

Evaluation of the Suitability of Tigernut Milk and Tigernut-Cow Composite Milks for Yoghurt Production

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ABSTRACT

The cost of animal milk used in yoghurt production in Nigeria has continued to rise, making the price of yoghurt to become prohibitive. This study investigated the suitability of tiger nut milk for yoghurt production. Five milk formulations prepared from tiger nut milk and cow milk were used to produce yoghurts. pH and titratable acidity (TA) of the milks and yoghurts were determined. The yoghurts were assessed for total plate count (TPC), total fungal count (TFC), fat content and sensory properties. Sensory properties were evaluated by a 10-man taste-panel using a 5-point hedonic scale. pH values of the yoghurts ranged from 3.94 – 4.68. TA values ranged from 0.56 – 0.64. TPC of the yoghurts ranged from 1.0×10^2 – 1.3×10^3 cfu/ml while TFC ranged from 0.1×10^1 – 0.3×10^1 . The microbial counts of the yoghurt samples were within acceptable safety limits. The yoghurts were generally acceptable to the panelists. There were significant ($P < .05$) differences in the sensory scores for appearance, taste, texture, and overall acceptability. Tiger nut-cow milk (75:25) yoghurt had the highest appearance and taste scores while tiger nut milk (100) yoghurt had the highest texture and overall acceptability scores. Tiger nut milk (100) yoghurt was the most preferred yoghurt with an overall acceptability score of 4.8 ± 0.42 followed by tiger nut-cow milk (75:25) yoghurt. Yoghurts analysed had fairly high fat contents. The study showed that tiger nut milk and tiger nut-cow milk composites could be used as alternatives to cow milk for yoghurt production.

Keywords: Composite milk, milk, yoghurt, tigernut.

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I. INTRODUCTION

Fermentation of milk is widely practiced in many countries of the world. For a very long time human beings have derived many benefits including extension of shelf life of milk through the process of fermentation (Tamime, 2002). In milk fermentation, milk is inoculated with a starter culture, mainly lactic acid bacteria, which converts part of the lactose in the milk to lactic acid. Depending on the lactic acid bacteria used in the fermentation, other metabolites such as acetic acid, diacetyl, and acetaldehyde are formed in the milk. These substances confer unique sensory characteristics such as fresh taste and aroma to the fermented milk product (Olokun *et al.* 2018).

There are various types of fermented milk products including yoghurt, cultured buttermilk, cultured cream, ymer, kefir, and koumiss. Of all cultured milk products,

yoghurt is the most popular worldwide (Early, 1998). The conventional milk for yoghurt production is animal milk (Sanful, 2009) which includes milks from cow, goat, ewe, and buffalo. Of the various kinds animal milk used in yoghurt production, cow milk is the most commonly used. The gap between demand and supply of animal milk in Nigeria has continued to widen with the inability of the indigenous dairy cattle breed to produce enough milk for the growing population (Bristone, 2015). Consequently, the price of animal milk in Nigeria has continued to increase (Robinson *et al.*, 2006). Skim milk used for industrial yoghurt production is usually imported at exorbitant costs which drains scarce foreign exchange and also makes the cost of the produced conventional yoghurt to be high, taking the product out of the reach of the common man. Added to this, certain individuals are allergic to milk and milk products from animal sources. Due to these factors, plant milks are being explored as alternatives to animal milk with

a view to reducing the cost of commercially available yoghurt and towards overcoming the problem of allergy for those allergic to cow milk yoghurt.

Attempts have been made to produce imitation milk from plant sources such as coconut, soybeans, and tiger nut (Akoma *et al.*, 2000; Sanful, 2009; Bristone *et al.*, 2015) among others. Yoghurt-like products have been produced from milk extracts of soybean (Terna and Musa, 1999; Bristone *et al.*, 2015), cowpea, and mung beans (Roa *et al.*, 1988), and tiger nut (Olokun, 2018).

