Original Research Article

Valorization of Tiger Nuts (*Cyperus esculentus*) Sourced from Cameroon in the Production of Yoghurt

ABSTRACT

Tiger nuts are one of the healthy sources to substitute for many consumer products such as skimmed milk and gluten. A 6-month study was conducted in the agricultural engineering research unit of the University of Dschang, Cameroon. This study aimed to enhance the use of tiger nuts (*Cyperus esculentus*) in the production of yoghurt. Phytochemical analyses were carried out and sensory parameters were evaluated. 1 kg of tiger nuts followed chronological steps to produce 2 liters of milk. These steps were: sorting and weighing, soaking, grinding using a blender, filtration through a polyethylene filter, pasteurization, packaging and filling at hot in polyethylene bottles then rapid cooling. The resulting milk went through a process to produce 2 liters of tiger nuts yoghurt. This process consisted of the following steps: pasteurization, cooling, inoculation, mixing and homogenization using a spatula, incubation 6 hours, packaging and storage. Tiger nuts yoghurt was served chilled to panelists for sensory analyses. The results of this study showed that 100 g of tiger nuts yoghurt contain 4.4 g protein, 1.9 g fat, 5.7 pH, 3.7 g sugar, 1.3 g fiber, 140 mg potassium, 126 mg calcium, 12.1 mg magnesium, 43 mg sodium, 0.40 mg zinc, 176 mg phosphorus, 0.001 mg vitamin A and 0.3 mg vitamin C. The overall acceptability of yogurt showed that 35% of panelists like the product very much while, 65% moderately like the product; this indicates that the product is highly valued. In order to improve the value addition of tiger nuts, the optimization of tiger nuts milk extraction can be done using a machine.

Keywords: Tiger nuts, milk, yoghurt, sensory analysis, phytochemical analysis, valorization.

1. INTRODUCTION

Yoghurt is a fermented product produced by bacterial fermentation of milk from animal source. Milk is an excellent source of all nutrients except iron and ascorbate [1]. Milk has been recognized as an important food for infants and growing children due to its liquid nature and exposure to digestion enzymes [2,3]. In developing countries, the cost of dairy milk and derivatives are prohibitive. As a result, the is a drastic decrease in milk consumption. This decrease in the consumption of milk and milk products stimulated in part the processing of milk from different seeds and nuts. Though undervalued in the past, milk from plant sources are key ingredient in the diet of African countries [4]. Recently, researchers have shown strong interest in these milk sources due to their high nutritional values and economic potentials. It is worth repeating that milk sources from plants are seen as a radiating hope towards solving health related problems [5] as well as an ally in the fight against hidden hunger [6]. In view of the scarce milk supply in various countries and the increasing gap

between demand and supply, efforts have been made over the recent years to develop alternative milk-like products from vegetable sources [7]. Soybeans, peanuts and cowpea have been accorded high attention in the investigations on milk substitutes. However, hardly any attention has been given to the use of local product such as tiger nuts as such or in combination with milk to produce a palatable ready-to-serve bottled beverage, like “Horchata de chufas” as done in South Europe especially in Spain [8]. As reported by Roselló-Soto et al. [9], a beverage produced with 25% incorporated tiger nut milk is capable of protecting against non-communicable diseases. They are cardiovascular problems such as atherosclerosis, coronary heart diseases, hypertension, diabetes and gastro-intestinal problems.

Cardiovascular disease (CVDs) takes the lives of over 17.9 million people every year, 31% of all global death [10]. An important cause of this health disorder is arteriosclerosis which is as a result of accumulated fats in the vascular system specifically the coronary artery. This major cause contributes to about 65% of all CVDs death recorded yearly in the world.

Present day consumers prefer foods that promote good health and prevent disease [11]. Hippocrates (the father of medicine) wrote 2400 years ago “Let food be thy medicine and medicine be thy food”. So, producing milk and yoghurt from tiger nuts will not only improve health conditions but will also improve the economy of yoghurt consumption.

Tiger nuts (*Cyperus esculentus*) is a tuber, mainly harvested in Spain, West and Central African countries like Nigeria, Cameroon, Senegal, Ghana, and also in South America, as in Chile [12]. Tiger nuts have been cultivated for both human and livestock consumption [13]. From an economic point of view, tiger nut is described as an underutilized African crop with high potential for development [14]. Tiger nuts are rich in oil which can be extracted for culinary and industrial use. As reported by Sanful [13], tiger nuts have long been recognized for its health benefits as they are high in fibre, protein and natural sugars. They have a high content of soluble glucose and oleic acid, along with high energy content. They are rich in minerals such as phosphorous and potassium and in vitamins E and C. Tiger nuts are believed to help prevent heart attacks, thrombosis and cancer especially of the colon. They are thought to be beneficial to diabetics, lactose intolerance, and those seeking to reduce cholesterol or lose weight. The very high fibre content combined with its delicious taste make tiger nuts ideal for healthy eating [15]. These numerous advantages and health benefits associated to tiger nuts makes it more attractive as an alternative source of milk in yoghurt production. Tiger nut was also reported to have high content of oleic with positive effect on cholesterol level due to the high content of vitamin E. The nut was found to be ideal for children, older persons and sportsmen [16]. Therefore, tiger nuts with its inherent nutritional and therapeutic advantage could serve as a good alternative to cow milk in the production of yoghurt. In addition, the inclusion of tiger nuts milk in the production of yoghurt could reduce the price of yoghurt and make it more affordable to many Cameroonians.

Between the years 2001 and 2006, Cameroon import more than 68,885 tons of powdered milk which cost 128,640,000 $US and from statistics, Cameroon is expected to import 662,000 tons of milk which will cost 2,566,368,000 $US from which 70% of this milk are used in yoghurt production [17]. In Cameroon, tiger nut utilization is unknown and not valorized despite it numerous economic and health benefits. A measure or possible solution to powder cow milk is to valorized the utilization of tiger nuts by processing the tuber to produce milk which will further be used to produced yoghurt which has nutraceutical and phytochemical properties.

