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DETERMINATION OF CERTAIN PHYSICOCHEMICAL CHARACTERISTICS AND SENSORY PROPERTIES OF GREEN TEA POWDER (MATCHA) ADDED ICE CREAMS AND DETECTION OF THEIR ORGANIC ACID AND MINERAL CONTENTS

Arzu Kavaz Yüksel[1], Mehmet Yüksel[2]* , İhsan Güngör Şat[2]

[1]Atatürk University, Erzurum Vocational Training School, Department of Food Technology, Erzurum, Turkey
[2]Atatürk University, Faculty of Agricultural, Department of Food Engineering, Erzurum, Turkey

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Abstract

This study aimed to evaluate certain physicochemical quality characteristics, organic acid and mineral compositions of ice creams produced with different green tea powder (GTP) concentrations. The increment of GTP caused an increase in the fat, titratable acidity, viscosity, overrun and b^* values, while decreasing the total solid, protein, pH, first dripping time, complete melting time, L^* and a^* values. The citric, lactic, acetic and propionic acid amounts of samples showed an increase with the increment of GTP, while orotic and butyric acids decreased. Conversely, malic acid was not detected in any of the samples. The Ca, Cu, Mg, K, Zn and Na concentrations of samples increased with the increment of GTP, while Al and Fe were not found in any of the samples. On the sensory evaluation, the highest overall acceptability scores were given to control by the panellists and followed by GTP(%1) and GTP(%2), respectively.

Keywords: Ice cream, green tea powder, organic acid, mineral, sensory

YEŞİL ÇAY TOZU (MATCHA) İLAVE EDİLEN DONDURMALARIN DUYUSAL ÖZELLİKLERİ VE FİZİKOKİMYASAL KARAKTERİSTİKLERİNİN BELİRLENMESİ, ORGANİK ASİT VE MİNERAL İÇERİĞİNİN TESPİTİ

Özet

Bu çalışmanın amacı farklı konsantrasyonlarla yeşil çay tozu (YÇT) ilavesiyle üretilen dondurmaların belirli fizikokimyasal özelliklerini, organik asit ve mineral içeriğini değerlendirmektir. YÇT'nin artışı, yağ, titrasyon asitliği, vizkozite, overrun ve b^* değerlerinde artışa; kuru madde, protein, pH, ilk damlama zamanı, erime süresi, L^* ve a^* değerlerinde ise düşüşe sebep olmuştur. Sitrik, laktik, asetik ve propiyonik asit miktarları YÇT konsantrasyonlarına paralel olarak artmış, orotik ve butirik asit miktarları azalmıştır. Yeşil çayın ilavesiyle Ca, Cu, Mg, K, Zn ve Na minerallerinin oranı artış gösterirken, hiçbir örnekte Al ve Fe bulunmamıştır. Duyusal değerlendirmede sırasıyla en yüksek kabul edilebilirlik skoru kontrol numunesi, YÇT(%1) ve YÇT(%2) numunelerine verilmiştir.

Anahtar kelimeler: Dondurma, yeşil çay tozu, organik asit, mineral, duyusal

* Yazışmalardan sorumlu yazar / *Corresponding author;*
mehmet.yuksel@atauni.edu.tr, ✆ (+90) 442 231 2494, (+90) 442 236 0958

INTRODUCTION

Ice cream is a popular frozen dairy product and is made using milk, cream, milk powder, fat sugar, emulsifiers, stabilizers, fruits, nuts, candies, jams, plants, colouring, flavouring and sweetening agents. The quality characteristics and sensory properties of ice creams are affected by some parameters, including ingredients, production practices, transportation, storage conditions and temperature fluctuations (1, 2). It is generally consumed lovingly by people of all ages (especially children) due to its cooling effect, taste, aroma and nutritional value. Ice cream industry has much improved in recent years due to the consumer preference (1). Consumers want to get natural foods including probiotics, prebiotics, fibres and natural fruits in their body. These agents can give nutritional value, organoleptic richness and health benefits to the product beyond their normal functional properties (3, 4). For that reason, different types of ingredients including; fruits, fruit juice, herbs, probiotics and some other additives were used for the production of ice cream (3, 5). These ingredients provide important nutritional and health benefits to the ice cream due to minerals, vitamins, fibre, antioxidants, natural colorants and flavours are contained by them (6, 7). Nowadays, different types of ice creams are sold in markets and bakeries. Also, new types and formulations are wanted to be found in the markets by consumers (8, 9).