According to Bristone *et al.*, (2015), yoghurt produced from imitation milk extracted from plant sources tend to lack a number of desired qualities of conventional yoghurt and as such needs to be mixed with cow milk toward incorporating flavor and other desirable characteristics of conventional yoghurt. The findings of different authors on this appear to be in contrast. It is therefore necessary to further explore the suitability of plant milks for yoghurt production.

Tiger nut (*Cyperus esculentum*) is a perennial plant abundantly cultivated in Nigeria (Oke, 2019). Tiger nut is Akiausa in Igbo, Ofio in Yoruba and Aya in Hausa. The tubers are about the size of peanuts and are available in Nigeria as fresh, semi-dried, and dried forms in the markets where they are sold locally. Milk extracted from tiger nut, apart from being nutritious (Oke, 2019), has been recommended for persons that do not tolerate gluten or are allergic to cow milk and its derivatives (Belew and Abodurin, 2006). The abundant availability of tiger nuts in Nigeria and the unique qualities of tiger nut milk necessitates further exploration of the milk as a potential resource for cheaper production of yoghurt of acceptable quality. This study aimed at evaluating the suitability of tiger nut milk and blends of tiger nut milk and cow milk for yoghurt production.

II. MATERIALS AND METHODS

A. Sample Collection

Tiger nuts and starter culture (farm fresh yoghurt starter) used in the study were purchased from sellers in Terminus market while fresh cow milk was procured from cattle farmers in Naraguta Village. The tiger nuts were collected in a clean polythene bag while the cow milk was collected in a clean plastic bucket with a cover. Both procurement locations are in Jos North Local Government Area of Plateau State, Nigeria. All the collected items were transported to the microbiology laboratory of the University of Jos where they were stored until used. The cow milk was stored in a refrigerator at 4 °C.

B. Extraction of Milks from Tiger Nuts

Tiger nuts (1 kg) were carefully sorted to free them of undesirable materials including bad nuts which could affect the taste of the yoghurt eventually produced. The nuts were washed and soaked in clean warm water for 24 hours to soften the fiber. The tiger nuts were washed again. A volume of 2.5 L of distilled water was added to 900 g of the tiger nuts which were then blended in domestic blender. The mash was filtered through a clean muslin cloth to obtain the milk. The flow chart for the wet extraction of tiger nut milk

is presented in Fig. 1.

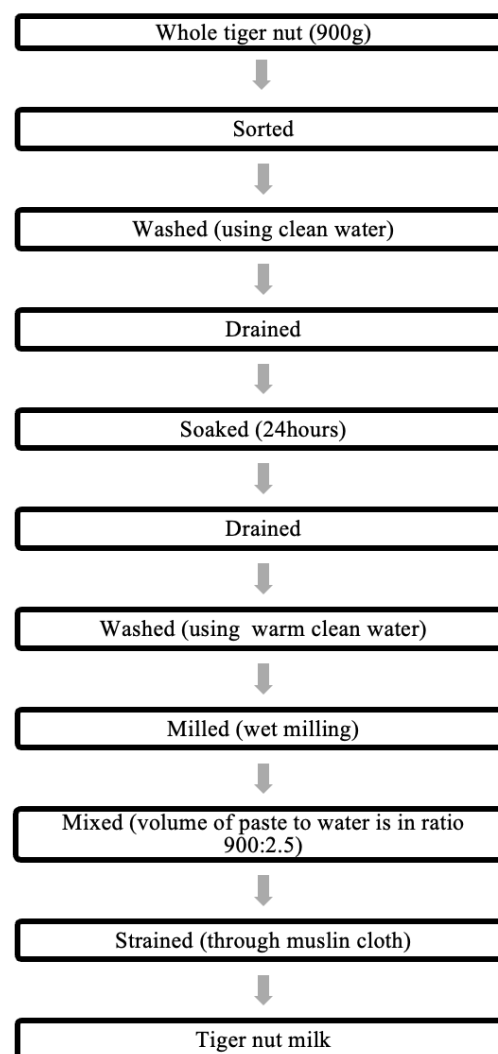


Fig. 1 Flowchart for Extraction of Milk from Tiger nut. Adopted with modifications from Bristone *et al.* (2015).

