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Journal homepage:
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The Effect of Loquat Fruit (*Eriobotrya japonica*) Marmalade Addition and Storage Time on Phsico-Chemical and Sensory Properties of Yogurt

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ARTICLE INFO

Research Article – Food Technologies
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Received: 03 December 2009, Received in Revised Form: 25 December 2012, Accepted: 19 February 2013

ABSTRACT

The objective of this study was to investigate the physico-chemical and sensorial changes during storage period in yogurts that were manufactured by adding loquat fruit (*Eriobotrya japonica*) marmalade at 4 different ratios (5%, 10%, 15%, 20%). The pH and yellowness/blueness (*b**) values of yogurts increased with increasing marmalade ratios, whereas titratable acidity, viscosity, syneresis, redness (*a**) and lightness (*L**) values decreased. The pH and viscosity values of the yogurts decreased continuously through storage. Yogurts containing loquat marmalade were overall acceptable in terms of sensory characteristics. The production of fruit flavoured yogurts by adding 15% marmalade would be recommended.

Keywords: Yogurt; Loquat marmalade; Syneresis; Viscosity

Yoğurdun Fiziko-Kimyasal ve Duyusal Özellikleri Üzerine Yenidünya (*Eriobotrya japonica*) Marmeladı İlavesi ve Depolama Süresinin Etkisi

ESER BİLGİSİ

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Geliş Tarihi: 03 Aralık 2009, Düzeltmelerin Gelişi: 25 Aralık 2012, Kabul: 19 Şubat 2013

ÖZET

Bu çalışmanın amacı, farklı düzeylerde yenidünya marmeladı katılmış yoğurtlarda depolama süresince meydana gelen fiziko-kimyasal ve duyusal değişiklikleri incelemektir. Yoğurtlar %5, %10, %15 ve %20 düzeyinde marmelat ilavesiyle üretilmiştir. Marmelat oranının artırılması yoğurtların titrasyon asitliği, viskozite, serum ayrışması, kırmızılık (*a**) ve beyazlık (*L**) değerlerini azaltırken, pH ve sarılık/mavilik (*b**) değerlerini artırmıştır. Depolama süresince pH ve

viskozite değerleri sürekli olarak azalmıştır. Yenidünya marmeladı ilavesi ile üretilmiş yoğurtlar duyusal olarak genel kabul edilebilir bulunmuş ve meyveli yoğurtların üretiminde %15 marmelat ilavesi önerilmiştir.

Anahtar Kelimeler: Yoğurt; Yenidünya marmeladı; Serum ayrışması; Viskozite

1. Introduction

The loquat (*Eriobotrya japonica*) is an evergreen fruit species grown in the subtropical zone, especially in the citrus-growing regions. However, loquat has more specific environmental requirements than citrus (Caballero & Fernández 2003). About 97% of loquat fruit production has been supplied from the Mediterranean region. The fruits of the loquat can be sold at a higher price in spring, since there are few competitive fruits on the market except for strawberry, green plum and green almond. Loquat fruit is usually eaten fresh but may be stewed, served as a sauce, syrup or jam, or made into an excellent jelly. The loquat is rich in vitamins A, B and C, having a very high carotene, mineral substances, salts, sugar and it is a good source of acid and pectin (Durgac et al 2006). The composition of loquat is 84%-89% water, 0.32%-0.35% protein, 0.30%-0.60% lipids, 9.89%-12.79% sugar and starch, 0.30%-0.37% cellulose and 0.26%- 0.29% ash.

The increasing annual consumption of yogurt in many countries has been attributed to the ever-increasing variety of fruit or flavoured yogurt, and to the wide diversity of presentations of the product. The improvement of aroma and flavour of yogurt would result in an increase in the consumption of final product. Fruit flavoured yogurts are widely consumed due to partially masked excessive acetaldehyde flavour in plain yogurt (Tamime & Robinson 2000). The types of flavouring material used in yogurt industry are fruits, fruits preserves, canned fruit, frozen fruits and miscellaneous fruit products. Most common fruits used in yogurt formula are peach, cherry, orange, lemon, purple plum, boysenberry, spiced apple, apricot, pineapple, strawberry, raspberry and blueberry.

