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Research Article

Development and Evaluation of Physicochemical and Sensory Properties of Camel Milk Frozen Yoghurt Enriched with Tropical Fruits

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Abstract

This investigation evaluate the addition of 5% pulp of mango (*Mangifera indica*), baobab (*Adansonia digitata*), and guava (*Psidium guajava*) fruit on some properties (physicochemical and sensory) of frozen yoghurt (FY) using camel milk (CM) during storage at -18 ℃ for a month. FCMY was prepared and divided into four batches: three fruit-fortified and one plain control, with evaluations conducted every 5 days. Physicochemical data obtained revealed significant variations ($P \leq 0.01$) in the values of total solids, ash, and acidity, with baobab-fortified FCMY recording the highest values. Fat content was higher in plain and guava samples, while protein levels were elevated in plain and guava FCMY. Sensory analysis revealed significant differences in flavour ($P \leq 0.01$), taste, texture, and the overall acceptability ($P \leq 0.05$). Baobab and guava samples shared the highest flavour scores, but baobab-fortified FCMY achieved the top scores for texture, taste and the overall acceptability. The study concluded that baobab pulp significantly enhances total solids, ash, acidity, taste, texture, and consumer preference compared to mango and guava, improving both physicochemical stability and sensory quality. Incorporating mango, baobab, and guava pulp is recommended to increase FCMY flavour and acceptance. Further studies using additional local fruits, vegetables, and spices are suggested to enhance nutritional and functional value.

Keywords

Camel Milk, Frozen Yoghurt, Mango, Baobab, Guava, Physicochemical, Sensory Properties, Storage Periods

1. Introduction

Fermented dairy products from camel showed longer shelf life, improving the digestibility, enhancing flavor and increased vitamins and short-chain fatty acids levels when compared with the fresh camel milk. It is a functional food with

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health benefits [1, 2]. Consumption the functional foods; either natural or fortified are found as an effective strategy in terms of cost and health values [3]. The fermented dairy products incorporated with fruits satisfied the consumer demand for obtaining natural heather functional foods [4].

Frozen yoghurt has become a popular dairy product among consumers because of its health significant as it could be a substitute to regular ice cream because of its flavour profile and its living cultures beneficial organisms [5]. The milk obtained from different animals including camel can be used for producing frozen dairy desserts [6]. However, cow's frozen yoghurt compared to that from camel showed high score of acceptability [7].

African baobab *(Adansonia digitata* L.) is a widespread indigenous tree that can be utilized for food [8, 9]. In comparison to certain commercial yoghurts, it was demonstrated that yoghurt fortified with the pulp of *Adansonia digitata* fruit was reported as valuable nutrients source due to its content of the phenolic compounds [10]. Processing of ice cream using milk of camel flavoured by *Adansonia digitata* fruits was recommended previously [11].

Mango (*Mangifera indica*) is an important consumed fruits worldwide because it has attractive color, pleasant aroma and sweet flavor, in addition to its nutritional value [12, 13]. Yoghurt can be blended with 22% mango pulp to produce a drink of acceptable quality, which will benefit consumers' health, improve the minerals, vitamins and antioxidant capacity of yoghurt drinks [14]. Moreover, it was found that when adding the mango pulp to the yoghurt, its nutritional, physicochemical and organoleptic characteristic were improved [15].

Guava (*Psidium guajava L.*), fruit is native to tropical America and is cultivated all over the the tropics [16]. Guava gained high prize among the consumers because of its nice flavor, rich taste, and high levels of nutrients including bioactive compounds [17, 18]. The guava enrichment improves the shelf life and functionality of frozen yoghurt [6]. The use of powdered pink guava showed a potentiality in boosting the functional attributes of yoghurt [18].

It was reported that the components of the fruits are interacting with the structure of yoghurt and thus influencing its physicochemical and sensory properties [4]. Moreover, fluid and weak texture was reported in yoghurt made from camel milk. The goal of the current study was to create a functional frozen yoghurt having better nutritional quality and characteristics by adding pulp of specific Sudanese tropical fruits, such as baobab (*Adansonia digitata*), guava (*Psidium guajava*), and mango (*Mangifera indica*), as natural sources of bioactive compounds, dietary fiber, vitamins, minerals, and antioxidants. This would increase the product's potential to promote health while making use of underutilized local resources. The study aims to provide consumers with natural, nutrient-dense alternatives in the frozen dessert category, encourage the sustainable use of native tropical fruits, lessen reliance on imported ingredients, and support developing of health-focused dairy products with added value in Sudan.

2. Materials and Methods

2.1. Materials

The source of milk was camels' farm located at East Nile Locality, Sudan. The experimental procedures and analyses were conducted at the Department of Dairy Production, Animal Production Faculty, University of Khartoum. This study was conducted from July 2018 to September 2018.

2.2. Mix used for Frozen Camel Yoghurt

The mix contained camel yoghurt (80%, w/v), sugar (14%, w/v), Gum Arabic (1%, w/v), and mango (5%, w/v) or guava (5%, w/v) or *Adanosonia digitata* (5%) fruits. Mango fruits obtained from Shandi (Nile River State), while guava and *Adanosonia digitata* from Khartoum State.

