REVISTA
DO INSTITUTO DE LATICÍNIOS CÂNDIDO TOSTES
v. 79, n. 1, jan-mar 2024

EPAMIG
Pesquisa Agropecuária

*Research Article* DOI: 10.14295/2238-6416.v79i1.955

# PRODUCTION OF FUNCTIONAL ICE CREAM WITH PROBIOTIC ADDITION FROM CAMEL MILK

**Produção de sorvete funcional com adição de probiótico a partir de leite de camela**

*Selda Bulca[1], Monica Bayrakçıoğlu[1], Oğuzhan Yıldırım[1], Nergiz Yüksel[1*]*

## ABSTRACT

In recent years, the use of camel milk has gained popularity due to its nutritional and health benefits, such as its anticancer, antidiabetic, antioxidant, antiobesity properties, and against autism. Therefore, the primary objective of this study was to incorporate these properties of camel milk into ice cream production. Camel milk is also known to provide a favorable environment for the growth of probiotic bacteria. To assess this potential, *Bifidobacterium bifidum* probiotic bacteria were added to ice cream samples made from 100% camel milk (with and without probiotic addition - Control), a mixture of 50% cow milk and 50% camel milk, and 100% cow milk. It was observed that the growth of probiotics was highest in ice cream made from 100% cow milk. Additionally, various analyses were conducted on the ice cream samples, including viscosity, first dripping time, complete melting time, overrun, total dry matter, volatile compounds, and sensory analyses. In the physicochemical tests, the ice cream produced from 100% camel milk with probiotic addition exhibited the lowest pH and viscosity values. Differences in viscosity values were attributed to variations in the dry matter content of the ice creams. Among the four ice cream samples, the mixture of 50% cow milk and 50% camel milk displayed the shortest first dripping and complete melting time. Sensory analysis results indicated that the most preferred ice cream was the one made from 100% camel milk without probiotic addition. 2-heptanone was detected in all four ice cream samples, with its concentration being highest in the cow milk ice cream.

**Keywords:** *Bifidobacterium bifidum*, viscosity, overrun, sensory properties.

## RESUMO

Nos últimos anos, o uso do leite de camelo ganhou popularidade devido aos seus benefícios nutricionais e de saúde, como suas propriedades anticancerígenas, antidiabéticas, antioxidantes, antiobesidade e contra o autismo. Portanto, o objetivo primário deste estudo foi incorporar essas

1 Aydın Adnan Menderes University, Zafer, Efeler, 09010, Aydın, Turquia. E-mail: nergiz.yuksel@adu.edu.tr

*Autor para correspondência

***Recebido / Received: 20/06/2023***
***Aprovado / Approved: 15/03/2024***

propriedades do leite de camelo na produção de sorvetes. O leite de camelo também é conhecido por apresentar um ambiente favorável para o crescimento de bactérias probióticas. Para avaliar esse potencial, bactérias probióticas *Bifidobacterium bifidum* foram adicionadas às amostras de sorvete feitas com 100% de leite de camelo (com e sem adição de probiótico - Controle), uma mistura de 50% de leite de vaca e 50% de leite de camelo e 100% de leite de vaca. Observou-se que a multiplicação de probióticos foi maior no sorvete feito com 100% de leite de vaca. Além disso, várias análises foram realizadas nas amostras de sorvete, incluindo viscosidade, tempo de primeiro gotejamento, tempo de derretimento, *overrrun*, matéria seca total, compostos voláteis e análises sensoriais. Nos testes físico-químicos, o sorvete produzido a partir de leite 100% camelo, com adição de probióticos, apresentou os menores valores de pH e viscosidade. As diferenças nos valores de viscosidade foram atribuídas a variações no teor de matéria seca dos sorvetes. Entre as quatro amostras de sorvete, a mistura de 50% de leite de vaca e 50% de leite de camelo apresentou o menor tempo de primeiro gotejamento e derretimento completo. Os resultados da análise sensorial indicaram que o sorvete preferido foi aquele feito com 100% de leite de camelo sem adição de probióticos. A 2-heptanona foi detectada em todas as quatro amostras de sorvete, sendo sua concentração mais alta no sorvete de leite de vaca.

**Palavras-chave**: *Bifidobacterium bifidum*, viscosidade, *overrun*, propriedades sensoriais.

## INTRODUCTION

Today, the demand for functional foods has increased due to changing lifestyles and people's preference for healthier food choices. Among milk products, functional products such as yogurt, cheese, kefir, and koumiss play an important role. Ice cream is produced by adding various ingredients and bacteria and is also recognized as a functional food (TAŞDEMIR, 2017).

Typically, ice cream is made by pasteurizing the ice cream mixture and then freezing it. The mixture consists of milk, cream, milk powder, sugar, and additives. It comes in many varieties and is enjoyed by people of all ages as a refreshing dessert, particularly during hot summer days (TÜRKMEN; GÜRSOY, 2017). In numerous countries, a significant portion of the milk produced is used for ice cream production.

Camel milk, a valuable food source consumed by nomadic people, has been recognized for its nutritional and medicinal properties for a long time (YADAV *et al.*, 2015). Recent studies indicate that the consumption of camel milk worldwide has increased over the past 50 years, reaching 3.11 million tons (KOÇ; ATASEVER, 2016). The growing popularity of camel milk can be attributed to its reported medicinal properties, such as cancer prevention, diabetes management, hypertension control, alleviation of allergic symptoms, and potential benefits for individuals with autism (KASKOUS, 2016). Additionally, camel milk is considered hypoallergenic due to the lack of the β-lactoglobulin fraction. Its high content of unsaturated fatty acids, lactoferrin, immunoglobulins, lysozyme, and vitamin C contribute to the overall quality of the diet (KONUSPAYEVA, 2009). The presence of protective proteins such as lysozymes, immunoglobulins, lactoperoxidase, peptidoglycan recognition protein (PGRP), and N-acetyl-β-glucosaminidase (NA Gas) suggests potential immunological effects (YADAV, 2015). While camel milk shares similarities with cow's milk, there are chemical composition differences, particularly in terms of protein and fat, which can impact milk processing, viscosity, heat stability, and the challenges of processing in dairy products. However, the functional properties of camel milk offer new opportunities for product development (IPSEN, 2017). The use of camel milk in ice cream production does not appear to require significant changes in processing parameters. However, studies have reported that the differences in composition and colloidal structure can influence the quality and storage stability of camel milk ice cream (SONI; GOYAL, 2013).

