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Berry pulp incorporation into probiotic yoghurt: Microbiological, textural and sensory properties, and antioxidant activity

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Abstract

The effect of different berry fruits on the bacterial survival, antioxidant, textural, and sensory characteristics of probiotic yoghurt containing *Lactobacillus acidophilus* LA-5, and *Bifidobacterium animalis* subsp. *lactis* BB-12® was investigated during 21 days of storage. In this context, raspberry (*Rubus idaeus*), goji berry (*Lycium barbarum*), or blueberry (*Vaccinium corymbosum*) pulp (15 %) containing fruit and sugar in a 1:1 ratio was used in the yoghurt manufacture. Yoghurt without any fruit pulp was the control sample. The viable cell counts of yoghurt starter bacteria and probiotic bacteria were above 7.50 and 8.70 log CFU/g, respectively, meeting the recommended minimum levels. The highest viability of *L. acidophilus* was in goji berry-added yoghurt for 14 days of storage. In contrast, the superiority of goji berries for the viable count of *B. lactis* could be determined only on the 14th and 21st days. Goji berry-supplemented probiotic yoghurt showed the highest total phenolic content and (2,2-diphenyl-1-picrylhydrazyl) radical (DPPH$^{\cdot}$) scavenging activity throughout the storage. Yoghurt containing blueberry pulp had a higher anthocyanin amount than the sample with raspberry during storage. In contrast, anthocyanin, in terms of the pelargonidin-3-glycoside, could not be determined in probiotic yoghurt with goji berry pulp. The supplementation of probiotic yoghurt with berry pulp improved the viscosity and water-holding capacity properties; however, it had generally no significant effect on the sensory characteristics.

Keywords: berry fruit; yoghurt; probiotic bacteria; viability; antioxidant activity

Introduction

Functional foods have garnered increasing attention worldwide in recent years, driven by consumers' heightened health awareness, demand for healthy foods, and shifts in eating habits. Additionally, the World Health Organization (WHO) has issued several guidelines to promote a balanced and healthy diet and lifestyle. Functional foods are considered to be foods that provide health benefits and reduce the risk of disease in addition to basic nutrition (Al-Sheraji et al., 2013). Functional dairy products, such as probiotic yoghurt, containing probiotic bacteria, are the most common known and consumed functional foods due to their health-promoting effects. FAO/WHO defined probiotics as 'live microorganisms that, when administered in adequate amounts, confer a health benefit on the host', and it is also reported that probiotics have the potential to prevent and treat various diseases. The definition of a prebiotic is "a non-viable food component that confers a health benefit on the host associated with modulation of the microbiota". It is well known that the health benefits of probiotics depend on the presence of a sufficient number of viable cells in the food and their survival through the gastrointestinal tract, allowing them to colonize the intestine and exhibit their beneficial health effects (Wang et al., 2025).

The inclusion of fruits and vegetables to enhance the functionality of dairy products is a growing trend. The use of certain fruits in dairy product production enhances the nutritional quality of the food and its acceptability to consumers, thanks to the vitamins and minerals present in the fruits, as well as their sensory properties. In recent years, have been widely evaluated as natural sources for the formulation of functional products. Berries can be consumed in various forms, including fresh fruit, juice, jams, dried berries, and candied berries. Berry fruits, rich in bioactive compounds, ascorbic acid, and mainly polyphenols such as anthocyanins, flavonols, tannins, and phenolic acids, may act as antioxidants and play a crucial role in mitigating oxidative stress-related diseases (Barkaoui et al., 2023). prevent cancers, inflammatory disorders, and/or cardiovascular diseases. Moreover, polyphenols in berry fruits, such as quercetin and resveratrol, have been shown to inhibit pro-inflammatory cytokines and enzymes, thereby reducing inflammation. Flavonoids and polyphenols in berries have also been reported to improve endothelial function, reduce blood pressure, and decrease LDL cholesterol levels, thereby having a beneficial effect on cardiovascular health (Murugan, 2024).

Besides their potent antioxidant properties, berries may exhibit a potential prebiotic effect due to their high dietary fiber content and polyphenolic compounds, which can promote the growth of beneficial microorganisms (Diez-Śanchez et al., 2023). Dietary prebiotics are generally carbohydrate-based; however, berry fruits contain substrates and biomolecules that can be utilized by the gut microbiota, such as pectic and hemicellulosic polysaccharides, as well as polyphenols and lignin (Komarnytsky et al., 2023). The possible prebiotic effect and/or antioxidant activity-improving effect of different berry varieties have been studied on fruits, fruit juice, and fruit by-products (Coman et al., 2018; Michel-Barba et al., 2019; Silva et al., 2023; Hurtado-Romero et al., 2024). Besides that, some studies have observed improvements in both starter culture viability and antioxidant properties in yoghurt supplemented with different types of berries (Bueno et al., 2014; Ni et al., 2018; Liu and Lv, 2019; Tavena and Valev, 2019; Dimitrellou et al., 2020; Şengül et al., 2022; Ścibisz and Ziarno, 2023; Plessas et al., 2024). Although there are some relevant studies, a gap remains in the literature regarding the prebiotic effect and other functional effects of fruit phenolics in yoghurt matrices containing different probiotic bacteria.

The focus of this study was to evaluate the potential applications of raspberry (*Rubus idaeus*), goji berry (*Lycium barbarum*), and blueberry (*Vaccinium corymbosum*) pulp on probiotic yoghurt containing *Bifidobacterium animalis* subsp. *lactis lactis* BB-12®, and *Lactobacillus acidophilus* LA-5. In this context, the physicochemical, textural, and sensory characteristics, as well as the antioxidant attributes, of probiotic yoghurt were determined during a 21-day storage period. The survival of both yoghurt starter bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and probiotic bacteria was also observed during the refrigerated storage.

Materials and methods

Fruits, strains, and ingredients

The study was conducted on raspberries, goji berries, and blueberries provided by commercial producers in Bursa and İzmir provinces, Turkey. The fruits were stored at -18 °C until use. The freeze-dried direct-vat-set yoghurt starter culture (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (YoFlex YC-380)) and probiotic bacteria (*Bifidobacterium animalis* subsp. *lactis* BB-12®, and *Lactobacillus acidophilus* LA-5) containing 10^{11} and 10^{12} cfu/g, respectively, were obtained from Chr. Hansen A/S, Hørsholm, Denmark. The raw milk (3.08 % milk fat, 4.60 % carbohydrate, and 3.11 % protein) and skim milk powder (1.25 % fat, 52 % carbohydrate, and 36 % protein) were kindly provided by Pınar Dairy Products, Pınarbaşı, İzmir, Turkey.

Yoghurt manufacture

Firstly, fruits that were brought to room temperature were blended to obtain a puree. Fruit puree and an equal amount of sucrose were heated to 85 °C for 20 minutes and then cooled to 5 °C. The fruit pulps were added to yoghurts at a ratio of 15 g pulp to 100 g yoghurt.