2.3. Frozen Camel Yoghurt Processing

2.3.1. Preparation of Camel Yoghurt

Plain camel yoghurt was prepared by heating whole camel milk at 72 ℃ for 15 seconds before cooling to 43 ℃ [19]. Then it was transferred into 100 ml plastic containers, where a 3% w/w commercial starter culture; CHR-HANSEN- YoFlex® Express 1.0 (CHR-HANSEN, Denmark) (was added to the youghurt mix.

2.3.2. Preparation of Natural Flavors

(i). Mango and Guava

To prepare mango (*Mangifera indica*) and guava (*Psidium guajava*) chunks, they were cleaned with water. After removal of the peel and seeds (mango kernel), the pulp was cut into slices before it was mixed with camel yoghurt (3 liters). The obtained mix was collected and added to the mixture of plain camel yoghurt, sugar, and Gum Arabic that had already been prepared.

(ii). *Adanosonia digitata*

Adanosonia digitate fruits were prepared by broken down the pulp and removing its the outer shell, then the powder was collected, filtered and mixed with camel yoghurt (3 liters), sugar and Gum Arabic that was already prepared.

2.4. Frozen Camel Milk Yoghurt Mix

Slight modifications on the procedure used for processing of frozen yoghurt from camel milk were done [19]. They include the incubation and pasteurization processes. The mix comprised camel yoghurt, sugar, Gum Arabic and one of the fruits (mango, guava and *Adanosonia digitate*), their addition was done simultaneously with homogenization of the mix at 300 RPM for 45 seconds (3000 Series Blender HR2042/13).

The obtained mix was kept cool at 5˚C in a refrigerator and then was divided into 4, one was a control and to each of the other three one type of the selected fruit was added. Then each mix was brought into an ice cream machine and after that they were packed using plastic cups (100 grams), then the products were and stored in a standing freezer (-18˚C) for a month to conduct the physicochemical analysis of camel milk, natural fruits and frozen camel yoghurt.

The physicochemical tests for examining the total solids, fat, protein and titratable acidity were performed in triplicate at the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum.

2.5. Examination of the Samples

2.5.1. The Analysis of Camel Milk

The milk analyzer Lactoscan (Milkotronic LTD, Europe) was used for analyzing the sample of camel milk according to the instructions of the manufacturer.

2.5.2. Fruits Analysis

The proximate composition (moisture, protein, crude fiber and ash, this in addition to total, reducing, and non-reducing sugars) of mango, guava, and *Adanosonia digitata* fruit pulps was determined using standard gravimetric, Kjeldahl, volumetric (Lane-Eynon), and difference calculation methods as described in Pearson's Composition and Analysis of Foods. It was carried out at the Food Research Center according to the method described previously [20].

2.5.3. Approximate Chemical Analysis of FCMY

The total solids and ash content of FCMY and its titratable acidity were determined according to AOAC [21]. The Gerber and the Kjeldahl methods were used for determining of the content of fat and protein level, respectively [21].

2.5.4. Sensory Evaluation of FCMY

The organoleptic characteristics and the acceptability of FCMY samples were performed according to the average scores obtained from 10 semi-trained panelists. Those panelists were both graduated and undergraduate students of the Faculty of Animal Production, University of Khartoum, Sudan. Also, some teaching and non-teaching staff members participated in the evaluation of the products.

The FCMY samples were coded and all panelist were given clean water for washing their mouths before testing a new sample. The rating was done using 5 hedonic rating scale [22]; excellent (5), very good (4), good (3), fair (2) and poor (1). The obtained average score as judged by all panelists was statistically analyzed.

2.5.5. Statistical Analysis

The recorded data underwent statistical analysis (Statistix 8.0 software) through a factorial experimental design, which included 4 treatments (3 fruits and a control) within a storage period (7 readings). The research used $P < 0.05$ to establish the statistical significance. The analysis used ANOVA to estimate the mean difference for the treatment, then the Duncan's multiple-range test was also used for post hoc evaluation. The results are presented as mean values with their corresponding standard deviations. Meanwhile, Microsoft Excel sheet was used for plotting the figures.

3. Results

3.1. The Physicochemical Content of FCMY

The solids non-fat of camel milk was 9.5%, while 3.18%, 3.08%, 4.25% and 0.88% were obtained for fat, protein, lactose and ash, respectively. The physicochemical content of mango, guava and *Adanosonia digitata* (Table 1).

Table 1. *The physicochemical content of mango, guava and Adanosonia digitate.*

Types of fruits	Moisture (%)	Ash (%)	Protein (%)	Fiber (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
Mango	78.3	2.07	4.18	11.29	57.23	19.05	35.29
Guava	79.16	3.66	4.22	24.92	23.28	19.63	3.47
Adanosonia digitata	10.01	5.98	3.9	9.18	14.94	6.5	8.02

The physicochemical content of flavoured FCMY revealed that the samples fortified with *Adanosonia digitata* showed the highest total solids, ash and titratable acidity compared to other samples of FCMY (Table 2). Higher average values were obtained for the fat and protein content of plain FCMY (Table 2).