Due to the low production rate and challenges associated with processing camel milk products, it is recommended to use camel milk as a mixture with other types of milk (BREZOVEČKI *et al*., 2015). While there have been studies on camel milk products such as cheese, yogurt, and other products, limited published data are available specifically on camel milk ice cream. In a previous study, Abu-Lehia *et al*. (1989) focused on the production of ice cream using camel milk. They found that ice cream can be produced using a mixture of 12% fat, 11% skim milk, and in the study of Mehta *et al*. (2019) ice cream was produced by enrichment of solid content on 37%. Increasing the fat and milk solid non-fat (MSNF) levels resulted in higher viscosity, but fat levels between 4% and 12% led to a decrease in the melting time of the ice cream. Another study by SAYAR *et al*. (2022) reported that camel milk can be used with the addition of blueberry in new ice cream formulations to create a nutritional and functional product.

Ice cream, being an important dairy product, provides a favorable environment for the growth of probiotics, enabling them to thrive and enhance their metabolic activity (GRANATO *et al*., 2010). Probiotics, such as *Bifidobacterium bifidum*, are living microorganisms that have positive effects on the gastrointestinal tract when consumed in sufficient quantities. LILY and STILLWELL, (1965) defined them as beneficial microorganisms for the digestive system. Prebiotics, on the other hand, are non-digestible food ingredients that promote the growth and activity of specific bacteria in the colon. Symbiotic refer to the combination of probiotics and prebiotics (TÜRKMEN; GÜRSOY, 2017). *Bifidobacterium bifidum* is a member of the bifidobacterium species, characterized as rod-shaped, gram-positive, and anaerobic bacteria (BIAVATI *et al*., 2000). Apart from their beneficial probiotic effects, they are also used in the food industry (MUŞ, 2018). Studies have shown that camel milk provides a suitable environment for the growth of lactic acid bacteria, particularly those with probiotic properties beneficial for human health (YATEEM *et al*., 2008). Camel milk has been found to be a rich source of microflora, especially in terms of Lactic Acid Bacteria (LAB) and Bifidobacteria. In one study, eight strains of bifidobacteria were isolated from raw camel milk and evaluated for their probiotic potential. Positive results were obtained in gastric juice and bile salt experiments, demonstrating the effectiveness of the probiotic strains (YASMIN *et al*., 2020).

The aim of this study was to produce four different ice creams. These are 100% camel milk with and without the addition of probiotics, 50% camel milk and 50% cow milk mixture, and 100% cow milk with the addition of probiotic strain. The second aim of this study is to evaluate the physical, chemical, microbiological, and sensory properties, volatile compounds of the ice cream samples and to compare them.

## MATERIALS AND METHODS

### Materials

Raw camel milk was obtained from a camel farm in İncirliova/Aydın, and raw cow milk was obtained from the local market. In this study, freeze dried *Bifidobacterium bifidum* (BB-12) strain was obtained from Chr. Hansen' Laboratorium Denmark A/S, Izmir. Sugar was obtained from local markets. Inulin was obtained from Smart Kimya Tic. and Dan. Ltd. Sti Çiğli/Izmir-Türkiye. Pure Sahlep was obtained from Herbal Vital online shop.

### Methods

In this study, we produced four different milk samples using the following compositions: 100% pure camel milk (with and without the addition of probiotics); a mixture consisting of 50% camel milk and 50% cow's milk; and 100% pure cow's milk with the addition of *Bifidobacterium bifidum*. After production, viscosity, first dripping time, complete melting time, overrun, total dry matter, titratable acidity, pH, volatile compounds and sensory analysis were performed on all ice cream samples shown in Figure 1.

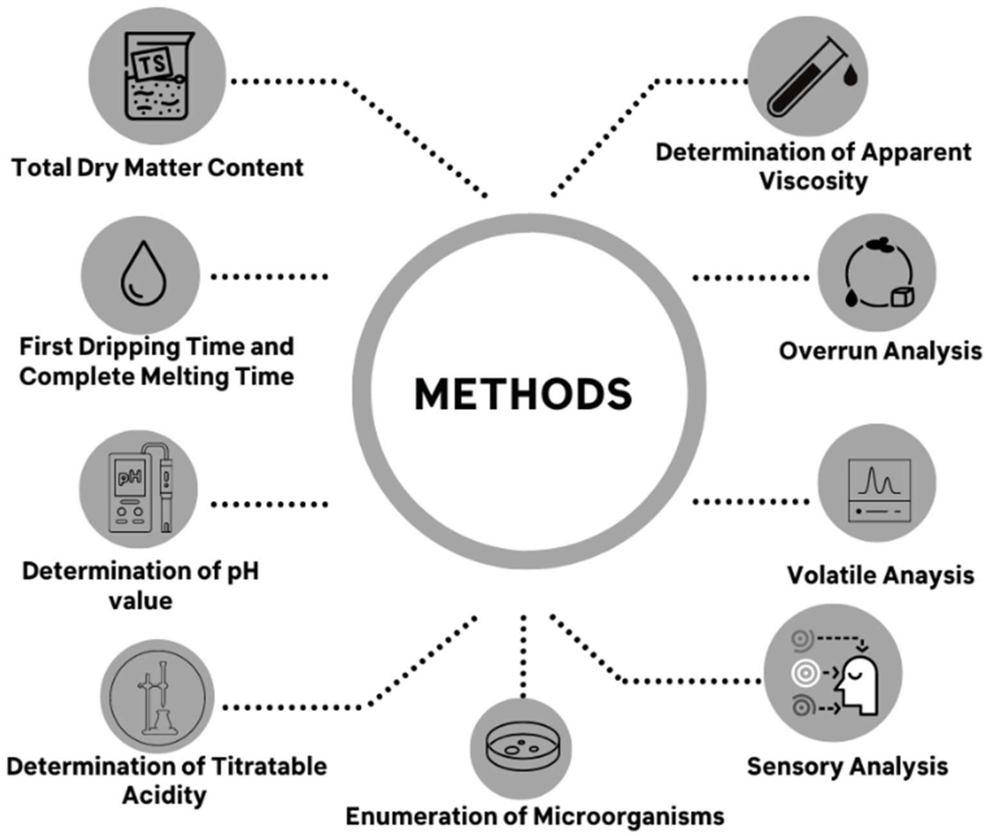


**Figure 1.** Schema of the methods applied

*Ice cream production*

100% camel milk without probiotic addition was indicated as the control group. The ingredients of the ice cream mix and their ratios were shown in Table 1. Sahlep was used as stabilizer in ice cream mix.

