



Research Article

Microbial and Quality Characteristics of Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

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ABSTRACT

The study aimed to assess the proximate, physicochemical, microbial and sensory characteristics of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends. Six (6) different formulations of yoghurt were prepared at different rations (cow milk: soymilk: baobab fruit pulp) at 100, 80:10:10, 70:15:15, 70:20:10, 60: 30:10 and 50:30: 20% respectively. Where sample A (100% cow milk) and Sample G (market sample) are the control samples. Results showed that moisture, fat, protein, Ash and carbohydrate ranged from 78.90 - 88.93, 2.27 - 4.06, 4.03 -3.16, 0.28 -1.13 and 3.35 – 9.24% respectively. However, the carbohydrate and ash contents increased with the level of soymilk and baobab fruit pulp addition. The pH ranged from 3.03-4.42 and sample A had the highest pH and Titratable acidity while Sample G had the highest viscosity. Total solids ranged from 12.51 -13.94 and sample F had the highest total solid. Also, the total solid increased with an increase in baobab fruit pulp. Among all the yoghurt samples, sample A had the total viable count and total coliform count. The sensory evaluation result showed significant differences ($p < 0.05$) in all the organoleptic attributes analyzed. Sample A is the most preferred in terms of colour, taste, and appearance and has the highest overall acceptability score followed by sample F. From this study, it can be concluded that yoghurt enriched with baobab fruit pulp blends is also acceptable and an alternative to produce affordable yoghurt with good health benefits to consumers

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INTRODUCTION

Yoghurt is usually produced by homogenization, pasteurization and fermentation of milk combined with a culture of acid-forming bacteria (Ani et al.,

2018). It is also one of the most popular dairy foods products produced by fermentation with or without probiotics with the addition of starter culture bacteria (Agwo et al., 2023). Globally, its

increase in gaining popularity is due to its nutritional quality such as high protein and calcium content (Bhandari et al., 2018). Nowadays, studies are focused on alternative sources of animal milk for the production of yoghurts because of the increased concern about health issues (high fat and cholesterol contents in animal milk) in addition to the high cost of animal milk (Olabiran et al., 2023; Awolu and Olofinlae, 2016). Compared to the nutritional quality of milk yoghurt, plant base yoghurts such as bambara groundnut, soybean and moringa oleifera (Ani et al., 2018), Baobab (*Adansonia digitata*) (Adelekan and Saleh, 2020), coconut milk (Peters et al., 2023) and other fortified yoghurts also promises a greater nutritional benefit. According to Adebowale and Lawal, (2004), cheaper and abundant proteins in legumes would also serve the purpose. Research has shown that the consumption of yoghurt may boost immunity, fight infection, protect against cancer and other digestion issues (ease diarrhoea) (Mishra, et al., 2008)

Soybean (*Glycine max*) belongs to the family *Leguminosae*, subfamily *Papilionoideae* and are used for the production of soy milk. According to Qin *et al.* (2022), soybean is a legume with higher advantages, including the absence of cholesterol or lactose and only small quantities of saturated fatty acids, in addition to their low cost of production. Also, soybeans have been known to contain several classes of anticarcinogens such as phytosterols, saponins, protease inhibitors, phenolic acids, phytic acid, and isoflavones (Sun et al., 2022). Soymilk has also been used as an alternative source of animal milk due to its high nutritional quality and low cost (Mazumder et al., 2016). Recently, studies have shown that the intake of soy protein could reduce the risk of developing several cancers and lower total serum cholesterol (Fan et al., 2022). Furthermore, studies are now focused on the use of soymilk as an alternative to animal milk.

The baobab fruit is a rich source of vitamins and minerals required by the body with a strong integral antioxidant capacity almost 10 times higher than orange pulp (Chabite et al., 2019). The Baobab tree (*Adansonia digitata*) is commonly known as the native tree to Africa, widely spread throughout the hot and drier regions of tropical Africa. According to Monteiro et al, (2022), baobab fruit pulp contains high antioxidant capability mainly because of its high natural vitamin C. Additionally, vitamin C content in baobab fruit pulp is two times more than the same amount of milk which aids the bodily uptake of iron and calcium (Evang, 2021). Moreover, the use of baobab fruit pulp as a food ingredient has been accepted by the European Union (EC 2008) and the US Food and Drug Administration (FDA, 2000) leading to an increase in demand and utilization of baobab in food production. Also, several vitamins such as vitamin C, riboflavin and niacin are increased by the addition of baobab fruit pulp (Kamatou et al., 2011). Hence, due to the higher antioxidant properties and pectin content of baobab fruit pulp, it has the ability to combat the formation of free radicals (Eke et al., 2013) and has been utilized in several food formulations including jam (Ndabikunze et al., 2011). Research has shown that the addition of baobab fruit pulp in yoghurt increased the nutritional content such as calcium, magnesium, potassium, sodium and several amino acids (Chabite et al., 2019). According to Rahul et al. (2015), baobab (the seed, bark and the pulp) are used traditionally for the treatment of malaria, diarrhoea, anaemia and others. Furthermore, several studies have shown that baobab has been used medicinally for its antiviral, antibacterial and anti-inflammatory properties (Bharskar, 2022; Samatha et al., 2017; Sulaiman et al., 2011).

The objectives of this study are to produce yoghurt from cow milk, soymilk and baobab fruit pulp and evaluate the proximate composition,

physicochemical properties, microbial and sensory qualities.

MATERIALS AND METHOD

Materials

The materials used in this study were fresh cow milk, soybean seed, Baobab fruit pulp and *kindirmu* (containing *Lactobacillus bulgaricus* and *Streptococcus thermophiles*) used as a yoghurt starter culture.

