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RESEARCH ARTICLE

Influence of Kiwi Marmalade on the Rheology Characteristics, Color Values and Sensorial Acceptability of Fruit Yogurt

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Summary

The effect of Kiwi marmalade on some chemical characteristics, viscosity, syneresis, and L*, a* and b* colour values and sensorial properties of yogurt were examined at a seven-day interval for 21 days. Significant differences were found between the control and flavoured yogurts with respect to syneresis and viscosity characteristics (P<0.05). The increasing amount of marmalade in yogurt resulted in a decrease in syneresis and L*, b* values of yogurt colour. However, increasing marmalade increased significantly (P<0.05) the values for a* colour, total solid, titratable acidity and viscosity. During the storage pH, syneresis and viscosity values of the yogurts decreased continuously (P<0.05). In conclusion, yogurts containing Kiwi marmalade were found to be acceptable with respect to overall acceptability.

Keywords: *Yogurt, Kiwi, Syneresis, Viscosity, Color, Sensorial properties*

Meyveli Yoğurdun Reolojik Karakterleri, Renk Değerleri ve Duyusal Kabul Edilebilirlik Özellikleri Üzerine Kivi Marmeladının Etkisi

Özet

Yoğurdun viskozite, serum ayrılması, L*, a* ve b* renk değerleri ve duyusal özellikleri üzerine Kivi marmeladı ilavesinin etkisi 7'şer gün arayla 21 gün boyunca analiz edilmiştir. Kontrol ve katkılı yoğurtların serum ayrılması ve viskozite karakterleri açısından istatistiksel olarak önemli farklılıklar gösterdiği belirlenmiştir (P<0.05). Yoğurtta marmelat oranının artışı serum ayrılmasını ve L*, b* renk değerlerini düşürürken, a* değerini, toplam kuru madde, titrasyon asitliği ve viskozite değerlerini önemli derecede (P<0.05) artırmıştır. Depolama süresi boyunca yoğurtların pH, serum ayrılması ve viskozite değerleri sürekli olarak düşüş göstermiştir (P<0.05). Sonuç olarak, kivi marmeladı ilaveli yoğurtların genel kabul edilebilirlik değerleri yüksek bulunmuştur.

Anahtar sözcükler: *Yoğurt, Kivi, Serum ayrılması, Viskozite, Renk, Duyusal özellik*

INTRODUCTION

According to the FAO/WHO Standards, yogurt is a coagulated milk product obtained by lactic acid fermentation through the action of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus* [1,2]. The use of yogurt dates back to many centuries, although there is no accurate record of the date when it was first made. According to the legend, yogurt was first made by the ancient Turkish people in Asia. Yogurt is one of the most unique dairy product, and a functional one [3]. The uniqueness of yogurt is attributable to the symbiotic fermentation involved in its production process [4]. 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 flavours, which are in regular demand, are surprisingly few in number [5]. Fruit-flavoured yogurts are produced by adding fruit concentrates or flavoured syrups to the cultured milk after or before the incubation process, therefore added flavour ingredients generally tend to decrease the product consistency [6]. On the other hand, it leads to an increase in its nutritional value and product variability in markets. Kiwi fruit was first introduced to Turkey in 1988. The production of this fruit is, in fact, continuously and

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rapidly increasing, and it was estimated at about 4.000 tons in 2006 [7]. In Turkey, the production and consumption of fruit-flavoured yogurt is lower compared with plain yogurt, but the mixture is widely made and consumed at home in most regions especially during the winter months. The objectives of this study are to develop flavoured yogurts by addition of Kiwi marmalade and to determine the effects of that addition on some of the qualities of the final product.

MATERIAL and METHODS

Cow's milk (3.1% fat) was supplied from a dairy farm in Ordu, Turkey. The Kiwi fruit was selected from a Kiwi producer in Ordu, and it was marmalade in the laboratory. The total solid content of the kiwi pulp was 16.57% and the pH was about 3.20. Non-fat milk powder (NFMP) was provided by Pinar Dairy Product Company Izmir, Turkey. The corn starch obtained Sakarya Gunes Company, Turkey. Commercial freeze-dried starter culture used in the production of yogurt (Y-080 F, a blend of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrucckii* subsp. *bulgaricus*) was provided by Sacco, Cadorago, Italy.

