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Physicochemical, functional, and sensory properties of yogurts containing persimmon

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Abstract: This study investigated the effects of various concentrations (10% and 12%, w/w) of persimmon marmalade and puree used in yogurt production. The antioxidant capacity, composition, and physicochemical and sensory properties of yogurts were established during the storage period. The titratable acidity contents and pH values of the samples changed slowly throughout the storage period. Yogurts made from persimmon marmalade had higher a and b values than did other yogurts. Yogurt containing 12% persimmon marmalade received the highest sensory analysis values. The dry matter contents of the samples fluctuated between 16.67% and 21.54% throughout the storage period. The highest viscosity and water capacity values were detected in the yogurt sample with 12% persimmon marmalade on the 15th day. The samples produced by adding persimmon puree exhibited lower antioxidant activity than did other samples.

Key words: Antioxidant activity, chemical properties, persimmon, sensory properties, yogurt

1. Introduction

Yogurt consumption has increased around the world because of its nutritional value, therapeutic effects, and functional properties (McKinley, 2005). The use of different fruits and additives in fruit yogurt production has improved its nutritional and sensory properties (Çakmakçı et al., 2012). Peaches, cherries, apricots, and blueberries are frequently used in yogurt production (Arslan and Özel, 2012).

Persimmon is an edible fruit that is a member of the family Ebenaceae, which is native to China and Japan (Baltacıoğlu and Artık, 2013). Persimmon is cultivated and known as "Trabzon hurması" in Turkey (Doymaz, 2012). In 2013, 33,232 t of persimmon was produced according to the Turkish Statistical Institute (http://www.tuik.gov.tr). The color of persimmon fruits varies from light yellow-orange to dark red-orange (Baltacıoğlu and Artık, 2013). Persimmon can be consumed fresh or dried (Ergun and Ergun, 2010; Doymaz, 2012).

Persimmon is traditionally used as an herbal medicine in China (Gu et al., 2008; Sun et al., 2011). Persimmon is generally consumed as a fresh fruit in Europe and has a positive impact on human health (Karaman et al., 2014a); it is an abundant source of vitamin C, vitamin A, calcium, and iron (Nicoleti et al., 2007). It contains many bioactive compounds, especially ascorbic acid, condensed tannins, and carotenoids. Bioactive compounds contribute to human health mainly through their antioxidant properties (Karaman et al., 2014a). In addition, some bioactive compounds can influence sensory characteristics (Najgebauer-Lejko, 2014).

Fresh fruits have a short shelf life. There are many methods for extending shelf life, such as drying and making fruit juice (Benedetti et al., 2011). Ergun and Ergun (2010) reported that the use of a honey dip solution prolonged the storage life of fresh persimmon based on the delay of off-aroma development. Karaman et al. (2014a) showed that the bioactive properties of persimmon were altered depending on the drying process used. They found that the highest bioactive value was obtained from freeze-dried samples. Recently, different properties of persimmon and preservation methods have been studied (Nicoleti et al., 2007; Gu et al., 2008; Sun et al., 2011; Baltacıoğlu and Artık, 2013). However, there are few studies concerning the addition of persimmon to food and food products (Han et al., 2012; Karaman et al., 2014b).

In this research, an alternative use for persimmon, which has a short shelf life, is provided. In addition, we aimed to increase the nutritional and functional properties of yogurt by adding persimmon and to evaluate an effective and suitable utilization of persimmon in yogurt production. The goal of this study was to develop a new type of stirred fruit-flavored yogurt by adding persimmon. The chemical, physicochemical, microbiological, and sensory properties of the yogurt samples were investigated during the storage period.

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2. Materials and methods

2.1. Materials

Raw milk was purchased from Sümer Dairy Co. (Denizli, Turkey). Skim milk powder was obtained from Aynes Dairy Co. (Denizli, Turkey). A commercial lyophilized yogurt starter culture consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (YF-L812, 50 U) was obtained from Chr-Hansen (İstanbul, Turkey).

Fresh persimmons, sugar, and starch were purchased from a local market in Denizli. Fresh and matured persimmons were cut into pieces, and then sugar was added and mixed to form persimmon marmalade. Whole persimmons were dried under the sun for 20–25 days. The dried persimmons were cut into pieces and boiled for 5 min, then mixed to form persimmon puree.

2.2. Yogurt production

For yogurt production, milk, skim milk powder (2%, w/v), sugar (3%, w/v), and starch (1%, w/v) were mixed in a boiler. This mixture was heated at 90 °C for 10 min and left to cool to 45 °C. Milk was inoculated with yogurt culture at 44 ± 1 °C. The milk was incubated at 44 ± 1 °C until it reached pH 4.7. After the coagulum was cooled to room temperature, it was broken gently. Following packaging, yogurt samples were divided into 5 parts. The first part was reserved as a control yogurt without the addition of persimmon (C sample). The samples PM1 and PM2 were produced by adding 10% and 12% (w/w) persimmon marmalade, respectively. PP1 and PP2 were produced by adding 10% and 12% (w/w) persimmon puree, respectively.