Sample Collection

A batch of fresh cow milk was purchased in the morning from the local provider at the market (Monday market) in polyether bags, stored on ice and taken to the lab for production. soybean seed and baobab fruit pulp were also purchased from Monday Market at Maiduguri Borno State from the local suppliers. The controlled samples used in this study were yoghurt produced from 100% cow milk and processed yoghurt which was also purchased from a shop in the market (market sample).

Soymilk Preparation

The soy milk was prepared according to the method described by Udeozor (2012). Soybeans (1kg) were cleaned, sorted, washed in clean water and soaked for 18 hrs in 3 Litres (3L) of warm water to give a bean: water ratio of 1:3. They were then decorticated, washed in water, boiled for 5 min in water and ground into a paste using attrition mill. The slurry was then filtered using a

cheesecloth and the filtrate (soymilk) was then obtained.

Baobab Fruit Pulp Preparation

The baobab fruit pulp was prepared according to the method described by (Adelekan and Saleh, 2020) where 500g of baobab pulp was placed in a litre of water and allowed to soak. It was then squeezed and filtered using a muslin cloth (2mm pore size) to obtain the milky juice. The seed and other residues were removed.

Preparation of Yoghurt

Yoghurt was prepared according to the previous method described by Adelekan and Saleh, (2020). The fresh cow milk, baobab fruit pulp and soymilk were mixed in the appropriate ratio of formulations (Table 1). About 6 (six) liters of fresh cow milk were pasteurized at 90°C for 15min and allowed to cool to 45°C. Six portions (1L each) of pasteurized milk were distributed. One litre of the cow milk sample (100%) served as the control while the other five (5) samples were substituted with soybeans and baobab fruit pulp at various percentages (80:10:10, 70:15:15, 70:20:10, 60: 30:10 and 50:30: 20% respectively). The samples were inoculated directly with 5% concentration starter culture and incubated at a temperature of 45°C for 18 hours. The coagulation obtained after incubation was broken using a blender to obtain a smooth texture of yoghurt shown (Figure 1).

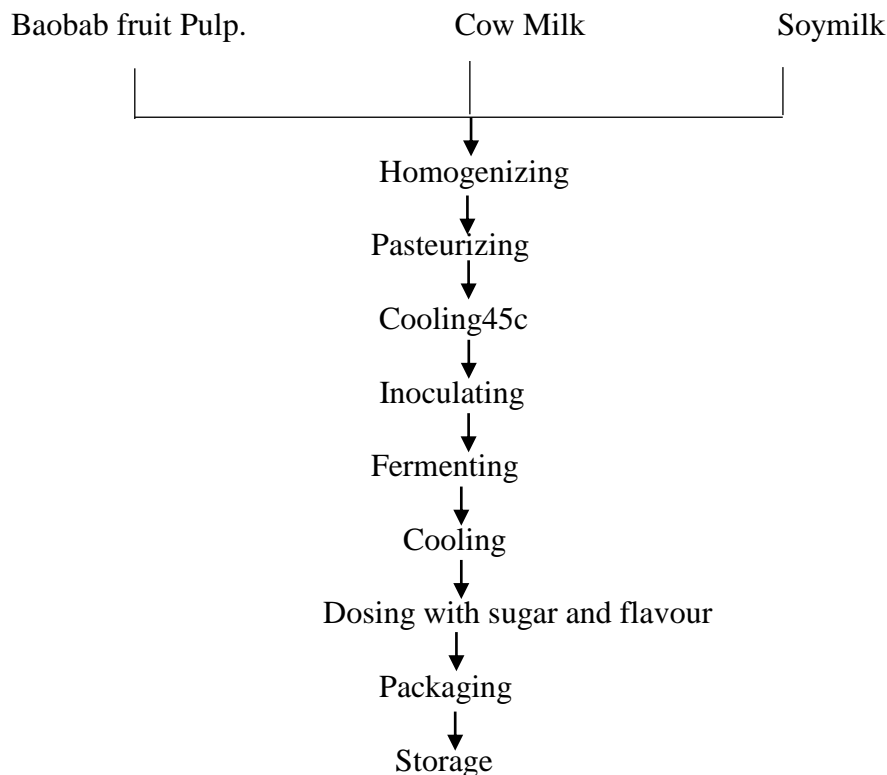


Figure 1: Flow chart for production of the yoghurt samples (Adelekan and Saleh, 2020).

Formulation of Blends

Six yoghurt formulations were produced by varying the proportions of cow milk, soymilk,

and baobab fruit pulp. Sample A (100% cow milk) and Sample G (market sample) were used as controls.

Table 1: Formulation of blends of the yoghurt samples

Samples	Cow milk (%)	Soymilk (%)	Baobab fruit pulp (%)	
Sample A	100	0	0	control
Sample B	80	10	10	
Sample C	70	15	15	
Sample D	70	20	10	
Sample E	60	30	10	
Sample F	50	30	20	
Sample G	Market sample	-	-	control

Proximate Composition of the Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

The proximate composition of the samples such as moisture, fat, carbohydrate and ash contents was determined by standard methods described

by AOAC, (2010). However, the crude protein was determined by kjeldah method as previously described by the Association of Official Analytical Chemists (AOAC, 2005).

Determination of Moisture Content

The moisture content of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends was determined using the oven drying method. The crucible was washed, dried in the oven and afterwards cooled in a desiccator. The crucible was then weighed as W_1 . About 2 ml of the yoghurt sample was poured into the weighed empty crucible and weighed as W_2 , the crucible

$$\% \text{ Moisture content} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1} \dots\dots\dots(1)$$

- W_1 = weight of empty crucible;
- W_2 = weight of wet sample + crucible;
- W_3 = weight of dry sample and crucible.