The ice cream mixture was produced according to Figure. 2. The mixture was pasteurized at 75 °C for 15 minutes in a water bath and cooled to 40 °C. *B. bifidum* culture containing $10^8$ CFU/g was then added to the mixture. All ice cream mixes and fermented at 40°C using an incubator until the pH arrived to 5.5. The control group, for which 100% camel milk was used, was prepared without *B. bifidum* addition. After the fermentation process, the ice cream mixes were cooled to 5 °C and kept at 4 °C for 24 hours. Afterwards, ice cream was frozen with a Delonghi ice cream machine and the samples were kept at -18 °C.

**Table 1**. The list of added ingredients in ice cream mix

| Ingredients | Amount of Ingredients | Percentage of Ingredients (%) |
|---|---|---|
| Milk | 1000 mL | 77 |
| Sugar | 150 g | 12 |
| Non-fat dry matter | 80 g | 6 |
| Fat | 30 g | 2 |
| Inulin | 20 g | 1 |
| Stabilizer (Sahlep) | 5 g | 0.3 |

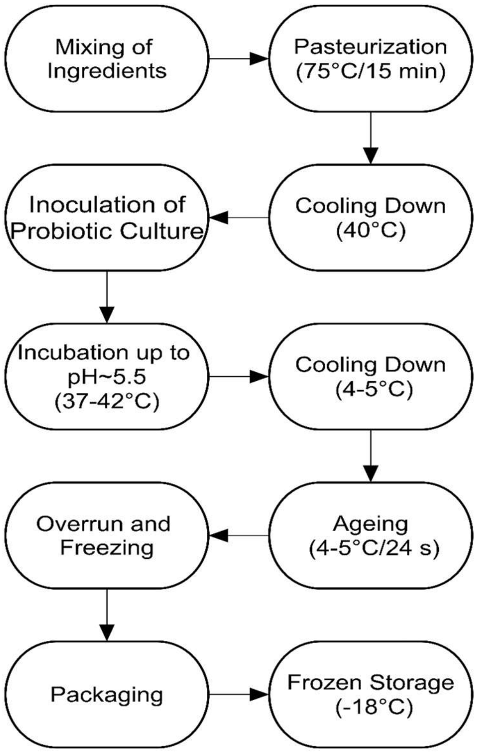


**Figure 2**. Flow chart of ice cream production

*Determination of total dry matter content of milk*

Determination of dry matter in camel milk and cow milk samples were determined using gravimetric method (ÖNER; ALOĞLU, 2018).

*Determination of Titratable Acidity (%) of Milk*

Titration acidity in camel milk and cow's milk was determined by the Soxhlet Henkel method. 1-2 drops of Phenolphthalein indicator were added into 100 mL of milk and neutralized with 0.25 N NaOH solution. The amount of spent NaOH was then defined as the titration acidity (BEKIROĞLU; ÖZDEMIR, 2020).

$$SH = (Used\ volume\ of\ 0.25\ N\ NaOH) \times 4$$

The titratable acidity of ice-cream samples determined by the Soxhlet–Henkel method is given by the number of milliliters of 0.25 N NaOH solution consumed in titrating 100 mL of sample with phenolphthalein as indicator. The results are expressed as Soxhlet–Henkel degrees (SH).

$$LA(\%) = SH \times 0.0025$$

*Determination of pH value*

Determination pH values of ice cream mix and milk samples were measured by using Milwaukee MW102 pH meter.

*Determination of Apparent Viscosity*

The viscosity of the melted ice cream was measured at 25 °C using a Fungilab Viscometer (V301002 Expert series, Spain) equipped with a TR11 spindle rotating at 50 rpm, and the results were reported in centipoise (cp) (GENÇDAĞ *et al.*, 2021).

*Overrun of Ice-Cream*

Overrun was measured by taking 20 g of ice cream sample in beaker and melted at 50 °C, after melting process the weight of melted ice cream recorded and weight difference gives the overrun (GENÇDAĞ *et al.*, 2021).

$$Overrun\ (\%) = \frac{Weight\ of\ mix - Weight\ of\ ice\ cream}{Weight\ of\ ice\ cream} \times 100$$

*First dripping time and Complete melting time*

10 g of ice cream sample was placed on wire grids with a pore diameter of 0.2 mm and 10 holes per 2.54 cm on 250 mL beaker and the first

dripping time and complete melting times were recorded (ŞIMŞEK *et al*., 2019).

*Sensory Analysis*

Sensory evaluation of ice cream samples by 10 panelists selected from Aydın Adnan Menderes University Department of Food Engineering, color, general texture, firmness, chewy structure, iced structure, smooth structure, slickness, the taste left in the mouth after eating, melt in mouth, it has been evaluated according to foreign taste and aroma, cream taste, general aroma, melt resistance, general acceptability features. Scoring was made between 0 and 9. The highest score was 9, the lowest score was 0.

*Enumeration of probiotics*

MRS (Merck 1.10660) agar medium was used for counting *Bifidobacterium bifidum.* MRS agar was heat sterilized at 121 ºC for 15 minutes, 0.05% L-cysteine was added to speed up the growth of probiotics. 1 g of both ice-cream mix, and ice-cream samples were diluted for plating. Afterwards, the incubation of petri dishes under anaerobic conditions were performed at 37 °C for 72 hours. To ensure the anaerobic environment anaerobic kits from SIGMA Co. (England) were used. For this purpose, 35 mL of distilled water was spread homogeneously on each kit and the kits will be immediately put into anaerobic jars.

