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ORIGINAL ARTICLE

The effect of terebinth (*Pistacia terebinthus* L.) coffee addition on the chemical and physical characteristics, colour values, organic acid profiles, mineral compositions and sensory properties of ice creams

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Abstract The aim of this research was to evaluate the effect of terebinth (*Pistacia terebinthus* L.) coffee addition (0.5, 1 and 2 %) on the chemical and physical properties, colour values, organic acid profiles, mineral contents and sensory characteristics of ice creams. The total solids, fat, titratable acidity, viscosity, first dripping time and complete melting time values, a^* and b^* colour properties, citric, lactic, acetic and butyric acid levels and Ca, Cu, Mg, Fe, K, Zn and Na concentrations of ice creams showed an increase with the increment of terebinth coffee amount, while protein, pH, L^*, propionic acid and orotic acid values decreased. However, Al and malic acid were not detected in any of the samples. The overall acceptability scores of the sensory properties showed that the addition of 1 % terebinth coffee to the ice cream was more appreciated by the panellists.

Keywords Ice cream · Terebinth coffee · Quality characteristics · Organic acid · Mineral

Highlights
- The influence of terebinth coffee addition on ice cream quality.
- The physico-chemical characteristics, colour values of ice creams
- The changing on the organic acid profiles of ice creams with the addition of terebinth coffee
- Mineral composition of terebinth coffee added ice creams.

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Introduction

Ice cream is a frozen dairy product consisting of milk, fat, sugar, emulsifiers, stabilizers, fruits and flavouring agents. Each of the ingredients was used for ice cream formulation influences the quality characteristics, functional and sensorial properties of it (Koxholt et al. 2001; Frost et al. 2005).

Recently, the production of different types of ice creams has shown a development worldwide, due to the changing of consumer preference towards functional products. Generally, people prefer more functional, aromatic and different types of ice creams in their diets. Natural additives that are used can give good sensorial properties, nutritional values (such as, vitamins, minerals, organic acids, fibre, antioxidants and colour etc.) and health benefits to the ice creams (Granger et al. 2005). Therefore, ice cream industry has shown an important developments in recent years . (Koxholt et al. 2001; Granger et al. 2005). For this purpose, different types of ingredients (fresh or dried fruits, marmalade, fruit juice, probiotics and other additives) and processing technologies have been used by industrialists and as a result of this, ice cream has become a product to be consumed in all seasons in the world (Çakmakçı et al. 2015).

Terebinth (*Pistacia terebinthus* L.) is a member of Anacardiaceae family and it is a fruit of turpentine tree which is one type of the 20 *Pistacia* species. Turpentine tree is localized especially in the shrubs and is found to grow in pine forests or on hillsides. It grows widely in the southern and western regions of Turkey and Mediterranean countries. The fruits of this tree are known as çögre, çitlenbik, çıtlak, çedene, sakız agacı, yabani fıstık, melengiç and menengiç (terebinth) among people (Baytop 1994). These fruits are rich in terms of organic nutrients. The 100 g of terebinth fruits contain approximately 594 kcal, 20.8 g protein, 51.6 g fat, 16.4 g carbohydrate, 2 g crude fiber, 500 mg P, 136 mg Ca, 7.3 mg Fe, 1.02 mg K,158 mg Mg, 66 IU vitamin A, 0.62 mg vitamin B1, 1.45 mg vitamin B2 0.4 mg vitamin B6,7 mg vitamin C and 5.2 mg vitamin E (Özcan 2004). Therefore, they are evaluated as an alternative to modern medicine in various ways. Generally, terebinth fruits are used in traditional medicine for the treatment of various diseases including cough, eczema, asthma, diarrhoea, ulcers and arthritis (Bonsignore et al. 1998). They are also, used in cookies, additives for bread making and preparation of various foods such as cooking oil. Moreover, fruits are evaluated as a raw material for making bıttım and turpentine soap and also used in the production of different seasonings and spices. Also, terebinth fruits are processed roasting the terebinth coffee that has an extremely attractive colour and smell. This coffee is one of the most consumed traditional coffees in Turkey and is generally cooked in milk (Matthäus and Özcan 2006).

