CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

FERMENTATION POTENTIALS OF BAOBAB (*Adansonia digitata*) PULP POWDER IN THE PRODUCTION OF YOGHURT FROM COW MILK

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https://doi.org/10.34302/crpjfst/2023.15.3.8

Article history:
Received: 26 March 2023
Accepted: 1 August 2023

Keywords:
Yoghurt;
Inoculum;
Baobab tree;
Baobab pulp powder;
Fermentation.

ABSTRACT

Yoghurt was produced from fresh cow milk inoculated with baobab pulp powder. Baobab pulp powder was added at 0.34%, 0.52%, 0.69%, and 0.85% respectively, while the control sample (A) was yoghurt produced from fresh cow milk inoculated with regular commercial starter culture. The physical, chemical, microbiological, anti-nutritional and sensory properties of the samples were analysed using standard procedures. The moisture content, crude protein and fat content decreased with the added baobab pulp powder, while the fibre, ash and carbohydrate contents increased. The pH ranged from 4.34 to 4.74, coupled with negligible anti-nutritional composition. The titratable acidity increased with added baobab pulp powder from 0.52-0.69%. Brix and viscosity of treated samples increased respectively from 30.85-40.02 and 200.05-200.14. Total bacterial and fungi counts ranged from 8.65×10^4 to 15.51×10^4 Cfu/mL and 1.12×10^4 to 4.54×10^4 Cfu/mL respectively, with the control sample having the higher loads. The over-all acceptability of the samples were significant ($p>0.05$); sample E (0.85% inoculation) was the most preferred, followed by sample B (0.34% inoculation), while the least accepted sample was the control. Inoculating milk with baobab pulp powder produced yoghurt with improved and acceptable qualities.

1. Introduction

Worldwide, fruit trees are important biological resources in many agro-ecological and forest ecosystems, with economic impact (Rasheed *et al*., 2015). Fruits usually have essential nutrients, antioxidants and health benefits important to humans and animals in all respect. Sometimes, fruits differ from vegetables and other edible agricultural/horticultural requiring pre-treatments, like heating, before being consumed (Rasheed *et al*., 2015; Cernansky, 2015), with the tropics blessed with many nutritious edible varieties (Paull & Duarte, 2011; Sthapit *et al.*, 2012).

Adansonia digitata from the genus *Adansonia* family, *Malvaceae,* is a deciduous tree, with the genus *Adansonia,* being the most common specie, and majorly found in the hot savannahs or sub Saharan Africa. The tree is locally called "ose" in "Yoruba" speaking areas of Nigeria or "kuka" in Hausa language (Stapleton, 2015). Baobab (*Adansonia digitata*) is a typical tropical fruit tree with nutritional and medicinal benefits (Donatien *et al*., 2011); the leaves are used for preparing soup, seeds as thickening agent or fermented and used as flavouring agent, or could be roasted and eaten as snacks (Bvenura & Sirakumar, 2017; Kamatou *et al*., 2011). The fruit pulp is licked or processed into drinks, while the tree bark is used to make rope (Donatien *et al*., 2011). As such, all baobab tree parts are useful; it included food provision, shelter, clothing, and for medicinal purposes.

Bilcke *et al*., 2013 and Afolabi & Popoola, 2005 reported lactic acid fermenting bacteria in baobab fruit pulp. The fruit is an indehiscent large egg-shaped capsule, while the pulp, when dried, hardens, and falls to pieces to look like chunks of powdery dry bread (Kamatou *et al*., 2011; Bvenura & Sirakumar, 2017; Namratha & Sahithi, 2015). The seeds are kidney shaped, hard and black in appearance (Donatien *et al*., 2011), with the pulps high in phytochemicals, like antioxidant, anti-inflammatory, anti-microbial etc. According to Bvenura & Sirakumar, 2017, baobab has about ten times Vit. C contents of orange, and as such, could increase products shelf-life (Donatien *et al*., 2011). Over the years, fermentation process has been improved upon to give varieties of digestible and edible foods that have improved sensory qualities, increased shelf-life, improved nutrition and preservation (Yasmine, 2002).

