https://doi.org/10.17221/189/2025-CJFS

Enhancing labneh with freeze-dried fruits or fruit flavours: Effects on physicochemical, microbiological, and sensory properties

Bayram Çetin[1], *Christina Rehagel*[2*], *Ömer Akineden*[1,3]

[1]*Department of Food Engineering, Faculty of Engineering, Kirklareli University, Kayali Campus, Kirklareli, Türkiye*

[2]*Faculty of Food and Nutrition Sciences, Hochschule Niederrhein, University of Applied Sciences, Mönchengladbach, Germany*

[3]*Dairy Sciences, Institute of Veterinary Food Science, Justus-Liebig-University Giessen, Giessen, Germany*

**Corresponding author: Christina.Rehagel@hs-niederrhein.de*

Citation: Çetin B., Rehagel C., Akineden Ö. (2026): Enhancing labneh with freeze-dried fruits or fruit flavours: Effects on physicochemical, microbiological, and sensory properties. Czech J. Food Sci., 44: 216–226.

Abstract: The present study aimed to formulate novel labneh variants containing freeze-dried fruit pieces or fruit flavour and to evaluate their influence on physicochemical properties, microbiological quality, and sensory acceptance during storage. For this purpose, fruit-piece labneh was prepared by incorporating 6% freeze-dried strawberry, blackberry, or kiwi pieces, while fruit-flavoured labneh was formulated by adding 0.01% colouring and 0.1% fruit flavour derived from strawberry, blackberry, or kiwi juice. The labneh variants developed in this study were subjected to additional post-fermentation pasteurisation followed by hot filling. Samples were analysed on days 1, 7, 15, and 30 of storage for selected physicochemical, microbiological and sensory parameters. Compared with plain labneh, fruit-piece samples showed increased dry matter content, except for those containing kiwi. Conversely, water activity and fat content decreased, and variations in titratable acidity and pH were influenced by the type of fruit added. Microbiological analyses based on classical indicator microorganisms revealed low levels of total aerobic mesophilic bacteria ranging from 1.5×10^1 to 8.1×10^1 CFU·g^{-1}. The Enterobacteriaceae, *Escherichia coli*, yeasts and moulds were not detected, indicating good product safety. Notably, structural defects such as syneresis and increased bitterness were determined in kiwi-piece samples during storage. Sensory evaluation indicated that strawberry-flavoured, blackberry-flavoured, and strawberry-piece labneh were the most preferred by panellists. Overall, fruit- or flavour-enriched labneh produced with an additional post-fermentation heat treatment represents an attractive option for product diversification in the dairy industry. Based on their satisfactory safety, good microbiological stability and high sensory acceptance, these variants offer a strong potential for industrial application.

Keywords: concentrated fermented milk; fruit enrichment; post-fermentation heat treatment; shelf-life stability; water activity; lactic acid fermentation

Supported by the Scientific and Technological Research Council of Türkiye (TÜBITAK) under the 2209-B Industry-Oriented Research Project Support Programme.

https://doi.org/10.17221/189/2025-CJFS

Labneh is a traditional fermented dairy product widely consumed in Middle Eastern countries, where it is recognised as a concentrated yoghurt obtained by the partial removal of whey from set yoghurt (Özer 2006). This process leads to a product with reduced water, lactose, and salt content compared to regular yoghurt, resulting in a denser consistency and richer texture. Traditionally, labneh is produced by heating whole milk, inoculating it with a yoghurt starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) or a portion of labneh from a previous batch, and allowing fermentation at 40–45 °C until full coagulation occurs. The fermented yoghurt is then refrigerated overnight, after which table salt (0.5–1%) is added and thoroughly mixed. The mixture is subsequently transferred to a cheesecloth bag and left to drain in a cool environment for 12–24 h, allowing whey removal and the development of the characteristic semi-solid consistency (Özer 2006).

Labneh is an integral part of the Middle Eastern diet, typically consumed with bread as part of the main meal. It exhibits a white to cream-coloured appearance, semi-solid, paste-like consistency, smooth texture with good spreadability, and mildly acidic taste (Gavião et al. 2021). From a physicochemical perspective, labneh generally contains 22–26% of total solids and 8–11% of fat. Its acidity and pH values range from 1.4% to 2.5% (titratable acidity expressed as lactic acid equivalents) and 3.9 to 4.2, respectively, placing it between yoghurt and cheese in terms of texture and composition (Aly et al. 2020).

The characteristic tangy flavour of labneh, often described as a combination of sour cream and cottage cheese, is primarily attributed to lactic acid formation during fermentation, while aroma-active compounds such as diacetyl contribute to its buttery and creamy notes. Whereas acetaldehyde is the key aroma compound of classical yoghurt cultures composed of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*, diacetyl production is primarily associated with lactococci. This product plays a crucial dietary role, particularly in the Balkans, Turkey, and the Middle East. To maintain its quality, fresh labneh should be stored under refrigeration (+5 °C ± 2.5 °C) and consumed within two weeks (Aly et al. 2020).

Compared to regular yoghurt, labneh is a highly nutritious food, containing approximately 2.5 times more protein, 50% more minerals, and a significantly higher concentration of beneficial living microorganisms such as *S. thermophilus*, *L. delbrueckii* subsp. *bulgaricus*, *L. acidophilus*, *Enterococcus faecalis* (Nsabimana et al. 2005; Habib et al. 2017). In recent years, there has been a growing interest in functional foods due to the increasing consumer awareness of nutrition and health-related risks. As a result, there is a rising demand for food products that not only provide essential nutrients but also health-promoting benefits (Abd El-Montaleb et al. 2022).

A key aspect of a healthy diet is the consumption of fruits and vegetables, which are rich in bioactive compounds such as phenolic compounds. These phytochemicals exhibit antioxidant properties and have been associated with a reduced risk of degenerative diseases, including cardiovascular disorders, various types of cancer, and neurological conditions (Usal and Sahan 2020). Additionally, antioxidant compounds can enhance food stability by delaying oxidative deterioration, particularly in lipid-rich substrates (Ismail et al. 2016). In many countries, incorporating fruits and flavours into dairy products has been a successful strategy to diversify product offerings and increase the consumer appeal (Temiz et al. 2012; Doğan 2016). For instance, fruit-flavoured yoghurts have been introduced to promote yoghurt consumption among children and are valued for their enhanced antioxidant content (Tarakçi and Küçüköner 2003; Wajs et al. 2023). However, with regard to labneh variants, there are currently few products on the Turkish market that contain fruit pieces or fruit flavours. Most of the available products are traditionally produced labneh. Despite this growing diversification, studies that systematically evaluate labneh-based products with added fruits or flavours in terms of physicochemical, microbiological, and sensory quality within the framework of current food legislation and standardised quality requirements remain limited. Therefore, the aim of this study was to formulate a novel labneh variant incorporating fruit pieces or fruit flavours based on strawberry, blackberry, and kiwi for potential industrial application, and to evaluate the influence of different fruit types and flavours on selected physicochemical properties, microbiological quality, and sensory characteristics during a 30-day period of storage.

