Journal of Agricultural Faculty of Gaziosmanpasa University
Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi
https://dergipark.org.tr/tr/pub/gopzfd

Research Article

JAFAG (2025) 42(2), 167-175
ISSN: 1300-2910
E-ISSN: 2147-8848
DOI: 10.55507/gopzfd.1665135

Investigation of physicochemical properties of some milk jams sold in the market

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Received: 25.03.2025 Accepted: 25.07.2025

Abstract: This study aimed to examine the physicochemical properties of 30 different cow milk jams purchased from the market to identify variations among these products, which lack a production standard. For this purpose, milk jams were examined in terms of pH, titratable acidity, total soluble solids, water activity, color properties (L*, a*, and b*), hydroxymethylfurfural, total sugar, fat and protein. The pH values of milk jam samples were found to be 5.33-7.30, whereas titratable acidity values were 0.057-0.884% (as lactic acid). Similarly, water soluble solids contents were 46.83-82.57 °Brix, while water activity values were 0.717-0.928. In the same way, total sugar contents were 21.39-58.87 g/100g, whereas fat contents were 0.27-4.63%. Likewise, protein contents were %0.73-5.02. The L* values ranged from 21.39-67.17, while a* values varied between -2.98-11.06 and b* values varied between -3.30-18.78. While HMF was not found in 16 of the samples, HMF was determined in the range of 2.97-221.29 mg/kg in the remaining 14 samples. The study revealed that the compositions of milk jams varied and that they were not produced to a certain standard.

Keywords: Cow milk, milk jam, physicochemical property, Türkiye

Piyasada satılan bazı süt reçellerinin fizikokimyasal özelliklerinin incelenmesi

Öz: Bu çalışma, piyasadan satın alınan 30 farklı inek sütü reçelinin fizikokimyasal özelliklerini inceleyerek, üretim standardı olmayan bu ürünler arasındaki farklılıkları belirlemeyi amaçlamıştır. Bu amaçla süt reçelleri pH, titrasyon asitliği, suda çözünür kuru madde, su aktivitesi, renk özellikleri (L*, a* ve b*), hidroksimetilfurfural, toplam şeker, yağ ve protein açısından incelenmiştir. Süt reçeli örneklerinin pH değerleri 5.33-7.30; titrasyon asitliği değerleri %0.057-0.884 (laktik asit cinsinden); suda çözünür kuru madde değerleri 46.83-82.57 briks; su aktivitesi değerleri 0.717-0.928; toplam şeker değerleri 21.39-58.87 g/100g; yağ değerleri %0.27-4.63 ve protein değerleri %0.73-5.02 aralığında tespit edilmiştir. Renk özellikleri incelendiğinde L* değerlerinin 21.39-67.17; a* değerlerinin -2,.98-11.06 ve b* değerlerinin ise -3.30-18.78 arasında değişiklik gösterdiği saptanmıştır. Örneklerin 16'sında HMF'ye rastlanmazken geri kalan 14 örnekte 2.97-221.29 mg/kg aralığında HMF belirlenmiştir. Yapılan çalışma ile süt reçellerinin bileşimlerinin farklılık gösterdiği ve belli bir standartta üretilmedikleri ortaya konmuştur.

Anahtar kelimeler: İnek sütü, süt reçeli, fizikokimyasal özellik, , Türkiye

1. Introduction

Milk has a vital place in adequate and balanced nutrition because it contains >100 different components and is a good source of protein, calcium, phosphorus, vitamin A, riboflavin, and some B vitamins such as B12 (Park & Haenlein, 2013). The production and consumption of various dairy products are rising everyday to capitalize on the beneficial properties of milk. Milk jam, a product derived from the condensation of milk, is one such item.

Milk jam is produced by heating a mixture of milk and sugar under controlled conditions, with a caramel-like color and pleasant taste (Vargas et al., 2021). The product, which is called milk jam in Türkiye, is known by different names in many different countries. It is called "dulce de leche" in Argentina and Uruguay,

To cite this article: Tokatlı, K., Küpcü, I.H., & Tokatlı, M. (2025). Investigation of physicochemical properties of some milk jams sold in the market. *Journal of Agricultural Faculty of Gaziosmanpasa University*, 42(2), 167-175. https://doi.org/10.55507/gopzfd.1665135

"arequipe" in Colombia, "manjar blanco" in Peru and "doce de leite" in Brazil (Ranalli et al., 2012).