Yoghurt from Turkish verb, "jugurt", means "curdled or coagulated" (Weerathilake *et al*., 2014; Obi *et* al., 2016). It is a fermented product with many nutritional and health benefits (Fisberg & Rachel, 2015). Its production involved the use of thermophilic organisms, lactobacillus and streptococcal species in the milk fermentation (Marshall, 1993). It was reported that fermenting organisms have symbiotic relationship to produce yoghurt from milk coagulation, with sufficient quantity of lactic acid (Obi *et al.*, 2016; Amanze, 2015). The consumption of dairy products with probiotic bacteria is highly beneficial, all because the high quantities of the organisms in the colon improve intestinal health. Michelle, 2005 as well as Fisberg & Rachel, 2015 were of the opinion that yoghurt supplies high quality proteins, minerals and sufficient quantities of vitamins. The use of starter cultures for yoghurt production helps to give the desired characteristics, and therapeutic benefits. As such, producers do add 2-4 % starter culture for production, but of recent, addition of fruit flavour is trending (Namratha & Sahithi, 2015; Ghadge *et al.*, 2008).

Yoghurts vary in appearance, flavour and ingredients, with its quality and composition influenced by bacterial cultures used (Kim & Ham, 2019). According to Weerathilake *et al.*, 2014, standardized milk sourced is homogenized at about 55-65°C and 15-20 MPa, and pasteurized for 30mins at 80-85°C. It was then cooled to between 40-45°C, incubation temperature for starter culture addition. The fermented milk could be transformed into either set or stirred yoghurt. For set yoghurt, the fermented milk is packed and incubated before chilling and cooling, while for stirred one, the fermented milk is incubated and cooled to 20-25°C before stirring, cooled again and pumped. Both set and stirred yoghurt are normally cold and stored before dispatch. Fisberg & Rachel, 2015, and Weerathilake *et al*., 2014, classified yoghurt on the following bases: Chemical composition based on fat content; physical nature, either solid, semi-solid or fluid; flavour component i.e. on flavour; and post fermentation process, where it was re-classified based on processes after fermentation e.g. enzyme hydrolysis, vitamin fortification, heat treatment etc.

Industrially, yoghurt production is in three stages of mix preparation of physical treatments (homogenization, heat treatment, cooling, de-aeration); fermentation process of inoculating the mix; and harvesting, post-treatment, and packaging etc., with the final product quality being a function of adopted production steps, except for the set-type yoghurt, product flavouring and cup filling after fermentation (Corrieu & Beal, 2016; Weerathilake *et al*., 2014).

Yoghurt nutrient depends on raw milk quality, animal feed, lactation stage, age, and environmental factors such as season or temperature, heat exposure period, exposure to light, and storage conditions etc. (Fisberg & Rachel, 2015; Michelle, 2005). The milk constituents variation during fermentation, strain of bacteria used, milk solids and source, fermentation duration etc. could also determine the final product (Rekha *et al*., 2012; Fisberg & Rachel, 2015).

Baobab fruit pulp is nutrient-dense, but the tree is practically going into extinction in this part of the world. This position informed the

design of this research work, which was aimed at increasing yoghurt consumption, enjoying the high medicinal, nutritional qualities, and particularly, exploiting the potentials of the pulp's fermenting organism. Utilizing the pulp will reduce the dependence on imported fermenting culture; increase the nation's external reserves, creates jobs through baobab planting to ease accessibility, and ultimately reduced yoghurt unit cost. The research aimed at studying the fermentation potentials of baobab (*Adansonia digitata)* pulp powder in yoghurt production.

2. Materials and methods

2.1. Sample Collection

Fresh baobab fruit was sourced from a village at Egbejila, Asa-dam area of Ilorin, Kwara State, while fresh cow milk was sourced from the University of Ilorin dairy farm.

2.2. Extraction of the fruit pulp

The pulp, which was reported to be high in lactic acid fermenting bacterial, according to Afolabi & Popoola, 2005 and Donatien *et al*. (2011), was extraction from the fruit. Fruit was washed, dirt removed, and broken up to remove pulp encrusted seeds, and dried for easy removal during pounding. The pulp was winnowed, properly pounded for smooth textured powder and sieved to remove dirt (Fig. 1).