*Determination of Volatile Compounds of ice cream*

Aroma analyzes were performed with solid phase microextraction gas chromatography (SPME-GC) with some modifications considering the work of Gençdağ *et al*., (2021). Aroma analysis was performed in all the samples. The 2 g ice cream samples were weighed in 20 ml headspace bottles and sealed with a poly (tetra fluoroethylene) (PTFE)/ silicone septum. The bottles were then stabilized to equilibrate at 35 °C for 10 minutes. The headspace of the samples was extracted using a manual SPME device and SPME fiber for 45 minutes at 35 °C. The fiber was then injected into gas chromatography for 2 minutes and the flavors were allowed to deabsorption. The speed of carrier helium was 4 mL/min. The inlet temperature was 250 °C. Analysis was performed in non-compartmental mode (GENÇDAĞ *et al*., 2021).

## RESULTS AND DISCUSSIONS

### Results of Physicochemical Analyses of Ice-Cream Samples

The results of physicochemical analysis of ice cream samples are given in Table 2. According to the Turkish Food Codex, the total fat-free dry matter ratio in ice creams varies between 30% and 40% (TARIM VE ORMAN BAKANLIĞINDAN, 2022). The total dry matter values of the 3 ice cream samples are shown in Table 2.

**Table 2.** The results of physicochemical analysis of ice cream samples

| Ice Cream | A | B | C | D |
|---|---|---|---|---|
| Overrun (%) | 26.32±0.67[a] | 27.32±0.87[a] | 29.15±0.23[a] | 26.12±0.56[a] |
| First Dripping Time (min) | 7.58±0.09[a] | 8.76±0.6[b] | 6.94±0.5[a] | 9±0.1[b] |
| Complete Melting Time (min) | 31.47±1[b] | 28.77±0.9[b] | 27.44±0.28[a] | 31.83±0.45[b] |
| Viscosity Values (cP) | 593.75±7.94[a] | 607.8±5.85[a] | 640.55±4.05[b] | 703.05±1.33[c] |
| Total Dry Matter (%) | 30.12±0.02[a] | 30.31±0.03[b] | 30.34±0.01[b] | 30.11±0.03[a] |
| pH | 5.48±0.01[a] | 5.58±0.01[b] | 5.64±0.01[c] | 6.25±0.02[d] |
| Lactic acid (%) | 0.34±0.04[b] | 0.33±0.04[b] | 0.36±0.02[b] | 0.27±0.03[a] |

*Different letters in the same row indicate statistically significant (P< 0.05). A: %100 Camel Ice Cream; B: %100 Cow Ice Cream; C: %50 Camel-%50 Cow Ice Cream; D: Sample Ice Cream (production was 100% camel milk without probiotic addition).

The total dry matter data of the ice cream samples were like each other and complied with the Turkish Food Codex (TARIM VE ORMAN BAKANLIĞINDAN, 2017). When comparing the total dry matter concentration between the samples, it was observed that sample A and D differed significantly from samples B and C. Ice cream samples B and C had the highest total dry matter content, while samples A and D had the lowest. These results were consistent with a result by Jafarpour (2017), which stated that camel milk had lower dry matter content than cow's milk.

The titratable acidity of the ice cream mix samples (Table 2), range from 0.27% to 0.36%. It was observed that the lactic acid concentration was higher in the ice cream mixes with probiotic addition compared to the sample without probiotic addition. The highest lactic acid concentration was obtained in the 50% camel-50% cow mix, while the lowest result was in the sample without probiotic addition. There was no significant difference among the first three ice cream samples (A, B, and C), while sample D (without probiotic addition) differed significantly from the first three samples ($P<0.05$). Similar results in acidity and pH values were found in studies by Elkot *et al*. (2022), who reported that the acidity of the ice cream ranged between 0.2% and 0.4% lactic acid concentration. On the other hand, AKALIN; ERIŞIR (2008) determined the lactic acid concentration of probiotic ice cream to be between 0.14% and 0.52%.

The pH values of the ice cream mixes are shown in Table 2. Significant differences were observed among the four samples. Sample D had a higher pH than the other samples, while sample C had the lowest pH. This result may be related to the different initial pH levels of the milk or the acid formation behavior of the probiotic strain in different milk sources. The pH values of the samples ranged between 5.48 and 6.25. The highest pH value was determined in the ice cream sample made from 100% camel milk without the addition of probiotic bacteria. The decrease in pH value in the probiotic-added ice cream samples was related to the fermentation of lactose. Similar results were obtained in studies by Sayar *et al*. (2022) and Elkot *et al*. (2022).

Viscosity values of the ice cream mix are directly related to proper processing and air holding capacity. Elevated viscosity in ice cream can lead to reduced air incorporation during the production process, potentially resulting in less volume expansion compared to control samples (YAZDI *et al.,* 2020). Regarding the viscosity data, statistically significant differences were observed between sample C and D, while no significant differences were found between sample A and B. Sample D had a higher viscosity than the other samples, while sample A had the lowest viscosity. The viscosity obtained in our study ranged from 593.75 cP to 703.05 cP. The lower viscosity of camel milk can be attributed to its lower dry matter content compared to cow's milk (VASILJEVIC *et al*., 2007). In a study by Karagözlü; Ayhan (2019), the viscosity of ice cream mixes was measured, and the viscosity values were found to be 197 cP for cow's milk ice cream, 316 cP for cow-goat milk ice cream, and 153 cP for goat milk ice cream. It was observed that the milk content had a significant effect on viscosity.

As Mazreati; Nateghi (2022) stated, there is a direct relationship between viscosity values and melting resistance in probiotic ice creams. As shown in Table 2, there were no statistically significant differences among the overrun (%) values of the four ice cream samples.

Table 2 presents the results of the first dripping time and melting time of the four ice cream samples, and Figure 3 shows the analysis of first dripping and complete melting time. The results of the first dripping time showed that samples A and C were significantly different from samples B and D. The results of the complete melting time values showed no significant differences among samples A, B, and D. Only sample C differed significantly from the other samples. It was found that the ice cream sample with a 50% camel-50% cow mixture had the shortest first dripping time. Moreover, it was observed that the sample without probiotic addition had the highest first dripping time and complete melting time. However, these changes were not statistically significant (Table 2). As stated in similar studies, the higher the solids content of the ice cream, the higher the resistance to melting. The higher viscosity of the ice cream mix may be responsible for the lower melting rate (DARWISH *et al.*, 2016; ELKOT *et al.*, 2017). Similar observations were made by Karagözlü; Ayhan (2019), who produced three different ice creams by mixing goat milk with cow milk and adding probiotics. In a study conducted by Kozłowicz *et al.* (2019), the longest melting time was observed in probiotic ice cream with cow's milk.

