

Original Research

Preparation and Properties of Frozen Yoghurt Made from Camel Milk Fortified with Dates and Banana Fruits

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Abstract

This study was conducted to process frozen yoghurt (FY) from camel milk (CM) flavored with either 5% or 8% banana (B) or dates (D). The mix of FY consists of stirred yoghurt, sugar, Gum Arabic, and banana (*Musa lutea*) or dates (*Phoenix dactylifera*). The mix was divided into 4 portions and then each mix was sub-derived into an ice-cream machine and then packed into plastic cups that were stored at -18°C for 5 weeks. The chemical composition and sensory evaluation were conducted weekly. The chemical composition of FY showed non-significant differences among the samples. The data revealed a higher mean total solids content in 8% banana frozen camel milk yoghurt (BFCMY), while the 5% banana samples had higher protein values. The acidity and ash content were high in 5% flavored BFCMY and DFCMY samples. The effect of storage period showed highly significant ($P < 0.001$) variations for protein, ash, and acidity, while there was no significant difference for total solids ($P > 0.05$). The sensory evaluation revealed significant ($P < 0.05$) differences for all flavored FCMY samples except



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color score. The highest mean color score was found in 5% BFCMY, and the lowest was observed in 8% DFCMY. The results showed that 5% and 8% DFCMY had significantly higher ($P < 0.05$) scores for flavor, texture, and overall acceptability. The effect of storage period showed highly significant variations for the scores for flavor, taste, texture, and overall acceptability, while there was no significant difference in the color score. It was concluded that FCMY with either 5% or 8% date and banana fruits yields products with good properties. This study recommends processing BFCMY and DFCMY as functional foods.

Keywords

Camel milk; processing; frozen yoghurt; banana; dates; chemical composition; sensory evaluation

1. Introduction

Most of the world's camels (*Camelus dromedarius*) are found in East African countries: Somalia, Sudan, Ethiopia, and Kenya, where camels are of significant importance many pastoralist communities of the dry zones of sub-Saharan Africa by providing milk [1]. Moreover, camel milk products are a good source of energy and nutrients [2]. The milk of the dromedary is considered a nutritious food, particularly when converted into yoghurt [3-5], although it is taking longer time to process camel milk into yoghurt [1, 3-5]. Moreover, it was reported that the difference in duration between camel's and cow's milk is due to difference in proteolysis and not to the presence of inhibitory substance in camel milk [1]. In particular, to be accepted by the consumers, there is a need to improve the consistency of yoghurt made from camel milk [5-7] as the production of acceptable camel milk yoghurt could be profitable for milk producers by allowing the use of surplus camel milk [3, 5, 7-9]. To extend the limited storage life of camel milk, it is mainly processed into fermented milk [2]. Moreover, the production of other innovative dairy products from camel, including ice cream, will help utilize this valuable milk [10, 11].

Yoghurt is one of the most popular fermented milk products worldwide for its nutritional and health benefits. Yoghurt made using camel milk (30%) was found to have significantly ($P < 0.05$) higher *in vitro* antidiabetic activity, indicating health benefits of camel milk when it is converted into yoghurt during manufacturing [12]. Yoghurt production from camel milk would diversify the dairy market and increase the income of camel keepers, and improve their livelihoods [13]. Yoghurt made from pure camel milk showed longer shelf life compared to that fortified with sheep milk, and if camel milk yoghurt is produced, marketing of camel milk will increase due to the health benefits of camel milk [5]. Moreover, camel milk's yoghurt can be prepared by incubation of camel milk at 42°C for 18 hours with the addition of some supplementary ingredients, as its acceptability can be improved with the use of fruits and some flavors [13]. Upon the use of 2.33% corn starch and 0.60% calcium chloride, camel milk required about 10 hours to be converted into yoghurt with desired properties of 0.35 Pa s viscosity, 4.07 pH, and 0.32% total titratable acidity [14].

Frozen yoghurt is a nutritious and refreshing dessert that combines the characteristics of ice cream and yoghurt [15-18]. The production process for frozen yoghurt was based on mixing and then freezing the natural stirred yoghurt, cold fruit syrup mix, stabilizer/emulsifier, and sugar [17].

Frozen yoghurt can be produced by fermentating an ice cream mix (i.e., direct acidification method) with cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *Bulgaricus* [18]. Frozen yoghurt can be regarded as a healthy alternative to ice cream for people with obesity, cardiovascular diseases, and lactose intolerance due to its low fat content and reduced lactose concentration [19]. The popularity of frozen yoghurt has increased and continues to grow, making it one of the most frequently consumed frozen desserts worldwide [20, 21]. Frozen yoghurt, which is produced under the proper conditions, can be stored between -18 and -35°C for 12 months [17]. Moreover, the probiotic guava frozen yoghurt and plain probiotic frozen yoghurt (PFY) were more appreciated in terms of structure and consistency after the 60th day of storage [15].

Date palm (*Phoenix dactylifera* L.) fruits are of diverse food and medicine traditions, and their high nutritional density is valuable in designing novel and improved products to satisfy the high demand for healthier foods [22]. Yoghurt enriched with 10% date had a significant sweetness record, the highest antioxidant values compared to plain yoghurt [23]. The addition of the date palm was reported to improve the viscosity, compositional quality, and sensory attributes of fermented camel's milk [24]. Moreover, the addition of banana to Moringa probiotic yoghurt resulted in a product with sensory qualities comparable to probiotic yoghurt alone [25]. The use of dates and fruits was reported for dairy products and non-dairy fermented foods [22]. Moreover, because camel milk is commonly used as a fermented product, reports on FCMY fortified with dates and banana fruits, to our best knowledge, are not well documented in scientific literature, specifically in the Northeastern region of Africa. Thus, the present study was done to produce functional FCMY fortified with dates and banana to utilize camel milk more economically as frozen yoghurt. The physicochemical properties and sensory characteristics of the products are also evaluated.

