

## Effect of Pekmez Addition on the Physical, Chemical, and Sensory Properties of Ice Cream

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### Abstract

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The effects of pekmez concentrates (0, 2.5, 5.0, 7.5 and 10.0%) on the physical, chemical, and sensory properties of ice cream samples were examined. The addition of pekmez to ice cream formula positively affected total solid (TS), total sugar, invert sugar, Saccharose, titratable acidity, ash, and melting, while protein, pH, overrun, and viscosity were negatively influenced. Hunter  $a^*$  and  $b^*$  values were positively influenced while Hunter  $L^*$  values were negatively affected by the treatment. Total acceptability scores of the samples showed variable results with the addition of pekmez while the highest scores were obtained with 7.5% addition of both mulberry and grape pekmez.

**Keywords:** ice cream; mulberry pekmez; grape pekmez

The ice cream production has increased rapidly in recent years in many countries of the world. The products related to ice cream have also become important in the ice cream industry. The ingredients and processing steps required to produce good ice cream are well known and are employed worldwide (SEGALL & GOFF 2002; GRANGER *et al.* 2005). The trend towards natural products with emphasis on quality has in general led to an increase in the development of new products.

Ice cream can be considered as an aerated suspension of crystallised fat and water in a highly concentrated sugar solution containing hydrocolloids, casein micelles, and proteins (KÖXHOLT *et al.* 2001; EISNER *et al.* 2005). The texture of the ice cream depends on many factors such as the state of aggregation of the fat globules, the amount of air, the size of the air cells, the viscosity of the aqueous phase, and the size and state of aggregation of ice crystals (BOLLIGER *et al.* 2000;

AIME *et al.* 2001; CAILLET *et al.* 2003; GRANGER *et al.* 2005). The energy value and nutrients of ice cream depend upon the food value of the products from which it is made. Ice cream also contains high levels of milk fat, i.e. 10–16%. Therefore, it is a source of high quality protein and energy. Ice cream may also contain other food products such as fruit, which enhances its nutritive value. Consequently, ice-cream plays an important role of actual food which, besides its digestive and metabolic qualities, has nutritive qualities, but can also influence the mind because of its organoleptic characteristics and its importance as thermoregulatory food in the fight against heat (DEL GIOVINE & PICCIOLI 2003).

Several studies of pediatrics recognise that ice cream plays a fundamental role in children's diets, who consume great amounts of it. But the presence of additives, particularly of dyes, can introduce a risk factor. Therefore the use of natural additives

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to ice cream has an important role (DEL GIOVINE & PICCIOLI 2003).

Pekmez is a traditional Turkish food widely produced from grape or raisin, mulberry, fig, and corn bean (ŞİMŞEK *et al.* 2004). Since pekmez contains high amounts of sugar, minerals, and organic acids, it is an important food product in human nutrition (YOĞURTÇU & KAMIŞLI 2006). Pekmez is easily assimilated because it mostly consists of carbohydrate (80%) in the form of monosaccharides like glucose and fructose. Furthermore, pekmez supplies approximately 1226 kJ/100 g of energy and also contains important organic acids and mineral matters (AKSU & NAS 1996; USTÜN & TOSUN 1997). This is nutritionally important, especially for babies, children, and sportsmen, as well as in situations demanding urgent energy supply (ŞENGÜL *et al.* 2005).

Although pekmez is produced from various fruits with a high sugar content such as mulberry, plum, apple, and grape, in recent years mulberry and grape pekmez have become increasingly more popular because of their functional properties (KAYA & BELİBAĞLI 2002). While mulberry and grape contain high amounts of calcium, iron, and vitamins B<sub>1</sub>, B<sub>2</sub>, and C (USTÜN & TOSUN 1997), grape contains valuable minerals such as calcium (840–866 ppm) and iron (50–100 ppm). The high iron content makes it a recommended treat for anemia (ARSLAN *et al.* 2005).

Pekmez is usually blended to obtain the desired sweetness and colour and to control the freezing point of ice cream. There are many studies on flavoured ice cream (DERVIŞOĞLU *et al.* 2005; FOREST *et al.* 2005; WILDMOSER *et al.* 2005; ISHII *et al.* 2007). But, to the best of our knowledge, there are no reports on the use of fruit pekmez for ice cream manufacturing. Therefore, the objective of this study was to investigate some physical, chemical, and sensory properties of ice cream with the addition different doses of fruit pekmez.

## MATERIALS AND METHODS

**Materials.** Non fat dry milk (NFDM) (pH 6.02, TS 96%, fat 0.1%, nitrogen 2.92%, and ash 7.78%) was obtained from Ova Company (Konya, Turkey). Cream (pH 6.30, total solid 62%, fat 60%) was obtained from Takışoglu Company (Samsun, Turkey). Cremodan DC-T was obtained from Danisco (Copenhagen K, Denmark). Admul MG 44-04K

was obtained from Kerry Ingredients (Johor, Malaysia). Saccharose was obtained from a local market, mulberry and grape pekmez were obtained from Koska (Istanbul, Turkey). Ice cream was made in the Pilot Plant of Food Engineering Department, Faculty of Engineering, Ondokuz Mayıs University.