Fruits, teas and herbs are good sources for the ice cream production due to flavour, colour, functional properties and antioxidant activities. Tea (*Camellia sinensis*) is one of the most important beverages consumed around the world after water. It can be prepared in different types in different parts of the world including black tea, green tea, white tea, yellow tea, dark tea, pu'erh tea and oolong tea. *Camellia sinensis* is mainly cultivated in China and Southeast Asia, although it is grown in approximately 30 countries of the World (10-12). Black form of it is consumed in Asian and Western countries, while green tea is mostly consumed in Japan, China, India and some countries of the Middle East and North Africa (13).

Green tea (*Camellia sinensis*) has a long history, but the beneficial medicinal properties of it have recently begun to be realized by the people (14). Green tea has beneficial effects on human health, including anti-inflammatory, antiarthritic, antibacterial, antiangiogenic, antioxidative, antiviral, neuroprotective and cholesterol-lowering effects, and prevention of cancer and cardiovascular diseases. The positive effects of green tea on the health are mainly stemmed from its polyphenol content especially flavonoids, flavonols, catechins, saponins, alkaloids, amino acids, glucosides, proteins, volatile compounds, minerals and trace elements (15).

Green tea powder is known as matcha. In ancient times, matcha was consumed in rituals by Zen Buddhists in China. However, matcha is rarely consumed nowadays in China, while it is commonly consumed in Japan. Recently, it has also become a popular component for the production of pastries, puddings, chocolates, candies, ice creams and beverages (16).

Organic acids affect the flavour, stability and quality characteristics of dairy products. They occur in dairy products as a result of a series of reactions including fermentation of carbohydrates, hydrolysis of milk fat and microbial activity during production or storage period. Generally, organic acids occur as major metabolites of carbohydrate catabolism of lactic acid bacteria and they can give taste and flavour to milk, yoghurt, cheese and other dairy products (17). On the other hand, they are formed at the end of metabolic processes of ruminant, bacterial growth, hydrolysis of milk fat and addition of fruits, acidulants and other additives (18-20). Quantitative determination of organic acids is important for the determination of flavour and nutritional quality of dairy products (21). Generally, organic acids generate important effects on foods such as acidifying (tartaric, malic, citric and ascorbic acids), antioxidant (malic, citric and tartaric acids), preservative (sorbic and benzoic acids) and sensorial (malic, citric, acetic and tartaric acids) properties when added to them (18, 22). Moreover, minerals are important for human nutrition. They have important roles for the protection of human health. Generally, minerals have beneficial effects on health when they are found in foods in small quantities, while they can show harmful properties if they exceed the limit values (23, 24).

The aim of this research was to produce a functional and new type of ice cream with different ratios of green tea powder (matcha) and evaluate their physical and chemical characteristics, colour values, organic acid contents, mineral compositions and sensory properties.

MATERIAL AND METHOD

Materials

Cows' milk (50 L) and cream were obtained from the dairy farm of Agriculture Faculty of Atatürk University in Erzurum province of Turkey, while green tea powder (GTP) supplied from Çaykur (General Directorate of Tea Business), Rize, Turkey. Skim Milk Powder (SMP) was provided by Pınar Dairy Products Co., İzmir, Turkey; while sugar, emulsifier (mono- and diglycerides) and sahlep were purchased from local markets in Erzurum, Turkey.

