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Effect of Processing Treatment on the Quality of Tigernut Milk

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Abstract: Tigernut tubers were differently processed into six products: Fermented Tigernut Milk (FTM), Pasteurized Tigernut Milk (PTM), Ultra-high Temperature Tigernut Milk (UHTM), Sterilized Whole Tigernut Milk (SWTM), Unheated Tigernut Milk (UTM) and Sweetened Tigernut Milk (STM). The effect of these treatments on the sensory, chemical and microbiological qualities of the various samples was investigated. Microbiological examination of the products was carried out over a 6 week storage period. Processing treatment significantly ($p<0.05$) affected the chemical composition of the samples. All the samples had high moisture content (77.0-80.7%) and reasonable amount of protein (6.4-8.2%). Total solid ranged from 20.2% in STM to 23.2% in SWTM. The pH of the sample ranged from 4.4 in UTM to 6.2 in PTM and UHTM. Significant difference ($p<0.05$) existed in sensory scores of mouth feel and general acceptability, but there was no significant ($p>0.05$) difference in colour and flavour. Although, all the samples were generally acceptable in terms of sensory quality, STM had the highest general acceptance while UTM had the least. The milk products were microbiologically stable during storage. UHTM and SWTM had no microbial growth throughout the storage period. The other samples recorded microbial growth from the 4th week of storage but was not high enough (bacteria and mould 10^2 cfu/ml maximum) to cause any appreciable spoilage of the samples. Processing treatment has effect on the qualities of tigernut milk.

Key words: Milk, tigernut milk, storage period, tigernut tubers

INTRODUCTION

Milk is an excellent source of all nutrients except iron and ascorbate. Milk has been recognized as an important food for infants and growing children (Obizoba and Anyika, 1995). In developing countries, the cost of dairy milk and their products are prohibitive. Adults who consume milk do so by adding small amount to breakfast cereals, porridge, cocoa beverage, tea or coffee probably owing to its exceptional scarcity. The high cost of milk in developing countries has led to the development of alternative source of milk from plant materials (Singh and Bains, 1988). An inexpensive substitute in the form of a milk or beverage made from locally available plant foods, high in protein, with satisfactory quality could play an important role to reduce protein malnutrition. Only soybean has been extensively investigated while other oil seeds and tubers such as tigernut, have not been studied comprehensively. However, prior to the development of such phyto milk like tigernut milk which serves as a less expensive substitute for dairy milk, direct milk consumption as a beverage was not common in Nigeria (Iwuoha and Umunnakwe, 1997; Onweluzo and Owo, 2005). Development of milk substitutes extracted from legumes serves as an alternative source of producing an acceptable nutritious drink (Harkins and Sarret, 1967). Among the sources of vegetable milk, soybean has received very high research attention and more research is still being designed to improve the quality of soy milk (Sun-young *et al*., 2000). Little research attention has been given to bambaranut (Obizoba and Egbunna, 1992), baobab (Obizoba and Anyika, 1995), peanut (Odo, 2001), melon seed (Akubor, 1998) and tigernut milk (Ukwuru *et al*., 2008) as sources of vegetable milk.

Tigernuts can be processed into varieties of milk products like natural tigernut milk, pasteurized tigernut milk, sterilized tigernut milk, ultra-high temperature tigernut milk and concentrated and condensed tigernut milk. Tigernut milk can be used by special people having milk allergies such as galactosemia and lactose intolerance.

Tigernut, 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 (Anderson *et al*., 1994). It has 5.8% moisture, rich in protein (7%) (Temple *et al*., 1990) and carbohydrate such as reducing sugar (7.4%), soluble polysaccharide (7.4%) and starch (86.4%) (Temple, 1989). According to Ojobe and Tempo (1983) the protein in tigernut 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 (2002a,b) and satisfy amino acid need of adults (Bosch *et al*., 2005).

