CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

A COMPARATIVE STUDY ON THE PHYSICOCHEMICAL CHARACTERISTICS, ORGANIC ACID PROFILES, MINERAL COMPOSITIONS AND SENSORY PROPERTIES OF ICE CREAMS PRODUCED WITH DIFFERENT TYPES OF NUTS

ArzuKavaz Yüksel[1], İhsanGüngör Şat[2], Mehmet Yüksel[2]*, Songül Çakmakçı[2]

[1]Atatürk University, Erzurum Vocational Training School, Department of Food Technology,25030, Erzurum, TURKEY

[2]Atatürk University, Faculty of Agriculture, Department of Food Engineering, 25030, Erzurum, TURKEY

**mehmet.yuksel@atauni.edu.tr*

Article history:

Received:
18 April 2017
Accepted:
8 September 2017

Keywords:
Ice cream;
Nuts;
Minerals;
Organic acid;
Physicochemical properties.

ABSTRACT

The aim of this study was to evaluate the selected physicochemical properties, organic acid profiles, mineral compositions and sensory properties of ice creams produced with hazelnut (HIC), almond (AIC), walnut (WIC) and pistachio (PIC). Obtained results showed that all physicochemical properties, and organic acid profiles of the ice creams affected by the addition of different types of nuts at the level of $p<0.01$. Ca, Cu, Mg, K, Zn and Na were determined in all ice cream samples, while Al was not found in any of the samples. However, Fe was determined in the WIC and PIC. Observing the sensory evaluations, colour and appearance ($p<0.05$), flavour ($p<0.05$) and overall acceptability ($p<0.01$) scores of the samples showed statistically significant differences from each other. The highest overall acceptability score belonged to HIC and it was followed by WIC, AIC, control and PIC samples, respectively.

1. Introduction

Ice cream is a complex colloidal frozen system and it consists of a lot of ingredients and components including milk, fat, sweeteners, emulsifiers, stabilizers, fruits and flavouring agents, air cells, ice crystals and a continuous aqueous phase (Goff et al., 1999; Koxholt et al., 2001; Frost et al., 2005). This product is consumed fondly worldwide especially during summer months. For that reason, production of different kinds of ice cream is of great importance. In recent years, natural, functional and aromatic additives such as fruits, nuts, plants and species are used for ice cream production (Diplock et al., 1999; Granger et al., 2005).

In recent years, nuts especially hazelnut, almond, walnut and pistachio are consumed popularly by the people due to their high unsaturated fatty acid compositions, phenolic compounds, mineral contents and functional properties (Gonzalez and Salas-Salvado 2006; Shahidi and Alasalvar, 2007). Nuts are known as a nutraceutical food sources and they have relatively high amount of lipid, fibre, Vitamin E and polyphenols. The regular consumption of them can significantly reduce the total LDL cholesterol level and cardiovascular disease risk of humans. Also, they reduce the risk of coronary heart disease, some types of cancer, physiological conditions and syndromes

(Abbey et al., 1994; Yurttas et al., 2000; Monagas et al., 2007).

Hazelnut (*Corylusavellana* L.) is a member of Betulaceae family and grows in temperate climates and humid regions. It is generally located along the coasts of the Black Sea Region of Turkey, in some areas of the United States (Washington and Oregon) and in southern Europe (Italy, Spain, Portugal, and France). Also, it is cultivated in Azerbaijan, Iran, China, New Zealand, Georgia and Chile (FAO, 2008). Hazelnut is evaluated in various ways by consumers such as raw fruit or snack and the production of various foods including chocolates, bakeries, cereals, dairy products, ice creams and candies. Hazelnut is an important source of unsaturated fatty acids, fibres, vitamins, minerals and phenolic compounds. It contains approximately 50–73% fat that is consisted of linoleic, linolenic, oleic, palmitic and stearic acids. For that reason, hazelnut and its oil is an important nutrient for human diet (Alphan et al., 1997; Özdemir and Akıncı, 2004; Köksal et al., 2006; Oliveira et al., 2008).

Almond (*Amygdaluscommunis* L.) is a member of Prunus belonging to the Rosaceae family. It is a perennial plant and grown in cold and temperate regions. The production of almond is focused in three regions of the world. These are Asian and Mediterranean countries, California and in limited amounts in Australia, South Africa, Chile and Argentina (Aslanta and Güleryüz, 2001). Lipid is the main component of almond seeds constituting the approximately 50% of the total weight of the seeds (Ren et al., 2001). Moreover, almond is rich with respect to phytochemicals, vitamin E, monounsaturated fatty acids, polyunsaturated fatty acids, arginine and potassium (Mandalari et al., 2010).

Walnut (*Juglansregia* L.) is a member of Juglandaceae family and it is one of the most important types of nuts in temperate regions (Ozcan, 2009). Walnut is an important nut for human nutrition and food industry in terms of organoleptic characteristics and health benefits. Walnut had beneficial effects on blood lipid and cholesterol levels of human due to its high poly unsaturated fatty acids content. These fatty acids reduce the risk of heart disease by decreasing total and LDL-cholesterol and increasing HDL-cholesterol level of blood. Health benefits of walnut stem from its chemical composition and they are important sources of essential fatty acids. The major fatty acid of walnuts is linoleic acid and is followed by oleic, linolenic, palmitic and stearic acids, respectively. It also contains important components including protein, carbohydrates, vitamins, pectic substances, minerals and phytochemicals (Amaral et al., 2003; Tapsell et al., 2004; Davis et al., 2007; Arranz et al., 2008; Pereira et al., 2008).

Pistachio nut (*Pistaciavera* L.) is one of the favourite kinds of nuts and only edible product of 11 genus of Pistacia. It is widely grown in the Middle East, Mediterranean countries and United States. On the other hand, Turkey is one of the important pistachio nut producers of the world (Shokraii and Esen, 1988; Kashaninejad et al., 2005). Pistachio nut is consumed by the consumers in different ways. It is generally consumed directly as snack, while it can be used for the preparation of confectionery, cakes, deserts, ice creams and chocolates (Peyman et al., 2013).