Figure 3 shows the melting images of 100% camel milk ice cream with the addition of probiotics during drip tests at 1 minute, 17 minutes, and 30 minutes.


**Figure 3**. A) First minute of the drip test; B) Drip test after 17 minutes; C) Drip test after 30 minutes

**Sensory Analyses**

For sensory evaluation, five criteria were selected out of nine criteria (color, overall texture, firmness, chewy structure, icy structure, smooth structure, slickness, aftertaste, melt-in-mouth).

The results of the sensory evaluation are shown in Figure 4. The ice cream sample referred to as "Sample ice cream" consists of 100% camel milk without probiotic addition.

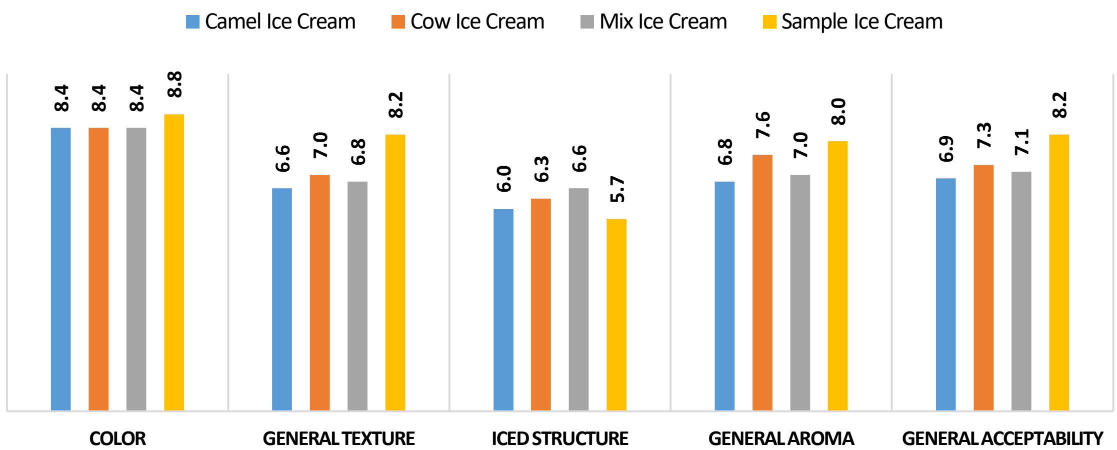


**Figure 4.** Results of sensory analysis

As shown in Figure 4, the most well-received ice cream was the 100% camel milk ice cream (without probiotic addition), followed by the 50% camel-50% cow milk mixture (with probiotic additive). All ice cream samples received acceptable scores in terms of color, overall texture, icy texture, overall flavor, and overall acceptability. In the study conducted by Mazreati; Nateghi (2022), ice cream samples produced with a mixture of 60% cow milk and 40% camel milk were investigated. The ice cream made from the cow-camel milk mixture received the highest score for color among other samples. It was also found that the ice cream made from a 60% camel milk and 40% cow milk mixture had the highest overall acceptance score. However, in our study, the 100% camel milk ice cream without probiotic addition received the highest score in terms of overall acceptability. These results suggest that the impact of probiotic supplementation on the overall acceptability of ice cream should be evaluated.

**Enumeration of Bifidobacterium bifidum in ice cream mix and ice cream samples**

In Figure 5 is shown the number of probiotic bacteria in ice cream mix and ice cream of ice cream samples.

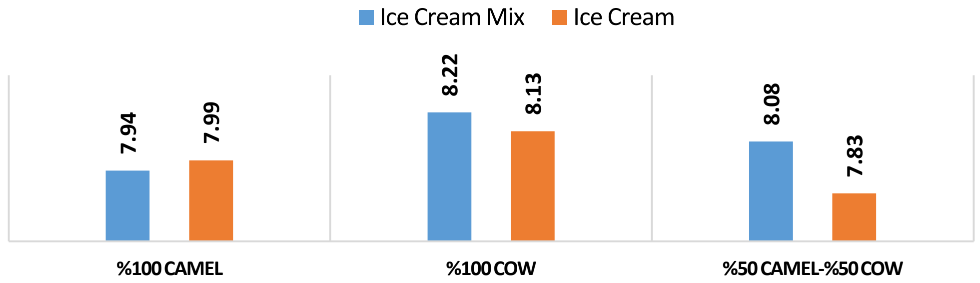


**Figure 5.** The enumeration of *Bifidobacterium bifidum* (log CFU/mL)

According to Turkish food codex a product, which contains probiotic cultures should exhibit $10^6$ CFU/g live bacteria in the final product. The data show that the ice cream sample and ice cream mix in which the highest number of *Bifidobacterium bifidum* was determined in the sample produced with 100% cow's milk. These results were remarkable because in all the ice cream mixtures the same bacteria count was inoculated. These results can be attributed that the growth of bacteria in camel milk is inhibited or suppressed due to the antibacterial activity of lysozyme (JUMAH *et al*., 2001), which is especially low in the 100 % camel milk mixture and ice cream sample. In addition, there was a difference between the number of ice cream mix and ice cream samples. The reason for this result is that oxygen enters the mix while the ice cream process is being made. In the ice cream process, a decrease has been detected due to the inability to fully provide anaerobic conditions. A remarkable decrease was observed in the 50% camel and 50% cow milk ice cream. In the study of Mazreati; Nateghi (2022) determined that the microbial growth was 8.38 log CFU/mL in ice cream samples produced by 50% camel milk and 50% cow milk using *L. acidophilus* culture, not by *Bifidobacterium bifidum* strain. It was concluded that *L. acidophilus* strain was more open to microbial growth in camel milk than *Bifidobacterium bifidum*.

Figure 6 shows the images of plates of growth of *Bifidobacterium bifidum* in plated after growth in different ice cream samples.

