Microstructure, Texture, and Some Other Properties of Ice Creams Produced with Different Processed and Different Varieties of Pumpkins

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Abstract: Pumpkin is a rich source of antioxidants, phenolic compounds, dietary fiber, and minerals. It is also harvested in large quantities around the world. Therefore, the present investigation was undertaken to enhance the nutritional and functional properties of ice creams by fortification of two different varieties of pumpkins – *Cucurbita moschata* and *Cucurbita maxima*. Different processes - freeze-drying, boiling, and baking - were applied to pumpkins to compare and determine the optimal processing steps. In doing so, two different concentrations were operated for each application. The health-promoting effects of pumpkins were evaluated, and their effects on the functional and sensory properties of ice creams were determined. Raw pumpkins have 24.5-31.1 % total dietary fiber (TDF), 26.2-9.0 % antioxidant content in terms of DPPH scavenging activity, and 237.5-123.9 (mg GAE / 100 g DM) total phenolic content. While TDF did not change with heat treatment, antioxidant and phenolic contents decreased slightly. Mineral substance contents were also generally not affected by the heat treatment ($P > 0.05$). As a result, all types of applications were approved for their similarity to the control sample of microstructural, textural, sensorial, and other characteristics.

Keywords: Ice cream, pumpkin, dietary fiber, phenolic compound, antioxidant.

Submitted: December 26, 2021. **Accepted:** April 11, 2022.

Cite this: Sıçramaz H, Ayar A. Microstructure, Texture, and Some Other Properties of Ice Creams Produced with Different Processed and Different Varieties of Pumpkins. JOTCSB. 2022;5(1):9–20.

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INTRODUCTION

Ice cream is a universally accepted valuable product that is rich in calcium and protein. While it's a sweet product, flavoring ingredients like fruits are usually demanded in ice creams. The addition of fruits brings additional nutritive value such as antioxidants, phenolic compounds, dietary fibers, etc., which are also essential for nutrition (1).

According to the American Council on Science and Health, "Functional foods can be considered to be those whole, fortified, enriched, or enhanced foods that provide health benefits beyond the provision of essential nutrients (for example, vitamins and minerals), when they are consumed at efficacious levels as part of a varied diet on a regular basis" (2). Studies have been carried out on the addition of antioxidant, phenolic substance, and fiber-rich components to ice cream for functional ice cream production. Çam et al. (3) fortified ice creams with pomegranate peel extract to increase the antioxidant and phenolic content, however, they have reached a product that was sensorially unexpected. Sagdic et al. (4) increased the antioxidant and phenolic content of ice cream by the addition of grape seed extract and Karaman et al. (5) have added persimmon puree for the same purpose. Soukoulis et al. (6) fortified ice cream with apple fiber and have also reached an ice cream with enhanced viscosity. These studies have shown that the addition of fruits and vegetables give ice cream functional properties that increase its health benefits, while at the same time, a more successful product can be obtained in terms of sensory and textural properties. Some researchers have reported that adding fruits and vegetables to ice cream can either increase or decrease the amount of minerals (7–9).

Cucurbita is the genus name of a wide group of vegetables containing gourds, melon, and pumpkin. It is mostly harvested in China (7.5 Mtonnes), India (5.1 Mtonnes), Russia (1.2 Mtonnes), and the USA (1.1 Mtonnes) (10). *Cucurbita moschata* and *Cucurbita maxima* are the pumpkin types rich in carotenoids, as well as minerals, vitamins, and dietary fiber (11). In recent years, besides the studies on the quality and yield of pumpkin (12–14), the effects as a food additive have also been investigated (15–17). In these studies, it has been suggested that pumpkin be ground into flour and added to various products such as corn flakes as a food additive. Some researchers also analyzed the effects of thermal processes on the nutritive compositions of pumpkins (18–20).

In this study, different processes (freeze-drying, boiling, and baking) were applied to the pumpkins - *Cucurbita moschata* and *Cucurbita maxima*, and the pumpkins were added to the ice cream mixture. The effects of pumpkin on the physical, chemical, sensory, and textural properties of ice cream were determined. The fiber-rich ice creams were illustrated using the scanning electron microscope (SEM) to explore the effects of processing treatments. The results revealed the effects of processing steps, concentration, and the genus type species of pumpkins on ice cream structure.