Organic acids are important components of dairy products and other foods adding to their flavour, stability and other quality characteristics. They occur in dairy products and foods during fermentation of carbohydrates, hydrolysis of fat, microbial activity during production or storage and addition of organic acids (Fernandez-Garcia and McGregor, 1994; Tormo and Izco, 2004). The determination of organic acids found in foods is extremely important with respect to determination of negative microbial activity and changes in quality parameters of final product (Gonzalez de Liano et al., 1996; Adhikari et al., 2002).

Minerals are important food components for human nutrition and health. Mineral deficiency may cause many important diseases in humans. On the other hand, minerals have beneficial effects in small quantities, while they can be harmful if they exceed the limit values must be present in foods (Rodriguez Rodriguez et al., 2002; Caggiano et al., 2005).

The aim of this research was to quantify the changes in physicochemical properties, colour values, organic acid profiles, mineral compositions and organoleptic qualities of ice creams produced with different types of nuts. For this purpose, hazelnut, almond, walnut, and pistachio were used for ice cream production and ice creams were analysed in terms of specified parameters. As a result of this study, tried to determine that the advantage of different types of nuts against each other and to determine which one is the best for ice cream production in terms of quality parameters.

2. Materials and methods

2.1. Materials

Bovine milk and cream were supplied from the dairy farm of Atatürk University located in Erzurum, Turkey. Hazelnut, almond, walnut, and pistachio were used as the materials in ice cream production and they were purchased from a local shop in Erzurum, Turkey. Skim Milk Powder (SMP) was provided by Pınar Dairy Products Co., Turkey, while sugar, emulsifier (mono- and diglycerides) and sahlep or salep were purchased from local markets.In this study, sahlep was obtained by powdering of dried tubers of wild orchids from Kahramanmaraş city. It was used as a stabilizer in ice creamproduction for obtaining high water holding capacity, high consistencyand viscosity.

2.2. Manufacture of experimental ice creams

In this study, ice cream preparation was done as duplicate. For the production of each party of ice cream mix, milk was divided into five equal parts to make 3 kg of ice cream mix. Mixes were produced including 5% fat, 4.7% skim milk powder, 18% sugar, 0.6% sahlep (stabilizer) and 0.2% emulsifier (mono- and diglycerides). They were pasteurized at 85°C for 25 s and cooled to 4°C, and stored for 24 hours at 4°C for maturation. Then, all nuts were minced into small pieces (almost equal size)using a cutter at the same speed and time in order to add to the mixes and were added to each mix at the level of 7%, separately. The first mix was taken as the control and the remaining batches were prepared with hazelnut (HIC), almond (AIC), walnut (WIC) and pistachio (PIC). After all these steps, ice cream mixes were iced in ice cream machinery (-5°C; Ugur Cooling Machineries Co., Nazilli, Turkey) and hardened at -22°C for 24 h and then stored at -20°C for analyses.

2.3. Physicochemical analysis of experimental ice creams

Total solid, ash, fat, titratable acidity and pH values of experimental ice creams were determined by the method of Demirci and Gündüz (1994). The pH was measured with a pH meter (model WTW pH-340-A, Weilheim, Germany) fitted with a combined glass electrode (Demirci and Gündüz, 1994). Viscosity value was measured at 15°C by a digital Brookfield Viscometer, using a spindle LV-4, Model DV-II (Brookfield Engineering Laboratories, Stoughton, MA, USA).The temperature control of the samples was performed using a cooler (±15°C) during the measurement. Overrun was found by the equation [(weight of mix)-(weight of ice cream)/weight of mix×100]. For this purpose, a standard 100 mL cup was used to measure both the weight of ice cream mix and ice cream (Jimenez-Florez et al., 1993). First dripping and complete melting times of ice cream samples were determined according to the method by Guven and Karaca (2002). For this analysis, hardened ice cream sample (25 g) was left on a 0.2 cm wire mesh screen above a beaker at room temperature (approximately 20°C) and first dripping and complete melting times of samples were found as seconds.

2.4. Colour analysis of experimental ice creams

Colour values of ice cream samples were determined in triplicate using a Minolta colorimeter (CR-200; Minolta Co., Osaka, Japan). These parameters were measured in port size of 20x15x10 cm with pulsed xenon arc lamp built into measuring head by CIE standard observer curves at room temperature and found *L**(lightness; 100=white, 0=black), *a** (redness; ±, red; -, green), and *b** (yellowness; ±, yellow; -, blue) colour parameters of the ice cream samples.

2.5. Organic acid analysis of experimental ice creams

Organic acid profiles of the ice cream samples were determined by the modified methods of Fernandez-Garcia and McGregor (1994) and Akalın et al. (2004) and for this purpose, a high-performance liquid chromatography (Agilent HPLC 1100 series G 1322 A, Germany) was used. At first, 4g ice cream sample was dissolved with 0.001 N H_2SO_4(25 mL) and centrifuged at the 5000x*g* for 10 min. Then, supernatant was filtered from Whatman No.1 filter paper and 0.45 μm membrane filter (PALL, USA), respectively. For each sample, 2 mL aliquot was stored in HPLC vials at -20ºC for HPLC analysis. 0.001 N H_2SO_4 was used as mobile phase at a flow rate of 0.6 mL/minute and the wavelength of detection was 210 nm for the quantification of organic acids. Duplicate injections (approximately 10 μL) were performed for each sample and the standard solutions of citric, orotic, malic, lactic, acetic, propionic and butyric acids were prepared in 0.001 N $H_2SO_4$for the detection of elution times and to prepare the calibration curves.