MATERIAL AND METHODS

Material

The production of fruit-piece labneh and fruit-flavoured labneh was carried out at Aslanağa Çiftliği Dairy Products Industry and Trade, Inc. in Kirklareli, Türkiye, while laboratory analyses were performed at the Food Engineering Department of Kirklareli

https://doi.org/10.17221/189/2025-CJFS

University. For production, freeze-dried strawberries, kiwis, and blackberries from the Fresheld brand (Miyadi Gida, Istanbul, Türkiye) and strawberry, kiwi and blackberry flavours from the Tito brand (Smart Kimya, Izmir, Türkiye) were used. Fresh cow's raw milk was obtained from a local dairy farm. Starter cultures used for fermentation included *Streptococcus thermophilus* (Sacco ST060), *Lactococcus lactis* subsp. *lactis,* and *Lactococcus lactis* subsp. *lactis* biovar *diacetylactis* (Sacco ST062), all purchased from Sacco System (Cadorago, Italy). Salt was purchased from Cihan-Kur A.Ş. (Konya, Türkiye).

Production of fruit-piece labneh and fruit-flavoured labneh

For labneh production, raw milk with fat content of 3.5% and total solids content of 13.5 % was pasteurised at 72 °C for 15 s using a plate pasteuriser and cooled to 50 °C. The pasteurised milk was then subjected to centrifugal fat separation to obtain skimmed milk. The skimmed milk was subsequently processed by ultrafiltration, resulting in a retentate with protein content of approximately 8%. The retentate was then blended with cream containing 65% of fat at 45 °C to adjust the fat content of the mixture to 14%. This mixture (retentate and cream) was heated to 85 °C for a short holding time in a plate heat exchanger and homogenised under pressure to ensure uniform fat distribution, followed by cooling to 43–44 °C for fermentation. The cooled mixtures were inoculated in a fermentation tank with 2 mL per 100 mL (~10^9 CFU·mL^{-1}) of a 1 : 1 mixed culture of the previously described starter cultures. Note: *Lactobacillus delbrueckii* subsp. bulgaricus was not included in the formulation. Fermentation was carried out at 42 °C until a firm coagulum formed (~7–8 hours), and the process was stopped when the pH reached 4.6. The coagulum was then subjected to curd-breaking, followed by thorough mixing with 0.3 g of salt per 100 g of product. At this stage, different ingredients were incorporated depending on the labneh type. For fruit-piece labneh, freeze-dried strawberries, blackberries, and kiwis (Miyadi Gıda) were processed to reduce their size and then added at a level of 6% (*w/w*). For fruit-flavoured labneh, 0.01% colouring and 0.1% fruit flavour (derived from strawberry, blackberry, or kiwi) were incorporated.

Thus, fruit-piece labneh included pieces of fruit, whereas fruit-flavoured labneh was prepared using colouring and fruit flavours to achieve the desired sensory characteristics. The samples consisted of the following labneh variants: control (C): plain labneh (no additional ingredients); strawberry-flavoured (SF): labneh with strawberry flavour and colouring; blackberry-flavoured (BF): labneh with blackberry flavour and colouring; kiwi-flavoured (KF): labneh with kiwi flavour and colouring; strawberry-piece (SP): labneh containing freeze-dried strawberry pieces; blackberry-piece (BP): labneh containing freeze-dried blackberry pieces; kiwi-piece (KP): labneh containing freeze-dried kiwi pieces. Subsequently, all labneh variants were subjected to an additional heat treatment after fermentation, prior to hot filling. Briefly, after heating at 85 °C for a few seconds, the labneh variants were then transferred to filling tanks, hot-filled into polystyrene containers under sterile conditions (HEPA-filtered air) and stored in a resting chamber. A rapid cooling step lowered the temperature to 10–11 °C for precooling, followed by further cooling to 4 °C for storage. The entire production process was repeated twice to ensure reproducibility.

Physicochemical, microbiological, and sensory analyses were conducted on days 1, 7, 15, and 30 of cold storage.

Physicochemical analyses

The analysed physicochemical properties included total solids, fat, titratable acidity, pH, salt, water activity, and colour. Five measurements were taken from equal portions of each sample, and arithmetic means were calculated (Uran and Çetin 2018).

Total solids determination. Moisture content was determined using the drying oven and balance method (ISO 5537:2023).

Titratable acidity. Titratable acidity was determined according to method 920.124, AOAC (2000). Briefly, 20 g of sample was diluted with distilled water, homogenised, and adjusted to 250 mL. An aliquot corresponding to 0.8 g was titrated with 0.1 N NaOH using phenolphthalein as an indicator until a stable light pink endpoint was reached. Results were expressed as % lactic acid (%LA).

Total fat content. Fat content of labneh samples was determined using the Van Gulik method with a cheese butyrometer (ISO 3433, 2008). Approximately 3 g of homogenised sample was treated with sulphuric acid and amyl alcohol, centrifuged in a Gerber centrifuge, and fat content (%) was directly read from the butyrometer scale.

pH. pH measurements were performed using a microcomputer based pH/conductivity/TDS/salinity and temperature meter (WTW Inolab Level 2) (AOAC methods, 1984).

https://doi.org/10.17221/189/2025-CJFS

Water activity. Water activity was determined at 25 °C using a LabSwift-aw meter (Novasina, Switzerland) (Fritzen-Freire et al. 2012). Samples were spread evenly to cover the bottom of the sample cup, and measurements were performed at room temperature.

Salt content. Salt content was determined according to method 935.43, AOAC (2000). Briefly, 20 g of sample was diluted to 250 mL with distilled water, filtered, and a 10 mL aliquot was titrated with 0.1 N $AgNO_3$ using 5% potassium chromate (K_2CrO_4) as an indicator. Results were expressed as % NaCl based on the volume of silver nitrate consumed.

Colour measurement. Colour parameters L^* (lightness), a^* (redness), and b^* (yellowness) were measured using a CR-400 Chroma Meter (Konica Minolta, Japan).

Microbiological analyses

Microbiological analyses of labneh samples were conducted on day 1, 7, 15, and 30 of storage to determine classical indicator microorganisms, including total aerobic mesophilic bacteria, yeasts and moulds, Enterobacteriaceae, and *Escherichia coli*.