MATERIALS AND METHODS

Materials

Whole milk powder (26% fat) was obtained from Milkon Dairy and Food Products Industry (Sakarya, Turkey). UHT milk (3% fat and 3% protein), kaymak (dairy cream with 65% fat, 0.8% protein), egg, sugar, and salep (as a stabilizer) were purchased from supermarkets in Sakarya. A 30 kilograms of *Cucurbita moschata* (11.4% dry matter) and *Cucurbita maxima* (8.0% dry matter) were obtained from local producers in Sakarya. Before the processing, peel, and seeds were separated, the flesh of pumpkins was cut into 1 cm^3 small cubes and then separated into 3 groups for different processing treatments (1- freeze-drying, 2- boiling, 3- baking). Raw consumed pumpkin group (R) was freeze-dried in Labconco Freezone 6 (Kansas, MO) at -45°C 0.045 mbar conditions and then blended. It was used as powder. For the boiled group (Bo), water was added in 1:1 (w:w) quantity, then boiled on a hot plate at 350 °C for 90 minutes and blended. It was used as puree. Baked pumpkin (Ba) was heated in the oven to 150 °C for 60 minutes and blended. It was also used as puree. The processed pumpkins were frozen until further use.

Preparation of Ice Cream Mix and Pumpkin Ice Creams

The ice cream mix was prepared according to the formulation; (w/w) 3.1% whole milk powder, 69.6% UHT milk, 4.3% whole egg, 9.9% kaymak (milk cream with 65% fat), 12.7% sugar, 0.4% salep. Production was carried out with some modifications on the method of Karaman et al. (5). First, milk powder and milk were blended for 2 minutes. Salep was mixed with sugar in another vessel. All of the ingredients in the mix formulation were mixed and pasteurized by indirect heating in a salep cooking machine (Remta CS3, Turkey) at 70 °C for 20 minutes, then cooled and matured at 4 °C for 48 hours.

All ice cream formulations were determined by preliminary sensory testing. The forms and concentrations of pumpkins *Cucurbita moschata* and *Cucurbita maxima* added to the ice cream mix were detailed in Table 1. Ice creams were frozen using a household ice cream machine (SIMAC GC6000 II Gelataio, Treviso, Italy). Ice creams were filled into 250 mL plastic containers for subsequent analyses and kept at -38 °C. The total formulation of ice creams is given in Table 1.

Table 1: The formulations of ice creams.

Group name	Type of pumpkin added	Properties of pumpkin	Concentration of pumpkin
NC *	None	None	None
PA-R3	A **	Raw, dried	3 %
PB-R3	B **	Raw, dried	3 %
PA-R4	A	Raw, dried	4 %
PB-R4	B	Raw, dried	4 %
PA-Bo5	A	Boiled	5 %
PB-Bo5	B	Boiled	5 %
PA-Bo10	A	Boiled	10 %
PB-Bo10	B	Boiled	10 %
PA-Ba5	A	Baked	5 %
PB-Ba5	B	Baked	5 %
PA-Ba10	A	Baked	10 %
PB-Ba10	B	Baked	10 %

* "NC" refers to the (Negative) Control sample
** "A" type of pumpkin refers to *Cucurbita moschata* and "B" type of pumpkin refers to *Cucurbita maxima*

Methods

General composition of ice cream mix
The total dry matter, fat, and protein percentage of ice cream mix were determined using a FOSS FoodScan (FoodScan Lab, Denmark) and the ash content was determined according to the method suggested by Turkish Standard Institute (21)*.*

Total dietary fiber of pumpkins
The total dietary fiber (TDF) AACC 32-05 method was followed (22). According to the method, samples gelatinized with α-amylase were treated with protease and amyloglucosidase to remove protein and starch. Soluble dietary fiber is precipitated with ethanol. The residue is filtered; washed sequentially with 78% ethanol, 95% ethanol, and acetone; dried, and weighed. The ash correction is made, and the result is calculated as suggested in the method.

Total phenolic contents and antioxidant capacities of pumpkins
The raw pumpkins were analyzed before freeze-drying process, and the other pumpkin groups were analyzed after boiling or baking processes for their antioxidant and total phenolic contents. The extraction of antioxidants and total phenolic compounds was performed by the procedure of Wojdyło et al. (23) with a few modifications. Pumpkin (3 g) was weighed into a test tube; 10 mL of 70% aqueous methanol was added, and homogenized. Tubes were sonicated for 15 min at room temperature (20 °C). The extract was centrifuged for 10 min (1250 *g*, 4 °C), and supernatants were used for the measurements of antioxidant capacity defined as 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity and total phenolic content expressed as mg of gallic acid equivalents (GAE) per 100 g dry weight.