Table 2. *Physico-chemical contents of frozen camel milk yoghurt flavoured by Adanosonia digitata, mango and guava.*

Types of frozen yoghurt	Total solids (%)	Fat (%)	Protein (%)	Ash (%)	Acidity (%)
Plain	24.32^{b}	2.08^{a}	1.75^{a}	0.682^{bc}	0.926^{b}
Adanosonia digitata	27.53^{a}	0.57^{d}	1.63^{b}	0.851^{a}	1.237^{a}
Mango	23.00^{c}	0.91^{c}	1.44^{c}	0.729^{b}	0.912^{b}
Guava	23.01^{c}	1.11^{b}	1.65^{b}	0.637^{c}	0.973^{b}
Standard erorr	0.4323	0.0398	0.0323	0.0343	0.0485

Means bearing the same superscript letters in the same column are not significantly different.

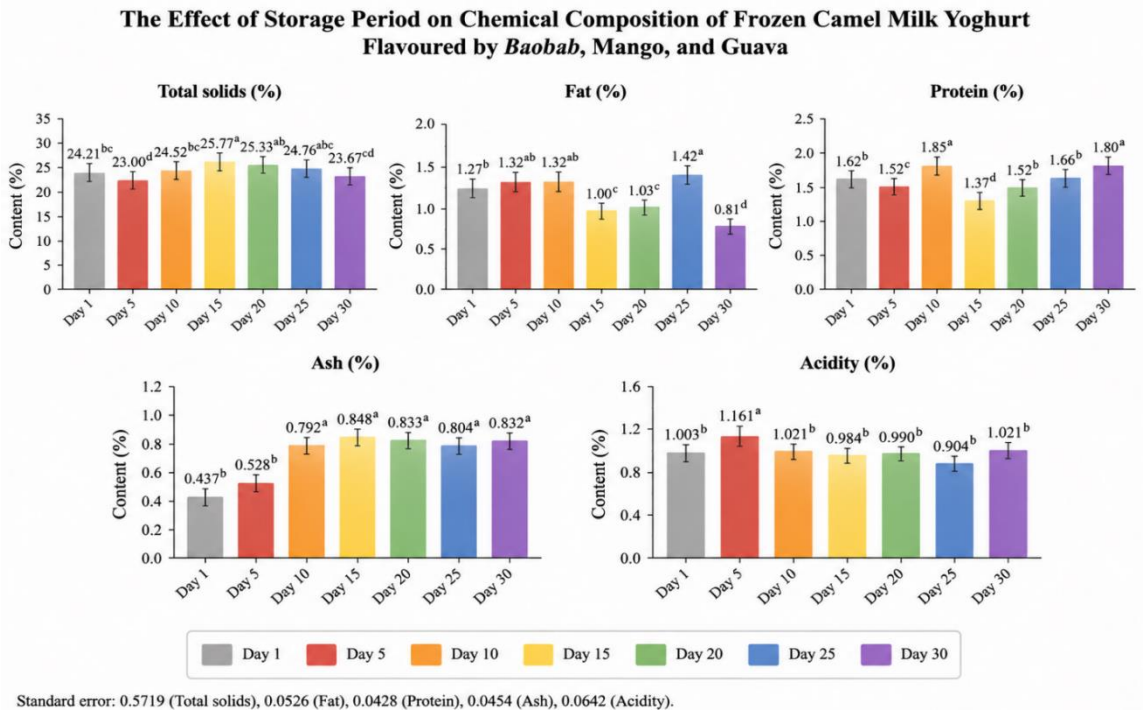


Figure 1. *Variation of the chemical composition of FCMY flavoured by baobab, mango, and guava during the storage.*

Higher average total solids was recorded on day 15 (25.77%), while lower means were found in FCMY on day 5 (23.01%) compared to data obtained during other days of examination (Figure 1). The fat content of FCMY was significantly ($P \leq 0.01$) fluctuated during storage and day 25 showed the highest ((1.42%) value, while the lowest value recorded after 30 days (0.81%) (Figure 1). The protein was also varied significantly ($P \leq 0.01$) due to the different types of FCMY and storage (Figure 1). The highest means of protein contents were found on day 10 (1.85%), while the lowest averages for protein contents were found on day 15 (1.37%). Significant ($P < 0.01$) differences were also found in the ash content of the different kinds of FCMY during their storage (Figure 1). The highest mean of ash content was found on day 15 (0.848%) and the lowest average for ash content were found on day 1 (0.437%). Significant ($P \leq 0.05$) variation were also reported in the titratable acidity among the different FCMY samples during their storage (Figure 1). The highest average of titratable acidity was obtained on day 5 (1.161%), while the lowest average was found on day 25 (0.904%).