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Like any other milk product, microorganisms such as *Bacillus subtilis, Staphylococcus aereus, Aspergillus flavus, A. niger, Fusariumsolani, Saccharomyces cerevisiae, S. fubiligera* and *Candidapseudo tropicalis* have been associated with tigernut milk (Onovo and Ogaraku, 2007). Hence processing conditions are fundamental to the storage stability and overall quality of tigernut milk. The need for a defined processing treatment to take care of its wholesomeness is necessary. Optimizing the processing techniques requires that the effect of processing on various products be studied. This gives an insight into process control as it affects tigernut milk. For instance, insoluble extract content of the milky beverage have been found to increase with increase in temperature, while the soluble extract content decreased under the same condition (Abaejoh *et al*., 2006). All these conditions have resulted in varied qualities of tigernut milk. Although milk has been successfully processed from fresh tigernut tubers, not much effort have been made in trying to standardize the processing treatment to maximize the nutritive value of the milk. Such standardization on processing and milk quality is of commercial and health significance. Two common processing techniques are pasteurization and ultra-high temperature sterilization and their effects on the nutritive qualities on milk can be manipulated to suit the desired tigernut milk quality.

This study was therefore aimed at using various processing treatments on fresh tigernut to obtain milk and to evaluate the effects of processing treatment on the chemical, microbiological and sensory characteristics of the resulting milk.

MATERIALS AND METHODS

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

Fermented Tigernut Milk (FTM): Five hundred milliliters (500 ml) of distilled water was added to 200 g of tigernut and blended several times with a blender (Qlink QB 15L40). The blended material was sieved using cheese cloth. The filtrate was boiled (80°C, 30 min). This was cooled to 45°C and fermented at 45°C for 18 h with *Streptococcus thermophillus* and *Lactobacillus bulgaricus*. The fermented sample was packaged and pasteurized at 75°C for 5 min (Fig. 1).

Pasteurized Tigernut Milk (PTM): Tigernut (200 g) was blended into slurry with water (400 ml). The slurry was pressed using cheese cloth to extract the milk. The extract was pasteurized at 75°C for 15 min. It was homogenized, bottled when hot and rapidly cooled (Fig. 1).

Ultra-High Temperature Tigernut Milk (UHTM): Tigernut (200 g) was wet milled with seed to water ratio of 1:5 (w/v). The slurry was filtered and the extract mixed with 2% w/v sugar and filled into sterile bottles. The milk was pasteurized at 145°C for 14 sec and cooled with cold water (6°C) (Fig. 1).

Sterilized Whole Tigernut Milk (SWTM): Tigernut (200 g) was soaked in warm water (40°C, 3 h) and blended to a smooth paste. The paste was mixed with 500 ml of water and sieved through a double layered cheese cloth. The filtrate was clarified by settling for 30 min, preheated at 50°C for 30 min and filled into bottles. The package was sterilized at 130°C for 10 sec and cooled (Fig. 1).

Unheated Tigernut Milk (UTM): Tigernut (200 g) was soaked in cold water (4-6°C) for 1 h and blended with cold water (4-6°C). Lime orange juice (pH 3.8) was added. The milk was filtered and the extracted milk was packaged and refrigerated (Fig. 1).

Sweetened Tigernut Milk (STM): Tigernut (200 g) was milled with 500 ml water in a blender. The slurry was filtered through double layered cheese cloth. The filtrate was boiled at 80°C for 30 min after which 5% sugar was added. The milk was flavoured with vanilla (0.1% w/v). The milk was filled hot into bottles and pasteurized at 75°C for 5 min (Fig. 1).

Analysis of products

Chemical analysis: Moisture, ash, fat, protein, carbohydrate by difference, titratable acidity, pH and total solids were determined according to standard methods (AOAC, 1995).

Microbial analysis: Plate counts of refrigerated samples were carried out every two weeks for a period of six weeks. Aliquots from serially diluted samples were mixed with plate count agar for bacteria and incubated at 37°C, 24 h and on potato dextrose agar for moulds and incubated at 25°C, 3 days. The plates were counted using colony counter (ALS Hulian) (Collins and Lyne, 1979).