Organic acids affect the pH, sensory properties, flavour, stability and keeping quality of dairy products. The important organic acids (lactic, acetic, pyruvic, propionic, formic, citric, fumaric) in dairy products commonly occur as a result of the physiological mechanisms of milk producing animal, lactose metabolism of lactic acid bacteria, metabolic pathways of carbohydrates, proteins and lipids, negative microbial activity and addition of organic acids, flavour modifiers and fruits (Fernandez-Garcia and McGregor 1994; Tormo and Izco 2004). Moreover, plants and fruits contain different types of organic acids. The organic acids have important roles (such as acidulant (tartaric, malic, citric and ascorbic acids), antioxidant (malic, citric and tartaric acids), preservative (sorbic and benzoic acids) and sensorial properties (malic, citric, acetic and tartaric acids) when added to the foods (Viljakainen et al. 2002).

The minerals are essential for the human nutrition and they have important roles for preventing several diseases. Minerals show beneficial effects on human health when they are found in foods in small quantities, although they can be harmful if they exceed the limit values (Rodriguez Rodriguez et al. 2002; Caggiano et al. 2005).

The objectives of this study were to produce a new functional ice cream with different concentrations of terebinth coffee and evaluate the chemical and physical properties, colour values, organic acid profiles, mineral compositions and organoleptic qualities of this ice cream.

Materials and methods

Materials

The used bovine milk and cream for ice cream production were obtained from the dairy farm of Atatürk University located in Erzurum province of Turkey. Skim Milk Powder (SMP) was purchased from Pınar Dairy Products Co., İzmir, Turkey. Terebinth coffee was supplied from a local shop in Adıyaman city, while sugar, emulsifier (mono- and diglycerides) and sahlep were purchased from markets in Erzurum, Turkey.

Ice cream production

Ice cream production was done in duplicates for this study. For this purpose, four different ice cream mixes were produced in the Pilot Dairy Factory of Atatürk University (Erzurum, Turkey). The obtained milk was divided into four equal parts and 3 kg mix was made for each party. Each of the ice cream mixes were produced including 5 % fat, 4.7 % skim milk powder, 18 % sugar, 0.6 % sahlep (stabilizer) and 0.2 % emulsifier (mono- and diglycerides). The mixes were prepared using a mixer and pasteurized at 85 °C for 25 s and then rapidly cooled to ±4 °C. The cooled ice cream mixes were maturated for 24 h at ±4 °C. The first mix was taken as the control and the other mixes ($TC_{\%0.5}$, $TC_{\%1}$ and $TC_{\%2}$) were prepared with different levels of the terebinth coffee (TC) in oily and liquid form. At last, the mixes were frozen in an ice cream machine (−5 °C; Ugur Cooling Machineries Co., Nazilli, Turkey) and hardened at −22 °C for 24 h and stored at −20 °C for analyses. The overall experimental analyses were made as duplicate for each sample.

Chemical and physical analysis

Total solid contents of experimental ice creams were determined using the gravimetric method, fat content by the Gerber method, and protein by the Kjeldahl method as described by Demirci and Gündüz (1994). The titratable acidity was determined as lactic acid percentage by titrating with 0.1 N NaOH, using phenolphthalein as an indicator. For the measurement of pH, approximately 10 g ice cream samples were dissolved in 90 ml distilled water, and then this mixes were homogenized. The pH of the samples was measured using a pH meter (model WTW pH-340-A, Weilheim, Germany) fitted with a combined glass electrode (Demirci and Gündüz 1994). The viscosity of the ice cream mixes was determined at 4 °C by a Brookfield viscometer, Model DV-II (Brookfield Engineering Laboratories, Stoughton, MA, USA) with an RV spindle set (spindle No. 2) at 50 rpm. All of the measurements were taken in duplicate and 20 readings (cP) were taken for each sample at 30 s (Dervisoglu 2006). Overrun was determined according to the equation [(weight of ice cream)−(weight of mix)/weight of mix ×100] and a standard 100 mL cup was used to determine both the weight of ice cream mix and ice cream (Jimenez-Florez et al. 1993). For the determination of first dripping and complete melting times of ice creams, the hardened 25 g sample was left on a 0.2 cm wire mesh screen above a beaker at room temperature and these parameters were determined as seconds (Guven and Karaca 2002).