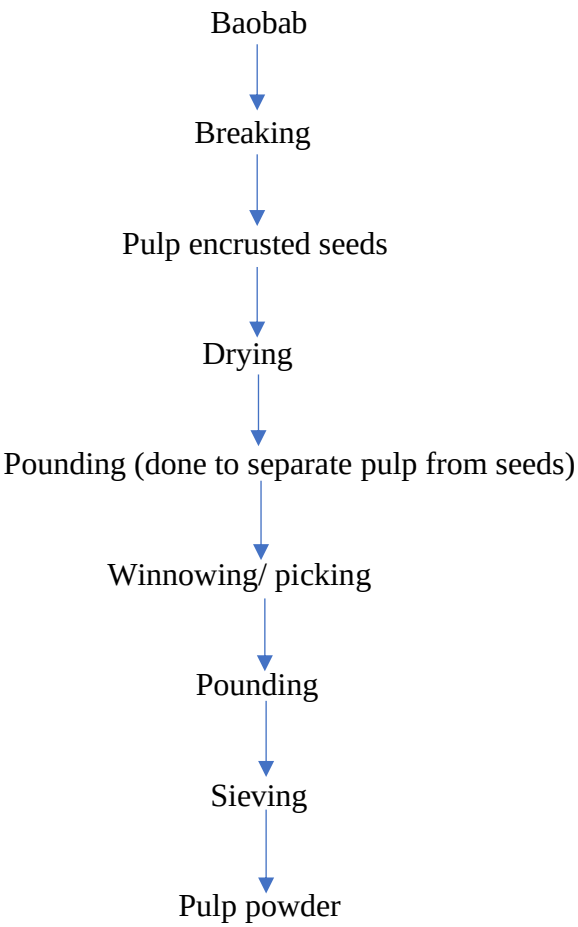

Figure 1. Production of Baobab pulp **(**Afolabi and Popoola, 2005)

2.3. Preparation of the Baobab Fermented Yoghurt

Milk was pasteurized (90ºC) for 3mins, homogenized, cool to 45-46ºC, inoculated with baobab pulp powder (Table 1), fermented for 20-22hrs, and cooled to 7ºC to deactivate fermenting organisms (Fig. 2) (Corrieu and Beal, 2016; Han *et al*., 2012; Abioye *et al*., 2012).

Table 1. Formulation table for the baobab fermented yoghurt

Sample	Fresh Milk (%)	Baobab pulp powder (%)
A	100	0
B	99.66	0.34
C	99.48	0.52
D	99.31	0.69
E	99.15	0.85

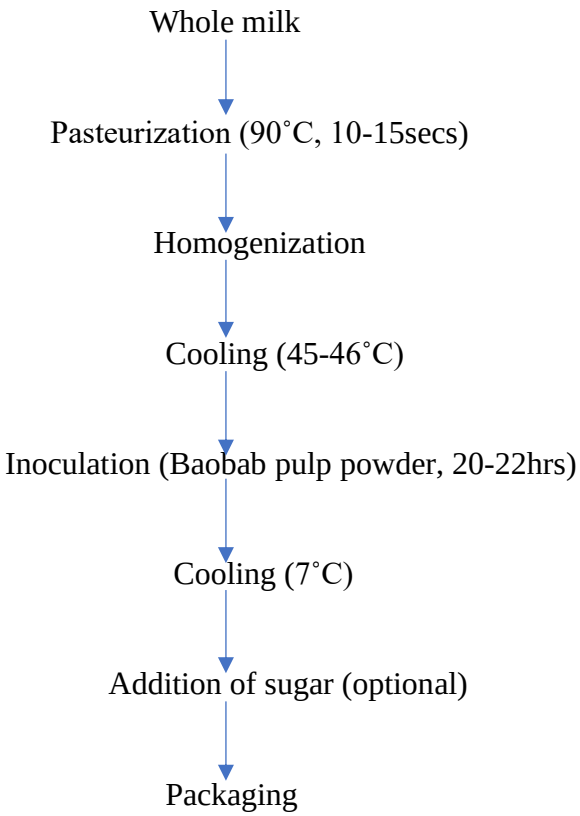

Figure 2. Production of baobab fermented yoghurt **(**Corrieu and Beal, 2016; Han *et al*., 2012)

2.4. Physicochemical Screening of Baobab Fermented yoghurt

Physicochemical properties of samples were analyzed with AOAC (2005) standard methods.

2.4.1. pH measurement

The pH was measured at room temperature (26±2˚C) with a digital pH meter previously calibrated with buffer standards of pH 4 and pH 10.

2.4.2. Total Titratable Acid (TTA)

Titratable acidity was determined by the method of Joseph & Joy, 2011, using phenolphthalein indicator, and end point volume of NaOH used was used to calculate acid percentage.

Titratable acidity: $\frac{Titre\ value \times M \times 90 \times 100}{volume\ of\ sample \times 1000}$

Where M= molar concentration of NaOH

(1)

2.4.3. Measurement of Viscosity

Viscosity was measured with a viscometer model HAAKE Viscosimeter (Mess Technik GmbH) (Brookfield Engineering Laboratories Inc., Stoughton, MA) in mPas (AOAC, 2005).

2.4.4. Measurement of Colour Attributes

The colour attributes (Hunter L*, a* and b* values) of the yoghurt samples was obtained with a colorimeter (Minolta CR 300 Series, Minolta Camera Co., Ltd., Osaka, Japan). The samples were placed on white standard plate, values were taken, and the parameters determined appropriately (Asal *et al*., 2015).