2.3. Analytical and physical measurements

Titratable acidity (expressed as lactic acid) was determined according to the alkali titration method (Bradley et al., 1992). The fat content of the samples was evaluated according to the Gerber method (Turkish Standards Institute, 1999). The protein and ash contents were determined using Association of Official Analytical Chemists (AOAC) methods (AOAC, 2000). pH analysis was carried out using a pH meter (Hanna HI 8314, Hanna Inc., Italy). The dry matter content was determined by the gravimetric method (AOAC, 2000).

Color properties (Hunter L, a, and b values) were measured by using a Hunter lab colorimeter (Hunter MiniScan Xe, Hunter Associates Laboratory, USA). A Brookfield viscometer was used to determine the viscosity of the yogurt. Viscosity measurements were performed using a No. 5 spindle at 25 rpm. Measurements were determined at 15 s; the results are expressed as cP. The water-holding capacity was determined according to Arslan and Özel (2012).

2.4. Phenolic content and antioxidant activity analysis

For total phenolic content and antioxidant analysis, extractions were performed according to Selçuk and Yılmaz (2009). Phenolic content determination was performed with the Folin–Ciocalteu method (Selçuk and Yılmaz, 2009). Antioxidant activity was investigated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. This analysis was performed using Thaipong et al.'s (2006) modified procedure. For stock solution, 24 mg of DPPH was dissolved with 100 mL of methanol; this solution was kept at –24 °C until the analyses. The working solution was prepared by mixing stock solution with methanol to obtain an absorbance of 1.1 ± 0.02 units at 515 nm using a spectrophotometer. Yogurt extracts (150 mL) were added to 2850 mL of the DPPH solution. After this mixture sat for 1 h, the absorbance was measured at 515 nm. The standard curve was linear between 5 and 50 µM Trolox. Antioxidant activity values of samples were expressed in µmol TE/g dry weight.

2.5. Sensory analysis

Eight panelists from the Food Engineering Department of Pamukkale University performed sensory analysis of the yogurt. Panelists were accustomed to yogurt and had previous sensory panel experience. This analysis was performed using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely, middle point, 5 = neither like nor dislike). The properties of appearance, odor, taste, structure, acidic taste, perceived sweetness, perceived fruit taste, and overall acceptability of the yogurt were evaluated by all panelists. Panelists were served water and unsalted crackers to clean their mouths before tasting each sample (Bodyfelt et al., 1988).

2.6. Microbiological analysis

Yogurt samples (10 g) were weighed in sterile Stomacher bags under aseptic conditions. After 90 mL of 0.1% peptone water (Merck) was added into the bags, further dilutions were done according to requirements. The standard pour plate method was employed to determine the counts of microorganisms. After incubation, plates with 3–300 colonies were counted, and the results were recorded as log number of colony-forming units per gram (log CFU/g).

The *S. thermophilus* count was enumerated in M17 agar. The plates were incubated at 37 °C for 48–72 h under aerobic conditions. MRS agar was used for enumeration of *L. delbrueckii* subsp. *bulgaricus*. The plates were incubated at 42 °C for 48–72 h (Ünal and Akalın, 2013). A double-layer pour plate technique was used for enumeration of *L. delbrueckii* subsp. *bulgaricus*.

2.7. Statistical analysis

The effects of 5 different treatments and 3 storage periods on the chemical, physicochemical, and sensory properties of the yogurts were investigated. This study included 3 replicates. Chemical, physicochemical, phenolic content, antioxidant activity, and microbiological analyses were carried out twice. Data were assessed using SPSS 16 for Microsoft Windows. Statistical results were analyzed by Duncan's multiple-range test at the $P < 0.05$ level of significance.

3. Results and discussion

3.1. Chemical analysis

Dry matter, protein, and fat contents and pH value of milk were 11.73%, 2.87%, 3.00%, and 6.74, respectively.

The chemical composition of the samples is described in Table 1. The dry matter contents of the samples were significantly ($P < 0.05$) affected by the treatment. The dry matter content of samples varied between 16.67% and 21.54% during the storage period. Addition of persimmon and the duration of the storage period did not influence the protein content. The pH value and titratable acidity content were significantly affected by the storage period ($P < 0.05$). The pH value and titratable acidity (lactic acid %) fluctuated between 4.49 and 4.65 and between 0.713% and 0.828%, respectively. The results could be related to the growth of lactic acid bacteria in the yogurt. The growth of lactic acid bacteria may be affected by the sugar content of the persimmon. Birollo et al. (2000) found that the viability of lactic acid bacteria in yogurt was negatively affected by a high sugar concentration in yogurt.

