

Development and Evaluation of Goat Milk Yoghurt Enriched with Baobab Fruit Pulp

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ABSTRACT

Baobab is a dry land product rich in vitamins and minerals but has remained underutilized. Therefore, value addition of the baobab pulp through incorporation of pulp to the probiotic yoghurt will promote dietary utilization. Different treatments were made by incorporating different amounts of ground baobab pulp. Treatments were analyzed for protein, fat, ash, and moisture content. Total solids, syneresis, titratable acidity, pH, butterfat and specific density, sensory evaluation and shelf life were analyzed. There were significant differences between the treatments in most of the parameters studied. The treatment with the highest amount of baobab pulp showed an increase in levels of total solids, titratable acidity and syneresis but decreased the viscosity of the yoghurt. There were significant variations in sensory attributes and samples with the highest baobab pulp scored the highest for taste, texture, aroma, color, and overall acceptability. Incorporating baobab pulp to yoghurt improved its nutritional and physicochemical properties.

Keywords: Baobab pulp, goat milk, yoghurt.

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I. INTRODUCTION

Africa has a lot of indigenous plant species that are highly rich in essential compounds that help boost human immunity. However, many of these species are undiscovered by the scientist. Baobab (*Adansonia digitata* L) is an essential tree helping in food security, nutrition, and income generation for the rural population in Africa [1]. Baobab tree grows mainly in dry lands of sub-Saharan Africa. The leaves, seeds and fruit pulp of the baobab are usually consumed and sold in the local markets. The fruits are usually big green or brownish in color and are naturally indehiscent [2]. The leaves are mainly consumed as staple food by much population in Africa. The leaves contain high amounts of proteins, carbohydrate, minerals which include calcium, iron, magnesium, potassium and zinc and fiber [3]. When in dry form, they exhibit highest level of pro vitamin A. The timber, fiber and fodder are the non-food parts of the baobab which are often used for income generation. The fruit pulp also is rich in vitamins, minerals, and also soluble and insoluble fiber. Despite its rich nutritional contribution of baobab pulp, the fruit has remained underutilized. There is need to increase the utilization of baobab fruit through incorporation in many products to improve the health of consumers. This project aims at incorporating baobab pulp into the goat milk to develop yoghurt. The yoghurt is a probiotic product. The starter cultures that are mostly used are bacterial cultures which include *Lactobacillus bulgaricus* and *Streptococcus*

thermophiles and also *Bifidobacterium bifidum* [4]. These cultures grow symbiotically as well as synergistically to achieve the desired characteristics of yoghurt. They help the milk to form a coagulum. Yoghurt helps to improve the health status due to its high calcium, potassium, vitamins and also the probiotics which help in enhancement of the gut micro flora. It helps to decrease gas, prevent diarrhea, constipation and also bloating of the customer. Making yoghurt from goat milk will help increase its nutritional content since goat milk has many beneficial nutrients. The development of goat milk yoghurt will minimize the bias of goat milk by the users [5]. Goat milk is associated with offensive flavor and disliked by many consumers. The best milk products should be of good quality and with absence of offensive essence with legal minimum limits of microorganisms and also nutrients. In recent years, improvement of the nutrition through use of probiotics products is a main encounter. Hence there is need to evaluate the influence of baobab pulp incorporation in goat milk yoghurt on nutritional and physicochemical properties.

II. MATERIALS AND METHODS

A. Sample Collection and Preparation

The baobab fruits were collected from Ikutha location in Kitui County. The baobab fruits were collected and sorted carefully to avoid any handling damage. The fruits were transported using cool boxes to the Institute of Food Bio

Resources Technology laboratory, at Dedan Kimathi University of Technology. The fruits were stored in polythene under room temperature while awaiting sample preparation. The hard woody shells were carefully crushed to expose the white flesh pulp which is surrounded by the seeds. Separation of the pulp from the seeds was done by grinding using a pestle and mortar. The resulting mixture was sieved using a 0.09-micron sieve to obtain a fine pulp. The pulp was then packed in a polythene bag and stored in a dark cool place.