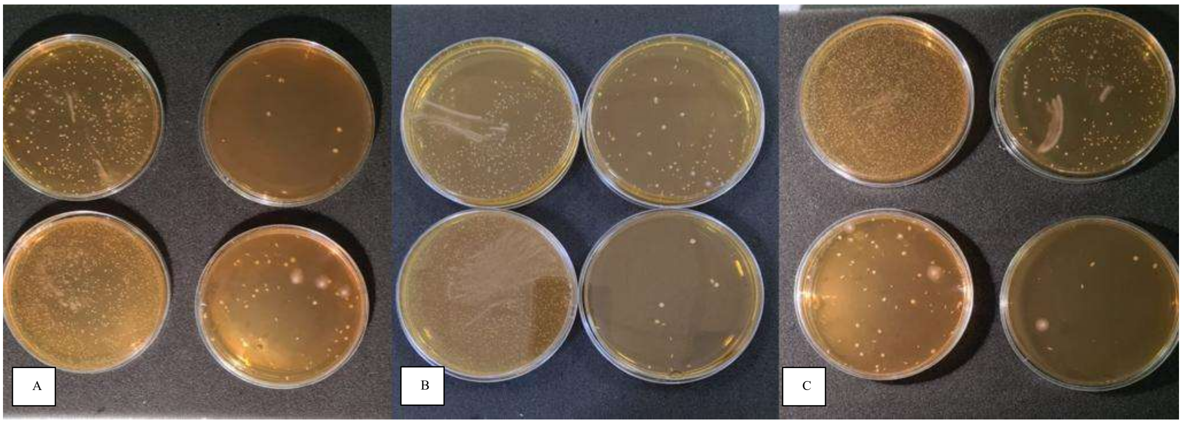


**Figure 6.** Plating of (A) 100% camel's milk, (B) 100% cow's milk and (C) 50% camel's 50% cow's milk ice creams, respectively

**Investigations of volatile compounds of ice cream samples**

Volatile compound analysis was conducted for the 4 ice cream samples. The results of volatile compound analysis using GC-MS chromatography for 100% camel milk ice cream and 100% cow milk ice cream with added probiotics are shown in Table 3. Table 4 presents the results of volatile components for the sample obtained from a mixture of 50% camel milk and 50% cow milk with probiotic addition, as well as for 100% camel milk without probiotics.

**Table 3.** Volatile component analysis results of 100% camel milk ice cream and 100% cow milk ice cream

| Camel Milk Ice Cream | | | Cow Milk Ice Cream | | |
|---|---|---|---|---|---|
| **Volatile Compound** | **RT** | **Area (%)** | **Volatile Compound** | **RT** | **Area (%)** |
| Propanedionic acid | 1.591 | 2.35 | Acetic Acid | 1.765 | 3.85 |
| Pentanal | 3.353 | 2.22 | 2-Heptanone | 5.045 | 43.02 |
| 2-Heptanone | 5.051 | 31.03 | 2-Octanamine, N-(1-methylheptyl) | 5.175 | 2.09 |
| 2-Hexanoic acid | 5.165 | 6.09 | Carbamic acid | 7.895 | 0.69 |
| l-Limonene | 8.653 | 3.16 | l-Limonene | 8.645 | 7.2 |
| 2-Nonanone | 10.467 | 6.06 | Acetophenone | 9.707 | 1.45 |
| Hexanal | 10.828 | 1.87 | 2-Nonanone | 10.458 | 7.44 |
| | | | Nonanal | 10.819 | 1.47 |
| | | | Benzothiazole | 14.362 | 0.89 |
| | | | 2-Undecanone | 16.346 | 0.93 |

**Table 4.** Volatile component analysis results of 50% camel 50% cow milk ice cream and sample ice cream

| Camel Milk Ice Cream | | | Cow Milk Ice Cream | | |
|---|---|---|---|---|---|
| **Volatile Compound** | **RT** | **Area (%)** | **Volatile Compound** | **RT** | **Area (%)** |
| Acetic acid | 1.709 | 9.86 | Methanamine, N,methyl | 1.32 | 2.12 |
| Hexanal | 3.48 | 2.27 | 2-Heptanone | 5.051 | 3.98 |
| 2-Heptanone | 5.518 | 24.39 | l-Limonene | 8.65 | 30.01 |
| 2-Nonanone | 13.716 | 4.48 | Nonanal | 10.825 | 1.41 |
| Nonanone | 13.715 | 2.35 | 1,6-Dioxacyclododecabe-7,12-dione | 25.257 | 5.46 |
| | | | 4-9-Decadien-2amine, N-butyl | 30.703 | 0.94 |
| | | | 2-Oxazolidinone, 3-amino-5-(4-morpholinylmethyl) | 34.444 | 5.84 |

With the addition of starter cultures to milk, various aromas are formed through the biochemical changes of carbohydrates, lipids, and proteins (GURKAN; HAYALOGLU, 2017). In recent years, the addition of probiotics to dairy products has become widespread due to increasing consumer demand for healthy products (ZHANG *et al.*, 2020). It has been determined that the addition of Bifidobacteria to milk increases the concentration of low molecular weight volatile compounds such as acetic acid, 2-pentanone, and 2-butanone (ZAREBA *et al.*, 2012).

In our study, the formation of different types and numbers of volatile compounds in the ice cream samples was observed. Notably, the formation of 2-heptanone was observed in all four ice cream samples, with concentrations ranging from 3.98% to 43.03%. This volatile compound has been described by YÜKSEL; BAKIRCI (2015) in their investigation of volatile compound profiles in probiotic yogurts produced with inulin and whey powder, imparting fruity and cinnamon flavors. The concentration of 2-heptanone was highest in the 100% cow milk ice cream sample and lowest in the 100% camel milk ice cream without probiotic addition. Another notable volatile compound was hexanal, which was detected in camel milk-based ice cream samples and belongs to the group of green leaf volatiles that function as signal molecules in plants (SUN; GAO, 2022). This compound is likely transferred to milk through camel feed. Other important volatile compounds detected included acetic acid, pentanal, hexanal, limonene, and 2-nonanone.