**Manufacture of ice cream.** The formulas of ice cream mixtures were determined based on preliminary tests and the mixtures were prepared as given below. For the mixtures compositions were used 10% saccharose, 10% fat, and 1% stabiliser/emulsifier (Cremodan DC-T as stabiliser and Admul MG 44-04K as emulsifier). The compositions of mulberry and grape pekmez added to the mixtures are given in Table 1. NFDM (118.1 g) with 100 g saccharose and water (1328.8 g) were mixed at 40°C. The remaining saccharose (100 g) was mixed with Cremodan DC-T, Admul MG 44-04K (20 g) in a glass container with constant stirring and was then added to the mixture. Cream (333.2 g) was added to the mixture at 50°C before pasteurisation. The ice cream mixtures were then pasteurised at 80°C for 30 min, cooled to 4°C, and stored at 4°C for 16 h (EISNER *et al.* 2005). The mixture was divided into nine batches. For each sample, a 2 kg batch of ice cream mixture was prepared. The first batch was used as a control, and the other batches were supplemented with different levels of pekmez whose compositions are presented in Table 1. 2.5% mulberry pekmez (50 g) for the sec-

Table 1. The chemical and physical characteristics of mulberry and grape pekmez

Parameters	Mulberry	Grape
Total dry matter (%)	74.70	73.80
Soluble dry matter (%)	72.55	72.25
Titrateable acidity (g/100 g)	0.57	0.49
pH	5.12	5.23
Protein (%)	2.20	2.15
Ash (%)	2.13	1.75
Total sugar (%)	59.20	61.15
Invert sugar (%)	51.96	54.15
Saccharose (g/100 g)	4.50	4.15
Color		
L*	28.88	32.23
a*	+9.92	+14.66
b*	+6.79	+22.33

ond batch, 5.0% mulberry pekmez (100 g) for the third batch, 7.5% mulberry pekmez (150 g) for the fourth batch, 10.0% mulberry pekmez (200 g) for the fifth batch were used. The other batches were prepared using grape pekmez instead of mulberry pekmez in the same proportions, respectively. Ice cream premixtures were frozen in a bench-top ice cream maker (Ugurmatik Type, 5L, Nazilli, Turkey) for 5 min at the outlet temperature  $-5^{\circ}\text{C}$ . The ice creams were filled into 80 g cups and hardened at  $-30^{\circ}\text{C}$  for 24 h, then stored at  $-18^{\circ}\text{C}$  for physical, chemical, and sensory analysis.

**Chemical and physical properties.** The ice cream samples were analysed in triplicates. Total solid content was determined according to the method 16.313 of the AOAC (1984). The fat content and overrun were determined according to the method of TS 4265 (ANONYMOUS 1984). Proteins and ash were determined by the method of KURT (1990). The titratable acidity was determined using 0.1N NaOH and phenolphthalein (ARBUCKLE 1986). The pH of the ice cream samples was determined using an inoLab-pH meter (inoLab<sup>®</sup>, Weilheim, Germany). Saccharose, invert, and total sucrose were determined according to CEMEROĞLU (1992).

Viscosity measurements of the molten ice cream were taken at  $10^{\circ}\text{C}$  with a Brookfield viscometer (Model DV-1+; Brookfield Engineering Laboratories, Inc., Middleboro, USA). The viscometer was operated at 30 rpm (spindle number 4). Each result in triplicate was recorded in cP after 30 s rotation (AKBULUT & ÇOKLAR 2008).

Melt-down rates of the ice cream samples were measured in a controlled temperature chamber ( $23 \pm 2^{\circ}\text{C}$ ). The ice cream samples were stored at  $-25^{\circ}\text{C}$  before carrying out the melting test. For melt-down rate, 75 g of ice cream were placed on a stainless-steel screen (mesh size 2.5 mm) under which a measuring cylinder was put for the melted ice cream collection. The timing of the melt-down rate began when the first drop of the melt (after 19–23 s) touched the bottom of the cylinder. The weight of the material passing through the screen was recorded every 15 min for 75 min (BOLLIGER *et al.* 2000).

For colour analysis, the instrument was calibrated using a white reference tile before the colour measurement. The ice cream samples were analysed by measuring Hunter  $L^*$  (brightness: 100 – white, 0 – black),  $a^*$  (+ red; – green) and  $b^*$  (+ yellow; – blue) parameters with a colorimeter (Model CR 300, Chromometer, Minolta, Japan).