Kiwi marmalade and Yogurt Production

Kiwi fruit was washed after the fruit skin was removed manually and then the pulp was obtained from the crushed fruit. The 70% ratio fruit pulp ± 28% ratio sugar; with 2% corn starch was mixed and pasteurized at 95±1°C for 5 min, and filled into cleaned glass jars. The marmalade was stored at room temperature until used in yogurt production. The NFMP (20 g/L) was added to the yogurt milk after filtration and milk was heated at 95°C for 10 min and then cooled to 45°C. Commercial freeze-dried yogurt starter culture was reactivated by inoculation in sterilized reconstituted milk and then cooled to 44±1°C. Then, milk was inoculated with 2% (w/w) activated yogurt cultures and incubated at 43±1°C for 3.5 h and stored for 12 h at 4±1°C. The obtained yogurt was separated within five batches. One batch of yogurt was taken as control (CY) and the remaining batches were mixed to Kiwi marmalade at different rates as 5.0% (K1), 10.0% (K2), 15.0% (K3) and 20.0% (K4). All experimental yogurts were divided into parts of approximately 250 g and stored at 4°C for 21 days for further analysis.

Colour characteristics

The color of yogurt samples was measured using the CIELAB system with a colorimeter (Minolta CR 300, 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 color. The yogurt with berries was put into an optically flat glass dish for measurements. Five readings were taken from each group of yogurt samples. L* (lightness; 100=white, 0=black), a* (redness; ±, red; -, green), and b* (yellowness; ±, yellow; -, blue) values were recorded.

Analytical methods

Total solids and ash contents of the experimental yogurts were determined by the gravimetric method, fat content by Gerber method and non-fat dry matter (NDM) content of yogurts were determined according to Case et al.[8]. A combined glass electrode was used for the pH measurements (Hanna, Italy). The titratable acidity was determined as lactic acid percentage (LA %) by titrating with 0.1 N NaOH, using phenolphthalein as an indicator. In the determination of syneresis, 5 ml of yogurt was centrifuged at 5000 rpm for 20 min at 4°C, and the separated whey was measured after 1 min. The syneresis rate (%) was expressed as volume of separated whey per 100 ml of yogurt [9]. Viscosity measurements were taken at 14.4°C with a Brookfield viscometer (Model DV-1±; Brookfield Engineering Laboratories, Inc., MA). The viscometer was operated at 30 rpm (spindle number 4). Each result was recorded in cP s after 20 s rotation. The samples were stirred for 40 seconds before measurement.

Sensorial characteristics

The experimental yogurt samples coded with random numbers were placed on white plates and presented together to the panel members in daylight, who 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 sample was noted separately. The qualities judged were: exterior appearance (by looking to yogurt sample in daylight directly), consistency by spoon (by gentle mixing yogurt with a spoon) and by mouth, odour and taste intensity, perceived fruit. To determine consistency by mouth, odour and taste intensity, perceived fruit and sweetness, a spoon of yogurt is taken and spreaded out by tongue. The overall acceptability was calculated as sum of the scores of the parameters judged [10]. The yogurts were evaluated on 1st, 7th, 14th, and 21st days of storing by eight panellists familiar with yogurt. Water was provided for mouth washing between samples.

Statistical analyses of the data for the effects of Kiwi marmalade on physicochemical and sensory properties of yogurt were analyzed by ANOVA procedures using SAS [11] statistical software. The differences among means were compared by the Duncan's multiple range tests.

RESULTS

Table 1 shows the total solid, fat, ash and nonfat dry matter (NFDM) contents of the plane and Kiwi marmalade yogurt samples. Total solid and NFDM contents of the yogurts with marmalade were significantly higher than those of the control yogurt (P<0.05).

and the changes were shown in *Fig. 2*. The differences between the control and the flavoured yogurt samples were found to be statistically (P<0.05) significant.