Ice cream production

Experimental ice creams were manufactured in duplicate. For this research, three different ice cream mixes were produced in the Pilot Dairy Factory of Atatürk University (Erzurum, Turkey). Firstly, the raw cows' milk was strained using a cloth filter. Afterwards, milk was divided into four equal parts and 3 kg mix was prepared for each party. Each ice cream mix included 5% fat, 4.7% skim milk powder, 18% sugar, 0.6% sahlep (stabilizer) and 0.2% emulsifier (mono- and diglycerides). The mixes were heated to 85°C for 25 s and then rapidly cooled to ±4°C. The cooled ice cream mixes were maturated for 24 hours at ±4°C. One batch of mix was taken as control, and the remaining batches were prepared with 2 different ratios (1% and 2%) of green tea powder (GTP(1%) and GTP(2%)). Finally, the prepared mixes were iced in an ice cream machine (-5 °C; Ugur Cooling Machineries Co., Nazilli, Turkey), hardened at -22 °C for 24 hours and stored at -20 °C for analyses. The overall analyses were made as duplicate for each sample.

Physicochemical analysis

Total solid contents of 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 (25). Titratable acidity (Lactic acid%) of samples was determined by titration method using 0.1N NaOH and phenolphthalein as an indicator. For the measurement of pH, approximately 10 g ice cream samples were dissolved in 90 ml distilled water and pH values of the samples were measured using a pH meter (model WTW pH-340-A, Weilheim, Germany) fitted with a combined glass electrode (25). 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. The viscosity values were measured in duplicate and twenty readings (cP) were taken for each sample at 30 s (26). The overrun measurements of the mixes and ice creams were determined according to the equation [(weight of ice cream)-(weight of mix)/weight of mix x 100] by Jimenez-Florez *et al.* (27). First dripping and complete melting times of ice cream samples were measured according to the method by Guven and Karaca (28). For this analysis, hardened ice cream sample (25 g) was left to melt on the 0.2 cm wire mesh screen above a beaker at approximately ±20 °C and first dripping and complete melting times of ice creams were measured in seconds.

Colour analysis

The colour values of the ice creams were determined in triplicates for each sample group using a Minolta colorimeter (CR-200; Minolta Co., Osaka, Japan). L^* (lightness; 100=white, 0=black), a^* (redness; ±, red; -, green), and b^* (yellowness; ±, yellow; -, blue) colour after the calibration of device with black and white standards. The colour of ice creams was measured in port size of 20x15x10 cm with pulsed xenon arc lamp built into measuring head by CIE standard observer curves at room temperature.

Organic acid analysis

The organic acid profiles of the ice cream samples were determined according to the modified methods by Fernandez-Garcia and McGregor (18). For the detection of organic acids, a high-performance liquid chromatography (Agilent HPLC 1100 series G 1322 A, Germany) was used. Firstly, 4g ice cream sample was diluted with

0.001 N H_2SO_4 (25 mL) and centrifuged at the 5000xg for 10 minutes. The obtained supernatant was filtered through Whatman No.1 filter paper and through a 0.45 _m membrane filter (PALL, USA), respectively. The 2 mL aliquot was stored for each sample in HPLC vials at -20 °C for HPLC analysis and 0.001 N H_2SO_4 was used as mobile phase at a flow rate of 0.6 mL/minute. Organic acids were separated using a Alltech IOA-1000 organic acid column (300mm x 7.8 mm, Alltech, IL, USA). The wavelength of detection was 210 nm for the quantification of organic acids. For each sample, duplicate injections (approximately 10 µL) were made. Finally, the standard solutions of citric, orotic, malic, lactic, acetic, propionic and butyric acids were prepared using 0.001 N H2SO4 for the detection of elution times and to generate the calibration curves.