2. Materials and Methods

2.1 Processing of Frozen Camel Milk Yoghurt

The experimental procedures and analysis were done at the Department of Dairy Production, Faculty of Animal Production, University of Khartoum, during October and November 2018. A pilot experiment was conducted using 3, 5, 8, and 10% of selected fruits, and the study chose 5 and 8% of the fortified fruit according to the composition of the fruits used, the overall properties of the mix, and the preliminary result of sensory evaluation.

2.2 Source of Materials

Raw whole camel milk (20 liters) was obtained from a local farm in Khartoum North. Milk pasteurization was done at the Dall (CAPO) Dairy Factory. Bananas were purchased at the Central Market in Khartoum. The dates were obtained from the Al Arabi market. All chemicals and reagents used in this work were of analytical grade standard and procured from certified retailers.

2.3 Ingredients Mix of Processing Frozen Yoghurt

The mix consisted of stirred yoghurt (71% or 74%), dates (8% or 5%) or banana (8% or 5%), sugar (20%), and Gum Arabic (1%).

2.3.1 Dates (*Phoenix Dactylifera*)

The dates were prepared by removing the pits, then washed and mixed with yoghurt at either 5% or 8%. The local Sudanese dates (Khudri dates), which were mature, were the selected variety for this study.

2.3.2 Banana (*Musa Lutea*)

The famous Sudanese banana (Cavendish variety), was chosen for this study. To prepare the banana, it was first cleaned with water, then the outer shell was removed, and the pulp was cut into slices and mixed with camel yoghurt at 5% or 8%.

2.4 Preparation of Stirred Yoghurt

Processing of stirred yoghurt was performed as previously outlined [26], with slight modifications to milk pasteurization, and the incubation time that was extended to 18 hours [5]. The camel milk was pasteurized at 75°C for 15 seconds, then cooled to 45°C and transferred into plastic containers. It was inoculated with 3% w/w commercial starter culture yoghurt according to the instructions of the manufacturer (CHR-HANSEN, YoFlex® Express 1.0) and incubated for 18 hours (pH 4.6). The resultant stirred yoghurt samples were then divided into 4 portions, which were stored in a refrigerator at $4 \pm 1^\circ\text{C}$ overnight. Then, 4 types of treatments were prepared by adding 5 or 8% w/w of selected fruits to make frozen yoghurt.

2.5 Preparation of Frozen Camel Milk Yoghurt

Preparation of camel milk frozen yoghurt was done according to the procedure described previously [26]. The mix contains stirred yoghurt (74% or 71%), 20% sugar, 1% Gum Arabic, and banana or dates (5% or 8%) that were added while homogenizing the mix. The mix was divided into 4 portions, and one of the fruits (5% banana, 8% banana, 5% dates, or 8% dates) was added to each portion. Then each mix was made into an ice cream machine. The packaging was done in plastic cups (160 grams) and stored at -18°C in a stand freezer for 5 weeks. The range obtained for the total bacterial count of the final products revealed $\log 4.308 \pm 0.132$ and $\log 4.939 \pm 0.132$.

2.6 Chemical Analysis

2.6.1 Chemical Analysis of Banana and Date Fruits

The chemical tests of banana and date fruits were conducted in duplicate to assess the total solids, protein, and ash [27].

2.6.2 Milk Analysis

The analysis of the milk sample was performed using the milk analyzer Lactoscan (Milkotronic LTD, Europe) according to the manufacturer's instructions.

2.6.3 Chemical Analysis of Frozen Camel Milk Yoghurt

The AOAC modified method was used to determine the total solids content of FY samples by oven drying at 100°C [27]. The protein content was determined by the Kjeldahl method, and the ash content was determined gravimetrically [27]. The titratable acidity was determined by the titration (0.1 N NaOH) method, expressed as percent lactic acid [27].

2.7 Sensory Evaluation of Frozen Camel Milk Yoghurt

Ten semi-trained panelists familiar with dairy products were asked to judge the quality of FCMY on color, flavor, texture, taste, and overall acceptability.

Before moving to a new sample, the panelists were provided with water to clean their mouths. The evaluation was based on the 5-Scales Hedonic Rating scale [28]. Sensory evolution sheet (excellent = 5, very good = 4, good = 3, fair = 2, poor = 1) was used. Meanwhile, the score for each attribute was calculated as the average score recorded by the panelists, and the resulting data were subjected to statistical analysis.

2.8 Statistical Analysis

The experiment was designed as a $2 \times 2 \times 5$ factorial. The data were analyzed using SPSS software (version 21.0, SPSS Inc., Chicago). Significant differences between means were determined at $P \leq 0.05$ and separated by DUNCAN. Also, Statistic 8 was used to estimate the differences in interaction between the treatment and storage time.

3. Results and Discussion

3.1 Processing of Camel Milk Frozen Yoghurt

The total solids, protein, and ash of the banana and date fruits used in the present study are shown in Table 1. Meanwhile, fewer values were reported for the date syrup, which was found to contain 80.42% total solids, 1.67% protein, 0.98% fat, and 0.98% 2.08% ash [29]. According to the pilot experiment and available literature, two concentrations (5% and 8%) of the selected fruits were used.

Table 1 The chemical composition of banana and date fruits used for processing frozen camel milk yoghurt.

Fruits	Dry matter (%)	Fat (%)	Crude protein (%)	Crude fiber (%)	Ash (%)
Dates	90.25	1.25	6.68	3.20	3.16
Banana	22.40	0.80	8.30	0.88	1.32

Frozen camel milk yoghurt containing banana and dates was processed in the present study to assess its chemical and sensory properties. Previously, it was stated that the frozen yoghurt process consists of mixing all ingredients to make natural stirred yoghurt with stabilizers/emulsifiers and sugar, then freezing the mix in a conventional ice cream freezer [26].