Colour analysis

The colour values were measured three times for each ice cream sample after the calibration of colorimeter with black and white standards. For this purpose, a Minolta colorimeter (CR-200; Minolta Co., Osaka, Japan) was used and L* (lightness; 100=white, 0=black), a* (redness; ±, red; −, green), and b* (yellowness; ±, yellow; −, blue) values of samples were determined.

Organic acid analysis

The organic acid analysis of ice cream samples was done according to the modified methods by Fernandez-Garcia and McGregor (1994). This analysis was performed by using high-performance liquid chromatography (Agilent HPLC 1100 series G 1322 A, Germany). For this purpose, 4 g ice cream sample was diluted with 25 mL 0.001 N H_2SO_4 and centrifuged at the 5000×g for 10 min. The obtained supernatant was filtered through Whatman No.1 filter paper and then through a 0.45 μm membrane filter (PALL, USA). The 2 mL aliquots for each sample were stored in HPLC vials at −20 °C for HPLC analysis. Organic acids were separated using a Alltech IOA-1000 organic acid column (300×7.8 mm, Alltech, IL, USA). The degassed mobile phase of 0.001 N H_2SO_4 was used at a flow rate of 0.6 mL/minute and the wavelength of detection was 210 nm for the quantification of organic acids. For each sample, duplicate injections (approximately 10 μL) were performed. The standard solutions of citric, orotic, malic, lactic, acetic, propionic and butyric acids were prepared in 0.001 N H_2SO_4 for the determination of elution times and to establish the calibration curves.

Mineral analysis

The mineral contents of the ice creams were analysed by using an Inductively Couple Plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT, USA) according to the modified methods by Rodriguez Rodriguez et al. (2002) and Caggiano et al. (2005). The ice cream samples were dried in a microwave oven (Berghof speed wave, Germany) at 70 °C until the amount of dry matter was fixed. For this analysis, approximately 0.5 g of ice creams were weighed to the vessels and 10 mL (9: 1 v/v) of nitric acid (65 % HNO_3)/ perchloric acid (70–72 % $HClO_4$) were added to each sample and they were left overnight. Next morning, the temperature of these samples were increased to 160–170 °C slowly using a hot-plate until the white smoke was appeared. Then, the samples were filtered through the Whatman no. 42 filter paper and completed with distilled water in flasks to 50 mL. All diluted samples were analysed by using an Inductively Couple Plasma spectrophotometer (ICP-OES) and the results were expressed as ppm.

Sensory analysis

For the evaluation of ice creams in terms of sensory properties, a group of 50 untrained panellists graded the samples using a scale of 0–9 (unacceptable/excellent). For this purpose, the modified version of hedonic scale suggested by Bodyfelt et al. (1988) was used. The ice cream samples were served approximately 30 g at −10 °C and tried to be provided same conditions to each panel member as much as possible. All of the samples were graded with respect to colour and appearance, texture, gumming structure and melting in mouth, flavour, sweetness and overall acceptability.

Statistical analysis

The obtained data were analysed using the SPSS statistical software program version 13 (SPSS Inc., Chicago, IL, USA). Analysis of variance (ANOVA) and Duncan's multiple range tests were used to determine the differences between results.

Results and discussion

Chemical and physical properties of the experimental ice creams

Chemical properties

The obtained results and mean values in both experiments are presented in Table 1. The addition of terebinth coffee (TC) decreased ($p<0.01$) the total solids values of the samples compared to the control sample, but the increment of TC concentration caused a statistically significant increase ($p<0.01$) in the total solids values of the ice creams. This situation might be occurred due to the liquid and oily structure of TC. Similar results were reported by Hwang et al. (2009), while Temiz and Yeşilsu (2010) found different results from this study for pekmez added ice cream. Observing the Table 1, fat values of samples showed an increase with the addition of TC, while protein values were decreased. From these results it might be said that oily structure of TC caused an increase on the fat values of ice creams, but protein values of samples decreased with the addition of TC. Similar results were also reported by Temiz and Yeşilsu (2010). From these findings, it might be said that these results were as expected.