Mineral analysis

Mineral composition of the ice cream samples were analysed using an Inductively Coupled Plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT, USA), a modified method taken from Rodriguez Rodriguez *et al.* (23) and Caggiano *et al.* (24). At first, ice cream samples were dried in a microwave oven (Berghof speed wave, Germany) at 70oC until the dry matter contents of them reached a stable weighing and nearly 0.5 g samples were weighed to the vessels. Then, 10 mL (9:1 v/v) nitric acid (65% HNO_3)/ perchloric acid (70-72 %$HClO_4$) were added to each vessel and left overnight in this way. In the next day, the temperature of the samples were increased slowly to 160-170°C until obtaining the white smoke. Finally, the samples were filtered through the Whatman no. 42 filter paper and completed with distilled water in flasks to 50 mL. All samples were analysed using an Inductively Couple Plasma spectrophotometer (ICP-OES) and the mineral results of the ice cream samples were calculated as ppm.

Sensory analysis

The sensory analysis of ice cream samples were carried out at the Sensory Analysis Laboratory of Food Engineering Department of Atatürk University (Erzurum, Turkey) with standard and uniform floodlight. The sensory characteristics of the samples were evaluated by randomly selected 50 untrained panellists (25 men and 25 women) by grading them on a scale of 1–9 (poor/ excellent) on 2 days of storage. For this purpose, the modified version of hedonic scale suggested by Bodyfelt *et al.* (29) was used. Ice cream samples were presented to the panellists that located in separate compartments in a special ice cream cups approximately 30 g at a serving temperature of ±10°C. Finally, all of the samples were graded by the panellists in terms of colour and appearance, texture, gumming structure and melting in mouth, flavour, sweetness and overall acceptability parameters.

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 and were used to determine the differences between the results.

RESULTS AND DISCUSSION

Physicochemical properties of ice creams

The analytical analysis results for the experimental ice cream samples are presented in Table 1. The addition of GTP to the ice creams caused statistically significant (P<0.01) change only in the total solid contents of them. The total solids, fat and protein values of the ice cream samples ranged between 39.30% to 41.23%, 5.30% to 5.40%, 4.94% to 5.31%, respectively. The obtained results showed that total solids and protein values of samples showed a decrease with the addition of GTP, while fat values of the samples increased. Statistical evaluations showed that only total solids values of samples showed differences from each other at the level of P<0.01. The determined differences among the samples might be due to the differences of GTP amount added to each ice cream samples. On the other hand composition, physical and foaming properties of GTP might cause differences on the physicochemical properties of samples. The foaming properties of GTP caused an increase on the volume, while reduced the weight scale of ice cream and depending on this result the total solid and protein values of samples decreased.

Table 1. The effect of different GTP concentrations on some physicochemical properties and colour values of ice creams (mean±SD)

Ice cream samples	Total solids (%)	Fat (%)	Protein (%)	Titratable acidity (%)	pH	Viscosity (cP) 50 rpm
Control	41.23±0.12a**	5.30±0.12	5.31±0.21	0.18±0.00c**	6.68±0.01	2773±133.03b**
GTP(1%)	39.67±0.25b**	5.30±0.35	5.00±0.20	0.22±0.01b**	6.66±0.02	3062±167.05b**
GTP(2%)	39.30±0.13c**	5.40±0.49	4.94±0.46	0.25±0.01a**	6.66±0.02	9504±445.97a**
Ice cream samples	**Overrun (%)**	**First dripping times (s)**	**Complete melting times (s)**	***L****	***A****	***b****
Control	30.74±2.17	545±71.94a*	3039±838.94	87.42±1.39a**	-.72±0.18a**	13.21±0.29c**
GTP(1%)	31.40±2.85	510±50.23a*	2396±116.51	71.09±1.10b**	-.00±0.19a**	21.03±1.17b**
GTP(2%)	33.47±1.71	391±59.94b*	2319±27.77	67.35±0.96c**	-.36±0.24b**	22.92±1.27a**

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. GTP: green tea powder

According to the statistical evaluations, titration acidity values of the ice creams showed a significant increase (*P*<0.01) with the increment of GTP amount, while pH values of them decreased. However, this decrease on the pH values was statistically insignificant. As seen in Table 1, all ice creams were completely different from each other in terms of titration acidity values at the level of *P*<0.01. Obtained results might be attributed to the natural organic acids found in GTP. Also, similar results reported by Murtaza *et al.* (30) in ice creams produced with fig addition at different levels.