The DPPH radical-scavenging activity was determined using the method described previously (24). For a DPPH stock solution, DPPH (5 μg) was dissolved in 70% methanol (250 ml). The stock solution was prepared fresh daily. The DPPH solution (3 mL) was added to 200 μL of extracts. The mixture was shaken and allowed to stand at room temperature in the dark for 30 minutes, and the resulting color was measured spectrophotometrically at 517 nm against blank. Methanol was used for blank measurement. The percent of DPPH discoloration of the sample was calculated according to the equation: % discoloration = $[1 - (A_{sample}/A_{control})] \times 100$.

Total phenolic content was measured using Folin-Ciocalteu colorimetric method described previously (25). Sample extracts prepared for total phenolic content (100 μL) were mixed with 0.2 mL of Folin-Ciocalteu reagent and 2 mL of H_2O, and incubated at room temperature for 3 min. Following the addition of 1 mL of 20% sodium carbonate to the mixture, total polyphenols were determined after 1 h of incubation in the dark at room temperature. The absorbance of the resulting blue color was measured at 765 nm with a spectrophotometer (Shimadzu UV–1240). Quantification was done with respect to the standard curve of gallic acid.

Determination of mineral compositions of pumpkins
The processed pumpkins were freeze-dried before the analysis. The determination of mineral composition and contents were carried out according to the method described by Ayar et al. (26); whereby 1.0 g of sample was weighed into the Teflon vessel, mixed with 5 mL of HNO_3 (65%, Sigma) and 2 mL of H_2O_2 (30%, Sigma); then digested by microwave irradiation in steps, increasing power from 250 to 650 W by 5 min increments. Mineral contents were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) (VARIAN-CCD Simultaneous ICP-AES, Australia).

Physicochemical analyses
The total dry matter (DM) and ash contents of processed pumpkins were determined before use according to AOAC methods 930.04 and 930.05 (27), respectively. Ice cream analyses were carried out, in triplicate, on the first week of storage. The titratable acidity was determined in ice creams according to AOAC 937.05 (27) and expressed as a percentage of lactic acid (LA %). The pH values of ice creams (4 °C) were measured with a pH meter (Mettler Toledo SevenCompact S220). The color of ice creams was monitored by a tintometer (Lovibond RT300, Salisbury, UK) in terms of L^*, a^*, b^* and the results were given as ΔE in terms of the color differences from the NK (negative control) ice cream sample.

Rheological analyses of ice creams
Overrun capacities of ice creams were determined by the comparison of the weight of ice cream mix and the final product (28). For testing rheological analyses, ice cream samples were transferred from the -38 °C freezer to a -18 °C freezer and held for a night. Before the viscosity analysis, samples were taken to a 4 °C refrigerator and held for 4 hours prior to testing. Viscosity measurements have been taken by Brookfield Viscometer RV-II

(Brookfield Engineering Laboratories, MA, USA) at 4 °C with spindle no. 7, at 100 pm on 40^{th} second of shearing, and the results were given in terms of Poise (P). Firmness analyses of ice cream samples were carried out using a Brookfield CT3 texture analyzer (Brookfield Engineering Laboratories, MA, USA) fitted with a cylindrical probe TA 4/1000. Penetration depth was 10 mm, and penetration speed was 2 mm/s. Results were given in grams.

Sensory analyses of ice creams

Fifteen panelists working at Sakarya University were chosen for the assessment of the sensory characteristics of ice cream samples. Sensory attributes were scored in a 9-point hedonic scale test. The scoring was as follows: gumminess (1-2: none, 3-4: very little, 5-6: little, 7-9: expected as normally), icy structure (1-2: none, 3-4: very little, 5-6: little, 7-9: distinctive), appearance and melting in mouth (1-2: very bad, 3-4: bad, 5-7: good, 8-9: very good), texture, flavor, and general acceptance (1-2: weak, 3-4: moderate, 5-7: good, 8-9: very good).

Microstructure of ice creams

The ice cream samples were freeze-dried before the analysis. The microstructure of dried ice creams was visualized using an FEI Quanta FEG 250 (FEI Corporate, Hillsboro, OR, USA) field emission scanning electron microscope (FE-SEM) with an LFD detector. Images were obtained at 2 kV and recorded at 2000 – 16,000 magnifications. The best results were taken in 2000 magnifications.