Fractions of samples (10 g) were homogenised in 90 mL of sterile saline-peptone water (0.9% NaCl, 0.1% peptone; Oxoid Ltd., UK) using a laboratory blender (BagMixer 400W, Interscience, France) for 3 min. The homogenates were serially diluted (10^{-1} to 10^{-8}) in 0.1% sterile peptone water, and microbiological analyses were performed using pour plate and spread plate methods in accordance with ISO standards. Total aerobic mesophilic bacteria were enumerated by the pour plate method on Plate Count Agar (PCA, Oxoid, UK), incubated at 30 °C for 48 h (ISO 4833-1:2013). Enterobacteriaceae counts were determined on Violet Red Bile Dextrose Agar (VRBDA, Merck, Germany), incubated at 37 °C for 24 h using the pour plate method (ISO 21528-2:2017). *Escherichia coli* counts were determined on Tryptone Bile X-Glucuronide (TBX) Agar (Oxoid), incubated at 44 °C for 24 h using the pour plate method (ISO 16649-2:2001). Yeasts and moulds were enumerated on Dichloran Rose-Bengal Chloramphenicol Agar (Oxoid) using the spread plate method, incubated at 25 °C for 5–7 days (ISO 21527:2008). Microbial counts were expressed as log $CFU \cdot g^{-1}$.

Sensory analyses

The sensory evaluation of the samples was conducted by a panel of 10 semi-trained panellists consisting of faculty members (n = 5) and students (n = 5) who had previous experience in the evaluation of milk and dairy products. The sensory criteria assessed included texture, taste, odour, colour, spreadability, and overall acceptability. Seven-point hedonic scale (1 = dislike extremely, 2 = dislike moderately, 3 = Dislike slightly, 4 = neither like nor dislike, 5 = like slightly, 6 = like moderately and 7 = like extremely) was used to rate the product acceptability described by Lawless and Heymann (2010). Panellists were served water and bread to clean their mouths before tasting each sample. The samples were served at an appropriate temperature (20–25 °C) and the evaluation was done in the laboratory of Food Engineering Department. The panellists were presented with fruit-flavoured labneh and fruit-piece labneh samples and asked to rate each sample on a scale of 1 to 7 on the sensory evaluation form. Each panellist scored samples independently and recorded the scores. The overall acceptability score was determined by calculating the arithmetic mean of all scores given by the panellists across the sensory criteria (Güneş and Çetin 2020). Sensory evaluations were conducted on day 1, 7, 15, and 30 of storage.

Statistical analysis

All analyses were performed in duplicate. Statistical evaluations were conducted using the SPSS 18.0 statistical software package (SPSS Inc., USA). Data were analysed using ANOVA, and differences between sample means were determined using Tukey's multiple comparison test at a significance level of $P < 0.05$.

RESULTS AND DISCUSSION

The quality characteristics of the finished labneh products evaluated in this study were interpreted within the framework of the current Turkish Food Codex for fermented milk products. Although labneh is not explicitly defined as a distinct product category in the Turkish Food Codex (No. 2022/44), it can be classified, based on its production technology and product characteristics, under the category of fermented milk products subjected to post-fermentation heat treatment', defined as fermented milk whose fermentation is terminated by heat treatment and whose coagulum is disrupted. Accordingly, the evaluated labneh samples were assessed in terms of hygienic production, microbiological safety, compositional integrity, and labelling requirements specified for this category, including compliance with the maximum permitted total specific bacterial count of 100 $CFU \cdot g^{-1}$.

Although the explicit sustainability indicators are not directly specified in the legislation, compliance with

https://doi.org/10.17221/189/2025-CJFS

these regulatory standards indirectly supports sustainability through food safety assurance, standardisation of production processes, traceability, and prevention of product adulteration.

Physicochemical analyses. The physicochemical properties of the labneh samples are summarised in Table 1. On day 1, the control group (plain labneh) exhibited the lowest dry matter content (28.62%), while the blackberry-piece labneh showed the highest content (33.02%). This observation is consistent with previous studies reporting that the incorporation of fruit pieces, particularly pectin-rich fruits such as blackberries, increases dry matter and pectin content, enhancing higher water binding (Arioui et al. 2016; Wajs et al. 2023). With the exception of kiwi-piece labneh, samples containing fruit pieces exhibited significantly higher dry matter values compared with both fruit-flavoured variants and the control group ($P < 0.05$). No statistically significant changes in dry matter were observed during storage ($P > 0.05$; Table 1), indicating compositional stability over the 30-day period.

Salt content of the samples ranged between 0.30% and 0.43% (Table 1). Fat content varied between 13.0% and 16.8%, with the lowest value in kiwi-piece labneh on day 30 and the highest value in blackberry-flavoured labneh on day 7. Compared to the control group,

Table 1. Physicochemical properties of the formulated fruit-flavoured and fruit-piece labneh samples compared to plain labneh during 30 days of storage