The syneresis values of yogurts were affected significantly (P<0.05) by both marmalade concentration and storage time and the changes were shown in *Fig. 3*. The highest mean value (46.87 mL/100 g) of syneresis was recorded in sample

Table 1. *The mean values of some chemical properties (%) of yogurts*
Tablo 1. *Yoğurtların bazı kimyasal özelliklerinin (%) ortalama değerleri*

Yogurts	Total solid (%)	Fat (%)	Ash (%)	NFDM (%)
Control (no marmalade)	13.56±0.41 ^{e}	3.00±0.14 ^{a}	0.92±0.03 ^{a}	10.56±0.27 ^{e}
K1 (5% marmalade)	14.94±0.07 ^{d}	2.85±0.07 ^{ab}	0.90±0.01 ^{ab}	12.09±0.01 ^{d}
K2 (10% marmalade)	17.34±0.12 ^{c}	2.75±0.07 ^{bc}	0.86±0.01 ^{b}	14.59±0.05 ^{c}
K3 (15% marmalade)	18.88±0.16 ^{b}	2.65±0.07 ^{bc}	0.86±0.02 ^{b}	16.23±0.09 ^{b}
K4 (20% marmalade)	21.02±0.37 ^{a}	2.55±0.07 ^{c}	0.87±0.02 ^{ab}	18.47±0.44 ^{a}

CY, *Control yogurt,* ***K1, K2, K3*** *and* ***K4*** *yogurts added Kiwi marmalade at ratios of 5, 10, 15, and 20 %, respectively* ^{abcde} *Letters indicate significant differences among yogurts, P<0.05*

Fig. 1 shows titratable acidity of yogurts during storage time. There were significant differences (P<0.05) in titratable acidity between the control yogurt and the yogurts made with Kiwi marmalade. In general, the pH values of all yogurt samples decreased during storage

CY (control) and the lowest mean value (43.12 mL/100 g) in sample K4. As seen in *Fig. 3*, the addition of marmalade caused a decrease of syneresis values in all samples of flavoured yogurts and the differences between the control and these samples were statistically significant (P<0.05).

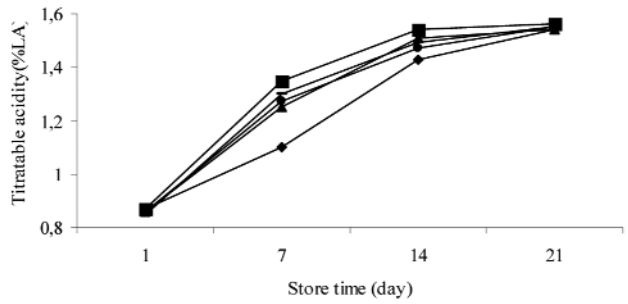

Fig 1. Effect of marmalade concentrations on titratable acidity of yogurts, ♦**:** CY control and ●**:** K1 5%, ▲ K2: 10%, ▬ K3: 15% and ■ K4: 20% marmalade, respectively

Şekil 1. Yoğurtların titrasyon asitliği üzerine marmelat konsantrasyonlarının etkisi, ♦**:** CY kontrol ve sırasıyla ●**:** K1 %5, ▲ K2: %10, ▬ K3: %15 ve ■ K4: %20 marmelatlı

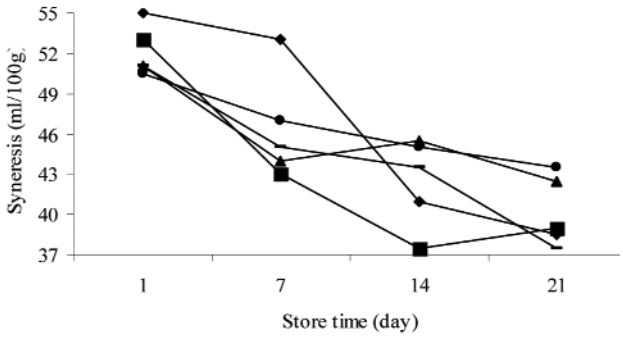

Fig 3. Effect of marmalade concentrations on syneresis values of yogurts

Şekil 3. Yoğurtların serum ayrılması değerlerine marmelat konsantrasyonlarının etkisi