Probiotic yoghurts were manufactured using milk standardized with skim milk powder to achieve 140 g/L of non-fat milk solids, and then heated at 85 °C for 30 minutes. After cooling to 43 °C, the yoghurt starter culture and probiotic bacteria (*B. lactis* Bb12 and *L. acidophilus* La5) were added to the milk base according to the manufacturer's instructions. For this purpose, the yoghurt starter culture was poured into 1 L of sterilized milk at 40 °C and mixed thoroughly. Then, 4 mL of the mixture was added to 1 L of milk. *B. lactis* Bb12 and *L. acidophilus* La5 were added in order to obtain 10^{10} cfu/g in the end product. The samples were then incubated at 40 °C until a pH of 4.7 was reached. After fermentation, the yoghurt samples were cooled to room temperature for 30 min and transferred to a refrigerator at 4 °C for one night. Then, yoghurt was divided into four equal parts as follows: (C) plain control probiotic yoghurt (without fruit pulp or sugar), (R) probiotic yoghurt added with 15 % raspberry pulp, (G) probiotic yoghurt added with 15 % goji berry pulp, (B) probiotic yoghurt added with 15 % blueberry pulp. Fruit pulps were added to yogurt at a 15 % ratio and then mixed carefully to prevent contamination. The yoghurt samples were then put into 200 mL plastic containers and stored at 4 °C for 21 days.

Physicochemical properties

The total soluble solid content of the fruit juice was determined using a digital refractometer (PR-1; Atago, Tokyo, Japan) and expressed as a percentage of the total solids. The determination of total solids, fat, and protein contents in yoghurt was made according to the methods described in the AOAC (2000). The pH values of both fruit juice and yoghurts were determined using a pH meter (Hanna Instruments Model pH: 211; Woonsocket, RI, USA). The color analysis of yoghurt samples was performed by a Minolta CR-400 Colorimeter (Japan), and the L*, a*, and b* color dimensions, which are lightness (L*), redness (a*), and yellowness (b*), were expressed in accordance with the CIE Lab. System.

Microbiological properties

The counts of *S. thermophilus* were enumerated using M-17 agar (Merck, Darmstadt, Germany) after incubating the plates aerobically at 37 °C for 72 hours. *Lactobacillus delbrueckii* subsp. *bulgaricus* was enumerated using MRS agar (Merck, Darmstadt, Germany) adjusted to pH 5.2, with anaerobic incubation at 42 °C for 72 h. *Bifidobacterium animalis* subsp. *lactis* was enumerated on a TOS-MUP agar after incubating the plates anaerobically at 37 °C for 72 h (Turgut and Çakmakçı, 2018). *L. acidophilus* was enumerated on MRS-sorbitol agar after incubating the plates anaerobically at 37 °C for 72 h. In the method, 100 mL of membrane-filtered (Sartorius, Minisart®) sterile water, containing 10 g of D-sorbitol, was added to 900 mL of MRS agar just before pouring the agar (Dave and Shah, 1996).

Total phenolic content, total antioxidant activity, and total anthocyanin content

The Folin method was used to determine the total phenolic content of probiotic yoghurt samples using the Ciocalteu method (Singleton et al., 1999). The phenolic content was compared to a gallic acid standard curve, and the total phenolic content of the samples was expressed as milligrams gallic acid equivalents (GAE) per liter of sample. The equation for the gallic acid calibration curve was $y = 0.0012x + 0.0683$, and the correlation coefficient was $R^2 = 0.9895$. Preparation of yoghurt extracts was performed according to the method described by Singleton et al. (1999). For this purpose, 10 g of the yoghurt sample was centrifuged (Sigma Centrifuge, Model 3-16K, SciQuip Ltd., Newtown, Wem, Shropshire, England) at 9383xg for 25 min, filtered using Whatman no. 1 filter paper (Global Life Sciences Solutions, Buckinghamshire, UK), and the supernatant was used in the method.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity of probiotic yoghurt samples was determined according to the procedure described by Ünal and Akalın (2012). A 0.1 mmol/L DPPH˙ radical solution in 95 % ethanol was prepared. Eight milliliters of an ethanolic DPPH solution was placed in a 50 mL centrifuge tube and mixed with 2 mL of the sample or 95 % ethanol (as a control), vortexed well, and then incubated for 30 min at room temperature. The samples were then centrifuged for 5 min at 13500 rpm at room temperature. Supernatants were filtered using Whatman no. 40 filter paper. Absorbance of each sample was measured at 517 nm. Trolox was used as a reference antioxidant at a concentration of 0.25 mg/mL. DPPH˙ scavenging activity percent was calculated as follows (Eq.1):

DPPH˙ scavenging activity (%) = [(control absorbance-extract absorbance) / (control absorbance)] X 100 (1)

The total anthocyanin content of the probiotic yoghurt extracts was measured using the pH differential method (Raikos et al., 2019). Results are expressed as milligrams of pelargonidin 3-glucoside (P 3-G) equivalents per 100 g of weight. Yoghurt extracts for anthocyanin analysis were obtained by diluting the yoghurt sample five times with a mixture of 95 % ethanol/water (80/20). After centrifugation (4 °C, 10 min, 500 rpm) and filtration (with a pore size of 0.45μm) steps, the supernatant was frozen (-20 °C) and used for the analysis.

Texture properties

The viscosity and water-holding capacity (WHC) of the yoghurt samples were determined according to Akalın et al. (2012). The viscosity of the yoghurt samples was determined at 4 °C using a Brookfield viscometer Model DVII (Brookfield Engineering Lab., 2014). The samples were analyzed using spindle no 4 at a rotation of 12 rpm, and the analysis was duplicated. The yoghurt mixture was gently stirred for 60 s before testing. The water-holding capacity was determined by weighing the amount of whey. The whey expelled from approximately 20 g of a yoghurt sample, which was centrifuged at 20 °C and 5000 × g for 10 min, was removed and weighed in grams. The following formula defines the WHC.

Water Holding Capacity (%) = [(Yoghurt – Whey expelled) / Yoghurt] × 100

Sensory properties

Sensory evaluation of the probiotic yoghurt samples was carried out according to Martin-Diana et al. (2003). Samples were evaluated for their taste, aroma, consistency, appearance, and overall acceptability. The sensory panel group consisted of 10 experienced academicians from the Department of Dairy Technology (Ege University, Izmir, Turkey) who were familiar with the attributes of fermented milk samples. The evaluation is based on the five-point hedonic scales (1, dislike extremely; 5, like extremely). Yoghurts, coded with three digits, were presented to the panellists in individual plastic containers.

Statistical analyses

The experiments, including the yoghurt production, were repeated three times. The data obtained were analyzed using one-way ANOVA with the general linear model (GLM) procedure in SPSS (version 11.05; SPSS Inc., Chicago, IL, USA). The means were compared using the Duncan multiple-comparison test at the p<0.05 level.