The data showed an interaction between treatments of FCMY flavoured with added mango, guava, and baobab during the storage period for total solids (Table 3). Higher total solids content were obtained on day 20 for baobab frozen camel milk yoghurt samples (28.60%) compared to other samples. On the other side, the lowest average of total solids was found on day 5 for guava-frozen camel milk yoghurt samples (20.57%).

Table 3. *The effect of interaction between the flavoured baobab, mango, and guava FCMY and their storage period on total solids.*

	Types of frozen yoghurt			
Storage Period	Plain	Baobab	Mango	Guava
Day 1	23.86defgh	28.22^{ab}	22.53^{ghij}	22.24^{ghij}
Day 5	23.63^{defgh}	25.90^{bcd}	21.91hij	20.57^{j}
Day 10	22.59^{fghij}	26.97^{abc}	24.96cde	23.58^{defghi}
Day 15	27.99^{ab}	27.79^{ab}	23.07efghi	24.22^{defgh}
Day 20	24.35^{defg}	28.60^{a}	23.47efghi	24.91^{cdef}
Day 25	24.40^{defg}	27.93^{ab}	22.39ghij	24.31^{defg}
Day 30	23.41^{efghi}	27.32^{ab}	22.70efghij	21.26^{ij}
Standard error	1.1439	1.1439	1.1439	1.1439

Means bearing similar superscript letters in the same column are not significantly (P > 0.05) different.

The data in Table 4 showed the interaction estimated for the different flavoured FCMY samples during the storage period for fat content. The highest average of fat was on day 25 for plain frozen camel milk yoghurt samples (2.45%), whereas the lowest value for the fat content was observed in day 30 for baobab frozen camel milk yoghurt samples (0.10%).

Table 4. *The effect of interaction between the flavoured baobab, mango, and guava frozen camel milk yoghurt and storage period on fat.*

	Types of frozen yoghurt			
Storage Period	Plain	Baobab	Mango	Guava
Day 1	1.90^{cd}	1.80^{d}	0.20^{l}	1.20^{ef}
Day 5	2.05^{bc}	0.50^{jk}	1.35^{e}	1.40^{e}
Day 10	2.05^{bc}	0.50^{jk}	1.35^{e}	1.40^{e}
Day 15	2.00^{bcd}	0.60^{ij}	0.90^{jh}	0.50^{jk}
Day 20	2.00^{bcd}	0.30^{kl}	1.10^{fg}	0.75^{hi}
Day 25	2.45a	0.20^{l}	1.05^{fg}	2.00^{bcd}
Day 30	2.15^{b}	0.10^{l}	0.45^{jk}	0.55^{ij}
Standard error	0.1052	0.1052	0.1052	0.1052

Means bearing similar superscript letters in the same column are not significantly (P > 0.05) different.

The result in Table 5 presented the interaction obtained for of the protein content of the different flavoured FCMY samples and their storage period. The highest average of protein was found on day 25 for *Adanosonia digitata* frozen camel milk yoghurt (2.55%). Meanwhile, the lowest (0.90%) mean of protein content was observed in day 25 for the flavoured FCMY samples fortified with mango.

Table 5. *The effect of interaction between the flavoured baobab, mango, and guava FCMY and their storage period on protein.*

	Types of frozen yoghurt			
Storage Period	Plain	Baobab	Mango	Guava

	Types of frozen yoghurt			
Day 1	1.80^{cd}	1.30^{hi}	1.70^{de}	1.70^{de}
Day 5	1.90^{c}	1.20^{i}	1.40^{gh}	1.60^{ef}
Day 10	1.80^{cd}	1.80^{cd}	1.60^{ef}	2.20^{b}
Day 15	1.50^{fg}	1.50^{fg}	1.30^{hi}	1.20^{i}
Day 20	1.60^{ef}	1.30^{hi}	1.60^{ef}	1.60^{ef}
Day 25	1.60^{ef}	2.55^{a}	0.90^{j}	1.60^{ef}
Day 30	2.10^{b}	1.80^{cd}	1.60^{ef}	1.70^{de}
Standard error	0.0856	0.0856	0.0856	0.0856

Means bearing similar superscript letters in the same column are not significantly (P > 0.05) different.

Results in Table 6 showed the interaction of the ash content in the different flavoured FCMY samples during the storing of FCMY. The highest reported means for the ash content were recorded on day 30 for baobab FCMY and their (0.969%), and the lowest average of ash content was found on day 5 for plain frozen camel milk yoghurt samples (0.365%).

Table 6. *The effect of interaction between the flavoured baobab, mango and guava FCMY and their storage period on ash*

	Types of frozen yoghurt			
Storage Period	**Plain**	**Baobab**	**Mango**	**Guava**
Day 1	0.428^{ij}	0.519^{hij}	0.654^{fgh}	0.448^{k}
Day 5	0.365^{j}	0.642^{fgh}	0.592^{ghi}	0.512^{hij}
Day 10	0.731^{fg}	0.946^{abcd}	0.736^{efg}	0.755^{efg}
Day 15	0.918^{abcde}	0.966^{ab}	0.783^{bcdef}	0.724^{fg}
Day 20	0.788^{abcdef}	0.963^{ab}	0.788^{abcdef}	0.793^{abcdef}
Day 25	0.773^{cdefg}	0.951^{abc}	0.732f^{g}	0.760^{efg}
Day 30	0.774^{cdefg}	0.969^{a}	0.820^{abcdef}	0.765^{defg}
Standard error	0.0908	0.0908	0.0908	0.0908

Means bearing similar superscript letters in the same column are not significantly (P > 0.05) different.