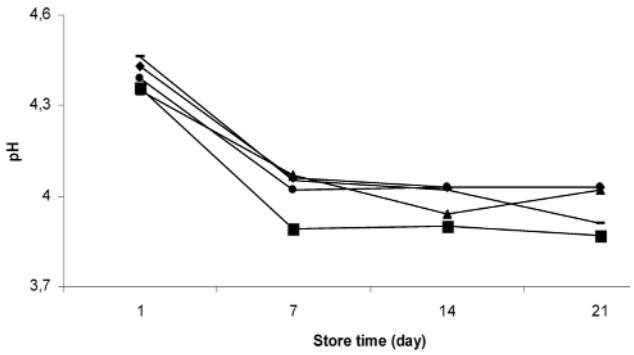

Fig 2. Effect of marmalade concentrations on pH acidity of yogurts

Şekil 2. Yoğurtların pH asitliği üzerine marmelat konsantrasyonlarının etkisi

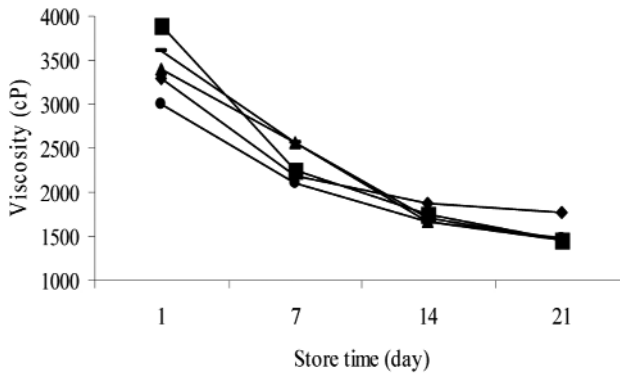

Fig 4. Effect of marmalade concentrations on viscosity values of yogurts

Şekil 4. Yoğurtların viskozite değerlerine marmelat konsantrasyonlarının etkisi

The viscosities of the yogurts were influenced by the marmalade rates and the changes were shown *Fig 4*. The viscosity of yogurt was affected significantly (P<0.05) by both marmalade concentration and storage time. The viscosity of the control and flavored yogurt decreased rapidly up to the 14th day, and then remained constant during storage.

The colour characteristics of the yogurts were shown in *Table 2*. Although the L* (whiteness) and a* (greenness) colour values of yogurts decreased by marmalade addition, b* (yellowness/blueness) values significantly increased (P<0.05). The K4 yogurt showed the lowest values in L* and a* color. Increasing marmalade ratios in yogurts had a darker yellow color with a higher degree of luminosity

Table 2. *Effect of kiwi marmalade concentrations on color values of yogurt*
Tablo 2. *Yoğurdun renk değerleri üzerine kivi marmeladı konsantrasyonlarının etkisi*

Properties	Yogurt	Storage time (day)				Y x̄
		1	7	14	21	
L value	CY	87.55±3.23	91.11±1.05	91.60±0.62	89.21±1.81	89.87 ^{a}
	K1	89.40±0.35	92.00±1.51	92.76±1.34	89.19±0.38	90.83 ^{a}
	K2	87.19±2.41	91.05±0.91	91.27±1.14	87.77±0.34	89.32 ^{a}
	K3	84.06±1.81	89.27±1.70	89.52±1.32	88.13±0.45	87.75 ^{b}
	K4	84.37±0.45	87.74±1.27	90.22±2.17	86.38±1.06	87.18 ^{b}
	ST X̄	86.51 ^{C}	90.23 ^{A}	91.07 ^{A}	88.13 ^{B}	
a value	CY	-2.16±0.42	-2.98±0.16	-2.75±0.17	-2.90±0.19	-2.69 ^{d}
	K1	-3.08±0.07	-3.09±0.02	-2.97±0.15	-2.93±0.10	-3.01 ^{c}
	K2	-3.12±0.02	-3.22±0.02	-3.20±0.12	-3.25±0.06	-3.19 ^{b}
	K3	-3.36±0.10	-3.41±0.06	-3.31±0.02	-3.24±0.09	-3.32 ^{ab}
	K4	-3.60±0.15	-3.48±0.09	-3.38±0.06	-3.31±0.05	-3.44 ^{a}
	ST X̄	-3.06 ^{B}	-3.23 ^{A}	-3.13 ^{AB}	-3.12 ^{AB}	
b value	CY	9.29±0.23	10.76±0.18	10.16±0.96	13.02±1.18	10.81 ^{c}
	K1	11.03±0.19	10.97±0.07	11.69±0.32	10.81±0.84	11.12 ^{c}
	K2	11.44±0.07	11.91±0.77	12.62±0.48	11.25±0.24	11.80 ^{b}
	K3	12.17±0.39	12.97±0.15	13.83±0.64	13.14±0.39	13.02 ^{a}
	K4	12.67±0.06	13.17±0.96	14.07±1.11	13.59±0.23	13.37 ^{a}
	ST X̄	11.32 ^{B}	11.95 ^{A}	12.47 ^{A}	12.36 ^{A}	