Results and discussion

Physicochemical properties

The total soluble solid content and pH values of raspberry, goji berry, and blueberry were determined to be 11.45 %, 26.73 %, and 14.47 %, respectively, and 3.29, 4.96, and 3.41, respectively. The total solids, fat, and protein contents of probiotic yoghurts ranged between 16.22-22.49 %, 2.80-3.00 %, and 3.99-4.64 %, respectively. The addition of fruit puree resulted in a significant increase (p<0.05) in total solids of probiotic yoghurts compared to the control sample, a finding also reported by some studies (Liu and Lv, 2019; Şengül et al., 2022; Lutchmedial et al., 2004). In parallel with raspberry having the lowest total solids among fruit varieties, raspberry yoghurt also had the lowest total solids content among fruit yoghurt samples. Blueberry fruit had a higher total soluble solid content than raspberry fruit, as reported by Hurtado-Romero et al. (2024). Therefore, it is expected that blueberry yoghurt would contain higher total solids than raspberry yoghurt. On the other hand, the protein and fat contents of yoghurt samples decreased significantly with the addition of fruit puree. Cuşmenco and Bulgaru (2020) also reported higher total solids and lower protein and fat content for yoghurts added with different fruits, which is in parallel to our results.

The pH values of the probiotic yoghurts during 21 days of storage are given in Figure 1. The addition of berry fruit pulp generally decreased the pH values of the yoghurt samples throughout the storage period (p<0.05), except for the addition of goji berries. This is expected considering that the pH value of the goji berry fruit is higher than that of other berries.

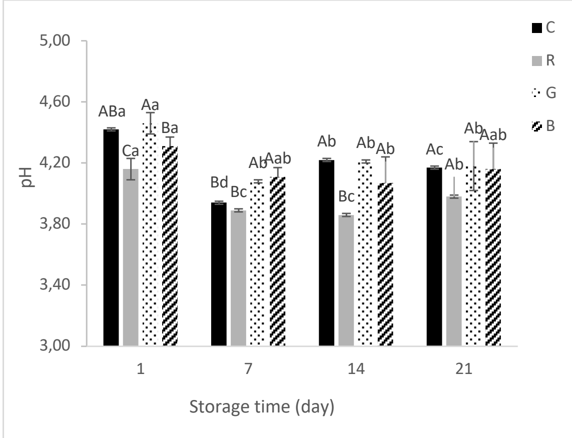

Figure. 1 Changes in pH values in control probiotic yoghurt oduced without fruit pulp (C), probiotic yoghurt produced with raspberry pulp (R), probiotic yoghurt produced with goji berry pulp (G), probiotic yoghurt produced with blueberry pulp (B)

Yoghurt supplemented with raspberry had the lowest pH values throughout storage, whereas there were no significant differences between the other fruit yoghurt samples, except on day 1. This result is consistent with the fact that the pH value of raspberries is significantly lower than that of other fruit types. Hurtado-Romero et al. (2024) also determined a lower pH value in raspberry fruit when compared to blueberry (p<0.05).

Some fluctuations were observed in the pH values of the experimental yoghurts during the 21-day storage period. All samples had lower (p<0.05) pH values at the end of storage compared to the first day, except for the blueberry yoghurt. Similarly, Şengül et al. (2022) could not determine a significant change in the pH value of blueberry yoghurt, containing 8 % blueberry and 8 % sugar, during 28 days of storage. However, Ścibisz et al. (2012) observed a significant decrease in the pH value of probiotic blueberry yogurt at the end of 8 weeks, which is likely due to a longer storage duration compared to our study.

Parallel to our findings, Bueno et al. (2014) detected a decrease in pH values of berry fruit added to symbiotic yoghurt after 21 days of storage. Raspberry pulp-enriched probiotic yoghurt also had a lower pH value when compared to the control sample at the beginning of the storage in that study. Consistent with these results, Cinbas and Yazici (2008) found that the control sample without fruit had the highest pH value among the blueberry yoghurts with varying fruit concentrations. The authors also detected a significant decline in values over the 20 days. Taneva and Dimitrovska (2019) also detected a significant decline in the pH value of goji berry yoghurt on day 7 compared to day 1, which is in parallel to our findings.

Color is a crucial factor that influences consumer appreciation of all foods, particularly those containing fruit. The L* (Lightness), a* (redness-greenness), and b* (yellowness-blueness) values of the probiotic yoghurts at 4 °C for 21 days are evaluated and given in Table 1. The supplementation of probiotic yoghurts with fruit pulp generally affected color properties ($p<0.05$). The L* values of the control yoghurt were mostly higher than those of the berry-added samples during the storage period, which is parallel to the result obtained by Bueno et al. (2014). The blueberry yoghurt showed the lowest L* value, probably due to the darker color of the blueberries compared to other fruit types. Although there were some fluctuations in the L* values of some experimental samples they did not differ on the 21st day compared to the beginning of the storage ($p<0.05$). The variation during the storage can be caused by factors related to the direction of the light or the person performing the measurement. On the other hand, it is an expected situation that there can be variations in L* values of fruit yoghurt samples due to the degradation of fruit pigments. As can be seen from the table, this situation is also reflected in the b* and a* values of the samples. These findings are consistent with the results obtained by Cinbas and Yazici (2008) and Şengül et al. (2022) for blueberry yoghurt samples.

Control probiotic yoghurt without any fruit pulp showed the lowest a* values throughout the entire storage period ($p<0.05$). Probiotic yoghurt containing raspberry pulp had the lowest values among fruit yoghurts during storage, whereas the highest a* value was detected in the sample supplemented with blueberry pulp, except on the 21st day.

Blueberry probiotic yoghurt had the lowest b* values, whereas goji berry probiotic yoghurt showed the highest b* values among all types of yoghurt during the storage period ($p<0.05$). Dimitrellou et al. (2020) also reported lower L* and b* values and higher a* values for blueberry juice-added yoghurt compared to the control sample. The observed loss of redness (a* values) and the increase in b* values of our berry fruit pulp-added yoghurt samples throughout storage can be attributed to the degradation of anthocyanins or the formation of yellow and brown polymerization compounds (Ścibisz et al., 2019).

Microbiological properties

The changes in the viable counts of *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, *Bifidobacterium lactis*, and *Lactobacillus acidophilus* are presented in Figure 2. *Lactobacillus bulgaricus* and *Streptococcus thermophilus* counts were kept above 7.50 log cfu/g in all probiotic yoghurt samples. These results are in agreement with the Codex Alimentarius Commission (2011), which establishes that the count of lactic acid bacteria must be greater than 10^7 cfu/g.

The viability of *L. bulgaricus* significantly increased on the seventh day and remained stable until the end of storage in all experimental yoghurts. Control yoghurts contained at least as many *L. bulgaricus* counts as fruit yoghurts throughout storage. The supplementation of probiotic yoghurt with any fruit pulp did not significantly enhance the viability of *L. bulgaricus*, whereas the lowest counts were generally found in raspberry yoghurt. This can be due to the low pH value of the raspberry yoghurt during storage.

Similar to the viability of *L. bulgaricus*, the lowest counts of *S. thermophilus* were generally detected in yoghurt with raspberry pulp. Since both yoghurt bacteria are known to be sensitive to acidic conditions, this may be because raspberry yoghurt had the lowest pH value. In parallel with our findings, Ścibisz and Ziarno (2023) reported lower yoghurt bacteria cell counts in a smoothie containing raspberry puree and yoghurt than in a sample with blueberry puree, attributing this to the differing citric acid content in raspberry and blueberry purees.

