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RESEARCH ARTICLE

Effects of oat milk added on the quality of probiotic yogurt

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Abstract: In this study, probiotic yoghurt was produced by adding oat milk to raw milk. For this purpose, oat milk was added to raw cow milk at the rates of 10%, 20%, 30% and 40%. After the milk was pasteurized, probiotic yoghurt was produced by inoculating it with ABT-3 culture consisting of *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium animalis subsp. lactis* (BB-12). The produced probiotic yoghurts were stored at 4ÚC ± 1ÚC for 20 days. Some quality characteristics were tried to be determined by performing physicochemical, textural, microbiological analysis and sensory evaluation on the 1st, 10th and 20th days of storage. The oat milk ratio significantly affected all the examined properties of probiotic yoghurts, and the storage time significantly affected the physicochemical, microbiological and sensory properties of probiotic yoghurts ($p<0.05$). Among the yoghurts, yoghurts (B and C) with 10% and 20% oat milk added were the most liked in sensory terms. As a result of; It has been concluded that a symbiotic feature can be gained by adding oat milk to probiotic yoghurt, and considering the physicochemical, microbiological and sensory properties, 10% oat milk can be easily used in probiotic yoghurt production.

Keywords: Probiotic, Oat milk, Prebiotic, Quality.

Introduction

Recently the increasing awareness among consumers regarding healthy food choices has led to a growing interest and demand for functional foods. Functional foods are defined as a group of foods that, in addition to their primary nutrients, contain components beneficial to health, including live microorganisms such as probiotics and other health compounds (Moghadam et al., 2023). Probiotics are live microorganisms that, when consumed in adequate amounts, have a positive impact on health (Joint FAO/WHO, 2001). Prebiotics, on the other hand, are typically referred to as indigestible food components that positively influence host health (Gibson and Roberfroid, 1995). In addition to probiotics, functional dairy products enriched with prebiotics (such as dietary fiber, hydrocolloids, flavorings, bioactive compounds, etc.) also offer significant health benefits (Coman et al., 2013). Therefore, producers are taking important steps to develop probiotic dairy products that are functionally enhanced. It is estimated that the global market for symbiotic yogurt, which is closely associated with probiotics and prebiotics, will reach $141,829.25 million by the year 2025 (Moghadam et al., 2023).

Oats (Avena sativa L.), one of the grains used in animal feeding in the past, contain high amounts of valuable nutrients such as protein, unsaturated fatty acids and dietary fiber (Brückner-Gühmann et al., 2019). It helps reduce the risk of heart disease, especially thanks to the b-glucan it contains (Murphy et al., 2020). Oat milk can be included in diets because it is lactose-free, gluten-free and contains cow's milk protein (Demir et al., 2021). In this study, it was aimed to investigate the use of oat milk, which is one of the plant-based milks that is becoming increasingly popular due to its health benefits and effects, in probiotic yoghurts, thus developing a new product and determining the effects of the addition of oat milk on the quality of probiotic yoghurts. For this purpose, 4 different proportions of oat milk were added to probiotic yoghurts and 5 different probiotic yoghurts were produced. Yogurts were stored for 20 days and physicochemical, textural, microbiological and sensory analyses were performed on the 1st, 10th and 20th days of storage.

Materials and methods

In the study, raw cow's milk obtained from the city center of Þanlýurfa was used. For increasing the solids content in the milk to be used for yogurt production, commercial milk powder (Pýnar Süt I.C., Ýzmir), lyophilized culture containing *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium*

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animalis subsp. lactis (ABT-3 culture from Peyma-Chr.Hansen, Turkey), and oat flour (Delarom Aroma and Food Additives Inc., Ýstanbul) were utilized.

Oat milk: It is prepared by mixing oat flour and water and homogenizing it to contain 7% oat flour.

Fermented milk: The skim milk powder, with a solids content of 12%, was reconstituted and sterilized in an autoclave at 105°C for 3 minutes. Afterward, it was cooled to 37°C and inoculated with *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium animalis subsp. lactis*. The mixture was then incubated at 37°C for 18 hours to prepare it.

