Effects of Processing Methods on The Quality of Yoghurt-Like Products From Tigernut (Cyperus Esculentus).

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Abstract
Yoghurt-like products from tiger nuts (Cyperus esculentus) were produced from their respective aqueous extracts, using hot water blanching, steam blanching and pasteurization while yoghurt from cow milk served as control. Aqueous extracts were produced by the following heat treatments; hot water blanching of the nuts for 5 and 30 min and steam blanching, both at 85°C prior to extraction, pasteurization (70°C for 15min) of the extract after extraction and untreated tiger nuts which produced untreated aqueous extract. Furthermore, ‘yoghumet’ (containing Lactobacillus bulgaricus and Streptococcus thermophilus) a commercial starter culture was inoculated into pasteurized tiger nut extract and pasteurized cow milk at 42°C in air tight containers respectively. Other yoghurt-like products were produced by inoculating the starter culture into to their respective aqueous extracts without being pasteurized. Peroxide value (PV), pH, TTA, viscosity, proximate composition and sensory evaluation on the yoghurt-like samples were determined. PV, pH, TTA, and viscosity at 60rpm for the freshly produced yoghurt samples ranged from 8 to 11meq/kg, 4.2 to 5.3, 1.3 to 2.4% and 151.5 to 202.3cP respectively. The protein, moisture, fat, carbohydrate and ash contents ranged from 1.51 to 3.97, 64.12 to 79.05%, 2.13 to 3.27, 16.06 to 27.50% and 1.13 to 1.41% respectively. Sensory evaluation scores of freshly prepared yoghurts revealed that cow’s milk yoghurt was most preferred followed by yoghurt produced from pasteurized aqueous tiger nut extract.

Keywords: Yoghurt-like products, Lactobacillus bulgaricus, Streptococcus thermophilus

Introduction
Yoghurt is a cultured ‘food’ obtained by controlled fermentation of milk by mixed culture of lactic acid bacteria selected to produce a characteristic mild clean lactic flavor and typical aroma (Early, 1992). Conventionally, yoghurt is produced from cow’s milk and a starter culture containing Lactobacillus bulgaricus and Streptococcus thermophilus (Farinde et al., 2008). Extensive studies have been conducted on alternative sources of milk for yoghurt production. The alternative sources of milk reported for use in yoghurt production is; bambara nuts, soybeans, groundnuts, melon seeds, cashew nuts (Priepke et al., 1980; Quasem et al., 2009). Earlier studies by Sanful, (2009) show that the inherent nutritional and therapeutic advantages of tigernuts make it a good alternative source of milk in yoghurt production. In a previous study by Adgidzi (2010), efforts led to the production of acceptable beverages from tigernuts. The products were found to contain a proximate composition of 1.89 and 2.67% protein, 0.92 and 1.33% fat, 0.16 and 0.21% ash, 0.24 and 0.33%
crude fiber, 76.86 and 80.27% moisture and 15.96 and 19.15% carbohydrates. Mineral composition (Calcium (Ca), Potassium (K), Sodium (Na), Magnesium (Mg) and Phosphorus (P) per 100g ranged between 14.90 and 25.60mg, 6.40 and 8.10mg, 1.98 and 3.24mg, 0.046 and 0.054mg, 0.060 and 0.083mg respectively. In a quest to add value to these extracts, the possibility of producing yoghurt-like products from these extracts was envisaged. Moreover, with the nutritional composition of the extracts, it was considered that it could be possible to support the growth of lactic acid bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and yield yoghurt-like products. Consequently, this study was carried out to determine the possibility of producing yoghurt-like products from tigernuts aqueous extracts.

**Materials and Methods**

**Procurement of Raw Material**

Approximately 3kg of yellow tiger nut (*Cyperus esculentus*) were obtained from a market in Makurdi, Benue State and transported to the Food Science and Technology laboratories in thick polyethelene bag.