Labneh samples	Day of storage	Physicochemical properties (mean ± standard deviation)				
		total solids (%)	fat (%)	titratable acidity (%)	salt (%)	pH (at 25 °C)
Plain labneh (no other ingredients)	1	28.60 ± 0.29^{Ba}	15.4 ± 0.30^{Aa}	0.96 ± 0.05^{ABab}	0.43 ± 0.01^{Ca}	4.62 ± 0.02^{Aab}
	7	30.18 ± 0.20^{Ba}	16.25 ± 0.30^{Aa}	0.98 ± 0.05^{ABab}	0.3 ± 0.01^{Cb}	4.86 ± 0.02^{Aa}
	15	30.29 ± 0.20^{Ba}	16.25 ± 0.30^{Aa}	0.73 ± 0.05^{ABa}	0.315 ± 0.01^{Cb}	4.65 ± 0.02^{Ab}
	30	28.97 ± 0.20^{Ba}	15.75 ± 0.30^{Aa}	0.66 ± 0.05^{ABb}	0.4 ± 0.01^{Ca}	4.62 ± 0.02^{Aab}
Strawberry -flavoured	1	28.69 ± 0.20^{Ba}	15.88 ± 0.30^{ABa}	0.635 ± 0.03^{Bab}	0.37 ± 0.01^{Ca}	4.59 ± 0.02^{ABab}
	7	30.38 ± 0.20^{Ba}	16.38 ± 0.30^{ABa}	0.685 ± 0.04^{Bab}	0.3 ± 0.01^{Cb}	4.78 ± 0.02^{ABa}
	15	30.71 ± 0.20^{Ba}	15.5 ± 0.30^{ABa}	0.73 ± 0.03^{Ba}	0.345 ± 0.01^{Cb}	4.65 ± 0.04^{ABb}
	30	31.34 ± 0.20^{Ba}	15.58 ± 0.30^{ABa}	0.69 ± 0.03^{Bb}	0.345 ± 0.01^{Ca}	4.63 ± 0.20^{ABab}
Blackberry -flavoured	1	30.17 ± 0.20^{Aa}	16.13 ± 0.30^{Aa}	0.475 ± 0.05^{Bab}	0.415 ± 0.01^{BCa}	4.68 ± 0.20^{ABCab}
	7	30.63 ± 0.20^{Aa}	16.75 ± 0.30^{Aa}	0.685 ± 0.04^{Bab}	0.37 ± 0.01^{BCb}	4.83 ± 0.20^{ABCa}
	15	30.83 ± 4.70^{Aa}	16.13 ± 0.30^{Aa}	0.65 ± 0.05^{Ba}	0.345 ± 0.01^{BCb}	4.65 ± 0.20^{ABCb}
	30	31.64 ± 0.20^{Aa}	15.38 ± 0.30^{Aa}	0.65 ± 0.05^{Bb}	0.36 ± 0.01^{BCa}	4.67 ± 0.20^{ABCab}
Kiwi -flavoured	1	30.14 ± 0.28^{Ba}	16.25 ± 0.30^{BCa}	0.705 ± 0.05^{ABab}	0.4 ± 0.01^{ABa}	4.65 ± 0.20^{ABab}
	7	30.60 ± 0.20^{Ba}	16 ± 0.30^{BCa}	0.655 ± 0.03^{ABab}	0.355 ± 0.01^{ABb}	4.73 ± 0.20^{ABa}
	15	30.90 ± 0.20^{Ba}	14.7 ± 0.30^{BCa}	0.735 ± 0.05^{ABa}	0.36 ± 0.01^{ABb}	4.61 ± 0.20^{ABb}
	30	31.56 ± 0.20^{Ba}	14.25 ± 0.30^{BCa}	0.685 ± 0.05^{ABb}	0.4 ± 0.01^{ABa}	4.68 ± 0.02^{ABab}
Strawberry -piece	1	32.16 ± 0.20^{ABa}	14.25 ± 0.30^{Ca}	0.615 ± 0.05^{ABab}	0.345 ± 0.01^{Aa}	4.47 ± 0.02^{BCD}
	7	32.59 ± 0.20^{ABa}	14.75 ± 0.30^{Ca}	0.735 ± 0.05^{ABab}	0.37 ± 0.01^{Ab}	4.59 ± 0.02^{BCDa}
	15	32.48 ± 0.20^{ABa}	14.75 ± 0.30^{Ca}	0.73 ± 0.05^{ABa}	0.375 ± 0.01^{Ab}	4.30 ± 0.02^{BCDb}
	30	32.54 ± 0.20^{ABa}	14.75 ± 0.30^{Ca}	0.685 ± 0.05^{ABb}	0.415 ± 0.01^{Aa}	4.36 ± 0.02^{BCDab}
Blackberry -piece	1	33.02 ± 0.20^{ABa}	14.75 ± 0.30^{CDa}	0.765 ± 0.05^{ABab}	0.355 ± 0.01^{ABCa}	4.41 ± 0.02^{Dab}
	7	32.72 ± 0.20^{ABa}	14.75 ± 0.30^{CDa}	0.59 ± 0.05^{ABab}	0.33 ± 0.01^{ABCb}	4.50 ± 0.02^{Da}
	15	32.89 ± 0.20^{ABa}	14.25 ± 0.30^{CDa}	1.022 ± 0.05^{ABa}	0.345 ± 0.01^{ABCb}	4.24 ± 0.02^{Db}
	30	32.47 ± 0.20^{ABa}	14 ± 0.30^{CDa}	0.72 ± 0.05^{ABb}	0.4 ± 0.01^{ABCa}	4.25 ± 0.02^{Dab}
Kiwi-piece	1	31.87 ± 0.20^{Ba}	13.75 ± 0.30^{Da}	0.685 ± 0.04^{Aab}	0.39 ± 0.01^{Aa}	4.39 ± 0.02^{CDab}
	7	32.00 ± 0.20^{Ba}	14.5 ± 0.30^{Da}	0.725 ± 0.03^{Aab}	0.355 ± 0.01^{Ab}	4.51 ± 0.02^{CDa}
	15	32.52 ± 0.20^{Ba}	13.5 ± 0.30^{Da}	1.14 ± 0.05^{Aa}	0.36 ± 0.01^{Ab}	4.26 ± 0.02^{CDb}
	30	31.11 ± 0.20^{Ba}	13 ± 0.30^{D}	0.665 ± 0.05^{Ab}	0.415 ± 0.01^{Aa}	4.34 ± 0.02^{CDab}

^{a,b}different letters significant difference between storage days ($P < 0.05$); $^{A–D}$indicate significant difference among samples ($P < 0.05$)

https://doi.org/10.17221/189/2025-CJFS

the fat content of fruit-flavoured samples was similar to that of the control ($P > 0.05$), whereas fruit-piece labneh samples exhibited significantly lower fat levels ($P < 0.05$) (Table 1). These findings are in accordance with previous reports. For instance, Ismail et al. (2016) determined the fat content of 10.7% in labneh containing 5% dried olive leaf powder, while Ali (2020) found 13.8% and 16.5% in samples with 5% and 15% avocado purée, respectively. The decrease in fat content and increased rancidity observed in kiwi-piece labneh during storage can be attributed to the proteolytic enzyme actinidin, which hydrolyses casein and whey proteins, thereby disturbing the protein matrix and promoting whey separation (Kaur et al. 2023).

Water activity (a_w) remained largely stable during storage for all samples, including the kiwi-piece labneh with no statistically significant changes over time ($P > 0.05$) (Figure 1). Although fruit-piece variants, particularly blackberry-piece labneh, exhibited slightly lower a_w values, compared to the control, these differences were small and within the measurement uncertainty of the LabSwift-aw instrument. Therefore, the observed variations in a_w should be interpreted as technologically marginal rather than practically relevant. Nevertheless, the a_w values obtained in this study (≈ 0.97–0.98) are consistent with those reported for labneh produced from sheep milk (Gavião et al. 2021) and indicate that the water activity alone is insufficient to inhibit microbial growth. Consequently, microbial stability of the formulated labneh variants should be primarily attributed to the combined effects of low pH, hygienic processing, and post-fermentation heat treatment rather than to minor changes in a_w. The addition of fruit pieces reduces both water activity and pH, thereby decreasing the risks related to the growth of pathogenic bacteria. Controlling acidity due to lactic acid formation is of great importance in fermented dairy products (Temiz et al. 2012), thus, especially in yoghurt and cheese production, the incubation process is determined by monitoring pH. Furthermore, the initial pH value significantly affects the rate of acidity development during storage (Çelik et al. 2018). The titratable acidity of the fruit-flavoured samples ranged between 0.48% and 1.14% (Table 1). Blackberry-flavoured labneh had the lowest titratable acidity of 0.47% on day 1, while kiwi pieces-containing labneh exhibited the highest titratable acidity of 1.14% on day 15. The titratable acidity of fruit pieces-containing samples, especially on day 15 of storage, was higher compared to fruit-flavoured samples ($P < 0.05$), reflecting the intensified lactic fermentation within the denser matrix.

