	4.4 ± 0.02
MSTM + $P_{Ref.T}$	76.4 ± 0.3	14.4 ± 0.02	0.5 ± 0.1	2.8 ± 0.2	5.5 ± 0.01
MSTM + P_{RT}	78.3 ± 0.2	11.8 ± 0.2	0.5 ± 0.1	3.5 ± 0.2	5.5 ± 0.02
$MSTM_{Ref.T}$	77.1 ± 0.2	10.2 ± 0.2	0.4 ± 0.06	3.7 ± 0.2	8.8 ± 0.02
$MSTM_{RT}$	79.0 ± 0.2	6.0 ± 0.02	0.5 ± 0.1	3.5 ± 0.06	10.9±0.03*
PTM + $P_{Ref.T}$	76.1 ± 0.1	11.1 ± 0.2	0.4 ± 0.05	3.6 ± 0.2	8.8 ± 0.01
PTM + P_{RT}	73.5 ± 0.2	12.8 ± 0.2	0.4 ± 0.1	4.5 ± 0.2	8.8 ± 0.01
$PTM_{Ref.T}$	77.1 ± 0.2	14.6 ± 0.2*	0.5 ± 0.06	3.2 ± 0.2	4.4 ± 0.02
PTM_{RT}	77.0 ± 0.2	13.2 ± 0.02	0.5 ± 0.06	2.7 ± 0.2	6.5 ± 0.02

150 Values are means ± SD of triplicate determinations

151 Values in same columns bearing the superscript (*) are significant at $P<0.05$

152 Key for tables 1-6:

153 WSTM+ $P_{Ref.T}$ = Water soaked tigernut milk + preservative (at refrigerating temperature).

154 WSTM+P_{RT} = Water soaked tigernut milk + preservative (at room temperature),

155 $WSTM_{Ref.T}$ = Water soaked tigernut milk (at refrigerating temperature),

156 $WSTM_{RT}$ = Water soaked tigernut milk (at room temperature);

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157 TTM = Toasted tigernut milk,

158 MSTM = Methanol soaked tigernut milk and

159 PTM= Pasteurised tigernut milk.

160 **Table 2. Proximate composition of tigernut milk products obtained from various processing**
161 **treatments after eight (8) days of production.**

Treatment Sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
WSTM + $P_{Ref.T}$	80.7 ± 0.2	7.6 ± 0.2	0.5 ± 0.1	3.5 ± 0.1	7.6 ± 0.02
WSTM + P_{RT}	81.7 ± 0.1	9.0 ± 0.2	0.5 ± 0.05	3.2 ± 0.2	5.5 ± 0.02
$WSTB_{Ref.T}$	84.1 ± 0.4	7.3 ± 0.01	0.5 ± 0.05	2.7 ± 0.2	5.5 ± 0.01
$WSTM_{RT}$	83.0 ± 0.2	3.7 ± 0.02	0.5 ± 0.05	2.7 ± 0.1	9.8 ± 0.02
TTM + $P_{Ref.T}$	80.0 ± 0.3	8.2 ± 0.02	0.5 ± 0.1	2.5 ± 0.2	8.8 ± 0.02
TTM + P_{RT}	79.2 ± 0.2	13.4 ± 0.02	0.5 ± 0.1	2.3 ± 0.2	4.4 ± 0.02
$TTM_{Ref.T}$	78.2 ± 0.2	14.0 ± 0.2	0.5 ± 0.05	2.6 ± 0.1	4.4 ± 0.02
TTM_{RT}	83.4 ± 0.1	4.8 ± 0.02	0.5 ± 0.05	2.5 ± 0.2	8.8 ± 0.02
MSTM + $P_{Ref.T}$	79.0 ± 0.2	11.5 ± 0.03	0.5 ± 0.05	3.4 ± 0.2	5.5 ± 0.01
MSTM + P_{RT}	82.2 ± 0.2	3.9 ± 0.02	0.6 ± 0.05	3.5 ± 0.2	9.8 ± 0.02
$MSTM_{Ref.T}$	79.3 ± 0.1	7.3 ± 0.02	0.5 ± 0.05	4.2 ± 0.2	8.8 ± 0.02
$MSTM_{RT}$	85.3 ± 0.2	5.0 ± 0.03	0.5 ± 0.05	2.5 ± 0.1	6.5 ± 0.02
PTM + $P_{Ref.T}$	79.0 ± 0.2	10.9 ± 0.03	0.5 ± 0.1	3.0 ± 0.2	6.5 ± 0.02
PTM + P_{RT}	80.3 ± 0.1	4.9 ± 0.02	0.5 ± 0.05	3.4 ± 0.2	10.7±0.02*
$PTM_{Ref.T}$	78.0 ± 0.2	9.9 ± 0.02	0.6 ± 0.2	2.8 ± 0.1	8.7 ± 0.02
PTM_{RT}	79.4 ± 0.2	9.7 ± 0.02	0.5 ± 0.1	2.7 ± 0.2	7.7 ± 0.02