The advantage of using goji berry and blueberry pulps on the viability of *S. thermophilus* was only observed on the 14th day of storage. In contrast, there were no significant differences in *S. thermophilus* counts among probiotic yoghurts at the end of the storage. The addition of blueberry flower pulp or blueberry juice significantly promoted the viable cell numbers of *S. thermophilus* in yoghurt in some studies (Liu

Table 1. *Color parameters of probiotic yoghurts during refrigerated storage*

	Product	Day 1	Day 7	Day 14	Day 21
L*	C	66.38 ± 3.32^{Ab}	74.74 ± 6.89^{Aa}	76.67 ± 2.45^{Aa}	62.56 ± 2.10^{Ab}
	R	63.57 ± 1.10^{Aab}	67.39 ± 1.83^{ABa}	63.33 ± 1.69^{Bab}	62.56 ± 2.10^{Ab}
	G	62.82 ± 1.44^{Ab}	68.12 ± 2.16^{ABa}	66.29 ± 4.23^{Bab}	64.33 ± 1.61^{Aab}
	B	55.75 ± 0.63^{Ba}	62.58 ± 1.67^{Ba}	62.45 ± 6.32^{Ba}	62.44 ± 2.95^{Aa}
a*	C	-1.33 ± 0.11^{Dc}	-1.18 ± 0.27^{Dc}	-0.88 ± 0.07^{Cb}	-0.36 ± 0.04^{Da}
	R	4.60 ± 0.20^{Cb}	4.96 ± 0.22^{Ca}	3.93 ± 0.12^{Bc}	3.06 ± 0.13^{Cd}
	G	6.34 ± 0.12^{Bb}	7.26 ± 0.31^{Ba}	7.68 ± 0.36^{Aa}	6.81 ± 0.78^{Aab}
	B	7.77 ± 0.46^{Aa}	7.93 ± 0.12^{Aa}	7.70 ± 0.18^{Aa}	5.15 ± 0.30^{Bb}
b*	C	7.36 ± 0.45^{Bb}	8.25 ± 0.79^{Ba}	8.68 ± 0.13^{Ba}	8.69 ± 0.15^{Ba}
	R	5.19 ± 0.36^{Cd}	6.29 ± 0.27^{Cc}	7.02 ± 0.23^{Cb}	7.81 ± 0.24^{Ca}
	G	15.4 ± 20.22^{Ab}	16.7 ± 10.69^{Aa}	17.78 ± 0.94^{Aa}	16.55 ± 0.54^{Aab}
	B	0.11 ± 0.01^{Dd}	2.78 ± 0.16^{Dc}	2.78 ± 0.16^{Db}	4.58 ± 0.16^{Da}

$^{a–d}$*Means ± standard deviations in the same row with different superscript lowercase letters are significantly different (p<0.05)*
$^{A–D}$*Means ± standard deviations in the same column with different superscript uppercase letters are significantly different (p<0.05)*
C = Control probiotic yoghurt produced without fruit pulp, R = Probiotic yoghurt produced with raspberry pulp, G = Probiotic yoghurt produced with goji berry pulp, B = Probiotic yoghurt produced with blueberry pulp

and Lv, 2019; Dimitrellou et al., 2020). The promoting effect of adding 7 % goji berry to yoghurt was observed on both the viability of *S. thermophilus* and *L. bulgaricus*, rather than the control sample (Rotar et al., 2015). Similarly, an increase in the count of *S. thermo*philus was observed in 6 % goji berry-added yoghurt compared to yoghurt without fruit, as determined by Taneva and Dimitrovska (2019). The viability of *S. thermophilus* in blueberry pulp-added yoghurt increased ($p<0.05$) on the 14th day, whereas the counts did not significantly change throughout the storage period in other yoghurt samples.

To be considered a functional food and provide health benefits, the recommended levels of Bifidobacteria (≥10^6 cfu/mL) were maintained in all probiotic yoghurts throughout storage (FAO, 2013). Although the pH value of the experimental yoghurts decreased throughout the storage, it was observed that Bifidobacteria remained alive at a high rate, probably due to the tolerance of the Bb12 strain to low pH levels (Jungersen et al., 2014).

The control group probiotic yoghurt maintained high levels of *B. lactis* viability, as did *L. bulgaricus* viability, during the first two weeks of storage, likely due to the symbiotic relationship between the two bacteria. Dave and Shah (1997) reported that the free amino acids released by the proteolytic effect of *L. bulgaricus* stimulated the viability of Bifidobacteria.

The enrichment of yoghurt with raspberry or blueberry pulp generally did not enhance the viability of *B. lactis*. Similarly, Liu and Lv (2019) reported that blueberry flower pulp had little effect on *B. bifidum*. A prebiotic effect on *B. lactis* was exhibited by goji berry pulp supplementation after the 14th day. On the other hand, the lowest viable counts of *B. lactis* were detected in blueberry yoghurt during the storage period.

It was determined that the viability of *L. acidophilus* in all yoghurt samples was sufficient to show probiotic properties and was above 8.90 log cfu/g. The enhancing effect of fruit pulp addition on *L. acidophilus* counts was observed mainly during 7 days of storage. Moreover, the prebiotic effect of goji berry pulp becomes apparent after 14 days of storage.

The supportive effect of berry bagasses, including raspberry and blueberry, on the viability of *L. acidophilus* LA3 was reported by Hurtado-Romero et al. (2024).

The viable counts of *L. acidophilus* in probiotic yoghurts generally decreased ($p<0.05$) on the seventh day, then increased in the rest of the storage and remained at the same level, which is also observed by Ścibisz et al. (2012) in blueberry yoghurt. It can be concluded that the viability of probiotic bacteria, *B. lactis* and *L. acidophilus*, was stable or increased throughout the storage. This suggests that oxygen toxicity on probiotic bacteria may have been mitigated, thereby encouraging their growth and development.