2.6. Mineral analysis of experimental ice creams

Mineral contents of the ice cream samples were determined by an Inductively Coupled Plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT, USA) (Rodriguez Rodriguez et al., 2002, Caggiano et al., 2005; Güler, 2007). For this purpose, the ice cream samples were dried in microwave oven (Berghof speed wave, Germany) at 70ºC until the dry matter contents of the samples were at a constant value. At first, approximately 0.5 g of ice cream samples 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, and then samples were kept overnight in this way. After this period, the temperature of the samples was increased slowly to 160-170ºC by a hot-plate until the white smoke appeared. Finally, the samples were diluted with 50 mL with distilled water and filtered through the Whatman no. 42 filter paper in flask and the volumes of the samples were completed to 50 mL. All samples were analysed using an Inductively Coupled Plasma Spectrophotometer (ICP-OES) and the results were expressed as ppm.

2.7. 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.

3.Results and discussions

3.1. General physicochemical characteristics of experimental ice creams

The results of total solids, ash, fat and protein values of the ice cream samples are presented in Table 1. The highest mean values of fat and protein were found in sample AIC and it was followed by WIC, HIC, PIC and control samples, while the highest mean total solids value was determined in PIC and followed by AIC, WIC, HIC and control samples. According to the statistical evaluations, there were statistically significant differences among the samples ($p<0.01$) with respect to quality characteristics. These determined differences among the ice creams can be explained by using different types of nuts.

As seen in Table 1, there were statistically significant differences ($p<0.01$) among the ice cream samples in terms of pH values. The pH values of control and WIC samples showed a similar trend with respect to statistical evaluations, while, HIC, AIC and PIC samples showed differences from each other and other ice cream samples (control and WIC) at the level of $p<0.01$. Observing Table 1, the highest mean pH value was found in AIC, although the lowest mean value was determined in PIC sample. These obtained results showed compliance with the organic acid profiles of nuts and ice cream samples.

According to Table 1, the highest mean viscosity value was found in WIC (11975 cP) and it was followed by PIC (11863 cP), AIC (3880 cP), HIC (3320 cP) and control (2773 cP), respectively. As seen in Table 1, WIC and PIC samples showed similar values in terms of viscosity changes, while other ice cream samples were completely different ($p<0.01$) from each other, and WIC and PIC samples statistically.Although all of the nuts were minced in equal size and added to the mixes in equal amounts, their different structural properties and hardness prevented forming homogenous mixture in the ice cream mixes.AIC and HIC remain hard and grain-structured in the ice cream mixes so, they are not effective in increasing the viscosity of mixes.This situation might occur as a result of the different structural characteristics, fibre, oil, mucilaginous compound contents of using nuts for ice cream production (El–Samahy et al., 2009).

Overrun (OR) is an increase in the volume of ice cream mix and this value shows the amount of air in the ice cream (Sofjan and Hartel, 2004). In the ice cream samples, the highest mean value of overrun (34.62%) was found in WIC sample and the lowest value (25.10%) was determined in the HIC sample. This situation might occur due to the fibre content, structural properties, oil contents and water binding capacities of using nuts. As seen in Table 1, control, AIC, WIC and PIC samples showed a similar trend with respect to statistical evaluations, although HIC sample was completely different ($p<0.01$) from them statistically.

The longest mean first dripping time and complete melting time values were found in HIC and followed by control, AIC, PIC and WIC samples, respectively (Table 1). The statistical evaluations showed that first dripping time values of C and HIC were similar to each other; and WIC and PIC samples showed a similar trend with respect to statistical evaluations. Contrary to this situation, this sample groups showed statistically significant differences ($p<0.01$) from in each other and AIC sample. On the other hand, AIC and PIC samples were similar in terms of complete melting time values, while control, HIC and WIC samples were found different from each other and AIC and PIC samples at the level of $p<0.01$. The differences in the first dripping and complete melting time values of the samples might be due to the different properties of nuts, the amount of air found in the mixes and treatments applied to the mixes (mixing and hardening process) (Sakurai et al., 1995; Sofjan and Hartel, 2004).

3.2.Colour values of the experimental ice creams

Visual and sensory parameters of foods affect the consumer demands on them. Accordingly, determination of colour and sensory parameters of food products carries more importance. As seen in Table 2, the highest mean values of $L*$ (87.42) was found in control sample, and the lowest mean value (71.32) was determined in the WIC sample. The $L*$ values of the ice creams were found completely different (p<0.01) from each other statistically. The highest mean value (-0.37) of $a*$ was determined in HIC and it was followed by WIC (-0.80), AIC (-0.86), control (-3.72) and PIC (-4.97) samples, respectively. According to the statistical evaluations HIC, AIC and WIC samples were similar in terms of $a*$colour values. Conversely, control and PIC showed statistically significant differences (p<0.01) from each other and this sample group. The highest $b*$ value was determined in the PIC (23.56) sample and this sample was followed by samples of AIC (15.30), WIC (14.77), HIC (14.47) and control (13.21), respectively. The $b*$ values of the AIC and WIC samples showed a similar trend with respect to statistical evaluations, although the control, HIC and WIC samples differed from each other and the other samples (p<0.01) statistically (Table 2).