The utilization of persimmon in yogurt production did not have a significant effect on the ash content ($P > 0.05$). Park et al. (2006) reported that the differences in the mineral content of fresh and dried persimmon were not statistically significant.

The fat content of samples was significantly ($P < 0.05$) affected by the treatment. The yogurt fat contents ranged between 1.95% and 2.65% during the storage period. Tarakçı and Küçüköner (2003) reported that the protein contents of yogurts prepared with different fruits (cornelian, Morello cherry, and rosehip marmalade, grape molasses, date pulp, and control [without added fruit]) varied between 3.58% and 4.26%, but our findings were higher than these results. The protein content of the samples in the present study was similar to that reported by Arslan and Özel (2012).

3.2. Physical properties

The physical properties of the yogurts are given in Table 2. The effect of different treatments on the water-holding capacity, color, and viscosity was statistically significant ($P < 0.05$). There were no significant differences in water-holding capacity, viscosity, or color values (except L value) during the storage period ($P > 0.05$). Karaman et al. (2014b) determined that the L values of ice cream prepared with different amounts of persimmon puree declined with increasing puree concentration. The water-

Table 1. Chemical composition of persimmon-supplemented yogurts during the storage period[a].

Parameters	Storage period (days)	C	Yogurt code[b]			
			PM1	PM2	PP1	PP2
Dry matter (%)	1	17.64 ± 0.65^{a}	20.67 ± 0.67^{c}	21.54 ± 0.42^{d}	19.14 ± 0.68^{b}	19.23 ± 0.71^{b}
	7	17.55 ± 0.65^{a}	20.71 ± 0.41^{c}	21.02 ± 0.30^{c}	19.23 ± 0.66^{b}	19.85 ± 1.07^{b}
	15	16.67 ± 0.30^{a}	20.86 ± 0.87^{c}	21.24 ± 0.97^{c}	19.20 ± 1.31^{b}	20.25 ± 1.66^{bc}
Protein (%)	1	4.81 ± 0.43	4.63 ± 0.47	4.34 ± 0.28	4.65 ± 0.25	4.65 ± 0.32
	7	4.79 ± 0.37	4.63 ± 0.16	4.32 ± 0.23	4.50 ± 0.15	4.52 ± 0.53
	15	4.36 ± 0.64	4.57 ± 0.43	4.40 ± 0.23	4.34 ± 0.40	4.35 ± 0.29
Fat (%)	1	2.40 ± 0.18^{ab}	2.30 ± 0.25^{a}	2.40 ± 0.27^{ab}	2.60 ± 0.16^{b}	2.35 ± 0.12^{ab}
	7	2.40 ± 0.027^{bc}	2.25 ± 0.16^{ab}	1.95 ± 0.41^{a}	2.60 ± 0.16^{c}	2.45 ± 0.22^{bc}
	15	2.45 ± 0.23^{bc}	2.35 ± 0.23^{b}	2.00 ± 0.25^{a}	2.65 ± 0.12^{b}	2.45 ± 0.12^{bc}
Titratable acidity (lactic acid %)	1	0.716 ± 0.061^{A}	0.728 ± 0.039^{A}	0.713 ± 0.051^{A}	0.732 ± 0.037^{A}	0.723 ± 0.059^{A}
	7	0.828 ± 0.009^{B}	0.787 ± 0.028^{B}	0.807 ± 0.025^{B}	0.761 ± 0.044^{A}	0.798 ± 0.047^{B}
	15	0.791 ± 0.057^{B}	0.792 ± 0.032^{B}	0.778 ± 0.017^{B}	0.746 ± 0.035^{A}	0.757 ± 0.053^{AB}
pH	1	4.65 ± 0.02^{B}	4.61 ± 0.08^{A}	4.61 ± 0.09^{A}	4.61 ± 0.09^{A}	4.59 ± 0.09^{A}
	7	4.52 ± 0.02^{A}	4.51 ± 0.09^{A}	4.50 ± 0.08^{A}	4.53 ± 0.05^{A}	4.49 ± 0.06^{A}
	15	4.54 ± 0.00^{A}	4.55 ± 0.08^{A}	4.53 ± 0.08^{A}	4.57 ±0.06^{A}	4.53 ± 0.07^{A}
Ash (%)	1	0.87 ± 0.01^{B}	0.81 ± 0.03^{A}	0.79 ± 0.03^{A}	0.80 ± 0.03^{A}	0.82 ± 0.04^{A}
	7	0.84 ± 0.04^{A}	0.87 ± 0.02^{B}	0.84 ± 0.09^{A}	0.88 ± 0.03^{B}	0.88 ± 0.04^{B}
	15	0.84 ± 0.03^{A}	0.79 ± 0.05^{A}	0.83 ± 0.04^{A}	0.80 ± 0.05^{A}	0.85 ± 0.03^{AB}

[a] All values are mean ± standard deviation (n = 6). $^{(A–B)}$ Different uppercase superscripts represent significant differences in the same column ($P < 0.05$). $^{(a–c)}$ Different lowercase superscripts represent significant differences in the same rows ($P < 0.05$).