Statistical analysis

The data obtained from the physicochemical, rheological, and sensory analyses and comparisons were statistically evaluated by one-way ANOVA followed by Tukey's test using SPSS Statistics 20.0.0 (SPSS Inc., Chicago, IL, USA). Values of $P < 0.05$ were regarded as statistically significant.

RESULTS AND DISCUSSION

The general composition of ice cream mix

The average composition of the ice cream mix was determined as: 41.3% dry matter, 10.0% fat, 5.4% protein, and 0.96% ash. The results were in accordance to the literature data (29,30) except for the fat content. Fat ratios vary according to the amount of cream added and the last products are labelled with different names depending on the fat content according to the Regulations (31). Our product can be labelled as "whole fat Maraş style ice cream" according to its fat and salep content.

Some chemical and compositional characteristics of processed pumpkins

The DM, ash, DPPH scavenging activity, total phenolic compounds, and TDF contents of processed pumpkins are given in Table 2, and the mineral compositions are shown in Table 3. According to the statistical analysis, the DM of the pumpkins differed according to the pumpkin variety and the process. The ash content differed independently from the variety and the process.

According to Table 2, the antioxidant capacity of *Cucurbita moschata* in terms of DPPH scavenging activity decreased with boiling and baking. In contrast, reverse baking caused an increase in the antioxidant content of *Cucurbita maxima*. According to the results of Dini et al. (32), cooking had increased the DPPH scavenging activity of pumpkin due to the production of redox-active secondary metabolites or breakdown compounds. However, Azizah et al. (33) also demonstrated the effect of boiling time in a decrease of the antioxidant activity, with a study of boiling the pumpkin from 2 minutes to 6 minutes. DPPH scavenging activity also is highly affected from the variety, from the region, from the parts of the pumpkin and from the maturity of the pumpkin (15,34).

The total phenolic content of *Cucurbita moschata* was considerably higher than the *Cucurbita maxima*. However, although its higher phenolic content, *Cucurbita moschata* samples were affected from heat treatment (boiling and baking) (Table 2). As a result, it can be concluded that *Cucurbita maxima* contains lower phenolic substances, but these phenolics are more resistant to thermal processes. Considering the effect of thermal processing on total phenolics, there are both studies showing the phenolics increase and decrease by heat treatment (32,33). On the other hand, freeze-drying has no effect on total phenol according to the results of the study done by Dirim and Çalışkan (35). Hussain et al. (36) also analyzed *Cucurbita maxima* and found the total phenolic content as 135 mg GEA / 100 g flesh fruit powder, close to our results. Kulczyński et al. (37) analyzed different varieties of *Cucurbita moschata* and the results have ranged from 47-101 mg GEA / 100 g DM.

The TDF content changed depending on the pumpkin variety. However, as expected, it was affected from neither boiling nor baking due to mass balance. TDF is a vital source for intestinal health, and it is a carrier for antioxidants, mainly polyphenolic compounds, as well (38). It is also a functional agent having fat-binding, gel-forming, chelating and texturizing properties (39). TDF content in the flesh of *Cucurbita moschata* and *Cucurbita maxima* were measured as 24.5% and 31.1%, respectively, in our study. However, lower TDF contents were determined respectively as 7.4% and 10.9% in another study (40).

Table 2: The properties of processed pumpkins.

Group name	DM (%)	Ash (%)	DPPH scavenging activity (%)	Total phenolic compds (mg GAE / 100 g DM)	TDF (%)
PA-R	11.4 ± 0.2 c	0.35 ± 0.02 bc	26.2 ± 1.2 a	237.5 ± 1.0 a	24.5 ± 0.1 b
PB-R	8.0 ± 0.3 e	0.48 ± 0.02 b	9.0 ± 0.1 c	123.9 ± 3.7 c	31.1 ± 0.2 a
PA-Bo	10.7 ± 0.1 c	0.31 ± 0.01 c	16.6 ± 1.4 b	192.1 ± 2.1 b	23.6 ± 0.1 b
PB-Bo	9.0 ± 0.0 d	0.42 ± 0.00 bc	9.9 ± 0.2 c	119.2 ± 1.4 c	30.5 ± 0.3 a
PA-Ba	18.1 ± 0.0 a	0.45 ± 0.03 bc	14.8 ± 0.1 b	208.0 ± 5.0 b	24.3 ± 0.2 b
PB-Ba	17.1 ± 0.2 b	0.83 ± 0.06 a	16.7 ± 0.3 b	130.9 ± 4.7 c	31.3 ± 0.0 a