3.3.Organic acid profiles of the nuts and experimental ice creams

The organic acid profiles of different types of nuts and ice cream samples are presented in Table 3 and Table 4. Citric acid is a weak organic acid and is found naturally in several fruits. It can be found in small quantities in milk and dairy products (Fernandez-Garcia and McGregor, 1994). As seen in Table 3, the highest mean concentration of citric acid was found in pistachio and it was followed by walnut, hazelnut and almond, statistically. All of the nuts showed statistically significant differences (p<0.01) from each other. Otherwise, the lowest mean concentration of citric acid was found in the AIC (35.69±0.91), while the highest mean value was determined in PIC (40.72±0.71) (Table 4). The obtained results showed parallelism with the organic acid profiles of nuts. According to statistical evaluations, HIC and AIC showed a similar trend, but control, WIC and PIC samples were completely different (p<0.01) from each other and HIC and AIC samples statistically. Orotic acid occurs during the biosynthesis of nucleic acids. It can be found in milk and dairy products in important quantities (Okonkwo and Kinsella, 1969; Fernandez-Garcia and McGregor, 1994; Güzel-Seydim et al., 2000; Kavaz and Bakirci, 2014). Observing Table 3, the highest mean concentration of orotic acid was found in walnut, while it was not detected in hazelnut and almond. Statistical evaluations showed that hazelnut, almond and pistachio were similar to each other, while walnut were found completely different (p<0.01) from them statistically (Table 3). As seen in the orotic acid concentrations of ice cream samples, the highest mean value was found in WIC and followed by PIC, control, AIC and HIC samples, respectively. Observing Table 4, control, WIC and PIC were similar and HIC and AIC showed similarity in terms of statistical evaluations. Contrary to this, sample groups showed differences from each other at the level of p<0.01. Malic acid is known as dicarboxylic acid and is generally used as flavouring agent and food additive in foods (Sniffen et al., 2006). The highest mean value of malic acid was determined in hazelnut, while it was not detected in walnut. Almond and pistachio were found similar in terms of malic acid concentration, while hazelnut and walnut showed significant differences ($p<0.01$) from each other and other nuts statistically (Table 3). As seen in Table 4, the highest mean malic acid value was determined in HIC and it was followed by PIC, respectively. Conversely, malic acid was not found in control, AIC and WIC samples. Statistical evaluations showed that control, AIC and WIC samples were similar, but HIC and WIC samples showed statistically significant differences ($p<0.01$) in between and from other samples (Table 4). Lactic acid is the most important organic acid. It is generally found in significant amounts in milk, and fermented dairy products (Tormo and Izco, 2004; Kavaz and Bakirci, 2014). Observing Table 3, the highest mean value of lactic acid was determined in pistachio and it was followed by hazelnut, walnut and almond, respectively. According to the statistical evaluations, hazelnut, almond and walnut showed a similar trend, but pistachio was completely different ($p<0.01$) from them statistically (Table 3). The mean lactic acid values of ice cream samples ranged between 2.49 µg/g (control) and 254.4 µg/g (PIC) (Table 4). As seen in Table 4, AIC and WIC were similar with respect to statistical evaluations. Contrary to this, control, HIC and PIC samples showed differences from each other and AIC and WIC samples at the $p<0.01$ level. Acetic acid is a natural organic acid and occurs as an intermediate substance in the metabolism of plants and animals (Sholberg and Gaunce, 1995; Kavaz and Bakirci, 2014). As seen in Table 3, the highest mean acetic acid value was found in hazelnut and followed by walnut, almond and pistachio, respectively. Statistical evaluations showed that all of the nuts were statistically different ($p<0.01$) from each other. Observing Table 4, the highest mean acetic acid value was in WIC (1.91 µg/g), while it was not determined in other ice cream samples. According to the statistical evaluations all ice cream samples except for WIC showed similarity, while the differences of WIC from other samples was at the level of $p<0.01$.

Propionic acid can be formed naturally in the metabolism of human, animal and some plants. Propionic acid is widely used as a fungicide and bactericide for controlling the microbial activity in foods, feeds and pharmaceuticals (Anonymous, 1991). The highest mean value of propionic acid was in pistachio and followed by almond. Contrary to this, propionic acid was not found in other nuts. Pistachio was found statistically different ($p<0.01$) from hazelnut, almond and walnut (Table 3). As seen in Table 4, the highest mean value of propionic acid was in PIC, while it was not determined in control and HIC samples. The control and HIC were statistically similar and WIC and PIC showeda similar trend with respect to propionic acid values. These sample groups were statistically significantly different ($p<0.01$) form each other and from sample AIC (Table 4). Butyric acid is formed as a result of microbial activity, hydrolysis of milk fat, deamination of amino acids and during the anaerobic fermentation (Molkentin, 1998).

Table 1. The effect of different types of nuts on pysico-chemical properties of ice creams (mean±sd)

Icecream samples	Total solids (%)	Fat (%)	Protein (%)	pH	Viscosity (cP) 50 rpm	Over run (%)	First dripping times (s)	Complete melting times (s)
Control	41.23±0.12c**	5.30±0.12c**	5.31±0.21c**	6.68±0.01c**	2773±133.03d**	33.47±1.71a**	533±33.01a**	3039±838.94b**
HIC	41.62±0.47c**	6.20±0.23bc**	5.88±0.16b**	6.73±0.02b**	3320±456.36c**	25.10±0.61b**	545±71.94a**	6226±15.37a**
AIC	43.31±0.13b**	7.60±1.08a**	6.67±0.56a**	6.79±0.03a**	3880±543.98b**	32.40±2.01a**	443±28.87b**	2808±66.48bc**
WIC	43.19±0.12b**	7.30±1.05ab**	6.02±0.02b**	6.69±0.02c**	11975±95.45a**	34.62±2.98a**	372±22.25c**	2349±37.74c**
PIC	44.93±0.55a**	5.85±0.60c**	5.82±0.38b**	6.64±0.01d**	11863±313.13a**	31.80±0.23a**	406±26.36bc**	2603±20.35bc**

Table 2. The effect of different types of nuts on the colour parameters of ice creams (mean±sd)

Icecreamsamples	L*	a*	b*
Control	87.42±1.39a**	-3.72±0.18b**	13.21±0.29c**
HIC	77.42±0.63c**	-0.37±0.22a**	14.47±0.22bc**
AIC	82.40±0.85b**	-0.86±0.34a**	15.30±0.90b**
WIC	71.32±1.46e**	-0.80±0.16a**	14.77±0.39b**
PIC	74.20±1.33d**	-4.97±0.70c**	23.56±1.65a**

Table 3. Organic acid profiles of different types of nuts that used for the ice cream production (mean±sd)