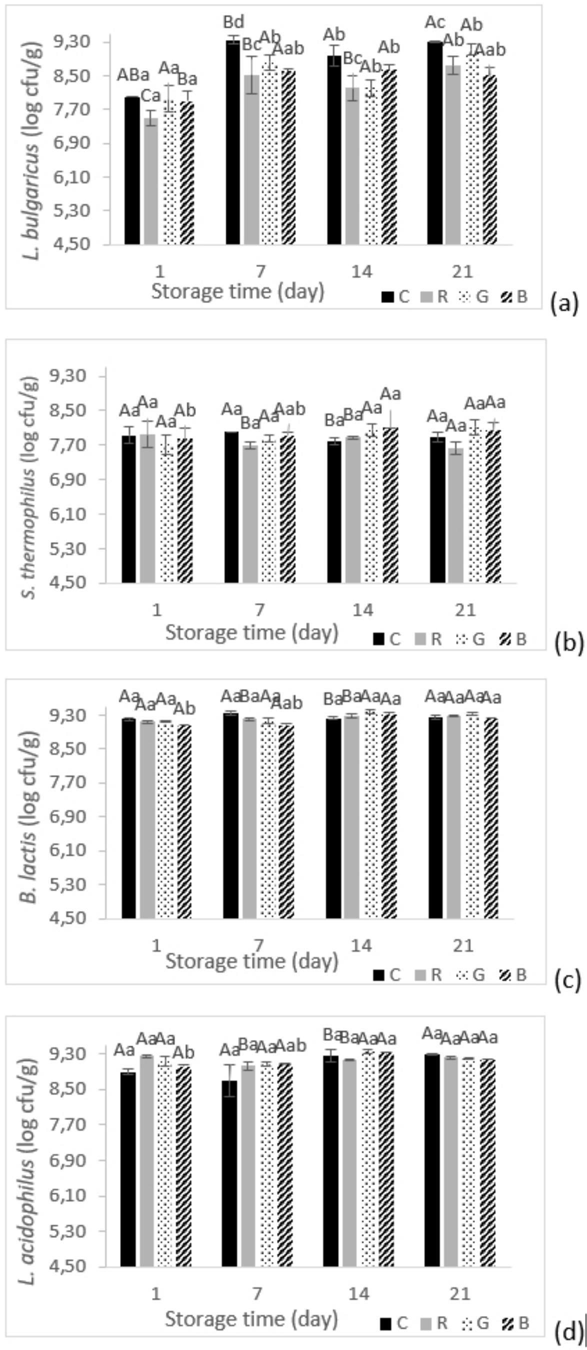

Figure. 2 Changes in the viable counts (log cfu/g) of L. delbrueckii subsp. bulgaricus (a), S. thermophilus (b), B. lactis (c), and L. acidophilus (d) in control probiotic yoghurt produced without fruit pulp (C), probiotic yoghurt produced with raspberry pulp (R), probiotic yoghurt produced with goji berry pulp (G), probiotic yoghurt produced with blueberry pulp (B) during refrigerated storage

Texture properties

The viscosity and water holding capacity (WHC) of the probiotic yoghurts during storage are given in Table 2. It has been observed that enrichment with berry fruit pulp has a significant effect on the viscosity of yoghurts. Probiotic yoghurt with goji berry showed the highest ($p<0.05$) viscosity values among fruit yoghurts after the seventh day, whereas control yoghurt had the lowest values throughout the storage. This can be explained by the fact that goji berry contains higher ($p<0.05$) total soluble solid content than other berry fruits. A significant change was not generally observed in the viscosity of experimental yoghurt samples throughout the storage period. In contrast to our findings, Cinbas and Yazici (2008) observed higher viscosity values in yoghurt without fruit pulp than those of yoghurts added with 12.5 % or higher amounts of blueberry. The authors noted that the increase in the mass fraction of fruit significantly reduced the viscosity values of the yoghurts; therefore, this contrast is likely due to the presence of more fruit in the reported study than in our study.

The WHC of experimental yoghurts varied between 51.00 and 62.50 %, and, similar to the viscosity, the addition of fruit pulp significantly increased the WHC of probiotic yoghurts during storage. This is due to the higher total solids content of fruit yoghurts compared to control yoghurts. It has been reported that an increase in the total solids level improves the WHC of yoghurt by reducing the shrinkage of yoghurt gel (Karam et al., 2013). Although there were some significant differences among the WHC values of fruit probiotic yoghurts during 7 days, the type of berry fruit did not affect this characteristic after the 14th day. The WHC of control yoghurt increased significantly on the 21st day of storage compared to the beginning of storage, whereas no significant change was observed in fruit yoghurts.

In parallel to our study, Liu and Lv (2019) found higher viscosity and WHC values for yoghurt containing blueberry flower pulp at a ratio of 3 %, 4 % and 5 % compared to control yoghurt. The authors attributed the higher viscosity to nonfat milk solids and dietary fiber from blueberry flower pulp. In contrast, the higher WHC was attributed to the interaction between crude fiber and protein from yogurt, which reduces syneresis and increases WHC. Similar to our results, the viscosity of the control and blueberry flower pulp-added yoghurt was relatively stable during 29 days of cold storage. On the other hand, our findings were in contrast with those reported by Şengül et al. (2022). The authors could not detect any significant differences in the viscosity and WHC values between the control yoghurt and yoghurt enriched with blueberry pulp (8 % blueberry and 8 % sugar), probably due to the differences in total solids between the samples in the two studies.

Total phenolic content, total antioxidant activity, and total anthocyanin content

Total phenolic content, DPPH radical scavenging activity, and total anthocyanin content of probiotic yoghurts during refrigerated storage are given in Figure 3. The highest phenolic contents were determined in probiotic yoghurts supplemented with goji berry, whereas the plain control probiotic yoghurt had the lowest values throughout the storage, as expected ($p<0.05$). On the other hand, higher total phenolic contents were found in blueberry yoghurt compared to raspberry yoghurt during the 21-day period, which is similar to some other studies (Ścibisz and Ziarno, 2023; Hurtado-Romero et al., 2024).

Some fluctuations were observed in the phenolic contents of yoghurt samples enriched with berry pulp throughout the storage period; however, the values did not change significantly at the end of the storage period compared to the first day. Similarly, Raikos et al. (2019) observed fluctuations in the phenolic content of a yoghurt beverage enriched with salal berry during storage, attributing this to the formation of compounds that react with the Folin-Ciocalteu reagent. The authors also reported that amino acids with phenolic side chains may be released through the proteolysis of milk proteins, potentially leading to an increase in total phenolic content. On the other hand, polyphenols can interact with milk proteins, forming insoluble complexes that reduce the total free polyphenol content (Oliveira et al., 2015). Bueno et

Table 2. *Changes in viscosity (mPa.s) and water holding capacity (%) values of probiotic yoghurts during refrigerated storage*

Product	Day 1	Day 7	Day 14	Day 21
Viscosity (mPa.s)				
C	10714.50±899.77^{Ba}	10539.75±1057.70^{Ca}	8231.75±156.89^{Cb}	9543.75±724.53^{Ca}
R	12263.75±782.31^{ABa}	12409.50±752.72^{Ba}	11880.75±1050.45^{Ba}	12963.75±931.96^{Ba}
G	13938.50±1209.10^{Ab}	16188.25±1527.48^{Aa}	15263.75±1170.49^{Aab}	16138.00±934.78^{Aa}
B	13792.75±1211.99^{Aa}	12185.25±659.93^{Bb}	11601.75±1049.45^{Bb}	11743.25±1086.71^{Bb}
Water holding capacity (%)				
C	52.83±0.58^{Cc}	51.00±1.00^{Cb}	54.50±0.18^{Bb}	56.00±0.70^{Ba}
R	60.83±1.26^{Aa}	60.00±0.50^{Ba}	61.43±0.77^{Aa}	61.12±0.25^{Aa}
G	62.50±1.50^{Aa}	59.17±0.29^{Bb}	61.33±0.20^{Aa}	61.87±0.75^{Aa}
B	57.67±1.76^{Bb}	62.00±1.32^{Aa}	62.18±1.33^{Aa}	60.00±1.60^{Aab}

$^{a–d}$ Means ± standard deviations in the same row with different superscript lowercase letters are significantly different ($p<0.05$)
$^{A–D}$ Means ± standard deviations in the same column with different superscript uppercase letters are significantly different ($p<0.05$)
C = Control probiotic yoghurt produced without fruit pulp, R = Probiotic yoghurt produced with raspberry pulp, G = Probiotic yoghurt produced with goji berry pulp, B = Probiotic yoghurt produced with blueberry pulp

al. (2014) also detected higher ellagic acid, which is an important polyphenol found in fruits, in berry fruit yoghurt, including raspberry, on the 21st day compared to the second day.