Although there is no standardized production process, the main ingredients used in milk jam production are milk, sugar and an acidity regulator. Sodium bicarbonate or calcium hydroxide can be added to prevent the coagulation of proteins and to promote the Maillard reaction responsible for the typical caramel color by raising the pH of the mixture above the isoelectric point of the proteins. Another purpose of adding these neutralizing agents is to reduce the acidity of the milk and prevent the destabilization of casein micelles. Acidification during the evaporation process is associated with an increase in colloidal calcium phosphate, the formation of organic acids from the degradation of lactose and the breakdown of casein phosphate esters. Sometimes, vanilla extract is added for flavoring (Giménez et al., 2008; Ranalli et al., 2012; Stephani et al., 2019).

Although it is mostly produced using cow milk, it can also be produced with milk powder (Malec et al., 2005), goat milk (Chaves et al., 2018; Önür, 2018), buffalo milk (Cebeci, 2020), and sheep milk (Ferreira et al., 2020; Lima et al., 2020). Therefore, product compositions differ. Ranalli et al. (2012) determined the physicochemical properties of seven different milk jams obtained from local producers in South America. The water activity values of the samples varied between 0.764-0.882, moisture contents between 31.5-48.8%, protein contents between 6.4-8.2% and fat contents between 1.3-7.9%. Akal et al. (2018) examined the effect of different sugar ratios (10%, 15%, and 20%) on the quality of milk jams produced from cow milk during 15 days of storage. It was determined that the protein values of milk jams were 7.51-10.87%, fat values were 2.60-5.63%, total sugar amounts were 45.36-72.34% and hydroxymethylfurfural values were in the range of 75.80-250.87µg/L during storage. When the sensory evaluation results were evaluated, the highest scores were found in the milk jam sample containing 15% sugar. The production of milk jam has increased in Türkiye during recent years. To the best of our knowledge, this is the most comprehensive analysis of commercial milk jam samples available in the Turkish market. Because the raw materials, formulation, and production techniques for milk jam vary, it is impossible to produce a standard product, resulting in different physicochemical characteristics. This study aims to determine some physicochemical properties of 30 milk jams produced using cow's milk obtained from the market.

2. Materials and Methods

2.1. Materials

The 30 milk jams produced from cow milk used in the present study were obtained from 30 different companies in Türkiye. Milk jam samples were categorized by numbers from 1 to 30 and stored in their original packaging under refrigerator conditions (4±1°C) in the laboratory of the Department of Nutrition and Dietetics, Faculty of Health Sciences, Tokat Gaziosmanpaşa University until analysis.

2.2. Methods

The analyses applied to the milk jam samples are given below, and the analyses were performed in three replicates per sample, and the results are expressed as mean±standard deviation.

pH

The pH values of the samples were determined using a pH-meter [WTW Inolab pH 7110 Set 2 (Germany)] (AOAC, 1995).

Titratable acidity

Titratable acidity (TA) values of the samples were determined potentiometrically and given as % in lactic acid (AOAC, 1995).

The total sol¬uble solids

The total sol¬uble solids (TSS) contents of the samples were measured using a digital refractometer [Hanna HI96801 (Romania)].

Water activity

Water activity (aw) values of the samples were measured using an AquaLab (Model Series 3TE) water activity meter set at 20°C.

Color

L*, a* and b* values of the samples were measured with Minolta color meter (CR-300, Japan). Color measurements were carried out by placing a 2 cm height sample in a 6x4 cm cylindrical glass tube. The browning index values were calculated by using the formula as follows (Aimi Azira et al., 2021):

Browning index: 100 (x-0.31) / 0.17

x: (a*+1.75L*)/(5,645L*+a*-0.3012b*)

Total sugar content

Total sugar contents of the samples were determined spectrophotometrically using the phenol-sulfuric acid

method according to Taylor (1995). 0.1 g of the homogenized sample was taken and hydrolyzed with 5 mL of 2.5N HCl at 95°C for 3 h. At the end of hydrolysis, the samples were quickly cooled to 1°C, 750 µL of 40% NaOH was added, and the hydrolysate was prepared by adding 750 µL of 40% NaOH to 250 mL of pure water. 600 µL of 5% (w/v) phenol was added to 600 µL hydrolysate and mixed for 30 s with a vortex (Velp 2X3, Italy). After adding 3 mL of concentrated H_2SO_4 to the mixture and mixing, the samples were incubated in an 80°C water bath (Mikrotest TT104, Turkey) for three minutes. After incubation, the samples were cooled, and the absorbance was read at 490 nm. D-Glucose solution was used as standard, and the results are expressed in g/100g.

Hydroxymethylfurfural content

Hydroxymethylfurfural (HMF) content of the samples was determined spectrophotometrically according to Cemeroğlu (2010). For the analysis, 10 g of the sample was weighed and dissolved in 20 mL of oxygen-free water and then 50 mL of pure water was added (sample solution). For each sample, 2 mL of sample solution and 5 mL of para-toluidine solution were added to two separate test tubes and 1 mL of water (blank) and 1 mL of barbituric acid solution (test) were added to one of the tubes. After the tubes were thoroughly mixed, the absorbance of the test tube at 550 nm was read against the witness tube and the amount of HMF was calculated using the formula below and expressed as mg/kg.