As seen in Table 1, titration acidity values of the ice creams increased with the increment of TC concentration, while pH values showed a decrease. These results might stem from the

Table 1 The effect of TC concentration on chemical and physical properties of the ice creams (mean±SD)

Ice cream samples	Total solids (%)	Fat (%)	Protein (%)	Titratable acidity (%)	pH	Viscosity (cP) 50 rpm	Overrun (%)	First dripping times (s)	Complete melting times (s)
Control	41.23±0.12a**	5.30±0.12	5.31±0.21	0.18±0.00b*	6.68±0.01a**	2773±133.03d**	33.47±1.71b**	545±71.94	3039±838.94a*
$TC_{0.5\%}$	39.28±0.25c**	5.50±0.58	5.16±0.23	0.19±0.01ab*	6.68±0.01a**	6953±335.57c**	38.23±0.35a**	501±22.08	2155±134.30b*
$TC_{1\%}$	40.37±0.18b**	5.80±1.05	5.17±0.34	0.20±0.01a*	6.65±0.01b**	12025±124.06b**	34.68±1.66b**	534±27.24	2228±245.86b*
$TC_{2\%}$	40.67±0.41b**	6.25±0.94	5.12±0.41	0.21±0.01a*	6.61±0.01c**	16897±473.91a**	26.14±1.17c**	561±94.39	2456±52.53ab*

Mean values±standard deviations of ice creams manufacturing with duplicate samples. The letters a, b, c and d indicates means that significantly different at $p<0.01$ and $p<0.05$ levels

**: $p<0.01$, *: $p<0.05$

TC Terebinth coffee

natural organic acids found in TC. These organic acids might reduce the pH despite the buffering actions of the milk protein. According to the statistical evaluations, titratable acidity values of $TC_{1\%}$ and $TC_{\%2}$ samples showed similarity in between. However, control and $TC_{0.5\%}$ samples showed differences ($p<0.05$) from each other and $TC_{1\%}$ and $TC_{\%2}$ samples statistically. In contrast, control and $TC_{0.5\%}$ samples were similar with respect to pH values, while $TC_{1\%}$ and $TC_{\%2}$ samples were different ($p<0.01$) from each other and other ice creams statistically. This situation was probably due to the organic acid that found naturally in TC. Similar results were reported by Murtaza et al. (2004), Temiz and Yeşilsu (2010).

Physical properties

Viscosity is an important factor for the ice cream quality, because this parameter significantly affects the textural and rheological properties of it (El–Samahy et al. 2009). According to Table 1, all ice cream samples were found different ($P<0.01$) from each other statistically. The highest mean viscosity value was determined in $TC_{2\%}$ and followed by $TC_{1\%}$, $TC_{\%0.5}$ and control samples, respectively. The obtained results demonstrated a compliance with the first dripping and complete melting time values of ice creams. The determined differences among the viscosity values of the samples might be due to the composition of TC (Contents of fibre, oil, mucilaginous compounds etc.) and the increase in the total solid content of mixes with the increment of TC level. On the other hand, the increase in the viscosity values might occur at low temperatures due to the aggregation of some proteins, agglutination of fat globules and small air cells formed in ice creams (Vega and Goff 2005; El–Samahy et al. 2009).

Overrun value shows the increase in the volume of the ice cream mix and amount of the air in it. The air found in the mix gives agreeable light texture to the ice cream. This parameter influences the physical properties, melting time and hardness of the final product (Sofjan and Hartel 2004). As seen in Table 1, the overrun values of the ice creams decreased with the addition of TC compared to the control sample. The decrease of the overrun values might be originated from oily structure, water binding capacity and compositional properties of TC. From these properties it might be said that the incorporated air amount into the mixes was inadequate, and for that reason, poor foam formation occurred in the ice cream mixes (El–Samahy et al. 2009; Temiz and Yeşilsu 2010). The statistical evaluations showed that control and $TC_{1\%}$ showed similarity, while $TC_{0.5\%}$ and $TC_{2\%}$ were different ($p<0.01$) from each other and other samples statistically.