The air cell and ice crystals measurements were performed using a modification of the method of CAILLET *et al.* (2003). The ice cream cups were firstly stored at  $-25^{\circ}\text{C}$ . The frozen ice cream cubic samples (1–2 cm diameter) were immersed in liquid nitrogen to solidify completely the fat components. A thin slice of ice cream was cut with a razor and the sample was placed carefully onto a microscope slide. As the temperature partially increased (approximately  $-6^{\circ}\text{C}$ ), the ice cream partially melted and became more fluid, which allowed the observation of the air bubbles formed from the air cells within the frozen ice cream. It was then monitored with a stereomicroscope (Nikon Eclipse E 200, with diascopic lighting) and a video camera (JVC Color Video camera TK-C601) and the images were collected on a personal computer at 15 s time intervals (CHANG & HARKEL 2002a). During the air bubble size measurement, 1 mm stage (optical) micrometer was placed on the microscope with the same magnificence for the image acquisition. The image of this stage micrometer was used as the calibration ruler for air cell sizing.

**Sensory analysis.** The ice cream samples were organoleptically examined by 7–12 semi-trained panelists from the Department of Food Engineering at the Ondokuz Mayıs University in Turkey. The ice cream samples were evaluated according to the method modified by BODYFELT *et al.* (1988) with maximum scores of 10 for flavour, of 5 for body and texture, and of 5 for appearance. Total score of flavour, body and texture, and appearance was defined as total acceptability. The samples stored at  $-18^{\circ}\text{C}$  were tempered at room temperature for 10 min prior to sensory testing.

**Statistical analysis.** The data obtained from three replicates were analysed by ANOVA using the SPSS statistical package program, and the differences between the means were compared using the Duncan's Multiple Range test at the significance level of 0.05.

## RESULTS AND DISCUSSION

The ice cream samples were produced by the conventional process with and without pekmez additions to provide extremes of the product quality. The effects of mulberry and grape pekmez on the chemical properties of the ice cream samples are shown in Table 2. The addition of pekmez

significantly affected the contents/values of total solid (TS), fat, protein, total sugar, invert sugar, saccharose, pH, titratable acidity (TA), and ash of the ice cream samples ( $P < 0.05$ ). Mulberry and grape pekmez increased total solids (36.69% and 36.80%, respectively) compared to the control sample (31.20%). The increase in the pekmez proportion had a positive effect on the total solid values of all samples. These results were predictable due to the composition of pekmez and the amounts used. The increase in total solids was reflected by the corresponding increase in invert sugar, total sugar, and saccharose. The fat-content-lowering effect of pekmez was less pronounced up to 5% pekmez addition and the fat contents of the samples decreased with pekmez addition above this value. The addition of pekmez reduced protein content of ice cream compared with the control (3.37% for mulberry pekmez, 3.56% for grape pekmez, and 4.19% for control) but no significant differences were detected between the samples with grape pekmez. The lowest protein content was detected in the sample with 10% mulberry pekmez. Increasing the pekmez proportion significantly decreased the pH and increased the titratable acidity values of all samples reflecting the organic acid content of the pekmez. These results were predictable because the pH values of mulberry and grape pekmez (pH 5.12–5.23, respectively) were lower than the average pH value of the control ice cream (pH 6.72). Additionally, acidity values of the ice cream with mulberry pekmez were higher than those obtained with grape pekmez addition. This finding was likely as the acidity value of mulberry pekmez is higher than that of grape pekmez. The ash content of the samples was significantly increased due to the higher ash contents in both pekmez. The highest ash value was determined in the ice cream sample with 10% grape pekmez added.

The samples with mulberry pekmez addition had significantly lower whiteness values ( $L^*$ ) than the control ice cream samples (Table 3). The addition of mulberry pekmez significantly decreased the whiteness values of the samples ( $P < 0.05$ ). However, no significant difference occurred between the samples with 2.5% and 10% mulberry pekmez. The control sample had a negative greenness value ( $-a^*$ ) and this colour turned red in response to mulberry pekmez addition. The addition of mulberry pekmez increased the greenness values ( $-a^*$ ) of the samples, indicating that the ice cream samples with mulberry pekmez addition had more

Table 2. Effects of mulberry and grape pekmez on the chemical properties of ice cream