The yogurt production followed the method recommended by Tamime and Robinson (1999). Yogurt production was carried out in two replicates. In each production, the milk was filtered through a cloth filter and divided into five groups. Control samples (raw milk), raw milk + oat milk (10%), raw milk + oat milk (20%), raw milk + oat milk (30%) and raw milk + oat milk (40%) samples were prepared by adding 3% milk powder and at 25°C then homogenized using a blender. The mixture was pasteurized at 90°C for 5 minutes. The milk was cooled down to 42°C, and an ABT-3 culture was added at a rate of 5%. It was left to incubate at 40±1°C until the pH reached 4.6. After incubation, the samples were cooled to +4°C and stored for 20 days.

Microbiological Analysis

In the yogurt samples, 10 gram of each sample were mixed with 90 mL of 0.1% sterile peptone water. To determine the counts of live microorganisms in the samples. *S. thermophilus* was determined by incubating on M17 agar under aerobic conditions, *Lactobacillus acidophilus* on MRS-Sorbitol agar, and *Bifidobacterium animalis subsp. lactis (BB-12)* on MRS-NNLP agar under anaerobic conditions at 37°C for 72 hours, following the methods described by Dave and Shah (1997) and Vinderola and Reinheimer (2000).

Physicochemical Analysis

The pH values and total acidity of raw milk and yogurt were determined using a pH meter (inoLab, WTW, Weilheim, Germany) and potentiometrically titrated with 0.1 N NaOH until reaching a pH of 8.3, following the method described by Guler-Akin and Akin (2007). Protein content was determined from the crude nitrogen content of the samples using the Kjeldahl method. Fat content was determined according to the Gerber method. Moisture content was measured through the oven-drying method. Ash content was determined through gravimetric analysis (Guler-Akin and Akin, 2007). The viscosity of the yogurts was measured using a Brookfield DV-II Pro viscometer, and the results were reported in centipoise (cP), as described by Özer et al. (1997). For the whey separation test in yogurt, a 25 g yogurt sample was allowed to pass through coarse filter paper at refrigerator temperature for 3 hour. The separated whey was then calculated gravimetrically in grams (g), following the methods outlined by Goncu et al., 2016.

Water holding capacity was determined by modifying the method described by Remeuf et al. (2003). Color determination was carried out by placing approximately 30 g of sample in the measuring cuvette of the Hunter-Lab device and placing the cuvette in the refrequency measuring chamber and L, a, b values were measured. Hardness, density, adhesiveness and viscosity values of yoghurts were measured with TA.XT2 Texture Profile analyzer (Texture Technologies Corp., Scardale, NY/Stable Microsystems, Godalming, UK) (Kahyaoðlu and Kaya, 2003).

Sensory Evaluation

In order to evaluate the yogurt samples comparatively from a sensory perspective, a study group of 10 people from Harran University's Department of Food Engineering was formed. The samples were subjected to sensory evaluation by trained ten panellists using 10 points hedonic scale to evaluate appearance, texture, and taste-aroma preferences (1 = strongly unacceptable, 10 = very good) following the procedures outlined by Bodyfelt et al. (1988).

Statistical Analysis

In the study conducted with two replications, the results of physicochemical, microbiological, textural and sensory analyses were subjected to statistical analysis using the SPSS 21.0 software package.To determine if there were differences among the samples, variance analysis (ANOVA) was conducted, and the significant differences were further analyzed using the Duncan test, as described by Bek and Efe (1995).

Results and Discussion

Bacterial Counts

The live cell counts of *S. thermophilus* probiotic *L. acidophilus* and *Bifidobacterium animalis subsp. lactis* in the samples during storage time are provided in Table 1. Maintaining the viability of microorganisms throughout the storage period in probiotic foods and ensuring that they do not fall below a certain level (minimum 10^6 CFU/g) is an important aspect (FDA, 2015; Casarotti and Penna, 2015). As seen in Table 1, the probiotic yogurts have maintained live cell counts above the minimum required level throughout the storage period.