2.4.5. Brix Measurement

Brix value was measured with a refractometer using the method of Amanze, 2015.

2.4.6. Proximate Composition of the Yoghurt Samples

2.4.6.1. Determination of Protein Content

Protein was determined by macro Kjeldahl method. 2 g sample was measured into Kjeldahl digestion flask; 10 g copper sulphate and sodium sulphate added in ratio 5:1, and 25 mL conc. sulphuric acid added to digest at high temperature in a fume cupboard until frothing ceased, with clear light blue. Digest was cooled and diluted with distilled water to 100 mL mark; 10 mL of dilute and 18 mL 40% NaOH were poured into the distillation apparatus. 25 mL of 2% boric acid was added to the receiving flask, with 2 drops of bromocresol green and methyl red mixed indicator. Distillation continued until boric acid turned yellowish green from pink, and then titrated with 0.1N HCl to end point, but the blank with distilled water (AOAC, 2005).

% crude protein=% nitrogen × 6.25

% nitrogen=

$$\frac{(\text{ml standard acid} - \text{ml blank}) \times \text{N of acid} \times 1.4007 \text{sample in gram}}{sample\ in\ grams} \quad (2)$$

2.4.6.2. Determination of Moisture Content

2 g sample was weighed into a dried crucible with known weight, and dried in a controlled oven (105˚C) for 5hrs, cooled in a desiccator and re-weighed (AOAC, 2005).

$$\%moisture\ content\ \frac{W1 - W_{\circ}}{W2} \times 100 \quad (3)$$

Where, W1=initial weight of crucible and dried sample; W2=weight of the sample; $W_{\circ}$= weight of the empty crucible

2.4.6.3. Determination of Ash Content

2 g sample was weighed into a dried crucible, and incinerated to ash in a muffle furnace at 550℃. It was removed, cooled in desiccator, and ash weight determined (kemelo *et al*., 2019).

% ash=

$$\frac{weight\ after\ ashing - weight\ of\ crucible}{weight\ of\ samples} \times 100 \quad (4)$$

2.4.6.4. Determination of Crude fat

5 g sample was properly mixed with 0.88 mL ammonia solution and 10 mL of 95% ethanol. 25 mL diethyl ether was added and vigorously shaken for 1 min. About 25 mL petroleum ether was added, shaken vigorously, and left to stand for 1hr to separate aqueous and organic phases. Fat extract (organic phase) was collected and aqueous phase removed by distillation. Fat extract dried at 100℃ for 30mins, cooled in a desiccator, and fat mass determined (Kemelo *et al*., 2019).

$$\%\ \text{fat} = \frac{\text{weight of extracted fat (g)}}{\text{weight of sample used (g)}} \times 100 \quad (5)$$

2.4.6.5. Determination of Crude Fibre

2 g sample was hydrolysed in a beaker containing 299 mL of 1.25% sulphuric acid and boiled for 30mins; mixture was filtered under vacuum, residue washed with hot distilled water thrice, re-boiled for 30mins with 200 mL of 1.25% of NaOH and filtered. Digested was washed with HCl to neutralize NaOH and distilled thrice with hot distilled water. Residue was poured into a crucible, oven dried (100℃;

2hrs), cooled in a desiccator and re-weighed. Dried residue was incinerated (500℃; 5hrs) to totally burn off carbonaceous matters, cooled and weighed (AOAC, 2005; Friedman & Brandon, 2013).

$$\% \text{ crude fibre} = \frac{\text{loss in weighed (g) after ignition}}{\text{weight of the original sample } (g)} \times 100 \quad (vi)$$

$$= \frac{W1-W2}{W} \times 100 \quad (6)$$

Where: W1= weight of digested sample and crucible before ash; W2=weight of crucible and ash; W=weight of sample used.

2.4.7. Determination of Ascorbic Acid (Vitamin C)

The official method of AOAC, 2005 was combined with that of Kim & Ham, 2019 was adopted, with results reported as mg ascorbic acid/100g. 20 mL sample solution was measured into 250 mL conical flask, with 2 mL oxalic acid, 150 mL distilled water and 1 mL starch indicator, and titrated with 0.005molL^{-1} iodine solution.