162 Values are means ± SD of triplicate determination. Values in same columns bearing the superscript (*) are
163 significant at $P<0.05$

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166 **Table 3. Proximate composition of tigernut milk products obtained from various processing**
167 **treatments after twelve (12) days of production.**

Treatment Sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
WSTM + $P_{Ref.T}$	74.0 ± 0.2	14.0 ± 0.3	0.5 ± 0.1	3.8 ± 0.2	7.7±0.02
WSTM + P_{RT}	78.2 ± 0.2	7.2 ± 0.2	0.5 ± 0.05	4.2 ± 0.3	9.8 ± 0.02
$WSTM_{Ref.T}$	71.0 ± 0.3	13.5 ± 0.02	0.5 ± 0.05	4.0 ± 0.2	10.9±0.02*
$WSTM_{RT}$	82.0 ± 0.2	5.4 ± 0.03	0.5 ± 0.1	4.4 ± 0.2	7.7 ± 0.02
TTM + $P_{Ref.T}$	73.0 ± 0.2	14.9 ± 0.02	0.4 ± 0.05	2.8 ± 0.1	8.8 ± 0.02
TTM + P_{RT}	80.0 ± 0.1	6.4 ± 0.2	0.5 ± 0.05	3.2 ± 0.2	9.8 ± 0.03
$TTM_{Ref.T}$	78.0 ± 0.2	12.5 ± 0.03	0.5 ± 0.1	3.0 ± 0.3	5.5 ± 0.01
TTM_{RT}	81.0 ± 0.1	7.7 ± 0.02	0.4 ± 0.05	3.2 ± 0.2	7.7 ± 0.02
MSTM + $P_{Ref.T}$	82.0 ± 0.2	5.0 ± 0.02	0.5 ± 0.1	3.6 ± 0.3	8.8 ± 0.03
MSTM + P_{RT}	80.4 ± 0.3	7.0 ± 0.03	0.5 ± 0.05	3.2 ± 0.1	8.8 ± 0.03
$MSTM_{Ref.T}$	76.0 ± 0.2	14.1 ± 0.02	0.5 ± 0.05	2.8 ± 0.2	6.5 ± 0.02
$MSTM_{RT}$	82.0 ± 0.2	6.0 ± 0.1	0.5 ± 0.1	3.8 ± 0.2	7.7 ± 0.01
PTM + $P_{Ref.T}$	73.0 ± 0.1	11.3 ± 0.2	0.5 ± 0.1	4.2 ± 0.2	10.9±0.02*
PTM + P_{RT}	72.3 ± 0.2	13.5 ± 0.02	0.5 ± 0.05	4.8±0.02*	8.8 ± 0.02
$PTM_{Ref.T}$	72.0 ± 0.2	13.5 ± 0.02	0.5 ± 0.1	4.0 ±0.3	9.8 ± 0.02
PTM_{RT}	72.0 ± 0.3	13.0 ± 0.2	0.5 ± 0.05	4.0 ± 0.2	9.8 ± 0.02

168 Values are means ± SD of triplicate determinations. Values in same columns bearing the superscript (*) are
169 significant at $P<0.05$

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Table 4. Proximate composition of tigernut milk products obtained from various processing treatments after sixteen (16) days of production.