In the study conducted by ZHANG *et al.* (2020), the volatile compounds formed because of fermentation in different dairy products using various starter cultures were analyzed. The results of these analyses showed the presence of aldehydes, ketones, acids, benzene species, and other different volatile compounds, which exhibited similarities with the volatile compounds identified in our study. In the same study, it was also determined that the volatile compound Nonanal contributes to the "fatty" odor in fermented camel milk, and this volatile component was detected in all ice cream samples. In a study by AL-GBOORY (2017) on the volatile compound analysis of fermented camel milk, compounds such as Octasiloxane, Hexasiloxane, and Heptasiloxane were found. However, these results were contrary to our findings.

## CONCLUSIONS

This study investigated the viability of *Bifidobacterium bifidum* in camel milk ice cream and its impact on various quality parameters, physicochemical attributes, sensory properties, and volatile compounds. The addition of probiotics to ice cream made from camel milk, as well as other milk types, can lead to alterations in structure and taste.

The findings indicated that ice cream was all deemed acceptable. Sensory analysis of the samples was generally well-received and suitable for consumption.

Gas chromatography-mass spectrometry (GC-MS) analysis demonstrated variations in the volatile compounds of the ice creams, potentially influenced by the milk type and fermentation behavior of the added probiotics. In conclusion, camel milk shows promise as a potential medium for probiotic growth and enhancement of ice cream's sensory qualities. This comprehensive study highlights the potential application of probiotics in ice cream production, suggesting that probiotic-enriched camel milk ice creams can be a high-quality and healthy choice. These findings lay a significant foundation for future product development in the food industry and for promoting healthy nutrition.

## ACKNOWLEDGMENT

This study was supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) BIDEB-2209.

## REFERENCES

ABU-LEHIA, I. H.; AL-MOHIEZEA, I. S.; ELBEHRY, M. Studies on the production of ice cream from camel milk products. **Australian Journal of Dairy Technology**, v. 44, n. 1, p. 31-34, 1989.

AKALIN, A. S., & Erişir, D. (2008). Effects of inulin and oligofructose on the rheological characteristics and probiotic culture survival in low-fat probiotic ice cream. **Journal of food science**, 73(4), M184-M188.

AL-GBOORY, H. L. Determination of Volatile Compound in Fermented Camel Milk by GC-MS. *In*: INTERNATIONAL SCIENTIFIC SYMPOSIUM "FARM MACHINERY AND PROCESSES MANAGEMENT IN SUSTAINABLE AGRICULTURE", 9., 2017, Lublin, Poland. **Proceedings** [...]. Lublin: University of Life Sciences, 2017. p. 21-26. DOI: 10.24326/fmpmsa.2017.4

BIAVATI, B., Vescovo, M., Torriani, S., & Bottazzi, V. (2000). Bifidobacteria: history, ecology, physiology and applications. **Annals of microbiology**, 50(2), 117-132.

BEKIROĞLU, H.; ÖZDEMIR, S. The quality of ice cream samples made from buffalo milk. **Food and Health**, v. 6, n. 1, p. 20-26, 2020. DOI: 10.3153/fh20003

BREZOVEČKI, A. *et al*. Camel milk and milk products. **Mljekarstvo**, v. 65, n. 2, p. 81-90. 2015. DOI: 10.15567/mljekarstvo.2015.0202

DARWISH, A. M.; ELKOT, W. F.; MOHAMED, O. R. Functional properties and nutritional quality of ice cream enriched with Jerusalem artichoke flour. **Journal of Agroalimentary Processes and Technologies**, v. 22, p. 87-94, 2016.

ELKOT, W. F. *et al*. Functional, physicochemical, rheological, microbiological, and organoleptic properties of synbiotic ice cream produced from camel milk using black rice powder and *Lactobacillus acidophilus* LA-5. **Fermentation**, v. 8, n. 4, p. 187. 2022. DOI: 10.3390/fermentation8040187

ELKOT, W. F.; ISMAIL, H. A.; RAYAN, A. M. Enhancing the functional properties and nutritional quality of ice milk with sebesten fruits (*Cordia myxa* L.). **Egyptian Journal of Food Science**, v. 45, p. 125-134, 2017.

GENÇDAĞ, E. *et al*. Techno-functional effect of stevia extract substitution on dry fig–fortified ice cream. **Journal of Food Processing and Preservation**, v. 45, n. 6, 2021. DOI: 10.1111/jfpp.15578

GRANATO, D. *et al*. Probiotic Dairy Products as Functional Foods. **Comprehensive reviews in food science and food safety**, v. 9, n. 5, p. 455-470. 2010. DOI: 10.1111/j.1541-4337.2010.00120.x

GURKAN, H.; HAYALOGLU, A. A. Volatiles and sensory characteristics of yogurt manufactured by incorporating basil (*Ocimum basilicum* L.). **International Journal of Food Properties**, v. 20, n. 70, p. 779-789. 2017. DOI: 10.1080/10942912.2017.1311344

IPSEN R. Opportunities for producing dairy products from camel milk: a comparison with bovine milk. **East African Journal of Sciences**. v. 11, n. 2, p. 93-98. 2017.

JAFARPOUR, A. Feasibility of manufacture and investigation of physicochemical properties of camel milk-based ice cream. **Journal of Scientific Agriculture**, v. 1, p. 300-302, 2017. DOI:10.25081/jsa.2017.v1.838

JUMAH, R. Y.; SHAKER, R. R.; ABU-JDAYIL, B. Effect of milk source on the rheological properties of yogurt during the gelation process. **International Journal of Dairy Technology**, v. 54, n. 3, p. 89-93, 2001. DOI: 10.1046/j.1364-727x.2001.00012.x

KARAGÖZLÜ, C.; AYHAN, E. Farklı Oranlarda Keçi Sütü İle Üretilmiş Probiyotik Dondurmaların Kalite Özellikleri Üzerine Bir Araştırma. **Ege Üniversitesi Ziraat Fakültesi Dergisi**, v. 53, n. 1, p. 131-140, 2019. DOI: 10.20289/zfdergi.448326

KASKOUS, S. Importance of camel milk for human health. **Emirates Journal of Food and Agriculture,** v. 28, n. 3, p. 158 -163. 2016. DOI: 10.9755/ejfa.2015-05-296

KOÇ, A.; ATASEVER, S. Production and characteristics of camel milk Conference: I. **International Selçuk-Ephesus Symposium on Culture of Camel-Dealing and Camel Wrestling** at: Selçuk/İzmir/Turkey. 2016.