2.4.8. Anti-nutrients in the yoghurt sample

2.4.8.1. Determination of Phytate Content

4 g sample was diluted with 100 mL 2% HCl and filtered. Within a conical flask was 25 mL filtrate and 5 mL 0.3% ammonium thiocyanate as indicator; 53.5 mL distilled water added to adjust pH to 3.5, and titrated with ferric chloride solution having 0.00195g iron/mL for brownish yellow colour persisting for 5mins, and phytate (mg/100g) calculated (Kayode *et al*, 2013):

$$\text{Phytate content (mol/Kg)} = \frac{T \times 564.11}{M} \quad (7)$$

Where: T = titre value; M= molar mass of phytate

2.4.8.2. Determination of Cyanide Content

4 g sample was added to mixture of 40 mL distilled water and 2 mL orthophosphoric acid, and left overnight (22-26˚C) to release bound hydrocyanic acid, with extract distilled with a drop of paraffin as antifoaming agent and broken chips as anti-bump. 5 mL distillate, 40 mL distilled water and 0.1g NaOH pellets were transferred into 50 mL volumetric flask and made up to mark with distilled water. 20 mL of solution and 1 mL of 5% KI solution were titrated with 0.01M silver nitrate solution, with distilled water used as blank (Oluwaniyi & Oladipo, 2017).

2.4.8.3. Determination of Oxalate Content

75 mL of 3.0M H_2SO_4 was added to 1 g sample and stirred intermittently with a magnetic stirrer for 1hr and filtered. 25 mL of filtrate was titrated while hot (80^{0}C) with 0.05M $KMnO_4$ solution until a faint pink colour appeared, and persisted for at least 30secs.

$$\text{Oxalates content (mg/100 g)} = \frac{T \times [Vme] \times [DF] \times 2.4 \times 10^2}{ME \times Mf} \quad (8)$$

Where: T = titer of $KMnO_4$,; Vme = Volume-mass equivalent (*i.e* 1 mL of 0.05 M $KMnO_4$ solution is equivalent to 0.00225 g anhydrous oxalic acid); DF = Dilution factor, VT/A; VT = Total volume of filtrate (75 mL),

A = Aliquot used (25 mL); ME = molar equivalent of $KMnO_4$, Mf = Weight of sample used (Kayode *et al*., 2013).

2.4.9. Microbial Analysis of the yoghurt

2.4.9.1. Sterilization of Materials

Wares, inoculating loop, needles, and other required materials were properly sterilized (160˚C) and sanitized to destroy possible contaminants. The environment was sanitized, and work benches wiped with 70% alcohol (Fawole & Oso, 2007).

2.4.9.2. Preparation of Culture Media

Bacterial nutrient agar used has 28 g powder dissolved in 1L distilled water, mixed and heated to dissolve complete. Flask mouth was plugged with cotton wool, wrapped in aluminum foil, sterilized at 121˚C for 15mins, cooled to 45˚C, and poured aseptically into petri-dishes.

2.4.9.3. Total Bacteria Count

1 mL sample was pipetted aseptically into 9 mL sterile distilled water in test tube, using serial dilution of 1mL into 9 mL sterile distilled water, prepared up to $10^{-4.}$. This was plated in duplicate by pouring 1 mL into separate petri-dishes, sterile molten agar added, plate mixed by swirling before solidifying, incubated at 37˚C for 24hrs and colonies counted in cfu g^{-1}.

2.4.9.4. Total Fungi Count

1 mL of sample was pipetted aseptically into 9 mL sterile distilled water in a test tube, using serial dilution of 1 mL into 9 mL sterile distilled

water up to $10^{-4.}$ It was plated in duplicate with sterile molten agar added, and mixed by swirling plate before solidifying. They were incubated (37˚C for 48hrs) and examined for growth, and colonies were counted in cfu g^{-1}.

2.4.10. Sensory Evaluation & Statistical analysis

50 untrained panellists, but regular yoghurt consumers, evaluated samples for taste, appearance, flavour, consistency and overall acceptability with 9-point hedonic scale of excellent (score = 9) to poor (score = 0) (Obi *et al*., 2010), and data computed and analyzed.

3. Results and discussions

3.1. Proximate Composition of the Yoghurt Samples

Table 2 showed the proximate composition of the yoghurt samples. The moisture content, crude fat, crude protein, ash and carbohydrate were significant ($p \geq 0.05$), but not in the crude fibre. Reduced moisture in the treated samples may be due to added baobab pulp powder. Sample E had the highest moisture among the treated samples, but the control sample was the least viscous, though with higher moisture content. The values obtained were similar to that of Obi *et al*., 2016. Crude protein values ranged from 5.87% to 6.26%, with the control having the highest value. The values reduced with increasing quantities of baobab pulp inoculum, perhaps due to its lower protein content when compared to that in animals. Protein value of 2.3% was reported for baobab pulp by Bvenura & Sirakumar, 2017, and Sadiq *et al*., 2009, reported 1.53%. Michelle, 2005, however, reported 6 to 8.6% protein in plain yoghurt, which was similar to our recorded values.