**Preparation of yoghurt from aqueous tigernut extracts and cow milk**

Five yoghurt samples were prepared from aqueous tigernut extracts and from cow milk from the following processing methods; These were;

1. Yoghurt-like product from aqueous extract of tigernuts subjected to hot water blanching for 5min,
2. Yoghurt-like product from aqueous extract of tigernuts subjected to hot water blanching for 30min,
3. Yoghurt-like product from aqueous extract of tigernuts subjected to steam blanching for 20min.
4. Yoghurt-like product from pasteurized aqueous tigernuts extracts
5. Yoghurt-like product from untreated aqueous tigernuts extracts

Blanching was the only treatment given to these extracts, and no heat treatment was given to the extracts prior to the production of yoghurt and after production. Five grammes of commercial starter culture (Yoghumet, contains *Lactobacillus bulgaricus* and *Streptococcus thermophilus*) was dissolved in small quantity of lukewarm water and inoculated into the filtrate (extract). The extract was dispensed into air-tight plastic containers and incubated for 4-6hrs to produce yoghurt samples. The yoghurt samples were stirred, packaged and stored at refrigerated temperature. Others were; yoghurt produced from aqueous extract, pasteurized at 70°C for 15min. Commercial starter culture, yoghumet containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* was dissolved in small quantity of lukewarm water and inoculated in the pasteurized
aqueous extract when temperature dropped to 42-45°C and incubated for 4-6hrs to produce sample. The sample was stirred, packaged and stored at refrigerated temperature. Yoghurt was also produced from aqueous extract from tigernuts that was not blanched or pasteurized. Earlier studies by Adgidzi, (2010) outlined the production of tigernuts aqueous extracts using different processing methods. Five grammes of commercial starter culture (Yoghumet contains Lactobacillus bulgaricus and Streptococcus thermophilus) was dissolved in small quantity of lukewarm water and inoculated in each sample.

About 1.5lttrs of deionized water was heated to boiling and 250g of powered milk and 30g of sugar were weighed out. One litre of the heated deionized water was used to dissolve the milk and sugar into smooth slurry. The slurry was pasteurized at 70°C for 15min (batch process) in a hot water bath and allowed to cool to 42-45°C. Five grammes of commercial starter culture (Yoghumet contains Lactobacillus bulgaricus and Streptococcus thermophilus) were dissolved in small quantity of lukewarm water and inoculated into the already pasteurized mixture (Early, 1992). The mixture was dispensed into air-tight plastic containers and incubated at 42-45°C for 4-6hrs to produce cow milk yoghurt (control). The prepared sample were stirred, packaged and stored at refrigerated temperature (10±2°C). The processing method is shown in Fig.1

**Physicochemical Analysis**

**Total Titratable Acidity (TTA):** Total titratable acidity (TTA) was determined as described by Nielsen (2002).

**pH:** Ten milliliters of sample was titrated against 0.1M NaOH with phenolphthalein as indicator. pH was determined as outlined by Kirk and Sawyer (1991).

**Viscosity:** Viscosity was determined by the method described by Onwuka (2005). Ten millilitres of samples were taken and the viscosity measured at room temperature (32±2°C) using the Brookfield viscometer (Type LV-8 Viscometer, UK LTD). Readings were taken after 120 seconds of rotation. Spindle No.1 rotating at 60rpm was used and viscosity read as centipoise.

**Peroxide Value:** Peroxide value was determined by the method of Kirk and Sawyer (1991). Two millilitres of sample was weighed into a 250ml conical flask, 10ml of chloroform was added and swirled gently until fat was dissolved. To it, 15 ml of glacial acetic acid and 1ml of fresh saturated aqueous KI solution were also added. The flask was stoppered, shaken for 1min and placed for exactly 1min in the dark. Five millilitres of water was added, mixed, and titrated with 0.01M Na₂S₂O₃ using soluble starch solution (1%) as indicator. A reagent blank determination (V₀) was carried out, it did not exceed 0.5ml of 0.01M Na₂S₂O₃ solution.
Proximate Analysis
Proximate analysis was carried out using standard methods of AOAC (2000); Moisture content was determined by the hot air oven method. Carbohydrates were determined by difference in the aqueous extracts as described by the methods of Ihekoronye and Ngoddy (1985).

Sensory Evaluation
Samples were assessed for sensory characteristics based on colour, taste, flavour and overall acceptability using a 20-member semi-trained panelists on 5-point hedonic scale, with (5) = extremely like and (1) = extremely dislike. The ratings from hedonic scale were subjected to analysis of variance (ANOVA). The significant differences between means were determined by Least Significant Difference (LSD) test as described by Ihekoronye and Ngoddy (1985).

Statistical Analysis
The data obtained were statistically analyzed by the GENSTAT package 2000. Sensory ratings were subjected to analysis of variance (ANOVA) as described by Ihekoronye and Ngoddy (1985); least significance difference (LSD) test was used to separate means. Significance level was taken at 5%. Values are means of duplicate samples.