B. Experimental Design

A laboratory-based experimental method was used for this study. A Completely Randomized Designed (CRD) was used in material collection and preparation of the treatments. The experiment was designed to have four treatments where varying quantities of baobab pulp were randomly assigned to the treatments. For this study, each treatment consisting of baobab pulp enriched yoghurt was made from whole goat milk with varied proportions of baobab pulp.

III. PRODUCTION OF BAOBAB PULP ENRICHED YOGHURT

The goat milk was collected from local farmers in Nyeri County. The raw milk was received and checked for suitability for processing by use of platform test. The milk was then sieved using a muslin cloth to remove the physical hazards present. The milk was then preheated to 55 °C whereby the starch, sugar and baobab pulp were mixed with some milk separately and then added to the preheated milk. The milk was then pasteurized to 85 °C to kill the pathogenic microorganism. The milk was held for 30 minutes and then rapidly cooled to 45 °C which was followed by inoculation by starter cultures. Then, incubation was done for 6 hours to allow for fermentation and lactic acid to be formed. The coagulum was broken, and the yoghurt was packed in sterile bottles and kept under refrigeration.

IV. PROXIMATE ANALYSIS

The samples (baobab pulp and probiotic yoghurt) were analyzed for moisture, protein, fat, and ash contents.

A. Determination of Moisture Content

Analysis of moisture content was done by the use of the dry air oven [6]. The crucible and the lid were first weighed and recorded. The crucibles were used to weigh two grams of each of the sample. An oven at 105 °C was used to heat the samples for 3 hours. These samples that were dried were cooled using the desiccators and then reweighed. The process was repeated until constant weight is obtained. The difference in weight was calculated as a percentage of the original sample [6].

$$W1 - W2 \text{ \% Moisture} = *100\%$$

where

W1 = Weight of the sample before drying;

W2 = Weight of sample after drying.

B. Determination of Crude Ash

The empty crucibles were cleaned and then put in a muffle furnace at 600 °C. After an hour, they were removed, cooled using the desiccators and weighed (W1). Each of the samples weighing 2 grams was put into crucibles (W2). The ignition was done to the samples by the use of the burner and blowpipe, until they charred. Afterwards, the crucibles were put into the muffle furnace at 550 °C and allowed to heat for 6 hours. The grey, white ash appearance indicated whole oxidation of the organic matter that was present in the sample. The crucibles were then cooled, and weight recorded as (W3). The percentage ash was calculated as follows:

$$\% \text{ Ash (dry basis)} = \frac{M_{ASH}}{M_{DRY}} \times 100$$

$$\% \text{ Ash (wet basis)} = \frac{M_{ASH}}{M_{WET}} \times 100$$

where M_{ASH} is the mass of the ashed sample, and M_{DRY} and M_{WET} is the mass of the dried and wet samples.

C. Determination of Protein

The Kjeldahl method [6] was used to determine the protein content present in the samples. Each sample weighing 1g was put into the digestion flask. This was followed by the addition of 20 ml of the concentrated H_2SO_4 and 5 g of digestion mixture of K_2SO_4 : $CuSO_4$. Suspension of the sample was done carefully by gently swirling the flask. The digestion unit was used in the digestion process. Digestion commenced until the mixture turned into a clear blue green in color. The whole process took a maximum of 2 hours to complete. Cooling was done to the digest and later transferred into a 100 ml volumetric flask. Topping of the volume was done up to the mark by use of distilled water. The digest (20 ml) was input in the distillation tube followed by gradual addition of 10 ml of 0.5 N NaOH. Distillation was done for 10 minutes. The produced NH_3 was collected as $NH_4 OH$ in the conical flask that contained 20 ml of 4% boric acid solution having a drop of modified methyl red indicator. Reaction of the NH_3 and boric acid occurred leading to the change of the color of the solution from red violet to green (pH 4.4-5.8). This was as a result of the color change of the indicator from acid to basic medium. The titration of the distillate was done using standard 0.1 N HCl solutions until a pink color appeared. A blank was run as previously done.