Fat content varies based on yoghurt type, with values of 0.5% in nonfat to about 2% in low-fat sample, and about 3.25% in full fat yoghurt (Mbaeyi-Nwaoha & Ekere, 2014). The fat content was 3.66-4.02%, portraying the samples to be full fat yoghurts, and similar to 3.17% to 3.95% reported by Obi e*t al*., 2016 and Fisberg & Rachel, 2015 for full fat yoghurt. Treated samples fibre content was not significant ($p<0.05$) from one another, but significant to the control, with values similar to that of Amanze & Amanze, 2011 and Michelle, 2005.

Carbohydrate values were between 10.03 and19.21%. Sample D had the highest value, while the control, had the least. The values were similar to 9.41-19.33% reported by Mbaeyi-Nwaoha & Ekere, 2014 for yoghurt from skimmed milk. Ash content usually measures mineral content of samples. The control sample was significantly different from the treated samples, with values (0.87-1.31%) increasing with increased addition of baobab pulp.

Table 2. Proximate Composition of the Yoghurt samples

Sample	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Carb. (%)	Ash (%)
A	78.23±0.013^{a}	6.26±0.023^{a}	4.21±0.005^{a}	0.00±0.008^{b}	10.03±0.025^{e}	0.87±0.001^{c}
B	73.44±0.022^{b}	6.12±0.018^{a}	4.02±0.024^{a}	0.07±0.014^{a}	15.44±0.076^{c}	1.10±0.013^{b}
C	72.12±0.021^{c}	6.04±0.036^{a}	3.86±0.036^{b}	0.07±0.000^{a}	17.35±0.065^{b}	1.23±0.054^{a}
D	73.34±0.031^{b}	5.94±0.002^{b}	3.71±0.001^{b}	0.08±0.001^{a}	19.21±0.027^{a}	1.23±0.056^{a}
E	75.03±0.011^{b}	5.87±0.017^{b}	3.66±0.012^{b}	0.09±0.000^{a}	13.84±0.010^{d}	1.31±0.047^{a}

Values are means ± SD. Mean sharing a common superscript letter in a column are not significantly different ($p \geq 0.05$).

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

3.2. Physicochemical Properties of the Yoghurt Samples

Table 3 showed the results of the physicochemical properties of the samples. The samples had lower pH (4.38-4.54), which were not different from 4.5-5.0 reported by Fisberg & Rachel, 2015, but close to 4.34-6.70 reported by Fatiha *et al*., 2016. The low pH values, according to Afolabi & Popoola, 2005, are attributable to the presence of *Lactobacillus acidophilus* and *Streptococcus lactis* in the pulp. Fermented milk lactose gives lactic acid that confirms presence of lactic acid fermenters in baobab pulp (Mataragas *et al*., 2011). Brix values increased with increased sugar content. Brix of baobab inoculated samples was between 40 and 40.02˚Brix, similar to that reported by Afolabi & Popoola, 2005 and Obi *et al*., 2010. Viscosity influence final product quality (Guzel-seydim *et al*., 2005), and is usually affected by the milk composition, heat, starter culture used, and processing method etc. (Dantas, 2016). The treated samples were slightly more viscous, and significant ($p \geq 0.05$) to the control.

Table 3. Physicochemical Properties of the Yoghurt Samples.

Sample	Viscosity (m.p.s)	Titratable Acidity (g/100ml)	pH	Brix (˚)
A	200.05±0.57^{b}	0.43±0.01^{b}	4.74±0.00^{a}	30.85±0.00^{b}
B	200.19±1.29^{a}	0.69±0.00^{a}	4.38±0.00^{a}	40.00±0.00^{a}
C	200.17±0.34^{a}	0.65±0.00^{a}	4.45±0.01^{a}	40.01±0.00^{a}
D	200.17±1.43^{a}	0.66±0.01^{a}	4.51±0.02^{a}	40.01±0.00^{a}
E	200.14±0.00^{a}	0.62±0.00^{a}	4.54±0.01^{a}	40.02±0.00^{a}

Values are means ± SD. Mean sharing a common superscript letter in a column are not significantly different ($p \geq 0.05$).

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

3.3. Ascorbic acid and Colour Parameters of Yoghurt Samples

Table 4 showed the result of ascorbic acid and colour parameters measured. Ascorbic acid content of treated samples was significant ($p > 0.05$) to the control, with the control sample having the least value. High Vit. C content in the treated samples was due to the high Vit. C reported in baobab pulp, and similar to that reported by Taneva & Panayotov, 2019. The high value will improve shelf life and medicinal derivatives because ascorbic acid is an antioxidant, and in foods, could prevent oxidation of free radicals and enhances proper functioning of the immune system.