Producing milk from tiger nuts to produce yoghurt will in a short run satisfy the demand of yoghurt and in a long run reduced the amount of powder cow milk importation there by

boosting the production of local farmers in other to satisfied the demand, since there will be a high demand to produced milk. Furthermore, tiger nuts are lactose free which is convenient to every individual. The aim of this study is to valorize tiger nut plants utilization in the transformation of tiger nuts to tiger nuts milk then to tiger nuts yoghurt which will increase livelihood by creating employment and also reduce the rate of CVDs.

2. MATERIAL AND METHODS

2.1 Presentation of the area of study

This study took place in the city of Dschang. Dschang is a historical and university city of Cameroon located in the department of Menoua, Western Region. It is the second largest city in the West region after Bafoussam and ahead of Foumban, Mbouda, Bangangté. It extends between 5°25' - 5°30' North Latitude and 10° - 10°5' East Longitude. The city is crossed by a main road with heavy traffic. It is 46 km from Bafoussam, the regional capital, 54km from Mbouda, 26 km from the border with the South-West, 46 km from Melong and 84km from Nkongsamba in Moungo. It extends over an area of 262 km^2 distributed in its urban area which has 20 communities and in the rural area which has 96. The five groups that make it up are Foto: 99 km^2; Foréké-Dschang: 86 km^2; Fongo-Ndeng: 31 km^2; Fossong Wentcheng: 18 km^2; Fotetsa: 11 km^2; Urban center: 7 km^2. The area of the urban space of Dschang is estimated at 5655 ha and is located in the intercession of the territory of the Foto and Foréké-Dschang chiefdoms.

2.2 Production of tiger nuts milk and yoghurt

2.2.1 Presentation of raw materials

The raw materials used during this process were: tiger nuts, sugar, powder milk. They were bought from market “B” in Dschang.

Despite their names, tiger nuts are not actually nuts but rather tubers (like potatoes, yams, and Jerusalem artichokes). They’re completely vegetarian, vegan and gluten free. Rich in prebiotic fibre. A single ounce of tiger nuts has 40% of our recommended fibre.

Sugar is an additive, it gives the sweet taste of the end product.

Tiger nut is the main raw materials in this process the skimmed milk has a negligible fat content; it was in other to stabilized the mixture and to increase the viscosity of the final product.

2.2.2 Presentation of equipment’s used during production

Thermometer is a crucial device since it aids to determine the temperature of the product which in a long run determine whether a product can be removed or added. In this process, a wireless grill thermometer of mark flora best was used. It is equipped with a sensor.

A measurable plastic cups were used of volume 1000 mL each. They were used to quantified the volume of products.

One stainless steel pot of volume 10 L was used. It was used to contain the products. Stainless steel pot was used due to it smoothness and has a very low degree of friction with

the spatula. Also, the stainless steel pot has no free space in the inner part and the force of adhesion is relatively low.

A spatula is a wooden material. it is shape like a spoon. It is used to stir the mixture.

A filter was used to separate liquid from solid particles during milk production.

A blender of mark singsung with capacity of 220-240 v, 50-60 Hz, 500 W was used to mill the tiger nuts into smaller particles to ease extraction of tiger nuts milk.

Three plastic bowls of 5, 1.5, 1.5 L were used respectively. This was used to collect and transfer materials from one spot to another.

Funnel is used to canalize the transfer of the end product in to plastic bottles.

Plastic bottles were served to receive the end product for storage.

Vernier calliper is a device used to measure the diameter of tiger nuts.

Electronic balance was used to measure the weight of tiger nuts tubers and other materials.

2.2.3 Stages in the production of tiger nuts milk

To obtain tiger nuts milk, product was passed through several stages from the reception of raw material (Fig. 1).