Determination of Fat Content

The solvent extraction method was used to determine the fat content of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends. The extraction flasks were washed using petroleum ether, dried and cooled and weighed. About 2 ml of the yoghurt sample was weighed into the extraction thimble and placed back into the soxhlet apparatus. The washed flask was filled with petroleum ether (with boiling temperature ranging from 40 - 60 °C) to about

$$\% \text{ Fat content} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1} \dots\dots\dots(2)$$

Determination of Ash Content

The determination of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends using the method described by AOAC (2010). A crucible was washed, dried in an oven and placed in a desiccator to cool. The cooled crucible was then weighed as W_1 . About 2 ml of yoghurt

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1} \dots\dots\dots(3)$$

- Where; W_1 = Weight of empty crucible
- W_2 = Weight of crucible + Weight of sample before ashing
- W_3 = Weight of crucible + Weight of sample after ashing

Determination of Carbohydrate

The carbohydrate content was determined as the nitrogen free extraction calculated by difference as shown in the equation below.

containing the yoghurt sample was the placed into a hot air oven (Fisher Isotemp oven model 175/U.S.A) and dried until a constant weight was obtained. The crucible containing the sample was removed from the oven and cooled in a desiccator and the weight was recorded as W_3

The % moisture was then calculated as shown in equation 1.

three-quarter of its volume. The apparatus was then set-up and extraction was carried out for a period of 4 - 6 hours. The petroleum ether was then recovered leaving only oil in the flask at the end of the extraction. The oil in the extraction flask was dried in the oven and then placed into a desiccator to cool. The final weight was then recorded. The fat content was expressed as a percentage of raw materials. The difference in weight of empty flasks and the flask with oil content was calculated as shown in equation 2.

sample was then poured into the crucible and weighed as W_2 . The sample in the crucible was charred and transferred into a preheated muffle furnace at 550 °C for 2 hours until a white and light grey ash was obtained and weighed as W_3 . The percentage ash content was calculated as shown in equation 3.

$$\% \text{ Carbohydrate} = 100 \% - (\text{protein} + \text{fat} + \text{fibre} + \text{ash} + \text{moisture}) \% \dots\dots\dots(4)$$

Determination of % Crude Protein

crude protein was determined by kjeldah method as previously described by the Association of Official Analytical Chemists (AOAC, 2005). The yoghurt sample was digested with concentrated sulphuric acid (H₂SO₄), 40% concentrated sodium hydroxide (NaOH), potassium sulphate (K₂SO₄) and copper sulphate (CuSO₄). Five (5) ml

of the digested sample was placed into a micro-Kjeldahl distillation apparatus and excess concentration NaOH was added to make the solution strongly alkaline. Ammonia was distilled into 5ml of boric acid indicator in a titrating flask. Above 45ml of the distillates was collected. Titration was done with 0.01m HCL. The end point of the titration was light green.

$$\% \text{ protein} = \% \text{ N} \times \text{F}$$

Where F = conversion factor 100 (% in food protein)

$$\% \text{ N} = \frac{V_s V_B \times N_{\text{acid}} \times 0.01401 \times 100}{W} \dots\dots\dots(5)$$

V_S = vol. (ml) of acid required to titrate sample

V_B = vol. (ml) of acid required to titrate blank

N_{acid} = normally of acid (0.1)

W = weighed of sample in grams

Each food type has its own percentage of nitrogen. The common factor for most food and food mixtures is 6.25.

Physicochemical Analysis of the Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

PH Determination

The pH of the yoghurt was determined using a pH meter (Precision pH/ORP Meter 920). Ten grams (10 g) of yoghurt sample was mixed with 90 mL of distilled water in a 250-mL beaker and homogenized for 1 min. The pH of the solution was measured after 15 min.

sample was added into a clean weighed crucible and placed in a water bath to boil for an hour to remove most of the water. The crucible was then transferred into a preheated oven at 105°C for 2 hrs to dry before transferring into a desiccator to cool (for 30 min). The weight was then taken and the process was repeated after 1hr 30min and 30 min until the weight of the consecutive weightings did not exceed 1 mg. The lowest value was accurately recorded. The percentage of total solids was calculated below

Total Solid Determination

The total solids were determined according to the method described by AOAC, (2005) where 5 g of

$$\% \text{ Total solids} = \frac{W_2 - W_1}{W_1 - W} \times 100 \dots\dots\dots(6)$$

Where

W= Weight of the crucible

W₁= Weight of the crucible and sample text portion

W₂= Weight of the crucible and dry sample

Determination of Titratable Acidity

Determination of titratable acidity was done as described by AOAC, (2005). About ten grams (10g) of yoghurt was placed in a beaker, 3 drops of the phenolphthalein indicator solution were

$$\% \text{ Titratable acidity} = \frac{\text{Titre value} \times M \times 90}{\text{Volume of sample} \times 1000} \times 100 \dots\dots\dots(7)$$

Determination of Viscosity

The viscosity of the sample was determined according to the method of Shihata and Shah (2002) with slight modifications. The viscosity was determined at a room temperature (30+1°C) Using spindle No. 4 rotation at 60 rpm using a viscometer (LV DV-1 prime Brookfield Engineering Labs Inc., Middleboro, MA). The samples were prepared in 12 replicates.

Microbial Evaluation of the Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends**Total Viable Bacterial Count**

The bacterial count was determined following the previous method described by Zumbes et al. (2014). About 1 ml of the sample was transferred into a bottle containing 9 ml of distilled water forming a stock solution and then 1 ml was taken, aseptically transferred into 9 ml of distilled water forming a required serial dilution. Nutrient agar was prepared according to the manufacturer's instructions and plated. Plates were then incubated at 37° C for 24 hours and colonies were counted and reported as colony-forming units per gram cfu/g. This was studied at day 0 (after production) and after 5 days of production.