The first dripping time values of ice cream samples ranged between 501 s ($TC_{0.5\%}$ and 561 s ($TC_{2\%}$). The increment of TC concentration positively affected the first dripping times of the samples (Table 1). On the other hand, complete melting time values of the samples decreased with the addition of TC compared to the control sample. The longest mean first dripping time value was in $TC_{2\%}$ sample and it was followed by control, $TC_{1\%}$ and $TC_{0.5\%}$ samples, respectively. However, the longest complete melting time value was determined in the control sample followed by $TC_{2\%}$, $TC_{1\%}$ and $TC_{0.5\%}$, respectively. As seen in Table 1, there were no significant differences between the samples in terms of first dripping time values. However, $TC_{2\%}$, $TC_{1\%}$ and $TC_{0.5\%}$ samples showed similarity with each other in terms of complete melting times, while the control sample was found different from them ($p<0.05$) statistically. This observed increase in the first dripping and complete melting time values of the experimental ice creams with the addition of TC might be explained with the compositional properties of it. As a result of the addition of TC, free movement of the water molecules reduced and melting times of samples prolonged (Guven and Karaca 2002; Sofjan and Hartel 2004).

Colour values of the experimental ice creams

The consumption of a food product depends on some visual parameters (colour, shape, appearance, etc.,) and flavour (smell, taste and aroma) characteristics. All of these parameters contribute to consumer preferences, because a food product is accepted or rejected by the consumers depending on its effects on their senses. It was seen from the Table 2 that L^* colour value of samples decreased with the addition of TC, while a^* and b^* colour values increased depending on the TC increment. The highest mean values of a^* and b^* were found in $TC_{2\%}$, the lowest mean values of them were in control sample. In contrast, the highest mean value of L^* was determined in control sample and it was followed by $TC_{0.5\%}$, $TC_{1\%}$ and $TC_{2\%}$ samples, respectively. According to the statistical evaluations, L^*, a^* and b^* colour values of the all samples were completely different ($p<0.01$) from each other statistically (Table 2). Also, Tarakcı (2010) reported similar results in terms of colour parameters of yoghurts.

Table 2 The effect of different TC concentration on the colour parameters of the ice creams (mean±SD)

Ice cream samples	L^*	a^*	b^*
Control	87.42±1.39a**	−3.72±0.18d**	13.21±0.29d**
$TC_{0.5\%}$	69.79±4.50b**	1.08±0.06c**	15.32±0.70c**
$TC_{1\%}$	64.51±0.91c**	2.86±0.25b**	18.98±0.51b**
$TC_{2\%}$	59.77±1.81d**	4.62±0.14a**	20.06±0.49a**

Mean values±standard deviations of ice creams manufacturing with duplicate samples. The letters a, b, c and d indicates means that significantly different at $p<0.01$ level

** : $p<0.01$

TC Terebinth coffee

Organic acid profiles of the experimental ice creams

The organic acid profiles of MC and ice cream samples are shown in Table 3.

Citric acid is a weak tricarboxylic acid that is found naturally in many fruits and fruit juices. Also, citric acid is one of the most important organic acids of fresh milk and it is found in it at 0.2 % level (Fernandez-Garcia and McGregor 1994; Tormo and Izco 2004). As seen in Table 3, citric acid concentration of TC was found as 55.65±3.64 μg/g. On the other hand, the highest mean value of the citric acid was found in $TC_{2\%}$ and the lowest mean value was determined in the control sample. The obtained results showed a compliance with the citric acid value of TC. According to the statistical evaluations, the control and $TC_{0.5\%}$ samples were similar, while $TC_{1\%}$ and $TC_{2\%}$ were different ($p<0.01$) from each other and from other samples statistically.

Orotic acid appears as an intermediate product during the biosynthesis of nucleic acids and it is found in significant levels in milk and dairy products (milk powder and whey powder) (Okonkwo and Kinsella 1969; Kavaz and Bakirci 2014). Observing Table 3, the highest mean concentration of orotic acid was found in the control sample, but it was not detected in TC and any of the ice creams produced with the addition of TC. The statistical evaluations showed that control sample was different ($p<0.01$) from other ice cream samples statistically.

Malic acid is a dicarboxylic acid and is formed in metabolic cycles of plants and animals. Also, this acid can be used as food additive and flavouring agent in foods (Sniffen et al. 2006). As seen in Table 3, the malic acid concentration of TC was 114.19±3.93 μg/g, while it was not determined in any of the ice cream samples.