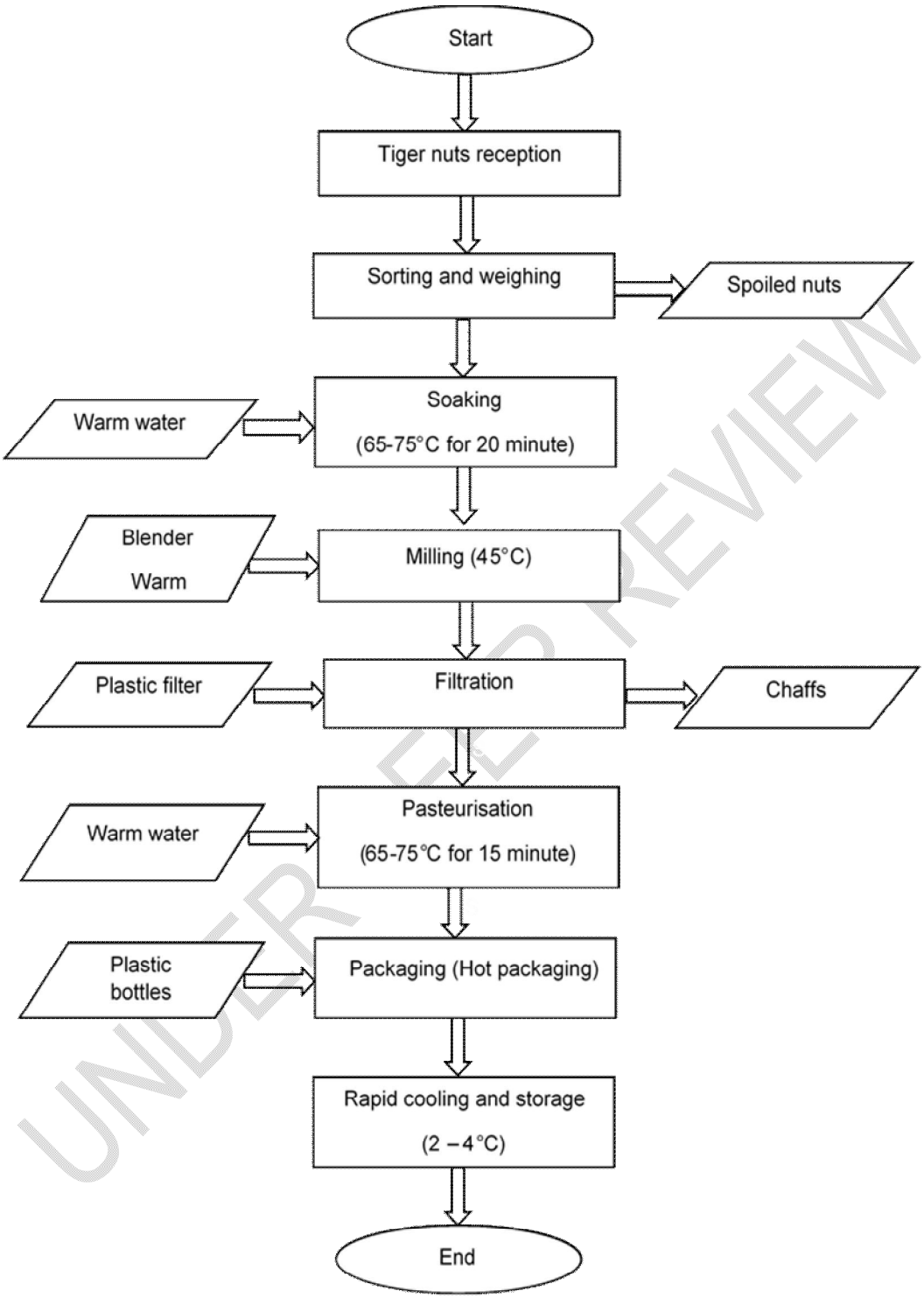

Fig. 1. Flow chart of tiger nut milk production

Sorting is the separation of food on the basis of measurable physical properties. The raw tiger nuts were sorted based on four main parameters which are: size, shape, weight and colour.

The sizes of the nuts were measured with the aid of a Vernier caliper and they had an average size of 55 mm in diameter. This average size after measurement was easily separated from sizes 3 times smaller than the average, from an analytical point of view. This was done in anticipation of a maximum yield with less defective qualities which could come from nuts that was not well developed [12]. The shape of the tubers was examined to remove mechanically injured or crack nuts or nuts eaten partly by pest since they might have been contaminated or might have exposed some enzymes to the nuts available nutrients. The weight was measured using an electronic balance of accuracy 0.01 g and they had an average weight of 0.52 g. The nuts with smaller weight float during buoyancy and they were removed. Colour is a very important parameter which aid to differential the tiger nuts from impurities. This was done with necked eyes. Tiger nuts used was the yellow tiger nuts. So, anything different from yellow was removed in other to enhance it texture.

The tiger nuts were soak at a temperature of 65-75 °C for 20 minutes in a 5 L bowl. This was done to soften the cell wall henceforth facilitating milling and milk extraction. Soaking was also done so as to considerably reduce the fresh sweet taste present in the nuts.

Milling is a machinery process that involves the use of cutting tools that are rotated at a set speed and then brought into contact with a work piece. The milling machine used was a blender. It functions in reducing (breaking) the size of the tiger nuts tuber. This unit operation is considered the first Critical Control Point (CCP) in the processing of this tiger nuts milk. The concern about the CCP of this unit is due to the fact that; the particle size and rate of extraction affects the wholesomeness of the end product. Here, the tiger nuts were transferred into the blender with water at 45 °C. This was to increase the solubility of the tuber's nutrients, reducing friction and thereby optimizing the rate of extraction. The blending time was approximately 20 minutes for 1 kg of tiger nuts.

Filtration is a process in which solid particles in a liquid or gaseous fluid are removed by the use of a filter medium that permits the fluid to pass through but retains the solid particles. In this process, a plastic filter of approximately 6micrometer of porosity was used. The filter was sterilized at a temperature of 90 °C. The mill nuts were pass through the filter, particles greater or equal to 6micrometer was retain and the fluid that passes became the filtrate (milk). The retains particles are chaffs. This process was repeated several time to ensure no solid particles will be present in the end product. The filtrate was collected in a plastic cup of volume 5litter and then pasteurized. 1 kg of tiger nuts produces 2liters of tiger nuts milk and chaffs of 713 g were produced.

Pasteurization The milk extract obtained during filtration, was transferred into a stainless steel pot (type 304SS) and heated using an automated gas plate up to the temperature of 72 °C. At this temperature, the heater was set at a constant temperature for 15minutes. This is aimed at deactivating enzymes and killing some low temperature heat labile microbes. During this process, the milk was constantly stir to ensure the temperature were uniformly distributed.

After pasteurization, the temperature was brought down to 60 °C. The nuts milk was then filled into two sterilized plastic material of 1 L capacity at 60 °C in other to destroy any existing microorganism which can exist for assurance purposes.

The purpose of rapid cooling is to create a thermal shock to destroy resistance microorganism. This is done by rapidly decreasing the temperature from 60°C to 5°C by inserting in a freezer then later transfer into a refrigerator to maintain a refreshing temperature. This is also to preserve certain vitamins like vitamin A and E.

Powder cow milk plays a critical role in the production line. It aids to stabilize and homogenize the product and most importantly aid to give the product it texture. Here, 400 mL were used. The assumption made was that 1 kg of powder cow milk produces 4 L of milk. So, 250 g of cow milk was inserted in a sterilized bow and 1 liter of mineral water added. The mixture was mixed and stir till homogeneity and 400 mL of negligible fat content was extracted to be used.

2.2.1 Stages in the production of tiger nuts yoghurt

To obtain tiger nuts milk, product was passed through several stages from the reception of raw material (Fig. 2).