RESULTS AND DISCUSSION**The Proximate Composition of Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends**

The proximate composition of yoghurt is depicted in Table 2. Generally, the moisture content in food is a major factor that can affect the keeping quality of fermented products. The moisture content of the yoghurt samples ranged from 78.90

added to the sample and titrated with 0.1N sodium hydroxide until the endpoint was reached (pink colour). The acidity as lactic acid (per cent m/v) was calculated using this formula.

Total Coliform Count (TCC)

The total coliform count (TCC) was carried out as described by Micanel et al. (1997). About 1 ml of the diluted yoghurt sample (using serial dilution) was dispersed on the surface of the sterile MacConkey agar medium. The plates were incubated at 37°C for 24 hrs after the medium was mixed immediately and shaken for 5-10 seconds and visible pink colonies were counted for the determination of TCC which was carried out at day 0 (after production) and after 5 days and expressed in log cfu/g per sample homogenate

Sensory Evaluation and Data Analysis of the Yoghurt Produced from Cow Milk, Baobab Fruit Pulp and Soybean Milk Blend

The sample was evaluated using fifteen (15) semi-trained panelists from the University of Maiduguri. The sensory attributes evaluated were appearance, flavour, taste, texture and overall acceptability. These were rated using a 5-point hedonic scale ranging from like extremely, to dislike extremely. The samples were set before the panelists to rate and fill the score sheet according to the likeness of each sample by choosing the appropriate category.

- 88.93%. Among all the samples produced, sample A had the highest moisture content while the lowest was observed in sample E. The finding from the current study agrees with that of Wairimu et al. (2022), where the moisture content was reported to be at a similar range (78.42 - 87.30%). According to Matin et al. (2018), the growth of microorganisms is always supported by higher moisture content leading to a decrease in

shelf life and quality of yoghurt. The fat content of the yoghurt samples ranged from 2.27 - 4.06% and sample F had the highest fat content as compared to all the samples. The high fat content of the yoghurt samples was as a result of increase in soy milk. However, there was no significant difference in fat content between samples D and sample E. Also, the increase in fat content may be due to the activities of lipases which hydrolyze fat to glycerol and fatty acids after fermentation (Kabore et al., 2011). According to Gemede et al. (2016), the amount of mineral content present in food products is as a result of crude ash content. In this study, the ash content of the yoghurt ranged from 0.28 - 1.13%. Sample F had the highest while sample A had the lowest. There was no significant difference ($p < 0.05$) in the ash content of sample B and sample D. The level of ash content increases with respect to the increase in both soymilk and baobab fruit pulp which could be attributed to the high ash content of the baobab pulp and soymilk thus indicating high mineral content in the sample. This is in agreement with a study on the development and

evaluation of goat milk yoghurt enriched with baobab fruit pulp reported by Wairimu et al. (2022). Again, this is also in agreement with a previous study on the chemical composition and microbiological quality of baobab fruit fortified yoghurt where the ash content ranged from 0.18 - 1.13% (Adelekan and Saleh, 2020). The protein content of the yoghurt samples ranged from 2.85 - 3.90%. The protein content was observed to be higher in sample A and lower in sample G. The protein content decreases with an increase in baobab fruit pulp and soy milk this could be due to the inhibitory effect of baobab pulp on the proteolytic organisms that could contribute to the breakdown of proteins (Madora et al., 2016). The total carbohydrate content of the sample ranged from 5.12 - 8.89. Similarly, it has been observed that a low content of carbohydrate content (5.25 - 10.01%) was also reported in yoghurt (Eke et al., 2013). According to Eke et al. (2013), a decrease in carbohydrate content could be as a result of the carbohydrate moiety that was fermented by the lactic acid bacteria.

Table 2: The proximate composition of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends

Sample	Moisture	Ash	Fat	Protein	CHO
Sample A	88.93 ± 0.01 ^a	0.66 ± 0.00 ^e	3.53 ± 0.02 ^c	3.90 ± 0.00 ^a	5.12 ± 0.00 ^g
Sample B	85.85 ± 0.02 ^b	0.73 ± 0.01 ^c	3.14 ± 0.02 ^e	3.66 ± 0.01 ^b	6.16 ± 0.01 ^f
Sample C	82.40 ± 0.00 ^c	0.79 ± 0.01 ^c	3.20 ± 0.00 ^d	3.21 ± 0.01 ^d	6.30 ± 0.00 ^e
Sample D	82.50 ± 0.00 ^c	0.72 ± 0.00 ^c	3.60 ± 0.00 ^b	3.34 ± 0.00 ^c	6.98 ± 0.00 ^d
Sample E	78.14 ± 0.01 ^d	0.86 ± 0.01 ^b	3.60 ± 0.00 ^b	3.32 ± 0.01 ^c	7.01 ± 0.01 ^c
Sample F	83.90 ± 0.00 ^e	1.13 ± 0.00 ^a	4.06 ± 0.02 ^a	3.05 ± 0.05 ^e	8.89 ± 0.00 ^a
Sample G	86.50 ± 0.00 ^b	0.28 ± 0.00 ^d	2.72 ± 0.01 ^e	2.85 ± 0.04 ^f	8.28 ± 0.02 ^b

Data are Mean ± SD (n=3). Mean values bearing similar superscripts are not significantly different ($p < 0.05$)

Sample A: 100% cowmilk, sample B: 80% cowmilk:10% soymilk: 10%baobab fruit pulp, sample C: 70% cowmilk:15% soymilk: 15% baobab fruit pulp, sample D: 70% cowmilk:20% soymilk: 10% baobab fruit pulp, sample E: 60% cowmilk :30% soymilk: 10% baobab fruit pulp, sample F: 50%cowmilk:30% soymilk: 20% baobab fruit pulp, sample G: purchased market yoghurt

The Physicochemical Properties of Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