[b] C, control yogurt; PM1, yogurt produced by adding 10% persimmon marmalade; PM2, yogurt produced by adding 12% persimmon marmalade; PP1, yogurt produced by adding 10% persimmon puree; PP2, yogurt produced by adding 12% persimmon puree.

holding capacity of samples ranged from 55.21% to 64.33% (Table 2). These water-holding capacity values were higher than the results of Karaca et al. (2012). The water-holding capacity value and viscosity value of the 12% persimmon marmalade supplemented yogurts were higher than those of the other yogurts. The viscosities of liquid and semisolid foods have a large impact on their quality properties (Karaman et al., 2014b).

Yogurts prepared from persimmon puree had lower viscosity value than that of yogurts prepared from persimmon marmalade. The viscosity values of samples (except for the C samples) increased slightly on the 7th day and decreased at the end of the storage period. A similar trend was found by Öztürk and Öner (1999) for yogurt containing concentrated grape juice. The highest L values during the storage period were observed for control yogurts. The a values of yogurts made with persimmon marmalade were higher than those of yogurts made with persimmon puree. Sample PM2 had the highest b value during the storage period.

3.3. Phenolic content and antioxidant activity

Regular intake of fruit and vegetables is related to the reduced risk of diseases such as cancer and cardiovascular diseases, because they include natural antioxidants (Jang et al., 2010).

The phenolic contents and antioxidant activity values of yogurt samples are presented in Table 3. Heat processing may lead to structural damage to phenolic compounds (Karaman et al., 2014a). Karaman et al. (2014a) reported that persimmon powder samples produced by vacuum oven drying and oven drying had phenolic content scores lower than those of freeze-dried samples. Drying temperature was found to have a great influence on the total phenolic content of red grape pomace by Larrauri et al. (1997). Chan et al. (2009) determined that air drying and thermal drying methods used for ginger leaves caused a reduction in its bioactivity properties, such as total phenolic content and ascorbic acid equivalent antioxidant capacity.

There were significant differences in the phenolic contents and antioxidant activity of the samples ($P < 0.05$). The samples PP1, PP2, and PM1 had the lowest phenolic content at the beginning of storage. Samples PP1 and PP2 had the lowest antioxidant activity values. These results could be related to the drying process. Drying may have caused a drop in antioxidant activity and structural destruction of phenolic compounds.

3.4. Sensory properties

The influence of different treatments on the appearance, odor, taste, perceived fruit taste, perceived sweetness, acidic taste, structure, and overall acceptability scores was statistically significant ($P < 0.05$). Table 4 shows the sensory

Table 2. Physical characteristics of persimmon-supplemented yogurts during the storage period[a].

Parameters		Storage period (days)	C	Yogurt code[b]			
				PM1	PM2	PP1	PP2
Water-holding capacity (%)		1	56.71 ± 4.633^{a}	61.58 ± 1.86^{bc}	63.71 ± 2.28^{c}	59.36 ± 3.03^{ab}	60.02 ± 2.00^{ab}
		7	58.11 ± 5.74^{ab}	61.63 ± 2.87^{bc}	64.33 ± 1.58^{c}	55.21 ± 1.54^{a}	58.73 ± 2.22^{ab}
		15	56.77 ± 3.74^{a}	61.33 ± 1.89^{b}	63.14 ± 3.28^{b}	56.33 ± 3.72^{a}	59.81 ± 1.65^{ab}
Viscosity (cP)		1	10,000 ± 654^{a}	11,880 ± 1566^{a}	11,240 ± 1175^{a}	9553 ± 2857^{a}	9593 ± 2330^{a}
		7	6875 ± 781^{a}	11,583 ± 1964^{b}	12,183 ± 1753^{b}	10,205 ± 2402^{b}	10,050 ± 2406^{b}
		15	8133 ± 659^{a}	11,467 ± 1559^{bc}	12,317 ±1316^{c}	8417 ± 3110^{a}	9522 ± 1080^{ab}
Color	L	1	86.79 ± 0.70^{Bb}	73.57 ± 5.84^{Aa}	71.44 ± 4.50^{Aa}	75.12 ± 2.45^{Aa}	75.22 ± 4.39^{Aa}
	a		−3.15 ± 0.42^{a}	2.68 ± 1.82^{c}	3.98 ± 0.61^{d}	−0.11 ± 0.15^{b}	−0.023 ± 0.56^{b}
	b		9.13 ± 0.10^{b}	8.90 ± 0.66^{b}	9.24 ± 0.19^{b}	6.92 ± 0.59^{a}	7.13 ± 0.54^{a}
	L	7	81.84 ± 0.23^{Ac}	70.75 ± 2.28^{Aab}	70.49 ± 3.93^{Aa}	73.36 ± 0.57^{Aab}	73.32 ± 1.35^{Aab}
	a		−3.79 ± 0.36^{a}	3.06 ± 1.49^{c}	3.22 ± 2.30^{c}	−0.39 ± 0.62^{b}	−0.28 ± 0.56^{b}
	b		8.52 ± 0.04^{b}	8.84 ± 0.98^{b}	9.02 ± 1.02^{b}	6.93 ± 0.78^{a}	6.90 ± 0.62^{a}
	L	15	81.82 ± 1.29^{Ab}	72.33 ± 2.26^{Aa}	71.16 ± 3.67^{Aa}	73.40 ± 0.68^{Aa}	72.59 ± 1.88^{Aa}
	a		−3.77 ± 0.36^{a}	2.19 ± 1.59^{c}	2.91 ± 2.00^{c}	−0.43 ± 0.68^{b}	−0.01 ± 0.96^{b}
	b		8.67 ± 0.14^{b}	8.54 ± 0.90^{b}	8.95 ± 0.97^{b}	6.75 ± 0.85^{a}	7.07 ± 0.95^{a}