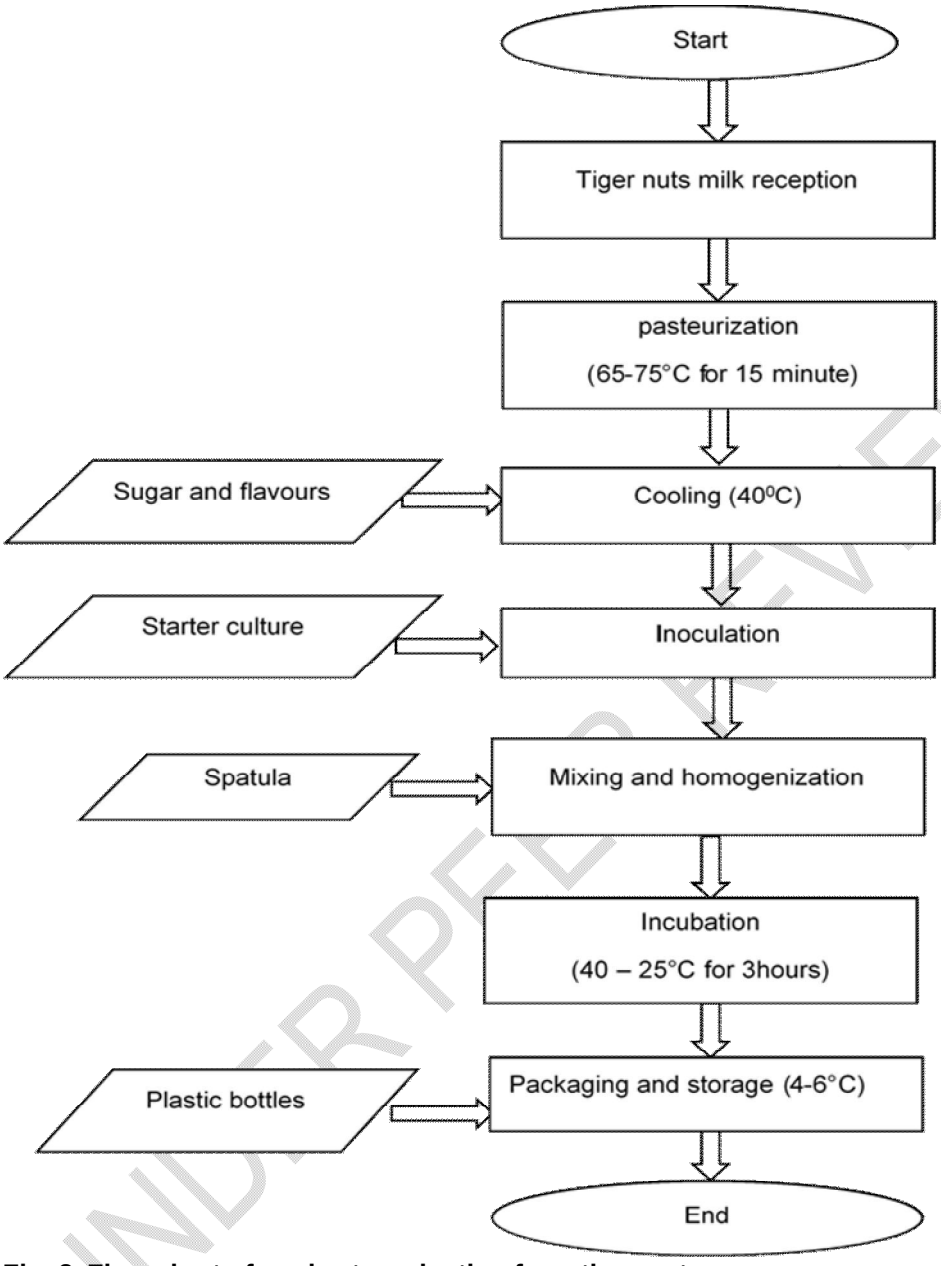

Fig. 2. Flow chart of yoghurt production from tiger nuts

The 2 litter tiger nuts milk was received in a stainless steel pot of 6 m^3 and was been subjected to heating.

The milk was heated at a constant temperature of 60-70 °C for 15 minute. This is aimed to neutralize any existing microbial bacterial which may be due to human errors or manipulation by deactivating enzymes and killing some low temperature heat labile microbes.

After heating for pasteurize, the temperature was brought down from 60-70 °C to 40 °C by allowing it to rest. This temperature is ideal for microbial activities.

The inoculation is the art of introducing probiotic microorganism into a medium for incubation. The microorganisms use were *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. *S*. *thermophilus* is mostly responsible for the flavour, aroma and texture of the yogurt, and is, in fact, capable of making yogurt on its own. The role of *L. bulgaricus* is to produce acid (lactic acid).

Mixing and homogenization is a process which consist of adding raw materials especially additives to the inoculated milk. 150 g of sugar was added and uniformly stir with a spatula applying a constant rotary force to obtain a well uniformly distributed product.

Incubation is the process of allowing the inoculated milk to obtain it required texture. During this process the milk is place in a light free zone because the microorganism is sensitive to light was may altered the texture and composition of the final product. Furthermore, the milk was place in dry and clean area to prevent any contamination. The incubation took place for 4 hours at room temperature. The room temperature was 21-25 °C.

After incubation, tiger nuts milk was filled into sterilized plastic cups of volume 500 ml each at 21-25 °C and store in a refrigerator temperature at 4-6 °C.

2.3 Evaluation of physicochemical properties of tiger nuts yoghurt

Physicochemical analysis evaluates the particular chemical properties of a test substance. Tiger nuts yoghurt was analyzed at the Faculty of Agronomy and Agricultural Science soil laboratory.

2.3.1 Sample collection

Beverage samples were collected in a sterilized beaker for physicochemical analysis (pH, sugar content, protein, lipid, fiber, vitamins and minerals).

2.3.2 Minerals

Preparation of the sample for minerals evaluation. 1 g of the sample(yoghurt) was introduced into a porcelain crucible, digested with a mixture of 7.5 mL of concentrated nitric acid and 2.5 mL concentrate hydrochloric acid. They were heated using an electric heater for 30minute at 80oC to obtain 5 mL of the solution, then cooled for 45 minute and filtered using a watt man filter paper in 50 mL volumetric flasks and complete with distilled water up to the gauge line to obtain 100 mL of the concentrate.