The physicochemical properties of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends are depicted in Table 3. The pH value of the yoghurt samples ranged from 3.03 - 4.42. Among all the yoghurt samples produced, sample A had the higher pH value. The pH of the samples decreases with an increase in soymilk and baobab fruit pulp. According to Ojuta *et al.* (2013), a decrease in the pH of the samples could be due to the presence of organic acids such as tartaric, citric, succinic and malic acids in the fruit pulp. However, the pH value of the yoghurt produced in this study was within the acceptable range recommended by the Food Standard Code for safe yoghurt (Peters *et al.*, 2023). This is similar to a previous study reported by Akoma *et al.* (2020) although on the production of yoghurt from coconut-tiger nut milk. The titratable acidity of the samples varied significantly ($p < 0.05$) ranging from 0.63 - 1.44% and sample A had the highest. According to CODEX (2010), this complies with 0.6% minimum standard level of titratable acidity for yoghurt. Also, the total solids

of the samples produced ranged from 13.06 - 18.86 %. Among all the samples, sample F had the highest soluble solids content (15.86 %). The finding of this study is similar to a previous study reported by Ndife *et al.* (2014) who recorded a total solid of 14.77 - 19.90 %. According to Baidoo *et al.* (2019), total solids in yoghurt are an indication of the dry matter content present in the samples. However, Wairimu *et al.* (2022) reported that the physical properties of the yoghurt produced highly depend on the total solids initially present in the milk used. The viscosity of the samples ranged from 1511.96 - 1800.91 (*cP*). Sample E and Sample F had the highest viscosity as compared to all the yoghurt samples produced. According to Mudgil *et al.* (2018), viscosity is one of the most important textural properties of a product. This is similar to a previous study reported by Brennan and Tudorica (2008) where the viscosity of reduced-fat yoghurt supplemented with β -glucan increased as a result of the supplementation. Similarly, Kim *et al.* (2020) also reported that the viscosity of yoghurt increased with the increase in the concentration of basil seed gum.

Table 3: The physicochemical properties of yoghurt produced from cow milk, baobab fruit pulp and soybean milk

Sample	pH	TTA (%)	Total Solid (%)	Viscosity (<i>cP</i>)
Sample A	4.42 ± 0.01 ^a	1.44 ± 0.00 ^a	13.06 ± 0.00 ^c	1623.00 ± 0.00 ^c
Sample B	3.29 ± 0.00 ^d	1.28 ± 0.00 ^c	13.94 ± 0.01 ^f	1600.86 ± 0.01 ^d
Sample C	3.21 ± 0.00 ^e	1.07 ± 0.00 ^e	15.61 ± 0.01 ^b	1621.51 ± 0.02 ^c
Sample D	3.45 ± 0.00 ^a	0.90 ± 0.00 ^e	13.13 ± 0.00 ^d	1820.11 ± 0.00 ^b
Sample E	3.08 ± 0.00 ^b	1.14 ± 0.01 ^d	13.10 ± 0.00 ^e	1800.91 ± 0.01 ^a
Sample F	3.03 ± 0.00 ^b	0.63 ± 0.00 ^f	15.86 ± 0.00 ^a	1801.71 ± 0.00 ^a
Sample G	3.36 ± 0.00 ^c	1.34 ± 0.00 ^b	12.51 ± 0.01 ^g	1511.96 ± 0.02 ^e

Data are Mean±SD (n=3). Mean values bearing similar superscripts are not significantly different ($p < 0.05$)

Sample A: 100% cowmilk, sample B: 80% cowmilk:10% soymilk: 10% baobab fruit pulp, sample C: 70% cowmilk:15% soymilk: 15% baobab fruit pulp, sample D: 70% cowmilk:20% soymilk: 10% baobab fruit pulp, sample E: 60% cowmilk:30% soymilk: 10% baobab fruit pulp, sample F: 50% cowmilk:30% soymilk: 20% baobab fruit pulp, sample G: purchased market yoghurt

The Microbial Properties of Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

Table 4 shows the microbial properties of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends. This was studied at day 0 (after production) and after 5 days of production. The yoghurt samples were stored at room temperature, the total viable bacteria count (TVBC) and total coliform count (TCC) were carried out. On the first day of production (i.e. 0 day) the results show no total viable bacterial count (TVBC) and total coliform count (TCC) in all samples. This is similar to a previous study reported by Sengupta *et al.* (2019) where no coliform, *E. coli*, or *Salmonella* spp in fresh and fortified soy yoghurts on the first day of production. However, after 5 days of production, the results for the TVBC ranged from 1.08×10^4 - 3.8×10^4 with sample A recording the highest TVBC while the lowest count was observed in sample D. High total viable bacterial count is

expected due to the presence of starter culture (lactic acid bacteria). The TCC of the yoghurt samples ranged from 1.5×10^4 - 1.7×10^4 and the highest count was observed in sample A while the lowest count was observed in sample G. The low level of TCC obtained could be attributed to the method of processing and handling (heat treatment) and the acidity of yoghurt samples (Jay, 1992). According to Martin *et al.* (2016), the presence of coliform bacteria in dairy food is an indication of poor hygienic practices during the handling of the product. In this study, both the TVBC and TCC were observed to be higher in sample A as compared to other samples. which shows that cow milk is a good medium for microbial growth. This is in agreement with a study reported by Bristone *et al.* (2015) where the highest count was also observed in yoghurt produced from cow milk (100%). The total bacterial load in any food product is mostly associated with the product history and its shelf life.