The pH measurements of the samples ranged between 4.24 and 4.86. Blackberry-flavoured labneh had the lowest pH of 4.2 on day 7, while blackberry-piece labneh had the highest pH of 4.8 on day 15 (Table 1).

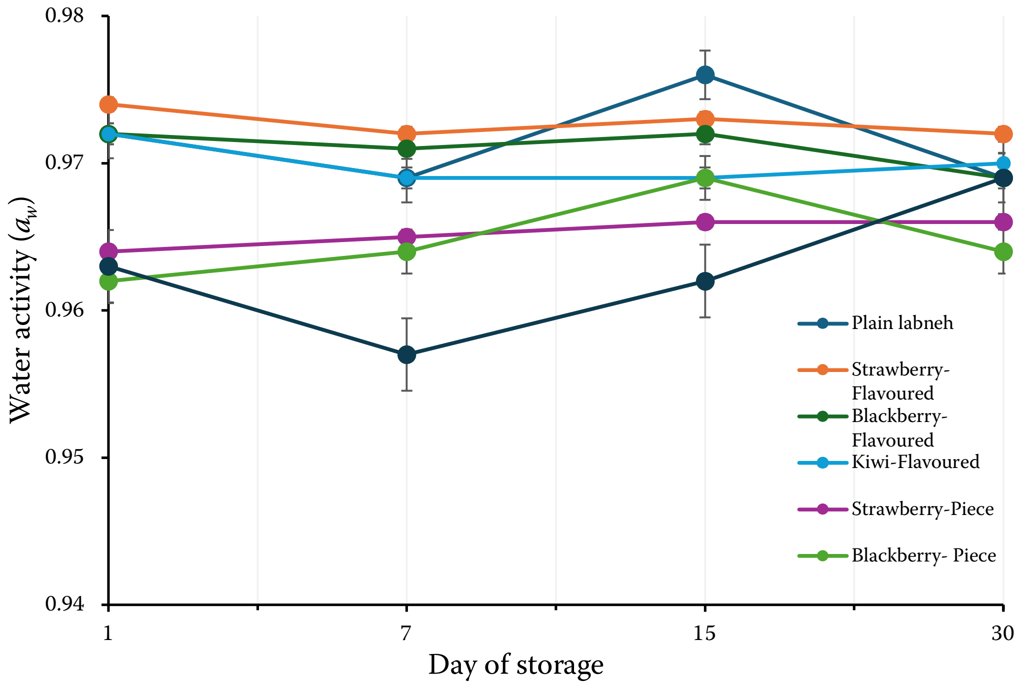

Figure 1. Changes in water activity (a_w) of the formulated fruit-flavoured and fruit-piece labneh samples compared to plain labneh during 30 days of storage

https://doi.org/10.17221/189/2025-CJFS

Table 2. Colour analysis data of the formulated fruit-flavoured and fruit-piece labneh samples compared to plain labneh during 30 days of storage

Colour parameters	Day of storage	Colour measurement (mean ± standard deviation)						
		plain labneh	strawberry-flavoured	blackberry-flavoured	kiwi-flavoured	strawberry-piece	blackberry-piece	kiwi-piece
L^* (lightness)	1	81.60 ± 1.00^{Aa}	90.08 ± 1.00^{Aa}	81.00 ± 1.00^{Ba}	81.18 ± 1.00^{Aa}	83.65 ± 1.00^{Ba}	74.37 ± 1.00^{Ca}	89.07 ± 0.97^{Aa}
	7	91.73 ± 1.00^{Aa}	90.28 ± 1.00^{Aa}	80.90 ± 1.00^{Ba}	91.10 ± 1.00^{Aa}	83.00 ± 1.00^{Ba}	74.24 ± 1.00^{Ca}	89.31 ± 0.84^{Aa}
	15	91.72 ± 1.00^{Aa}	90.02 ± 1.00^{Aa}	81.27 ± 1.00^{Ba}	91.18 ± 1.00^{Aa}	82.74 ± 1.00^{Ba}	74.22 ± 1.00^{Ca}	88.32 ± 0.84^{Aa}
	30	91.89 ± 1.00^{Aa}	90.25 ± 0.50^{Aa}	81.08 ± 1.00^{Ba}	91.12 ± 1.00^{Aa}	83.27 ± 1.12^{Ba}	74.58 ± 1.01^{Ca}	88.54 ± 1.02^{Aa}
a^* (redness)	1	-2.15 ± 0.05^{Ea}	2.28 ± 0.05^{Da}	2.91 ± 0.05^{Ca}	-3.96 ± 0.05^{Ga}	6.97 ± 0.05^{Ba}	12.36 ± 0.05^{Aa}	-2.30 ± 0.05^{Fa}
	7	2.22 ± 0.05^{Ea}	-2.33 ± 0.05^{Da}	3.03 ± 0.05^{Ca}	-4.08 ± 0.05^{Ga}	6.97 ± 0.05^{Ba}	12.38 ± 0.05^{Aa}	-1.93 ± 0.05^{Fa}
	15	-2.19 ± 0.05^{Ea}	2.20 ± 0.05^{Da}	2.98 ± 0.05^{Ca}	-3.97 ± 0.05^{Ga}	5.92 ± 0.05^{Ba}	12.18 ± 0.05^{Aa}	$-2.15 \pm 0.0\ 5^{Fa}$
	30	-1.85 ± 0.05^{Ea}	2.21 ± 0.05^{Da}	3.02 ± 0.05^{Ca}	-3.82 ± 0.05^{Ga}	5.37 ± 0.08^{Ba}	11.60 ± 0.05^{Aa}	-2.19 ± 0.05^{Fa}
b^* (yellowness)	1	7.95 ± 0.05^{Ba}	6.54 ± 0.05^{Da}	-1.72 ± 0.05^{Ga}	7.15 ± 0.05^{Ca}	5.21 ± 0.05^{Ea}	1.46 ± 0.05^{Fa}	9.28 ± 0.05^{Aa}
	7	7.98 ± 0.05^{Ba}	6.69 ± 0.05^{Da}	-1.77 ± 0.05^{Ga}	7.67 ± 0.05^{Ca}	5.60 ± 0.05^{Ea}	1.74 ± 0.05^{Fa}	8.92 ± 0.05^{Aa}
	15	7.93 ± 0.05^{Ba}	6.45 ± 0.05^{Da}	-1.60 ± 0.05^{Ga}	7.39 ± 0.05^{Ca}	5.70 ± 0.05^{Ea}	1.88 ± 0.05^{Fa}	9.28 ± 0.05^{Aa}
	30	7.93 ± 0.05^{Ba}	6.58 ± 0.05^{Da}	-1.57 ± 0.05^{Ga}	7.18 ± 0.05^{Ca}	6.23 ± 0.05^{Ea}	2.07 ± 0.05^{Fa}	7.93 ± 0.05^{Aa}