2.3.2.1 Phosphorus

Yoghurt of 2 mL extract are carried in a test tube then 6 mL of distilled water and 2 mL of nitro-vanada-molybdate reagent are added, homogenized and left to react for 1 hour then test by spectrophotometry at 430 nm, following the descriptions below:

- Switch on the spectrophotometer and allow it to stabilize for a minimum of 10 minutes;
- Set the assay in absorbance mode using the "Change mode" function;
- Fix the absorbance at 430 nm using the “Fix nm” function;
- Establish zero absorbance with an aliquot of deionized water in the quartz cell;
- Placed in the optical path of the detector by activating the “Measure white” function;
- Measure the absorbance of each of the calibration curve standard and sample by placing the cell in the optical path of the detector and using the same quartz cell. Record the absorbance on the worksheet;

- Calculation and result expression.

2.3.2.2 Zinc

Yoghurt of 20ml extract +20ml of ammonium chloride (NH_4Cl) + 1 mL of hydrochloride acid (HCl) Con + 1 drop of sodium sulphite + 1 mL of 0.5% potassium cyanoferrate, leave to act for 5 minutes in the dark and read with the visible Ultra Violet (UV) spectrophotometer at 650 nm.

2.3.2.3 Sodium and Potassium

They were determined by flame spectrophotometry. (10 mL of extract + 10 mL of demineralized water (pH12.5 for the extract + water mixture) + 1 mL of 5% potassium cyanide (KCN) + a pinch of Patton and Reeder's reagent).

2.3.2.4 Calcium and Magnesium

They were determined by complexiometry with ethylene diamine tetra acetic acid (EDTA). (10 mL of extract + 10 mL of demineralized water (pH10 for the mixture) + 1ml of 5% KCN + 1 mL of EDTA-magnesium (Mg) + a pinch of Patton and Reeder's reagent) the Mg is obtained by the difference: [calcium(Ca) + Mg] - Ca.

2.3.3 Lipid

One gram of the sample is introduced into a cellulose capsule. It is continuously extracted at boiling point with a miscible solvent (hexane) which gradually dissolves the fat. The fat-containing solvent returns to the flask by successive spills caused by a siphon effect in the side bend. As only the solvent can evaporate again, the fat accumulates in the flask until the extraction is complete. Once the extraction is complete, the solvent is evaporated, usually on a rotary evaporator, and the fat is weighed. The percentage of fat is given by the following equation:

$$\mathbf{L} = \frac{\mathbf{L}_m \times 100}{\mathbf{S}_m} \quad (1)$$

Where:

$\mathbf{L}$ = lipid (%)
$\mathbf{L}_m$ = lipid mass (g)
$\mathbf{S}_m$ = sample mass (g)

2.3.4 Protein

It consists beforehand of the complete mineralization of nitrogen (N) by a mixture of sulphuric acid (H_2SO_4) concentrate and hot salicylic acid (350 °C). The mineralized product is distilled by steam distillation. The distillate is then titrated with a solution of H_2SO_4 (0.01 N).

2.3.5 Fiber

One gram of the sample is extracted and introduced into a beaker containing 0.255N sulphuric acid. The mixture is boil for 30 min and then filtered. The residue is added 0.313N sodium hydroxide then the mixture is brought to boil again for 30 min. After filtration, the residue is washed 3 times with hot distilled water (5 mL) and 2 times with acetone (5 mL),

the insoluble material obtained is dried at 105 °C for 8 hours and weighed. This dry residue is subjected to incineration at 550 °C for 3 hours and the ashes are weighed.

2.3.6 Acidity

The pH of the yoghurt is measured using a pH meter fitted with a glass electrode; the pH measured will be pH_{H20} 24 hours after mixing 10 g of the yoghurt sample in 25 mL of distilled water.

2.3.7 Carbohydrates

The quantity of carbohydrate is obtained from the following equation:

$$G = 100 - (P + L + F + A_S + X) \quad (2)$$

Where:

G = Carbohydrate (g)
P = Protein (g)
L = Lipid (g)
F = Fiber g)
A_S= Ash (%)
X = Water content (%)

To obtain dry matter, 5 g of the sample were dried under study until constant weight and weigh after cooling in a desiccator.

2.3.8 Vitamins

2.3.8.1 Vitamin A

Due to the redox properties of ascorbic acid on appropriate coloured solutions, many assay techniques have been developed, the simplest of which is titration by iodometry, a classic method that is quick and simple.

The following titration is performed to determine the concentration of the triiodide solution. A volume V_1= 25 mL of the triiodide solution of unknown concentration C_1 is pipetted, then poured into an Erlenmeyer flask.
The burette is filled with the sodium thiosulphate solution with a concentration C_2=0.001M. While stirring, the sodium thiosulphate solution is poured until a light yellow colour is obtained, so a few drops of starch paste are added, the solution takes an intense blue colour which explains why the iodine is present in excess, the thiosulphate solution is then continued to be poured drop by drop until the equivalence point is reached. The volume V_2 of thiosulphate poured is noted. The concentration of triiodide ions is calculated according to the following equation:

$$C_1 = \frac{C_2 \cdot V_2}{2V_1} \quad (3)$$

Where:

C_1 = Concentration of the triiodide ion solution
C_2 = Concentration of sodium thiosulfate solution
V_2 = Volume of sodium thiosulfate
V_1 = Volume of triiodide

2.3.8.2 Vitamin C

- In an Erlenmeyer flask, we introduced:
- 5 mL of the sample (unknown concentration (CAA) with the addition of a few drops of phosphoric acid) and
- 10 mL of the solution of triiodide ions of concentration C1 with the addition of a few drops of starch.

Tiger nuts yoghurt physicochemical properties and cost of production is being compared to "dolait" yoghurt. This is because, from an analytical point of view and from a mouth to mouth discussion, "dolait" yoghurt is the most consumed yoghurt in Cameroon, it is found all around the country, it is the most certified diary yoghurt, there is certainty of safety compare to other yoghurts.