[a] All values are mean ± standard deviation (n = 6). ($^{A–B}$): Different uppercase superscripts represent significant differences in the same column ($P < 0.05$). ($^{a–c}$): Different lowercase superscripts represent significant differences in the same rows ($P < 0.05$).

[b] C, control yogurt; PM1, yogurt produced by adding 10% persimmon marmalade; PM2, yogurt produced by adding 12% persimmon marmalade; PP1, yogurt produced by adding 10% persimmon puree; PP2, yogurt produced by adding 12% persimmon puree.

Table 3. Phenolic contents and total antioxidant activities of persimmon-supplemented yogurts[a].

Parameters	Storage period (days)	C	Yogurt code[b]			
			PM1	PM2	PP1	PP2
Phenolic contents[c]	1	0.88 ± 0.11[b]	0.62 ± 0.05[a]	0.74 ± 0.15[ab]	0.62 ± 0.19[a]	0.62 ± 0.16[a]
	15	0.95 ± 0.12[b]	0.79 ± 0.14[ab]	0.73 ± 0.14[a]	0.72 ± 0.25[a]	0.83 ± 0.16[ab]
Total antioxidant activity[d]	1	0.17 ± 0.02[a]	0.16 ± 0.03[a]	0.17 ± 0.02[a]	0.13 ± 0.07[a]	0.13 ± 0.06[a]
	15	0.20 ± 0.01[c]	0.19 ± 0.06[c]	0.18 ± 0.03[bc]	0.11 ± 0.07[a]	0.13 ± 0.07[ab]

[a] All values are mean ± standard deviation (n = 6). [(a–c)] Different lowercase superscripts represent significant differences in the same rows (P < 0.05).
[b] C, control yogurt; PM1, yogurt produced by adding 10% persimmon marmalade; PM2, yogurt produced by adding 12% persimmon marmalade; PP1, yogurt produced by adding 10% persimmon puree; PP2, yogurt produced by adding 12% persimmon puree.
[c] Data are mg gallic acid equivalent (GAE) per g dry weight.
[d] Data are µmol Trolox equivalent (TE) per g dry weight.

Table 4. Sensory analysis results of persimmon-supplemented yogurts during the storage period[a].