Sensory evaluation: Six samples of tigernut milk were subjected to sensory evaluation by a 10 semi-trained panelists selected on the basis of their familiarity with phyto milk. Samples of the tigernut imitation milk were coded and presented to the panelist using white glass cups. Water was provided for mouth wash in between evaluations. Panelists were asked to evaluate the samples for colour, flavour, taste, mouth feel and overall acceptability using a 5-point Hedonic Scale (5 = like extremely and 1 = dislike extremely) (Onwuka, 2005).

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA) and Turkey's test was used for comparison of means. Statistical significance was accepted at $p<0.05$ (Ihekoronye and Ngoddy, 1985).

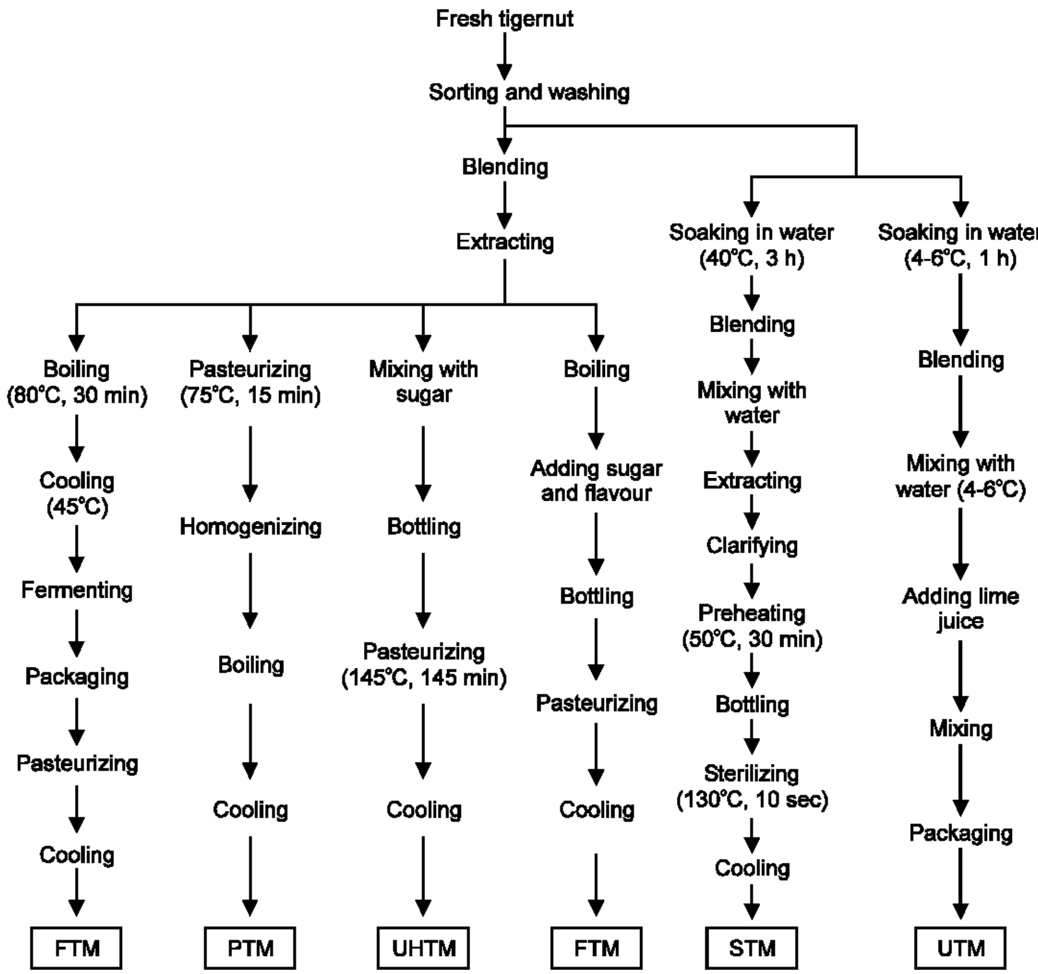

Fig. 1: Flow chart for the production of tigernut milk products

RESULTS AND DISCUSSION

Effect of processing treatment on the chemical characteristics of tigernut milk products: The effect of processing treatment on the chemical properties is presented on Table 1. Crude protein content of the various treatments ranged from 6.4-8.2% and were higher than *Treculia africana* seed milk (3.85%) and soy milk (3.20%) (Onweluzo and Nwakalor, 2009). Previous work suggested that tigernut milk could have 8.07% protein (Belewu and Belewu, 2007). There were significant differences in SWTM and UTHM samples with other treatment samples in protein contents. Apparently these differences in protein values reflected the effect heat had on the milk. A study by Alkanhal (2001) suggested that this could be due to maillard reaction initiated during heat treatment of ultra-high temperature milk and sterilized milk. The various treatment methods had no significant effect ($p>0.05$) on the moisture, carbohydrate, fat and titratable acidity (Table 1). The pH ranged from 4.4 in UTM to 6.2 in PTM, UHTM and SWTM. UTM sample showed the least pH. The lime juice added may have induced a decrease in pH. This is advantageous because it will discourage the growth of