The antioxidant activity of probiotic yoghurt samples was expressed by the DPPH (2,2,-diphenyl-1-picrylhydrazyl) radical scavenging activity. The DPPH˙ scavenging activity of probiotic yoghurts was between 79.14 and 91.35 %. The reference antioxidant, Trolox, at a concentration of 0.25 mg/mL, exhibited a radical scavenging activity of 90.00 %.

The control probiotic yoghurt exhibited good DPPH˙ scavenging activity during storage. It was observed that on some days, it had higher antioxidant capacity than fruit yoghurts. This case can be associated with various factors. Firstly, it should not be forgotten that plain yoghurt itself exhibits antioxidant activity due to its bioactive peptides, which possess antioxidant properties. Farvin et al. (2010) reported that the oxidative stability of yoghurt might be due to antioxidant peptides released during the fermentation of milk by lactic acid bacteria. They also concluded that these peptides act as electron donors and could react with free radicals to convert them to more stable products.

Secondly, the other possible reason may be the analysis method used. Several methods have been developed to evaluate the antioxidant capacity of food compounds or biological systems. For different reasons linked to the mechanisms, endpoint, quantification method, analysis conditions, and substrate used, there is often a lack of correlation between results obtained through different assays. DPPH˙ assay has been widely used to test the ability of compounds to act as free radical scavengers or hydrogen donors. However, the results for the antioxidant activity of dairy products can vary depending on the analysis method used. In addition, Chandrasekar et al. (2006) reported that although the colorimetric estimation of DPPH˙ is a simple method, it sometimes exhibits some problems due to the interference of the radical with the pigments of coloured foods. The authors also pointed out that, as both the DPPH˙ radical and anthocyanins exhibit strong absorption at 500–550 nm, minor changes in the DPPH˙ absorbance can occur throughout the analysis. Wang (2011) reported that the correlations between antioxidants and antioxidant enzyme activities (especially phenylalanine ammonia-lyase) and radical scavenging activities in berry fruits are also affected by heat treatment, maturity, tissue type, cultural practices, and postharvest handling techniques.

The number and position (orthophenol) of the hydroxyl groups that polyphenols possess were also said to primarily affect their radical-scavenging activity (Hatano et al., 1997). Amakura et al. (2000) studied the correlation between the total phenolic content of different berries and their DPPH˙ scavenging activity. The authors detected a strong correlation (R = 0.9495 and 0.9685) in blackcurrant and blackberry, whereas the correlation was relatively low for blueberry and raspberry (R = 0.5736 and 0.6359). Dvaranauskaite et al. (2006) also reported a weak correlation between the DPPH˙ radical scavenging capacity and the total amount of phenolic compounds in raspberry extracts.

Another reason why the control sample showed high antioxidant activity may be the high viability of *L. bulgaricus* it

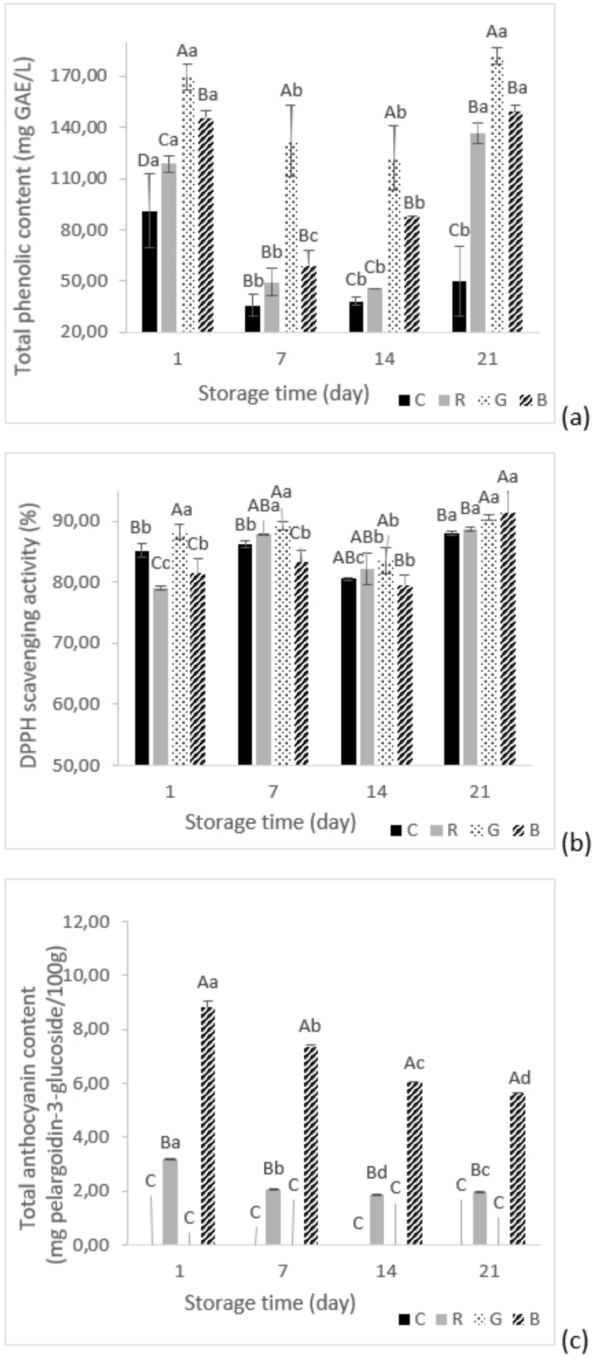

Figure 3. Changes in the total phenolic content (mg GAE/L) (a), DDPH scavenging activity (%) (b), and total anthocyanin content (mg pelargoidin-3-glucoside/100 g) (c) in control probiotic yoghurt produced without fruit pulp (C), probiotic yoghurt produced with raspberry pulp (R), probiotic yoghurt produced with goji berry pulp (G), probiotic yoghurt produced with blueberry pulp (B) during refrigerated storage

contains. As can be seen from the microbiological results, the control yoghurt had higher viability of *L. bulgaricus*. This can affect the high DPPH˙ scavenging activity of the sample. This is also supported by the results of Kudoh et al. (2001), who determined a peptide with DPPH˙ scavenging activity found in milk fermented with *L. bulgaricus*.

The highest DPPH˙ scavenging activity, as well as the total phenolic content, was detected in probiotic yoghurt with goji berry pulp throughout the storage period, probably due to the strong DPPH˙ radical scavenging activity of goji berry fruit (Ozkan et al., 2018). Goji berry is well known to be a good source of phenolic compounds, including phenolic acids, flavonoids, phenylpropanoids, coumarins, lignans, and their derivatives, which selectively contribute to their bioactivities. Moreover, it has been reported that the antioxidant activity of goji berry is closely associated with the presence of polysaccharides, carotenoids, flavonoids, and AA-2ßG, and this activity largely depends on genotypes (Vidovic et al., 2022). This information was also consistent with the knowledge that phenolic compounds are secondary metabolites that can interfere with the lactic acid fermentation process through their antioxidant properties (Hunaefi et al, 2012).

Yoghurts with raspberry and blueberry also showed DPPH˙ scavenging activity, although not as much as the yoghurt with goji berry. It has been well reported that antioxidant activity varies greatly among berry cultivars and is highly correlated with their content of phenolic compounds (Pantelidis et al., 2007).