In all the samples, it can be observed that the count of the mentioned bacteria decreased on the 10th and 20th days. It was found that the accumulation of lactic acid in the environment over time negatively affected the bacterial population, leading to a decrease in live cell counts. Basyigit Kýlýç and Kankaya (2016) reported that *S. thermophilus* was fed very little in probiotic yoghurts with β-glucan added during 21 days of storage. A study that investigated the addition of cactus flour in probiotic yogurt also found an increase in the count of *S. thermophilus* during the first 14 days of storage (Silva Dantas et al., 2022).

It is known that the â-glucan contained in oats has a prebiotic effect (Ýbrahim et al., 2020). It was also observed that oat milk had a prebiotic effect in trial yoghurts but increase in the number of *Lactobacillus acidopillus* was not statistically significant (p>0.05). *Lactobacillus acidopillus* bacterial counts of the samples decreased during the storage period and the effect of storage time was found to be statistically significant (p<0.05). It was determined that the prebiotic bacterial counts of all samples (except the control yoghurt on the 20th day) provided a therapeutic effect and were above 10^6 cfu/g. Similar studies have also reported that the therapeutic level of *L. acidophilus* was maintained throughout the storage period (Kumar et al., 2020; Sharma et al., 2014).

It was determined that oat milk ratio and storage time caused a decrease in the number of *Bifidobacterium animalis subsp lactis* (BB-12) in yoghurts (p<0.05). Asadzadeh et al. (2021) reported that the number of *Bifidobacterium lactis* in a probiotic drink produced with oat bran increased slightly until the 14th day of storage and decreased significantly on the 21st day.

Physicochemical Analysis

pH values

A decrease in pH values of the samples was observed during the storage period, and this decrease was found to be statistically significant (p<0.05) (Table 4). The pH values of the samples were affected during the 20-day storage period due to post-acidification (Garavand et al. 2022). These changes were significant based on added of oat milk and the storage time (p<0.05). A decrease in pH values was observed in all yogurts throughout their shelf life. The results suggest that the oat milk may have promoted bacterial growth, resulting in a decrease in pH values. Bacteria, through metabolic activity, break down lactose, proteins, and fats during storage, increasing acidity and consequently lowering the pH values of yogurt samples (Tamime and Robinson, 1999).

Titration acidity (%L.A.) values

As the oat milk ratio increased (up to 30%), the titratable acidity of the samples increased, and it decreased in the samples with 40% oat milk added (p<0.05) (Table 2). In samples to which oat milk was added, bacterial growth slowed down and acidity decreased accordingly. Microbiological analysis results also support this finding (Table 4). The titratable acidity of oat milk is thought to encourage bacterial growth and therefore increase in acidity.

Indeed, the increase in acidity during storage in fermented products can be attributed to the activities of probiotic bacteria, starter cultures, and the enzymes they produce. This phenomenon

Table 1. Changes in the number of viable bacteria of yoghurts during storage (log cfu'"g˜¹)

Yogurts*	Storage (Day)	*S.thermophilus*	*L.acidophilus*	*Bifidobacterium animalis subsp. lactis* (BB-12)
	1	9.24±0.31^{a1}	8.17±0.43^{b1}	7.61±0.36^{b1}
A	10	8.87±0.13^{a2}	7.35±0.27^{b2}	6.78±0.25^{b2}
	20	8.16±0.28^{a3}	6.05±0.39^{d3}	5.88±0.18^{c3}
	1	8.82±0.41^{b1}	8.32±029^{a1}	7.76±0.27^{b1}
B	10	8.24±0.49^{b2}	7.59±0.41^{a2}	6.91±0.41^{b2}
	20	7.73±0.36^{b3}	7.19±0.31^{a3}	6.34±0.331^{b3}
	1	8.52±0.24^{c1}	8.40±0.28^{a1}	8.1±0.44^{a1}
C	10	8.19±0.92^{b3}	7.71±0.33^{a2}	7.29±0.22^{a2}
	20	7.63±0.29^{b3}	7.37±0.45^{a3}	6.91±0.39^{a3}
	1	8.24±0.14^{d1}	8.43±0.48^{a1}	7.72±0.43^{b1}
D	10	7.88±0.31^{c2}	7.56±0.38^{a2}	6.63±0.29^{c2}
	20	7.58±0.25^{b3}	7.02±0.41^{b3}	6.27±0.30^{b3}
	1	8.05±0.54^{d1}	8.09±0.27^{b1}	7.59±0.25^{b1}
E	10	7.84±0.24^{d2}	7.34±0.32^{b2}	6.62±0.21^{c2}
	20	7.36±0.56^{c3}	6.49±0.17^{c3}	6.26±0.18^{b3}

*A: Control. B: 10% oat milk, C: 20% oat milk, D: 30% oat milk, E: 40% oat milk added.