This study indicates the possibility of using camel milk to produce a special, functional, and frozen yoghurt enriched with natural fruit. The possibility of using camel milk to produce special functional ice cream was previously highlighted [10]. Moreover, because of the rising interest in camel milk, converting it into products, particularly yoghurt, has been evaluated as a functional food [12]. Moreover, incorporating dates into food formulations will meet consumers' demand for natural, healthy foods [30].

The produced FCMY showed good compositional stability for 5 weeks during storage at -18°C . This goes in line with the findings, which concluded that pasteurization and refrigeration of camel fermented products improve keeping quality and extend shelf life [31]. Functional FCMY was produced in this study using dates and banana fruits. It was concluded that consumption of dates by patients suffering from diabetes and dyslipidemia will help in reducing their blood glucose, cholesterol, and triglyceride levels [32]. Dates might help reduce cognitive deficits caused by hypoglycemia by replenishing glucose stores and delivering essential antioxidants [33]. On the other hand, the flour obtained from green banana pulp and peel was found to have a significant ($P < 0.05$) effect on the chemical composition of ice creams [34]. Generally, the addition of different fruits revealed substantial variations in the chemical composition of camel milk ice cream [35].

3.2 The Chemical Composition of Frozen Yoghurt from Camel Milk

The higher average of total solids ($30.04 \pm 2.05\%$) was obtained for 8% BFCMY, and the lowest one ($27.33 \pm 2.05\%$) was found in 5% BFCMY (Table 2). Similarly, banana-stirred yoghurt revealed significantly ($P < 0.05$) higher values for total soluble solids when using 8% of banana juice [36].

Table 2 Chemical composition of frozen yoghurt made from camel milk using banana and dates.

Type of frozen yoghurt	Chemical composition			
	Total solids (%)	Protein (%)	Ash (%)	Acidity (%)
Banana (8%)	$30.04^a \pm 2.05$	$1.94^a \pm 0.02$	$0.608^a \pm 0.064$	$0.990^a \pm 0.013$
Banana (5%)	$27.34^a \pm 2.05$	$1.96^a \pm 0.02$	$0.600^a \pm 0.064$	$1.012^a \pm 0.013$
Dates (8%)	$29.12^a \pm 2.05$	$1.94^a \pm 0.02$	$0.613^a \pm 0.070$	$0.999^a \pm 0.013$
Dates (5%)	$28.62^a \pm 2.25$	$1.94^a \pm 0.02$	$0.616^a \pm 0.064$	$1.029^a \pm 0.013$
Significant level	$0.824^{\text{N.S}}$	$0.860^{\text{N.S}}$	$0.998^{\text{N.S}}$	$0.207^{\text{N.S}}$

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

N.S = not significantly different.

The obtained data revealed non-significant ($P > 0.05$) variation for the total solids content of frozen camel yoghurt across different fruits used, storage period, and their interaction (Table 2, Table 3, Figure 1). It was observed that as the level of fruit fortification in the mix increased, the total solids of frozen camel milk increased. This is mainly because of the high water content of camel milk [5, 7]. The present result supported the finding that chemical analysis showed no significant differences among the three levels of banana (10, 12, and 14%) in the percentages of fat, total solids, and solids not fat [37]. The results in Table 1 confirmed that dates are richer in dry matter, fat, and ash than those estimated for banana, which is rich in protein. Dates fortified samples revealed high

values (Table 2 and Table 3). Dates are rich in natural sugars, including glucose, fructose, and sucrose, which are helpful as a quick energy source for athletes [29, 38]. Dates are also an excellent source of dietary fiber and contain considerable amounts of lipids and protein [8, 39-43]. Meanwhile, adding dates (flesh or powder) to yoghurt appears to increase the dry matter content due to dates' high nutrient content, including sugars, proteins, fiber, and vitamins [39]. Similarly, the total solids were found to increase with increasing the percentage of dates added to fermented camel's milk products compared to the control [24, 28]. It was also observed that the addition of date syrup and bovine colostrum to yoghurt significantly enhanced the content of total solids, protein, and minerals compared to the control [40]. On the other hand, it was reported that there was an increase in protein content and the titratable acidity of samples with added dates compared to the control samples of ice cream from camel milk [41].

Table 3 The effect of storage period on the chemical composition of frozen yoghurt made from camel milk.

Storage period	Chemical composition			
	Total solids (%)	Protein (%)	Ash (%)	Acidity (%)
Week 1	26.92 ^a ± 2.29	1.78 ^b ± 0.02	0.225 ^a ± 0.017	0.899 ^a ± 0.015
Week 2	27.58 ^a ± 2.29	1.70 ^a ± 0.02	0.730 ^{bc} ± 0.017	1.037 ^b ± 0.015
Week 3	28.81 ^a ± 2.29	1.70 ^a ± 0.02	0.504 ^b ± 0.079	0.930 ^a ± 0.015
Week 4	32.64 ^a ± 2.29	2.20 ^c ± 0.02	0.815 ^c ± 0.017	1.088 ^c ± 0.015
Week 5	27.95 ^a ± 2.56	2.35 ^d ± 0.02	0.773 ^c ± 0.017	1.082 ^c ± 0.015
Significant level	0.448 ^{N.S}	0.001***	0.001***	0.001***

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

N.S = not significantly different.