Nuts	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)
Hazelnut	58.74±8.90b**	0.00±0.00b**	481.48±6.08a**	5.04±1.10b**	55.62±33.66c**	0.00±0.00b**	0.00±0.00
Almond	39.50±0.54c**	0.00±0.00b**	42.78±0.44b**	0.61±0.14b**	4.22±1.67b**	0.56±0.07b**	0.00±0.00
Walnut	72.00±1.50d**	0.24±0.10a**	0.00±0.00c**	3.24±1.27b**	144.79±2.59d**	0.00±0.00b**	0.00±0.00
Pistachio	84.89±1.97a**	0.02±0.01b**	40.30±1.26b**	3275.50±155.43a**	0.00±0.00a**	5.40±1.11a**	0.00±0.00

Table 4. The effect of different types of nuts on the organic acid profiles of the ice creams (mean±sd)

Ice cream samples	Citricacid (µg/g)	Oroticacid (µg/g)	Malicacid (µg/g)	Lacticacid (µg/g)	Aceticacid (µg/g)	Propionicacid (µg/g)	Butyricacid (µg/g)
Control	32.92±0.72d**	6.96±0.23a**	0.00±0.00c**	2.49±1.53d**	0.00±0.00b**	0.00±0.00c**	4.68±0.50bc**
HIC	35.76±1.39c**	6.62±0.13b**	37.77±0.71a**	12.76±0.07b**	0.00±0.00b**	0.00±0.00c**	6.62±0.46a**
AIC	35.69±0.91c**	6.65±0.13b**	0.00±0.00c**	4.31±0.52c**	0.00±0.00b**	10.62±1.82b**	4.54±0.48c**
WIC	37.22±0.48b**	7.15±0.18a**	0.00±0.00c**	4.35±0.40c**	1.91±0.69a**	12.14±0.23a**	4.40±0.84c**
PIC	40.72±0.71a**	7.08±0.16a**	4.82±0.35b**	254.41±1.09a**	0.00±0.00b**	12.75±0.30a**	5.62±0.75b**

Table 5. Mineral composition of different types of nuts used for the ice cream production (mean±sd)

Nuts	Ca (ppm)	Al (ppm)	Cu (ppm)	Mg (ppm)	Fe (ppm)	K (ppm)	Zn (ppm)	Na (ppm)
Hazelnut	1559.35±149.84b**	0.00±0.00	12.95±1.34ab**	2056.00±85.70b**	0.00±0.00c**	4850.15±464.78b**	18.50±0.42c**	53.65±2.19a**
Almond	1614.65±68.24b**	0.00±0.00	8.35±0.78c**	1557.55±85.06c**	0.30±0.42c**	7312.10±328.24a**	21.60±0.28c**	36.20±4.38b**
Walnut	1296.10±110.73b**	0.00±0.00	14.30±0.57a**	1865.45±144.32b**	4.25±6.01b**	3476.95±562.79c**	36.20±2.83a**	33.00±1.84b**
Pistachio	2581.15±224.36a**	0.00±0.00	10.60±0.57bc**	3127.15±109.53a**	26.85±4.17a**	5868.85±293.80b**	31.50±0.00b**	33.50±1.56b**

Table 6. The effect of different types of nuts on the mineral composition of ice creams (mean±sd)

Icecreamsamples	Ca (ppm)	Al (ppm)	Cu (ppm)	Mg (ppm)	Fe (ppm)	K (ppm)	Zn (ppm)	Na (ppm)
Control	4674.05±514.00a**	0.00±0.00	9.15±10.20b*	455.40±1.41d**	0.00±0.00b*	3766.35±173.74b*	26.05±0.7a**	678.30±2.55d**
HIC	2236.80±304.34b**	0.00±0.00	9.00±0.28b*	614.15±28.21c**	0.00±0.00b*	2876.40±181.30c*	14.05±0.21d**	806.10±4.81a**
AIC	4065.60±33.23a**	0.00±0.00	4.95±0.64b*	658.50±39.17bc**	0.00±0.00b*	4571.15±290.13a*	14.20±0.14d**	794.85±7.00a**
WIC	2935.40±229.81b**	0.00±0.00	23.85±2.05ab*	736.40±72.69b**	0.95±1.34b*	3796.55±476.24b*	22.95±0.07b**	750.00±2.97c**
PIC	3962.40±325.41a**	0.00±0.00	5.60±0.42b*	974.55±8.13a**	6.05±8.56a*	3633.90±43.98b*	17.95±0.07c**	777.45±7.42b**

Table 7. The effect of different types of nuts on some sensory properties of ice creams (mean±sd)

Icecream Samples	Colour andappearance	Texture	Gummingstructureandmelting in mouth	Flavour	Sweetness	Overallacceptability
Control	7.50±0.00ab*	7.11±0.33	7.20±0.64	6.74±0.01b*	7.45±0.06	7.17±0.03b**
HIC	7.68±0.14ab*	7.65±0.23	7.70±0.29	7.92±0.42a*	7.83±0.43	7.77±0.15a**
AIC	7.21±0.70b*	7.00±0.69	7.20±0.46	7.00±0.58b*	7.24±0.62	7.26±0.18b**
WIC	7.39±0.44ab*	7.53±0.61	7.37±0.05	6.86±0.53b*	7.39±0.33	7.35±0.23b**
PIC	7.92±0.21a*	7.70±0.17	7.37±0.32	6.63±0.72b*	7.56±0.30	7.06±0.33b**

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

According to Table 3, butyric acid was not determined in all nuts. As seen in Table 4, the highest mean value was determined in HIC and it was followed by PIC, control, AIC and WIC, respectively. According to the statistical evaluations, AIC and WIC were similar, while other samples were statistically different ($p<0.01$) from each other and this two ice cream samples.

Obtained results showed that organic acid profiles of ice cream samples showed compliance with the organic acid values of used nuts for ice cream production.

3.4. Mineral composition of the nuts and experimental ice creams

Mineral composition of the different types of nuts and ice cream samples were shown in Table 5 and Table 6, respectively.