** Values shown in different lower case letters in the same column are statistically different from each other depending on the oat milk content (p<0.05). Values shown with different numbers in the same row are statistically different from each other depending on the storage period (p<0.05).

has been observed in various studies, as you mentioned (Garavand et al., 2022; Coman et al., 2013; Guler-Akin and Akin, 2007). For example, in the study involving the fermentation of sorghum with *L. plantarum*, a decrease in pH and an increase in titratable acidity were observed over time (Pranoto et al., 2013).

Viscosity (cP)

The effect of storage time and oat milk addition on the samples was found to be statistically significant ($p<0.05$). As oat milk increased, the dry matter content of yoghurts decreased and as a result, the viscosity values decreased. It is thought that the change detected in viscosity is due to the water-binding property of dietary fibers in oats (Kanwar et al., 2023). It was determined that as the oat milk ratio increased, viscosity values increased due to the increase in dry matter in the samples. Tamime and Robinson (1999) suggested that by increasing the dry matter and/or protein content, the water retention capacity of yoghurt could be increased and a new product with higher than normal viscosity could be obtained. Dietary fibers include pectin, gum, mucilages and water-soluble pentosans (Jalili, 2019; Ralapati, 2002) and they bind water and form a gel and tight structure. It was observed that viscosity values increased during storage.

Whey Separation (%)

It was determined that there was a negative correlation between the ratio of oat milk added to yoghurts and the whey separation value of yoghurts (Table 2). It has been found that as oat milk increases, there are significant decreases in whey separation values ($p<0.05$). The change detected in wheyt separation is thought to be due to the stabilizing effect of b-glucan in oats (Jirdehi et al., 2013). It was determined that there was a decrease in whey separation values of the samples during the storage period ($p<0.05$).

Water Holding Capacity

It was determined that as the oat ratio in yoghurts increased, their water holding capacity increased and the effect of this increase was found to be significant ($p<0.05$) (Table 2). This result can be explained by the high water binding property of dietary fibers. It has been found that in thermal protein gels, fibers and proteins compete to bind water and the bonds between the proteins are rearranged (Xu et al., 2011). Şahan et al. (2008) reported that the addition of β-glucan increased the water retention capacity of yoghurts. It has been determined that there is an increase in the water retention capacity of yoghurts during storage ($p<0.05$). This increase may have been due to increased acidity and rearrangement of bonds between proteins as a result of some metabolic activities created by starter cultures during storage. Ziarno et al. (2024) also determined that the water retention capacity of probiotic fermented oat beverage increased until the 21st day of storage.

Colour values

The changes in the color values of yoghurts during storage are given in Table 3. It was found that as the oat milk ratio increased, the L value of the samples decreased ($p<0.05$). The brightness of

Table 2. Changes in the some physicochemical properties of yogurts during storage