3.2. Sensory Characteristics of Flavoured Frozen Camel Milk Yoghurt

The colour of flavoured FCMY scores recorded by the panellists was not significantly (P > 0.05) different (Figure 2). The result in Figure 3 for the means colour scores of flavoured frozen camel yoghurt were also not significant (P > 0.05). The effect resulted in the colour scores due to the interaction between the flavoured (baobab, mango, and guava) frozen camel milk yoghurt and their storage were not significant (P > 0.05).

Data in Figure 2 showed that the flavour for different flavoured FCMY samples revealed higher scores in the samples flavoured by *Adanosonia digitata* and guava.

The present result (Figure 2) revealed significant (P≤0.01) differences for taste scores among different flavoured frozen camel milk yoghurt. Meanwhile, higher mean value (3.7) was recorded for taste score in baobab FCMY samples . However, the lowest mean (2.9) was recorded for the taste score of plain FCMY samples. The mean score of texture was high in the baobab frozen camel milk yoghurt compared to other samples (Figure 2). The overall acceptability scores shown in Figure 3 revealed improvement of the quality of FCMY samples when adding 5% of baobab.

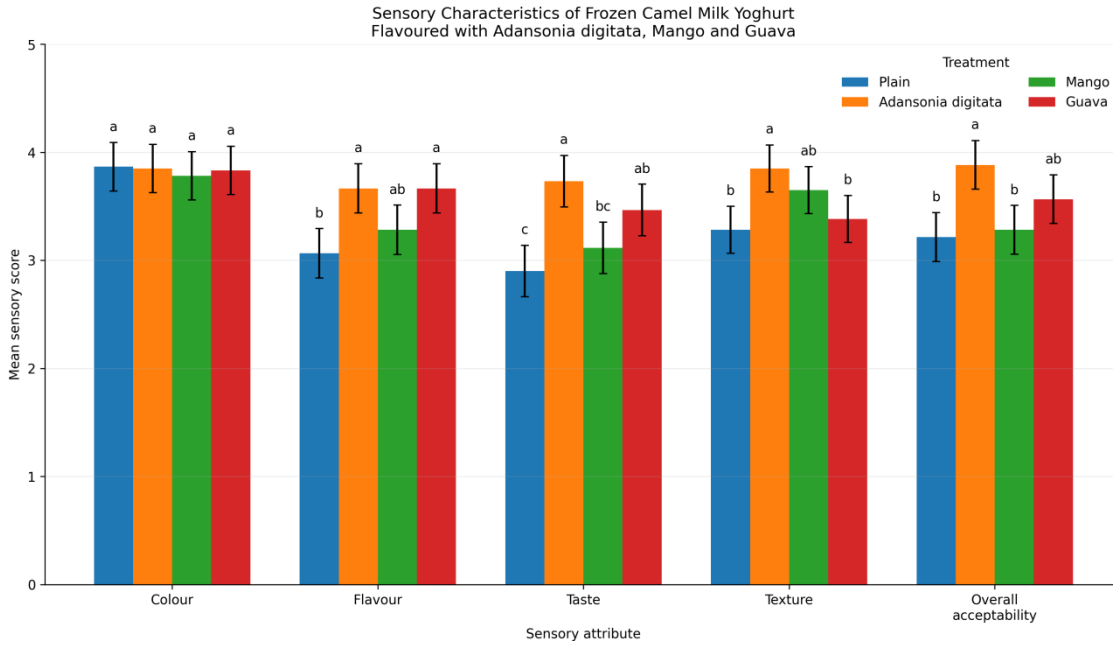


Figure 2. *Sensory characteristics of FCMY flavoured with Adansonia digitata, mango and guava.*