Lactic acid is the most important organic acid found in milk, yoghurt, fermented milks and other dairy products. This organic acid has a quite importance in the formation of flavour, protection of quality characteristics and prevention of degradations in dairy products (Fernandez-Garcia and McGregor 1994; Tormo and Izco 2004; Kavaz and Bakirci 2014). The mean lactic acid value of TC was determined as 474.75±52.23 μg/g. Observing Table 3, the highest mean value of the lactic acid was found in $TC_{2\%}$, followed by $TC_{1\%}$, $TC_{0.5\%}$ and control samples, respectively. According to the statistical evaluations, $TC_{2\%}$ and $TC_{1\%}$ showed a similar trend, but other samples were completely different ($p<0.01$) from each other and this sample group statistically.

Acetic acid is a natural metabolic component that occurs as an intermediate substance within the metabolism of plants and animals. On the other hand, acetic acid is formed in milk and dairy products as a result of the citrate, lactose and amino acid metabolism of the lactic acid bacteria. It shows inhibitory effect against the spoilage microorganisms and fungi due to their strong bactericidal properties. In contrast, acetic acid

Table 3 Organic acid profiles of TC and the effect of different TC concentrations on the organic acid profiles of the ice creams (mean±SD)

	Citric acid (μg/g)	Orotic acid (μg/g)	Malic acid (μg/g)	Lactic acid (μg/g)	Acetic acid (μg/g)	Propionic acid (μg/g)	Butyric acid (μg/g)
TC	55.65±3.64	0.00±0.00	114.19±3.93	474.75±52.23	312.73±53.20	15.97±1.18	13.38±15.46
Ice cream samples							
Control	32.92±0.72c**	6.96±0.23a**	0.00±0.00	2.49±1.53c**	0.00±0.00b**	0.00±0.00b**	4.68±0.50
$TC_{0.5\%}$	33.59±0.14c**	0.00±0.00b**	0.00±0.00	9.35±0.26b**	4.25±0.87a**	13.83±0.72a**	4.09±0.74
$TC_{1\%}$	35.37±1.97b**	0.00±0.00b**	0.00±0.00	12.27±2.29a**	6.03±0.00a**	13.51±0.60a**	4.93±0.73
$TC_{2\%}$	37.17±0.76a**	0.00±0.00b**	0.00±0.00	12.84±0.15a**	6.23±2.97a**	13.50±0.13a**	5.00±0.45

Mean values±standard deviations of ice creams manufacturing with duplicate samples. The letters a, b and c indicates means that significantly different at $p<0.01$ level

** : $p<0.01$

TC Terebinth coffee

gives undesirable taste and vinegary aroma to the product when formed in excess amount (Kavaz and Bakirci 2014). As seen in Table 3, the TC had 312.73±53.20 μg/g of acetic acid. The highest mean acetic acid value was found in $TC_{2\%}$, while it was not determined in the control sample. Observing Table 3, $TC_{0.5\%}$, $TC_{1\%}$ and $TC_{2\%}$ showed a similar trend with respect to statistical evaluations, but control sample was different ($p<0.01$) from them statistically.

Propionic acid is an organic acid that has oily, liquid and colourless properties and pungent aroma. It can be formed naturally in dairy products (butter, cheese) and in metabolism of human, animal and some plants (Anonymous 1991). Propionic acid is widely used as a fungicide and bactericide for controlling the bacteria and fungi in foods, feeds, stored grains, solvents and pharmaceuticals (Anonymous 1991; Kosmider et al. 2010). Observing Table 3, the highest mean concentration of propionic acid was found in $TC_{2\%}$, while propionic acid was not determined in the control sample. According to the statistical evaluations, $TC_{0.5\%}$, $TC_{1\%}$ and $TC_{2\%}$ were similar to each other, while the control sample showed differences ($p<0.01$) from them statistically.

Butyric acid is formed in dairy products as a result of biochemical reactions, microbial activity, hydrolysis of milk fat, deamination of amino acids and as a product of anaerobic fermentation (Molkentin and Precht 1998). According to Table 3, 13.38±15.46 μg/g butyric acid was determined in TC. The butyric acid concentration of ice cream samples ranged between 4.09±0.74 μg/g ($TC_{0.5\%}$) and 5.00±0.45 μg/g ($TC_{2\%}$) values. However, there was no statistically significant difference among the samples in terms of butyric acid concentrations.