HMF (mg/kg) = A550 × 162

A550: Absorbans at 550nm

Total fat content

Total fat content of the samples was determined gravimetrically using an Ankom fat extraction device (Ankom XT10 Extractor, New York, USA) (Komarek et al., 2019). To determine the fat content of the samples, approximately 2 g of each dried sample was subjected to extraction with petroleum ether in an Ankom device for 60 minutes.

Total protein content

The Kjeldahl method was used to determine the total nitrogen content of the samples (AOAC, 1997). After adding 2 g of K_2SO_4, 100 µL of 5% $CuSO_4$ and 5 mL of concentrated H_2SO_4 to 1 g of sample, the samples were incinerated at 400ºC. After combustion, 40% (w/w) NaOH was added for neutralization and distillation was performed and collected in 10 mL of 4% boric acid solution. After distillation, the samples were titrated with 0.02 N HCl and the % nitrogen values were calculated using the formula given below. Protein content of the samples was calculated by multiplying the nitrogen ratios by a factor of 6.38.

% Nitrogen: (V1-V0)*0.014*N*100/ Sample weight (g)

V1: Amount of HCl spent for the sample in the titration (mL)

V0: Amount of HCl spent for the blank (mL)

N: Normality of HCl used in the titration

3. Results and Discussion

The pH, TA, TSS, and aw values of the milk jam samples are shown in Table 1. The pH results are consistent with other studies on milk jam in the literature. Gaze et al. (2015) found that the pH values of seven different commercial brands of milk jams sold in were in the range of 6.14-6.37 and Ranalli et al. (2012) found that the pH values of seven different milk jams obtained from local markets in South America were in the range of 5.57-5.97. Cebeci (2020) reported that the pH values of 10 different combinations of milk jams produced with 100% cow milk, goat milk, buffalo milk, sheep milk and 25-75% and 50-50% goat + cow, sheep + cow, buffalo + cow milk ranged from 6.21 to 6.55 and that the production of milk jams with different milk types did not cause a significant effect on pH.

Titratable acidity values of milk jam samples were determined in terms of lactic acid, and the lowest value was determined in sample number 20 with 0.057% (lactic acid), while the highest value was determined in sample number 7 with 0.884% (lactic acid). The pH and TA values of milk jam samples were found to be in wide range. This may be due to the different amounts of neutralizing agents used during the production process and/or the addition of organic acids for preservative purposes. Önür (2018) reported that the titratable acidity values of six commercial milk jams produced in Türkiye were 0.098-0.386 g/100 g lactic acid. Different from our study, Sulejmani et al. (2021) determined the titratable acidity values of 16 different low-fat milk jams produced by adding two different types of inulin and different concentrations of sucrose, sodium bicarbonate and calcium as 1.12-2.83% (lactic acid).

The highest total soluble solid value was determined in sample number 20 with 82.57 °Brix and the lowest total soluble solid value was determined in sample number 7 with 46.83 °Brix. The observed difference in TSS values may result from variations in the sugar source and ratio, or additives used during milk jam production.

Cebeci (2020) found that the TSS contents of 10 different milk jams produced from different milk sources were in the range of 65.10-81.00; Tuna (2018) determined the TSS contents of fruit milk jams produced by adding dried mulberry, dried fig and dried apricot in the range of 58.15-58.60 °Brix in the control sample, 58.48-59.05 °Brix in the milk jam sample with dried fig, 61.48-61.78 °Brix in the milk jam with dried apricot and 61.08-61.78 °Brix in the milk jam sample with dried mulberry during 60 days of storage.

Table 1. pH, TA, TSS, and a_w values of milk jam samples (mean±standard deviation, n=3)