$^{A–G}$indicate significant difference among samples ($P < 0.05$)

The findings of the analysis are consistent with earlier reports on labneh and similar fermented dairy products (Ali 2020; Abd El-Montaleb 2022). The increase in titratable acidity and the decrease in labneh pH during storage have been well documented (Kebary et al. 2007). Interestingly, Ismail et al. (2016) found that olive leaf powder can elevate pH, possibly due to its buffering capacity − an effect not observed in the present formulations.

The colour analysis results of the samples are shown in Table 2. The L^*, a^*, and b^* values represent a three-dimensional coordinate system, where the L^* value indicates lightness (higher values indicate more brightness), $+a$ represents redness, $-a$ greenness, $+b$ yellowness, and $-b$ blueness (Doğan 2016). The L^* value of plain labneh (control group) was 91.72, while it was 90.10, 81.15, 91.12, 83.00, 74.22 and 88.32 for the strawberry, blackberry and kiwi pieces-containing and flavoured samples, respectively. The sample with the lowest brightness (L^* value) was blackberry pieces-containing labneh, whereas the brightest sample was plain labneh (91.72). The a^* value was −1.85 in plain labneh, while it was 2.20, 2.91, −3.82, 5.92, 12.18 and −2.15 for the strawberry, blackberry and kiwi pieces-containing and flavoured samples, respectively. Blackberry pieces-containing labneh was closest to the positive (+) value, meaning it had the most reddish hue, whereas kiwi-flavoured samples were closest to the negative (−) value, appearing greener. The b^* value in plain labneh was 7.93, while it was 6.45, −1.60, 7.39, 5.60, 1.88 and 8.92 for the strawberry, blackberry and kiwi pieces-containing and flavoured samples, respectively. The sample with the highest yellow intensity was kiwi pieces-containing labneh, while the most bluish sample was strawberry-flavoured labneh. The colour analysis findings on days 7, 15, and 30 indicated no significant changes in colour values during storage ($P > 0.05$). Peker (2012) reported a statistically significant decrease in a^* values during the storage of fruit-flavoured yoghurts containing olive leaf extract. Another study found that the asparagus fibre addition reduced yoghurt transparency and increased b^* values. Additionally, the increasing extract concentration led to higher b^* values (Sanz et al. 2008). L^* value is a measure of food whiteness. The whiteness of liquid milk is attributed to colloidal particles, such as milk fat globules and casein micelles, which scatter light in the visible spectrum. Milk whiteness significantly impacts the consumer appeal, and as fermentation progresses, milk loses its translucency (Garcia-Perez et al. 2005). The intensity of the colour meeting the consumer acceptance is a valid principle in fruit-flavoured yoghurt production (Temiz et al. 2012), and the same can be suggested for cheese.

Microbiological analyses. The microbiological results of the control, fruit-flavoured, and fruit-piece labneh samples are presented in Table 3. The Enterobacteriaceae, *E. coli*, yeasts and moulds were not detected in any of the samples throughout the storage period (below the method detection limits), indicating satisfactory hygienic quality and microbiological safety of the products. Only a low number of total aerobic mesophilic bacteria colonies were observed, with no statistically significant changes during storage ($P > 0.05$) (Table 3).

Importantly, the total aerobic mesophilic counts in all samples remained well below the maximum limit of 100 $CFU \cdot g^{-1}$ specified in the Turkish Food Codex

Table 3. Quantitative results ($CFU \cdot g^{-1}$) for total aerobic mesophilic bacteria in the formulated fruit-flavoured and fruit-piece labneh samples compared with plain labneh during 30 days of storage (Enterobacteriaceae, *Escherichia coli*, yeasts and moulds were not detected)

Labneh samples	Total aerobic mesophilic bacteria ($CFU \cdot g^{-1}$) day of storage			
	1	7	15	30
Plain labneh	$< 1.0 \times 10^{1Cb}$	2.4×10^{1Ca}	7.1×10^{1Ca}	1.8×10^{1Ca}
Strawberry-flavoured	$< 1.0 \times 10^{1Db}$	4.4×10^{1Da}	7.9×10^{1Da}	5.6×10^{1Da}
Blackberry-flavoured	$< 1.0 \times 10^{1Bb}$	$< 1.0 \times 10^{1Ba}$	3.5×10^{1Ba}	$< 1.0 \times 10^{1Ba}$
Kiwi-flavoured	$< 1.0 \times 10^{1Cb}$	2.1×10^{1Ca}	4.5×10^{1Ca}	$< 1.0 \times 10^{1Ca}$
Strawberry-piece	$< 1.0 \times 10^{1Cb}$	3.0×10^{1Ca}	8.1×10^{1Ca}	1.5×10^{1Ca}
Blackberry-piece	$< 1.0 \times 10^{1Ab}$	7.8×10^{1Aa}	6.5×10^{1Aa}	7.8×10^{1Aa}
Kiwi-piece	$< 1.0 \times 10^{1Bb}$	2.0×10^{1Ba}	3.8×10^{1Ba}	6.3×10^{1Ba}