Results and /Discussion

Effects of processing methods on some physicochemical attributes of yoghurt-like samples.
Effects of processing methods on some physicochemical attributes of yoghurt-like samples are shown in Table 1. Peroxide value (PV) of produced yoghurt samples ranged between 8 to 11meq/kg. Pasteurized yoghurt-like product from tiger nuts had the least peroxide value, while cow milk yoghurt had the highest peroxide value. Peroxide value monitors the development of rancidity through the evaluation of the quantity of peroxides generated in the product. Fresh oils usually have peroxide values below 10 meq/kg. The onset of rancid taste begins when peroxide value is between 20 and 40 meq/Kg (Onwuka, 2005).

pH values of yoghurt samples ranged between 4.2 and 5.3. TTA values of yoghurt samples ranged between 1.3 and 2.4%. The pH and TTA (% lactic acid) values obtained from this study differed from the finding reported by Akoma et al., (2000) who obtained pH, 3.9 to 4.1 and TTA (% lactic acid), 0.5 to 0.75. It was observed in this study, that pH value of yoghurts decreased with increased acidity (TTA), this could be attributed to fermentation. During fermentation, microorganisms use sugars such as lactose and
glucose for their metabolic activity and in the process secrete acids as by-products. Yoghurt production is a biological process and cooling is one of the most popular methods used to control the metabolic activity of the starter culture and its enzymes. Lactic acid bacteria show limited growth activity around and below 10°C and increased growth activity above 10°C. The primary objective of cooling is to drop the temperature of the coagulum from 45°C to less than 10°C as quickly as possible to control the final acidity of the product (Early, 1992).

Viscosity of yoghurt samples at speed of 60rpm ranged between 151.50 and 202.30cP. Yoghurt-like product from hot water blanched (5mins) tiger nuts had the least viscosity, while cow milk yoghurt had the highest viscosity (cP). Higher viscosities were recorded from cow milk yoghurt and pasteurized yoghurt-like product from tiger nuts. This could be attributable to the heat treatment (pasteurization) given to the aqueous extracts prior to the cooling to 42 to 45°C and inoculation of the lactic acid bacteria (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*). The lactic acid bacteria proliferate at 42 to 45°C and metabolize sugars to acids. Increased acidity causes proteins to denature and form gel resulting to the characteristic viscous nature of yoghurts. According to Reeds (1982) pasteurization is believed to modify milk protein so as to enhance proper viscosity and gelatinization of yoghurt, thus account for the uniformity and smoothness in the body texture of product. Higher values of viscosities were observed on freshly produced samples than samples stored at various conditions. Muhammad *et al.*, (2008) reported that yoghurts with low protein contents tend to have low viscosity due to low water-holding capacity of coagulum. Bile and Keya (2002) reported that viscosity declines with increasing time due to syneresis.

**Effects of Processing Methods on the proximate composition of Yoghurt-like samples**

The effects of processing method on the proximate composition of Yoghurt-like samples are given on Table 2. The result shows that protein, moisture, fat, carbohydrate and ash contents varied. There were significant differences (p > 0.05) and similarities among samples for all the parameters assessed. Protein content of yoghurt samples ranged between 1.51 to 3.97%. These result agree with the findings by Akoma *et al.*, (2004) who revealed that, crude protein values of yoghurt and yoghurt-like products ranged from 2.66 to 3.78%, cow milk yoghurt had the highest value. Also, moisture content of yoghurt samples ranged between 64.12 to 79.05%. Moisture contents of yoghurt-like products were significantly higher than dairy yoghurt, this is in agreement with similar study by Cheng (1988), who revealed that high moisture in soy yoghurts is present as free water which is not incorporated in the coagulated protein. This implies the occurrence of syneresis during coagulation. Cheng (1988) suggested that stabilizers can be used to tie up free water in yoghurt-like products. Egan *et al.*, (1981),
recommended that commercially prepared yoghurt should have the minimal proximate compositions of protein, 3.5%; fat, 3.25% and moisture content 87.70%.

Fat, carbohydrate and ash content of yoghurt samples ranged between 2.13 to 3.46%, 16.06 to 27.50% and 1.13 to 1.41% respectively. It was observed that, carbohydrate content (27.50%) of cow milk yoghurt was higher than other samples probably because there was concentration of nutrient as the moisture content reduced to 64.12%.