Sample no	pH	TA (lactic acid%)	TSS °Brix	a_w
1	6.93±0.05	0.198±0.00	78.80±0.10	0.736±0.01
2	6.15±0.02	0.281±0.03	71.43±0.15	0.801±0.01
3	6.98±0.02	0.178±0.00	70.10±0.20	0.816±0.01
4	6.87±0.01	0.237±0.01	49.20±0.10	0.920±0.00
5	6.27±0.00	0.271±0.01	67.40±0.10	0.839±0.01
6	6.63±0.04	0.222±0.03	62.63±0.06	0.880±0.00
7	5.97±0.07	0.884±0.02	46.83±0.06	0.928±0.00
8	6.65±0.02	0.337±0.02	70.43±0.06	0.830±0.01
9	6.58±0.01	0.397±0.01	54.60±0.10	0.906±0.00
10	6.44±0.03	0.354±0.01	66.03±0.06	0.836±0.01
11	6.86±0.04	0.296±0.02	60.83±0.06	0.870±0.00
12	6.73±0.03	0.254±0.01	63.33±0.06	0.865±0.01
13	7.30±0.10	0.205±0.03	54.87±0.15	0.902±0.00
14	6.25±0.00	0.264±0.05	67.60±0.00	0.844±0.01
15	7.06±0.00	0.224±0.01	57.30±0.10	0.896±0.00
16	6.89±0.00	0.256±0.00	54.47±0.06	0.912±0.00
17	6.58±0.01	0.369±0.02	72.60±0.00	0.800±0.01
18	6.64±0.01	0.353±0.02	49.57±0.06	0.922±0.00
19	6.48±0.01	0.350±0.00	66.50±0.26	0.846±0.01
20	5.33±0.14	0.057±0.01	82.57±0.12	0.717±0.01
21	6.07±0.01	0.495±0.03	65.23±0.06	0.841±0.00
22	6.66±0.03	0.253±0.01	60.13±0.06	0.851±0.01
23	6.55±0.01	0.341±0.04	58.00±0.10	0.892±0.00
24	6.65±0.01	0.349±0.05	64.40±0.00	0.846±0.01
25	6.59±0.02	0.235±0.01	65.57±0.06	0.844±0.01
26	6.78±0.01	0.408±0.03	49.47±0.06	0.919±0.00
27	6.79±0.00	0.339±0.03	71.17±0.06	0.798±0.01
28	6.77±0.01	0.302±0.02	53.77±0.06	0.911±0.01
29	6.49±0.00	0.368±0.02	56.67±0.12	0.884±0.01
30	6.37±0.01	0.202±0.01	69.43±0.06	0.717±0.01
Mean	6.38±0.38	0.321±0.15	62.47±8.91	0.852±0.06

The lowest water activity value was determined in samples 20 and 30 with 0.717 and the highest water activity value was determined in sample 7 with 0.928. In general, bacteria cannot grow at water activity values below 0.91, yeasts below 0.88 and molds below 0.80 (Ünlütürk et al., 1999). It can be said that only samples 1, 20 and 30 had water activity values below 0.80 and these products are presumed to be safe in terms of bacteria, yeasts and molds. In six samples (samples 4, 7, 16, 18, 26, and 28), the water activity value was above the critical value of 0.91. Sugar added during jam production contributes to the taste and aroma of the product and supports the microbiological stability of the product by reducing water activity. Sample number 20, with the highest °Brix and total sugar content, showed the lowest aw value. However, the highest aw value was 0.928 in sample number 7, which had the lowest TSS value and the lowest total sugar content. Ranalli et al. (2012) determined the water activity values of seven different types of milk jams offered for sale between 0.764-0.882.

The formation of HMF, which is a compound that occurs as an intermediate product during the breakdown of hexoses or Maillard reaction in an acidic media, is accelerated because of the heat treatment applied in the production of products such as jam and marmalade at higher temperatures or for longer durations than necessary (Saldamlı, 1998; Aslanova, 2005). No HMF was found in 16 milk jam samples examined in the study. In 14 samples, HMF was determined in the range of 2.97-221.29 mg/kg, and the highest HMF value was determined in sample number 30 (Table 2). HMF formation may be particularly related to the amount of sugar. However, no significant correlation was found

between the amount of HMF in the milk jam samples and the sugar content of the samples ($p>0.05$). The Turkish Food Codex does not specify an HMF limit for milk jam. However, HMF limits (50-100 mg/kg) exist for similar sugary products such as jam, molasses, and honey. Considering the limits set for these comparable products and public health concerns, the HMF values in our milk jam samples were found to be acceptable. Only sample number 30 was found to have a high HMF content (221.29 mg/kg). This suggests that manufacturers should optimize their production processes (temperature, time, pH control) and pay attention to storage conditions to minimize HMF formation in their products. Consumers should also be informed and avoid products that may have been subjected to excessive heat treatment or stored improperly for extended periods. According to the literature, the HMF content in various milk jam samples differs. Cebeci (2020) reported that the HMF contents of milk jam samples produced from different milk sources were determined between 5.99-39.63 mg/kg, and the sample with the highest HMF value was determined in the sample produced with 50% cow + 50% buffalo milk. Akal et al. (2018) found that the HMF contents of milk jams produced using different sugar ratios were in the range of 75.80-250.87 µg/L. Sarı et al. (2024) determined the HMF contents of banana, strawberry and cocoa milk jams produced by applying evaporation, at two different rates (30% and 50%) and adding 1.5% flavoring agent between 12.96-43.80 µg/L during 21 days of storage. This study emphasized that the application of the evaporation processes up to 50% dry matter level significantly reduced the HMF content of milk jam samples.