Texture is one of the most important characteristics that define the quality of yogurt and affects its appearance, mouth-feel and overall acceptability. The most frequent defects related to yogurt texture, which may lead to consumer rejection, are apparent viscosity variations and the occurrence of syneresis. These changes may be due to variations in milk composition, as well as changes in processing, incubation and storage conditions. The objective of this study was to develop a new type of stirred fruit-flavoured yogurt by adding loquat fruit marmalade. Therefore, we investigated the effect of adding loquat fruit marmalade at different ratios on changes in the physico-chemical and sensory properties of the yogurts through storage.

2. Material and Methods

Raw cow's milk (3.10% fat), loquat fruit and granulated sugar used in the manufacture of fruit flavored yogurt were obtained from the market in Ordu, Turkey. Loquat fruit marmalade was made in the laboratory. The total solid content of the marmalade was 16.13 kg/100 kg, and the pH was about 4.5. Non-fat milk powder was obtained from Pınar A.Ş. Dairy Product Company, Pınarbaşı, İzmir, Turkey and commercial freeze-dried starter culture (Y-080 F: the blend of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrucckii* subsp. *bulgaricus*) from Sacco, Cadorago, Italy.

2.1. Production of loquat fruit marmalade

First, decayed and unripe fruits were separated and then, the rest of the fruits were washed. Seeds of fruits were removed manually and the pulp was homogenized with an Ultra Turrax homogenizer (Cat X120, Germany). Twenty five per cent granulated sugar was added to the pulp. The pulp was then pasteurized at 90 ± 1 °C for 5 min and transferred into sterile glass jars. After cooling they were kept at ambient temperature until using in the experimental yogurts.

2.2. Manufacture of experimental yogurts

Yogurt was manufactured according to the method reported by Tamime & Robinson (2000). The total solid of milk was adjusted to 13.70% with non-fat milk powder at 50 °C. Then milk was pasteurized at 95 °C for 10 min, cooled to 45 °C, and divided into five equal parts. Commercial freeze-dried yogurt starter culture was reactivated by inoculation in sterilized reconstituted milk and incubated at 44±1°C before use in the yogurt production. Then, milk was inoculated with 2.5% (v/v) reactivated yogurt cultures, and incubated at 43±1 °C for 3.5 h. After cooling procedure, while one of the equal parts was kept as control group (0%), loquat marmalade was added to the other parts at 5%, 10%, 15% and 20% ratios. All experimental yogurts in sterile glass cups (250 g) were stored at 4-5 °C for 21 days. Samples were analyzed for physicochemical and sensory properties at 1, 6, 12 and 18 days of storage. Experiments were replicated twice.

2.3. Physico-chemical properties

Ash, fat, and titratable acidity were determined using the method by Case et al (1985). Titratable acidity results were expressed as lactic acid. Non-fat total solid (NFDM) contents of yogurt samples were calculated. The pH of each sample was measured with a digital pH meter (Hanna, Italy) equipped with a glass electrode that was inserted directly into the yogurt sample for the measurement.

In order to determine syneresis, 5 ml of yogurt was centrifuged at 5 000 rpm for 20 minutes at 4 °C, and syneresis was measured 1 minute after centrifugation. The syneresis rate (%) was expressed as volume of separated whey per 100 ml of yogurt (Çelik & Bakırcı 2003). Viscosity was measured at 14.4 °C with a Brookfield viscosimeter (Model DV-1; Brookfield Engineering Laboratories, Inc., MA). The viscosimeter was operated at 30 rpm (spindle number 4). Each result was recorded as cP after 20 seconds rotation. Samples were stirred for 40 seconds before measurement.

The colour of yogurt samples was measured using the CIELAB system with a colorimeter (Minolta CR 400, Japan), calibrated with a white tile (Minolta calibration plate, No: 21733001, Y=92.6, x=0.3136, y=0.3196) at 2° observation angle with a C illuminant source. Triplicate pouches were emptied and stirred to achieve uniform colour. The yogurt was put into an optically flat glass dish for measurements. Five readings were taken from each group of yogurt samples. Lightness (L^*: 100=white, 0=black), redness (a^*: +, red; -, green) and yellowness/blueness (b^*: +, yellow; -, blue) values were recorded.

2.4. Sensory properties

The experimental yogurt samples were coded with random numbers and placed on white plates in order to present to the panel members in daylight. Initially, eight panellists were trained in 2-hour sessions prior to evaluation to be familiar with the attributes and scaling procedures of the samples. The panellists were asked to evaluate each sample in turn covering a list of judged parameter attributes using a hedonic scale with 1 being the worst (1: very poor, 5: very good). The score given by panellists for each attribute of a sample was noted separately. The qualities judged were exterior appearance by looking directly at yogurt samples in daylight, consistency by mixing yogurt gently with a spoon and by mouth, odour and taste intensity and perceived fruit. A spoon of yogurt was taken and spread out by tongue for consistency by mouth, odour and taste intensity, and perceived fruit and sweetness. Water was provided for mouth washing between samples. The overall acceptability was calculated as sum of the scores of the parameters judged (Larmond 1987).