Table 4. Ascorbic acid content and Colour Parameters of Yoghurt Samples

Sample	Vit. C (mg/100g)	L*	a*	b*
A	8.02±0.01^{b}	48.73±0.12^{b}	1.14±0.14^{a}	7.17±0.10^{d}
B	10.04±0.02^{a}	49.53±0.46^{a}	1.08±0.02^{a}	10.73±0.07^{c}
C	10.02±0.02^{a}	49.94±0.42^{a}	0.27±0.04^{b}	11.43±0.15^{b}
D	10.03±0.01^{a}	49.74±0.34^{a}	0.15±0.03^{c}	12.32±0.02^{a}
E	8.02±0.01^{a}	49.87±0.13^{a}	0.06±0.07^{d}	11.57±0.50^{b}

Values are means ± SD. Mean sharing a common superscript letter in a column are not significantly different ($p \geq 0.05$).

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

The addition of baobab significantly affected colour. Lightness (L*) increased from 48.73 in the control to 49.94 in sample C. High L* value was associated with whiteness (Emmanuel *et al*.,

2019), and this increase, perhaps, may be due to presence of bioactive component in baobab pulp, which aided the breakdown of some milk compounds (Bojana *et al*., 2020). Redness a* was significant (1.14 to 0.06), probably because of carotene presence, while b* values of treated samples were higher than the control, likely due to pulp colour and thickness (Hasim *et al*., 2009).

3.4. Anti-Nutritional Composition of Yoghurt Samples

Cyanide values were not significant ($p>0.05$), but the oxalate and phytate were significant. Analog milk usually has anti-nutrient compounds absent in dairy. Baobab with 2% phytic acid, 10% oxalate according to Bvenura & Sirakumar (2017), could have reduced during the processing regimes.

Table 5. Anti-nutritional Composition of the Yoghurt Samples

Samples	Phytate (mg/100g)	HCN (mg/100g)	Oxalate (mg/100g)
A	0.01^{b}±0.01	0.02^{a}±0.00	0.05^{b}±0.01
B	0.33^{a}±0.32	0.04^{a}±0.23	0.05^{b}±0.02
C	0.43^{a}±0.30	0.02^{a}±0.21	0.06^{b}±0.34
D	0.57^{a}±0.01	0.04^{a}±0.02	0.07^{b}±0.05
E	0.73^{a}±0.32	0.06^{a}±0.12	0.10^{a}±0.01

Values are means ± SD. Mean sharing a common superscript letter in a column are not significantly different ($p\geq0.05$).

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

3.5. Total Bacterial and Fungi Count of the Yoghurt Samples

Table 6 showed the total bacterial and fungal counts of the samples (in Cfu/mL), with significant differences ($p>0.05$) noticed. The control sample had the highest bacterial and fungal loads. Lesser loads noticed in the treated samples may be due to lower pH value and high ascorbic acid contents (an antioxidant) in baobab pulp. Sample D had least bacteria load, and better preserved, which corroborated the report of Afolabi & Popoola, 2005 that the presence of baobab pulp in fermented tempe reduced the growth of spoilage bacteria. Aside sample E, fungi count of treated samples decreased with baobab pulp, likely due to the bioactive components of baobab pulp. Chadare *et al.,* 2009 and Ramadan *et al.,* 1993 had reported the bioactive components to include triterpenoids, flavonoids, phenolic compounds, saponins, β-sitosterol, phytates etc.

Table 6. Total Bacterial and Fungi Count of the Yoghurt Samples

Samples	Total bacterial count (Cfu/ml) (10^4)	Total Fungi count (Cfu/ml) (10^4)
A	15.51 ± 0.16^{a}	4.54 ± 022^{a}
B	11.32 ± 0.12^{b}	1.12 ± 1.11^{c}
C	9.15 ± 0.42^{d}	1.14 ± 1.32^{c}
D	8.65 ± 0.62^{d}	2.47 ± 1.58^{b}
E	10.76 ± 0.57^{c}	2.76 ± 0.06^{b}

Values are means ± SD. Mean sharing a common superscript letter in a column are not significantly different ($p\geq0.05$).

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

3.6. Sensory Evaluation of the Yoghurt Samples

Table 7 showed the sensory scores of the samples, as well as the radar graph of the sensory evaluation. The mouth feel was not significant, but the flavour, appearance, taste, consistency and overall acceptability were significant ($p \geq 0.05$). Baobab pulp had effect on the samples judging by the recorded scores. Control had the best rating for appearance (7.51), while sample E was rated least (6.13). The control was equally rated highest for flavour, but treated samples had less pronounced yoghurt flavour, and as longer as fermentation progressed, baobab pulp masked its effect. Sample E had the lowest flavour (6.00).