The total sugar content of the milk jam samples examined in this study was determined between 21.39-58.87 g/100g. The highest value was determined in sample number 20 and the lowest value was determined in sample number 7, similarly to the TSS content. Consistent with our study, Silva et al. (2015) reported the total sugar content of milk jams produced using different formulations in the range of 50.92-53.74%; Akpınar et al. (2021) reported the total sugar content of three different traditional milk jams produced by improving their functional properties with probiotics and prebiotics in the range of 34.69-38.35 g/100mL. Akal et al. (2018) reported that the total sugar contents of the milk jam they produced using 10, 15 and 20% sugar ratios were in the range of 45.36-72.34% during the 15-day storage period and that the total sugar amount increased with the increase in the sugar ratio added in production.

The fat content of the 30 milk jams examined ranged from 0.27 to 4.63%. This may be due to the difference in the composition of the milk used in milk jam production. Ranalli et al. (2012) examined 6 different “dulce de leche” sold in South American local markets. Their research showed that the fat content of these products varied between 1.3% and 7.9%, and they highlighted that the “dulce de leche” made from reduced fat milk had the least fat. Cebeci (2020) examined the fat content of jams produced with different milk and milk combinations and reported that the milk jam with the lowest fat content was jam made with 100% buffalo milk (4.25%) and the milk jam with the highest fat content was jam made with goat milk (11.00%). In the same study, the fat content of milk jam produced with 100% cow's milk was 5.50%. Gaze et al. (2015) determined the fat content of 7 different milk jams sold commercially in Brazil as 3.56-6.99 g/100g; Sarı et al. (2024) determined that the fat content of banana, strawberry and cocoa milk jams produced by applying evaporation at two different rates and adding 1.5% flavoring agent was between 4.1-4.4%.

The protein content of milk jam number 20 was below the measurable value (<0.01%). This may be because little or no milk was used in the production of the product offered for sale as milk jam. The protein amounts of the remaining 29 samples varied between 0.73-5.72%. The finding of very low protein content and high sugar content in some milk jam samples increases the risk of the product being a source of 'empty calories'. From a public health perspective, this situation indicates the need for consumer awareness through nutritional education, making food labels more understandable and transparent, and encouraging food manufacturers to enrich their product formulations with better nutritional value. Consumers should not view such products as a primary protein source; instead, they should be consumed as only a small part of a balanced diet and in moderation. Cebeci (2020) determined that the protein contents of milk jams produced with different milk and milk combinations were in the range of 4.59-7.89% and emphasized that the protein value decreased with the increase in the proportion of cow's milk used. Sarı et al. (2024) reported that the protein contents of flavored milk jams produced with eight different recipes were in the range

of 12.4-12.6%; Gaze et al. (2015) reported the protein contents of seven different commercial milk jams in the range of 2.10-7.12 g/100g; Ranalli et al. (2012) reported the protein contents of seven different milk jams sold in the market in the range of 6.4-8.2%. Akal et al. (2018) determined the protein content of milk jams produced with different sugar ratios (10, 15 and 20%) in the range of 7.51-10.87% during 15 days of storage at room temperature and found that the protein content of the samples decreased with the increase in the added sugar ratio.

The L*, a* and b* values of milk jam samples are given in Table 3. L* values expressing the brightness of the samples were determined between 21.39-72.49; a* values between -2.98-11.06; b* values between -3.30-18.78; browning index values between -1.92-37.35. In general, a* values decreased as L* increased. Sample number 16, with the highest brightness value, showed the lowest a* value and sample number 21 with the lowest brightness value, showed the highest a* value. The browning index is one of the most common browning indicators in food products that contain sugar. The low value of the browning index indicates less of a browning reaction (Aimi Azira et al., 2021). The HMF could not be detected in sample number 16, which had the lowest browning index value (-1.92). In products such as milk jam, where browning occurs during the process, a positive correlation is expected between the browning index and HMF content. In the data obtained from the milk jam samples examined, the correlation between the browning index and the HMF content of the samples was not found to be significant ($p>0.05$). This situation may also be due to differences such as raw material, process, and colorant addition. The differences among the samples with respect to the colour parameter are probably due to the differences in protein and sugar composition, as well as the changes in time and temperature, according to the production protocol..