2.5. Statistical analysis

The data obtained from three replications were analyzed as a completely randomized design procedure using the general linear model procedure of the SPSS statistical package program (SPSS, Inc., Chicago, IL). The model included marmalade ratio and storage time as main effects, and marmalade ratio x storage time interaction. Duncan's multiple range test was used to detect significant differences between means ($P<0.05$). The results of the statistical analysis were presented as mean values ± SE in the tables for 4 storage times and 5 marmalade ratios.

3. Results and Discussion

3.1. Physico-chemical properties of yogurts

Changes in total solid, fat, non-fat dry matter and ash content (%) of yogurt samples containing loquat fruit marmalade at different ratios were monitored at different storage times. The addition of loquat fruit marmalade to yogurt at different ratios affected all these properties of yogurt samples (Table 1; $P<0.05$), whereas no significant differences were detected between storage times in terms of these properties ($P>0.05$). Marmalade ratio x storage time interaction was not significant for total solid, fat, non-fat dry matter and ash ($P>0.05$). With increasing marmalade ratio, total solid, non-fat dry matter and ash increased ($P<0.05$), while fat decreased ($P<0.05$). Total solid, fat, non-fat dry matter and ash ratios ranged between 13.69%-20.87%, 2.85%-2.45%, 10.84%-18.42% and 0.96%-1.18%, respectively. When compared to control sample, higher total solid, nonfat dry matter and ash might be due to increasing total solid and ash quantities of loquat marmalade. Loquat marmalade addition in yogurt significantly decreased fat content ($P<0.05$). As expected, after 10% marmalade added, fat content of the samples decreased significantly when compared with control sample ($P<0.05$). The mean fat content of the stirred yogurts was similar to the finding of Cinbaş & Yazıcı (2008) for blueberry added yogurt and of García-Pérez et al (2005) for fiber containing yogurt.

The control of acidity due to the formation of lactic acid in the product is of great importance. Therefore, pH is routinely determined with a pH-meter as a standard technique in the yogurt industry. However, it is advisable to determine the titratable acidity, since this value gives a rapid indication of changes in the activity of the starter microorganisms, and it is a good indication of the activity of the ferment inoculated (Sanz et al 2008). Acidity (pH) values of yogurt samples are presented in Table 2.

Both marmalade ratio ($P<0.05$) and storage time ($P<0.01$) affected pH values of yogurt samples. The mean pH values of the yogurts were detected between 4.01 and 4.36. The mean pH value increased with increasing marmalade ratio, whereas it decreased with increasing storage time. Our pH values were consistent with the pH values of Cinbaş & Yazıcı (2008) for blueberry added yogurts and Hurşit & Temiz (1999) for fruit-flavoured yogurts while Öztürk & *Öner* (1999) reported lower pH values for yogurts with concentrated grape juice. The interaction between marmalade ratio and the storage time was detected in pH values of samples ($P<0.01$; Figure 1). No significant differences were found in pH values of yogurts at the first 6 days, whereas a rapid decrease was observed for all samples thereafter. The samples with marmalade at 10%, 15% and 20% ratios showed the highest pH values, while control and 5% marmalade added samples showed the lowest pH values at the end of storage time. Marmalade addition above 5% prevented the decline of pH values (Figure 1). The pH of yogurt is influenced by the growth of both starter and non-starter lactic acid bacteria in pasteurized milk yogurt (Kailasapathy et al 2008; Vargas et al 2008). Similarly, Öztürk & Öner (1999) observed that the pH decreased during storage at

Table 1-Basic chemical ingredients of yogurt samples containing loquat fruit marmalade at different ratios

Çizelge 1- Farklı oranlarda yenidünya marmeladı içeren yogurt örneklerinin kimyasal temel komponentleri

Marmalade ratio (%)	*Total solid (%)*	*Fat (%)*	*NFDM (%)*	*Ash (%)*
Control	13.69±0.37^{e}	2.85±0.07^{a}	10.84±0.31^{e}	0.96±0.04^{b}
5	15.41±0.11^{d}	2.75±0.07^{ab}	12.66±0.17^{d}	0.97±0.03^{b}
10	17.29±0.27^{c}	2.55±0.07^{bc}	14.74±0.34^{c}	1.11±0.04^{a}
15	18.70±0.31^{b}	2.50±0.14^{c}	16.21±0.18^{b}	1.14±0.03^{a}
20	20.87±0.18^{a}	2.45±0.08^{c}	18.42±0.11^{a}	1.18±0.03^{a}

Small letters (a, b, c) indicate significant differences between means within a column ($P<0.05$).