The percentage of protein was calculated using the following formula [6].

$$\text{Nitrogen} = (V1 - V2) \times N \times f \times 0.014 \times 100 / V \times 100 / S$$

where

V1 = Titer for the sample (ml);

V2 = Titer for blank (ml);

S = Weight of sample taken (g);

F = Factor of standard HCl solution;

N = Normality of HCl solution (0.002);

D = Dilution of sample after digestion;

V = Volume of diluted digest taken for distillation (10 ml);

0.014=Milli equivalent weight of Nitrogen.

$$\text{Protein \%} = \text{Nitrogen} \times \text{protein factor}$$

D. Crude Fat Analysis by Sox Let's Method (AOAC 2016)

The samples weighing 5grams each was extracted in the thimble using Petroleum ether (boiling point of 40-60 °C) for 6 hours. The vacuum rotary evaporator at 40 °C was used to remove the solvent. The fat was dried using the oven for 30 minutes at 70 °C. The final weight of the oil was obtained by subtracting the weight of the empty flask. This was expressed as a percentage of the weight of the sample.

Calculations were done using the formula below:

$$\text{Fat\%} = \left(W1 - \frac{W2}{W1} \right) \times 100$$

where:

W1= Weight of sample before extraction;

W2 = Weight of sample after extraction.

V. PHYSICOCHEMICAL PROPERTIES OF THE ENRICHED YOGHURT

A. Butter Fat Analysis of Raw Goat Milk Using Garber Method

Fat content was determined using Gerber method by weight as described in AOAC Official Method 2016, for fat content of raw whole milk. The samples of the milk were put in the water bath that was maintained at 39 °C. Mixing was done for 10 times through inversion. After mixing of the milk thoroughly, the test portions were weighed immediately. Sulphuric acid (10 ml) was added into a butyrometer carefully without wetting the neck of the tube. 10mls of milk sample was weighed into the butyrometer. The addition of the milk was done slowly to avoid charring and violent reaction with acid from occurring. 1ml isoamyl alcohol was added to the butyrometer. The stopper was inserted carefully. Shaking was to eliminate the curd. By holding the butyrometer carefully, inversion was for 4 times. This was done to mix acid that remained in the small bulb and graduated neck with the contents of larger bulb. Centrifuging was done for 5 min. The butyrometers were then put in the water bath that was maintained at 60–63 °C leaving only small bulb exposed. The fat column was left to equilibrate for 5 minutes. The scale was promptly read at bottom of upper meniscus. The analysis was repeated if fat column was found to be turbid or dark in color, or if there was a white or black material at the bottom of fat column. Acceptable fat columns were pale to strong yellow and uniform throughout with light or dark particles.

B. Determination of pH

Mixing of the yoghurt samples (10 g each) was done with distilled water. The digital pH meter (PL-600 pH/mV/Temp Meter) was calibrated using pH 4.0 and 7.0 standard buffers and the pH determined. The tip of probe put into the sample solution, while avoiding touching the base of the beaker, and allowed to stand for about five minutes before taking the reading.

C. The Determination of Titratable Acidity

Measurement of the titratable acidity was carried out following the method of [6]. Samples (10 g each) were placed in a beaker. Three drops of phenolphthalein indicator was added to the sample which was then titrated against NaOH (0.1N) until it reached the endpoint marked by pink color. Titratable acidity (%) was calculated as lactic acid percentage as shown in the equation.

$$\% \text{Titratable acidity} = \left(\frac{\text{Titre value} \times M \times 90}{\text{vol of sample} \times 1000} \right) \times 100$$

D. Determination of Total Solids in Yoghurt

The total solids of the yoghurt sample were carried out using [6]. Clean crucibles were dried alongside their lids in an open dry oven (105 °C) for 1 hour and 15 minutes. The lids were replaced on the crucibles and transferred into the desiccator where they were allowed to cool to room temperature for 30 minutes before weighing them to the nearest 0.01 mg. A sample (5 g) was added into the crucible and then placed uprightly on the rack of water bath with vigorously boiling water for about 1hour to remove most of the water. The crucibles were then transferred into a preheated oven (105 °C) and allowed to dry alongside the lids for 2 hours then immediately transferred to the desiccator for cooling 30 minutes). The weight was then taken. The process was repeated after an interval of 1 hour, 45 minutes and 30 minutes until the weight of the consecutive weightings did not exceed 1 mg. The lowest value was accurately recorded. The percentage total solids were calculated as indicated.

$$\% \text{ Total solids} = \left(\frac{W2 - W1}{W1 - W} \right) \times 100$$

where

W=Weight of the crucible;

W1=Weight of the crucible and sample text portion;

W2=Weight of the crucible and dry sample.