C. Preparation of Milk formulations for Yoghurt Production

Five different milk formulations were used in the study. The formulations included tiger nut milk, cow milk and their composites derived by blending tiger nut milk and cow milk in varying proportions as shown in Table I.

TABLE I: PERCENTAGE COMPOSITION OF TIGER NUT MILK AND COW MILK IN MILK FORMULATIONS USED IN YOGHURT PRODUCTION

Milk Type	Percentage Composition				
	A	B	C	D	E
Tiger nut milk	100	50	75	25	0
Cow milk	0	50	25	75	100
Total	100	100	100	100	100

D. Yoghurt Production

A volume of 2.5 L each of the five milk formulations (A - E) was heated at 90 °C for 15 minutes and then cooled to 43°C. The different milk samples were poured separately into plastic bowls in equal volumes. The initial pH of each sample was taken using a pH meter. The milk samples were inoculated at the temperature of 43 °C with 10% v/v of Farm Fresh yoghurt which was used as starter culture and

mixed thoroughly. The bowls containing the milk samples were covered and incubated at 43 °C for 4,5 h for fermentation and curdling of the milk samples to take place. At the end of the incubation period, the five different yoghurts produced from the milk formulations were kept in a refrigerator to cool at a temperature of 4 °C. Fig. 2 shows yoghurt flowchart for the production.

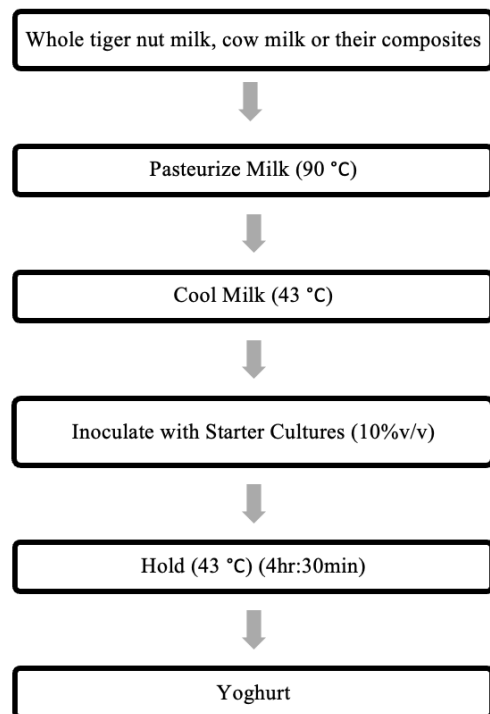


Fig. 2. Flow chart for yoghurt production using tiger nut milk, cow milk and their composites. Adopted with modifications from Bristone *et al.* (2015).

E. Physicochemical Analysis of Milk Samples and Yoghurts

Acidity (pH) and titratable acidity of the milk formulations and yoghurts produced were determined. After carrying out a sensory analysis of the produced yoghurts, the two most preferred yoghurts were analysed for Crude fat content. pH was determined with the aid of a pH metre that had been calibrated using pH buffers 4 and 7. In the pH determination, 10 ml each of milk and yoghurt samples were transferred into separate 100 ml conical flasks. The pH metre probe was dipped into the milk and yoghurt samples and readings were taken in triplicates and recorded. Titratable acidity (TA) of milk and yoghurt samples was also determined. A volume of 10 ml each of milk and yoghurt sample was pipetted into a 100 ml conical flask with three drops of phenolphthalein added as indicator. Titration was carried out using 0.1N NaOH until a persistent faint pink color was observed. The volume of the titrant (NaOH) used was taken and TA was calculated as percentage lactic acid using the following formula:

$$\% \text{ TA} = \frac{\text{Volume of base} \times \text{Normality of base} \times 0.090 \times 100}{\text{Volume of sample used}}$$