Table 2- Psycho-chemical properties of loquat fruit marmalade added yogurt samples

Çizelge 2- Yenidünya marmeladı ilave edilmiş yoğurt örneklerinin fiziko-kimyasal özellikleri

	Storage time	*Marmalade ratio*					
		0%	*5%*	*10%*	*15%*	*20%*	*Overall*
pH value	1 day	4.40±0.07^{a}	4.35±0.02^{a}	4.37±0.02^{a}	4.34±0.04^{a}	4.35±0.01^{a}	4.36±0.04
	6 days	4.32±0.04^{a}	4.39±0.06^{a}	4.34±0.04^{ab}	4.33±0.02^{a}	4.39±0.03^{a}	4.35±0.04
	12 days	3.91±0.04^{bC}	4.19±0.03^{bB}	4.26±0.04^{bAB}	4.28±0.02^{aA}	4.25±0.01^{bAB}	4.18±0.15
	18 days	3.93±0.03^{bB}	3.95±0.03^{cB}	4.06±0.03^{cA}	4.05±0.03^{bA}	4.06±0.01^{cA}	4.01±0.07
	Overall	4.14±0.25	4.22±0.19	4.26±0.12	4.25±0.13	4.26±0.14	
Titratable	1 day	0.91±0.01	0.87±0.01	0.86±0.21	0.82±0.03	0.81±0.02	0.86±0.04^{d}
	6 days	1.07± 0.03	1.07± 0.03	1.03± 0.05	1.08± 0.01	1.08± 0.02	1.06±0.03^{c}
	12 days	1.32± 0.04	1.28± 0.02	1.24± 0.03	1.25± 0.02	1.24±0.03	1.27±0.04^{b}
	18 days	1.53± 0.05	1.54± 0.03	1.51± 0.01	1.54±0.02	1.53± 0.05	1.53±0.03^{a}
	Overall	1.21±0.25^{A}	1.19±0.25^{AB}	1.16±0.25^{B}	1.17±0.28^{AB}	1.16±0.28^{B}	
Viscosity	1 day	3460±56.55^{aC}	3540±50.914^{aBC}	3690±24.74^{aA}	3621±29.66^{aAB}	3600±50.91^{aAB}	3582.3±88.45
	6 days	2598±73.50^{bA}	2245±21.21^{bB}	2271±38.18^{bB}	2264±19.77^{bB}	2325±29.63^{bB}	2340.60±88.45
	12 days	2073±38.18^{cA}	1718±39.56^{cB}	1710±42.40^{cB}	1688±16.96^{cB}	1640±22.61^{cB}	1765.80±114.91
	18 days	1875±35.35^{dA}	1327±74.95^{dC}	1403+24.07^{dBC}	1434±8.45^{dB}	1404±16.90^{dBC}	1488.60±828.80
	Overall	2501±656.79	2207±893.94	2268±938.89	2251±904.33	2242±913.05	
Syneresis	1 day	49.0±1.42^{aABC}	49.0±1.41^{aBC}	48.0±2.84^{aAB}	47.0±1.42^{aA}	45.0±1.43^{aC}	47.6±2.07
	6 days	41.0±1.41^{b}	40.0±2.84^{b}	44.0±0.00^{ab}	45.0±1.41^{ab}	37.0±1.40^{b}	41.4±3.27
	12 days	43.0±4.24^{ab}	40.5±1.42^{b}	41.5±2.13^{b}	41.5±2.13^{b}	37.0±1.41^{b}	40.4±2.91
	18 days	49.0±1.41^{aA}	47.0±1.41^{aAB}	45.5±0.71^{abB}	45.0±1.41^{abB}	37.0±1.41^{bC}	44.7±4.42
	Overall	45.5±4.24	43.75±4.83	44.75±4.87	44.62±2.45	39±3.86	

Small letters (a, b, c) indicate significant differences between means within a column. Capital letters (A, B, C) indicate significant differences between means within a row. Storage time x marmalade ratio interactions: pH (P<0.01), viscosity (P<0.01), syneresis (P<0.05).