In the nuts, the highest mean concentration of calcium (Ca) was found in pistachio and the lowest value was determined in the walnut. Pistachio was found statistically different ($p<0.01$) from other nuts (Table 5). As seen in Table 6, the highest mean Ca value was in control and followed by AIC, PIC, WIC and HIC, respectively. The Ca values of the control, AIC and PIC samples were similar to each other, likewise HIC and WIC samples showed a similar trend with respect to statistical evaluations, whereas these two sample groups were completely different ($p<0.01$) from each other statistically (Table 6). In this research, aluminum (Al) was not determined in any types of nuts and in any ice cream samples.

Observing Table 5, the highest mean value of copper (Cu) was determined in walnut and it was followed by hazelnut, pistachio and almond, respectively. Statistical evaluations showed that all of the nuts were different from each other at the level of $p<0.01$. As seen in Table 6, the highest mean values of Cu were found in WIC, and the lowest mean value was determined in the AIC sample. The Cu contents of control, HIC, AIC and PIC samples were similar to each other, although WIC showed differences ($p<0.05$) from them statistically.

As seen in the magnesium (Mg) content of the nuts, the highest mean value was in pistachio and followed by hazelnut, walnut and almond, respectively. Hazelnut and walnut were statistically similar in terms of Mg amounts, while almond and pistachio were different ($p<0.01$) in between and from hazelnut and walnut (Table 5). As seen in Table 6, the highest mean value of Mg was determined in PIC, whereas the lowest mean value was determined in control sample. According to statistical evaluations, all ice cream samples showed statistically significant ($p<0.01$) differences to each other (Table 6).

Iron (Fe) values of the nuts were determined as 26.85 ppm (pistachio), 4.25 ppm (walnut), 0.30 ppm (almond) and 0.00 ppm (hazelnut), respectively (Table 5). Hazelnut and almond showed a similar trend with respect to the statistical evaluations. Conversely, walnut and pistachio were different ($p<0.01$) in between and two other nuts statistically (Table 5). As seen in Table 6, the highest mean value was found in PIC, but Fe was not detected in three ice cream samples (control, HIC and AIC). All ice cream samples, except for PIC ($p<0.05$), showed similarity in terms of statistical evaluations (Table 6).

In the nuts, the highest mean concentration of potassium (K) was found in almond and followed by pistachio, hazelnut and walnut, respectively. Observing Table 5, hazelnut and pistachio were similar with respect to statistical evaluations. Contrary to this, almond and walnut were different from each other and from other nuts at the $P<0.01$ level. As seen in Table 6, the mean K values of ice cream samples ranged between 4571.15 ppm (AIC) and 2876.40 ppm

(HIC). According to statistical evaluations, control, WIC and PIC were similar and HIC and AIC were completely different ($p<0.05$) from each other and WIC and PIC samples statistically (Table 6).

The highest mean value (36.20 ppm) of zinc (Zn) was found in the walnut and the lowest mean value (18.50) was determined in hazelnut. Hazelnut and almond were similar statistically, while walnut and pistachio showed differences ($p<0.01$) from each other and other nuts statistically (Table 5). Observing Table 6, Zn concentrations of samples changed between the 26.05 ppm (control) and 14.05 ppm (HIC). HIC and AIC samples were found similar with respect to Zn concentrations, while other ice cream samples were completely different ($p<0.01$) from each other and HIC and AIC samples statistically.

Sodium (Na) values of the nuts were determined as 53.65 ppm (hazelnut), 36.20 ppm (almond), 33.50 ppm (pistachio) and 33.00 ppm (walnut), respectively. According to statistical evaluations, almond, walnut and pistachio were similar to each other, but these sample groups were statistically different ($p<0.01$) from hazelnut (Table 5). The highest mean value of Na was determined in HIC and it was followed by AIC, PIC, WIC and control samples, respectively. Observing the statistical evaluations, the HIC and AIC could be grouped together. Conversely, control, WIC and PIC samples were found statistically different ($p<0.01$) from each other and HIC and AIC samples.

From these results it might be said that K was the highest concentration mineral component that was found in the observed hazelnut, almond, walnut and pistachio, and it was followed by Mg, Ca, Na, Zn, Cu, Fe, respectively. As seen in the mineral amounts of the ice creams the most important one of the observed minerals was Ca and followed by K, Na, Mg, Zn, Cu, Fe, respectively. Generally, the mineral profiles of nuts and ice cream samples showed a compliance with each other. Obtained differences might stem from the milk, ingredients, used containers, storage and from other environmental factors.

3.5.Sensory properties of the experimental ice creams

The effect of different types of nuts on the sensory characteristics of experimental ice cream samples were presented in Table 7. PIC sample was appreciated in terms of colour and appearance, texture and gumming structure by the panellists, while the highest mean scores of gumming structure and melting in mouth, flavour, sweetness and overall acceptability scores were given to HIC sample. Statistical evaluations showed that the effects of different types nuts on the colour, appearance and flavour scores of the samples were at the level of $p<0.05$, while their effects on the overall acceptability scores were at $p<0.01$ level. However, other sensory parameters of the ice cream samples were not affected statistically by the addition of different types of nuts. As seen in Table 7, control, HIC, and PIC samples showed similarity in terms of colour and appearance scores, while AIC and PIC samples were found different ($p<0.05$) from each other and from other ice creams statistically. However, HIC sample showed statistically significant differences from control, AIC, WIC and PIC samples with respect to flavour ($p<0.05$) and overall acceptability ($p<0.01$) scores (Table 7).