Pekmez type	Pekmez ratio	TS	Fat	Protein	Total sugar (%)	Invert sugar	Saccharose	Acidity	pH (–)	Ash (%)
Control	0	31.20 ± 0.49 <sup>e</sup>	10.00 ± 0.00 <sup>a</sup>	4.19 ± 0.12 <sup>a</sup>	15.30 ± 0.16 <sup>i</sup>	3.72 ± 0.04 <sup>g</sup>	10.99 ± 0.11 <sup>e</sup>	0.23 ± 0.01 <sup>h</sup>	6.72 ± 0.01 <sup>a</sup>	0.82 ± 0.01 <sup>e</sup>
Mulberry	2.5	32.56 ± 0.33 <sup>d</sup>	10.00 ± 0.00 <sup>a</sup>	3.83 ± 0.07 <sup>bc</sup>	17.28 ± 0.06 <sup>h</sup>	5.48 ± 0.08 <sup>e</sup>	11.22 ± 0.14 <sup>de</sup>	0.27 ± 0.01 <sup>ef</sup>	6.64 ± 0.06 <sup>b</sup>	0.85 ± 0.04 <sup>e</sup>
	5.0	34.90 ± 0.12 <sup>c</sup>	9.91 ± 0.03 <sup>b</sup>	3.73 ± 0.08 <sup>bcd</sup>	18.42 ± 0.23 <sup>f</sup>	6.46 ± 0.12 <sup>d</sup>	11.43 ± 0.03 <sup>d</sup>	0.29 ± 0.01 <sup>d</sup>	6.61 ± 0.01 <sup>c</sup>	0.94 ± 0.06 <sup>bc</sup>
	7.5	35.82 ± 0.43 <sup>b</sup>	9.85 ± 0.05 <sup>c</sup>	3.66 ± 0.12 <sup>d</sup>	19.59 ± 0.08 <sup>d</sup>	7.20 ± 0.10 <sup>c</sup>	11.79 ± 0.16 <sup>c</sup>	0.35 ± 0.01 <sup>b</sup>	6.55 ± 0.01 <sup>d</sup>	0.95 ± 0.05 <sup>bc</sup>
	10.0	36.69 ± 0.34 <sup>a</sup>	9.75 ± 0.05 <sup>d</sup>	3.37 ± 0.10 <sup>e</sup>	21.82 ± 0.19 <sup>b</sup>	7.74 ± 0.10 <sup>b</sup>	13.40 ± 0.27 <sup>a</sup>	0.41 ± 0.02 <sup>a</sup>	6.50 ± 0.00 <sup>e</sup>	0.98 ± 0.05 <sup>ab</sup>
Grape	2.5	35.02 ± 0.73 <sup>c</sup>	9.90 ± 0.1 <sup>bc</sup>	3.92 ± 0.17 <sup>b</sup>	17.69 ± 0.34 <sup>g</sup>	5.29 ± 0.08 <sup>f</sup>	11.81 ± 0.41 <sup>c</sup>	0.23 ± 0.01 <sup>gh</sup>	6.65 ± 0.02 <sup>b</sup>	0.87 ± 0.09 <sup>de</sup>
	5.0	35.28 ± 0.56 <sup>bc</sup>	9.85 ± 0.05 <sup>c</sup>	3.80 ± 0.16 <sup>bc</sup>	19.04 ± 0.16 <sup>e</sup>	6.55 ± 0.08 <sup>d</sup>	11.94 ± 0.23 <sup>c</sup>	0.25 ± 0.01 <sup>fg</sup>	6.65 ± 0.02 <sup>b</sup>	0.91 ± 0.06 <sup>cd</sup>
	7.5	35.66 ± 0.47 <sup>bc</sup>	9.65 ± 0.05 <sup>e</sup>	3.66 ± 0.09 <sup>cd</sup>	20.85 ± 0.23 <sup>c</sup>	7.18 ± 0.05 <sup>c</sup>	12.96 ± 0.16 <sup>b</sup>	0.28 ± 0.01 <sup>de</sup>	6.63 ± 0.02 <sup>b</sup>	1.00 ± 0.05 <sup>ab</sup>
	10.0	36.80 ± 0.22 <sup>a</sup>	9.55 ± 0.05 <sup>f</sup>	3.56 ± 0.08 <sup>de</sup>	22.39 ± 0.06 <sup>a</sup>	8.32 ± 0.04 <sup>a</sup>	13.38 ± 0.03 <sup>a</sup>	0.33 ± 0.01 <sup>c</sup>	6.49 ± 0.01 <sup>e</sup>	1.02 ± 0.06 <sup>a</sup>

Data were expressed as means ± SD of duplicate experiments, and means in the same column with different superscripts are significantly different at ( $P < 0.05$ )



Table 3. Effect of mulberry and grape pekmez addition on the color values ( $L^*$ ,  $a^*$  and  $b^*$ ), overrun and viscosity of ice cream