The antioxidant activity of the experimental yoghurts generally increased on the 21st day compared to the beginning of storage. This increase may be caused by the accumulation of antioxidative peptides in the environment due to the general increase in the viability of yoghurt bacteria and *L. acidophilus* towards the end of storage. It has already been reported that these peptides act as electron donors and react with free radicals, converting them into stable products (Farvin et al., 2010).

Anthocyanins, which are found in high amounts, especially in blue, purple, and red vegetables and fruits, are known to affect the antioxidant activity and color properties of these foods, varying depending on the plant type. Most of the anthocyanins (~90 %) consist of six common anthocyanidin glycosides: pelargonidin (Pg), cyanidin (Cy), delphinidin (Dp), peonidin (Pn), petunidin (Pt), and malvidin (Mv). The total anthocyanin content of experimental probiotic yoghurts was analyzed and expressed as pelargoidin-3-glucoside/100 g.

No values were detected in the control probiotic yoghurt as expected. Higher ($p<0.05$) anthocyanin contents were detected in blueberry yoghurt than in raspberry yoghurt during 21 days, which is most likely since blueberries contain higher amounts of anthocyanins than raspberries (Kirina et al., 2020). This result is also consistent with the color properties of the two yoghurts, which are related to anthocyanins. Similar to our results, Ścibisz and Ziarno (2023) detected higher anthocyanin content in yoghurt added blueberry smoothie than in the same product containing raspberry. Blueberry fruits have also been reported to be a rich source of anthocyanins by Kirina et al. (2020).

On the other hand, anthocyanin content in the form of pelargonidin-3-glucoside could not be detected in goji berry yoghurt. Goji berries are usually rich in anthocyanins. However, it has been reported that the types and amounts of anthocyanins in berries vary depending on the fruit type and can also be positively or negatively affected by external temperature and day length (Barkaoui et al., 2023; Ścibisz & Ziarno, 2023). Therefore, the fact that anthocyanin in the form of pelargonidin-3-glucoside was not detected in goji berries may be due to the presence of this anthocyanin form in trace amounts in this fruit.

Another reason why anthocyanins in this form could not be detected in goji fruit-added yoghurt in our study may be the extraction procedure used in anthocyanin analysis. It has been reported that it is important to extract pelargonidin from goji berries in water or alcohol. In a study using alcohol extraction for anthocyanin analysis in goji berry, pelargonidin-3-glucoside, similar to our study, could not be detected, while other anthocyanins, such as cyanidin chloride and kaempferol-3-O-rutinoside, were detected. (Ozkan et al., 2018). Khoo et al. (2017) reported that although anthocyanins maintain their stability against highly acidic conditions, at increasing pH conditions, colorless structures are formed. Therefore, since the goji berry-added yoghurt sample in our study had higher pH values than other yoghurt types during storage, it can be thought that color transformation may have occurred in the anthocyanins in the goji berry yoghurt.

There were fluctuations in the total anthocyanin content of raspberry yoghurt throughout storage, but it significantly decreased on the 21st day compared to the beginning of storage. In contrast, the values for blueberry yoghurt continuously decreased ($p<0.05$) during storage. The difference in the reduction behavior of the two yoghurts during storage may be due to the differences in the structural stability of the basic anthocyanins found in the fruits. Additionally, the decrease in anthocyanin content may be attributed to the degradation of anthocyanins, resulting in a decrease in their amount (Ścibisz and Ziarno, 2023). Trigueros et al. (2014) also reported that storage had a significant effect on the reduction of anthocyanins, especially pelargoidin-3-glucoside, in fruit yoghurt. In addition, the authors attributed this decrease to the fact that anthocyanins may be negatively affected by the acidity developed by starter bacteria during storage. In another study, a decline was also observed in blueberry probiotic yoghurt, containing La5 or Bb12, for the second week compared to the value detected after production (Ścibisz et al., 2012).

Sensory evaluation

Sensory properties were evaluated in terms of taste, aroma, texture, appearance, and overall acceptability. The changes in sensory properties during the 21-day storage period are presented in Table 3. There were no significant differences among probiotic yoghurts in terms of taste, aroma, texture, and appearance during the storage period ($p>0.05$). Experimental yoghurt samples showed similar attributes in terms of overall acceptability on most days of storage. However, the lowest score for overall acceptability was observed

Table 3. *Sensory scores of probiotic yoghurts during refrigerated storage*

	Product	Day 1	Day 7	Day 14	Day 21
Taste	C	4.48 ± 0.50^{ABa}	4.10 ± 0.22^{ABab}	3.60 ± 0.82^{Ab}	4.47 ± 0.45^{Aa}
	R	4.66 ± 0.41^{ABa}	4.32 ± 0.84^{ABa}	4.62 ± 0.41^{Aa}	4.65 ± 0.49^{Aa}
	G	4.10 ± 0.74^{Ba}	3.48 ± 0.91^{Ba}	4.08 ± 1.24^{Aa}	4.06 ± 0.44^{Aa}
	B	5.00 ± 0.00^{Aa}	4.46 ± 0.46^{Ab}	4.56 ± 0.36^{Aab}	4.36 ± 0.42^{Ab}
Aroma	C	4.36 ± 0.86^{Aa}	3.90 ± 1.14^{Aa}	4.60 ± 0.55^{Aa}	4.50 ± 0.71^{Aa}
	R	4.90 ± 0.22^{Aa}	4.16 ± 1.28^{Aa}	5.00 ± 0.00^{Aa}	4.82 ± 0.25^{Aa}
	G	4.16 ± 0.79^{Aa}	3.74 ± 1.02^{Aa}	4.60 ± 0.55^{Aa}	4.34 ± 0.42^{Aa}
	B	4.70 ± 0.45^{Aa}	4.58 ± 0.53^{Aa}	5.00 ± 0.00^{Aa}	4.70 ± 0.45^{Aa}
Texture	C	4.80 ± 0.45^{Aa}	4.40 ± 0.89^{Aa}	5.00 ± 0.00^{Aa}	5.00 ± 0.00^{Aa}
	R	4.70 ± 0.45^{Aa}	4.40 ± 0.89^{Aa}	5.00 ± 0.00^{Aa}	4.90 ± 0.22^{Aa}
	G	4.50 ± 0.87^{Aa}	4.60 ± 0.42^{Aa}	5.00 ± 0.00^{Aa}	4.85 ± 0.34^{Aa}
	B	5.00 ± 0.00^{Aa}	5.00 ± 0.00^{Aa}	5.00 ± 0.00^{Aa}	4.85 ± 0.34^{Aa}
Appearance	C	4.70 ± 0.45^{Aa}	4.80 ± 0.45^{Aa}	5.00 ± 0.00^{Aa}	5.00 ± 0.00^{Aa}
	R	4.70 ± 0.45^{Aa}	4.60 ± 0.55^{Aa}	4.70 ± 0.45^{Aa}	4.70 ± 0.45^{Aa}
	G	4.40 ± 0.89^{Aa}	4.00 ± 1.00^{Aa}	4.80 ± 0.45^{Aa}	4.60 ± 0.55^{Aa}
	B	5.00 ± 0.00^{Aa}	4.80 ± 0.45^{Aa}	5.00 ± 0.00^{Aa}	4.85 ± 0.34^{Aa}
Overall acceptability	C	4.38 ± 0.82^{Aa}	4.00 ± 0.48^{ABa}	4.16 ± 0.48^{Ba}	4.64 ± 0.57^{Aa}
	R	4.76 ± 0.25^{Aa}	4.28 ± 0.81^{ABa}	4.64 ± 0.42^{ABa}	4.78 ± 0.30^{Aa}
	G	4.20 ± 0.76^{Aa}	3.86 ± 0.79^{Ba}	4.28 ± 0.61^{ABa}	4.33 ± 0.36^{Aa}
	B	5.00 ± 0.00^{Aa}	4.82 ± 0.20^{Aab}	4.48 ± 0.21^{Aab}	4.61 ± 0.27^{Aa}