*** = P < 0.001.

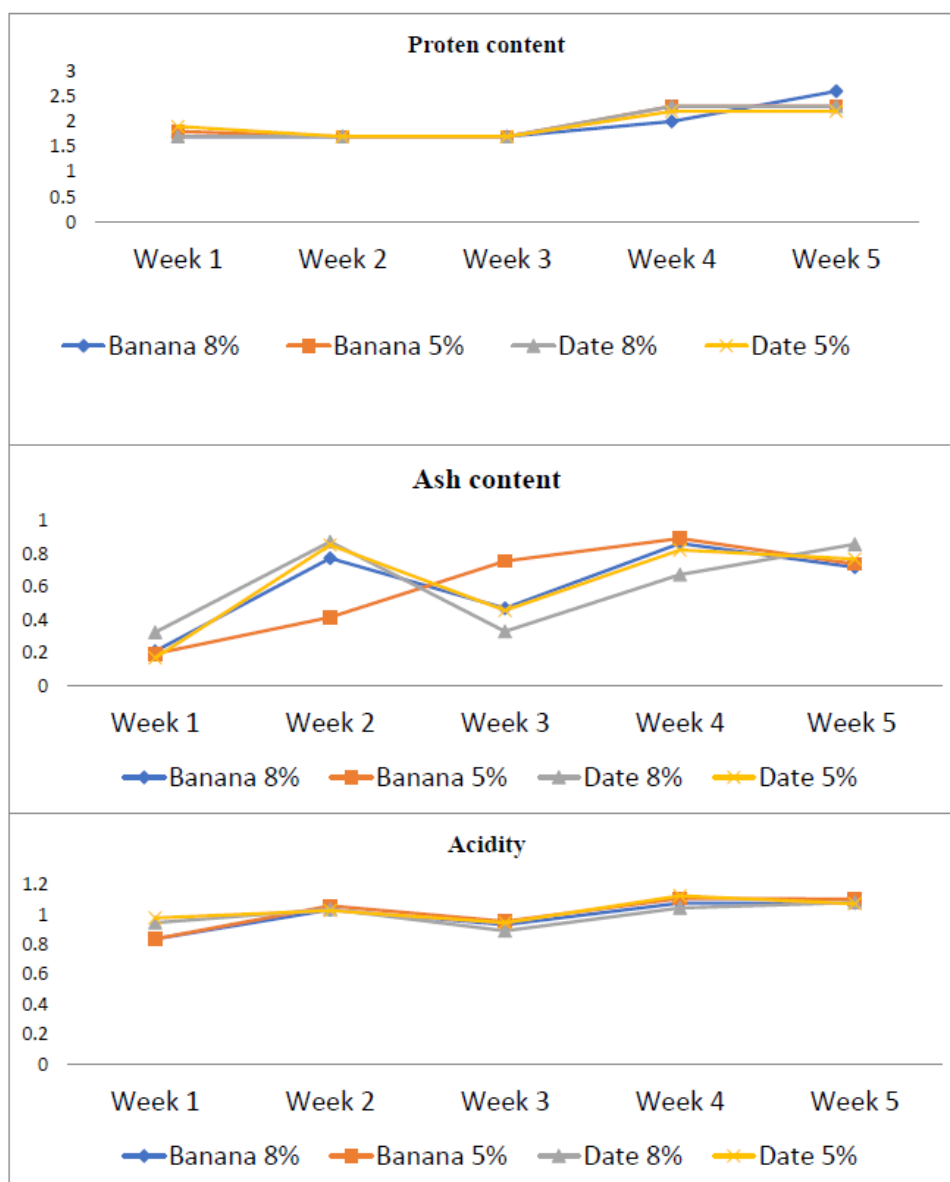


Figure 1 Composition of protein, ash, and acidity content of frozen yoghurt made from camel milk during the storage period.

The total or partial replacement of sucrose with dates flesh and dates powder improves the nutritional quality of yoghurts, such as protein, fat, ash, and dry matter [43]. The total solids content of fermented camel milk showed a significant ($P < 0.05$) increase with increasing the level of dates syrup fortification, and this increase was proportional to the level of dates syrup fortification [29]. Similar to the present study, non-significant changes in the total solids content of fermented camel milk were found during storage [29].

The highest protein content was found in 5% banana frozen yoghurt ($1.96 \pm 0.02\%$), compared to those flavored with 8% banana and 5% and 8% dates ($1.940 \pm 0.02\%$). Similarly, a lower level of protein content was reported in yoghurt made from pure camel milk [5, 7]. Previously, it was reported that banana-stirred yoghurt provides high-quality protein and fat content with significantly ($P < 0.05$) higher values when using 8% banana juice [36]. Meanwhile, the protein and fat showed a decreasing trend as the increase level of added date palm is increase in the fermented obtained

camel's milk products compared to the control [24]. This is because dates contain a small amount of protein and pectin [29]. However, it was reported that dates contain 0.5-3.9% pectin, which may have significant health benefits [42]. Also, the proteins are nitrogenous compounds used by lactic starters and bacteria for their growth and multiplication [43].

The protein content showed no significant differences ($P > 0.05$) between FCMY types (Table 2) or during storage (Table 3). However, the interaction between the treatment of different flavored FCMY during the storage period on protein content (Figure 1) revealed significant ($P < 0.05$) differences. The protein content was lower than the values reported for frozen yoghurt containing 5% apple and banana, which had significantly higher protein content (4.38%) [42]. Banana fruit was reported to contain considerable amounts of carbohydrates, dietary fibers, specific vitamins, and minerals [44]. Meanwhile, mixing yoghurt and banana provides high-quality protein, essential fatty acids, valuable minerals, and vitamins, which will benefit the consumers [36]. On the other hand, the use of banana purée as a nutrient source for the probiotic and polydextrose as a fat substitute in the set yoghurt was beneficial for both consumers and manufacturers [45]. Consuming yoghurt and banana together provides probiotics and prebiotics, which have a positive impact on the digestive and cardiovascular systems [36]. Moreover, the protein content of yoghurt samples was affected significantly by the addition of date syrup and colostrum [46].

It was also found that the total or partial replacement of the sucrose by date flesh and date powder improves the nutritional quality of the yoghurt, such as proteins [43]. However, total protein and fat content did not show significant changes upon fortification of date syrup into fermented camel milk [29].