Pekmez type	Pekmez ratio (%)	$L^*$	$a^*$	$b^*$	Overrun (%)	Viscosity (cP)
Control	0	$89.50 \pm 0.46^a$	$-4.28 \pm 1.14^d$	$17.77 \pm 0.28^e$	$30.00 \pm 4.34^{ab}$	$4388.67 \pm 125.48^a$
Mulberry	2.5	$79.52 \pm 3.69^{bcd}$	$-0.92 \pm 0.28^c$	$22.97 \pm 1.02^d$	$26.00 \pm 3.60^{bc}$	$2593.33 \pm 251.66^f$
	5.0	$79.39 \pm 3.64^{bcd}$	$-0.63 \pm 0.33^c$	$25.05 \pm 1.92^{bc}$	$21.67 \pm 4.62^d$	$2923.33 \pm 96.09^{de}$
	7.5	$77.01 \pm 1.69^{de}$	$0.14 \pm 0.33^b$	$26.24 \pm 1.80^{ab}$	$20.33 \pm 3.06^d$	$2689.00 \pm 167.69^{ef}$
	10.0	$75.50 \pm 1.46^e$	$0.84 \pm 0.39^a$	$26.92 \pm 1.07^a$	$19.00 \pm 2.00^d$	$3015.33 \pm 276.59^d$
Grape	2.5	$81.85 \pm 4.80^b$	$-1.03 \pm 0.66^c$	$22.79 \pm 2.18^d$	$30.67 \pm 4.04^a$	$3448.33 \pm 170.61^b$
	5.0	$80.82 \pm 4.42^{bc}$	$-0.71 \pm 0.60^c$	$23.06 \pm 2.35^d$	$26.00 \pm 0.00^{bc}$	$3112.00 \pm 173.06^{cd}$
	7.5	$78.90 \pm 4.29^{bcde}$	$-0.01 \pm 0.74^b$	$23.70 \pm 2.33^{cd}$	$22.67 \pm 1.15^{cd}$	$2927.00 \pm 111.36^{de}$
	10.0	$77.36 \pm 5.34^{cde}$	$0.66 \pm 0.99^a$	$25.01 \pm 2.15^{bc}$	$21.00 \pm 2.00^d$	$3299.67 \pm 129.46^{bc}$

Data were expressed as means  $\pm$  SD of duplicate experiments, and means in the same column with different superscripts are significantly different at ( $P < 0.05$ )

red colour compared to the control. Unexpectedly, the lowest whiteness value (75.50) and the highest greenness value ( $-a^*$ ) (0.84) were observed in the samples with 10% mulberry pekmez. Increasing mulberry pekmez amount significantly increased the yellowness values ( $-b^*$ ) of the ice cream samples ( $P < 0.05$ ). 7.5% and 10% pekmez-added samples had the highest positive  $b^*$  values while the control sample had the lowest  $b^*$  value, indicating that the ice creams changed in colour from yellow to blue with the increasing mulberry pekmez content. The main consumers of ice cream are children and the colour of ice cream always attracts them. The addition of mulberry pekmez turns the colour of ice cream into pink, making its appearance more attractive for the consumers. The intensity of the colour is acceptable up to 10% pekmez used.

Using grape pekmez for making ice cream significantly affected the colour values ( $P < 0.05$ ). Increasing grape pekmez content decreased the whiteness values of the samples.  $a^*$  and  $b^*$  values of ice cream with grape pekmez added were similar to those of mulberry pekmez added ice cream.

Table 3 shows overrun values of the ice cream samples with and without pekmez. All ice cream samples had normally lower overrun values (19–30%) compared to the literature values (80–120%) due to the soft serve ice cream freezer used. The addition of pekmez significantly decreased the overrun values of the samples ( $P < 0.05$ ). Increasing pekmez proportions reduced the protein values and increased the sweetness values of ice creams. TRGO *et al.* (1999) reported that sweeteners, depending

on the type and concentration, affect the freezing point of the ice cream mixture, the amount of frozen water at a certain temperature. Besides, the addition of pekmez increases the amounts of organic acids that affect the whipping properties of ice cream. This may contribute to the poor foaming capacity of ice cream. The overrun values of the samples with 5%, 7.5%, and 10% mulberry pekmez additions were similar to one another. The highest overrun values were detected in the sample with 2.5% grape pekmez.

Viscosity is considered an important characteristic of ice cream, since it frequently accompanies the desirable body and texture (INNOCENTE *et al.* 2002). The addition of pekmez to the ice cream mixtures significantly affects the viscosity values of the ice cream samples (Table 3). A higher viscosity was obtained in the control sample. This may be explained by that control sample includes smaller air cells (VEGA & GOFF 2005), smaller air cells with a narrower size distributions increasing the viscosity of the ice cream foam once it is molten (EISNER *et al.* 2005). The addition of pekmez decreased the viscosity when compared to the control. Therefore, the decrease in viscosity may be supported with some cream and protein additions.

The sensory evaluation of the ice cream samples with added mulberry and grape pekmez is shown in Table 4. While the addition of mulberry pekmez significantly affected the flavour, appearance, and total acceptability ( $P < 0.05$ ), the addition of grape pekmez significantly affected the flavour, body and texture, and total acceptability ( $P < 0.05$ ).