F. Assessment of Microbial Counts of Yoghurts Produced

The produced yoghurts were assessed for total plate count (total aerobic mesophilic bacterial count) and fungal count

using the dilution plate method. Total plate count and fungal count were determined on plate count agar (PCA) and malt extract agar (MEA) respectively. Ten-fold serial dilutions of each yoghurt sample were prepared in sterile distilled water up to the 106 dilution and 1ml each of appropriate dilutions was pour plated on sterile molten agar. The agar plates were swirled gently and allowed to set. The PCA plates were incubated aerobically at 37 °C for 24 h. while the malt extract agar plates were incubated at 30 °C for 2 - 5 days. Triplicate plates were used for each determination. After incubation, the colonies on each plate were counted and the mean of triplicate plates for both total plate count and total fungal count determinations. Means of total plate count and fungal count were expressed in colony forming units per milliliter (cfu/ml).

G. Sensory Analysis of Yoghurt

Sensory evaluation of the various yoghurts produced was carried out to determine the acceptability of the products. Sensory parameters assessed included appearance, aroma, taste, texture, and overall acceptability. The products were assessed by a panel of 10 individuals who were familiar with yoghurt. The panel included students and members of staff of the Department of Science Laboratory Technology of the University of Jos. The yoghurt samples were served in clean cups. Water for rinsing of mouth and cups before and after each assessment was provided. Each of the panelists was requested to assess each yoghurt sample based on the different sensory parameters and to indicate their degree of likeness (preference) for each sample on a questionnaire provided. The yoghurt samples were scored for each sensory parameter using a 5-point hedonic scale ranging from 1-5 indicating “dislike extremely to like extremely” where 1 = dislike very much, 2 = dislike, 3 = neither like nor dislike, 4 = like slightly, 5 = like very much (Larmond, 1977). Cow milk yoghurt served as the control in this experiment.

H. Determination of Fat Content of Selected Yoghurt Samples

Out of the five produced yoghurts, the two most preferred yoghurts (in terms of overall acceptability) were selected and analysed for crude fat content. The method of AOAC (2005), was used to determine the fat content.

I. Statistical Analyses

Statistical analyses of experimental data was carried out using Analysis of variance (ANOVA) with the aid of Microsoft excel version 2010 software. P-values less than 0.05 were considered significant. Least Significant Difference (LSD) was used to test for significant differences between means.

III. RESULTS

Table II shows pH and titratable acidity of the milk samples used in yoghurt production and those of the yoghurts produced. pH values of the five milk formulations ranged from 6.30-6.60 while that of the yoghurt products ranged from 3.94 – 4.68. Raw cow milk had the highest pH (6.60) among the various milk formulations while the lowest pH of 6.30 was recorded for tiger nut milk. At the end of the fermentation period, pH values of the fermenting milk

samples had dropped to a range of 3.94 – 4.68. Thus, tiger nut milk (100) yoghurt had the lowest pH of 3.94 and tiger nut-cow milk (50:50) had the highest pH of 4.68. Titratable acidity (TA) of tiger nut milk, cow milk and their combinations ranged from 0.150 – 0.310. The TA of the milk samples increased during yoghurt production to a range of 0.560 – 0.640. Yoghurt produced from 100% tiger nut milk had the highest TA of 0.640 while yoghurt produced from tiger nut – cow milk (25:75) had the lowest TA of 0.560.

Details of total plate count and total fungal counts of the yoghurt products are given in Table III. Total plate count of the yoghurts ranged from 1.0×10^2 – 1.3×10^3 cfu/ml. Tiger nut milk (100) yoghurt had the highest total plate count (1.3×10^3 cfu/ml) while cow milk (100) yoghurt had the lowest plate count of 1.0×10^2 cfu/ml. Fungal counts of the yoghurts ranged between 0.1×10^1 and 0.3×10^1 cfu/ml. Tiger nut-Cow milk (25:75) yoghurt had the highest fungal count of 0.3×10^1 cfu/ml.