The ash content revealed non-significant ($P > 0.05$) differences between different types of frozen camel milk yoghurt, with the highest mean of ash reported in 5% DFCMY ($0.616 \pm 0.064\%$), as shown in Table 2. This might be because the dates contained higher ash content than the banana (Table 1). Similarly, the total or partial replacement of the sucrose by date flesh and date powder was found to increase the ash and reduce the total sugars of yoghurt [43]. This will help the consumers who are suffering from dietary diseases. Whereas, banana-stirred yoghurt was found to contain the maximum ash value in samples fortified with 7% banana juice compared to those containing 0, 1, 3, 5, and 8% [36]. On the other hand, increasing the proportion of date syrup added to fermented camel milk resulted in a significant ($P < 0.05$) increase in ash and some mineral content, including sodium, potassium, and iron [29]. Also, higher ash and mineral content were reported for fermented camel's milk beverages compared to the control when the percentage of added date fruit was increased [24]. The present ash content was lower than that reported for frozen yoghurt (1.03%) [44]. It was also reported that ash content increased in samples with added dates compared to the control samples of ice cream made with camel milk [41]. Dates contain vital minerals [38]. Dates are rich in specific nutrients and provide a good source of minerals (0.10-916 mg/100 g dry weight), some vitamins (C, B1, B2, B3, and A), and with very little or no starch [46].

The ash content revealed significant ($P < 0.001$) differences between the different types of frozen yoghurt during the storage period (Table 3). The obtained values for the different flavored FCMY during the storage period for ash content (Figure 1) revealed non-significant ($P > 0.05$) differences. Similarly, non-significant differences were reported during storage in the ash, sodium, potassium, and iron content of fermented camel milk that was fortified with date syrup [29]. On the other hand, banana fruits showed rich mineral content, which might also influence ash content. This supported the findings that incorporating banana into yoghurt resulted in a significant increase in mineral

content, particularly calcium, magnesium, and potassium [47]. Date pits also contain considerable amounts of minerals. In addition to their dietary use, dates are of medicinal use and are used to treat a variety of ailments in the various traditional systems of medicine [39].

The highest mean acidity was observed in 5% DFCMY ($1.029 \pm 0.013\%$), and the lowest in 8% BFCMY ($0.990 \pm 0.013\%$). However, fortification with a low level of (4.5%) date fiber did not cause significant changes in yoghurt acidity, although pH increased [8]. This supported the finding that the titratable acidity of fermented camel milk increased significantly ($P < 0.05$) when 8% date syrup was added compared with 6% [29]. This might be due to the activity of the yoghurt starter culture and/or their enzyme systems [48].

When using 7% banana juice to make a stirred yoghurt, the highest titratable acidity was found compared to those containing 0, 1%, 3%, 5% and 8% banana juice [36]. Acidity content showed no significant ($P > 0.05$) differences between the different types and concentrations of frozen camel milk yoghurt (Table 2). The total titratable acidity content increased with increasing date honey concentration in dairy desserts, while the pH decreased [49]. The final product of frozen yoghurt should have a pH of 3.45-4.65 and acidity of 0.78-1.20% [50].

The prolonged fermentation time (2-22 hours) resulted in increased total titratable acidity and decreased pH in yoghurt [14]. Meanwhile, the acidity content revealed significant ($P < 0.001$) differences between the different types and concentrations of frozen yoghurt during the storage period (Table 3 and Figure 1). It was observed that the rate of acidity increase was slow at the beginning of incubation and storage in yoghurt samples made from pure camel milk [5]. However, the titratable acidity of fermented camel milk revealed non-significant differences during the storage period [29]. It was previously reported that titratable acidity increased in ice cream samples fortified with dates compared to control samples from camel milk [41]. The difference in acidity is a reflection of the content of the lactic starter culture, which supported the previous study showing that camel milk samples had significantly ($P < 0.05$) higher *Streptococcus thermophilus* count on the first day of storage compared to the control yoghurt [12].

3.3 Sensory Characteristics of Camel Milk Frozen Yoghurt

The color scores of camel milk frozen yoghurt obtained in this study were not significantly ($P > 0.05$) different among all flavoring frozen yoghurt samples. The frozen yoghurt made from camel milk required more time for melting than that from cow milk [42]. The highest mean color score was observed in 5% BFCMY (4.00 ± 0.18), while the lowest was observed in 8% DFCMY (3.78 ± 0.18), as shown in Table 4. Similarly, the different concentrations of date paste added to the yoghurt revealed significant scores for color and appearance [51]. In a different study, yoghurts fortified with date fiber showed a darker color compared with control yoghurts [8]. Moreover, the consumer test results indicated that the appearance [29] and color ratings were significantly affected by fiber fortification [8]. However, the appearance of probiotic fermented camel milk was improved after the addition of date syrup at a level of 8%. However, the incorporation of different varieties of banana in the formulation of frozen yoghurt revealed variable values for protein content. The color, taste, texture, and overall likeness of frozen yoghurt were reported to vary across different varieties of banana [52]. Meanwhile, there were no significant ($P > 0.05$) differences between the interaction of the different treatments and storage periods on the color score of FCMY (Table 5 and Figure 2).

Table 4 The sensory characteristics (mean $\pm$ SE) of banana and dates camel milk frozen yoghurt.