Table 4. Effects of mulberry and grape pekmez on the sensory properties of ice cream

Pekmez type	Pekmez ratio (%)	Flavor	Body and texture	Appearance	Total acceptability
Control	0	6.33 ± 0.58 <sup>de</sup>	5.00 ± 0.00 <sup>a</sup>	4.67 ± 0.58 <sup>a</sup>	16.00 ± 1.00 <sup>bc</sup>
Mulberry	2.5	7.33 ± 0.58 <sup>cd</sup>	4.00 ± 1.00 <sup>ab</sup>	3.67 ± 0.58 <sup>abcd</sup>	15.00 ± 1.00 <sup>cd</sup>
	5.0	8.33 ± 0.58 <sup>bc</sup>	3.33 ± 0.57 <sup>b</sup>	3.00 ± 0.00 <sup>cd</sup>	14.67 ± 1.15 <sup>cde</sup>
	7.5	10.00 ± 0.00 <sup>a</sup>	4.00 ± 0.00 <sup>ab</sup>	4.33 ± 0.58 <sup>ab</sup>	18.33 ± 0.58 <sup>a</sup>
	10.0	6.00 ± 1.00 <sup>e</sup>	4.33 ± 0.57 <sup>ab</sup>	2.67 ± 0.58 <sup>d</sup>	13.00 ± 1.73 <sup>de</sup>
Grape	2.5	7.33 ± 0.58 <sup>cd</sup>	3.33 ± 0.57 <sup>b</sup>	4.00 ± 0.00 <sup>abc</sup>	14.67 ± 1.15 <sup>cde</sup>
	5.0	7.50 ± 0.58 <sup>cd</sup>	4.00 ± 0.00 <sup>ab</sup>	4.00 ± 1.00 <sup>abc</sup>	15.50 ± 1.80 <sup>bc</sup>
	7.5	9.00 ± 1.00 <sup>ab</sup>	4.16 ± 1.04 <sup>ab</sup>	4.33 ± 0.58 <sup>ab</sup>	17.50 ± 1.50 <sup>ab</sup>
	10.0	5.67 ± 0.58 <sup>e</sup>	3.33 ± 0.28 <sup>b</sup>	3.33 ± 0.29 <sup>bcd</sup>	12.33 ± 0.58 <sup>e</sup>

Data were expressed as means ± SD of duplicate experiments, and means in the same column with different superscripts are significantly different at ( $P < 0.05$ )

The sensory scores for flavour were influenced by the addition of mulberry pekmez. The mulberry pekmez increased the flavour score of the ice cream up to 7.5% mulberry pekmez addition. The flavour of ice cream was influenced by the addition of mulberry pekmez and increased with mulberry pekmez addition of up to 7.5%. An increase in pekmez content contributed to the sweetness. Therefore, most panelists (57%) criticised the sample with 10% mulberry pekmez for having an extreme pekmez flavour. None of the samples was criticised for having bitter, metallic, rancid, or oxidised flavours. The sensory panel rated the samples as being too much pinky as the pekmez content increased. The sample with 7.5% pekmez was the only one rated similar to the control sample in terms of appearance, thus indicating that maximum level of 7.5% pekmez can be used in the ice cream production without any appearance defect. No significant differences in the body and texture were detected between the samples. Total acceptability scores of the ice cream samples are shown in Table 4. As in the case of the

flavour and appearance scores, the sample with 7.5% pekmez addition was rated superior to the other samples. This demonstrates that mulberry pekmez improved the sensory properties of the samples at up to 7.5% level, but further increases led to a reduction in the sensory scores.

The panelists also preferred the samples with 7.5% grape pekmez over the control. The ice cream containing 2.5, 5.0, and 7.5% of grape pekmez showed no difference in terms of body and texture compared to the ice cream produced without pekmez, indicating that the maximum grape pekmez level of 7.5% can be used in the ice cream production without any body and texture defect. The mouthfeel of ice cream is affected by the size and size distribution of the ice crystals (TrGO *et al.* 1999). In the worst possible case, the ice crystals grow large enough for the consumer to detect them as rough particles on the tongue. In this research, most panelists criticised the samples with 10% grape pekmez added as rough. Total acceptability scores demonstrated that the samples with 7.5%