There were statistically significant ($P < 0.05$) differences in the appearance mean scores of the different yoghurts produced. The appearance scores of the yoghurt products ranged from 3.7 – 4.8. Tiger nut milk-Cow milk (75:25) yoghurt had the highest appearance mean score while tiger nut milk-cow milk (50:50) yoghurt had the lowest score. Four out of five of the yoghurt products had significantly higher ($P < 0.05$) scores for appearance compared to the tiger nut-cow milk (50:50) yoghurt, but the observed differences in the appearance mean scores of the four yoghurts were not statistically significant ($P > 0.05$).

The taste panelists' scores for taste of the yoghurt products ranged from 3.0 – 4.5. Yoghurt produced from tiger nut milk-cow milk (75:25) had the highest taste mean score (4.5) while tiger nut-cow milk (50:50) yoghurt had the lowest score. The difference between the taste mean scores of the two yoghurt products was statistically significant ($P < 0.05$). All other differences in the taste scores of the five yoghurt products were not statistically significant ($P > 0.05$).

TABLE II: PH AND TITRATABLE ACIDITY OF YOGHURTS PRODUCED FROM COW MILK, TIGER NUT MILK AND THEIR COMPOSITES

Analyses	Yoghurt Products				
	¹ TM:100	² TM-CM (75:25)	³ TM-CM (50:50)	⁴ TM-CM (25:75)	⁵ CM:100
pH					
0 h	6.30±0.03	6.40±0.06	6.50±0.01	6.50±0.03	6.60±0.04
4:30 h	3.94±0.02	4.60±0.02	4.68±0.03	4.48±0.05	4.62±0.03
Titratable Acidity					
0h	0.310±0.02	0.300±0.03	0.281±0.02	0.265±0.03	0.150±0.02
4:30 h	0.640±0.02	0.601±0.01	0.600±0.01	0.560±0.02	0.610±0.02

Values are Mean ± SD of triplicate determinations. ¹100% tiger nut milk; ²mixture of tiger nut milk (75%) and cow milk (25%); ³mixture of tiger nut milk (50%) and cow milk (50%); ⁴mixture of tiger nut milk (25%) and cow milk (75%); ⁵100% cow milk

Table IV: SENSORY SCORES OF YOGHURT PRODUCTS FROM TIGER NUT MILK, COW MILK, AND THEIR COMPOSITES

Sensory Attributes Yoghurt Products					
	¹ TM:100	² TM-CM (75:25)	³ TM-CM (50:50)	⁴ TM-CM (25:75)	⁵ CM:100
Appearance	4.7±0.48 ^{ad}	4.8±0.42 ^{cd}	3.7±0.95 ^c	4.5±0.71 ^{ad}	4.0±1.05 ^{ac}
Taste	4.3±0.95 ^{bc}	4.5±0.53 ^b	3.7±0.67 ^{ac}	3.8±0.63 ^{bc}	3.9±0.88 ^{bc}
Texture	4.7±0.67 ^{ac}	4.5±0.52 ^{ad}	3.5±0.97 ^c	4.4±0.70 ^{ad}	3.9±1.00 ^{dc}
Aroma	4.4±0.70 ^a	4.4±0.70 ^a	4.4±0.70 ^a	4.4±0.67 ^a	4.5±0.53 ^a
Overall Acceptability	4.8±0.42 ^c	4.5±0.53 ^{bc}	3.8±0.79 ^a	4.1±0.57 ^{ab}	3.7±0.48 ^a

Values are Mean ± SD of scores of ten panelists. Values with different superscripts which are on the same row are significantly different ($P < 0.05$)

¹100% tiger nut milk yoghurt; ²yoghurt produced from mixture of tiger nut milk (75%) and cow milk (25%); ³yoghurt produced from mixture of tiger nut milk (50%) and cow milk (50%); ⁴yoghurt produced from mixture of mixture of tiger nut milk (25%) and cow milk (75%); ⁵100% cow milk

The yoghurt products deferred significantly ($P < 0.05$) in terms of textural acceptance. Mean scores for texture acceptance were in the range of 3.5 – 4.7. The highest mean textural score was observed in yoghurt produced from tiger nut milk alone (tiger nut milk (100) yoghurt) while tiger nut milk-cow milk (50:50) yoghurt recorded the lowest texture rating of 3.5.