4. Conclusions

Finally, the obtained results showed that using different types of nuts (Hazelnut, almond, walnut and pistachio) for ice cream production caused significant effects on the majority of observed quality characteristics of ice creams. Addition of nuts caused an increase on the physicochemical properties and colour values of samples except for pH (PIC), overrun (HIC, AIC and PIC), first dripping (AIC, WIC and PIC) and complete melting time values (AIC, WIC and PIC), *L** (HIC, AIC, WIC and PIC) and *a** (PIC) values. From the obtained results, it might be said that the organic acid profiles and mineral composition of ice cream samples showed generally a compliance with the organic acid values and mineral amounts of nuts that were used for ice cream production. Generally, HIC and PIC samples came to fore with respect to observed sensory quality characteristics of ice creams. However, the highest overall acceptability score belonged to the hazelnut added ice cream sample. The obtained results also showed that each of the nuts gavedifferent values to the ice creams and they can be considered as suitable natural additives for ice cream production due to their nutritional values, flavour properties, organic acid profiles and mineral compositions.

5.References

Abbey, M., Noake, M., Belling, G.B.,Nestel, P.J. (1994). Partial replacement of saturated fatty acids with almonds or walnuts lowers total plasma cholesterol and low-density-lipoprotein cholesterol. *American Journal of Clinical Nutrition*, 59, 995-9.

Adhikari, K., Grun, I. U., Mustapha, A., Fernando, L.N. (2002). Changes in the profile of organic acids in plain set and stirred yogurts during manufacture and refrigerated storage. *Journal of Food Quality*,25, 435-51.

Akalin, A.S., Fenderya, S., Akbulut, N.(2004). Viability and activity of bifidobacteria in yoghurt containing fructooligosaccharide during refrigerated storage. *International Journal of Food Science and Technology*, 39, 613-21.

Alphan, E., Pala, M., Açkurt, F., Yilmaz, T. (1997). Nutritional composition of hazelnuts and its effects on glucose and lipid metabolism. *Acta Horticulturae*, 445, 305-10.

Amaral, J.S., Casal, S., Pereira, J., Seabra, R., Oliveira, B. (2003). Determination of sterol and fatty acid compositions, oxidative stability, and nutritional value of six walnut (*Juglansregia* L.) cultivars grown in Portugal. *Journal of Agricultural and Food Chemistry*, 51, 7698–702.

Anonymous.(1991). R.E.D FACTS, Propionic acid, United States Environmental Protection Agency, Pesticides and toxic substances, 738, 91-106.

Arranz, S., Cert, R., Perez-Jimenez, J., Cert, A., Saura-Calixto, F. (2008). Comparison between free radical scavenging capacity and oxidative stability of nut oils. *Food Chemistry*, 110, 985-990.

Aslanta, R., Güleryüz, M. (2001). Almond selection in microclimate areas of northeast Anatolia. In: Ak B.E. (ed.) 11 GREMPA Seminar on pistachios and almonds. *Cahiers Options Méditerranéennes*, 56, 339-342.

Caggiano, R., Sabia, S., D'Emilio, M., Macchiato, M., Anastasio, A., Ragosta,

M., Paino, S. (2005). Metal levels in fodder, milk, dairy products, and tissues sampled in ovine farms of Southern Italy. *Environmental Research*, 99, 48–57.

Davis, L., Stonehouse, W., Loots, D.T., Mukuddem-Petersen, J., Van Der Westhuizen, F., Hanekom, S.J., Jerling, J.C. (2007). The effects of high walnut and cashew nut diets on the antioxidant status of subjects with metabolic syndrome. *European Journal of Nutrition*, 46, 155–64.

Demirci, M., Gunduz, H.H. (1994). In Dairy Hand Book (p. 66), Istanbul, Hasad Publ.

Diplock, A.T., Aggett, P.J., Ashwell, M., Bornet, F., Fern, E.B., Roberfroid, M.B. (1999). Scientific concepts of functional foods in Europe: Consensus document. *British Journal of Nutrition*, 81, 1–27.

El–Samahy, S.K., Youssef, K.M., Moussa–Ayoub, T.E. (2009). Producing ice cream with concentrated cactus pear pulp: A preliminary study. *Journal of the Professional Association for Cactus Development*, 11, 1–12.

FAO (Food and Agriculture Organization). 2008. http://www.faostat.fao.org.tr.

Fernandez-Garcia, E., Mcgregor, J.U.(1994). Determination of organic acids during the fermentation and cold storage of yogurt. *Journal of Dairy Science*, 11, 2934-9.

Frost, M.B., Heymann, H., Bredie, W.L.P., Dijksterhuis, G.B., Martens, M. (2005). Sensory measurement of dynamic flavour intensity in ice cream with different fat levels and flavourings. *Food Quality and Preference*, 16, 305-14.

Goff, H.D., Verespej, E., Smith, A.K. (1999). A study of fat and air structures in ice cream. *International Dairy Journal*, 817-29.

Gonzalez De Liano, D., Rodrriguez, A., Cuesta. (1996). Effect of lactic starter cultures on the organic acid composition of milk and cheese during ripening-analysis by HPLC. *Journal of Applied Microbiology,* 80, 570-6.

González, C.A., Salas-Salvadó, J.(2006). The potential of nuts in the prevention of cancer. *British Journal of Nutrition*, 96, 87-94.

Granger, C., Leger, A., Barey, P., Langendorff, V., Cansell, M. (2005). Influence of formulation on the structural networks in ice cream. *International Dairy Journal*,15, 255–62.

Güler, Z. (2007). Levels of 24 minerals in local goat milk, its strained yoghurt and salted yoghurt (tuzluyoğurt). *Small Ruminant Research,* 71, 130–7.

Guven, M., Karaca, O.B. (2002). The effects of varying sugar content and fruit concentration on the physical properties of vanilla and fruit ice-cream-type frozen yogurts. *International Journal of Dairy Technology,* 55(1), 27-31.

Güzel-Seydim, Z.B., Seydim, A.C., Grene, A.K.(2000). Organic acids and volatile flavour components evolved during refrigerated storage of kefir. *Journal of Dairy Science*, 83, 275-277.