pathogens that may cause gastrointestinal problems. The PTM, UHTM and SWTM (pH 6.2) were comparable to the pH of melon seed milk (6.25), cowpea milk (6.79) and soymilk (6.6) reported by Akubor (1998); Nnam (2003) and Onweluzo and Owo (2005) respectively. The UTM and STM had lower total solids 20.0% and 20.2% respectively and were significantly different ($p<0.05$) from other samples. These values were below the minimum standard for sweetened dairy milk (28%) (FAO/WHO, 2002a,b). The nature of processing of SWTM sample may have influenced the extractability of more tigernut solids (23.3%). The crude fat extract of the milk samples were within the same range (5.3-5.5%) and were below minimum of 8% standard for dairy milk (FAO/WHO, 2002a,b). Tigernut, itself was reported to be rich in fat (25.50%) (Belewu and Abdunrin, 2006). The wide difference between fat in tigernut tubers and its milk reflect the extraction and pre-extraction treatments. The level in the milk products was higher than the minimum

Table 1: Chemical qualities of tigernut milk products obtained from various processing treatments

Treatment sample	Moisture (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)	pH	TTA (%)	Total solid (%)
FTM	77.7^{a}	7.8^{a}	0.7^{b}	5.3^{a}	8.2^{a}	5.2^{a}	0.21^{a}	21.4^{ab}
PTM	79.3^{a}	6.7^{a}	0.7^{b}	5.5^{a}	7.7^{a}	6.2^{a}	0.15^{a}	20.6^{ab}
UHTM	76.7^{a}	11.0^{a}	0.7^{b}	5.3^{a}	6.4^{b}	6.2^{a}	0.15^{a}	22.9^{a}
SWTM	77.0^{a}	10.7^{a}	0.7^{b}	5.2^{a}	6.4^{b}	6.2^{a}	0.15^{a}	23.2^{a}
UTM	80.0^{a}	6.6^{a}	0.7^{b}	5.4^{a}	7.3^{a}	4.4^{c}	0.20^{a}	20.0^{b}
STM	80.7^{a}	5.1^{a}	1.2^{a}	5.5^{a}	7.7^{a}	6.0^{a}	0.14^{a}	20.2^{b}
LSD	14.4	14.3	0.29	0.90	0.98	0.39	0.28	2.04

Means with different superscript in each column are significantly different ($p<0.05$). FTM = Fermented Tigernut Milk; PTM = Pasteurized Tigernut Milk; UHTM = Ultra High Temperature Tigernut Milk; SWTM = Sterilized Whole Tigernut Milk; UTM = Unheated Tigernut Milk; STM = Sweetened Tigernut Milk; LSD = Least Significant Difference