KONUSPAYEVA. G.; FAYE, B.; LOISEAU, G. The composition of camel milk: A meta-analysis of the literature data. **Journal of Food Composition and Analysis**, v. 22, n. 2. p. 95-101. 2009. DOI: 10.1016/j.jfca.2008.09.008

KOZŁOWICZ, K. *et al*. Effect of ice cream storage on the physicochemical properties and survival of probiotic bacteria supplemented with zinc ions. **LWT Food Science and Technology**, v. 116. e 108562, 2019. DOI: 10.1016/j.lwt.2019.108562

KUMAR, Y. A. *et al*. Composition and medicinal properties of camel milk: A Review. **Asian Journal of Dairy and Food Research**, v. 34, n. 2, p. 83-91, 2015. DOI: 10.5958/0976-0563.2015.00018.4

LILLY, D. M., STILLWELL, R. H. Probiotics: Growth-promoting factors produced by microorganisms. **Science**, v. 147, n. 3659, p. 747-748, 1965. DOI: 10.1126/science.147.3659.747.

MAZREATI, M.; NATEGHI, L. Evaluation of the quality characteristics of probiotic ice cream produced from a mixture of camel milk and cow milk during frozen storage. **Journal of Nutrition and Food Security**, v. 7, n. 2, 2022. DOI: 10.18502/jnfs.v7i2.9334

MEHTA, B. *et al*. Camel milk: opportunity and challenges. **National Seminar on "Indian Dairy Industry - Opportunities and Challenges**, p. 138-142. 2019.

MUŞ, T. E. Probiyotik Olarak Bifidobakteriler (*Bifidobacterium* as Probiotic). **Türkiye Klinikleri**, p. 21-27. 2018.

ÖNER, Z.; ALOĞLU, H. S. **Süt ve Süt Ürünleri Analiz Yöntemleri**. Sidas Yayinlari, 2018. p. 590

SAYAR, E.; ŞENGÜL, M.; ÜRKEK, B. Antioxidant capacity and rheological, textural properties of ice cream produced from camel's milk with blueberry. **Journal of Food Processing and Preservation**, v. 46, n. 3, p. e16346, 2022. DOI: 10.1111/jfpp.16346

ŞIMŞEK, B. *et al*. Effects of mastic gum (*Pistacia lentiscus*) on chemical, rheological, and microbiological properties of yogurt ice cream. **Journal of Food Processing and Preservation**, v. 43, n. 7, p. 1-8. DOI: 10.1111/jfpp.13945

SONI, V.; GOYAL, M. Potential of using camel milk for ice cream making. **Journal of Camel Practice and Research**, v. 20, n. 2, p. 271-275. 2013.

SUN, H.; GAO, H. Benefits of a combination of hexanal and Pantoea agglomerans KSC03 on plant growth and accumulations of bioactive isoflavone glycosides in Astragalus membranaceus var. mongholicus. **Journal of Plant Growth Regulation**, v. 41, n. 1, p. 1-7, 2022. DOI:10.1007/s00344-021-10307-4

TARIM VE ORMAN BAKANLIĞINDAN. **Türk Gida Kodeksi Dondurma Tebliği** (Taslak:2017/...). 2017. Disponível em: https://members.wto.org/crnattachments/2017/TBT/TUR/17_5329_00_x.pdf.

TARIM VE ORMAN BAKANLIĞINDAN. **Turkish Food Codex Communique on Fast Frozen Foods** (Community No: 2022/44). 2022. Available at: www.resmigazete.gov.tr/eskiler/2022/11/20221130-5.htm

TAŞDEMIR, A. Probiyotikler, prebiyotikler ve sinbiyotikler. **Sağlık Akademisi**, v. 2, n. 1, p. 72-88, 2017. DOI: 10.25279/sak.300045

TÜRKMEN, N.; GÜRSOY, A. Fonksiyonel Dondurma. **Akademik Gıda**, v. 15, n. 4, p. 386-395. 2017. DOI: 10.24323/akademik-gida.370110

VASILJEVIC, T.; KEALY, T.; MISHRA, V. Effects of β- glucan addition to a probiotic containing yogurt. **Journal of Food Science**, v. 72, n. 7, p. C405- C411. 2007. DOI: 10.1111/j.1750-3841.2007.00454.x

YASMIN, I. *et al*. In vitro probiotic potential and safety evaluation (hemolytic, cytotoxic activity) of *Bifidobacterium* strains isolated from raw camel milk. **Microorganisms**, v. 8, n. 3, p. 354. 2020. DOI: 10.3390/microorganisms8030354

YATEEM, A. *et al*. Isolation of Lactic Acid Bacteria with probiotic potential from camel milk. **International Journal of Dairy Science**, v. *3*, n. 4, p. 194-199, 2008. DOI: 10.3923/IJDS.2008.194.199

YAZDI, A. P. G. *et al*. Physicochemical properties and organoleptic aspects of ice cream enriched with microencapsulated pistachio peel extract. **International Journal of Dairy Technology**, v. 73, n. 3, p. 570-577, 2020. DOI: 10.1111/1471-0307.12698

YÜKSEL, A.; BAKIRCI, İ. An investigation of the volatile compound profiles of probiotic yogurts produced using different inulin and demineralised whey powder combinations. **Food Science and Biotechnology**, v. *24*, p. 807-816, 2015. DOI: 10.1007/s10068-015-0105-0

ZAREBA, D.; ZIARNO, M.; OBIEDZINSKI, M. Volatile profile of non-fermented milk and milk fermented by *BifidoBacterium animalis* subsp. *lactis*. **International Journal of Food Properties**, v, 15, n. 5, p. 1010-1021, 2012. DOI: 10.1080/10942912.2010.513024

ZHANG, L. *et al.* Evaluation of volatile compounds in milks fermented using traditional starter cultures and probiotics based on odor activity value and chemometric techniques. **Molecules**, v. 25, n. 5, 2020. DOI: 10.3390/molecules25051129