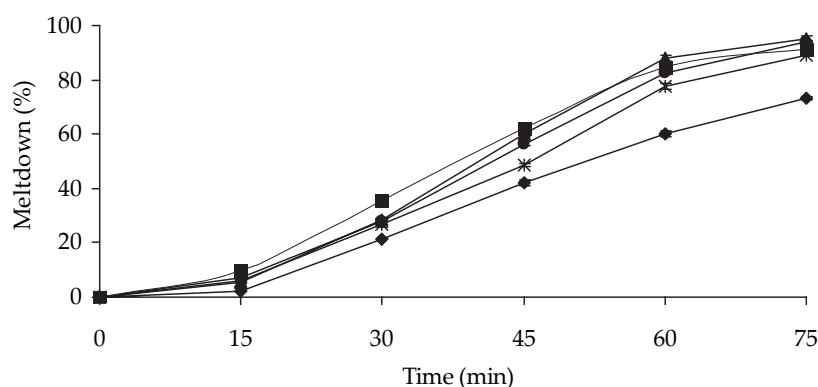
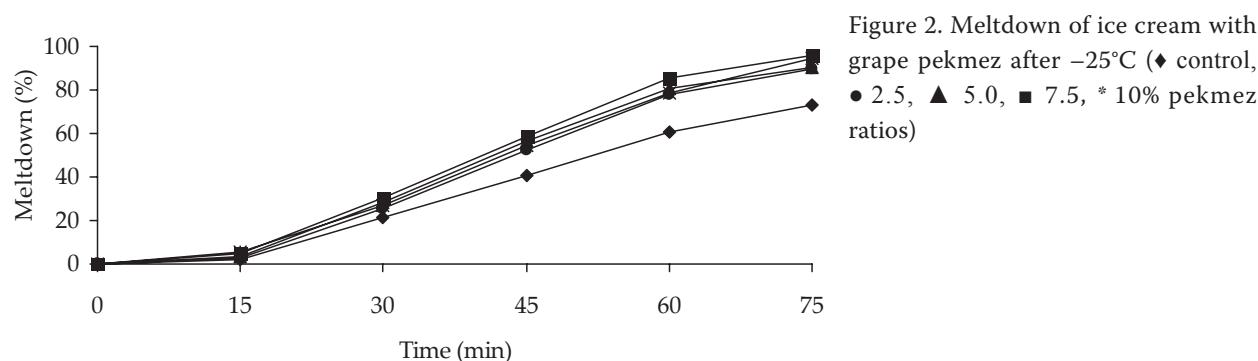


Figure 1. Meltdown of ice cream with mulberry pekmez after  $-25^{\circ}\text{C}$  (♦ control, ● 2.5, ▲ 5.0, ■ 7.5, \*10% pekmez ratios)



added mulberry and grape pekmez were rated superior to the other samples. Based on all the sensory properties, mulberry and grape pekmez can be incorporated into the ice cream mixture to maximum concentration of 7.5%.

The impact of the changes in the foam structure on the consumer quality can be best observed during thawing of ice cream. With rising temperatures ice crystals are melting, the highest concentrated matrix phase (composed of unfrozen proteins salts, polysaccharides and water) is locally diluted with water and its viscosity decreases (GOFF 2002). This process was monitored by a melting test. Meltdown rates of the ice cream tested were measured after 5 days of storage at  $-25^{\circ}\text{C}$ . The presence of pekmez in the ice cream caused a marked increase in the melting rate compared to those without pekmez (Figures 1 and 2). At 75 sec the control sample had 76% meltdown rate while those with added pekmez had 90% meltdown at 75 seconds. The meltdown ratios of the ice cream with added mulberry and grape pekmez were similar to each other. These results may be explained by the differences in the air cell and ice crystal sizes between the samples. Although the sizes of ice crystals were not measured in this study, it is possible that the ice cream containing

pekmez had larger air cells and ice crystals after hardening. The potential cause of the slower melt down of the control sample may be the difference in the heat transfer rate due to the higher percentage of air (SOFJAN & HARTEL 2004). In addition, higher levels of sugars and organic acids impacts on the freezing point depression which causes an increase in the level of unfrozen liquid in the ice cream and whipping capacity negatively which shows aircell distribution. Therefore, the addition of pekmez caused a faster meltdown.

As shown in Figures 1 and 2, the meltdown rates were rapid in the first 60 min, slowing down thereafter. As reported by EISNER *et al.* (2005), the local lowered viscosity of the matrix phase due to the ice cream melting induces drainage effects. This liquid flows through the fat network in the lamellas between the air cells and finally drips through the mesh on which the ice cream samples are placed. After a long time, the drainage rate slows down once all the ice is molten and the low viscous regions of the matrix phase have been already drained and are not diluted by melting ice anymore (EISNER *et al.* 2005).

Good quality control of the ice texture and particularly of the ice crystals growth relies on a large

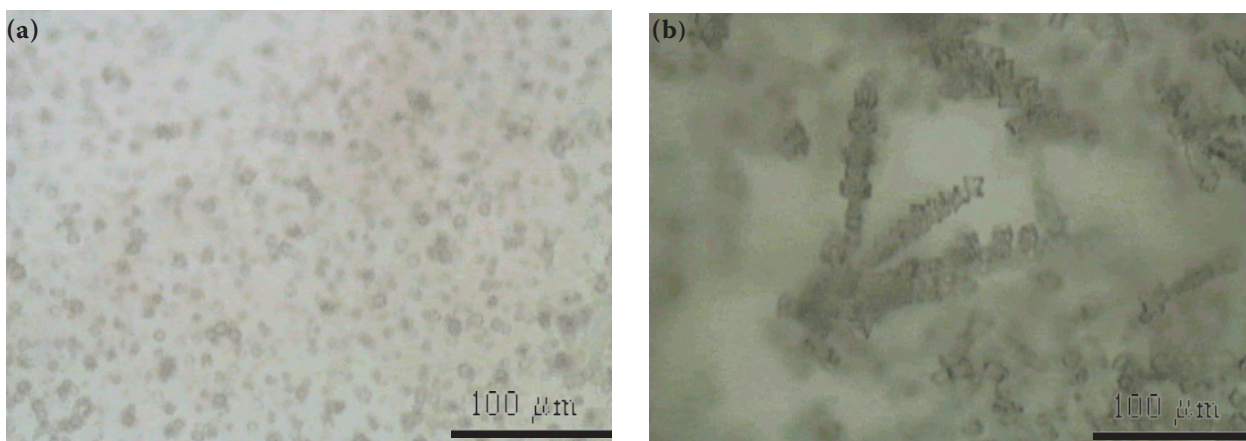


Figure 3. Structure of ice crystals size by direct microscopy method: (a) control ice cream and (b) ice cream with pekmez