Viscosity is an important parameter for the determination of quality of ice creams. The structural characteristics of ice creams are related to the viscosity values of ice cream mixes (31). As seen in Table 1, the highest mean viscosity value was determined as 9504±445.97 cP in $GTP_{(2\%)}$ sample and the lowest mean value was 2773±133.03 cP in the control sample (Table 1). From the obtained results, it might be said that $GTP_{(\%2)}$ sample showed a significant increase with the increment GTP concentration. According to the statistical evaluations, control and GTP(1%) samples showed similarity in between, while $GTP_{(2\%)}$ was completely different (*P*<0.01) from them in terms of viscosity. The increase in the viscosity values of samples might be attributed to small air cells occurred in ice creams during production, aggregation of some proteins and agglutination of fat globules at low temperatures. Moreover, differences among the viscosity values of the samples might be stemmed from the physicochemical properties of GTP and water-binding capacity of the fibre and other compounds found in it (31).

Overrun value is an increase in the volume of ice cream mix and the presence of air in mix (32). As seen in Table 1, the highest mean overrun value was determined in the $GTP_{(2\%)}$ it was followed by $GTP_{(1\%)}$ and control samples, respectively. The results showed that the increment of GTP amount caused an increase on the overrun values of ice creams, but the differences among the samples were not significant statistically. These obtained results showed differences with the first dripping and complete melting time values of the observed experimental ice creams. From these findings, it might be said that the addition of GTP caused excess amount of air incorporation to the ice cream mix. The excess air amount caused abundant foaming occurrence in the mix (33). Similar results were found by Yuksel Kavaz (34) on a study about the blackthorn added ice creams. The researcher determined the thermal properties of ice creams with the measurements of Differential Scanning Calorimetry (DSC).

The longest mean first dripping time and complete melting time values were found in the control sample and it was followed by $GTP_{(1\%)}$ and $GTP_{(2\%)}$ samples, respectively (Table 1). According to statistical evaluations, the mean first dripping time values of the control and $GTP_{(1\%)}$ samples showed similarity with each other, while $GTP_{(2\%)}$ samples were different (*P*<0.05) from other samples statistically. However, ice cream samples did not show any differences in terms of complete melting time values. From the obtained results, it might be said that the physical properties of GTP formed a loose texture and due to this situation, water molecules moved freely, thus shortened the melting time values of ice cream samples (35).

Colour values of ice creams

The visual parameters of a food product including colour, shape, taste and flavour provide the formation of consumer preference. Observing the Table 1, *L** and *a** colour values of ice creams decreased depending on the GTP increment, while *b** values of the samples showed an increase with the addition of GTP. The highest mean values of *L** (87.42) and *a** (-3.72) were found in control sample, while the lowest mean values of them were 67.35 and -4.36, respectively in GTP(2%). However, the highest mean *b** colour value was in $GTP_{(2\%)}$ (22.92), followed by $GTP_{(1\%)}$ (21.03) and control (13.21) samples, respectively. According to the statistical evaluations, all of the samples showed statistically significant differences (P<0.01) in terms of *L** and *b** colour values. As seen in the *a** values of the ice creams, control and $GTP_{(1\%)}$ showed similarity in between, while $GTP_{(2\%)}$ was found different (P< 0.01) from them statistically. The determined differences among the samples probably due to the changing of colour density with the addition GTP.

Organic acid profiles of green tea powder and ice creams

Organic acids are important food components for the formation of taste and flavour, and determination of the quality and safety of food products. In this research, seven organic acids were detected in GTP and ice cream samples. The organic acid compositions of GTP and ice cream samples are presented in Table 2 and Table 3.