Treatment	Sensory characteristics scores				
	Color	Flavor	Taste	Texture	Overall acceptability
Banana (8%)	3.86 ^a $\pm$ 0.18	3.56 ^a $\pm$ 0.15	3.30 ^a $\pm$ 0.15	3.54 ^a $\pm$ 0.14	3.50 ^a $\pm$ 0.14
Banana (5%)	4.00 ^a $\pm$ 0.18	3.38 ^a $\pm$ 0.15	3.42 ^a $\pm$ 0.15	3.62 ^a $\pm$ 0.14	3.42 ^a $\pm$ 0.14
Dates (8%)	3.78 ^a $\pm$ 0.18	3.62 ^a $\pm$ 0.15	3.48 ^a $\pm$ 0.15	3.88 ^a $\pm$ 0.14	3.66 ^a $\pm$ 0.14
Dates (5%)	3.84 ^a $\pm$ 0.18	3.64 ^a $\pm$ 0.15	3.56 ^a $\pm$ 0.15	3.70 ^a $\pm$ 0.14	3.64 ^a $\pm$ 0.14
Significant level	0.85 ^{N.S}	0.60 ^{N.S}	0.64 ^{N.S}	0.38 ^{N.S}	0.58 ^{N.S}

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

N.S = Non-significant.

SE = standard error.

Table 5 The effect of storage period on the sensory characteristics (mean $\pm$ SE) of banana and dates frozen yoghurt made from camel milk.

Storage period	Sensory characteristics scores				
	Color	Flavor	Taste	Texture	Overall acceptability
Week 1	4.20 ^b $\pm$ 0.20	4.03 ^c $\pm$ 0.17	3.63 ^a $\pm$ 0.16	4.23 ^c $\pm$ 0.16	4.00 ^{ac} $\pm$ 0.16
Week 2	3.90 ^{ab} $\pm$ 0.20	3.48 ^b $\pm$ 0.17	3.58 ^b $\pm$ 0.16	3.73 ^b $\pm$ 0.16	3.43 ^b $\pm$ 0.16
Week 3	3.78 ^{ab} $\pm$ 0.20	3.53 ^b $\pm$ 0.17	3.58 ^b $\pm$ 0.16	3.78 ^a $\pm$ 0.16	3.68 ^{bc} $\pm$ 0.16
Week 4	3.43 ^a $\pm$ 0.20	2.98 ^a $\pm$ 0.17	2.90 ^b $\pm$ 0.16	3.00 ^b $\pm$ 0.16	2.93 ^b $\pm$ 0.16
Week 5	4.05 ^b $\pm$ 0.20	3.75 ^{bc} $\pm$ 0.17	3.53 ^b $\pm$ 0.16	3.70 ^b $\pm$ 0.16	3.75 ^{bc} $\pm$ 0.16
Significant level	0.072 ^{N.S}	0.001 ^{***}	0.009 ^{**}	0.001 ^{***}	0.001 ^{***}

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

N.S = Non significant.

** = P < 0.01.

*** = P < 0.001.

SE = standard error.

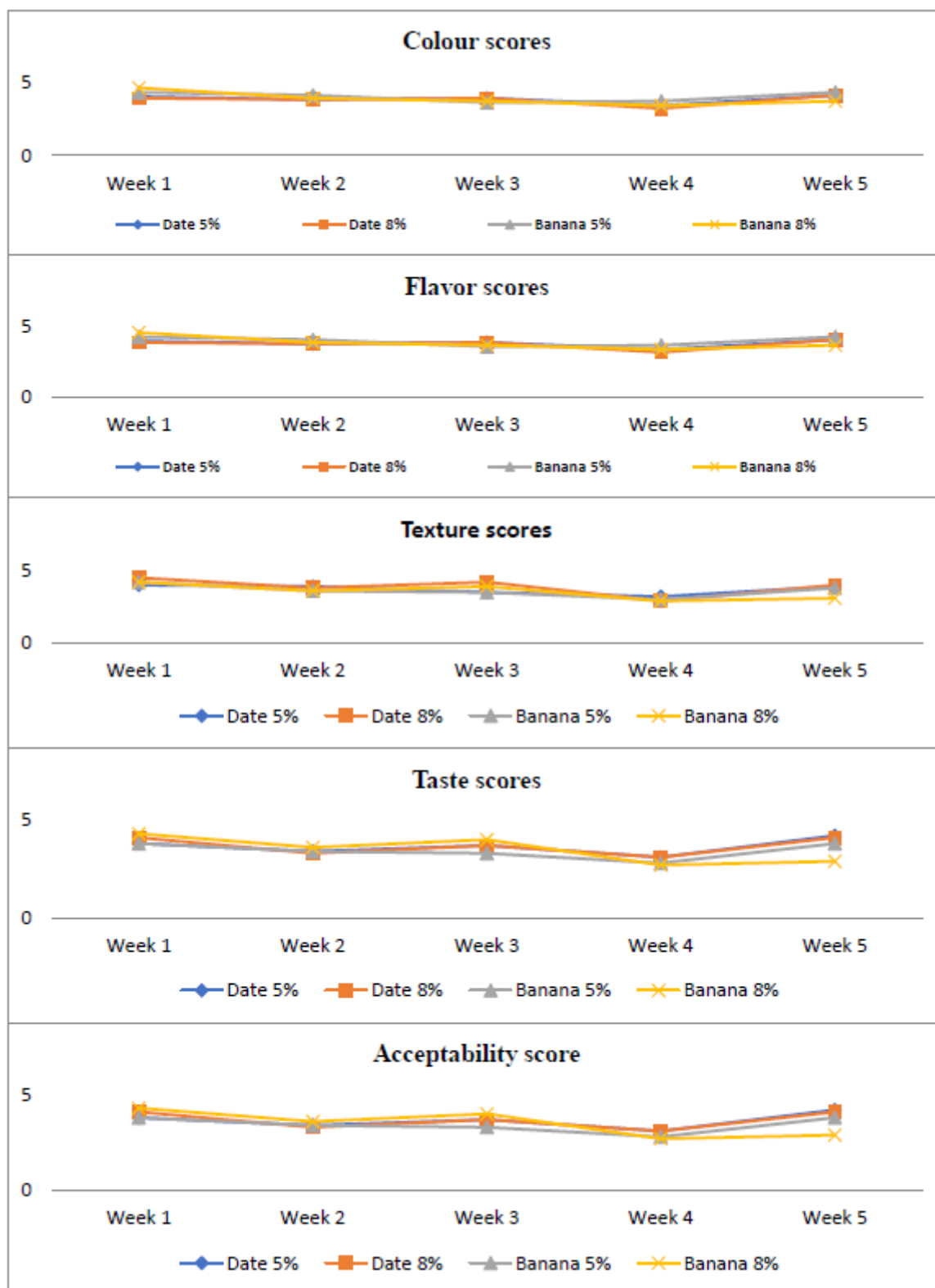


Figure 2 Scores of overall acceptability for banana and dates frozen yoghurt samples made from camel milk during the storage period.