^{a,b}different letters significant difference between storage days ($P < 0.05$); $^{A–D}$indicate significant difference among samples ($P < 0.05$)

https://doi.org/10.17221/189/2025-CJFS

(No: 2022/44) for fermented milk products subjected to post-fermentation heat treatment, demonstrating full compliance with the applicable microbiological criteria. Nevertheless, slightly higher counts were observed in fruit-piece labneh samples, possibly due to the microbial load introduced from the fruit material itself. Similar findings were reported by Çon et al. (1996), who observed an increase in yeast and mould counts with higher fruit levels in yoghurt. Likewise, Tarakçı and Küçüköner (2003) noted that total aerobic mesophilic bacterial counts in control samples were lower than in yoghurt samples containing fruit juice. Aly et al. (2020) reported similar findings in labneh samples containing sesame paste, attributing the low microbial counts to the heat treatment applied before packaging, which effectively eliminated pathogenic and non-pathogenic microorganisms. Similarly, in the present study, a post-fermentation heat treatment was applied prior to packaging, which likely contributed to the low microbial counts observed across all labneh variants. Towards the end of storage, a minor increase in microbial growth was observed, likely due to contamination during fruit particle processing and manual packaging, which may have allowed airborne contaminants to enter the product. These observations agree with previous findings for fruit-enriched fermented dairy products (Ismail 2016; Ali 2020; Abd El-Montaleb 2022). One limitation of this study is the absence of lactic acid bacteria enumeration. As all fruit-enriched labneh variants underwent an additional post-fermentation heat treatment followed by hot filling, the viable lactic acid bacteria were not expected to be present at levels suitable for comparative evaluation.

Sensory analyses. Labneh samples were evaluated by panellists on a seven-point hedonic scale assessing texture, flavour, odour, colour, spreadability, and overall acceptability. The main acceptability score, calculated as the arithmetic mean of these criteria, ranged between 2.9 and 6.5 (Figure 2). On days 1, 7, 15, and 30, the overall acceptability of plain labneh was between 6.1 and 6.5. The highest acceptance at 6.4 on day 30 was observed in strawberry-flavoured labneh, while

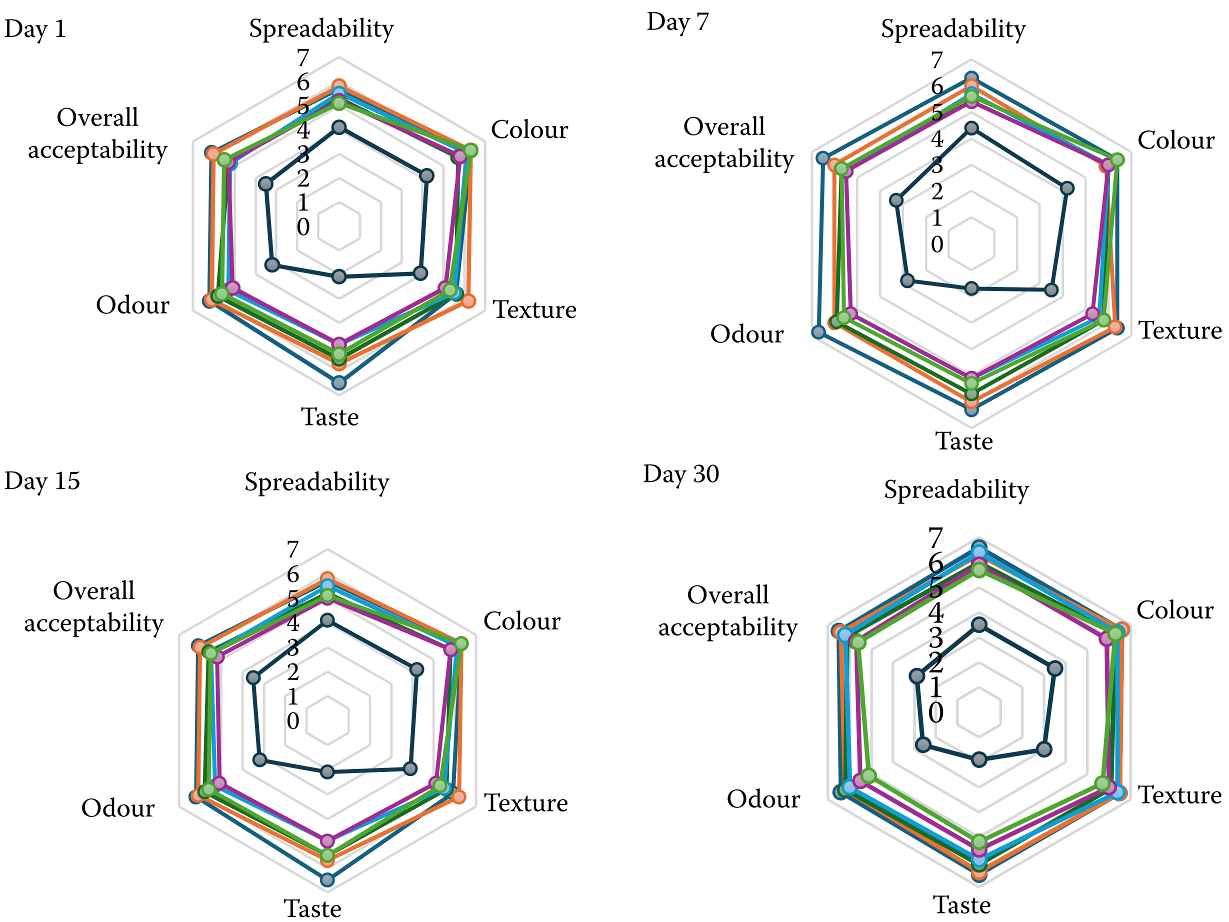

Figure 2. Sensory properties of the formulated fruit-flavoured and fruit-piece labneh samples compared to plain labneh during 30 days of storage

https://doi.org/10.17221/189/2025-CJFS

kiwi-piece labneh had the lowest acceptability at 2.4 on day 30. After 30 days of storage, all samples, except the kiwi-piece labneh, showed no significant differences in overall acceptability scores ($P > 0.05$), suggesting that the addition of strawberry and blackberry components did not adversely affect the consumer perception and that these variants were considered suitable for industrial production.

CONCLUSION

From a regulatory aspect, the physicochemical stability, microbiological safety, and sensory acceptability of the developed labneh formulations indicate their suitability for industrial application under the provisions of the Turkish Food Codex (No. 2022/44) for fermented milk products. Although labneh is not explicitly defined as a separate product category, the results show that the formulations comply with the regulatory requirements applicable to fermented milk products subjected to post-fermentation heat treatment, including the microbiological criterion for total specific bacterial counts. Based on the results, strawberry- and blackberry-flavoured labneh, as well as strawberry-piece labneh, demonstrated high sensory acceptability, good microbiological stability, and favourable physicochemical properties, making them promising candidates for industrial production. In contrast, kiwi-piece labneh exhibited significant structural defects, such as excessive syneresis and pronounced bitterness, which intensified during storage. These defects are likely attributable to the seeds and proteolytic activity in freeze-dried kiwi pieces, indicating that kiwi-piece labneh is unsuitable for industrial production. The formulated fruit-piece and fruit-flavoured labneh variants offer a valuable approach to diversifying dairy products while enhancing nutritional and sensory properties. Such products have the potential to increase both fruit and dairy consumption and provide tangible benefits to the dairy industry. Future research should focus on optimising ingredient incorporation and process parameters to further improve product stability and sensory quality.