E. Total Soluble Solids and Viscosity

The total solid was determined with a calibrated hand-held refractometer. Viscometer was used to measure the viscosity.

VI. SENSORY EVALUATION OF THE BAOBAB PULP ENRICHED YOGHURT

The yoghurt samples were subjected to sensory evaluation using 20 panelists on the second day of storage. The panelist was drawn from the students and staff in the Institute of Food Bio Resources Technology (IFBT) of Dedan Kimathi University of Technology, Nyeri, Kenya. Simple random sampling procedure was applied when selecting the subjects to take part in this study. The temperature was controlled so as to remain the same for all the samples. The volume (10mls) of the yoghurt sample was equal for all the samples and was put in covered cups for each panelist. The samples were labeled with three-digit codes to avoid bias and the served in counterbalanced order whereby if two different samples were served; the first half of the panelist would receive the first one while the other half received the next sample. The panelist

was provided with clean water to rinse their mouths in between sample tasting.

The sensory evaluation was done using tables which compared the results. The parameters observed were as follows: taste, texture, color, aroma, and overall acceptability. The tasting room was well lit and ventilated. Sensory evaluation was done to determine the consumer's preferences. The value of 5 represented like very much, 4 – like, 3 – neither like nor dislike, 2 – dislike, 1 – dislike very much).

VII. DATA ANALYSIS

All proximate and physicochemical parameters were conducted in triplicate while microbial experiments were done in quadruplicate and the mean values \pm standard deviation (SD) recorded. Statistical analyses were performed by applying Analysis of Variance (ANOVA) to determine the significance of the 95% confidence interval and correlation coefficient using GenStat version 23 as statistical software.

VIII. RESULTS AND DISCUSSION

A. Proximate Composition of Yoghurt Samples

The proximate composition of yoghurt samples is presented in Table I. The moisture content for the yoghurt samples ranged from 78.42% to 87.30% (Table I). The results of moisture content in the samples were in agreement with those reported by Osman, [7] who indicated a range of 78.62 to 82.41%. The moisture content in treatment BEY0 was significantly higher ($p < 0.05$) than the other treatments. The values for moisture content in the enriched yoghurt treatments were significantly lower as compared to that of BEY0. This could be attributed by the effect of baobab pulp absorbing the moisture and reducing its level due to high solid content. Moisture in yoghurt is important in determining the texture and mouth feel of the.

The crude fat content of the baobab enriched yoghurt ranged from 4.342% in BEY0 to 5.952 % in BEY3 (Table I). These values are reasonably high as compared to the minimum value of 'not less than 2.25 percent milk fat' as stated by NCLR. Treatment BEY3 recorded a significantly higher fat content ($p < 0.05$) than the other treatments. This could be attributed to the high level of baobab pulp incorporated increasing the level of fat in the samples. The high fat content in the baobab pulp contributed to the increased levels of the fat content in the yoghurt. There was no significance difference ($p > 0.05$) of fat content between treatment BEY1 and BEY2. The fat content increased with increase in baobab pulp proportions in the yoghurt samples. The fat content increased with increase in baobab pulp proportions in the yoghurt samples. The high fat content in the baobab pulp contributed to the increased levels of the fat content in the yoghurt.

As reported by [8], the fat content of yoghurt should be less than 15%. The data in the study indicated that the fat content of the treatments used in the treatments comply with the specified standards. In this study, the samples had a fat content that was above 3.25% and hence they fall under the category of high fat yoghurt. According to the standards,

yoghurt values higher than 3.25% of fat content should be characterized as high fat yoghurt while those with fat content of 0.5-2.0% characterized as low-fat yoghurt as concluded by the United States Department of Agriculture (USDA). According to research by [9], the structural network formed by caseins during the fermentation process of yoghurt is strengthened by the presence of high fat content in the milk matrix. This leads to increased viscosity in yoghurt with the milk being concentrated.