Yogurts*	Storage (Day)	pH	Titration Acidity (%L.A.)	Viscosity (cP)	Whey Seperation (%)	Water Retention Capacity
A	1	4.67 ± 0.15^{a1}	0.78 ± 0.07^{a2}	5383 ± 251^{a2}	39.56 ± 1.58^{a1}	41.01 ± 1.32^{e3}
	10	4.47 ± 0.13^{a2}	0.85 ± 0^{a1}	5990 ± 14^{a1}	$33.61\pm38.^{a2}$	42.30 ± 1.53^{e2}
	20	4.43 ± 0.13^{a2}	0.87 ± 0.04^{a1}	5968 ± 414^{a1}	31.69 ± 1.24^{a3}	43.78 ± 1.20^{d1}
B	1	4.63 ± 0.01^{a1}	0.8 ± 0.05^{a3}	5087 ± 182^{b3}	37.22 ± 1.73^{b1}	46.16 ± 2.69^{d3}
	10	4.48 ± 0.4^{a2}	0.83 ± 0.04^{a2}	5158 ± 124^{b2}	31.67 ± 1.94^{b2}	48.36 ± 1.90^{d2}
	20	4.40 ± 0.03^{a2}	0.86 ± 0.02^{a1}	5589 ± 23^{b1}	30.88 ± 1.07^{b3}	49.19 ± 0.25^{c1}
C	1	4.65 ± 0.25^{b1}	0.80 ± 0.07^{a2}	4870 ± 191^{c3}	35.63 ± 1.36^{c1}	51.75 ± 1.26^{c3}
	10	4.51 ± 0.18^{a2}	0.81 ± 0.10^{a1}	5128 ± 117^{b2}	29.68 ± 2.25^{c2}	53.12 ± 2.41^{c2}
	20	4.52 ± 0.19^{a2}	0.83 ± 0.08^{b1}	5276 ± 206^{c1}	27.13 ± 1.28^{c3}	55.98 ± 2.30^{b1}
D	1	4.62 ± 0.10^{a1}	0.77 ± 0.03^{a2}	4840 ± 240^{c3}	33.03 ± 1.04^{d1}	53.13 ± 0.84^{b3}
	10	4.47 ± 0.06^{a1}	0.779 ± 0.04^{a2}	5075 ± 28^{c2}	29.54 ± 0.91^{d2}	54.23 ± 2.48^{b2}
	20	4.40 ± 0.03^{a2}	0.86 ± 0^{a1}	5155 ± 42^{d1}	24.75 ± 0.94^{d3}	56.04 ± 3.40^{b1}
E	1	4.70 ± 0.29^{b1}	0.68 ± 0.03^{b3}	4750 ± 160^{d1}	28.41 ± 2.39^{e1}	56.26 ± 3.39^{a2}
	10	4.57 ± 0.24^{b2}	0.75 ± 0.09^{b2}	4633 ± 46^{d2}	27.57 ± 1.06^{e2}	58.84 ± 1.20^{a1}
	20	4.50 ± 0.13^{b2}	0.78 ± 0.6^{c1}	4798 ± 216^{e1}	25.34 ± 0.52^{e3}	58.65 ± 1.40^{a1}

*A: Control. B: 10% oat milk, C: 20% oat milk, D: 30% oat milk, E: 40% oat milk added.

** Values shown in different lower case letters in the same column are statistically different from each other depending on the oat milk content ($p<0.05$). Values shown with different numbers in the same row are statistically different from each other depending on the storage period ($p<0.05$)

all samples during the storage period was consistent with the study on oat yoghurt added with symbiotic microcapsules and various prebiotics (Luca and Oroian, 2022). There were very slight decreases in L* values of the samples during the storage period but this change was not found to be statistically significant (p>0.05).

The effect of oat milk on the a* values of the samples was found to be statistically significant (p<0.05). There were very slight

Table 3. Changes in the Color Values of Yogurts During Storage (%)

Yogurts*	Storage (Day)	L*	a*	b*
A	1	88.75±0.19^{a1}	-1.5±0.01^{a1}	9.39±0.07^{d2}
	10	88.28±0.06^{a1}	-1.48±0^{a1}	9.72±0.09^{d1}
	20	88.20±1.41^{a1}	-1.38±0.20^{a2}	9.79±0.15^{c1}
B	1	88.10±0.13^{b1}	-1.27±0.01^{b1}	9.50±0.01^{c2}
	10	87.28±0.03^{b1}	-1.24±0.01^{b2}	9.59±0.05^{e1}
	20	87.54±0.22^{b1}	-1.11±0.09^{b3}	9.62±0.02^{d1}
C	1	86.78±0.31^{c1}	-1.10±0.02^{c1}	9.98±0.013^{b2}
	10	86.53±0.18^{c1}	-0.99±0.03^{c2}	10.05±0.05^{c2}
	20	86.29±0.45^{c1}	-0.97±0.03^{c3}	10.50±0.66^{b1}
D	1	85.66±0.25^{d1}	-0.89±0.02^{d1}	10.31±0.04^{a2}
	10	85.88±1.10^{d1}	-0.83±0.07^{d2}	10.38±0.21^{b2}
	20	85.03±0.24^{d1}	-0.80±0.01^{d3}	10.54±0.11^{b1}
E	1	84.24±0.17^{e1}	-0.81±0.01^{e1}	10.38±0.18^{a3}
	10	84.48±0.71^{e1}	-0.78±0.07^{e2}	10.61±0.01^{a2}
	20	84.38±0.5^{e1}	-0.78±0.04^{d2}	10.72±0.08^{a1}