Parameters	Storage period (days)	C	Yogurt code[b]			
			PM1	PM2	PP1	PP2
Appearance	1	7.78 ± 0.83[Bb]	7.00 ± 2.05[Aab]	7.50 ± 1.72[Aab]	6.40 ± 1.71[Aab]	6.10 ± 1.79[Aa]
	7	7.10 ± 0.88[ABa]	7.60 ± 1.17[Aa]	7.70 ± 1.16[Aa]	7.00 ± 1.49[Aa]	6.80 ± 1.32[Aa]
	15	6.50 ± 1.18[Aa]	7.60 ± 1.43[Aa]	7.80 ± 1.87[Aa]	7.00 ± 1.94[Aa]	6.20 ± 2.35[Aa]
Odor	1	6.78 ± 0.83[ab]	7.40 ± 1.17[b]	6.90 ± 1.10[ab]	6.20 ± 1.69[ab]	5.90 ± 1.50[a]
	7	6.30 ± 0.95[ab]	6.70 ± 0.95[ab]	6.90 ± 0.74[b]	5.50 ± 1.78[a]	5.60 ± 1.43[a]
	15	5.80 ± 1.81[a]	7.40 ± 1.26[a]	7.10 ± 1.91[a]	6.50 ± 1.90[a]	6.00 ± 2.50[a]
Taste	1	6.56 ± 1.33[a]	7.50 ± 1.08[a]	7.50 ± 0.97[a]	6.00 ± 2.50[a]	6.40 ± 2.07[a]
	7	5.80 ± 1.32[a]	7.40 ± 0.97[b]	7.30 ± 1.25[b]	6.30 ± 1.70[ab]	5.90 ± 1.66[a]
	15	4.40 ± 2.07[a]	6.60 ± 2.63[b]	7.40 ± 2.37[b]	6.20 ± 1.48[ab]	5.60 ± 2.27[ab]
Structure	1	6.67 ± 1.93[a]	7.20 ± 1.23[a]	7.00 ± 1.63[a]	6.10 ± 1.97[a]	6.00 ± 2.11[a]
	7	6.70 ± 1.25[a]	7.00 ± 1.05[a]	7.00 ± 0.82[a]	6.30 ± 1.77[a]	6.40 ± 1.51[a]
	15	5.00 ± 1.76[a]	7.40 ± 1.51[bc]	7.80 ± 1.48[c]	5.90 ± 2.23[ab]	5.30 ± 2.41[a]
Acidic taste	1	6.44 ± 1.67[a]	6.20 ± 2.20[a]	6.20 ± 2.35[a]	5.40 ± 1.58[a]	5.70 ± 2.06[a]
	7	4.40 ± 1.58[a]	6.40 ± 1.71[b]	6.10 ± 1.60[ab]	5.50 ± 1.90[ab]	6.00 ± 1.94[ab]
	15	2.70 ± 1.34[a]	6.80 ± 2.10[b]	6.80 ± 2.40[b]	5.50 ± 2.17[b]	5.80 ± 1.81[b]
Perceived fruit taste	1		7.40 ± 0.52[b]	7.50 ± 0.53[b]	6.10 ± 1.50[a]	6.20 ± 1.93[a]
	7		7.40 ± 1.17[a]	7.00 ± 0.82[a]	6.90 ± 0.88[a]	6.50 ± 1.51[a]
	15		6.80 ± 2.20[a]	7.40 ± 2.01[a]	6.80 ± 1.55[a]	7.00 ± 1.57[a]
Perceived sweetness	1	6.78 ± 1.30[a]	6.70 ± 1.77[a]	6.90 ± 1.67[a]	6.40 ± 1.43[a]	6.00 ± 1.56[a]
	7	4.70 ± 1.50[a]	7.20 ± 1.14[c]	7.00 ± 1.41[bc]	5.70 ± 1.70[ab]	6.10 ± 1.20[bc]
	15	3.10 ± 2.13[a]	7.40 ± 1.90[c]	7.70 ± 1.25[c]	5.50 ± 2.17[b]	5.50 ± 2.27[b]
Overall acceptability	1	6.89 ± 0.93[Bab]	7.60 ± 0.84[Ab]	7.70 ± 1.06[Ab]	6.30 ± 1.06[Aa]	6.10 ± 1.29[Aa]
	7	6.00 ± 0.94[Ba]	7.50 ± 0.85[Ac]	7.20 ± 0.92[Abc]	6.40 ± 1.26[Aab]	6.10 ± 1.10[Aa]
	15	4.00 ± 1.33[Aa]	7.30 ± 1.63[Acd]	7.80 ± 1.87[Ad]	6.00 ± 2.00[Abc]	5.50 ± 2.12[Aab]

[a] All values are mean ± standard deviation. [(A–B)] Different uppercase superscripts represent significant differences in the same column (P < 0.05). [(a–d)] Different lowercase superscripts represent significant differences in the same rows (P < 0.05).
[b] C, control yogurt; PM1, yogurt produced by adding 10% persimmon marmalade; PM2, yogurt produced by adding 12% persimmon marmalade; PP1, yogurt produced by adding 10% persimmon puree; PP2, yogurt produced by adding 12% persimmon puree.

analysis results of persimmon-supplemented yogurts during the storage period. The utilization of persimmon marmalade in yogurt production caused an increase in appearance, odor, taste, perceived sweetness, perceived fruit taste, acidic taste, structure, and overall acceptability scores. Karaman et al. (2014b) reported that an increase in the taste scores of persimmon-based ice cream correlated with an increase in persimmon puree concentration. Karaman et al. (2014b) showed that structure scores did not significantly change in ice cream enriched with persimmon puree. The addition of persimmon marmalade contributed to the sensory properties. Samples PM1 and PM2 had higher sensory scores than samples PP1 and PP2. The low sensory scores of yogurts containing persimmon puree might be due to the use of dried persimmon in the puree's production.

3.5. Microbiological properties

The microbiological analysis results of the yogurt are shown in Table 5. The *S. thermophilus* counts of the samples (except for the C sample) decreased throughout the storage period. Sample PP2 had the lowest *S. thermophilus* counts at 7 and 15 days of storage.