4 °C for 21 days. Decrease in pH may be due to use of sugar and organic acids by yeasts.

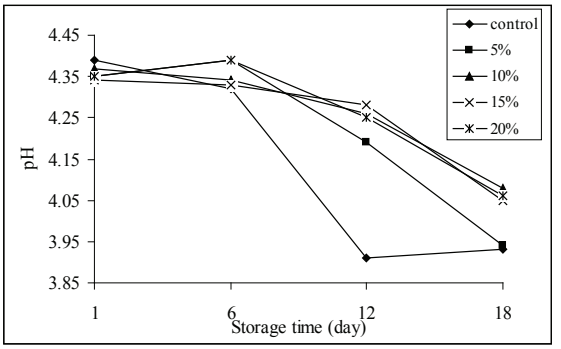

Figure 1- The time dependent variation in the pH values of yogurt samples containing loquat fruit marmalade at different ratios

Şekil 1- Farklı oranlarda yenidünya marmeladı içeren yoğurt örneklerinin pH değerlerinde zamana bağlı değişim

Titratable acidity of yogurts was detected between 0.86% and 1.53%. A significant increase in titratable acidity was detected throughout storage (P<0.01), while a significant decrease was detected with increasing marmalade ratio (P<0.05). Marmalade ratio x storage time interaction was not found to be significant (P>0.05). Control samples had the highest mean titratable acidity value when compared to the marmalade added samples. This could be attributed to the osmotic effect of sugar in marmalade. The lowest mean value of titratable acidity was found at first day of storage, while the highest mean value was found at 18th day. Tarakçı & Küçüköner (2004) and Çelik et al (2006) reported that the titratable acidity of fruit-flavoured yogurts increased along with storage. Singh & Muthukumarappan (2008) reported a similar increase in acidity of control and calcium enriched fruit yogurts during storage. This might be due to the

fermentation of lactose by the action of the starter culture in the experimental yogurts during storage.

The viscosity is a typical major parameter for semi liquid foods (Amaya-Llalo et al 2008). The viscosity of yogurt was affected by both marmalade ratio (P<0.01) and storage time (P<0.01; Table 2). The interaction between marmalade ratio and the storage time was detected in viscosity (P<0.01). The addition of the fruit marmalade reduced the mean viscosity values compared to the control samples. The viscosity values for all samples decreased rapidly up to the end of storage time. But, the lowest decrease was detected in control yogurt sample (Figure 2). Çelik & Bakırcı (2003) found that the increase in mulberry pekmez ratio reduced the viscosity values of the yogurts. They also stated that the viscosity of mulberry added yogurts decreased throughout the storage. Similar results were reported by Çelik et al (2006). Our findings were similar to those found in blueberry added yogurts (Cinbaş & Yazıcı 2008) and lower than those found in concentrated grape juice yogurts (Öztürk & *Öner* 1999). Consequently, the structure of fruit yogurt can be improved by using stabilizing agents such as starches, gelatin or pectin.

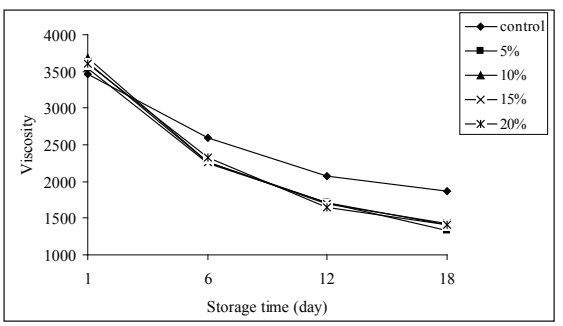

Figure 2- The time dependent variation in the viscosity values of yogurt samples containing loquat fruit marmalade at different ratios

Şekil 2-Farklı oranlarda yenidünya marmeladı içeren yoğurt örneklerinin viskozite değerlerinde zamana bağlı değişim

Syneresis is defined as a spontaneous water release from the gel caused by contraction. The most important causes of syneresis in fermented products are the use of high temperatures of incubation, low solid content or inadequate storage temperatures (Amaya-LIano et al 2008). The syneresis of yogurt samples was affected by both storage time (P<0.01) and marmalade ratio (P<0.01; Table 2). Marmalade ratio x storage time interaction was detected for syneresis (P<0.05; Figure 3).