2.4 Sensory analysis evaluation

The Sensory evaluation was done using a 5-point Hedonic scale ranging from 1 (poor) to 5 (excellent). Samples were served chill at 10-15 °C using a disposable cup. 20 panelists were randomly selected most of which were researchers and engineers. Panelists were asked to evaluate the degree of appraisal for parameters such as: appearance, clarity, aroma or smell, taste, mouth feel, after taste and were grade as follows:

- E = Excellent
- VG = Very good
- G = Good
- FG = Fairly good
- P = Poor

The overall acceptability of consumers is then evaluated to determine whether the product can be generally accepted or not and was graded as follows:

- Like very much = 5 points
- like moderately = 4 points
- neutral = 3 points
- dislike moderately = 2 points
- dislike = 1 point

2.5 Data Analysis

The concentration of a sample is obtained using linear regression concentrations relative to the absorbance of the standard. The calibration curve and the calculation of concentrations, expressed in mg/100 g, are established using Excel software 2016.

3. RESULTS AND DISCUSSION

3.1 Production of milk from Tiger nuts

After executing the different unit operations in a chronological manner, 2 liters' tiger nuts milk were obtaining. The milk has an opaque white texture with a relatively low viscosity, slightly sweet taste and very good appearance. The 2 liters' tiger nuts milk was used still following a chronological manner to produced yoghurt of approximately 2 liters. Tiger nuts yoghurt has an opaque white texture with a moderate viscosity. Moderately sweet and have a very good appearance (Fig. 3).

Fig. 3. Tiger nuts milk

3.2 Physicochemical analysis of tiger nuts yoghurt

Table 1 shows the nutriments found in tiger nuts yoghurt for a 100 g after analysis.

Table 1. Calculations parameters and constants used

Nutriments	**Quantity (g)**
Protein	4.4
Lipid	1.9
pH	5.7
Sugar content	3.7
Fiber	1.3
Vitamins	
Vitamin A	1 ug
Vitamin C	0.3 mg
Minerals	**(mg)**
Potassium	140
Calcium	126
Magnesium	12.1
Sodium	43
Zinc	0.40
Phosphorus	176

From an economic (cost of production) point of view yoghurt production from tiger nuts (plant source) is highly economical compare to “dolait” yoghurt which is made from milk (animal source). 1 kg of tiger nuts cost approximately 1.61 $US while 1 kg of powder milk cost 6.43 $US. 500 g of “dolait” yoghurt cost 1.61 $US while 500 g of tiger nuts yoghurt will cost 1.29 $US. Furthermore, 99% of milk used by “Soticam” to produced “dolait” yoghurt is imported meanwhile 100% of tiger nuts used in tiger nuts yoghurt production are cultivated in Cameroon. Therefore, tiger nuts yoghurt is more economically beneficial to Cameroonians compare to “dolait” yoghurt because; tiger nuts yoghurt will help increase the rate of employment of youths since more labour will be needed for tiger nuts production and processing, the demand of tiger nuts will increase thereby increasing the livelihood of farmers involved in tiger nuts production compare to “dolait” yoghurt. Through tiger nuts processing to yoghurt, it will inspire many youths to valorized local products through transformation. Also, tiger nuts yoghurt production will aid reduce the rate of milk importation

for yoghurt production. It is said “agriculture is the back bone of Cameroon economy” but “food processing is the back bone of Cameroon agriculture”.

Table 2 shows certain physicochemical properties of tiger nuts yoghurt are greater than that of “dolait” yoghurt and tiger nuts have more nutrient compare to “dolait” yoghurt.

Table 2. Comparison between tiger nuts yoghurt and “dolait” yoghurt

Nutriments	Tiger nuts yoghurt	“Dolait” yoghurt
Protein	4.4 g	3.9 g
Lipid	1.9 g	3.0 g
pH	5.7	_
Sugar content	3.7 g	13.0 g
Fiber	1.3 g	_
Vitamin A	1 ug	_
Vitamin C	0.3 mg	_
Potassium	140 mg	_
Calcium	126 mg	120 mg
Magnesium	12.1 mg	_
Sodium	43 mg	50 mg
Zinc	0.40 mg	_
Phosphorous	176 mg	_

Tiger nuts yoghurt is free from lactose thereby lactose intolerance patient can save fully consumed mean while “dolait” yoghurt contain lactose which cannot be consumed by lactose intolerance patient. “Dolait” yoghurt contain saturated fats which is one of the major cause of CVD’s and obesity while tiger nuts contain unsaturated fats which is good for the health and aid fight against obesity. The rate of lipid content is higher compare to tiger nuts yoghurt therefore, a constant consumption of “dolait” yoghurt is not good for the health compare to tiger nuts yoghurt. Looking at the sugar content, “dolait” yoghurt content nearly 4 times more sugar then tiger nuts yoghurt, this isn’t appropriate for diabetes patient and also exposes individual to diabetes meanwhile tiger nuts yoghurt is very low thereby add to regulate blood sugar level and diabetes patient can consume. Also, plant doesn’t contain cholesterol therefore, tiger nuts is free from cholesterol mean while animal contain cholesterol therefore “dolait” yoghurt contain cholesterol which is good for the health.

3.2 Sensory analysis of tiger nuts yoghurt

The sensory evaluation demonstrates that 95% of the panelist have consumed tiger nuts tuber before while 5% said they have never. Also, 55% of the panelist said they have consumed any form of plant yoghurt before while 45% said no. Furthermore, 95% of the same panelist agree they have never consumed tiger nuts yoghurt while 5% said they have consumed tiger nut yoghurt. And the 5% who drank tiger nuts yoghurt said it was imported from Italy. This implies there is little or no knowledge about tiger nuts processing in Cameroon. Sensory parameters were examining and graded in order to have a critical and analytical point of view of the tiger nuts yoghurt.