Jimenez-Florez, R., Klipfel, N.J., Tobias, J. (1993). Ice cream and frozen desserts. In Dairy Science and Technology Handbook Hui Y. H. (Ed.), Product manufacturing. VCH Publishers, New York 2, 57-159.

Kashaninejad, M., Mortazavi, A., Safekordi, A., Tabil L.G. (2005). Some physical properties of pistachio (*Pistaciavera* L.) nut and its kernel. *Journal of Food Engineering*, 72(1), 30-8.

Kavaz, A., Bakirci, I. 2014. Influence of inulin and demineralised whey powder addition on the organic acid profiles of probiotic yoghurts. *International Journal of Dairy Technology*, 67(4), 577–83.

Koxholt, M.M.R., Eisenmann, B., Hinrichst, J. (2001). Effect of the fat globule sizes on the meltdown of ice cream. *Journal of Dairy Science*, 84, 31–7.

Köksal, A.İ., Artik, N., Şimşek, A., Güneş, N. (2006). Nutrient composition of hazelnut (*Corylusavellana* L.) varieties cultivated in Turkey. *Food Chemistry*, 99, 509-515.

Monagas, M., Garrido, I., Lebron-Aguilar, R. (2007).Almond [(*Prunusdulcis* (Mill.) D.A. Webb] skins as a potential source of bioactive polyphenols. *Journal of Agricultural and Food Chemistry*, 55, 8498-507.

Molkentin, J., Precht, D. (1998). Comparison of gas chromatographic methods for analysis of butyric acid in milk fat and fats containing milk fat. *European Food Research and Technology*, 206, 213-6.

Mandalari G, Tomaino A, Arcoraci T, Martorana M, Turco VL, Cacciola, F.(2010). Characterization of polyphenols, lipids and dietary fibre from almond skins (*Amygdaluscommunis* L.). *Journal of Food Composition and Analysis*, 23, 166-74

Okonkwo, P., Kinsella, J. (1969). Orotic acid in food milk powders. *American Journal of Clinical Nutrition*, 22, 532.

Oliveira, I., Sousa, A., Sa´ Morais, J., Ferreira, I.C.F.R., Bento, A., Estevinho, L., Pereira, J.A. (2008). Bioactive properties and chemical composition of six walnut (*Juglansregia* L.) cultivars. *Food and Chemical Toxicology*, 46, 1801-7.

Ozcan, M.M. (2009). Some Nutritional characteristics of fruit and oil of walnut (*Juglansregia* L.) growing in Turkey. *Iranian Journal of Chemistry and Chemical Engineering*, 28, 57-62.

Özdemir, F., Akinci, İ. (2004). Physical and nutritional properties of four major commercial Turkish hazelnut varietes. *Journal of Food Engineering*, 63, 341-7.

Peyman, L., Mahmoudi, A., Ghaffari, H. (2013). Some physical properties of Pistachio nuts. *International Journal of Agriculture and Crop Sciences*, 5(7), 704-1.

Pereira, J. A., Oliveira, I., Sousa, A., Ferreira, C.F.R., Bento, A., Estevinho, L. (2008). Bioactive properties and chemical composition of six walnuts (*Juglansregia* L.) cultivars. *Food and Chemical Toxicology*, 46, 2103-11.

Ren, Y., Waldron, K.W., Pacy, J.F., Brain, A., Ellis, P.R. (2001). Chemical and histochemical characterisation of cell wall polysaccharides in almond seeds in relation to lipid bioavailability, p. 448–452. In: Pfannhauser, W. Fenwick, G.R. and Khokhar, S. (Eds.), Biologically-active phytochemicals in food. The Royal Society of Chemistry, Cambridge, United Kingdom.

Rodriguez Rodriguez, E.M., SanzAlaejos, M., Diaz Romeo, C. (2002). Mineral content in goats' milks. *Journal of Food Quality*, 25, 343-58.

Sakurai, K., Kokub, S., Hakamata, K., Tomita, M., Yoshida, S. (1996). Effect of production conditions on ice cream melting resistance and hardness. *Milchwissenschaft*. 51, 451-4.

Shahidi, F., Alasalvar, C., Lyiana-Pathirana, C.M. (2007). Antioxidant phytochemicals in hazelnut kernel (*Corylusavellana* L.) and hazelnut byproducts. *Journal of Agricultural and Food Chemistry*, 55, 1212-20.

Shokraii, E.H., Esen, A. (1988). Composition, solubility and electrophoretic patterns of protein isolated from Kerman pistachionuts. *Journal of Agricultural and Food Chemistry*, 36, 425-9.

Sholberg, P.L., Gaunce, A.P. (1995). Fumigation of fruit with acetic acid to prevent postharvest decay. *Hortscience.* 30(6), 1271-5.

Sofjan, R., Hartel, R.W. (2004). Effects of overrun on structural and physical characteristics of ice-cream. *International Dairy Journal*, 14, 255-62.

Sniffen, C. J., Ballard, C.S., Carter, M.P., Contach, K. W., Danna, H. M., Grant, R. J., Mandepvu, P., Suekawa, M., Martin, S.A. (2006). Effects of malic acid on microbial efficiency and metabolism in continuous culture of rumen contents and on performance of mid-lactation dairy cows. *Animal Feed Science and Technology*, 127, 13-31.

Tapsell, L., Gillen, L. J., Patch, C. S., Batterham, M., Owen, A., Bare´, M., Kennedy, M. (2004). Including walnuts in a low-fat/modified-fat diet improves HDL cholesterol-to-total cholesterol ratios in patients with type 2 diabetes. Diabetes Care, 27, 2777-2783.

Tormo, M., Izco, J.M. (2004). Alternative reversed-phase high performance liquid chromatography method to analyse organic acids in dairy products. *Journal of Chromatography A*,1033, 305-10.

Yurttas, H.C., Schafer, H.W., Warthesen, J.J. 2000). Antioxidant activity of nontocopherol hazelnut (*Corylus* spp.) phenolics. *Journal of Food Science*, 65, 276-80.