The aroma scores of the yoghurt products were relatively similar. Differences observed in aroma preference were minimal and statistically insignificant ($P > 0.05$). Cow milk (100) yoghurt had the highest aroma score (4.5) while tiger nut milk-cow milk (25:75) yoghurt had the lowest score of 4.3.

In terms of overall acceptability, tiger nut milk (100) yoghurt was the most preferred among the yoghurt products. It had the highest acceptability mean score of 4.8. Cow milk (100) yoghurt was least preferred by the panelist and had a mean score of 3.7. Observed differences in overall acceptability were statistically significant ($P < 0.05$).

Details of the sensory scores for appearance, taste texture, aroma, and overall acceptability of the yoghurt products are presented in Table IV.

The fat content of tiger nut (100) and tiger nut-cow milk (75:25) yoghurts which had the highest overall acceptability scores were 7.12% and 5.89% respectively.

TABLE III: MICROBIAL LOAD OF YOGHURT SAMPLES PRODUCED USING TIGER NUT MILK AND COW MILK IN SINGLES AND IN COMBINATIONS

Yoghurt Samples	Total Plate Count (cfu/ml)	Fungal Count (cfu/ml)
Tiger nut milk (100) yoghurt	1.3×10^3	0.1×10^1
Tiger nut milk-cow milk (75:25) yoghurt	1.2×10^2	0.1×10^1
Tiger nut milk-cow milk (50:50) yoghurt	1.2×10^2	0.2×10^1
Tiger nut milk-cow milk (25:75) yoghurt	1.1×10^2	0.3×10^1
Cow milk (100) yoghurt	1.0×10^2	0.1×10^1

IV. DISCUSSION

Tiger nut milk used in this study had a pH value of 6.3. This pH value is close to the pH range of 6.5 - 6.8 reported by Wakil *et al.* (2014) for tiger nut milk samples from three varieties of tiger nuts. It is however higher than the pH of 4.7 reported by Babatuyi *et al.* (2019) for tiger nut milk. Differences in the pH values of tiger nut milk reported by different authors could be due to possible variations in environmental conditions such as chemical composition of the soils in which the tiger nuts were grown. This could affect the chemical composition of the milk extracts of the tiger nuts thereby affecting the pH. Fresh cow milk used in the study had a pH value of 6.6. This pH value is within the range of 6.07 – 6.67 reported by Gemechu *et al.* (2015) for cow milk samples from different sources in Southern Ethiopia. It is also within the normal pH range of 6.6 – 6.8 recommended by FAO (1999) for fresh cow milk. Tiger nut milk, cow milk and their composites used in the present study for yoghurt production had a pH range of 6.3 – 6.6. This is higher than the pH range of 5.52 – 6.40 reported by Sanful (2009) for tiger nut milk, cow milk, and a 1:1-composite of both milks. pH of the milk formulations decreased with time during the fermentation. The resultant yoghurt products had a pH range of 3.94 - 4.68 which is within acceptable pH for yoghurts. This pH range is comparable to the 3.97 – 4.75 pH range reported by Bristone *et al.* (2015) for yoghurts produced from cow milk, tiger nut milk, soybean milk and their combinations. Imele and Atemkeng (2001) reported a pH range of 4.2 – 4.4 for yoghurt products while Makut *et al.* (2018) reported a pH range of 4.0 – 4.5 for tiger nut milk yoghurt and a commercially sold yoghurt.