Taste of treated samples was not significant ($p > 0.05$), though sample E had highest rating (7.22), and the control, the lowest (6.43); probably due to its lesser ascorbic acid content. For consistency, the rating ranged from 6.48 (control) to 7.57 (sample E). Consistency increased with added baobab pulp, except for sample C, which was comparable to that of Afolabi & Popoola, 2005, as well as Fisberg and Rachel, 2015, who stated that decreased pH of milk medium to about 4.6 could lead to casein coagulation (< 4.6 here). Mouth feel was not significant ($p > 0.05$), but was similar to 5.05-7.80 reported for beetroot flavoured yoghurt by Mbaeyi-Nwaoha & Nwachukwu, 2012. Overall acceptability of the samples was significant ($p > 0.05$). The control was rated least (6.65), and different from some of the treated samples, while samples B and E were rated the best.

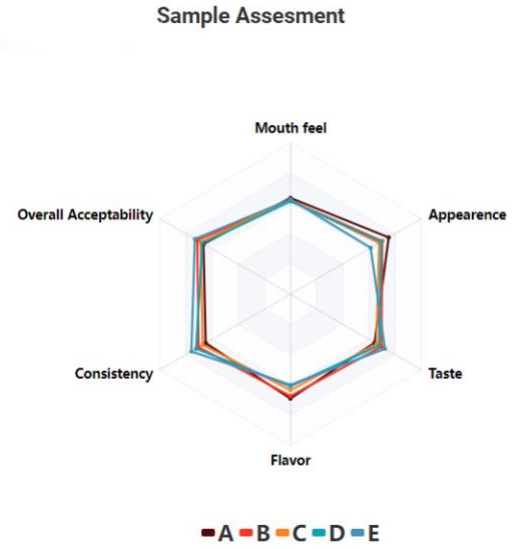

Figure 3: Radar Graph of the Samples Sensory Evaluation

Table 7. Sensory Evaluation of Yoghurt Samples

Sample	Mouth feel	Appearance	Taste	Flavour	Consistency	Overall acceptability
A	$6.36^{a}\pm1.83$	$7.51^{a}\pm1.65$	$6.43^{b}\pm2.04$	$6.91^{a}\pm1.51$	$6.48^{b}\pm1.31$	$6.65^{b}\pm1.56$
B	$6.18^{a}\pm1.25$	$7.01^{a}\pm1.50$	$6.96^{a}\pm1.61$	$6.74^{a}\pm1.74$	$7.02^{a}\pm1.20$	$7.12^{a}\pm1.26$
C	$6.23^{a}\pm0.93$	$6.78^{b}\pm1.45$	$6.57^{b}\pm1.20$	$6.35^{b}\pm1.19$	$6.70^{b}\pm1.10$	$6.87^{b}\pm0.90$
D	$6.14^{a}\pm2.14$	$6.93^{b}\pm1.59$	$6.78^{a}\pm1.78$	$6.08^{c}\pm1.35$	$7.21^{a}\pm1.18$	$6.73^{b}\pm1.13$
E	$6.27^{a}\pm1.33$	$6.13^{c}\pm1.83$	$7.22^{a}\pm1.83$	$6.00^{c}\pm1.75$	$7.57^{a}\pm1.23$	$7.30^{a}\pm1.29$

Mean ± Standard deviation. Mean with different superscripts along the column are significantly different ($p < 0.05$)

Sample key:

A- 100% Cow Milk (Control); **B**- 99.66% Cow Milk; 0.34% (2g) Baobab Pulp Powder; **C**- 99.48% Cow Milk; 0.52% (3g) Baobab Pulp Powder; **D**- 99.31% Cow Milk; 0.69% (4g) Baobab Pulp Powder; **E**- 99.15% Cow Milk; 0.85% (5g) Baobab Pulp Powder

4. Conclusions

From the research results, it could be concluded that the use of baobab pulp powder as inoculum in yoghurt production at 2g and 5g was effective, could be recommended for commercial use. The range of this baobab powder did not affect the overall acceptability of the yoghurt. It however improves taste, consistency and shelf-life due to its acidic nature. It equally reduced production cost, as expensive streptococcus and lactobacillus species for inoculation need not be purchased and stored at extra cost. The use could also increase sales, as consumers in this part of the world are familiar with the plant, but the availability and accessibility of baobab fruit should be seriously looked into.

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