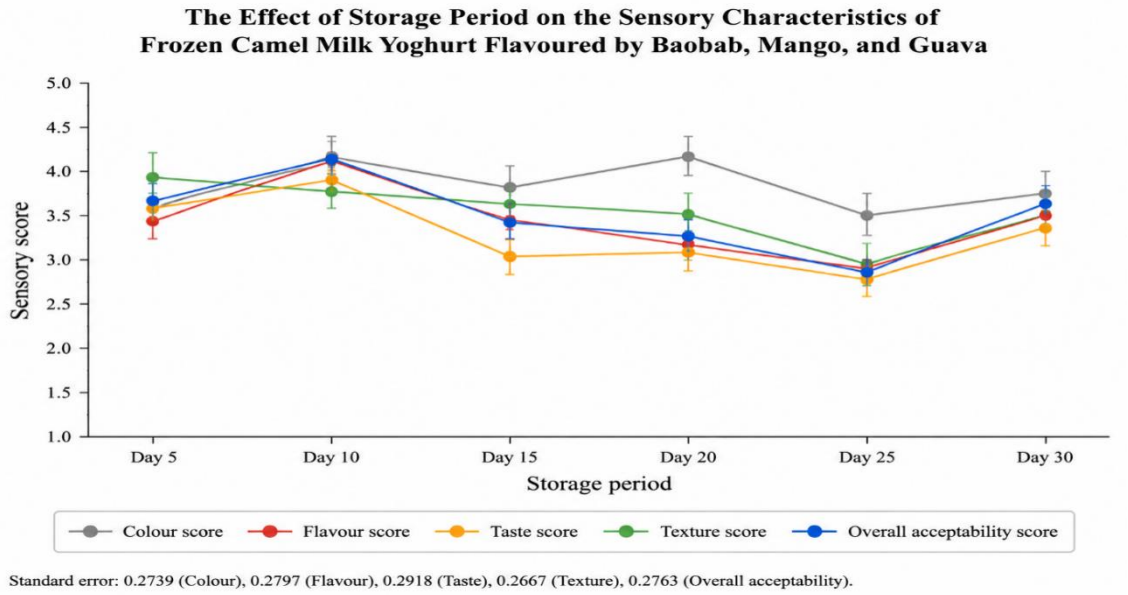


Figure 3. *Variation of the sensory characteristics of FCMY flavoured by Adanosonia digitata, mango and guava during the storage.*

The flavour score revealed significant ($P \leq 0.01$) differences for flavoured FCMY during their storage (Figure 3). The highest mean flavour score was obtained during day 10 and day 15 (4.1 and 3.5, respectively). However, the lowest score was obtained on day 25 (3.0). The data in Figure 3 showed that the taste scores of flavoured FCMY was significantly ($P \leq 0.01$) different during storage. Moreover, higher (3.9) mean was found on day 10 in comparison to other days of storage and the lowest mean was found on day 25 (2.9). The overall means of interaction obtained for the taste score of different flavoured FCMY during their storage was not significant ($P > 0.05$) as shown in Figure 3. However, significant ($P \leq 0.01$) variations were found among the different types of FCMY samples during their storage (Figure 3). The highest value of means texture score was found on day 5 (3.9), while the lowest value was found on day 25 (2.9). In addition, significant ($P \leq 0.01$) variations were also shown among the different types of FCMY samples during the storage. The highest average of the overall acceptability scores was obtained on day 10 (4.1), while the lowest average was found on day 25 (2.9).

4. Discussion

The used camel milk for producing FCMY showed a solids non-fat content of 9.5% (3.18, 3.08, 4.25, and 0.88% for fat, protein, lactose and ash content, respectively). The obtained values supported those reported previously [23-25]. Table 1 shows the physicochemical content of mango, guava and *Adanosonia digitata*.

The physicochemical content of flavoured FCMY revealed that the samples fortified with *Adanosonia digitata* showed the highest total solids, ash and titratable acidity compared to other samples of FCMY (Table 2). This was due to the lowest moisture and higher ash content, as was illustrated in Table 1. However, the 5% mango pulp sample showed promising physicochemical properties and was considered the best yoghurt sample [26]. Similar to the present result, significantly higher total solids and ash were reported previously in camel milk ice cream fortified with 5% *Adanosonia digitata* fruit [27]. This could be because of the added pulp of the fruit of *Adanosonia digitata*, which contains respective amounts of ash, vitamin C and ascorbic acid [28].

The highest average of fat and protein was found in plain frozen camel milk yoghurt (Table 2). Table 1 also reflected higher values for the protein than those estimated for camel milk. Another justification for the high protein and fat might reflect the dilution effect caused by adding fruit pulp, which increases moisture and carbohydrate content, thereby lowering the relative concentration of fat and protein [29]. Camel milk protective proteins (lactoferrin and immunoglobulins) can slow starter culture growth and fermentation [30]. Moreover, adding fruits to plain yoghurt was found to enhance its antioxidant, probiotic contents, and increasing both its dietary fiber, and bioactive compounds that resulted in health benefits including immune modulation, improved the health of the gut, and reducing the risk of metabolic disorders [4].

The content of the total solids in different samples of FCMY recorded the highest mean on day 15 (25.77%), while the lowest means were estimated on day 5 (23.01%), as presented in Figure 1. Meanwhile, the total solids tested in camel milk ice cream showed its highest mean (32.86%±1.15) during week 6. This could be due to the water loss or sublimation, both of which increase total solids [27].