From these results it might be said that citric, lactic, acetic and butyric acid concentrations of ice creams increased with the increment of TC concentration, while orotic and propionic acid values of the samples showed a decrease. In contrast, malic acid was not determined in any of the samples. Similarly Fernandez-Garcia and McGregor (1994), Tormo and Izco (2004), and Kavaz and Bakirci (2014) reported that the organic acid profiles of dairy products were affected by starter microorganisms, used ingredients, ratios of ingredients and storage period.

Mineral composition of the experimental ice creams

As seen in Table 1, Ca, Al, Cu, Mg, Fe, K, Zn and Na elements were determined in TC at the amounts of 1511.55, 0.00, 7.65, 1408.10, 45.80, 8788.75, 14.40 and 108.00 ppm, respectively. In this study, the increment of TC concentration caused an increase in the Ca, Cu, Mg, Fe, K, Zn and Na contents of the samples (Table 4). The highest mean values of Ca, Cu, Mg, K, Zn and Na were found in $TC_{2\%}$ and it was followed by $TC_{1\%}$, $TC_{0.5\%}$ and control samples, respectively. However, Fe was determined only in the $TC_{2\%}$ sample, while Al was not detected in any of the samples.

Calcium (Ca) is an important mineral in human nutrition because the deficiency of Ca may cause the development of osteoporosis. Ca is absorbed in the intestinal system and is used in the body for many essential functions (Tunick 1987). As seen in Table 4, Ca values of the ice cream samples were found statistically different ($p<0.05$) from each other.

Aluminium (Al) is a non-essential component for human nutrition, but it is the most common element found in the environment. It can be contaminated to the dairy products from the containers and ingredients during the production (Deeb Azza and Gomaa 2011). In this study, Al was not determined in TC and other ice cream samples.

Some of the heavy metals including copper (Cu) and iron (Fe) are essential for the metabolic activity of human and other living organisms, but high concentrations of them can cause toxicity for human beings (Ayar et al. 2009). According to statistical evaluations, $TC_{0.5\%}$ and $TC_{1\%}$ samples were similar to each other in terms of Cu values, while control and $TC_{1\%}$ samples were statistically different ($p<0.05$) from each other and from other samples. On the other hand, Fe content of the

Table 4 Mineral composition of TC and the effect of different TC concentrations on the mineral composition of ice creams (mean±SD)

Ice cream samples	Ca (ppm)	Al (ppm)	Cu (ppm)	Mg (ppm)	Fe (ppm)	K (ppm)	Zn (ppm)	Na (ppm)
TC	1511.55±248.27	0.00±0.00	7.65±0.07	1408.10±8.49	45.80±0.71	8788.75±443.29	14.40±0.00	108.00±1.41
Ice cream samples								
Control	3194.60±118.09c*	0.00±0.00	10.00±0.57b*	382.70±0.85	0.00±0.00b*	3215.20±63.07	13.85±0.64c**	753.50±1.41b**
$TC_{0.5\%}$	3626.95±293.80bc*	0.00±0.00	17.20±0.42ab*	412.20±0.85	0.00±0.00b*	3422.10±319.61	17.10±0.28b**	766.80±13.01b**
$TC_{1\%}$	4277.05±51.55ab*	0.00±0.00	26.00±0.42ab*	455.40±1.41	0.00±0.00b*	3766.35±173.74	18.50±0.71b**	794.85±7.00a**
$TC_{2\%}$	4674.05±514.00a*	0.00±0.00	39.45±19.73a*	478.70±81.03	3.90±5.52a*	3839.05±252.08	26.05±0.78a**	812.10±0.71a**

Mean values±standard deviations of ice creams manufacturing with duplicate samples. The letters a, b and c indicates means that significantly different at $p<0.01$ and $p<0.05$ levels

** : $p<0.01$, * : $p<0.05$

TC Terebinth coffee

samples showed similarity with each other except for $TC_{2\%}$. $TC_{2\%}$ was statistically different ($p<0.05$) from other samples.

Mg has a relation with the functions of Ca and P. It can bind to the non-phosphorylated binding sites of the caseins (De La Fuente et al. 2003). Mg values of the ice cream samples did not change with the addition of TC statistically.