Treatment Sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
WSTM + $P_{Ref.T}$	78.0 ± 0.2	7.3 ± 0.2	0.5 ± 0.1	3.2 ± 0.2	10.9±0.02
WSTM + P_{RT}	81.0 ± 0.1	3.5 ± 0.2	0.5 ± 0.05	4.0 ± 0.2	10.9±0.02
$WSTM_{Ref.T}$	80.0 ± 0.2	8.3 ± 0.3	0.5 ± 0.05	3.5 ± 0.2	7.7 ± 0.02
$WSTM_{RT}$	85.0± 0.3*	4.4 ± 0.02	0.5 ± 0.1	3.6 ± 0.2	6.5 ± 0.02
TTM + $P_{Ref.T}$	79.0 ± 0.2	10.0 ± 0.2	0.5 ± 0.1	2.8 ± 0.2	7.7 ± 0.01
TTM + P_{RT}	79.0 ± 0.1	8.5 ± 0.2	0.5 ± 0.05	3.2 ± 0.1	8.8 ± 0.02
$TTM_{Ref.T}$	77.0 ± 0.2	10.7 ± 0.02	0.5 ± 0.1	3.0 ± 0.2	8.8 ± 0.02
TTM_{RT}	81.0 ± 0.3	9.5 ± 0.03	0.5 ± 0.1	3.5 ± 0.2	5.5 ± 0.01
MSTM + $P_{Ref.T}$	81.0 ± 0.2	11.5 ± 0.2	0.5 ± 0.1	2.5 ± 0.2	4.4 ± 0.02
MSTM + P_{RT}	80.0 ± 0.2	12.2 ± 0.02	0.5 ± 0.05	3.0 ± 0.3	4.4 ± 0.02
$MSTM_{Ref.T}$	82.0 ± 0.2	10.3 ± 0.1	0.5 ± 0.05	2.8 ± 0.2	4.3 ± 0.01
$MSTM_{RT}$	86.3± 0.3*	3.3 ± 0.2	0.5 ± 0.1	3.4 ± 0.2	6.5 ± 0.02
PTM + $P_{Ref.T}$	79.0 ± 0.2	5.3 ± 0.2	0.5 ± 0.06	4.2 ± 0.1	10.9±0.03
PTM + P_{RT}	80.0 ± 0.1	6.8 ± 0.2	0.5 ± 0.05	3.8 ± 0.2	8.8 ± 0.03
$PTM_{Ref.T}$	79.0 ± 0.2	9.4 ± 0.02	0.5 ± 0.1	4.5 ± 0.2*	6.5 ± 0.01
PTM_{RT}	77.0 ± 0.3	10.8 ± 0.3	0.5 ± 0.06	4.0 ± 0.3	7.6 ± 0.02

Values are means ± SD of triplicate determinations.

Values in same columns bearing the superscript (*) are significant at P<0.05

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183 **Table 5. Proximate composition of tigernut milk products obtained from various processing**
184 **treatments after twenty (20) days of production.**

Treatment Sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
WSTM + $P_{Ref.T}$	75.0 ± 0.2	14.2 ± 0.1	0.5 ± 0.1	3.7 ± 0.2	6.5 ± 0.02
WSTM + P_{RT}	83.0± 0.3*	3.2 ± 0.03	0.5 ± 0.1	4.5 ± 0.3*	8.8 ±0.02
$WSTM_{Ref.T}$	80.0 ± 0.3	8.9 ± 0.2	0.5 ± 0.05	4.0 ± 0.2	6.5 ±0.03
$WSTM_{RT}$	83.0± 0.2*	7.5 ± 0.2	0.5 ± 0.1	3.5 ± 0.1	5.5 ± 0.03
TTM + $P_{Ref.T}$	78.0 ± 0.2	13.0 ± 0.3	0.4 ± 0.06	3.0 ± 0.2	5.5 ± 0.02
TTM + P_{RT}	83.0± 0.2*	6.4 ± 0.2	0.5 ± 0.2	3.5 ± 0.2	6.5 ± 0.01
$TTM_{Ref.T}$	76.0 ± 0.2	14.6 ± 0.3	0.5 ± 0.06	3.5 ± 0.02	4.4 ± 0.03
TTM_{RT}	83.0± 0.2*	9.1 ± 0.2	0.5 ± 0.05	4.0 ± 0.3	3.3 ± 0.02
MSTM + $P_{Ref.T}$	79.0 ± 0.3	12.2 ± 0.2	0.5 ± 0.2	2.7 ± 0.2	5.7 ± 0.02
MSTM + P_{RT}	78.0 ± 0.2	13.3 ± 0.4	0.4 ± 0.1	3.8 ± 0.2	4.3 ± 0.01
$MSTM_{Ref.T}$	78.0 ± 0.3	12.0 ± 0.03	0.5 ± 0.05	3.0 ± 0.2	6.5 ± 0.02
$MSTM_{RT}$	80.0 ± 0.3	7.0 ± 0.02	0.5 ± 0.06	3.4 ± 0.1	8.7 ± 0.03
PTM + $P_{Ref.T}$	80.0 ± 0.3	8.9 ± 0.2	0.5 ± 0.2	4.0 ± 0.2	6.5 ± 0.02
PTM + P_{RT}	79.0 ± 0.2	8.3 ± 0.1	0.5 ± 0.2	4.5 ± 0.2*	7.6 ± 0.02
$PTM_{Ref.T}$	77.0 ± 0.1	12.7 ± 0.2	0.5 ± 0.1	4.2 ± 0.3	5.5 ± 0.01
PTM_{RT}	81.0 ± 0.2	6.0 ± 0.2	0.4 ± 0.05	3.8 ± 0.06	8.8 ± 0.02