Table 4: The microbial properties of yoghurt produced from cow milk, soymilk and baobab fruit pulp blends

Sample	Formulation	TVBC (cfu/ml)	TCC (cfu/ml)
Sample A	100:00:00	3.8×10^4	1.7×10^4
Sample B	80:10:10	2.0×10^4	1.5×10^4
Sample C	70:15:15	2.0×10^4	1.6×10^4
Sample D	70:10:20	1.0×10^4	1.6×10^4
Sample E	60:25:15	2.0×10^4	1.6×10^4
Sample F	50:30:20	2.4×10^4	1.6×10^4
Sample G	Market sample	3.2×10^4	1.4×10^4

Sample A: 100% cowmilk, sample B: 80%cowmilk:10%soymilk: 10%baobab fruit pulp, sample C: 70%cowmilk:15%soymilk: 15%baobab fruit pulp, sample D: 70%cowmilk:20%soymilk: 10%baobab fruit pulp, sample E: 60%cowmilk:30%soymilk: 10%baobab fruit pulp, sample F: 50%cowmilk:30%soymilk: 20%baobab fruit pulp, sample G: purchased market yoghurt

The Sensory Evaluation of Yoghurt Produced from Cow Milk, Soymilk and Baobab Fruit Pulp Blends

The result of the sensory properties of yoghurts produced from cow milk, soymilk and baobab fruit pulp blends are presented in Table 5. There was a significant difference ($p < 0.05$) in colour,

taste, texture and overall acceptability in all samples. Among all the yoghurt samples, sample A was rated the highest in colour, taste and aroma. However, there was no significant difference ($p > 0.05$) in aroma among samples B, C, D, E, and F while sample G had the lowest score. Considering the texture of the yoghurt,

sample B has the best texture followed by sample G. In terms of overall acceptability, sample A (the control) is the most preferred among all the

samples followed by sample F. However, all the yoghurt samples were acceptable to the panelists because they were all rated above the average.

Table 5: Sensory evaluation of yoghurts produced from cow milk, baobab fruit pulp and soybeans milk

Sample	Colour	Taste	Aroma	Texture	Overall Acceptability
Sample A	8.21 ± 0.01 ^a	8.46 ± 0.00 ^a	8.11 ± 0.02 ^a	6.87 ± 0.00 ^c	8.66 ± 0.00 ^a
Sample B	7.14 ± 0.01 ^b	7.01 ± 0.01 ^c	6.24 ± 0.02 ^b	8.26 ± 0.02 ^a	8.33 ± 0.00 ^d
Sample C	7.00 ± 0.00 ^c	6.34 ± 0.01 ^e	6.23 ± 0.00 ^b	6.74 ± 0.01 ^d	6.66 ± 0.00 ^g
Sample D	6.66 ± 0.00 ^f	6.33 ± 0.00 ^e	6.23 ± 0.01 ^b	7.00 ± 0.00 ^b	8.02 ± 0.03 ^e
Sample E	6.66 ± 0.00 ^f	7.86 ± 0.00 ^b	6.24 ± 0.07 ^b	6.55 ± 0.03 ^e	8.51 ± 0.02 ^c
Sample F	6.65 ± 0.01 ^f	6.06 ± 0.00 ^f	6.23 ± 0.01 ^b	7.01 ± 0.02 ^f	8.62 ± 0.02 ^b
Sample G	6.86 ± 0.00 ^d	6.86 ± 0.00 ^d	6.02 ± 0.00 ^c	7.76 ± 0.00 ^b	6.80 ± 0.00 ^f

Data are Mean±SD (n=3). Mean values bearing similar superscripts are not significantly different ($p<0.05$)

Sample A: 100% cowmilk, sample B: 80%cowmilk:10%soymilk: 10%baobab fruit pulp, sample C: 70%cowmilk:15%soymilk: 15%baobab fruit pulp, sample D: 70%cowmilk:20%soymilk: 10%baobab fruit pulp, sample E: 60%cowmilk:30%soymilk: 10%baobab fruit pulp, sample F: 50%cowmilk:30%soymilk: 20%baobab fruit pulp, sample G: purchased market yoghurt

CONCLUSION

In this study, acceptable and nutritious yoghurt was produced from the blends of cow milk, soymilk and baobab fruit pulp. It was discovered that the ash, carbohydrate and physicochemical properties of yoghurt are improved by substituting various levels of soy milk and baobab fruit pulp with cow milk. As the amount of baobab fruit pulp was added to the cow milk and soymilk milk, the total solid and viscosity were also observed to be improved. From an organoleptic point of view, the most acceptable (overall acceptable) yoghurt sample was sample A (100% cow milk) followed by sample F which was produced from 50% cow milk 30% soy

milk:20% baobab fruit pulp. This shows that soymilk and baobab fruit pulp can be utilized as an alternative for the production of yoghurt that is acceptable, low cost and good nutritional quality for consumers. Also, the safety of food along with nutrition is an important issue in our present society which ensures a healthy balanced diet to consumers. The total viable bacteria count (TVBC) and total coliform count (TCC) were observed to be higher above the regulatory limit therefore, more hygienic practice is required during yoghurt processing.

CONFLICT OF INTERESTS

The authors declare no conflict of interests

REFERENCES

- Adebowale, K. O., & Lawal, O. S. (2004). A comparative study of the functional characteristics of some underutilized African Legume flours: Bambara groundnut (*Voandzeia subterranean*), Jack bean (*Canavalia ensiformis*) and Mucuna bean (*Mucuna pruriens*). *Food Research International*, 37, 335-365
- Adelekan, A. O., & Saleh, A. A. (2020). Chemical composition and microbiological quality of baobab (*adansonia digitata*) fruit fortified yoghurt. *Nigerian Journal of Microbiology*, 34(1): 4998 - 5006
- Agwo, O. E., Princewill-Ogbonna, I. L., Adinnu, C. M., & Igwilllo, U. C. (2023). Effects of