$^{a–d}$ Means ± standard deviations in the same row with different superscript lowercase letters are significantly different ($p<0.05$)
$^{A–D}$ Means ± standard deviations in the same column with different superscript uppercase letters are significantly different ($p<0.05$)
C = Control probiotic yoghurt produced without fruit pulp, R = Probiotic yoghurt produced with raspberry pulp, G = Probiotic yoghurt produced with goji berry pulp, B = Probiotic yoghurt produced with blueberry pulp

in the control probiotic yoghurt on the 7th and 14th days. Liu and Lv (2019) also detected lower overall acceptance scores for control yoghurt compared to yoghurt samples with 2 %, 3 %, and 4% blueberry flower pulp added. On the other hand, the researchers observed significantly higher ($p<0.05$, $p<0.01$) aroma, taste, and texture scores for yoghurts containing 2 %, 3 %, 4 %, and 5 % blueberry flower pulp compared to the control. This finding is not in parallel with our results, likely due to the use of a different type of fruit pulp in that study.

Taneva and Valev (2019) evaluated the appearance and taste characteristics of yoghurt samples fortified with different ratios of goji berries. The researchers reported that yoghurt samples containing 6 % goji berry showed the highest scores among all samples. However, the assessors did not approve of the color properties of yoghurts with a larger amount of goji berries. In the study by Şengül et al. (2022), no significant differences were observed ($p>0.05$) between the control and yoghurt samples with 4 %, 8 %, and 12 % blueberry additions in terms of texture scores during 28 days of storage. In the same study, all yoghurt samples were more desired in terms of flavor and general acceptability at the beginning of the storage period compared to the end, which is similar to our results.

The effect of storage was not generally significant in terms of sensory parameters in all probiotic yoghurts. However, a slight decline in the overall acceptability scores of blueberry yoghurt was observed on days 7 and 14. Cinbas and Yazici (2008) also observed a negative impact on flavor scores on the seventh day. In contrast to our findings, the authors determined a significant effect on the appearance and color of blueberry yoghurts containing 12.5 %, 25 %, and 37.5 % blueberry pulp, which is likely due to the higher amount of pulp compared to our study.

Conclusions

The present study indicated that adding different berry fruit pulps to probiotic yoghurt provided high viable counts of both yoghurt starter bacteria and probiotic bacteria. The viability of *S. thermophilus* and *L. bulgaricus* was maintained above the recommended level by Codex Alimentarius Commission (10^7 cfu/g) for lactic acid bacteria in all experimental yoghurts. The berries used in our study showed a positive effect on *B. lactis* and *L. acidophilus* counts on different days of storage; however, the promoting effect of goji berry addition on probiotic viability has become apparent. Viable counts of both *B. lactis* and *L. acidophilus* were maintained at the minimum recommended probiotic bacteria level throughout storage, indicating health benefits.

The addition of berry pulp enhanced the viscosity and WHC characteristics of probiotic yoghurt, and goji berry pulp generally had the highest values throughout the storage period.

It has been observed that goji berry yields more advantageous results than the other two fruit types in terms of total phenolic content and DPPH radical scavenging activity, especially after 14 days. On the other hand, more phenolic content and antioxidant activity were detected in probiotic yoghurt containing blueberry pulp than in the sample containing raspberry pulp. These antioxidant properties tended to increase during storage. Probiotic yoghurt with blueberry pulp had a higher anthocyanin amount than that of raspberry probiotic yoghurt; however, anthocyanin could not be detected in the sample with goji berry pulp in the form of pelargonidin-3-glucoside. Experimental yoghurt samples exhibited similar sensory characteristics on most days of storage, whereas the lowest overall acceptability score was observed in the control probiotic yoghurt on the 7th and 14th days.

In conclusion, berry fruits have importance in terms of providing possible prebiotic effects and antioxidant properties to yoghurt. This study demonstrated that goji berries appear to be more advantageous than other varieties in terms of exhibiting these functional properties. In this study, goji berries appear to have more advantages than other varieties in terms of reported functional properties. However, it should be noted that the effect of fruit on the growth of probiotics is specific to the fruit variety and bacterial strain. To increase the functionality of fermented dairy products by using different fruit varieties, future studies are needed to reveal other functional properties of the products and provide scientific validation of their beneficial effects.

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Dodatak pulpe bobičastog voća u probiotički jogurt: Mikrobiološka, teksturalna i senzorska svojstva te antioksidacijska aktivnost

Sažetak

Ispitan je učinak različitih bobičastih plodova na preživljavanje bakterija, antioksidacijska, teksturalna i senzorska svojstva probiotičkog jogurta koji sadrži *Lactobacillus acidophilus* LA-5 i *Bifidobacterium animalis* subsp. *lactis* BB-12® tijekom 21 dana skladištenja. U tu svrhu u proizvodnji jogurta korištena je pulpa maline (*Rubus idaeus*), goji bobice (*Lycium barbarum*) ili borovnice (*Vaccinium corymbosum*) (15 %) s omjerom voća i šećera 1:1. Jogurt bez dodatka voćne pulpe korišten je kao kontrolni uzorak. Broj živih stanica starter kultura jogurta i probiotičkih bakterija bio je iznad 7,50, odnosno 8,70 log CFU/g, što zadovoljava preporučene minimalne razine. Najveća održivost *L. acidophilus* zabilježena je u jogurtu s dodatkom goji bobica tijekom 14 dana skladištenja. Suprotno tome, prednost goji bobica u održavanju broja živih stanica *B. lactis* uočena je samo 14. i 21. dan. Probiotički jogurt s dodatkom goji bobica pokazao je najviši ukupni sadržaj fenola i najjaču aktivnost uklanjanja DPPH˙ radikala tijekom skladištenja. Jogurt s pulpom borovnice imao je veći sadržaj antocijana u usporedbi s uzorkom s malinom tijekom skladištenja. S druge strane, antocijanini u obliku pelargonidin-3-glikozida nisu utvrđeni u probiotičkom jogurtu s pulpom goji bobica. Dodavanje pulpe bobičastog voća poboljšalo je viskoznost i sposobnost zadržavanja vode u probiotičkom jogurtu, no općenito nije imalo značajan utjecaj na senzorska svojstva.

Ključne riječi: bobičasto voće; jogurt; probiotičke bakterije; održivost; antioksidativna aktivnost

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