Citric acid is a weak tricarboxylic acid and is found naturally in many fruits. In addition, it is an important organic acid in fresh raw milk and approximately 0.2% of citric acid is found in it (18, 22). As seen in Table 2, GTP contained 19.05±2.31 µg/g citric acid. Sample $GTP_{(2\%)}$ ranked first in terms of citric acid value, followed in descending order by GTP(1%) and control samples, respectively (Table 3). Citric acid concentrations of the samples showed an increase compliance with the citric acid value of GTP. Similar results also reported by Yuksel Kavaz *et al.* (36) in terebinth added ice creams. According to the statistical evaluations, there were not any differences between the samples.

Orotic acid is found in significant amounts in milk and dairy products. Generally, it is formed as an intermediate compound during the biosynthesis of nucleic acids (18, 37). Observing the Table 2, the orotic acid concentration of GTP was found as 0.02±0.02 µg/g. On the other hand orotic acid was determined as 6.96 µg/g in control and $GTP_{(1\%)}$, while the level of it was found as 6.95 in $GTP_{(2\%)}$ sample (Table 3). Also, Fernandez-Garcia and McGregor (18); Tormo and Izco (22); Güzel-Seydim *et al.* (38) reported that orotic acid concentrations of milk and milk products reduced to the levels of 45-48% during fermentation and storage period. Statistical evaluations showed that there were not any statistical differences between the samples (Table 2).

Lactic acid is an important organic acid in milk and dairy products. It is important in terms of flavour and quality of dairy products (22, 37).

Table 2. Organic acid profiles of GTP (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)
Green tea powder	19.05±2.31	0.02±0.02	0.00±0.00	219.33±92.56	4.00±0.01	11.90±1.70	0.00±0.00

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. GTP: green tea powder

Table 3. The effect of different GTP concentrations on the organic acid profiles of the ice creams (mean±SD)

Ice cream samples	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)
Control	32.92±0.72	6.96±0.23	0.00±0.00	2.49±1.53c**	0.00±0.00b**	0.00±0.00c**	4.68±0.50
$GTP_{(1\%)}$	36.16±0.44	6.96±0.22	0.00±0.00	8.78±0.25b**	2.34±1.13a**	3.95±0.15b**	4.11±0.88
$GTP_{(2\%)}$	37.13±3.88	6.95±0.24	0.00±0.00	12.59±0.29a**	3.04±0.09a**	4.74±0.09a**	3.78±0.36

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. GTP: green tea powder

Observing the Table 2, the mean lactic acid value of GTP was determined as 219.33±92.56 µg/g. The highest mean concentration of lactic acid was in sample $GTP_{(2\%)}$, followed in descending order by samples $GTP_{(1\%)}$ and control, respectively (Table 3). Lactic acid concentration of samples showed an increase depending on the lactic acid value of GTP. The statistical evaluations showed that there were significant ($P<0.01$) differences among the ice cream samples in terms of lactic acid concentrations.

Acetic acid is a natural organic acid and occurs at the end of citrate, lactose and amino acid metabolism. The highest concentration of acetic acid in product is unwanted due to the pungent and vinegary taste and flavour of it (39). The acetic acid concentration of GTP was determined as 4.00±0.01 µg/g. As seen in Table 3, the highest mean acetic acid value (3.04±0.09 µg/g) was found in $GTP_{(2\%)}$ and followed by $GTP_{(1\%)}$ (2.34±1.13 µg/g) and control (0.00±0.00 µg/g), respectively. The acetic acid concentration of samples stemmed from the acetic acid value of GTP. Similar findings were determined in terebinth added ice creams by Yuksel Kavaz *et al.* (36). According to the statistical evaluations, GTP(1%) and GTP(2%) showed a similar trend, but control sample showed statistically significant differences ($P<0.01$) from these two samples.

Propionic acid can be found naturally in some plants. It is oily, liquid and colourless and has pungent taste and flavour (40). According to Table 2, propionic acid concentration of GTP was 11.90±1.70 µg/g. The highest mean concentration of propionic acid was found in $GTP_{(2\%)}$, but propionic acid was not determined in the control sample. The propionic acid values of samples increased with the increment of GTP amount. As seen in Table 3 all of the ice cream samples were different ($P<0.01$) from each other statistically.