The mineral content present in a food material is as a result of the crude ash content [10]. In the study, the ash content ranged from 0.1400% in BEY0 to 0.2657% in BEY3. There was significance difference ($p < 0.05$) in ash content in all the treatments. The level of ash content increased in relation to the increasing amounts of baobab pulp used in all the yoghurts samples. This has been contributed by the high ash content of the baobab pulp and thus indicates high mineral content could be present in the baobab enriched yoghurts. These findings are similar to results from other plant based enriched yoghurt which have equally reported high ash contents [11].

The crude protein for the baobab enriched samples of yoghurt ranged from 4.248% in BEY0 to 3.182% in BEY3. The crude protein content in the samples was significantly different ($p < 0.05$) between the treatments. Increase in baobab pulp led to decreased values of protein content in the yoghurt samples. The decrease in protein content with increase in baobab pulp was due to the inhibitory effect of baobab pulp on the proteolytic organisms that could contribute to breakdown of proteins [12] The hydrolysis of proteins is as a result of proteolytic activity of the lactic acid bacteria which is influenced by the increase in protein content in yoghurt.

TABLE I: PROXIMATE COMPOSITION OF DIFFERENT FORMULATION OF YOGHURT

	87.30 \pm 1.91 ^a	78.42 \pm 0.96 ^b	76.97 \pm 1.40 ^{bc}	72.67 \pm 4.93 ^c
Moisture	87.30 \pm 1.91 ^a	78.42 \pm 0.96 ^b	76.97 \pm 1.40 ^{bc}	72.67 \pm 4.93 ^c
Crude ash	0.14 \pm 0.01 ^a	0.16 \pm 0.02 ^d	0.23 \pm 0.01 ^c	0.27 \pm 0.06 ^b
Crude protein	4.25 \pm 0.09 ^a	3.28 \pm 0.01 ^b	3.18 \pm 0.04 ^b	3.18 \pm 0.04 ^b
Crude fat	4.34 \pm 0.17 ^a	5.68 \pm 0.01 ^c	5.78 \pm 0.04 ^c	5.95 \pm 0.01 ^b

The data are mean value \pm standard deviation (SD) of six replicates. Values within a column marked with different superscript are significantly different ($p < 0.05$).

B. Psychochemical Properties of the Yoghurt Samples

The results of the physicochemical properties for the different yoghurt samples are presented in Table II. The pH of the yoghurt samples ranged from 4.567 to 3.997. These values were within the range as recommended by Kenya Bureau of Standards (KEBS). The pH of the fresh milk decreased as the proportion of baobab powder increased. The pH values were more than the ones found by [13] and [9] in goat. From the results, the pH values were not significantly different ($p > 0.05$) between the baobab pulps enriched yoghurt samples. However, the results between BEY0 and the other treatments were significantly different ($p < 0.05$). This could be attributed to production of lactic acid during fermentation and the presence of organic acids in the baobab enriched yoghurt. The fermentation process, draining of yogurt, cooking, and manufacturing utensils are determined by the constituents in yogurts [14]. The pH values of the baobab enriched yoghurt decrease due to lactic acid produced

during milk- lactose fermentation leading to low pH [15]. Organic acid such as citric, tartaric, malic, succinic, and ascorbic acid in baobab pulp [2] and yeast also could contribute towards the reduction in pH of the baobab enriched yoghurt [16].

The viscosity of the baobab enriched yoghurt ranged from 5.963% to 3.38%. The control yoghurt sample (BEY0) was very viscous than the baobab enriched yoghurt samples. The viscosity results were significant different ($p < 0.05$) between all the treatments. The addition of baobab pulp might have interrupted the structure of the gel in the enriched samples. The strength, number of bonds between casein micelles, structure and spatial distribution affects the viscosity of the yoghurt [17]. This is because yogurt is a gel contributed by the matrix of casein micelles with entrapped water. Hence the yoghurt sample with 1% baobab pulp was more viscous as compared to the yoghurt sample with 3% baobab powder. This indicates that as we increase the amounts of baobab pulp in the yoghurt the viscosity decreases.