Effects of Processing Methods on Sensory properties of Yoghurt-like samples

The effects of processing method on sensory properties of Yoghurt-like samples are given on Table 3. There were significant differences (p > 0.05) and similarities among samples in terms of flavor, taste, color and overall acceptability. Mean scores ranged between 2.1 to 4.6, 2.4 to 4.1, 2.2 to 4.9 and 2.4 to 4.6 for flavor, taste, color and overall acceptability respectively. Generally, in terms of flavor, taste, color and overall acceptability cow milk yoghurt was most preferred, followed by pasteurized yoghurt-like product from tiger nuts. Other samples were least preferred. This could be because cow milk yoghurt is from animal source (cow) while other samples are from plant source (tigernuts). Most panellists were familiar with cow milk yoghurt because it is popularly produced and consumed than yoghurt from plant sources, especially tigernuts. This finding is in accordance with that of Favaro-Trindade et al., (2001) who compared cow’s milk yoghurt with soy yoghurt and observed that panellists had more preference for the cow milk- based yoghurt than soy yoghurt. They concluded that the preference was because the yoghurts were made from different heterogeneous sources. Generally, cow milk yoghurt was most preferred, followed by pasteurized yoghurt-like product from tiger nuts, while the other samples were rated lower by panellists. This could be due to the absence of pasteurized in the production of yoghurt from these samples. Hence, the lactic acid bacteria (LAB) were not able to proliferate and give the desired product, because the environment was not favourable for their growth. LAB (L. bulgaricus and S. thermophilus) grow best at a temperature range of 42 to 45°C (Ariahu et al., 2004). Sensory assessment of tiger nut milk, cow’s milk and their composites as substrates for yoghurt production was investigated (Sanful, 2009). The finding of the work showed that in terms of appearance, consistency and general acceptance, yoghurt produced from a 50:50 blend of cow’s milk and tiger nut was most preferred, as compared to 100% tiger nut milk. Sanful, (2009) attributed the preference to be possibly due to the synergistic effect of the two substrates, hence producing a wider scope of interaction of biomolecules such as volatile aromatic compounds from anaerobic breakdown of carbohydrates from the blend of substrates. Also, previous study by Akoma et al., (2004) suggested the improvement of viscosity of tigernut yoghurt by the addition of stabilizers to improve product quality.
Conclusion and Recommendation

In this study, it was found that pasteurization plays a major role in yoghurt production and product quality. Cow milk and tigernut aqueous extracts subjected to pasteurization prior to the inoculation of starter culture for yoghurt production were most acceptable by panellist while those produced from blanched tigernuts prior to crushing, extraction and inoculation of starter culture were least accepted. The study also revealed the possibility of producing tigernut yoghurt, a derivative of dairy yoghurt with inherent nutritional advantage.

The processing method of pasteurizing tigernut aqueous extracts prior to inoculation of starter culture should be adopted other than blanching of tigernuts for yoghurt production. Increase in product acceptability can be enhanced by blending cows’ milk with tigernuts extracts to produce yoghurt. Also, the addition of stabilizers may improve product quality by reducing syneresis, thus improve the body (viscosity) of yoghurt-like products.

References
Cheng Y.J (1988). Comparison of dairy yoghurt with imitation yoghurt fermentation by different lactic culture from soybean milk. An MSc Thesis submitted to Graduate faculty of Texas Technology University in partial fulfilment of the requirements for the degree (MSc) in Food Technology.


Table 1: Effects Processing Methods on some Physicochemical attributes of Yoghurt-like samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Peroxide value (meq/kg)</th>
<th>pH (0.0)</th>
<th>TTA** (60rpm)</th>
<th>Viscosity (60rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk Yoghurt</td>
<td>11.0(0.0)</td>
<td>4.2(0.0)</td>
<td>2.4(0.1)</td>
<td>202.3(1.1)</td>
</tr>
<tr>
<td>Yoghurt-like product from pasteurized aqueous tigernuts extracts</td>
<td>8.0(0.2)</td>
<td>5.3(0.0)</td>
<td>1.3(0.0)</td>
<td>184.5(0.3)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching (5min)</td>
<td>10.5(0.1)</td>
<td>5.2(0.0)</td>
<td>1.5(0.0)</td>
<td>151.5(0.0)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching (30min)</td>
<td>10.2(0.1)</td>
<td>4.8(0.1)</td>
<td>1.3(0.1)</td>
<td>178.9(0.0)</td>
</tr>
<tr>
<td>Yoghurt-like product from untreated aqueous tigernuts extracts</td>
<td>11.0(0.0)</td>
<td>4.6(0.0)</td>
<td>1.5(0.1)</td>
<td>124.0(1.0)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to steam blanching (20min)</td>
<td>10.4(0.1)</td>
<td>4.8(0.0)</td>
<td>1.7(0.0)</td>
<td>126.0(0.0)</td>
</tr>
</tbody>
</table>