Decrease in the pH of the fermenting milk samples was accompanied by increase in titratable acidity (TA). Increase in TA of milk samples is often due to activity of lactic acid bacteria which are predominant in milk fermentations. In this type of fermentation, LAB ferment sugars with production of lactic acid resulting in decrease in pH and increase in TA (Wakil and Onilude, 2011; Omola *et al.*, 2014). Titratable acidity of the milk formulations ranged from 0.150 to 0.310 while titratable acidity values of the yoghurt products were in the range of 0.560 – 0.640. This TA range is similar to the 0.50 – 0.65 titratable acidity range reported by Akoma *et al.* (2000) for yoghurts produced from tiger nut milk and a tiger nut-cow milk composite. Makut *et al.* (2018) reported a higher TA range of 0.91 – 0.95 for tiger nut milk yoghurt and a commercially sold yoghurt in Keffi, Nigeria. Bristone *et al.* (2015) reported an even higher TA range of 1.09 and 1.13 for yoghurt produced from a tiger nut-cow milk (50:50) blend and a tiger nut-cow milk (80:20) blend respectively. Variations in the TA values of yoghurts produced in the present study and that reported by these other authors could be attributed to differences in fermentation time and in type of starter culture used in the yoghurt production process.

Total plate count (aerobic mesophilic bacterial count) and total fungal count of the yoghurt products were in the ranges of 1.0×10^2 - 1.3×10^3 and 0.1×10^1 and 0.3×10^1 cfu/ml respectively. Total plate count and total fungal count of the yoghurt products in this study were lower than those

reported by Wakil *et al.* (2014) for starter-developed fermented milk from three varieties of tiger nut. Bristone *et al.* (2015) reported a 6.0×10^5 – 7.1×10^5 cfu/ml range for total bacterial plate count and a fungal count range of 5.8×10^5 – 6.3×10^5 cfu/ml for yoghurts produced from two blends of tiger nut milk and cow milk. The lower microbial counts observed in this study was probably due to proper handling and maintenance of good sanitary standards at all stages of the yoghurt production process, differences in fermentation time, and type of starter used. The total plate count and total fungal count of the yoghurts produced in this study were within acceptable safety limits ($< 10^5$ and $< 10^6$ cfu/ml for total plate count and total fungal count respectively) specified by the International Commission on Microbiological Specifications for Foods (ICMSF) (1986).

Sensory evaluation of the yoghurts produced indicated that there were significant differences ($P < .05$) in the acceptability ratings for appearance, taste, texture, and overall acceptability.

Observed differences in aroma acceptability scores were not statistically significant ($P > .05$) which implies that yoghurt aroma did not significantly contribute to the panelists' preference for any of the yoghurt products. The finding on aroma in this study agrees with that of Akoma (2000) who similarly reported non-significant differences in the aroma of yoghurts produced from cow milk, tiger nut milk, coconut milk, and their composites.

Tiger nut-cow milk (75:25) yoghurt was the most preferred yoghurt in terms of appearance and taste. Akoma *et al.* (2000) had a somewhat different finding. The authors reported that yoghurt produced from tiger nut milk alone had higher appearance and taste acceptability over yoghurt produced from tiger nut + cow milk (3:2 w/v) composite. Yoghurt produced from tiger nut milk alone (Tiger nut milk (100) yoghurt) in the present study was also scored highly in terms of appearance acceptability; there was no statistically significant ($P > 0.05$) difference between its appearance score and that of the tiger nut-cow milk (75:25) yoghurt. The finding on appearance acceptability in this study is similar to that of Sanful (2009) who reported that yoghurt produced from composite milk composed of equal proportions of tiger nut milk and cow milk had higher appearance acceptability over yoghurts produced from tiger nut milk alone or cow milk alone. The high appearance acceptability of the tiger nut-cow milk (75:25) yoghurt was probably due to its light brown colour which resulted from colour synergy between cow milk and tiger nut milk. This light brown colour of the yoghurt could have had a visual appeal to the panelists. This was also the opinion of Sanful and his co-workers.