PA : *Cucurbita moschata*, PB : *Cucurbita maxima* ; R : Raw, Bo : Boiled, Ba : Baked

According to Table 3, K content was pumpkin variety dependent; however, the other analyzed minerals Ca, Mg, Mn, Na, and P were not affected by variety. The Ca and K contents of *Cucurbita maxima* decreased significantly by boiling or baking. However, no change was observed in *Cucurbita moschata*. *Cucurbita maxima* was more heat stable than *Cucurbita moschata* according to their phenolic content in Table 2, but the opposite was observed when their Ca and K contents in Table 3 were evaluated. Zn content revealed an increase by boiling process in *Cucurbita moschata* pumpkin variety. The increase can be explained by possible contamination from the distilled water used for boiling (41). In a study from literature, Ca, K, Mg, Mn, Na, P, and Zn contents of *Cucurbita maxima* from Colombia were measured respectively as 2400, 33467, 1733, 1.33, 333, 3400, and 12.0 mg / kg DM (42). In this study, Ca, Mg and Mn contents were lower than our study, while K, Na, P and Zn contents were higher. K represented the main mineral with the highest content in both our study and Leterme et al. (42).

Table 3: Mineral composition of processed pumpkins (mg / kg DM).

Group name	Calcium (Ca)	Potassium (K)	Magnesium (Mg)	Manganese (Mn)	Sodium (Na)	Phospho-rus (P)	Zinc (Zn)
PA-R	3830 ± 160 ab	9860 ± 216 c	973 ± 37 a	4.81 ± 0.25 a	472 ± 61 a	2161 ± 119 a	11.2 ± 0.3 ab
PB-R	4652 ± 166 a	18725 ± 148 a	1115 ± 53 a	4.60 ± 0.04 a	450 ± 43 a	2158 ± 112 a	10.6 ± 0.6 b
PA-Bo	3797 ± 116 ab	9925 ± 192 c	937 ± 33 a	4.68 ± 0.33 a	417 ± 34 a	2114 ± 160 a	13.6 ± 0.2 a
PB-Bo	3760 ± 154 b	16950 ± 171 b	1106 ± 56 a	4.65 ± 0.43 a	428 ± 41 a	2186 ± 93 a	11.4 ± 0.5 ab
PA-Ba	3785 ± 173 ab	9754 ± 182 c	937 ± 38 a	4.66 ± 0.22 a	383 ± 34 a	2021 ± 123 a	11.5 ± 0.1 ab

PB-Ba	3729 ± 155 b	16165 ± 133 b	1041 ± 54 a	4.64 ± 0.15 a	392 ± 45 a	2195 ± 69 a	10.0 ± 0.6 b

PA : *Cucurbita moschata*, PB : *Cucurbita maxima* ; R : Raw, Bo : Boiled, Ba : Baked

pH, Acidity, and Color Properties of Ice Cream Samples

The pH, acidity, and color properties of ice creams are given in Table 4. According to the literature, while the pH of raw vegetables can be increased by heat treatment, pH decreases as the heat treatment load increases (43). In our study, it was determined that the pH of the products with the addition of baked pumpkin was significantly lower. (P < 0.05). Color properties differed irregularly in all samples. However, when the results are taken into account, some inferences can be made; *Cucurbita maxima*-based ice creams more different than the *Cucurbita moschata*. The concentration of the pumpkins was an important factor on color. Raw pumpkins affected the color more than processed pumpkins, because of their high concentrations in powder form. Another finding was that the effect of baking on the color was greater than that of boiling. In a study in the literature, color of ice creams fortified with peach fibers exhibited identical changes with varying peach fiber contents (44). Guiné and Barroca (45) stated that freeze-drying led to a more pronounced lightening (higher L values) and less green discoloration (lower Δb) of *Cucurbita maxima*.

Table 4: pH, acidity and color properties of ice cream samples.