185 Values are means ± SD of triplicate determinations.

186 Values in same columns bearing the superscript (*) are significant at P<0.05

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188 **4. Discussion**

189 It was observed that all samples had high moisture content, with the samples stored at room
190 temperature having the highest percentage of moisture. This could affect the stability and safety of
191 the various beverage samples with respect to microbial growth and proliferation; as high moisture
192 content allows microbial growth [19]. Total ash content in the various treatments was lower than
193 the ash content of 1.5% as reported by Ukwuru *et al.* [6]. The crude fat content of the various milk

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194 samples were within the range of 2.3 – 6.5% and were below the minimum of 8% standard for dairy
195 milk [12,13]. According to Belewu and Abodurin [16], tigernut itself is rich in fat (25.5%). This
196 shows that there is a wide difference between fat in tigernut tubers and its milk.

197 The current study is in accordance with the result of a previous study by Adgidzi in 2010 [20] ,
198 where production of acceptable beverages were made from tiger nuts. The beverage products were
199 found to contain a proximate composition of 1.89% protein, 0.92% fat, 0.16% ash, 0.24% crude fiber,
200 76.86% moisture and 15.96% carbohydrates.
201 In general, it was established that processing treatment of the various tigernut milk samples
202 has effect on the chemical characteristics of the milk products. Processing treatments affected the
203 characteristics of the various samples in different ways; soaking increased the protein and fat, but
204 sometimes reduced the moisture and carbohydrate content. It also reduced soluble antinutrients (eg
205 tannins and polyphenols) which can be eliminated with the discarded soaking water. Toasting on
206 the other hand, aids flavour development, removes heat labile antinutrients and increased the
207 protein and fat contents. The increase in protein and fat could be attributed to the concentration of
208 the constituents during toasting brought about by loss of moisture and reduction/destruction of
209 certain protease inhibitors and other anti-nutrients like phytic acid and tannins which form
210 complexes with protein and make protein unavailable during hydrolysis. A similar increase in
211 protein content has been reported for *Terminalia catappa* seeds toasted at a high temperature [21].
212 Soaking in methanol reduced the fat content in the tigernut milk samples, as the raw tigernut was
213 defatted with methanol. Pasteurization of the tigernut milk mixture also aided in destroying
214 pathogens likely to be present as well as most spoilage organisms in the mixture as it normally
215 controls both health and spoilage hazards.

216 Addition of preservative during processing had a significant effect on the chemical
217 characteristics of the tigernut milk samples. During storage, the samples which had no preservative
218 and were stored at room temperature dropped significantly in quality after 2 days, whereas the
219 preserved samples without pasteurization deteriorated significantly ($P<0.05$) in quality on the first
220 week, while the preserved samples that received pasteurization were found to stay more than a
221 week with fair quality. All samples fell below acceptable range at third week.

222 There is increased utilization of tiger nut (Cyperus esculentus) nowadays, which might be as a
223 result of awareness on the composition of tiger nut especially the protein content which helps in
224 body development and tissue repair [15].

225 **5. Conclusions**

226 Tigernut tubers can be processed into various tigernut milk products using different
227 treatments. The chemical characteristics of the various beverage products were significantly
228 affected by the different processing treatments. The preservative treated samples that received
229 pasteurized treatment were found to stay more than a week with fair quality.

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231 experiments; A.S., M.A. and H.A. analyzed the data; M.A. contributed reagents/materials/analysis tools; A.S.
232 wrote the paper."

233 **Conflicts of Interest:** The authors declare no conflict of interest.