REFERENCES

Abd El-Montaleb H.S., Abbas K.A.E, Mwaheb M.A., Hamdy S.M. (2022): Production and characteristic quality of probiotic Labneh cheese supplemented with broccoli florets. British Food Journal, 124: 3666–3679.

Ali H.M. (2020): Comparative study on Labneh cheese made from milk fat and avocado paste. Al-Azhar Journal of Agricultural Research, 45: 86–90.

Aly A.A., Refaey M.M., Hameed A.M., Sayqal A., Abdella S.A., Mohamed A.S., Hassan H.M.A., Ismail H.A. (2020): Effect of addition sesame seeds powder with different ratio on microstructural and some properties of low fat Labneh. Arabian Journal of Chemistry, 13: 7572–7582.

Arioui F., Saada D.A., Cheriguene A. (2016): Physicochemical and sensory quality of yogurt incorporated with pectin from peel of *Citrus sinensis*. Food Science & Nutrition, 5: 358–364.

Çelik Ş., Ünver N., Güç B., Ceylan P. (2018): (Some characteristic of fruity yoghurt produced with adding carob molasses). Harran Tarım ve Gıda Bilimleri Dergisi, 22: 215–224. (in Turkish)

Çon A.H., Çakmakçı S., Çağlar A., Gökalp H.Y. (1996): Effects of different fruits and storage periods on microbiological qualities of fruit-flavoured yogurt produced in Turkey. Journal of Food Protection, 59: 402–406.

Doğan C. (2016): Menengiç ve bazi sert kabuklu meyve diş kabuklarına ait ekstraktlarin antimikrobiyal ve antioksidan özelliklerinin belirlenmesi ve meyveli yoğurt üretiminde kullanimi [Determination of antimicrobial and antioxidant properties of Menengiç and some nut husks and their use in fruit yogurt production]. [PhD. Thesis]. Şanliurfam, Harran University, Institute of Science, Department of Food Engineering.

Fritzen-Freire C.B., Prudencio E.S., Amboni R.D.M.C., Pinto S.S., Murakami A.N.N., Murakami F.S. (2012): Microencapsulation of bifidobacteria by spray drying in the presence of prebiotics. Food Research International, 45: 306–312.

Garcia-Perez F.J., Lario Y., Fernandez-Lopez J., Sayas E., Perez-Alvarez J.A., Sendra E. (2005): Effect of orange fiber addition on yogurt color during fermentation and cold storage. Color Research and Application, 30: 457–463.

Gavião E.R., Munieweg F.R., Czarnobay M., Dilda A., de Cássia Moura Stefani L., Nespolo C.R. (2021): Development and characterization of two novel formulations of Labneh cheese of sheep's milk. Food Science and Technology (Campinas), 41: 708–715.

Güneş R., Çetin B. (2020): Investigation of some quality parameters of pickled pepper produced by low value dairy by-products. GIDA, 45: 448–460.

Habib E.E., Shamsia S.M., Awad S.A., Hamed M.Z. (2017): Physicochemical and sensory properties of labneh fortified with *Salvia officinalis*. Alexandria Science Exchange Journal, 38: 761–769.

Ismail A.I., Zaki N.L., El-Shazly H.A. (2016): Labneh fortified with olive leaves as innovative dairy products. Journal of Food and Dairy Sciences, 7: 415–419.

https://doi.org/10.17221/189/2025-CJFS

Kaur S., Vasiljevic T., Huppertz T. (2023): Influence of actinidin-induced hydrolysis on the functional properties of milk protein and whey protein concentrates. Foods, 12: 3806.

Kebary K.M.K., Hussein S.A., Badawi R.M., Badran I. (2007): Incorporation of bifidobacteria in low fat labneh. In: Proceedings of the 10th Egyptian Conference of Dairy Science and Technology, Cairo, Egypt, Nov 19–21, 2007: 359–375.

Lawless H.T., Heymann H. (2010): Sensory Evaluation of Food Principles and Practices. 2nd Ed. New York, Springer: 1–21.

Nsabimana C., Jiang B., Kossah R. (2005): Manufacturing, properties and shelf life of labneh: A review. International Journal of Dairy Technology, 58: 129–137.

Peker H. (2012): (Keçiboynuzu gamı kullanilarak az yağli yoğurt ve zeytin yaprağı ekstrakti kullanilarak fonksiyonel meyveli yoğurt üretimlerinin araştirilmasi) [Investigation of production of low-fat yoghurt by using locust bean gum and functional fruit yoghurt by using olive leaf extract]. [Master's Thesis]. Denizli, Pamukkale University, Institute of Science, Department of Food Engineering.

Özer B. (2006): Production of concentrated products. In: Tamime A. (ed): Fermented Milks. Hoboken, Blackwell Publishing: 128–155.

Sanz T., Salvador A., Jimenez A., Fiszman S.M. (2008): Yogurt enrichment with functional asparagus fibre, effect of fibre extraction method on rheological properties, colour and sensory acceptance. European Food Research and Technology, 227: 1515–1521.

Tarakçi Z., Küçüköner E. (2003): Physical, Chemical, microbiological and sensory characteristics of some fruit-flavored yoghurt. YYÜ Veteriner Fakültesi Dergisi, 14: 10–14.

Temiz H., Tarakçı Z., Karadeniz T., Bak T. (2012): The effect of loquat fruit (*Eriobotrya japonica*) marmalade addition and storage time on physico-chemical and sensory properties of yogurt. Journal of Agricultural Sciences, 18: 329–338.

Uran H., Çetin B. (2018): (Effect of vaporized ethyl pyruvate on the shelf life of chicken meat). Avrupa Bilim ve Teknoloji Dergisi, 14: 255–260. (in Turkish)

Usal M., Sahan Y. (2020): *In vitro* evaluation of the bioaccessibility of antioxidative properties in commercially baby foods. Journal of Food Science and Technology, 57: 3493–3501.

Wajs J., Brodziak A., Król J. (2023): Shaping the physicochemical, functional, microbiological and sensory properties of yoghurts using plant additives. Foods, 12: 1275.

Received: November 11, 2025
Accepted: March 12, 2026
Published online: June 22, 2026