Group name	**pH**	**Acidity (% LA)**	**Color (ΔE)**	**Overrun (%)**	**Firmness (g)**	**Viscosity (P)**
NC	6.66 ± 0.01 ab	0.34 ± 0.01 b	0.0 ± 0.0 i	26.7 ± 0.3 a	48.5 ± 0.9 h	56.8 ± 1.6 g
PA-R3	6.68 ± 0.01 a	0.43 ± 0.01 a	26.7 ± 0.3 c	22.2 ± 0.1 abc	82.8 ± 3.5 ef	91.7 ± 1.3 de
PB-R3	6.64 ±0.00 b	0.40 ± 0.00 a	31.2 ± 0.2 b	18.8 ± 0.6 abc	103.3 ± 2.9 cd	125.3 ± 0.5 c
PA-R4	6.68 ± 0.02 a	0.44 ± 0.00 a	26.5 ± 0.2 c	20.9 ± 0.1 abc	126.0 ± 4.2 b	142.5 ± 1.1 b
PB-R4	6.64 ± 0.01 b	0.42 ± 0.02 a	38.6 ± 0.6 a	14.9 ± 0.2 c	116.7 ± 6.4 bc	135.0 ± 0.6 b
PA-Bo5	6.65 ± 0.00 b	0.32 ± 0.01 b	5.4 ± 0.4 h	23.1 ± 4.2 abc	57.3 ± 0.8 gh	74.0 ± 2.2 f
PB-Bo5	6.65 ± 0.01 b	0.31 ± 0.03 b	5.7 ± 0.1 gh	18.3 ± 1.2 abc	90.0 ± 5.4 de	119.5 ± 3.9 c
PA-Bo10	6.65 ± 0.00 b	0.30 ± 0.00 b	8.1 ± 0.2 f	21.3 ± 4.5 abc	89.5 ± 3.5 de	90.1 ± 0.4 e
PB-Bo10	6.64 ± 0.00 b	0.30 ± 0.00 b	10.1 ± 0.4 e	15.4 ± 0.2 bc	146.3 ± 3.2 a	175.0 ± 1.8 a
PA-Ba5	6.59 ± 0.00 c	0.31 ± 0.00 b	6.8 ± 0.2 g	26.1 ± 0.1 ab	70.2 ± 1.3 fg	72.3 ± 0.7 f
PB-Ba5	6.58 ± 0.02	0.29 ± 0.01	11.0 ± 0.6	22.9 ± 1.3	65.8 ± 2.0	88.4 ± 1.3

	c	b	e	abc	fgh	e
PA-Ba10	6.59 ± 0.01 c	0.32 ± 0.03 b	10.2 ± 0.2 e	21.0 ± 0.3 abc	68.8 ± 1.8 fg	91.2 ± 0.3 e
PB-Ba10	6.58 ± 0.00 c	0.30 ± 0.00 b	15.1 ± 0.6 d	19.2 ± 2.6 abc	83.0 ± 1.7 ef	100.3 ± 0.1 d

NC : Negative control PA : *Cucurbita moschata*, PB : *Cucurbita maxima* ; R : Raw, Bo : Boiled, Ba : Baked

Rheological Properties of Ice Cream Samples

The rheological properties of ice cream samples are given in Table 4. The addition of pumpkin reduced the overrun capacity. *Cucurbita maxima* added ice creams revealed a lower overrun capacity than *Cucurbita moschata* added ones. Increasing pumpkin concentrations caused an increase in firmness and viscosity values of ice creams. The rheological effect of pumpkin on ice cream was also confirmed by Kulkarni et al. (46). While the firmness value was 48.5 g in the negative control sample, the addition of pumpkin increased the value and with a 146.3 g measurement, the ice cream containing boiled *Cucurbita maxima* had the highest firmness value among the groups. Viscosity results also correlated with hardness. The viscosity of the product with the highest hardness was measured as 175.0 P, and the viscosity value in the control sample was found to be relatively low (56.8 P).

In addition, while the DM of *Cucurbita maxima* was lower, higher firmness and viscosity were measured in *Cucurbita maxima* added groups compared to *Cucurbita moschata* added ones. If the rheological properties of ice creams are summarized, the overrun capacity was not statistically affected by pumpkin addition (except for the PB-R4 sample); however, firmness and viscosity characteristics were improved by increasing pumpkin concentrations.