- the functional properties of corn, cassava and potato starches on the physical, sensory and whey separation properties of soy yoghurt. *Nigeria Agricultural Journal*, 54(1), 296-303.
- Ahmed, A., & Tiisekwa, B. P. (2020). Uses, constraints and quality characteristics of juice developed from a wild fruit-baobab. *Journal of Research and Development*, 1(2), 9-9.
- Akoma, O., Elekwa, U. O., Afodunrinbi, A. T & Onyeukw, G. C. (2000). Yoghurt from coconut and tiger nuts. *Journal of Food Technology in Africa*, 5(4), 132-134. doi: 10.4314/jfta.v5i4.19270
- Ani, E., Amove, J., & Igbabul, B. (2018). Physicochemical, microbiological, sensory properties and storage stability of plant-based yoghurt produced from Bambara nut, soybean and moringa oleifera seed milk. *American Journal of Food and Nutrition*, 6(4), 115-125. doi:10.12691/ajfn-6-4-4
- AOAC. Official Methods of Analysis. Association of Official Analytical Chemists, 18th Edition. Washington DC, 2005.
- AOAC (2010): Official methods of analysis. Association of Official Analytical Chemists. 18th Edition). Gaithersburg, USA.
- Awolu, O. O., & Olofinlae, S. J. (2016). Physico-chemical, functional and pasting properties of native and chemically modified water yam (*Dioscorea alata*) starch and production of water yam starch-based yoghurt. *Starch-Stärke*, 68(7-8), 719-726. doi/10.1002/star.201500302/full
- Baidoo I. K., Fletcher J. J., Poku L. O., Ntiforo A., Simons J. B., Opata N. S., et al. (2019). Major, minor and trace element analysis of baobab fruit and seed by instrumental neutron activation analysis technique. *Food and Nutrition Science*, 4(8), 772-778.
- Bhandari, L., Chawla, P., Dhull, S. B., Sath, P. K., & Kaushik, R. (2018). Technological and functional aspects of yoghurt cheese. *Advances in Animal Biotechnology and its Applications*, 259-267. doi.org/10.1007/978-981-10-4702-2_16
- Bharskar, G. R. (2022). A review on *Adansonia digitata*: An African tree. *Research Journal of Science and Technology*, 14(2), 127-132. doi: 10.52711/2349-2988.2022.00021
- Bristone, C., Badau, M. H., Igwebuikwe, J. U., & Igwegbe, A. O. (2015). Production and evaluation of yoghurt from mixtures of cow milk, milk extract from soybean and tiger nut. *World Journal of Dairy & Food Sciences*, 10(2), 159-169. doi: 10.5829/idosi.wjdfs.2015.10.2.94216
- Chabite, I. T., Maluleque, I. F., Cossa, V. J., Presse, I. J., Mazuze, I., Abdula, R. A., et al. (2019). Morphological characterization, nutritional and biochemical properties of baobab (*Adansonia digitata* L.) fruit pulp from two districts of Mozambique. *EC Nutrition*, 14(2), 158-164.
- Codex Alimentarius Commission. (2010). Codex Alimentarius Commission (CAC) Codex standard for fermented milk (Codex Standard 243–2003), Accessed 2 Feb 2023.
- Eke, M. O., Olaitan, N. I., & Sule, H. I. (2013). Nutritional evaluation of yoghurt-like product from baobab (*Adansonia digitata*) fruit pulp emulsion and the micronutrient content of baobab leaves. *Advance Journal of Food Science and Technology*, 5(10), 1266-1270. doi.org/10.19026/ajfst.5.3094
- El Qaidi, S., Chen, K., Halim, A., Siukstaite, L., Rueter, C., Hurtado-Guerrero, R., Clausen, H. & Hardwidge, P.R. (2017) NleB/ SseK effectors from *Citrobacter Rodentium*, *Escherichia coli* and *Salmonella enterica* display distinct differences in host substrate specificity. *Journal of Biological Chemistry*, 292 (27), 11423-11430. doi.org/10.1074/jbc.M117.790675
- Evang, E. C. (2021). Impact of baobab (*Adansonia digitata* L) fruit pulp consumption on haemoglobin and iron status in Kenyan schoolchildren: A randomized, controlled trial. (Doctoral