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References

1. Obizoba, I.C.; Anyika, J.U. Nutritive value of baobab milk (Adansoniadigitata L), Hungary rice, Acha (Digitanaexillis) flours. *Plant Foods for Hum. Nutr*. 1995, 46: 156-165.

2. Singh, T.; Bains, G.S. Grain extract-milk beverage, processing and physico- chemical characteristics. *J. Food Sci*. 1988, 53: 1387-1390.

3. Obizoba, I.C.; Egbunna, H.I. Effect of germination on fermentation on the nutritional quality of bambara nut (Vagndzei subterranean Thourars) and its products (milk). *Plant Foods for Hum. Nutr*. 1992, 42: 13-23.

4. Odo, F.O. Consumer acceptance of groundnut milk. Proceedings of the 25 Annual Conference of the Nigerian Institute of Food Sci. and Tech. (NIFST). 2009, November 5-9, Lagos, Nigeria, pp: 135137.

5. Akubor, P.I. Physico-chemical and sensory characteristics of melon seed milk. *J. Food Sci. Tech*. 1998, 35: 93-95.

6. Ukwuru, M.U.; Omachona, L.J.; Onokah, N. Production and quality assessment of tigernut (Cyperus esculentus) imitation milk during storage. *J. Food Sci. Technol*. 2008, 45: 180-182.

7. Anderson, J.W.; Smith, B.M.; Gustatson, N.J. Health benefits and practical aspects of high fibre diets. *Am. J. Clin. Nutr*. 1994, 59: 12425-12475.

8. Temple, V.T.; Ojobe, T.O.; Kapu, M.M. Chemical analysis of Tigernut (Cyperus esculentus). *Journal Science Food Agriculture*. 1990, 50: 261- 263.

9. Temple, V.J. Lesser known plant foods. In: Nutritional quality of plant foods. Osagie AU and Eka OU (Eds). Post-harvest Research Unit, University of Benin, Nigeria. 1989 pp: 245-274.

10. Omode, A.; Fatoki, O.; Olaogun, K.A. Physico-chemial properties of some under- exploited and non-conventional oil seed. *J. Agric. Food Chem*. 1995, 11: 50-53.

11. Ojobe, T.O.; Tempo, V.J. Amino acid composition of tigernut tubers (Cyperus esculentus). Nig. *J. Sci. Biotechnol*.. 1983, 2: 35-38.

12. FAO/WHO. Milk and milk products. Joint FAO/WHO Food standards programme. Codex Alimentarius Commission. 2002a, Pp: 42.

13. FAO/WHO. Joint FAO/WHO Expert Report on diet, nutrition and the prevention of chronic diseases, cited in Food and Nutrition Bulletin. 2002b, 24: 255-256.

14. Bosch, L.; Alegria, A.; .Farri, R. RP-HPLC determination of tigernut and its amino acid contents. *Food Sci. Technol. Inter*. 2005, 11: 33-40.

15. Gambo, A.; Da'u, A. Tiger nut (*cyperus esculentus*): Composition, Products, Uses and health benefits – A review. *Bayero Journal of Pure and Applied Sciences*. 2014, 7(1): 56 – 61

 doi:10.20944/preprints201802.0054.v1

16. Belewu, M.A.; Abodunrin, O.A. Preparation of Kunnu from unexploited rich food source: Tiger nut (*Cyperus esculentus*). *World Journal of Diary and Food Sciences*. 2006, 1: 19-21.

17. Adejuyitan, J.A. Tigernut processing: its food uses and health benefits. *Am J Food Technol.* 2011, 6(3):197–201.

18. Association of Official Analytical Chemists. Official methods of analysis. 17th Edn., Association of Official Analytical Chemists. 1995, Washington DC.

19. Sa'id, A.M.; Abubakar, H.; Bello, B. Sensory and microbiological analysis of Tigernut (*cyperus esculentus*) beverage. *Pak. J. Nutr*. 2017, 16: 731-737.

20. Adgidzi, E.A. Effect of processing methods on the yield and quality of aqueous extracts and yoghurt-like products from Tigernuts (*Cyperus esculentus*). MSc Thesis submitted to the Department of Food Science and Technology. University of Agriculture, Makurdi. Benue State. 2010, p. 73.

21. Ezeokonkwo, C.A. Effect of wasting nutrient composition of Terminalia Catappa L. seed. Nig. *J. Nutr. Sci.* 2005, 26 (1) : 19-24.