The color and appearance scores estimated for probiotic-frozen yoghurt revealed significant ($P < 0.05$) differences during the storage period [53]. Moreover, the addition of date syrup at 8% resulted in the highest sensory scores for probiotic fermented camel milk [29].

The present results showed non-significant ($P > 0.05$) differences in the flavor scores (Table 4 and Figure 2) between the different flavored frozen yoghurt samples made from camel milk. The highest score was obtained for 5% DFCMY (3.640 ± 0.150), followed by 8% DFCMY (3.620 ± 0.150). Similarly, the flavor ratings were significantly affected by date fiber fortification in yoghurt [8]. Meanwhile, the addition of 15% date paste to the yoghurt resulted in substantially higher flavor scores than at other added levels [51]. Flavour scores of the frozen yoghurt made from camel milk constituents were substantially lower ($P < 0.05$) than those made from cow milk [42].

The addition of date syrup also significantly ($P < 0.05$) improved the sensory scores for flavor of probiotic fermented camel milk flavored with 8% date syrup [29]. Incorporation of date honey showed enchantment of dairy desserts' flavor, in addition to its significant health benefits, and thus the positive role in the creation of functional foods [49].

Significant ($P < 0.05$) variations were obtained during the storage period (Table 5), while there was a non-significant ($P > 0.05$) difference as a result of the interaction between the different frozen camel milk yoghurt samples and storage period for flavor score (Figure 2). Flavour scores of the frozen yoghurt made from camel milk were significantly ($P < 0.05$) lower than those made from cow milk [54]. The color and flavor ratings were affected considerably by fiber fortification [9]. Similarly, the different concentrations of date paste added to the yoghurt revealed significant scores for color, appearance, flavor, body, texture, and flavor, body, and texture, and flavor 15% date paste and acidity [51]. These results could be explained on the basis that the addition of date syrup masks the salty flavor of camel milk. These results agree with those stating that the addition of 3% date syrup or dried date extracts improved the flavor of fermented milk [23, 40]. On the other hand, the addition of baobab or papaya fruits to camel milk was found to improve the flavor of ice cream [35].

The highest mean taste score was found in 5% DFCMY (3.560 ± 0.146), and the lowest mean was reported for 8% BFCMY (3.300 ± 0.146), as shown in Table 4. This study supported those who concluded the maximum sweetness obtained, possibly due to the increase in fructose content in the samples, as fructose is sweeter than glucose [47]. Replacing sucrose with dates was found to improve the taste of yogurts [23, 43]. Dates have a sweet taste and are a good source of natural sugars in addition to other valuable bioactive compounds [38], as most of the carbohydrates in dates are in the form of glucose and fructose, which are easily absorbed by the human body [43]. On the other hand, at the onset of ripening, stored starch in bananas is converted to simpler sugars such as sucrose and glucose [54]. Using fruits containing high fructose, such as bananas, will contribute positively to the inherent sweetness [55].

In Table 4, the taste score revealed non-significant ($P > 0.05$) differences between the different fruits used in frozen camel milk yoghurt samples. Also, there were no significant ($P > 0.05$) differences between the interaction of the other treatments and storage periods for taste scores of FCMY (Table 5 and Figure 2). However, the taste and odor scores were improved significantly ($P < 0.05$) during storage of probiotic-frozen yoghurt [53]. This might be because the taste of camel milk is usually sweet when camels are fed on green fodder [56]. On the other hand, when fruits are fortified into yoghurt, the consistency, viscosity, and mouthfeel are improved due to the pectin and sugar content of the fruits [57].

The present result showed that the highest score of texture was recorded for frozen camel milk yoghurt fortified with 8% and 5% dates (3.880 ± 0.143 and 3.700 ± 0.143 , respectively). Yoghurts fortified with date fiber had firmer texture compared to the control, and that yoghurt fortified with up to 3% date fiber had similar firmness as the control yoghurt [8]. However, the lowest score was

obtained for frozen camel milk yoghurt fortified with 8% banana, as shown in Table 4. This aligns with the result showing that adding 15% date paste resulted in the best score for the body and texture of yoghurt [51]. It was reported that the presence of date pectin allows the product to dissolve easily in the mouth [47].

The texture score of frozen camel milk yoghurt, as recorded by panelists, showed non-significant ($P > 0.05$) differences using different flavoring fruits (Table 4) and due to the interaction of the various treatments and storage periods for texture score (Figure 2). However, there were significant ($P < 0.001$) differences between different treatments of frozen camel milk yoghurt samples during the storage period (Table 5). Similarly, the structure and consistency values were significantly ($P < 0.05$) recorded on the first day compared to the advancement of the storage period of probiotic-frozen yoghurt [53]. In this study, it was proven that the watery texture of camel milk frozen yoghurt is corrected by incorporating both dates and banana in the mix. Also, the present result was in agreement with those found that replacement of the sucrose with dates improves the texture of yoghurts [43]. Also, yoghurts fortified with date fiber had firmer texture [9]. The addition of 8% date syrup significantly ($P < 0.05$) increased consistency scores for probiotic fermented camel milk [29]. On the other hand, protein and fat are commonly added to combat the defects in texture, physical properties, and mouthfeel of low-fat yoghurt [58]. Because yoghurt texture is an important characteristic that affects its quality and consumer acceptance, many attempts were conducted to solve the problems related to the poor texture of fermented camel milk and to produce set-type yoghurt from this milk. Of which, the addition of hydrocolloids and stabilizers [59] or fortification with sheep milk [5]. Nevertheless, it was reported that yoghurt, which has a low viscosity but a complex structure, can be produced using twice the main components of milk and yoghurt culture in twice their amounts [9].