- dissertation, Justus Liebig University Giessen) dx.doi.org/10.22029/jlupub-423
- Fan, Y., Wang, M., Li, Z., Jiang, H., Shi, J., Shi, X., et al. (2022). Intake of soy, soy isoflavones and soy protein and risk of cancer incidence and mortality. *Frontiers in Nutrition*, 9, 847421. doi.org/10.3389/fnut.2022.847421
- Gemedo, H. F., Haki, G. D., Beyene, F., Woldegiorgis, A. Z., & Rakshit, S. K. (2016). Proximate, mineral, and antinutrient compositions of indigenous Okra (*Abelmoschus esculentus*) pod accessions: implications for mineral bioavailability. *Food Science & Nutrition*, 4(2), 223-233. doi.org/10.1002/fsn3.282
- Kabore, D., Hagrétou, S., Bréhima, D., Clarisse S. C., Mamoudou H. D. & Mogens, J. (2011). A review of baobab (*Adansonia digitata*) products: Effect of processing techniques, medicinal properties and uses. *African Journal of Food Science*, 5 (16): 833-844.
- Kamatou, G. P. P., Vermaak I., & Viljoen A. M. (2011). An Updated Review of *Adansonia Digitata*: A Commercially Important African Tree. *South African Journal of Botany*, 77(4): 908-919. doi.org/10.1016/j.sajb.2011.08.010
- Madora, E. P., Takalani, T. K. & Mashau, M. E. (2016). Physicochemical, microbiological and sensory properties of low-fat yoghurt fortified with carrot powder. *International Journal of Agricultural and Biological Engineering*, 9(1), 118–124. doi.org/10.3965/j.ijabe.20160901.1874.
- Matin, A., Banik, T., Badsha, M. R., Hossain, A., Haque, M. M., & Ahmad, M. (2018). Microbiological quality analysis of yoghurt in some selected areas of Bangladesh. *International Journal of Natural and Social Sciences*, 5(4), 82-86.
- Martin, N. H., Trmčić, A., Hsieh, T. H., Boor, K. J., & Wiedmann, M. (2016). The evolving role of coliforms as indicators of unhygienic processing conditions in dairy foods. *Frontiers in microbiology*, 7, 220072.
- Mazumder, M. A. R., & Begum, A. A. (2016). Soy milk as source of nutrient for malnourished population of developing country: A review. *International Journal of Advanced Scientific and Technical Research*, 5(6), 192-203.
- Micanel, N., Haynes, I., & Playne, M. (1997). Viability of probiotic cultures in commercial Australian yogurts. *Australian Journal of Dairy Technology*, 52(1): 24
- Mishra, V. K., Mohammad, G., Jha, A., & Mohammad, G. (2008). Immunomodulation and anticancer potentials of yoghurt probiotic. *EXCLI Journal*, 7(1), 177-184.
- Monteiro, S., Reboredo, F. H., Lageiro, M. M., Lourenço, V. M., Dias, J., Lidon, F. et al. (2022). Nutritional properties of baobab pulp from different Angolan origins. *Plants*, 11(17), 2272. doi.org/10.3390/plants11172272
- Ndabikunze, B. K., Masambu, B. N., & Tiisekwa, B. P. M. (2011). The production of jam from indigenous fruits using baobab (*Adansonia digitata* L.) powder as a substitute for commercial pectin. *African Journal of Food Science*, 5(3), 168-175.
- Ndife, J., Idoko, F., & Garba, R. (2014). Production and quality assessment of functional yoghurt enriched with coconut. *International Journal of Nutrition and Food Sciences*, 3(6): 545-550. doi.org/10.11648/j.ijnfs.20140306.19
- Olabiran, T. E., Awolu, O. O., & Ayo-Omogie, H. N. (2023). Quality characterization of functional soy-based yoghurt incorporated with scent leaf (*Ocimum gratissimum*) essential oil microcapsules. *Food Chemistry Advances*, 3, 100336. doi.org/10.1016/j.focha.2023.100336
- Peters, O. O., Afolabi, M. O., & Makinde, F. M. (2023). Chemical, physicochemical and sensory properties of yoghurt and yoghurt simulates produced from the blends of cow milk and coconut milk. In *IOP Conference Series: Earth and Environmental Science*, 1219 (1), 012020. doi.10.1088/1755-1315/1219/1/012020
- Qin, P., Wang, T., & Luo, Y. (2022). A review on plant-based proteins from soybean:

- Health benefits and soy product development. *Journal of Agriculture and Food Research*, 7, 100265. doi.org/10.1016/j.jafr.2021.100265
- Rahul, J., Jain, M. K., Singh, S. P., Kamal, R. K., Naz, A., Gupta, A. K., & Mrityunjay, S. K. (2015). *Adansonia digitata* L.(baobab): A review of traditional information and taxonomic description. *Asian Pacific Journal of Tropical Biomedicine*, 5(1), 79-84. doi: 10.1016/S2221-1691(15)30174-X
- Samatha, T., Shama, N., Chandrakala, G., Thirupathi, K., & Rama Swamy, N. (2018). Antibacterial activity of *Adansonia digitata* L.: A globally endangered tree. *International Journal of Pharmacognosy and Phytochemical Research*, 9(11), 9-12. doi:10.25258/phyto.v9i11.11183
- Sengupta, S., Koley, H., Dutta, S., & Bhowal, J. (2019). Hepatoprotective effects of synbiotic soy yoghurt on mice fed a high-cholesterol diet. *Nutrition*, 63, 36-44. /doi.org/10.1016/j.nut.2019.01.009
- Shihata, A., & Shah, N. P. (2002). Influence of addition of proteolytic strains of *Lactobacillus delbrueckii subsp. bulgaricus* to commercial ABT starter cultures on texture of yoghurt, exopolysaccharide production and survival of bacteria. *International Dairy Journal*, 12(9), 765-772. doi.org/10.1016/S0958-6946(02)00071-7
- Sulaiman, L. K., Oladele, O. A., Shittu, I. A., Emikpe, B. O., Oladokun, A. T., & Meseko, C. A. (2011). In-ovo evaluation of the antiviral activity of methanolic root-bark extract of the African Baobab (*Adansonia digitata* Lin). *African Journal of Biotechnology*, 10(20), 4256-4258. doi :10.5897/AJB10.2225
- Sun, W., Shahrajabian, M. H., & Cheng, Q. (2022). Bioactive ingredients of legumes. In *Functional Foods and Nutraceuticals in Metabolic and Non-Communicable Diseases* (pp. 371-382). Academic Press.
- Tanwar, B., & Goyal, A. (Eds.). (2021). *Oilseeds: health attributes and food applications* (p. 20220004233). Singapore: Springer.
- Udeozor, L. O. (2012). Tigernut-soy milk drink: preparation, proximate composition and sensory qualities. *International Journal of Food and Nutrition Science*, 1(4), 18-26.
- Wairimu, N., Owaga, E. E., & Koskei, K. (2022). Development and evaluation of goat milk yoghurt enriched with baobab fruit pulp. *European Journal of Agriculture and Food Sciences*, 4(2), 100-105. https://doi.org/10.24018/ejfood.2022.4.2.485
- Zumbes, J. H., Dabo, A. D., Dakul, D. A., Afolabi, S. A., & Apiya, H. S. (2014). Enteropathogenic bacterial contamination of some ready-to-eat foods sold in Jos Metropolis, Nigeria. *Indian Journal of Applied Research*, 4(7), 456-458