CY, *Control yogurt,* ***K1, K2, K3*** *and* ***K4*** *yogurts added Kiwi marmalade at ratios of 5, 10, 15, and 20 %, respectively*
^{abcd} *Letters indicate significant differences among yogurts (YX̄), P<0.05,* ^{ABC} *Letters indicate significant differences among storage times (STX̄), P<0.05*

Table 3. *Effect of kiwi marmalade concentrations on sensory properties of yogurt*
Tablo 3. *Yoğurdun duyusal özellikleri üzerine kivi marmeladı konsantrasyonlarının etkisi*

Properties	Yogurt	Storage time (day)				Y x̄
		1	7	14	21	
Appearance and color	CY	4.37±0.52	4.37±0.52	4.37±0.51	4.12±0.64	4.31 ^{a}
	K1	4.12±0.64	3.87±0.64	3.87±0.64	3.75±0.89	3.91 ^{b}
	K2	4.37±0.51	4.00±0.76	3.87±0.83	4.12±0.64	4.09 ^{ab}
	K3	4.25±0.71	4.00±0.92	4.12±0.83	3.75±0.71	4.03 ^{ab}
	K4	4.12±0.83	4.25±0.71	4.25±0.71	4.12±0.64	4.19 ^{ab}
	ST X̄	4.25 ^{A}	4.10 ^{A}	4.12 ^{A}	3.97 ^{A}	
Body and texture	CY	4.25±0.71	4.25±0.70	4.50±0.53	4.00±0.75	4.25 ^{a}
	K1	4.00±0.76	3.62±0.74	3.87±0.83	3.75±0.71	3.81 ^{b}
	K2	4.00±0.75	3.62±0.74	4.00±0.75	3.62±0.52	3.81 ^{b}
	K3	4.12±0.83	4.25±0.71	4.00±0.75	4.12±0.64	4.12 ^{ab}
	K4	3.62±0.74	3.87±0.83	4.00±0.76	4.25±0.70	3.94 ^{ab}
	ST X̄	4.00 ^{A}	3.92 ^{A}	4.07 ^{A}	3.95 ^{A}	
Flavor	CY	4.25±0.70	4.12±0.83	3.75±0.70	4.37±0.74	4.12 ^{a}
	K1	4.12±0.83	4.25±0.88	3.62±0.91	4.00±0.53	4.00 ^{a}
	K2	3.75±0.88	4.37±0.74	4.12±0.64	4.00±0.53	4.06 ^{a}
	K3	4.12±0.83	4.62±0.51	4.00±0.75	4.00±0.75	4.18 ^{a}
	K4	4.12±0.83	4.62±0.51	3.75±0.46	4.12±0.64	4.15 ^{a}
	ST X̄	4.07 ^{AB}	4.40 ^{A}	3.85 ^{B}	4.10 ^{AB}	
Overall acceptable scores	CY	12.87±2.02	12.74±1.86	12.62±1.75	12.49±1.97	12.68 ^{a}
	K1	12.24±2.07	11.74±2.26	11.36±2.34	11.51±2.09	11.71 ^{b}
	K2	12.12±1.97	11.99±2.20	12.00±2.20	11.74±1.58	11.96 ^{b}
	K3	12.49±2.34	12.87±1.97	12.12±2.25	11.87±2.25	12.34 ^{a}
	K4	11.86±2.07	12.74±2.00	12.00±1.97	12.49±1.97	12.27 ^{a}
	ST X̄	12.32 ^{A}	12.41 ^{A}	12.02 ^{B}	12.02 ^{B}	

^{AB} *Letters indicate significant differences among yogurts (YX̄), P<0.05,* ^{ab} *Letters indicate significant differences among storage times (STX̄), P<0.05*

than that of the control yogurt.

The mean values obtained from sensorial evaluation carried out at seven intervals for the 21st day were summarized in *Table 3*. The addition of marmalade to yogurt in different proportions significantly affected (P<0.05) the scores for appearance and colour, body and texture and acceptable fruit level, whereas a significant effect (P>0.05) was not observed for flavour intensity and overall acceptability by the addition of Kiwi marmalade.