The titratable acidity of the baobab goat milk yoghurt ranged from 0.8190% to 0.9810%. The results between BEY0 and the yoghurt samples enriched with the baobab pulp were significantly different ($p < 0.05$). However, the results between BEY1 and BEY2 were not significantly different ($p > 0.05$). BEY3 differed significantly ($p < 0.05$) with BEY0, BEY1 and BEY2. These results agree with the report of [18] who specified 0.6% minimum level of titratable acidity for yoghurt. The results indicated a lower value in titratable acidity for control yoghurt than the other treatments. This observation can be explained to have resulted from whey separation as a result of the decreased acid production in yogurt due to the lactose hydrolysis [19]. The lactic acid amount rises as a result of hydrolyses of the sugar by the lactic acid bacteria. The fermentable sugar usually glucose is responsible for the faster growth of starters which contribute to this effect of increasing titratable acidity [19]. The pH values do not necessarily depend on variation of the titratable acidity [20].

The results showed that the total solids for the different samples of yoghurt were from 19.23% to 24.10% (Table II). The total solid content is an indication of the dry matter content present in the yoghurt samples [21], [22]. According to Haenlein [23], high content of total solids is present in goat's milk. The results for BEY0 and that of enriched baobab yoghurt samples were significantly different ($p < 0.05$). This can be as results of monosaccharides that dominate in the baobab powder which was added in the enriched yoghurt samples. The physical properties in the yoghurt highly depend on the total solids initially present in the milk used. As milk fermentation proceeds, the casein instability of the casein contributes to its coagulation thus forming a firm gel that comprises of casein micelles strands. The whey becomes entrapped inside this matrix forming protein matrix. The disulphide bonding that occurs between κ -casein and whey proteins that are denatured contribute to the yoghurt structure. The aggregation of casein as the pH drops to the isoelectric point of the casein proteins during fermentation [24].

The syneresis index of the samples ranged from 5.13 to 11.567 of the samples. There was a significant difference ($p < 0.05$) between BEY0 and all the baobab pulp enriched yoghurt samples. The total solids present, proteins, salts,

homogenization, type of culture, acidity resulting from the growth of bacterial cultures and heat pretreatment of milk highly affect the syneresis of the yoghurt product [25]. The shrinkage of gel is referred to as syneresis. This occur when the network of gel becomes unstable as a result of the ejection of liquid or whey separation. This leads to the loss of the ability to entrap all the serum phase. Some possible causes of wheying-off in acid gels include increased temperatures for incubation, extreme mix treatment, little total solids content (protein and/or fat), movement or agitation during or just after gel formation and very low acid production ($pH > 4.8$) [25], [26].

TABLE II: THE PSYCHOCHEMICAL PROPERTIES IN DIFFERENT FORMULATIONS OF THE BAOBAB ENRICHED YOGHURT

Syneresis	5.13±0.15 ^d	6.53±0.16 ^c	8.20±0.1 ^b	11.57±0.35 ^a
pH	4.56±0.01 ^a	4.09±0.03 ^b	4.01±0.04 ^b	3.99±0.07 ^b
TTA%	0.82±0.01 ^c	0.85±0.09 ^b	0.870±0.01 ^b	0.98±0.02 ^a
Total solids	0.82±0.01 ^c	23.20±1.2 ^a	23.25±1.64 ^a	24.10±0.40 ^a
Viscosity	5.96± 0.25	4.79±0.17 ^c	4.34± 0.13 ^b	3.38±0 0.17 ^a

The data are mean value ± standard deviation (SD) of six replicates. Values within a column marked with different superscript are significantly different ($p < 0.05$).

C. Sensory Evaluation

The sensory evaluations for the different samples of the yoghurt are presented in Table III. The results for the different sensory attributes were significantly different ($p < 0.05$) between all the treatments.

The hedonic rating for taste ranged from 3.91 in BEY0 to 4.82 in BEY3. Treatments BEY2 and BEY3 had the highest score in taste while treatment BEY0 and BEY1 had the lowest score for taste attribute. Most panelists preferred a higher quantity of baobab pulp being incorporated in the yoghurt. There was a significance difference ($p < 0.05$) in taste between all the treatments based on the scores of the panelists. A higher significant score for taste in goat milk yogurt enriched with 3% baobab pulp was observed indicating a higher acceptability of the new product. It may be due to the masking ability of the peculiar thinness by the addition of the baobab powder.