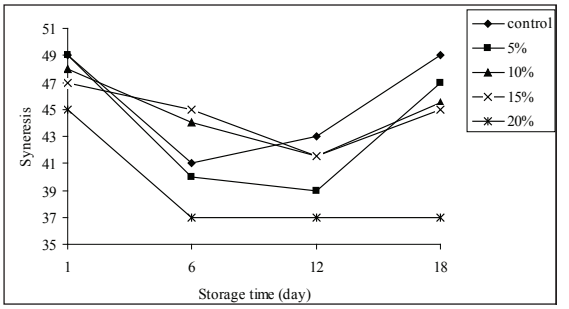

Figure 3- The time dependent variation in the syneresis values of yogurt samples containing loquat fruit marmalade at different ratios

Şekil 3- Farklı oranlarda yenidünya marmeladı içeren yoğurt örneklerinin serum ayrışması değerlerinde zamana bağlı değişim

Marmalade addition up to 15% did not affect the syneresis value, but the syneresis value decreased, when 20% marmalade was added to the samples. In general, syneresis value of all yogurt samples decreased until 6 days of storage, and then increased for all samples. Syneresis values of all yogurt samples except for sample with 20% marmalade decreased up to 12 days then increased quickly at 18th day. The lowest syneresis value observed in sample with 20% marmalade was 37%. The reason for this fluctuation could not be explained. These results are in good agreement to the findings of Bakırcı & Kavaz (2008) for yogurt with banana and Çelik et al (2006) for yogurt with cornelian cherry. Similar results were reported by Boeneke & Aryana (2008) for yogurt with lemon.

L^* value is a measure of food whiteness. Whiteness in fluid milk results from the presence of colloidal particles, such as milk fat globules and casein micelles, capable of scattering light in the visible spectrum. Previous reports indicated that

perception of milk whiteness has the most positive influence on consumer appeal. Also, it should be mentioned that milk is a translucent food and as fermentation goes on it loses translucency (García-Pérez et al 2005). The colour characteristics of the control and marmalade added yogurts are presented in Table 3.

Both marmalade ratio and storage time affected *L** value ($P<0.01$ and $P<0.01$, respectively), *a** value ($P<0.01$ and $P<0.05$, respectively) and *b** value ($P<0.01$ and $P<0.01$, respectively) of yogurt samples. Marmalade ratio x storage time interaction did not occur in *L** value ($P>0.05$), whereas the interactions appeared in *a** value ($P<0.01$) and *b** value ($P<0.01$; Figure 4). *L** and *a** values of yogurt samples decreased with marmalade addition, whereas *b** value increased. The mean *L** value of the control yogurt samples was significantly higher than those of marmalade added samples. These results are in good agreement with the findings of García-Pérez et al (2005) for colour characteristics of the yogurt breads produced with protein concentrate and Kumar & Mishra (2004) for mango soy fortified set yogurts. The increase in marmalade ratio in yogurts caused a darker yellow colour with a higher degree of luminosity than that of the control yogurt. Accordingly, 20% marmalade added samples had the lowest *L** values. These results are consistent with the findings of Tarakçı et al (2009) on the perception of colour in various fruit-flavoured yogurts. This situation was also acceptable in the industrial production of fruit added yogurt, for which colour intensity does meet the consumer acceptance.

The mean *b** values of all yogurt samples increased up to end of storage at 18th day (Figure 4), but the highest increase was detected in control yogurt samples at the end of storage time. In the present study, the lowest *b** values were determined in control sample at 12 days of storage. Needs et al (2000) observed that *b** values of yogurt increased during storage.