*A: Control. B: 10% oat milk, C: 20% oat milk, D: 30% oat milk, E: 40% oat milk added.
** Values shown in different lower case letters in the same column are statistically different from each other depending on the oat milk content (p<0.05). Values shown with different numbers in the same row are statistically different from each other depending on the storage period (p<0.05).

Table 4. Textural Properties of Yogurts

Yogurts	Day	Hardness	Intensity	Adhesiveness	Viscosity
A	1	262.69±7.53^{a3}	3657.47±181.99^{a2}	-84.3±4.61^{a}	-130.15±22.95^{a3}
	10	286.78±22.91^{a2}	3652.22±110.01^{a2}	-80.13±10.65^{a}	-144.85±15.39^{a2}
	20	394.81±2.3^{a1}	4828.26±427.48^{a1}	-103.79±5.67^{a}	-209.23±41.3^{a1}
B	1	145.82±15.69^{b3}	2357.36±223.25^{b3}	-86.05±0^{a}	-105.1±1.96^{b2}
	10	168.92±32.31^{b2}	2526±302.92^{b2}	-74.03±3.18^{b}	-121.6±11.44^{b1}
	20	186.97±24.97^{b1}	2977.57±309.15^{c1}	-88.04±4.98^{b}	-124.35±11.32^{c1}
C	1	131.25±34.99^{c3}	2154.29±507.94^{c3}	-75.28±5.54^{b}	-101.09±4.25^{b3}
	10	143.02±21.73^{c2}	2343.25±277.96^{c2}	-67.31±2.3^{c}	-115.28±38.11^{b2}
	20	168.3±17.37^{c1}	2687.21±368.55^{d1}	-79.45±9.71^{c}	-132.95±27.13^{b1}
D	1	122.03±7.47^{c3}	1967.09±86.95^{d3}	-71.29±21.85^{b}	-102.31±3.53^{b3}
	10	145.76±0.19^{c2}	2197.82±184.78^{c2}	-66±5.6^{c}	-121.71±27.07^{b2}
	20	171.35±20.67^{c1}	2668.1±289.78^{d1}	-75.46±7.85^{c}	-139.34±7.49^{b1}
E	1	92.39±11.95^{d2}	923.78±204.42^{e2}	-32±6.35^{c}	-32.88±5.92^{c2}
	10	120.15±1.99^{d2}	903.01±31.59^{d2}	-26.59±0.06^{d}	-52.15±25.91^{c1}
	20	153.53±14.26d1	1121.25±240.06^{e1}	-35.49±5.73^{d}	-56.38±11.82^{d1}

*A: Control. B: 10% oat milk, C: 20% oat milk, D: 30% oat milk, E: 40% oat milk added.
** Values shown in different lower case letters in the same column are statistically different from each other depending on the oat milk content (p<0.05). Values shown with different numbers in the same row are statistically different from each other depending on the storage period (p<0.05).