Butyric acid is produced in dairy products as a result of the raw material, microbial activity and biochemical reactions (41). As seen in the Table 2, butyric acid was not determined in GTP. The highest mean concentration of butyric acid was found in the control sample, followed in descending order by the samples $GTP_{(1\%)}$, and GTP(2%) (Table 3). From these results it might be said that butyric acid contents of samples progressively decreased with the addition of GTP. Butyric acid amounts of ice cream samples were determined as statistically insignificant.

Obtained results showed that citric, lactic, acetic and propionic acid amounts of ice cream samples showed an increase with the increment of GTP concentration, while orotic and butyric acid contents of the samples showed a decrease. However, malic acid was not determined in any of the ice cream samples. The organic acid profiles of ice creams showed compliance with the organic acid profiles of GTP.

Mineral compositions of green tea powder and ice creams

The mean concentrations of minerals of GTP and ice cream samples are shown in Table 4. As seen in Table 4, Ca, Al, Cu, Mg, Fe, K, Zn, and Na values of GTP ranged from 3061.60 ppm, 0.00 ppm, 6.05 ppm, 1205 ppm, 0.00 ppm, 1148 ppm, 37.55 ppm and 160.35 ppm, respectively.

Aluminium (Al) is not an essential component for the nutrition of human, although it is the most common element that found in the environment (42). Iron (Fe) and cooper (Cu) are essential for the human health, but high concentration of them can cause toxicity on living cells (43). According to Table 4, Al and Fe were not determined in any of the ice cream samples, while Cu was determined in all of the samples.

Calcium (Ca) is an important mineral for human health. It is absorbed in the intestinal system and used for many essential functions in the body (44). The function of magnesium (Mg) in metabolism is related to the functions of Ca and P (45). Fresh fruits and vegetables are important sources of potassium (K). They have a key mechanism in nerve transmission of living cells (46). Zinc (Zn) is an essential trace element and deficiency of it causes many diseases (47). Finally, sodium (Na) is an essential mineral for many functions in the metabolism including water balance of cells, proper functioning of both nerve impulses and muscles, and regulates blood pressure (46). As seen in Table 4, the highest mean Ca, Cu, Mg, K, Zn and Na amounts were detected in $GTP_{(2\%)}$ and it was followed by $GTP_{(1\%)}$ and control samples, respectively. Statistical evaluations showed that, there were no differences among the ice cream samples in terms of Cu and

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

Green tea powder	Ca (ppm)	Al (ppm)	Cu (ppm)	Mg (ppm)
	3061.60±62.51	0.00±0.00	6.05±0.21	1205.15±56.07
Ice Cream Samples				
Control	1182.50±54.59b*	0.00±0.00	18.45±1.73	455.40±1.41
$GTP_{(1\%)}$	3755.20±19.32a*	0.00±0.00	18.70±3.11	513.10±40.02
$GTP_{(2\%)}$	3974.05±14.00a*	0.00±0.00	19.30±1.98	525.95±0.64
Green tea powder	Fe (ppm)	K (ppm)	Zn (ppm)	Na (ppm)
	0.00±0.00	1148.05±17.32	37.55±0.35	160.35±1.48
Ice Cream Samples				
Control	0.00±0.00	3156.55±23.41b*	18.45±1.73	17.70±0.00c**
$GTP_{(1\%)}$	0.00±0.00	3616.70±67.74a*	20.65±0.07b**	755.75±10.96b*
$GTP_{(2\%)}$	0.00±0.00	3766.35±73.74a*	26.05±0.78a**	794.85±7.00a*

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; **: $P<0.01$, *: $P<0.05$. GTP: green tea powder

Mg concentrations, while Zn amounts of the samples were different ($P<0.01$) from each other statistically. However, $GTP_{(1\%)}$ and $GTP_{(2\%)}$ samples showed similarity in terms of Ca and K values, while control sample was different ($P<0.05$) from them statistically. Conversely, Na values of the control and $GTP_{(1\%)}$ samples showed similarity in between, while $GTP_{(2\%)}$ was found different from them at the level of $P<0.05$. From these results it could be said that the differences of mineral (Ca, Cu, Mg, K, Zn and Na) amounts of ice cream samples might be related to the concentration and chemical structure of using GTP, raw material (milk), used containers, technological processes and some other factors.