There were significant ($P < 0.05$) differences in the textural scores of the produced yoghurts. Tiger nut milk (100) yoghurt was the most preferred yoghurt in terms of texture (mouthfeel) acceptability. In contrast to this finding, Akoma *et al.* (2000) and Ajibade *et al.* (2015), in similar studies, reported that mouth feel (texture) had no significant effects on the preferences of panelists for different yoghurt products.

In terms of overall acceptability, tiger nut milk (100) yoghurt was most preferred by the panelists, followed by tiger nut-cow milk (75:25) yoghurt. This finding is in

contrast with that of Ajibade *et al.* (2015) who evaluated the nutritional qualities of yoghurt prepared from different plant milk sources. The authors reported that yoghurt produced from cow (50%)-tiger nut (50%) composite milk had the highest overall acceptability over 100% tiger nut milk yoghurt and yoghurts produced from cow milk and other composite milks. On the other hand, the overall acceptability finding in the present study agrees with that of Akoma *et al.* (2000) who reported that panelists generally preferred yoghurt produced from tiger nut milk alone to those produced from cow milk and other plant milks. Though tiger nut milk (100) yoghurt recorded a higher overall acceptability score than tiger nut-cow milk (75:25), the difference between the two scores was not statistically significant ($P > 0.05$). This implies that consumers are likely to choose yoghurt produced from tiger nut milk alone and yoghurt made from a mixture of tiger nut milk and cow milk (1:3) over the other yoghurt products in this study.

The fat contents of tiger nut milk (100) yoghurt and tiger nut-cow milk (75:25) yoghurt were 7.12% and 5.89% respectively. The fat contents of the two yoghurt products were higher than the 1.88 – 4.00% fat content range reported by Olugbuyiro and Oseh (2011) for some market yoghurts in Nigeria, but were within the fat content range of 5.1 - 9.7% reported by Ajibade *et al.* (2015) for yoghurt produced from tiger nut milk alone and those produced from combinations of tiger nut milk with either cow milk, soybean milk, or coconut milk. The fat content of tiger nut milk (100) yoghurt in this study was comparable to the 7.63% fat content of tiger nut milk yoghurt reported by Makut *et al.* (2018). The fat contents of the two most preferred yoghurts (tiger nut (100) milk yoghurt and tiger nut-cow milk (75:25) yoghurt) were within the FAO standard as reported by Omola *et al.* (2014). In the FAO standard, yoghurts with 0.5 – 10% fat content are said to be good while yoghurts with fat content of 3.0% are said to be the best. In terms of fat content, yoghurts can be placed into three categories. Yoghurts with less than 0.5% fat content are to be labelled 'non-fat yoghurt', those with fat content of 0.5 - 3.25% are to be labelled 'yoghurt' while those with fat contents above 3.25% are termed 'high fat yoghurts' (USDA, 2001 as cited by Olugbuyiro and Oseh, (2011). Tiger nut (100) milk yoghurt and tiger nut-cow milk (75:25) yoghurt which were the most preferred yoghurts in this study fall within the category of high fat yoghurts. Total energy value of milk is from the fat content and higher fat content is an indication of more total available energies (Belewu and Belewu, 2007). This implies that tiger nut milk (100) yoghurt and tiger nut-cow milk (75:25) yoghurts are of high energy value.

V. CONCLUSION

The findings from this study have shown that tiger nut milk and tiger nut milk-cow milk composites are suitable alternatives to cow milk for yoghurt production. Yoghurt produced from the various milk formulations were generally acceptable with tiger nut milk (100) yoghurt and tiger nut-cow milk (75:25) yoghurt being the most preferred yoghurts. Tiger nut milk, therefore, has a great potential for use as alternative milk source of plant origin for yoghurt production. Use of tiger nut milk, whether singly or in

appropriate combinations with cow milk, would help reduce the cost of yoghurt production which will make the finished product more affordable. Use of tiger nut milk for yoghurt production would increase yoghurt variety for consumers and would also provide yoghurt that will meet the need of consumers that are allergic to cow milk and cow milk products.

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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