The effects of storage period and the variation of treatment on *L. delbrueckii* subsp. *bulgaricus* counts were statistically significant ($P < 0.05$). At the end of the storage period, the yogurts with 10% persimmon puree had higher *L. delbrueckii* subsp. *bulgaricus* counts than the other samples. *S. thermophilus* counts were significantly affected ($P < 0.05$) by storage. Ünal and Akalın (2013) reported that *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* counts of yogurts fortified with sodium–calcium caseinate and whey protein concentrate fluctuated between 8.47 and 9.09 (log CFU/g) and 6.93 and 7.76 (log CFU/g) during the storage period.

3.6. Conclusions

In this study, the addition of persimmon to yogurt production significantly changed ($P < 0.05$) the dry matter content and the values of water-holding capacity, viscosity, and color. The pH and titratable acidity values were not affected by enrichment with persimmon. Persimmon puree-supplemented yogurts had lower antioxidant activity than that of the other yogurts. Generally, addition of persimmon marmalade increased a (redness) and b (yellowness) values. This difference may be explained by the drying process. The *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* counts of the samples decreased throughout the storage period. Panelists preferred the yogurt samples made with persimmon marmalade. The effect of the addition of different persimmon forms on the appearance, odor, taste, perceived fruit taste, acidic taste, structure, perceived sweetness, and overall acceptability was significant. In conclusion, persimmon marmalade may be used in yogurt production successfully.

Table 5. Counts (log CFU/g) of *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* of persimmon-supplemented yogurts during the storage period[a].

Parameters	Storage period (days)	C	Yogurt code [b]			
			PM1	PM2	PP1	PP2
S. thermophilus (log CFU/g)	1	9.02 ± 0.06^{A}	9.60 ± 0.00^{A}	9.70 ± 0.14^{A}	9.23 ± 0.07^{B}	9.46 ± 0.20^{B}
	7	9.34 ± 0.44^{A}	9.37 ± 0.50^{A}	9.25 ± 0.23^{A}	9.16 ± 0.04^{B}	8.86 ± 0.07^{A}
	15	9.30 ± 0.13^{A}	8.93 ± 0.13^{A}	9.21 ± 0.38^{A}	8.96 ± 0.03^{A}	8.81 ± 0.01^{A}
L. bulgaricus (log CFU/g)	1	7.35 ± 0.40^{Ba}	6.93 ± 0.04^{Ba}	6.94 ± 0.02^{Ba}	6.97 ± 0.05^{Aa}	6.99 ± 0.05^{Ba}
	7	7.23 ± 0.11^{Bc}	5.77 ± 0.10^{Aa}	6.68 ± 0.28^{Bbc}	6.78 ± 0.54^{Abc}	6.15 ± 0.04^{Aab}
	15	5.97 ± 0.06^{Ab}	5.56 ± 0.07^{Aa}	5.48 ± 0.02^{Aa}	7.06 ± 0.31^{Ac}	6.10 ± 0.13^{Ab}

[a] All values are mean ± standard deviation (n = 6). (A–B) Different uppercase superscripts represent significant differences in the same column ($P < 0.05$). (a–c) Different lowercase superscripts represent significant differences in the same rows ($P < 0.05$).
[b] C, control yogurt; PM1, yogurt produced by adding 10% persimmon marmalade; PM2, yogurt produced by adding 12% persimmon marmalade; PP1, yogurt produced by adding 10% persimmon puree; PP2, yogurt produced by adding 12% persimmon puree.

References

AOAC (2000). Official Methods of Analysis. 17th ed. Washington, DC, USA: Association of Official Analytical Chemists.

Arslan S, Özel S (2012). Some properties of stirred yoghurt made with processed grape seed powder, carrot juice or a mixture of grape seed powder and carrot juice. Milchwissenschaft 67: 281–285.

Baltacıoğlu H, Artık N (2013). Study of postharvest changes in the chemical composition of persimmon by HPLC. Turk J Agric For 37: 568–574.

Benedetti PCD, Pedro MAM, Telis-Romero J, Telis VRN (2011). Influence of encapsulating materials on water sorption isotherms of vacuum-dried persimmon pulp powder. J Food Process Pres 35: 423–431.

Birollo G, Reinhemer J, Vinderola C (2000). Viability of lactic acid microflora in different types of yoghurt. Food Res Int 33: 799–805.

Bodyfelt FW, Tobias J, Trout GM (1988). The Sensory Evaluation of Dairy Products. New York, NY, USA: Van Nostrand Reinhold.

Bradley RL, Arnold E, Barbano DM, Semerad RG, Smith DE, Vines BK (1992). Chemical and physical methods. In: Marshall RT, editor. Standard Methods for the Examination of Dairy Products. 16th ed. Washington, DC, USA: American Public Health Association, pp. 433–531.