TTA** expressed as % lactic acid                                     Values in parenthesis are standard deviations.
Table 2: Effects of Processing Methods on Proximate composition Yoghurt-like samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Protein</th>
<th>Moisture</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Ash</th>
</tr>
</thead>
</table>
| Cow milk yoghurt                                                       | 3.97(0.5)
|                                                                        | a        | 64.12(1.5)
|                                                                        | f        | 3.27(0.3)
|                                                                        | e        | 27.50(0.7)
|                                                                        | a        | 1.14(0.3)
| Yoghurt-like product from pasteurized aqueous tigernuts extracts     | 2.04(1.0)
|                                                                        | b        | 72.23(1.4)
|                                                                        | e        | 3.46(1.0)
|                                                                        | a        | 20.99(1.2)
|                                                                        | a        | 1.28(0.1)
| Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching (5min) | 1.63(1.1)
|                                                                        | e        | 79.05(1.3)
|                                                                        | a        | 2.13(1.0)
|                                                                        | a        | 16.06(1.2)
|                                                                        | a        | 1.13(0.5)
| Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching (30min) | 1.51(1.2)
|                                                                        | e        | 75.33(1.3)
|                                                                        | d        | 2.50(1.1)
|                                                                        | a        | 19.49(1.0)
|                                                                        | a        | 1.17(0.3)
| Yoghurt-like product from untreated aqueous tigernuts extracts        | 1.27(1.3)
|                                                                        | d        | 76.40(1.2)
|                                                                        | c        | 2.56(1.2)
|                                                                        | a        | 18.45(1.0)
|                                                                        | a        | 1.32(0.1)
| Yoghurt-like product from aqueous extract of tiger nuts subjected to steam blanching (20min) | 1.54(1.3)
|                                                                        | c        | 77.41(1.4)
|                                                                        | b        | 2.18(1.0)
|                                                                        | a        | 17.46(1.2)
|                                                                        | a        | 1.41(0.7)
| LSD                                                                   | 0.25     | 0.78        | 0.83      | 0.91         | 0.09      |

Any two mean values bearing the same superscript in the same column are not significantly different (p<0.05)
Values in parenthesis are standard deviations
Table 3: Effects of Processing Methods on Sensory properties of Yoghurt-like samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Flavor</th>
<th>Taste</th>
<th>Color</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk Yoghurt</td>
<td>4.6 (0.5) (^a)</td>
<td>4.1 (1.5) (^a)</td>
<td>4.9 (0.3) (^a)</td>
<td>4.6 (0.7) (^a)</td>
</tr>
<tr>
<td>Yoghurt-like product from pasteurized aqueous tigernuts extracts</td>
<td>3.0 (1.0) (^b)</td>
<td>3.1 (1.4) (^ab)</td>
<td>3.6 (1.0) (^b)</td>
<td>3.3 (1.2) (^b)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching (5min)</td>
<td>2.6 (1.1) (^bcde)</td>
<td>2.6 (1.3) (^bcde)</td>
<td>2.7 (1.0) (^bd)</td>
<td>2.6 (1.2) (^bd)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to hot water blanching for (30min)</td>
<td>2.1 (1.2) (^bcde)</td>
<td>2.3 (1.3) (^bcde)</td>
<td>2.6 (1.1) (^bcde)</td>
<td>2.4 (1.0) (^cde)</td>
</tr>
<tr>
<td>Yoghurt-like product from untreated aqueous tigernuts extracts</td>
<td>2.7 (1.3) (^bcd)</td>
<td>2.4 (1.2) (^bcd)</td>
<td>2.6 (1.2) (^bcd)</td>
<td>2.4 (1.0) (^cde)</td>
</tr>
<tr>
<td>Yoghurt-like product from aqueous extract of tiger nuts subjected to steam blanching (20min)</td>
<td>2.7 (1.3) (^bcd)</td>
<td>2.6 (1.4) (^bcd)</td>
<td>2.2 (1.0) (^cde)</td>
<td>2.4 (1.2) (^cde)</td>
</tr>
<tr>
<td>LSD</td>
<td>0.991</td>
<td>1.224</td>
<td>1.106</td>
<td>0.729</td>
</tr>
</tbody>
</table>

Any two mean values bearing the same superscript in the same column are not significantly different (p<0.05)
Values in parenthesis are standard deviations