Fig. 1 Changes in color and appearance values of yoghurt during storage time

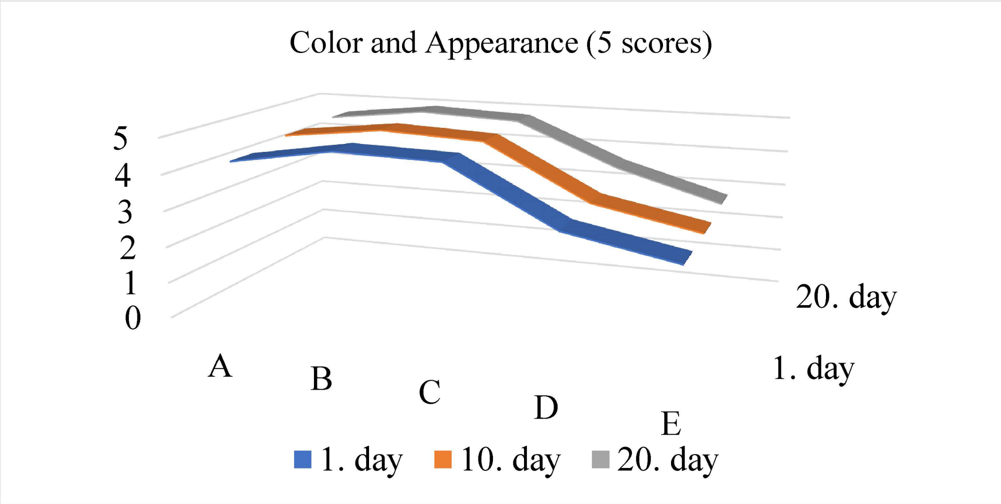
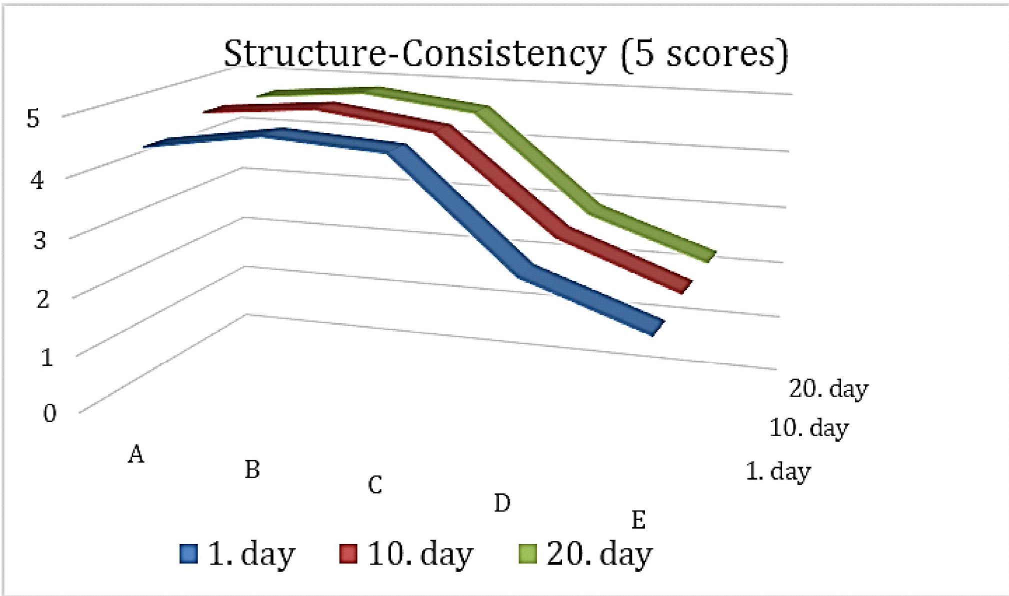


Fig. 2 Change in structure-consistency values of yoghurt during storage time



decreases in the a* values of the samples during the storage period and this change was found to be statistically significant ($p<0.05$). If the b value is positive, it indicates jaundice. As the oat milk ratio increased, the b* values of the samples also increased ($p<0.05$). It was determined that the b* value increased during the storage period ($p<0.05$).