DISCUSSION

Compositional properties of the experimental yogurts

The highest total solid (21.02%) was observed in the K4 yogurt with 20.0% marmalade, while the lowest value was obtained in control sample without marmalade (P<0.05). The average fat content of the yogurts was between 2.55% and 3.00%. The mean fat content of the stirred yogurts was similar to that found by Tarakci and Kucukoner [12], Rahman et al.[13] and Cinbas and Yazici [14], but lower than that reported by Yazici and Akgun [15]. The increasing marmalade rate in yogurts decreased fat and ash contents significantly (P<0.05). Considering the content of total solids of milk, the amount of marmalade and NFMP added these results were expected.

Titratable acidity and pH properties of the experimental yogurts

The lowest mean value of titratable acidity was found at the 1st day of storage, as the highest value was found at the 21st day of storage. In the range of 0.86-1.55%, for the 1st day of storage, sample CY (control yogurt) had the lowest mean value, for the 21st day of storage and the sample K4 had the highest mean value of titratable acidity. Some authors reported similar results [5,12]. This might be due to the acid production in the experimental yogurts during storage as a result of the fermentation of lactose by the action of the starter cultures [16]. In general, the pH values of all samples decreased during storage and these differences were found to be significant (P<0.05). This can be explained by further metabolic activities of starter cultures during storage [17]. When pH decreased, aroma and acidic taste increased as a result of decreased flavouring characteristics. Laye et al.[18] reported lower titratable acidity values than ours and similar results were reported by Isleten and Karagul-Yuceer [19] for non-fat yogurt.

Syneresis and viscosity properties of the yogurts

The mean value of syneresis obtained after 1 day of storage was significantly highest than those of yogurts examined after 7, 14 and 21 days of storage. Lower viscosity and higher syneresis were characteristic for fruit marmalade yogurts. Similar results were reported for fruit-flavored yogurt containing rosehip marmalade and date pulp [12] and for yogurt prepared with banana pure and sugar combinations [16]. This result was similar to that reported by Kucukcetin [20], indicating that the levels of syneresis decreased as the final fermentation pH decreased. The viscosity values of the control and flavoured yogurts decreased rapidly up to the 7th day, and then remained constant until to the end of storage (P<0.05). Similar viscosity pattern of yogurt with cornelian cherry marmalade during storage was reported by Celik et al.[21]. On the other hand, the viscosities of the flavoured yogurts were influenced by the marmalade addition rates. The increasing marmalade rate in yogurts increased the mean viscosity values and this was also found to be concentration-dependent (P<0.05).

Colour measurements of the experimental yogurts

When a food product is evaluated for consumption, all the senses have an important part. A food product is accepted or rejected and valued higher or lower in accordance with the impression that it produces on all the senses [22]. The difference in the colour between the CY yogurt and the K1, K2, K3 and K4 yogurts increased with the increase in the level of Kiwi marmalade in the samples (P<0.05). The K4 yogurt added 20.0% marmalade showed the greatest difference in colour. The increasing fruit ratios in yogurts had a darker yellow colour with a higher degree of luminosity than that of control yogurt. These results are in good agreement with the findings of Calvo et al.[22] for fruit-flavoured yogurts.

Sensory evaluations of the experimental yogurts

Differences among treatments for smell, taste, and perceived sweetness were non-significant. It was also observed that the storage time affected differently each panellists in all sensory parameters evaluated. Yogurt texture characterization is important for product and process development, quality control and to ensure consumer acceptability. This characterization can be done using either instrumental or sensory measurements [23]. The overall acceptable scores of the yogurts containing 15% and 20% marmalade were found to be generally higher than that the other types of flavoured yogurts. In the production of Kiwi marmalade yogurt, the additions of 15.0% (K3) and 20.0% (K4) fruit marmalade could be recommended.

There were significant differences in physical, chemical and sensory properties of Kiwi marmalade added yogurts compare to the control. The values of

viscosity, syneresis, titratable acidity, pH and sensory scores of yogurt were significantly affected by the additional marmalade rate. The addition of Kiwi marmalade to the yogurts lead to a remarkable decrease of the syneresis, L* and b* values.

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