The results of hedonic rating for texture ranged between 3.33 in BEY0 and 3.79 in BEY3. The results between BEY0, BEY1, BEY2 and also BEY3 were not significantly different ($p < 0.05$) as shown in (Table III). Treatment BEY3 scored the highest while treatment BEY 0 scored the lowest in texture attribute.

The results indicated that the scores for aroma ranged from 3.16 to 4.51. All the yoghurt samples were significantly different ($p < 0.05$). BEY3 had the highest mean for aroma in hedonic rating as compared to all the other samples based on panelist acceptance. The score for treatment BEY2 was significantly higher than that of treatments BEY1 and BEY0 indicating a better acceptability as rated by the panelist. The panelist could clearly differentiate taste from aroma since aroma is the sensation judged by the sense of smell while taste is determined by the tongue. According to [26], the fat content in yoghurt affects its sensory and instrumental features. Oil impact positively the rheology of the yoghurt since it acts as an aroma solvent.

TABLE III: THE SENSORY EVALUATION SCORE FOR THE BAOBAB ENRICHED YOGHURT

	Texture	Aroma	Color	Overall acceptability
BEY0	3.91±0.51 ^a	3.33±0.08 ^a	3.16±0.08 ^a	4.51±0.07 ^a
BEY1	4.48±0.15 ^d	3.53±0.19 ^d	3.237±0.19 ^d	4.67±0.29 ^a
BEY2	4.76±0.14 ^c	3.65±0.17 ^c	3.850±0.17 ^c	4.70±0.09 ^b
BEY3	4.82±0.10 ^b	3.79±0.06 ^b	4.15±0.07 ^b	4.72±0.08 ^c

The data are mean value ± standard deviation (SD) of six replicates. Values within a column marked with different superscript are significantly different ($p < 0.05$).

From the results for color, the rating was between 3.52 to 4.40 as indicated in Table III. The rating for color was significantly different ($p < 0.05$) between treatment BEY0 and BEY1. There was also a significant difference ($p < 0.05$) in the rating for color between treatment BEY1, BEY2 and BEY2.

The results for overall acceptability indicate that treatment BEY0 had the lowest score of 4.51 while treatment BEY3 had the highest score of 4.72. There was significant difference ($p < 0.05$) between all treatments on the scores for overall acceptability. An increase of the scores for smell, color, texture, and aftertaste was observed in all the baobab enriched yoghurt treatments. Goat milk use in yoghurt production is reported to be low in consistency but high in acidity. It has a non-typical yogurt taste and flavor [27], [28]. These poor characteristics in the goat milk yoghurt were improved by enriching the yoghurt with baobab pulp.

IX. CONCLUSION

This study aimed at developing probiotic yoghurt enriched with various concentrations of baobab pulp while monitoring its characteristics during the three weeks of storage. Incorporation of baobab pulp to the probiotic yoghurt improved the nutritional content. According to this study, the crude protein decreased as the amount of the baobab pulp increased while the crude fat increased with increase in baobab powder increased. The ash content increased with increase in baobab powder and the moisture content decreased with increase in baobab powder.

There was an increase in the physicochemical properties of the different formulations of the yoghurt samples. The addition of 3% baobab pulp increased total solids, titratable acidity and syneresis compared to other treatments. It was also observed that as the baobab pulp increased in the yoghurt, the viscosity decreased. The pH of the fresh milk decreased as the proportion of baobab powder increased due to lactic acid bacteria that produce lactic acid and the presence of organic acids in baobab pulp.

According to the hedonic rating, the yoghurt sample with the highest baobab pulp scored the highest for taste, texture, aroma, color, and overall acceptability. Hence addition of baobab pulp improved the sensory attributes of the goat milk yoghurt.

According to the findings, the results warrant the need for further studies on the use of baobab pulp for value addition in yoghurt. There is need for further research to examine the functional properties in baobab pulp enriched yoghurt as well as analyzes the activities of the compounds present. Research was undertaken to assess variation on in functional properties of baobab fruits from different regions.

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