Table 2. HMF, total sugar content, total fat content and total protein protein contents of milk jam samples (mean±standard deviation, n=3)

Sample no	HMF mg/kg	Total sugar content g/100g	Total fat content %	Total protein content %
1	-	45.09±0.63	1.81±0.04	2.58±0.16
2	10.42±0.67	36.96±0.89	3.78±0.98	2.47±0.40
3	-	28.66±1.76	3.87±0.07	4.18±0.66
4	-	23.39±0.88	1.10±0.35	4.34±0.42
5	-	31.64±1.42	2.55±0.29	0.73±0.55
6	9.72±4.99	41.04±0.32	0.68±0.02	0.74±0.02
7	4.64±1.51	21.39±1.60	1.19±0.24	2.52±0.11
8	3.35±0.89	40.89±1.90	0.72±0.06	2.87±0.51
9	-	23.95±0.05	3.38±1.62	2.94±0.10
10	-	29.15±0.52	2.44±0.61	3.37±0.34
11	4.91±0.57	26.61±0.44	3.22±0.02	2.54±0.21
12	-	26.74±0.19	2.43±0.22	4.16±0.43
13	12.74±0.41	22.61±0.41	2.31±0.21	2.58±0.002
14	5.35±0.32	27.10±0.62	2.22±0.29	2.74±1.16
15	-	25.50±0.34	0.47±0.04	2.81±1.33
16	-	24.79±0.44	1.48±0.29	2.13±0.49
17	12.10±1.05	32.08±0.29	3.06±0.07	3.64±1.74
18	-	25.01±0.64	0.27±0.03	2.09±0.09
19	-	25.58±0.62	1.54±0.14	3.26±0.36
20	29.48±3.23	58.87±0.35	0.46±0.05	<0.01
21	2.97±0.47	27.50±0.90	1.19±0.08	4.70±0.27
22	-	27.16±0.60	3.53±0.57	3.08±0.68
23	5.67±1.29	27.67±0.52	1.03±0.27	2.07±0.61
24	-	27.36±0.30	1.69±0.14	4.02±0.01
25	-	30.91±0.52	2.33±0.15	1.98±0.07
26	-	22.39±0.63	4.63±0.24	1.75±0.16
27	-	28.02±0.49	0.67±0.35	5.02±0.79
28	5.35±2.61	25.66±1.22	2.74±0.16	2.38±0.61
29	5.45±1.62	21.82±0.21	2.39±0.18	2.36±0.07
30	221.29±4.81	33.45±0.57	2.90±0.02	2.73±0.07
Mean	11.12±40.18	29.63±8.04	2.07±1.16	2.76±0.42

- Undetected

Table 3. L*, a* and b* values of milk jam samples (mean±standard deviation, n=3).

Sample no	L*	a*	b*	Browning index
1	30.03±0.21	7.70±0.23	12.45±0.15	20.00±0.40
2	33.00±0.25	8.68±0.18	13.10±0.05	22.22±0.48
3	47.75±0.66	2.35±0.14	13.84±0.69	6.41±0.16
4	47.90±0.05	8.82±0.09	17.14±0.07	16.50±0.12
5	45.70±2.63	5.06±2.48	17.06±2.42	11.75±4.82
6	40.36±3.64	8.66±1.16	18.65±1.61	19.85±3.26
7	67.17±1.03	1.13±0.78	17.01±1.20	3.71±0.98
8	35.41±0.25	8.17±0.31	14.37±0.03	20.15±0.44
9	39.97±0.56	9.88±0.12	15.94±0.34	21.18±0.40
10	29.59±0.08	9.56±0.10	10.83±0.08	25.83±0.22
11	44.09±0.07	7.02±0.04	15.39±0.12	14.71±0.02
12	41.21±0.12	7.80±0.08	15.41±0.07	17.02±0.10
13	45.54±0.43	8.59±0.13	18.78±0.21	17.39±0.30
14	33.59±0.06	8.80±0.23	13.51±0.04	22.19±0.45
15	56.27±0.89	0.79±0.11	12.20±1.14	3.15±0.27
16	72.49±0.85	-2.98±0.03	7.89±0.80	-1.92±0.11
17	33.04±0.02	8.47±0.16	12.46±0.06	21.56±0.33
18	51.66±0.30	7.04±0.16	18.04±0.19	13.13±0.24
19	34.85±0.29	9.24±0.54	13.10±0.31	22.12±0.95
20	62.89±1.44	0.49±0.02	-3.30±0.27	0.05±0.03
21	21.39±0.70	11.06±1.35	6.70±0.68	37.35±2.99
22	34.19±0.19	8.96±0.32	12.53±0.15	21.83±0.59
23	37.76±0.92	10.43±0.45	15.61±0.91	23.25±0.58
24	39.26±0.79	7.79±0.27	15.29±0.51	17.81±0.51
25	38.25±0.17	6.03±0.22	12.70±0.13	14.41±0.36
26	40.24±0.59	9.15±0.14	16.01±0.56	19.84±0.36
27	49.05±0.07	5.37±0.34	18.63±0.12	11.58±0.52
28	56.88±0.14	4.09±0.11	17.35±0.05	8.17±0.16
29	36.79±0.19	8.48±0.15	13.11±0.04	19.62±0.35
30	31.58±0.35	8.65±0.16	11.48±0.30	22.57±0.21
Mean	42.70±11.57	6.84±3.39	13.78±4.38	16.45±1.07