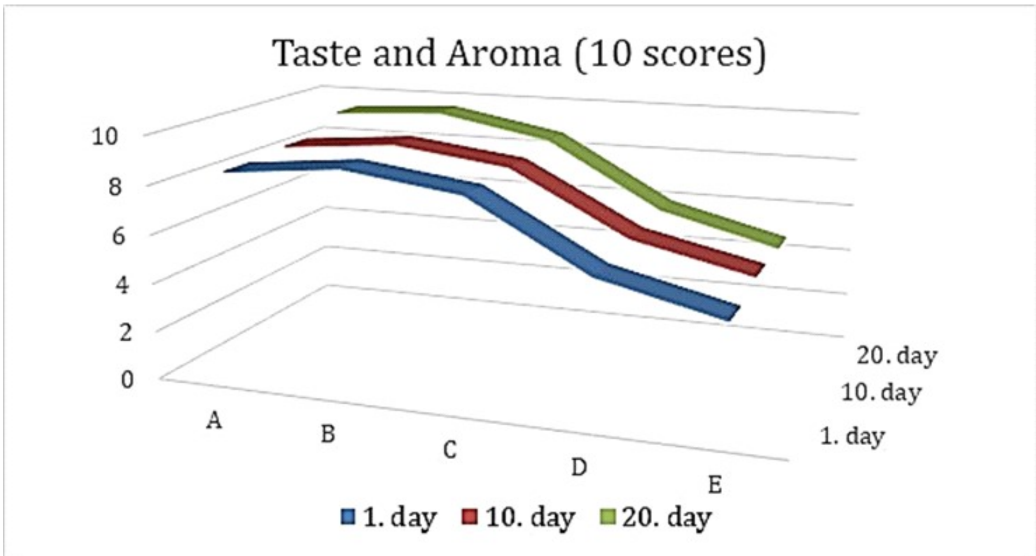
Textural Properties

In the study, textural parameters of hardness, density, adhesiveness and viscosity were examined (Table 4).

As the oat milk ratio increased, the hardness values of the samples decreased ($p<0.05$). It is thought that the weakening of the textural properties of yoghurts is due to the decrease in dry matter due to the increase in the oat milk ratio. The hardness values of the samples increased during the storage period ($p<0.05$). It is thought to increase due to interactions and cross-linking between proteins in acid casein gels during storage (Raak et al., 2014).

As the oat milk ratio increased, decreases in the density values of the samples were detected ($p<0.05$). This can be explained by the fact that the density of oat milk is lower than that of cow's milk. The increase in the density values of the samples during the storage period was also found to be statistically significant ($p<0.05$).

Fig. 3 Change in taste and aroma values of yoghurts during storage time



It has been determined that as oat milk increases, the external adhesiveness value of yoghurts decreases ($p<0.05$). It is estimated that this situation may be due to the water retention capacity of yoghurts. An increase in the external adhesiveness values of the yoghurt samples was observed throughout the storage period until the 10th day, after which a decrease was observed. However, this situation was found to be statistically insignificant ($p>0.05$). Luca and Oroian (2022) determined a similar situation in oat yoghurts produced with symbiotic microcapsules.

It has been determined that the addition of oat milk has a significant effect on the viscosity values of yoghurts ($p<0.05$). It was determined that as the oat milk ratio increased, the viscosity values also increased due to the increase in dry matter in the samples. Tamime and Robinson (1999) suggested that by increasing the dry matter and/or protein content, the water retention capacity of yoghurt could be increased and a new product with a higher than normal viscosity could be obtained. It has been observed that viscosity values increase during storage ($p<0.05$).

Sensory-Evaluation

Panelists evaluated the yoghurt samples separately in terms of color-appearance, structure-consistency and taste-aroma (Figure 1, 2, 3). Yoghurts with 10% oat milk added received the highest scores. This was followed by control yoghurts with 20%, 30% and 40% oat milk, respectively. During storage, the color-appearance and taste-aroma scores of the samples increased, but the structure-consistency scores did not change.

Conclusion

The oat milk ratio affected all the examined properties of probiotic yoghurts, and the storage period affected the physicochemical, microbiological and sensory properties of probiotic yoghurts significantly ($p<0.05$). The addition of oat milk positively affected the physical and textural properties of yoghurts, especially whey separation, water holding capacity and viscosity. It also encouraged the growth of probiotic bacteria and ensured a higher number of live bacteria. Among the yogurts, the ones with 10% and 20% oat milk added (B and C) were the most appreciated in terms of sensory evaluation. As a result, it was concluded that probiotic yoghurt can be given a symbiotic feature by adding oat milk. Considering the physicochemical, microbiological and sensory properties, it was concluded that 10% oat milk can be easily used in the production of probiotic yoghurt.

Conflict of interest

The authors have not any conflict of interest to declare.

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