Çakmakçı S, Çetin B, Turgut T, Gürses M, Erdoğan A (2012). Probiotic properties, sensory qualities, and storage stability of probiotic banana yogurts. Turk J Vet Anim Sci 36: 231–237.

Chan EWC, Lim YY, Wong SK, Lim KK, Tan SP, Lianto FS, Yong MY (2009). Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species. Food Chem 113: 166–172.

Doymaz İ (2012). Evaluation of some thin-layer drying models of persimmon slices (*Diospyros kaki* L.). Energ Convers Manage 56: 199–205.

Ergun M, Ergun N (2010). Extending shelf life of fresh-cut persimmon by honey solution dips. J Food Process Pres 34: 2–14.

Gu HF, Li CM, Xu YJ, Hu WF, Chen MH, Wan QH (2008). Structural features and antioxidant activity of tannin from persimmon pulp. Food Res Int 41: 208–217.

Han L, Shan Q, Lu Z, Li L (2012). Effects of immature persimmon (*Diospyros kaki* Linn. F.) juice on the pasting, textural, sensory and color properties of rice noodles. J Texture Stud 43: 187–194.

Jang IC, Jo EK, Bae MS, Lee HJ, Jeon GI, Park E, Yuk HG, Ahn GH, Lee SC (2010). Antioxidant and antigenotoxic activities of different parts of persimmon (*Diospyros kaki* cv. Fuyu) fruit. J Med Plants Res 4: 155–160.

Karaca OB, Saydam İB, Güven M (2012). Physicochemical, mineral and sensory properties of set-type yoghurts produced by addition of grape, mulberry and carob molasses (Pekmez) at different ratios. Int J Dairy Technol 65: 111–117.

Karaman S, Toker ÖS, Çam M, Hayta M, Doğan M, Kayacier A (2014a). Bioactive and physicochemical properties of persimmon as affected by drying methods. Drying Technol 32: 258–267.

Karaman S, Toker ÖS, Yüksel F, Çam M, Kayacier A, Doğan M (2014b). Physicochemical, bioactive, and sensory properties of persimmon-based ice cream: technique for order preference by similarity to ideal solution to determine optimum concentration. J Dairy Sci 97: 97–110.

Larrauri JA, Ruperez P, Calixto FS (1997). Effect of drying temperature on the stability of polyphenols and antioxidant activity of red grape pomace peels. J Agric Food Chem 45: 1390–1393.

McKinley MC (2005). The nutrition and health benefits of yoghurt. Int J Dairy Technol 58: 1–12.

Najgebauer-Lejko D (2014). Effect of green tea supplementation on the microbiological, antioxidant, and sensory properties of probiotic milks. Dairy Sci Technol 94: 327–339.

Nicoleti JF, Silveira V, Telis-Romero J, Telis VRN (2007). Influence of drying conditions on ascorbic acid during convective drying of whole persimmons. Drying Technol 25: 891–899.

Öztürk BA, Öner MD (1999). Production and evaluation of yogurt with concentrated grape juice. J Food Sci 64: 530–532.

Park YS, Jung ST, Kang SG, Delgado-Licon E, Ayala ALM, Tapia MS, Martin-Bellosa O, Trakhtenberg S, Gorinstein S (2006). Drying of persimmons (*Diospyros kaki* L.) and the following changes in the studied bioactive compounds and the total radical scavenging activities. LWT-Food Sci Technol 39: 748–755.

Selçuk AR, Yılmaz Y (2009). İşlenmiş üzüm çekirdeği tozu ilavesinin lokum benzeri bir ürünün toplam fenolik madde içeriği ile antioksidan aktivitesi üzerine etkisi. Acad Food J 7: 56–61 (in Turkish).

Sun L, Zhang J, Lu X, Zhang L, Zhang Y (2011). Evaluation to the antioxidant activity of total flavonoids extract from persimmon (*Diospyros kaki* L.) leaves. Food Chem Toxicol 49: 2689–2696.

Tarakçı Z, Küçüköner E (2003). Physical, chemical, microbiological and sensory characteristics of some fruit-flavored yoghurt. YYU Vet Fak Derg 14: 10–14.

Thaipong K, Boonprakob U, Crosby K, Cisneros-Zevallos L, Byrne DH (2006). Comparison of ABTS, DPPH, FRAP and ORAC assay for estimating antioxidant activity from guava fruit extracts. J Food Compos Anal 19: 669–675.

Turkish Standards Institute (1999). Yoghurt Standard, TS 1330. Ankara, Turkey: Turkish Standards Institute.

Ünal G, Akalın S (2013). Influence of fortification with sodium–calcium caseinate and whey protein concentrate on microbiological, textural and sensory properties of set-type yoghurt. Int J Dairy Technol 66:264–272.