When the studies conducted with milk jam in the literature are examined, it is seen that the color values of milk jam samples vary considerably. Önür (2018) found that L* values of six commercial milk jams produced in Türkiye ranged from 30.66 to 57.36, a* values between 1.73-8.36 and b* values between 3.30-17.63; Gaze et al. (2015) found that L* values of 7 milk jams sold commercially in Latin America ranged between 48.59-62.11, a* values between 13.60-16.90 and b* values between 17.89-27.70; Ranelli et al. (2012) determined L* values between 36.4-50.4, a* values between 6.56-9.07, b* values between 16.9-26.1 for 6 different milk jams sold in South America

5. Conclusion

The variations in the content of milk utilized in the fabrication of milk jam samples, together with differences in product formulations and manufacturing procedures, resulted in different physicochemical characteristics of the milk jams. Consequently, it is essential to standardize the production of milk jam and scale its manufacturing to industrial levels to introduce it to the jam market, which has significant importance in Türkiye.

Standards compliant with national and international food codex must be established and legally formalized for milk jam. Producers, researchers, and relevant institutions in the sector should collaborate to create and implement these standards. This is important for both consumer protection and increasing the product's market potential. The milk used in milk jam production must have its basic compositional properties, such as fat, protein, lactose, and dry matter ratios, at certain standard levels. Standardized, scientifically based recipes should be created for each type of milk jam. In these recipes, the ratios of milk, sugar, flavorings, and other additives should be adjusted to maintain the desired sensory and physicochemical properties of the product. Additionally, all parameters in the production process, such as cooking time, temperature, stirring speed, and cooling methods, must be meticulously determined, and these parameters must be applied consistently in every production. Industrial automation systems will greatly benefit the precise control of these

parameters. By taking these steps, milk jam can transition from being a traditional delicacy to achieving its rightful industrial position in our country's jam market and gain the potential to open to international markets.

Conflict of interest

The authors declare no conflicts of interest.

Authorship contribution statement

KT: Visualization, Conceptualization, Methodology, Data analysis, Supervision, Writing – original draft, Review & editing; IHK: Methodology, Investigations, Data analysis, Visualization; MT: Methodology, Investigations, Data analysis, Visualization, Writing – original draft, Review & editing.

References

Aimi Azira, S., Wan Zunairah, W. I., Nor Afizah, M., Nor-Khaizura, M. A. R., Radhiah, S., Ismail Fitry, M. R., & Nur Hanani, Z. A. (2021). Prevention of browning reaction in banana jam during storage by physical and chemical treatments. *Food research*, *5*(5), 55-62.

Akal, C., Buran, İ., Delialioğlu, R. A., & Yetişemiyen, A. (2018). Farklı Şeker Oranlarının Süt Reçelinin Kalite Özellikleri Üzerine Etkisi. *Gıda*, *43*(5), 865-875. https://doi.org/10.15237/gida.GD18067

Akpınar, A., Söbeli, C., Çetin, M. G., Zeytin, M., & Dilek, Z. (2021). Production of traditional milk jam with improved functional properties via probiotic and prebiotic. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, *58*(3), 325-334. https://doi.org/10.20289/zfdergi.772761

Anonim. (2023). ANKOM Technology Method Analytical Procedure XT10/XT10i/XT15/XT15i (www.ankom.com, erişim 10.07.2023)

AOAC. (1995). Official methods of analysis of AOAC International, 16th Ed.

AOAC. (1997). Official Methods of Analysis of AOAC International (16th. Pub). Arlington, VA.USA: AOAC.

Aslanova, D. (2005). Reçel üretimi ve depolanması sürecinde HMF oluşum kinetiği. Ankara Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği Anabilim Dalı (Yüksek Lisans Tezi), Ankara, 51s.

Cebeci, Ç. (2020). Farklı Süt Kombinasyonlarının Süt Reçeli Üzerine Etkisi. Tekirdağ Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği Anabilim Dalı (Yüksek Lisans Tezi), Tekirdağ, 67s.

Cemeroğlu, B. (2010). Gıda analizleri. Gıda Teknolojisi Derneği Yayınları No. 34, Ankara.