The highest mean overall acceptability score was recorded in 8% DFCMY samples (3.660 ± 0.143), while a lower mean was observed in 5% BFCMY samples (3.420 ± 0.143). Moreover, the use of date as a new flavor in the fermented camel milk can provide high nutritional and health value. It could attract consumers, as it does not contain refined sweeteners, artificial additives, and preservatives [29]. However, the sensory scores of banana-stirred yoghurt are significantly ($P < 0.05$) higher as judged by the panelists for yoghurt containing 5% compared to those fortified with 0%, 1%, 3%, 7% and 8% banana juice [36]. Similar to the present result, probiotic fermented camel milk flavored with date syrup at 8% showed improved total scores for the resultant products [29]. Moreover, the highest score was reported for yoghurt prepared with 15% date paste, followed by 10%, compared with the control yoghurt [51]. This is because the date fruits, and its co-products were reported to improve the sensory, nutritional, and nutraceutical qualities of a wide range of dietary items [22].

The overall acceptability scores revealed non-significant ($P > 0.05$) differences between different types of frozen camel milk yoghurt (Table 4). The addition of fruits for preparing yoghurts was found to improve their color, aroma, and texture [55]. Similarly, there were no significant differences ($P > 0.05$) in the interaction between treatments and storage periods for overall acceptability scores (Figure 2). This indicates that the addition of some fruity ingredients in the formulation of yoghurt resulted in more acceptance by the consumers [52]. However, the acceptability score revealed highly significant ($P < 0.001$) differences between the different types of frozen camel milk yoghurt during storage (Table 5). The present result supported the previous report, showing that fermented camel's milk beverages fortified with 10% to 20% date palm fruits showed good properties and higher sensory scores compared to the control during the storage periods [24]. The addition of date

syrup to yoghurt improved its organoleptic characteristics [60]. The present result supported the previous robust finding that the total acceptability scores for probiotic-frozen yoghurt were significantly improved ($P < 0.05$) during storage [53]. Yoghurt fortified with up to 3% date fiber revealed similar overall acceptance ratings similar to those of the control yoghurt [8]. Moreover, ice cream made from camel milk, with or without dates, was acceptable, acclaimed by the arbitrators, and showed no defects [41].

In this study, the panelists liked the aroma of dates. Similarly, it was concluded that dates may be considered as an almost ideal food, providing a wide range of fruit-flavoured yoghurts [46]. In a previous report, the panel test showed no significant differences among the three banana levels in sensory evaluations, and the 14% sample received the highest score [37]. Moreover, the sensory results showed that ice cream samples containing date fibre at 1% and 2% received the highest scores from panelists [34]. On the other hand, an acceptable fruit-based probiotic yoghurt can be produced by adding ripe banana to the yoghurt mix [61]. Yoghurt containing 7.5% banana was most satisfactory and contained 148 kcal 100 g⁻¹, 76.81% moisture, 12.37% carbohydrates, 6.18% protein, 3.35% fat, 0.77% ash, and 1.04% calcium. Moreover, frozen yoghurt is often consumed by lactose-sensitive people, replacing ice cream, as the live cultures can help to digest the lactose [19]. Frozen yoghurt is a fermented frozen dairy dessert that blends the physical qualities of ice cream with the sensory and nutritional benefits of fermented milk items. Because of its low-fat content, frozen yoghurt may be considered a healthier alternative to ice cream [52]. This is because fermented camel milk is rich in nutrients and vitamins essential to human health and has therapeutic properties [29]. It is worth noting that higher antioxidant activity has been reported for both fermented camel milk [62-64] and banana-fortified yoghurt [55, 65-67]. Moreover, the phytochemicals in date fruits have shown significant antioxidant capacities [22, 29, 33, 39, 51, 67-69].

4. Conclusions

Frozen yoghurt can be processed by adding dates and banana at 5% or 8% using camel milk. There was no significant effect on the compositional content, the acidity, and the color score between the different types of frozen camel milk yoghurt. However, the means of other measured sensory attributes revealed significant ($P < 0.05$) differences in flavored FCMY samples. The effect of storage period showed substantial variation in protein, ash, and acidity content, and in the scores for flavor, taste, texture, and overall acceptability, while there was no significant difference in total solids and color score. Both 5% and 8% BFCMY and DFCMY have good sensory properties, especially 5% BFCMY. The present study encourages the processing and consumption of frozen camel milk yoghurt using indigenous fruits, including dates and bananas, as a functional food. The practical applications of the present study include the use of camel milk as an alternative to ice cream for people with diabetes and heart disease. However, further research should be conducted to develop frozen camel milk yoghurt using local fruits and to conduct clinical trials in humans suffering from certain diseases.

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Author Contributions

Ola Mohamed contributed to the study's design, performed the experiments and conducted data analysis, interpreted the results and drafted the manuscript. Ibtisam El Zubeir supervised the candidates work, approved the design and the results obtained and finalized the manuscript. The 2 authors approved the final version of the manuscript.

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Competing Interests

The authors would like to declare that there is no conflict of interest regarding this manuscript.

Data Availability Statement

The data used in the present study will be available upon the request from the corresponding author.

AI-Assisted Technologies Statement

The authors would like to declare that only Google scholar and Grammarly of AI-assisted tools are used during writing this manuscript. All scientific content, data interpretation, and conclusions were developed independently by the author. The authors have thoroughly reviewed and edited the AI-assisted text to ensure its accuracy and accept full responsibility for the content of the manuscript.

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