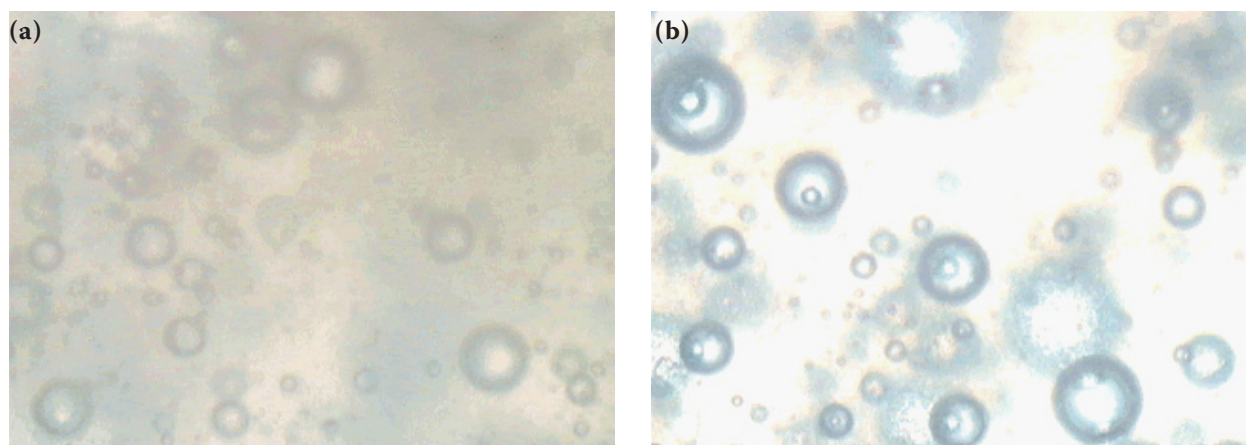


Figure 4. Structure of air cells size by direct microscopy method: (a) control ice cream and (b) ice cream with pekmez

number of small crystals. According to FLORES and GOFF (1999), a certain amount of air is necessary for a noticeable impact on the microstructure and that air would not only affect the ice cream thermal properties but may also act as a physical barrier during freezing. Indeed, a well dispersed air structure reduces the probability of collisions between ice particles and reduces the recrystallisation phenomena. The literature source indicates that the average air bubble diameter is about 40  $\mu\text{m}$  (CHANG & HARTEL 2002b). In this study, the air cell images were taken by optical microscope technique instead of cryo-SEM technique due to slight differences in the air cell size distribution proved by CHANG and HARTEL (2002b). Partial melting of the ice cream samples was observed during optical microscope imaging. The imaging of ice crystal and air cell sizes of the ice cream with and without pekmez is shown in Figures 3 and 4. The range of the ice cream aircell size with and without pekmez was 5–50  $\mu\text{m}$  and 10–80  $\mu\text{m}$ , respectively. This observation was also reported by CAILLET *et al.* (2003) (40  $\mu\text{m}$ , 29.3  $\mu\text{m}$ ) and is shown in Figure 4. The smaller size and narrower aircell size distribution in the control samples may be the reason why those cells were under higher pressure during freezing than those of the larger sizes. Since the control samples froze sooner than the others, the air cell distribution in the control samples was homogenous. Namely, the control samples had more aircells due to more whipping properties compared to the ice cream samples containing pekmez.

## CONCLUSIONS

The addition of pekmez positively affected total solid, total sugar, invert sugar, sucrose, acidity, ash,

but on the contrary, meltdown, protein, pH, overrun and viscosity were negatively affected. Pekmez addition of up to 7.5% improved the total acceptability scores of the samples. The overrun values of the control and the samples with 2.5% pekmez were significantly different from the other samples. The viscosity values of the ice cream with the addition of 2.5, 5.0, 7.5, and 10.0% mulberry pekmez and of 5.0, 7.5, and 10% grape pekmez were similar to one another. The meltdown rate (%) of the samples with pekmez addition was significantly faster compared to the control. Based on the results, it can be concluded that mulberry and grape pekmez varieties can be used successfully in the ice cream production. Further research is required to improve physical properties, thereby the economic advantage of the ice creams containing different kinds of pekmez.

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