Chaves, M. A., Souza, A. H. P. D., Colla, E., Bıttenccourt, P. R. S., & Matsushita, M. (2018). Influences of chia flour and the concentration of total solids on the characteristics of 'dulce de leche'from goat milk. *Food Science and Technology*, *38*, 338-344. https://doi.org/10.1590/1678-457X.22017

Ferreira, M. B., Nespolo, C. R., Centenaro, G. S., Messa, S. P., Farias, A. C. D. R., & Stefani, L. M. (2020). Innovative dulce de leche made by sheep's milk with and without the addition of sheep's milk cream. *Food Science and Technology*, *41*, 65-71. https://doi.org/10.1590/fst.11120

Gaze, L. V., Costa, M. P., Monteiro, M. L. G., Lavorato, J. A. A., Júnior, C. C., Raices, R. S. L., ... & Freitas, M. Q. (2015). Dulce de Leche, a typical product of Latin America: Characterisation by physicochemical, optical and instrumental methods. *Food Chemistry*, *169*, 471-477. https://doi.org/10.1016/j.foodchem.2014.08.017

Giménez, A., Ares, G., & Gámbaro, A. (2008). Consumer reaction to changes in sensory profile of dulce de leche due to lactose hydrolysis. *International Dairy Journal*, *18*(9), 951-955. https://doi.org/10.1016/j.idairyj.2007.12.007

Lima, P. C., Marco, I. D., Stein, V., Pagotto, C. K., Rigo, E., Cavalheiro, D., & Schogor, A. L. B. (2020). Obtaining and characterizing "dulce de leche" prepared with sheep's and cow's milk in different proportions. *Food Science and Technology*, *40*, 832-837. https://doi.org/10.1590/fst.16819

Malec, L. S., Llosa, R. A., Naranjo, G. B., & Vigo, M. S. (2005). Loss of available lysine during processing of different dulce de leche formulations. *International journal of dairy technology*, *58*(3), 164-168. https://doi.org/10.1111/j.1471-0307.2005.00202.x

Önür, Z. Y. (2018). Milk jam or dulce de leche: physicochemical characterization. *Gıda*, *43*(6), 1091-1099. 10.15237/gida.GD18111

Park, Y. W., & Haenlein, G. F. (Eds.). (2013). Milk and dairy products in human nutrition: production, composition and health. John Wiley & Sons.

Ranalli, N., Andrés, S. C., & Califano, A. N. (2012). Physicochemical and rheological characterization of "dulce de leche". *Journal of Texture Studies*, *43*(2), 115-123. https://doi.org/10.1111/j.17454603.2011.00321.x

Saldamlı, İ. (1998). Gıda Kimyası. Hacettepe Üniversitesi Yayınları. Ankara.

Sarı, M. M., Yetişemiyen, A., & Akal, C. (2024). Farklı Oranlarda Evaporasyon Uygulamasıyla Aromalı Süt Reçeli Üretimi. *Gıda*, *49*(2), 356-369. https://doi.org/10.15237/gida.GD23138

Silva, F. L., Ferreira, H. A. L., Souza, A. B., Almeida, D.F., Stephani, R., Pirozi, M. R., & Perrone, I. T. (2015). Production of Dulce de leche: the effect of starch addition. Food Sci Technol, 62(1), 417-423. https://doi.org/10.1016/j.lwt.2014.10.062

Stephani, R., Francisquini, J., Perrone, Í. T., de Carvalho, A. F., & de Oliveira, L. F. C. (2019). Dulce de leche–chemistry and processing technology. *Milk production, processing and marketing*, 1-18.

Sulejmani, E., Boran, O. S., Huppertz, T., & Hayaloglu, A. A. (2021). Rheology, microstructure and sensory properties of low-fat milk jam: Influence of inulin type, sucrose content, sodium bicarbonate and calcium chloride. *International Dairy Journal*, *123*, 105162. https://doi.org/10.1016/j.idairyj.2021.105162

Taylor, K.A.C.C. (1995). A modification of the phenol/sulfuric acid assay for total carbohydrates giving more comparable absorbances; *Journal: Applied Biochemistry and Biotechnology*. 53 (3): 207-214.

Tuna, C. (2018). Farklı Meyvelerle Zenginleştirilen Süt Reçellerinin Bazı Özelliklerinin Belirlenmesi. Pamukkale Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği Anabilim Dalı. (Yüksek Lisans Tezi). Denizli, 116s.

Ünlütürk, A., Karapınar, M., & Turantaş, F. (1999). Mikroorganizmalar ve Gıda (A. Ünlütürk, F. Turantaş Editör). *Gıda Mikrobiyolojisi*, *2*, 1-82.

Vargas, M. O., Prestes, A. A., Miotto, M., & Prudêncio, E. S. (2021). Dulce de leche: product types, production processes, quality aspects and innovations minor EDITS. *International Journal of Dairy Technology*, *74*(2), 262-276. https://doi.org/10.1111/1471-0307.12762