Fresh fruits and vegetables are important sources of potassium (K). K is necessary for many functions of (especially it has is a key mechanism in nerve transmission) all living cells (Szefer and Nriagu 2007). Observing Table 4, K values of the ice cream samples increased with the increment of the TC addition, but this increase was not significant statistically.

Zinc (Zn) is an essential trace element for the biological activity of human beings. Zn deficiency causes many diseases including growth retardation and infection susceptibility (Hambidge and Krebs 2007). Zn concentrations of ice cream samples showed a statistically significant increase with the addition of TC. The $TC_{0.5\%}$ and $TC_{1\%}$ showed a similarity with respect to statistical evaluations. Contrary to this, control and $TC_{2\%}$ samples were different ($p<0.01$) from each other and $TC_{0.5\%}$ and $TC_{1\%}$ samples statistically.

Sodium (Na) is an important mineral for many functions of the body. It provides water balance of cells and proper functioning of both nerve impulses and muscles, and also plays a crucial role in blood pressure regulation (Szefer and Nriagu 2007). According to the statistical evaluations, control and $TC_{0.5\%}$ samples were similar to each other, while $TC_{1\%}$ and $TC_{2\%}$ samples grouped together. However, these sample groups were different ($p<0.01$) from each other statistically.

Sensory properties of the experimental ice creams

The sensory properties of the experimental ice cream samples are shown in Table 5. The highest mean scores of colour and appearance, texture and gumming structure and melting in mouth were given to the $TC_{0.5\%}$ sample by the panellists, while $TC_{1\%}$ sample had the highest mean scores of flavour, sweetness and overall acceptability. The lowest overall acceptability score was given to control sample and it was followed by $TC_{2\%}$, $TC_{0.5\%}$ and $TC_{1\%}$ samples, respectively. Statistical evaluations showed that the addition of TC at different concentrations affected the overall acceptability score at the level of $p<0.01$, while colour and appearance, texture, flavour and sweetness scores of the samples showed differences at $p<0.05$ level. However, the score for gumming structure and

Table 5 The effect of different TC concentration on some sensory properties of the ice creams (mean±SD)

Ice cream samples	Colour and appearance	Texture	Gumming structure and melting in mouth	Flavour	Sweetness	Overall acceptability
Control	7.50±0.00ab*	7.11±0.33b*	7.20±0.64	6.74±0.01c*	7.45±0.06a*	7.17±0.03b**
$TC_{0.5\%}$	7.66±0.45a*	7.75±0.23a*	7.50±0.06	7.38±0.43ab*	7.51±0.17a*	7.65±0.23a**
$TC_{1\%}$	7.25±0.18b*	7.54±0.27a*	7.36±0.06	7.47±0.25a*	7.59±0.10a*	7.69±0.98a**
$TC_{2\%}$	7.18±0.08b*	7.46±0.05ab*	7.39±0.13	6.99±0.31bc*	7.16±0.31b*	7.18±0.28b**

Mean values±standard deviations of ice creams manufacturing with duplicate samples. The letters a, b and c indicates means that significantly different at $p<0.01$ and $p<0.05$ levels

** : $p<0.01$, * : $p<0.05$

TC Terebinth coffee

melting in mouth of the samples was not affected with the addition of TC.

Conclusion

Finally, this study showed that TC was a new and functional ingredient for ice cream production due to its nutritional, physical and chemical properties. The increment of TC concentration caused an increase on the observed physico-chemical properties and colour values of the samples except for protein, pH, overrun and L^* values. Observing the organic acid profiles and mineral concentrations of ice cream samples, it was determined that citric, lactic acetic and butyric values and Ca, Cu, Mg, Fe, K, Zn and Na concentrations of the samples showed an increase with the addition of TC, while orotic and propionic acid values decreased. However, malic acid and Al were not detected in any of the ice cream samples. The sensorial parameters showed that $TC_{0.5\%}$ sample came to fore in terms of colour and appearance, texture and gumming structure and melting in mouth, while $TC_{1\%}$ was the first with respect to other sensory properties. The ice cream produced with the addition of 1 % TC was more appreciated by the panellists in terms of overall acceptability scores. The obtained results showed that TC was an important natural food additive for ice cream production due to high nutritional value, organic acid profile, mineral content and attractive flavour and colour properties.

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