Sensory Attributes of Ice Cream Samples

The sensory scores of ice cream samples are given in Table 5. According to the panelists, the addition of pumpkin slightly affected the melting properties of ice cream but did not cause any change in other sensory properties. These sensory results are promising in terms of incorporation of pumpkin into ice cream. Most of them have scored 7 and above, except for icy structure. Icy structure is a texture defect in ice creams, and 1-3 points for icy structure evaluation is desired in an ice cream. These scores revealed that ice cream formulation and processing was available according to its textural quality and the addition of pumpkin did not cause any icy texture. Karaman et al. (47) stated that the persimmon puree addition decreased the taste scores and general acceptance of the ice creams. Çam et al. (3) stated that the product to which they added pomegranate peel extract caused astringency and an unnatural taste. In a study that added soluble soybean polysaccharides to ice cream as a fiber source, the flavor and sweetness intensity decreased, and an adverse effect on the texture was observed (48).

The Microstructure of Ice Cream Samples

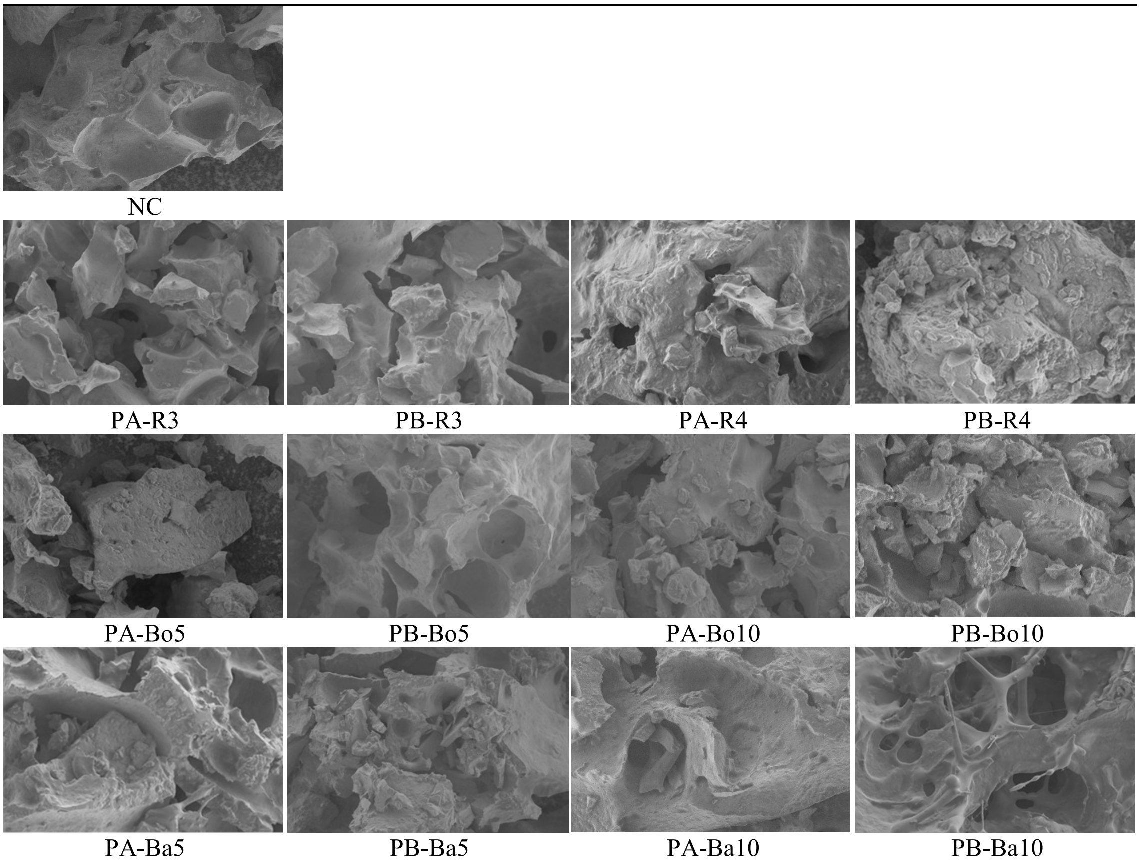
The microstructures of pumpkin-added ice creams are shown in Figure 1 with the magnification of 2000 x. Samples presented porous structures. The application of freeze drying in ice creams caused air gaps. According to our results and literature knowledge (49), it is observed that, air gaps are also significantly affected by the formulation of the product.

It was observed that the fibrous image was mostly lost by boiling. The boiled pumpkin added samples (Bo) were featured closest to the control sample (NC). Especially in the PB-Ba10 sample, the structure of fibers and bridges was obtained clearly.

Table 5: The sensory properties of ice creams.