Table 3- Colour values of loquat fruit marmalade added yogurt samples

Çizelge 3- Yenidünya marmeladı ilave edilmiş yoğurt örneklerinin renk değerleri

		Marmalade ratio					
	Storage time	*0%*	*5%*	*10%*	*15%*	*20%*	*Overall*
*L** value	1 day	85.34±6.30	84.61±3.01	83.54±3.51	79.79±2.41	76.16±2.28	81.89±4.61^{c}
	6 days	89.37±1.14	91.98±1.53	91.55±0.21	90.12±0.89	87.75±1.26	90.15±1.81^{a}
	12 days	90.95±0.13	90.84±1.37	88.10±0.55	86.88±0.18	85.26±0.57	88.41±2.41^{ab}
	18 days	88.79±1.18	89.32±0.31	86.43±0.84	85.43±0.82	83.33±0.82	86.66±2.41^{b}
	Overall	88.61±3.31^{A}	89.19±3.31^{A}	87.41±3.39^{AB}	85.55±4.12^{B}	83.13±4.73^{C}	
*a** value	1 day	-2.75±0.07^{abA}	-1.71±0.28^{aB}	-0.83±0.19^{bC}	-0.59±0.10^{abCD}	-0.34±0.56^{aD}	-1.24±0.93
	6 days	-2.07±0.12^{bA}	-1.58±0.53^{aAB}	-1.31±0.19^{aB}	-0.85±0.15^{aBC}	-0.37±0.11^{aC}	-1.23±0.65
	12 days	-1.96±0.26^{bA}	-1.30±0.03^{aB}	-0.78±0.02^{bC}	-0.52±0.04^{bC}	-0.20±0.05^{aD}	-0.95±0.66
	18 days	-3.17±0.50^{aC}	-1.44±0.09^{aC}	-0.69±0.12b^{BC}	-0.52±0.09^{bB}	-0.33±0.09^{aA}	-1.23 ±1.12
	Overall	-2.48±0.59	-1.51±0.28	-0.91±0.27	-0.62±0.17	-0.31±0.10	
*b** value	1 day	8.73±1.69^{bC}	12.93±0.05^{aB}	16.08±1.02^{aA}	17.17±0.53^{aA}	18.32±0.71^{bA}	14.65±3.72
	6 days	9.76±0.48^{bD}	14.63±0.31^{aC}	14.95±1.37^{aC}	17.94±1.11^{aB}	21.17±0.93^{aA}	15.69±4.06
	12 days	8.02±0.76^{bD}	14.75±0.41^{aC}	16.50±0.24^{aBC}	17.75±1.06^{aB}	20.74±0.91^{aA}	15.56±4.51
	18 days	13.57±0.48^{aD}	13.46±1.43^{aD}	16.30±0.38^{aC}	18.79±0.94^{aB}	21.90±0.41^{aA}	16.81±3.45
	Overall	10.02±2.41	13.94±1.01	15.96±0.93	17.92±0.94	20.53±1.55	

Small letters (a, b, c) indicate significant differences between means within a column. Capital letters (A, B, C) indicate significant differences between means within a row. Storage time x marmalade ratio interactions: *a** value ($P<0.01$), *b** value ($P<0.01$).

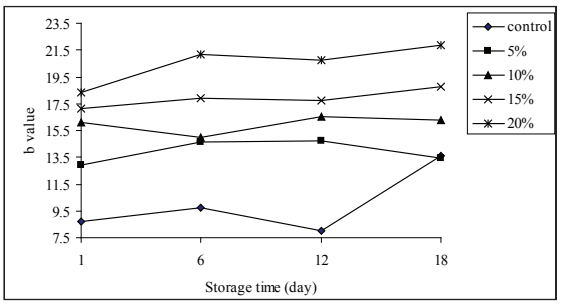

Figure 4- The time dependent variation in b* values of yogurt samples containing loquat fruit marmalade at different ratios

*Şekil 4-Farklı oranlarda yenidünya marmeladı içeren yoğurt örneklerinin b*değerlerinde zamana bağlı değişim*

3.2. Sensory properties of yogurts

Natural yogurts available in the market present at wide range of sensory properties. Consumers may not detect the same particular sensory attributes as trained assessors, and results obtained from an analytical panel are usually more precise and repeatable than those from consumers (Amaya-Llano et al 2008). Yogurt texture characterization is important for product and process development, and quality control to ensure consumer acceptability (Benezech & Maingonnat 1994). This characterization can be done using either instrumental or sensory measurements (Ares et al 2007). A food product is accepted or rejected and valued higher or lower in accordance with the impression that it produces on all the senses (Calvo et al 2001). The sensorial evaluation results of the marmalade added yogurts are presented in Table 4. Significant differences were detected between yogurt samples in terms of sensory properties. The marmalade addition to yogurt samples at different ratios affected the appearance and colour (P<0.05), body and texture (P<0.01), flavour (P<0.01) and overall acceptability

Table 4- Sensory scores of loquat fruit marmalade added yogurt samples

Çizelge 4- Yenidünya marmeladı ilave edilmiş yoğurt örneklerinin duyusal skorları