The fat content was significantly ($P \leq 0.01$) fluctuations during the storage of different FCMY samples. Its higher value observed on day 25 (1.42%) and the lowest value recorded after 30 days (0.81%) (Figure 1). Reduced levels of protein, fat, viscosity, pH, and general sensory acceptability for the pulp of *Dovyalis caffra* fruit was reported for yoghurt made from cow's milk [31]. Significant increase of the fat in yoghurt fortified with orange pulp was also reported [32]. The amounts of protein and fat, and their derived amino acids and fatty acids respectively, were gradually decline when camel milk was kept in a milk tanker truck at 4 ℃ [33]. However due to a few waters may out of the flavoured frozen camel yoghurt or slow sublimation in frozen storage lead to relative concentration of fat. On the other hand, it worth to mentined that the pulp of Baobab fruit is has low fat [27] and higher fiber and soluble carbohydrates [34]

The protein content varied significantly ($P \leq 0.01$) in the different FCMY samples during their storage (Figure 1). The highest means of protein contents were found on day 10 (1.85%), while the lowest averages for protein contents were found on day 15 (1.37%). This might be because the camel milk contains high levels of antibacterial substances (lactoferrin, lysozyme and immunoglobulins) compared to bovine milk [35]. So, the breakdown of protein in plain frozen yoghurt will be slow, compared to other samples. Moreover, the protein becomes less soluble or structurally altered, not fully detected in analysis at day 15, or due to proteolysis by starter culture [36]. Meanwhile, *Adanosonia digitata* pulp showed high pectin and polysaccharide content that resulted in stable protein–polysaccharide complexes [37-39]. However, the proteolytic enzymes in mango fruit increases protein breakdown [40].

The ash content was found to vary significantly ($P < 0.01$) in different kinds of FCMY samples during their storage (Figure 1). Similarly, it was found that *Adanosonia digitata* yoghurt had significantly higher ash and iron compared to the control and commercial yoghurts [10]. Table 1 confirmed that *Adanosonia digitata* contains higher ash content. The highest mean of ash content was found on day 15 (0.848%) and the lowest average for ash content were found on day 1 (0.437%). This result supported the previous results [41, 42]. The minerals that may be increasingly released from the fruit into the frozen yoghurt during storage, raising the detectable ash level from *Adanosonia digitata* [43], guava [44] and mango [45].

Significant ($P \leq 0.05$) differences were shown for the titratable acidity among the different types of FCMY samples during their storage (Figure 1). The highest average of titratable acidity was obtained on day 5 (1.161%), while the lowest average was found on day 25 (0.904%). Similarly, an increase in the acidity was reported as slow at the beginning of storage for yoghurt made from pure camel milk [25]. This because of the increased titratable acidity due to the growth of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus* (lactic acid bacteria) that produces lactic acid as a result of their fermentation of lactose [46]. Also, similar findings were reported previously [47]. The lowest average found on day 25 (0.9044%) could be attributed to the stress resulting from the freezing temperatures on lactic acid bacteria, which decreases the viability and buffering effects of milk proteins and minerals resulting in reducing the measurable titratable acidity. However, the interaction reported for the mean values of the titratable acidity during the storage period of the different types of FCMY samples was not significant ($P > 0.05$).

The total solids content as affected by the interaction between treatments (mango, guava, and baobab) of FCMY samples and their storage showed the highest value (28.60%) on day 20 for baobab FCMY (Table 3). On other side, the lowest

average of total solids was found on day 5 for guava-frozen camel milk yoghurt samples (20.57%). This could be due to the compositional and physicochemical properties of the baobab and guava content of moisture (Table 1).

The data in Table 4 showed the variations of the fat content due to the interaction of different flavoured FCMY samples and their storage period. The highest average of fat was on day 25 for plain frozen camel milk yoghurt samples (2.45%), whereas the lowest one was reported in day 30 for baobab FCMY samples (0.10%) due to Plain frozen camel milk yoghurt does not contain fruit pulp Therefore, the fat content reflects the natural fat composition of camel milk. Pulp of Baobab fruit is known for its low fat [27] and its high fiber and soluble carbohydrates [34].

The result in Table 5 presented the interaction obtained in the protein content of the flavoured FCMY samples and storage period. The highest average protein value was found in protein content of FCMY samples flavoured with *Adanosonia digitata* on day 25 2.55%). Meanwhile, the lowest mean of protein content (0.90%) was found on day 25 for the frozen camel milk yoghurt samples fortified with mango. Variations of the compositional content of the used fruits could be the reason for the differences (Table 1). *Adanosonia digitata* yoghurt had significantly higher crude fibre than the control and commercial yoghurts [10]. This could be attributed to *Adanosonia digitata* pulp, which had high pectin and polysaccharide content that might form stable protein–polysaccharide complexes [37, 38, 39]. On the other hand, when adding four grams powdered of pink guava as a source of fiber to yoghurt, the requirement was fulfilled by providing a total dietary fiber of 3.88 g/100 gram [19]. Meanwhile, the proteolytic enzymes in mango may increase protein breakdown [40].

Results in Table 6 showed the interaction estimated for for the ash content in different flavoured of FCMY samples during their storage. The highest mean of ash content (0.969%) was that reported on day 30 for baobab FCMY, and the lowest one was obtained on day 5 for plain frozen camel milk yoghurt samples (0.365%). The reason is because of the high content of ash in the pulp of baobab fruits [8]. The ash in baobab is estimated as high as 5.25% [27].