Group name	Appearance	Gumminess	Icy structure	Melting in the mouth	Texture	Flavor	General acceptance
NC	7.8 ± 1.3 a	7.8 ± 1.1 a	1.3 ± 0.6 a	8.8 ± 0.5 ab	8.8 ± 0.5 a	7.5 ± 1.3 a	7.5 ± 1.4 a
PA-R3	6.8 ± 1.1 a	7.8 ± 1.1 a	1.7 ± 0.6 a	8.3 ± 1.0 ab	7.3 ± 2.2 a	6.8 ± 2.6 a	7.2 ± 1.3 a
PB-R3	7.4 ± 1.1 a	7.2 ± 1.1 a	3.3 ± 1.5 a	7.3 ± 0.5 bc	6.8 ± 1.9 a	7.3 ± 2.1 a	7.8 ± 1.2 a
PA-R4	7.0 ± 1.0 a	7.4 ± 1.5 a	2.0 ± 1.0 a	6.5 ± 1.0 c	7.0 ± 0.8 a	7.3 ± 1.0 a	6.5 ± 1.9 a
PB-R4	6.6 ± 1.1 a	7.6 ± 1.1 a	2.7 ± 2.1 a	7.3 ± 1.0 bc	6.3 ± 1.5 a	7.3 ± 0.5 a	6.5 ± 1.4 a
PA-Bo5	8.2 ± 1.1 a	8.0 ± 1.0 a	1.3 ± 0.6 a	8.3 ± 0.5 ab	8.0 ± 0.8 a	7.3 ± 1.0 a	6.5 ± 1.8 a
PB-Bo5	8.0 ± 1.2 a	8.2 ± 1.3 a	1.3 ± 0.6 a	8.0 ± 0.8 abc	8.0 ± 0.8 a	6.3 ± 2.4 a	6.8 ± 1.5 a
PA-Bo10	8.0 ± 1.0 a	7.0 ± 1.4 a	1.3 ± 0.6 a	8.5 ± 0.6 ab	7.8 ± 1.0 a	5.5 ± 1.7 a	5.8 ± 1.8 a
PB-Bo10	7.6 ± 0.9 a	6.0 ± 1.4 a	1.3 ± 0.6 a	8.8 ± 0.5 ab	6.5 ± 1.9 a	5.3 ± 1.7 a	6.0 ± 1.4 a
PA-Ba5	7.6 ± 1.5 a	7.4 ± 1.1 a	1.3 ± 0.6 a	9.0 ± 0.0 a	8.0 ± 0.8 a	6.8 ± 2.1 a	6.7 ± 1.6 a
PB-Ba5	8.0 ± 1.4 a	6.8 ± 1.3 a	1.3 ± 0.6 a	8.8 ± 0.5 ab	8.0 ± 0.8 a	6.5 ± 1.3 a	67.2 ± 1.5 a
PA-Ba10	7.4 ± 2.1 a	7.4 ± 0.9 a	1.3 ± 0.6 a	8.5 ± 0.6 ab	8.0 ± 0.8 a	6.3 ± 2.2 a	6.5 ± 1.4 a
PB-Ba10	8.0 ± 1.4 a	7.2 ± 1.1 a	1.3 ± 0.6 a	8.5 ± 0.6 ab	8.0 ± 0.8 a	7.0 ± 1.4 a	7.2 ± 1.2 a

NC : Negative control PA : *Cucurbita moschata*, PB : *Cucurbita maxima* ; R : Raw, Bo : Boiled, Ba : Baked



NC : Negative control PA : *Cucurbita moschata*, PB : *Cucurbita maxima* ; R : Raw, Bo : Boiled, Ba : Baked

Figure 1: The microstructures of ice creams (FE-SEM x 2000).

CONCLUSIONS

As a conclusion of our study, pumpkin addition to ice cream is a sensorially acceptable application. Processing steps of boiling and baking decreased some health-promoting effects (DPPH scavenging capacity and total phenolic content), while some of them revealed the same (TDF content and mineral composition). Fortification with pumpkin did not cause a significant decrease in the overrun but improved the firmness considerably. The baking process did not reveal a change in TDF content but screened a higher fiber image. There were also some differences according to the variety of the pumpkins. Comparison all the data with NC samples, it can be revealed that pumpkin addition achieved health-promoting compounds to the ice cream without any adverse effect on its quality properties.

FUNDING

This study was funded by the Scientific Research Projects Unit of Sakarya University (grant number 2016-01-16-020).

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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