		Marmalade ratio					
	Storage time	*0%*	*5%*	*10%*	*15%*	*20%*	*Overall*
Appearance and color	1 day	4.50±0.00	4.37±0.17	4.50±0.00	4.37±0.53	4.37 ±0.53	4.42±0.26^{A}
	6 days	4.37±0.17	3.75±0.00	4.25±0.35	4.50±0.35	4.12 ±0.17	4.20±0.33^{AB}
	12 days	4.25±0.00	4.00±0.00	4.12±0.53	4.25±0.00	4.00 ±0.35	4.12±0.24^{B}
	18 days	4.25±0.00	3.37±0.17	4.12±0.17	4.00±0.35	4.25 ±0.00	4.00±0.37^{B}
	Overall	4.34±0. 13^{a}	3.87±0. 40^{b}	4.25±0.30^{a}	4.28±0.34^{a}	4.19±0. 30^{a}	
Body and texture	1 day	4.50±0.35	4.25±0.35	4.37±0.53	3.75±0.35	3.62 ±0.17	4.10±0.46
	6 days	4.37±0.17	3.87±0.53	4.37±0.17	4.37±0.17	3.50 ±0.00	4.10±0.43
	12 days	4.62±0.17	4.12±0.17	4.25±0.00	4.12±0.17	3.62±0.53	4.15±0.39
	18 days	4.37±0.17	4.25±0.35	4.12±0.17	4.12±0.53	3.37±0.17	4.05±0.44
	Overall	4.46±0.21^{a}	4.12±0.54 ^{b}	4.28±0.25^{ab}	4.09±0.35^{b}	3.53±0.24^{c}	
Flavour	1 day	4.50±0.00	3.87±0.14	4.25±0.35	4.50±0.00	4.12±0.53	4.25±0.33
	6 days	4.50±0.00	3.50±0.00	4.24±0.00	4.25±0.00	4.50±0.35	4.20±0.40
	12 days	4.37±0.17	3.87±0.17	3.75±0.35	4.12±0.17	4.37±0.17	4.10±0.31
	18 days	4.37±0.17	4.50±0.00	4.25±0.00	4.25±0.00	4.00±0.00	4.27±0.18
	Overall	4.43±0.11^{a}	3.93±0.39^{c}	4.12±0.29^{bc}	4.28±0.16^{ab}	4.25±0.32^{ab}	
Overall acceptability	1 day	13.50±0.35	12.49±0.34	13.12±0.88	12.62±0.17	12.12±0.17	12.77±0.61
	6 days	13.25±0.35	11.12±0.53	12.87±0.17	13.12±0.53	12.12±0.53	12.50±0.89
	12 days	13.25±0.00	12.00±0.00	12.12±0.88	12.50±0.35	12.00±1.06	12.37±0.68
	18 days	13.00±0.35	12.12±0.17	12.50±0.00	12.35±0.88	11.62±0.17	12.32±0.58
	Overall	13.25±0.29^{a}	11.93±0.59^{c}	12.65±0.65^{b}	12.65±0.51^{b}	11.96±0.50^{c}	

Capital letters (A, B, C) indicate significant differences between means within last column.
Small letters (a, b, c) indicate significant differences between means within a row.

(P<0.01) scores. However, storage time did not affect these scores (P>0.05) except for appearance and colour (P<0.05). No significant interactions between marmalade concentration and storage time were detected in sensory properties (P>0.05). The lowest overall acceptability scores were detected in 5% and 20% marmalade-added yogurt samples, while the higher overall acceptability scores were detected in 10% and 15% marmalade-added yogurt samples. Appearance and colour score decreased consistently up to the end of storage time (Table 4). Our results demonstrated that the addition of 10% and 15% loquat fruit marmalade would be recommended in the production of fruit marmalade yogurt.

4. Conclusions

Effects of loquat marmalade addition at different ratios on physico-chemical and sensory properties of yogurts were investigated. Yogurts had different properties depending on marmalade ratio and storage time. During storage, pH and viscosity of yogurts decreased, but the titratable acidity, L^* and b^* values increased, while sensory evaluations showed that, body and texture, flavour and overall acceptability scores were not affected significantly by storage time. In the sensory evaluations, yogurts containing 10% and 15% marmalade were preferred by panellists more than the other marmalade added samples. The results revealed that loquat marmalade can be used in manufacture of yogurt to increase consumption. Nevertheless, further investigations are inevitable to obtain the best physico-chemical and sensory properties of the final product. In particular, the effect of different stabilizing agents should be investigated for fruit-flavoured yogurts.

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