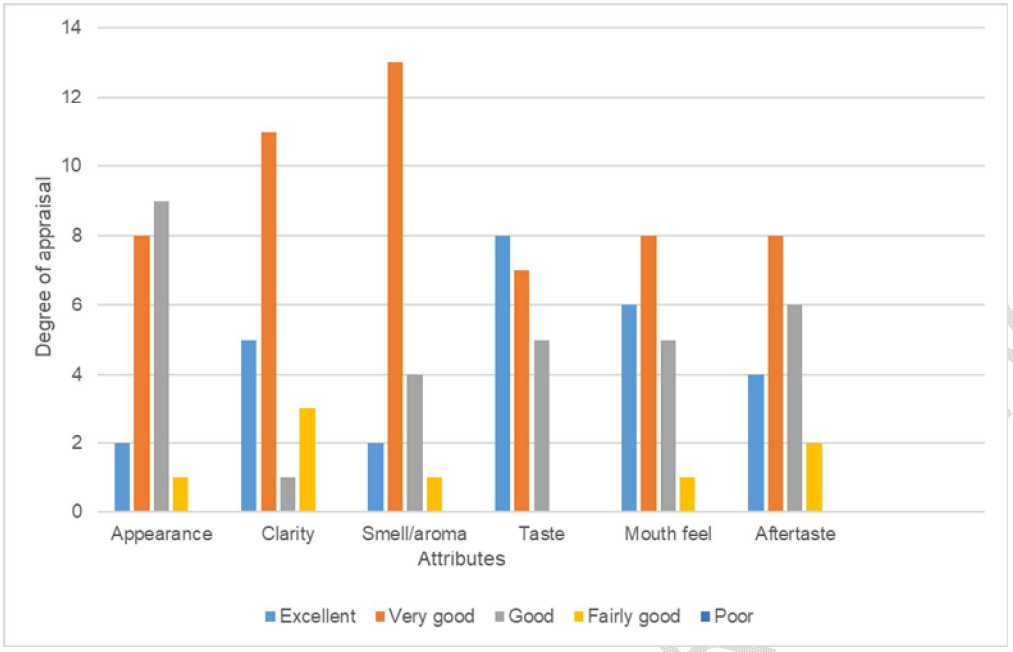

Fig. 4. Degree of appraisal of the sensory parameters examined

After examining these parameters, it was important to determine the overall acceptability (Fig. 5) of the yoghurt which is very important since it is a product meant for consumption.

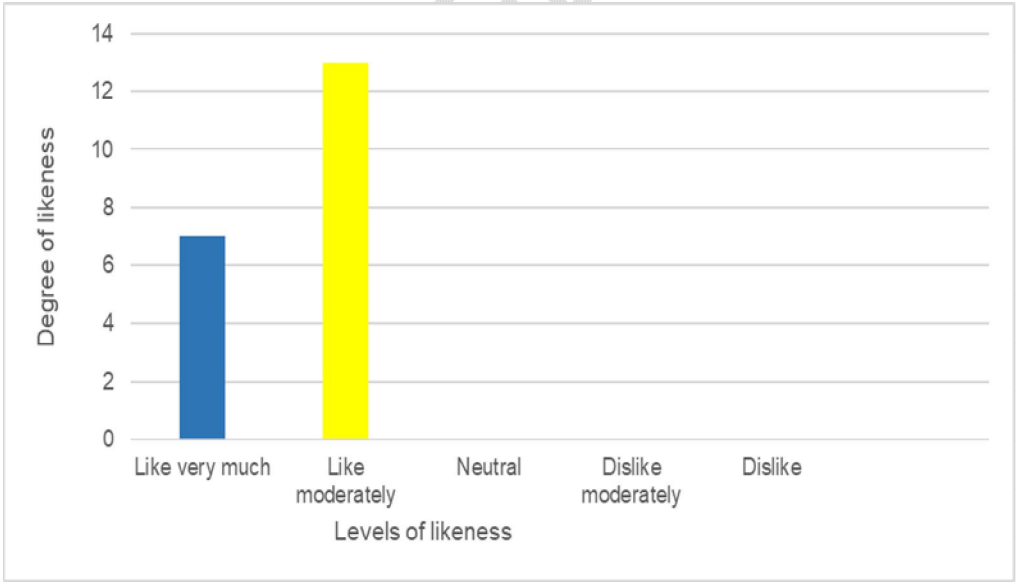

Fig. 5. Overall degree of likeness of tiger nuts yoghurt

Sensory analysis is a very important parameter which permit to examine the acceptancy of the product. This is a because a new formulation especially dairy products that doesn't have good sensory properties will be automatically rejected by the consumer. From the analysis

above, it shows 55% of individuals has consume yoghurt made from any varieties of plants source. And from the same analysis, it shows 95% of the individuals has consume tiger nuts tuber and 100% know about the plant. Going further in the questioning, 5% knew they can be process in any form. In addition, still in the same analysis, 5% has drank milk made from tiger nuts (imported from Italy). This shows the is little or no knowledge or interest about tiger nuts processing despite its economic and health benefit. Certain important sensory parameters were examined (Fig. 4) in other to have an inclusive point of view of tiger nuts yoghurt and are explains as follows:

Appearance. From the analysis above the following result were obtain: 10% said the product was excellent, 40% went for very good, 45% for good, 5% for fairly good and 0% for poor. These statistics shows there is an average satisfaction concerning the product.

Clarity. Clarity was examined to determine the level of residue present in the yoghurt. Statistics shows that: 25% agreed for excellent, 55% for very good, 5% for good, 15% for fairly good and 0% for poor. This show clearly the clarity was generally accepted.

Smell/aroma. Smell is an important aspect when it comes to consumer's acceptability. So, the tiger nuts were given for appreciation and 20% agreed for excellent, 65% for very good, 10% for good, 5% for fairly good and 0% for poor. This shows the product had positive impact and is highly appreciated so far as aroma is concern.

Taste. Considering the same parameters above the taste of tiger nuts were examine and they had the following appreciations: 40% for excellent, 35% for very good, 20% for good, 0% for fairly good and 0% for poor. From the results, it clearly shows the product is highly appreciated so far as taste is concern.