Data in Figure 2 showed some sensory measurements of flavoured frozen camel milk yoghurt the result was found for the flavour among the baobab flavoured frozen camel milk yoghurt, might be due to citric, tartaric, malic, succinic, and could be attrbuted to the ascorbic acid in baobab [48]. Meanwhile, the distinct flavors of guava attributed to volatile organic compounds [49]. The presence of both organic acids and phenolic compounds in the pulp of baobab fruits have positive effect on scores obtained for taste attribute [50].

The present result (Figure 2) revealed significant ($P \leq 0.01$) differences among flavoured frozen camel milk yoghurt for taste score. Higher mean value for taste score was reported for baobab frozen camel milk yoghurt samples (3.7). However, the lowest one was estimated in plain frozen camel milk yoghurt samples (2.9). Previously, when adding 3% baobab fruit in the mix of ice cream camel milk, its organoleptic properties were improved and a good flavor was reported [11].

The texture secured the highest mean score in the baobab FCMY (Figure 2). The reason may be because of the unique content of dietary fibers and calcium and magnesium ions in baobab fruit pulp [56]. These components contribute to the superior textural of baobab enriched frozen camel milk yoghurt.

The overall acceptability scores (Figure 2) revealed improvement of the quality of FCMY samples when adding 5% of baobab, which could be due to enhancing flavor, texture, therefore the scoring given by untrained panelists increased [29, 59, 60].

The flavour score result (Figure 3) revealed significant ($P \leq 0.01$) variations for the different types of the flavoured FCMY samples during their storage. The highest mean flavour score was obtained during day 10 and day 15 (4.1 and 3.5, respectively). However, the lowest score was obtained on day 25 (3.0), which might be attributed to the fermentation compounds like diacetyl and acetaldehyde and Fruit volatiles are still fresh and aromatic, enhancing the flavour [51-53]. Also, the fat content in camel milk and added fruit could be oxidated producing off-flavours or aromatic compounds from fruits or fermentation products may degrade over time [54]. However, the effect of the overall interaction on flavour score due variation of flavoured FCMY and their storage was not significant ($P > 0.05$).

The taste scores (Figure 3) showed significant ($P \leq 0.01$) variations for the different flavoured FCMY samples during their storage. The highest (3.9) mean was found on day 10, while the lowest mean was found on day 25 (2.9). Yoghurt taste and aroma were considerably declining as storage temperatures and duration rose [55]. The overall means reported for the taste score as a result of the interaction between treatments of different flavoured FCMY samples during their storage was not significant ($P > 0.05$) as shown in Figure 3. However, significant ($P \leq 0.01$) differences were found among the different flavoured FCMY samples during their storage in the taste score (Figure 3). The highest value of means texture score was found on day 5 (3.9), while the lowest value was found on day 25 (2.9). This finding with aligned with those reported previously [57, 58]. However, there no significant ($P > 0.05$) differences in the texture scores due to the interaction between the different flavoured FCMY samples during their storage period.

In addition, the data showed significant ($P \leq 0.01$) differences in the overall acceptability scores among the different flavoured FCMY samples during their storage. The highest average of the overall acceptability scores was obtained on day 10 (4.1), while the lowest average was found on day 25 (2.9). The mean values of color or appearance, body or texture, flavor, consistency, and the overall acceptability all decreased in goat milk frozen yoghurt samples towards the end of the storage period [47]. The present findings supported the previous study, which suggested that the preference of flavored fro-

zen camel yogurts was based on multiple sensory factors including flavor, aroma, texture [61]. However, there was non-significant ($P \geq 0.05$) difference in overall acceptability score due to the interaction between different flavoured FCMY samples during their storage. Similarly, the quality attributes of the goat frozen yoghurt were influenced by storage period and treatment [47].

5. Conclusion

Its concluded that when incorporated the fruit pulp of *Adanosonia digitata* at a rate of 5% revealed better quality of the flavoured frozen camel milk yoghurt in terms of higher total solids, ash and titratable acidity, thus enhancing the flavour, taste, texture and the overall acceptability scores of FCMY in comparison to the samples with added mango and guava. Moreover, the results showed that *Adanosonia digitata* FCMY samples revealed higher total solids, ash and titratable acidity. Moreover, it was also found to improve the flavour, taste, texture and overall acceptability scores of FCMY. The reason is because *Adanosonia digitata* pulp has high dry matter, minerals and organic acids. *Adanosonia digitata* also helps in enhancing the acidity and imparting fruity flavors for better sensory scores. Adding tropical fruits to camel milk frozen yoghurt enhances physicochemical properties and sensory appeal, aligning with health food trends due to the natural antioxidants and increasing its fiber content. Thus, promoting local resource utilization for innovative value-added dairy products.

Abbreviations

FCMY	Frozen Camel Milk Yoghurt
ANOVA	Analysis of Variance

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Author Contributions

Alameen Mohameed Ibrahim Alnogome: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft.

Ibtisam Elyas Mohamed El Zubeir: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing

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Conflict of Interest

Both authors confirmed that no declaration is needed as there is no conflict of interest for this research.

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