Table 2: Sensory qualities of tigernut milk products obtained from various processing treatments

Treatment sample	Sensory quality: Colour	Flavour	Taste	Mouthfeel	General acceptability
FTM	4.5^{a}	3.9^{a}	3.9^{ab}	3.7^{ab}	4.3^{ab}
PTM	4.0^{a}	3.9^{a}	4.2^{a}	3.7^{ab}	4.0^{ab}
UHTM	3.9^{a}	3.6^{a}	3.4^{b}	3.6^{ab}	3.8^{b}
SWTM	4.2^{a}	3.8^{a}	3.6^{b}	3.7^{ab}	4.0^{ab}
UTM	3.7^{a}	3.7^{a}	3.6^{b}	3.4^{b}	3.5^{b}
STM	4.3^{a}	4.7^{a}	4.6^{a}	4.4^{a}	4.8^{a}
LSD	1.06	1.23	0.93	0.89	0.93

Means with different superscript in each column are significantly different ($p<0.05$). FTM = Fermented Tigernut Milk; PTM = Pasteurized Tigernut Milk; UHTM = Ultra High Temperature Tigernut Milk; SWTM = Sterilized Whole Tigernut Milk; UTM = Unheated Tigernut Milk; STM = Sweetened Tigernut Milk; LSD = Least Significant Difference

(3%) level required by the Codex Alimentarius Standard (Passmore and Eastwood, 1986). Total ash in the various treatments was lower than ash content of 1.5% as reported by Ukwuru *et al.* (2008). STM was significantly ($p<0.05$) different from others. Addition of sugar may have contributed to this. All sample treatments had high moisture contents between 77.0-80.7%. This could affect the stability and safety of food with respect to microbial growth and proliferation hence the products require cold storage. The flash high temperature used in processing did not have significant effect on the compositional (nutritional) quality of the milk products as shown in Table 1.

Effect of processing treatment on the sensory quality of tigernut milk products: The main sensory scores for tigernut milk products obtained through various treatments are presented on Table 2. Various treatments were rated alike in almost all the quality attributes evaluated indicating the minimal effect processing had on the organoleptic property of the milk. There was no significant difference ($p>0.05$) observed between various treatments in terms of colour and flavour. The tigernut milk products had creamy colour just like conventional milk (dairy milk). The uniformity in colour and flavour were attributed to heat process. The exception was UTM which had the least mean score for colour (3.7). STM sample had the highest score for flavour due to added flavour. The flavour, taste, mouth feel and general acceptability of STM sample were higher than those of the other treatments. The high mean score of STM for mouth feel was attributed to its high fat content. Fat is known to promote good mouth feel (Onweluzo and Nwakalor, 2009). However, the panelists commented that all the milk products were good but STM was the best. The UTM was least preferred. Unlike other phytomilk, tigernut milk has no beany flavour and throat catching sensations. Significant ($p<0.05$) difference was observed in taste, mouth feel and general acceptability between the various treatments. The STM sample had the highest mean score for taste, mouth feel and general acceptability. Despite the significant differences in sensory quality in some tigernut milk products as earlier mentioned, all the product samples were generally acceptable to the panelists. Similar processing treatment carried out on tigernut (Belewu and Abdunrin, 2006; Ukwuru *et al.*, 2008) and other similar vegetable milk (Zaruwa *et al.*, 2005) recorded high acceptability. Such acceptability has led to the commercialization of a profile tigernut milk products in Spain (Tigernut Traders, online).