Mouth feel. The mouth feels of tiger nuts yoghurt had the following appreciations: 30% for excellent, 40% for very good, 25% for good, 5% for fairly good and 0%. This results indicate the mouth feel of tiger nuts yoghurt had a positive sensation in people's mouth.

After taste. This is generally the last sensory parameters which is also very important for consumer's acceptability. After examination, after taste gave: 20% for excellent, 40% for very good, 30% for good, 10% for fairly good and 0% poor. From the statistics, it stipulates the after taste is highly appreciated.

It should be noted that, amongst all the parameters evaluated a poor wasn't attribute to any of those parameters and for all the sensory parameters evaluated recommendations were taken into consideration.

After the examination of the sensory parameters, the general acceptability of the product was then examined. This shows that 35% of the panelist like the product very much while 65% like the product moderately, 0% for neutral, dislike moderately and dislike (Fig. 5). This indicate that the product was highly appreciated and recommendations were taken into considerations.

4. CONCLUSION

Due to the attempts to change and valorized many sources of alimentary products such as skim milk and gluten by other healthy sources, tiger nuts is one of the best solutions. Its high content of nutrients and minerals makes it an important alimentary and medicinal plant. benefits for human health and economy. There is very little or no transformation of tiger nuts plant despite it numerous health and economic importance. And this lack of transformation is

due to the fact that, the is very little or no technical knowledge about tiger nuts processing. The cost of raw materials used in tiger nuts yoghurt production is considerably low compare to yoghurt made from animal source.

This study shown that, 1 kg of tiger nuts produces 2 liters of milk and this quantity can increase using an optimized system like a juice extracting machine. The physicochemical properties clearly show tiger nuts yoghurt has numerous vitamins and minerals. It also has high quantity of protein compare to animal based yoghurts like “dolait” yoghurt. The sensory evaluation demonstrate that tiger nuts yoghurt is highly appreciated and certain person prefer it to cow milk yoghurt. Therefore, tiger nuts should have broader research and more use regarding its important. It will be beneficial to carry out studies, especially in areas where agricultural production of tiger nuts is limited and to increase research on production and medicinal uses. Tiger nuts is an underutilized crop in Cameroon which has numerous benefits both healthy and financial aspect. So, Cameroonian farmers should show more interest for it cultivation and raise awareness on the consumption of tiger nuts.

REFERENCES

1. Ukwuru MU, Ogbodo AC. Effect of Processing Treatment on the Quality of Tigernut Milk. Pakistan Journal of Nutrition. 2011; 10(1): 95-100.
2. Obizoba IC, Anyika JU. Nutritive Value of Baobab Milk (*Adansonia digitata*), Hungary Rice, Acha (*Digitana exillis*) Flour. Plant Foods for Human Nutrition. 1995; 48: 156-165.
3. Wakil S, Ayenuro O, Oyinlola K. Microbiological and Nutritional Assessment of Starter-Developed Fermented Tigernut Milk. Food and Nutrition Sciences. 2014; 5(6): 495-506.
4. Adejuyitan JA, Otunla ET, Akande EA, Bolarinwa IF, Oladokun FM. (2009) Some Physicochemical Properties of Flour Obtained from Fermentation of Tiger Nut (Cyperus esculentus) Sourced from a Market in Ogbomoso, Nigeria. African Journal of Food Science. 2009; 3: 51-55.
5. FAO/WHO. FAO expert consultation. Dietary protein quality evaluation in human nutrition. In FAO Food and Nutrition Paper; FAO/WHO: Auckland, New Zealand. 2013; 92, 19p.
6. Belewu MA, Belewu KY. Comparative physicochemical evaluation of tigernut, soybean and coconut milk sources. Intl J Agric Biol. 2007; 5(5): 785–790.
7. Djomdi RAE, Ndjouenkeu R. Characteristics of Tiger Nut (*Cyperus-esculentus*) Tubers and Their Performance in the Production of a Milky Drink. Journal of food Preservation. 2006; 30, 145-163.
8. Opata NC, Owusu EE, Appienti-Ansah W. The impacts of ghanaian culture, traditions and norms on small scale enterprises (smes): a case of the female entrepreneur. International Journal of Small Business and Entrepreneurship Research. 2016; 4(3): 12-32.
9. Roselló-Soto E, Barba FJ, Putnik P, Kovacevic DB, Lorenzo JM, Cantavella-Ferrero Y. Enhancing Bioactive Antioxidants’ Extraction from “Horchata de Chufa” By-Products. Foods. 2018; 7, 161.
10. World Health Organization. World health statistics: monitoring health for the SDGs, sustainable development goals. 2018; 86p.
11. Khurana HK, Kanawjia SK. Recent trends in development of fermented milks, Current Nutri. Food Sci. 2007; 3: 91-108.
12. Sánchez-Zapata E, Fernández-López J, Pérez-Alvarez AJ. Tiger nut (*Cyperus esculentus*) commercialization: Health aspects, composition, properties, and food applications. Compr. Rev. Food Sci. Food Saf. 2012; 11: 366-377.

13. Sanful RE. The use of tiger nut (*Cyperus esculentus*), cow milk and their composite as substrates for yoghurt production. Pakistan Journal of Nutrition. 2008; (8)6. DOI: 10.3923/pjn.2009.755.758
14. Bamishaiye E, Bamishaiye O. Review article on tiger-nut: as a plant, its derivatives and benefits. African J Food, Agri, Nutrition and Devel. 2011; 11: 5157-5170.
15. Beniwal RS. A randomised trial of yoghurt for prevention of antibiotic-associated diarrhoea, Digestive Disease and Sci. 2004; 48: 2077-2052.
16. Akpojotor P, Njoku B, Bestman Njoku, Nwoke UKyrian. Effects of ethanolic extract of *Cyperus esculentus* (tiger nut) on some liver function parameters using albino wistar rats. European Journal of Pharmaceutical and Medical Research. 2015; 2(5):1705-1715.
17. Camagro.cm: the new online Cameroonian agropastoral interface. https://www.journalducameroun.com/ retrieved on 22 decmber 2022.