Sensory properties of ice creams

The sensory properties of ice cream samples are shown in Table 5. The addition of GTP to ice cream mix significantly affected ($P<0.05$) the sensory properties of the samples except for texture and, gumming structure and melting in mouth scores. The control sample ranked first in terms of colour and appearance, flavour, sweetness, and overall acceptability scores, followed in descending order by $GTP_{(1\%)}$ and $GTP_{(2\%)}$ samples (Table 5). However, the highest values of texture and, gumming structure and melting in mouth were given to $GTP_{(2\%)}$ by the panellists and it was followed by $GTP_{(1\%)}$ and control samples, respectively. Statistical evaluations showed that colour and appearance, and flavour scores of samples were completely different ($P<0.05$) from each other. The sweetness scores of the $GTP_{(1\%)}$ and $GTP_{(2\%)}$ were similar, while control sample showed differences from them at the level of $P<0.05$. Conversely, control and $GTP_{(1\%)}$ showed similarity with each other with respect to overall acceptability score, while $GT_{(2\%)}$ was found different ($P<0.01$) from them statistically. The highest overall acceptability scores were given to control and followed by $GTP_{(\%1)}$ and $GTP_{(2\%)}$, respectively. This situation might be related to consumer preferences in terms of the taste and flavour of ice creams besides the normal functional and structural properties of them. The GTP gave important functional and structural properties to experimental ice creams, although grass like flavour of it might not be preferred by some consumers. However, it is thought that GTP added ice creams will be consumed desirably by the consumers who want to consume functional foods.

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

Ice cream samples	Colour and appearance	Texture	Gumming structure and melting in mouth	Flavour	Sweetness	Overall acceptability
Control	7.50±0.00a*	6.41±0.47	6.50±0.58	6.74±0.01a*	7.45±0.06a*	7.17±0.03a**
$GTP_{(1\%)}$	6.95±0.38ab*	6.64±0.62	6.51±0.47	5.63±0.95ab*	6.45±0.74b*	6.48±0.61a**
$GTP_{(2\%)}$	6.35±0.86b*	7.11±0.33	7.20±0.64	4.40±1.27b*	6.40±0.69b*	5.46±0.53b**

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; **: $P<0.01$, *: $P<0.05$. GTP: green tea powder

CONCLUSIONS

Consequently, obtained results also showed that the addition of GTP significantly affected the physicochemical properties, colour scores, organic acid profiles, mineral composition and sensory characteristics of ice cream. The increment of GTP concentration caused an increase on the physicochemical characteristics and colour values of the ice creams except for total solids, protein, pH, first dripping time, complete melting time, L^* and a^* values. As seen in the organic acid profiles and mineral compositions of the samples, citric, lactic acetic and propionic acid amounts, and Ca, Cu, Mg, Fe, K, Zn and Na concentrations of the ice creams increased with the increment of GTP concentration, but orotic values decreased. However, malic acid, Al and Fe were not determined in any of the samples. Generally, $GTP_{(2\%)}$ came to fore with regard to most of the observed parameters, although control was more appreciated by the panellists in terms of sensory properties except for the scores of resistance to texture, and gumming structure and melting in mouth. Obtained results showed that the addition of GTP to ice creams earned different values to them. Moreover, GTP can be considered as a suitable natural additive for ice cream production with regard to its nutritional value, physicochemical properties, organic acid profiles and mineral compositions.

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