Effect of processing treatment on the microbial quality of tigernut milk products: The microbial quality of milk products from various processing treatments are shown on Tables 3 and 4. There was no growth of microorganisms on the freshly prepared samples except in FTM sample. Although, the fermentation of the FTM sample created an acidic medium (pH 5.2), which

Table 3: Bacterial load (cfu/ml) of various tigernut milk products under storage at 4°C

Treatment sample	Storage period (week) 0	2	4	6
FTM	3.1 x 10^2	4.2 x 10^2	1.0 x 10^2	1.2 x 10^2
PTM	NG	NG	0.8 x 10^2	0.9 x 10^2
UHTM	NG	NG	NG	NG
SWTM	NG	NG	NG	NG
UTM	NG	3.7 x 10^2	3.6 x 10^2	4.0 x 10^2
STM	NG	NG	2.7 x 10^2	2.8 x 10^2

NG = No Growth; FTM = Fermented Tigernut Milk; PTM = Pasteurized Tigernut Milk; UHTM = Ultra High Temperature Tigernut Milk; SWTM = Sterilized Whole Tigernut Milk; UTM = Unheated Tigernut Milk; STM = Sweetened Tigernut Milk

Table 4: Moulds and yeasts counts, under storage at 4°C

Treatment sample	Storage period (week) 0	2	4	6
FTM	NG	NG	1.7 x 10^2	1.8 x 10^2
PTM	NG	1.0 x 10^2	2.0 x 10^2	3.2 x 10^2
UHTM	NG	NG	NG	NG
SWTM	NG	NG	NG	NG
UTM	NG	1.6 x 10^2	1.5 x 10^2	3.2 x 10^2
STM	NG	NG	2.5 x 10^2	2.9 x 10^2

NG = No Growth; FTM = Fermented Tigernut Milk; PTM = Pasteurized Tigernut Milk; UHTM = Ultra High Temperature Tigernut Milk; SWTM = Sterilized Whole Tigernut Milk; UTM = Unheated Tigernut Milk; STM = Sweetened Tigernut Milk

was antagonistic to the survival of non-acidtolerant organisms. The growth may be attributed to cells of lactic acid bacteria that might have survived processing treatment. The growth declined during storage from 3.1 x 10^2 to 1.2 x 10^2 cfu/ml. In both bacterial and mould counts, there was no growth in UHTM and SWTM samples throughout the storage period (4°C). This implies that UHTM and SWTM were microbiologically stable. PTM sample recorded more mould counts than bacterial counts. The processing method might have affected the cell metabolic process that bacteria growth could only occur after 4 weeks of stable storage. At pH 4.2, growth was noticed in UTM sample after two weeks. The pH and temperature interaction effectively inhibited the growth of microorganisms, but heat was not used on the UTM sample. Although Abaejoh *et al.* (2006) indicated that deterioration effect of microorganisms on the tigernut milk hampered its production in Nigeria, the various processing treatments adopted in this study retarded microbial growth and spoilage. The data obtained on Tables 3 and 4 were below the limit of acceptable counts for dairy milk (Jay, 1978). Evidently, various processing treatments affected maximum destruction of microorganisms and made the products microbiologically safe. Microbial species such as *Bacillus subtillus, Staphyloccus aureus, Aspergillus flavus, A. niger, Fusariumsolari, Saccharomyces cereviseae, S. fubiligera* and *candida* isolated and identified by Onovo and Ogaraku (2007) were possibly destroyed using various processing treatments. Comparatively, 4.2 x 10^2 and 3.2 x 10^2 cfu/ml of bacterial and mould counts respectively were below 1.2 x 10^3 and 0.2 x 10^3 cfu/ml microbial load for exposed and unexposed tigernut milk respectively according to Onovo and Ogaraku (2007). Throughout the period of storage there was no observable or detectable spoilage in the various milk products and microbial counts (Table 3 and 4) were below the limit of acceptance which is 2.0 x 10^5 cfu/ml for dairy milk by Codex Alimentarius Commission (FAO/WHO, 2002a,b).

Conclusion: Tigernut tubers can be processed using various techniques into different products. Generally, processing treatment significantly affected the quality of the products. The milk products were highly acceptable. Fermentation increased the protein content of the product. Variations in chemical values of the samples were a function of processing treatment. The products were microbiologically stable during storage. UHTM and SWTM samples had no growth of microorganisms throughout storage. Based on these results, an acceptable standard procedure can be developed for processing tigernut into various products with an effective process control programme.

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