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Original Article

The effect of date versus sugar on sensory, physicochemical, and antioxidant properties of ice cream

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Abstract

Background: Despite the popularity of ice cream, its high content of sugar and fat is worrisome. Substituting sugar with natural and useful resources is one possible solution. Dates (*Phoenix dactylifera*) are rich in carbohydrates and are a good source of energy; they also have a large amount of phenolic compounds and anthocyanin. **Aims:** The aim of this study is to evaluate the effect of ice cream sugar replacement with date products. **Methods:** Accordingly, four ice cream samples with different sweeteners including 1) sucrose (as a control), 2) date pulp + sucrose, 3) date liquid sugar, and 4) sucrose + date liquid sugar, were produced. Total phenolics, anthocyanins, and antioxidant activities of dates and their effects on physicochemical and sensory properties of ice cream were investigated. **Results:** A large amount of phenolic compounds and anthocyanin was found in the ice cream contained date pulp and liquid sugar, which enhanced the reducing power and antioxidant effect of it. The overrun and density of an ice cream did not change with sugar replacement. Total substitution of sucrose by date liquid sugar, increased the titratable acidity, viscosity, and antioxidant properties of ice cream, but it was found to have some negative effects on the organoleptically score of color. However, the partial replacement of granular sugar with date pulp/liquid sugar, improved the antioxidant value of this dairy dessert without any change in its color. **Conclusion:** It seems that the addition of date pulp to an ice cream, not only maintain the quality and sensory properties of an ice cream, but also provides an antioxidant property.

Key words: Antioxidants, Dates, Ice cream, Sugar

Introduction

Ice cream is the most nutritious and popular semi-solid dairy dessert in the world. It is an aerated suspension of water and fat in a concentrated sugar solution that contains proteins, stabilizers, emulsifiers, and flavoring agents, while is poor in some of the natural antioxidants (Erkaya *et al.*, 2012). Consumer acceptance of ice cream depends largely on its textural quality and flavor. Sucrose is the main sugar in ice cream, which imparts flavor. Growing concern about health has encouraged people to decrease the consumption of food rich in sucrose.

Dates (*Phoenix dactylifera*) are one of the oldest and most well-known cultivated plants in the Middle East and North Africa (Al-Farsi *et al.*, 2005). It is the second most important horticultural crop in Iran after pistachio (Hajian and Hamidi Esfahani, 2015), and its production was more than 1.15 million tons in 2014 (FAO, 2014). Dates contain a high percentage of carbohydrates with the predominance of glucose (G) and fructose (F), and also proteins, pectin, lipid, dietary fibers, and minerals (Al Farsi and Lee, 2008). Date varieties can be served as good natural antioxidants (Al-humaid *et al.*, 2010). Antioxidants have received increased attention for their potential effects in the prevention of chronic diseases such as cardiovascular diseases and aging (Kaur and

Kapoor, 2001). With the increasing consumer awareness of the relationship between diet and wellness, the production and consumption of functional foods have become of great interest today. The benefits of the dates make it a candidate for improvement of the nutritional value of food products (Habib and Ibrahim, 2009).

This study was aimed to examine the possibility of manufacturing a functional ice cream with date pulp or date liquid sugar instead of granular sugar and evaluate its sensory and physicochemical properties.

Materials and Methods

Analysis of raw materials

Date and date liquid sugar analysis

The sugar contents of date (pulp/liquid sugar) were determined using high-performance liquid chromatography (HPLC) (Shimadzu LC-10ATVP, Japan) with Supelcosil LC-NH₂ (25 cm × 4.6 mm, 5 μm) column and a RID-10A refractive index detector. The mobile phase of acetonitrile: deionized water (8:2 v/v) by the rate of 1.3 ml/min and isocratic method was used. The volume of the sample injected was 20 μL.

The quantification of each sugar (fructose, glucose, and sucrose) was accomplished by comparing sample peak height to the standard peak height. The F/G ratio was then calculated (Bogdanov *et al.*, 1997).

Table 1: The different ice cream mix ingredients and proportions

Treatment groups	Ice cream mix ingredients (%)								
	Raw milk	Vegetable oil	Granular sugar	Date liquid sugar	Date pulp	Skim milk powder	Whey powder	Vanillin	Emulsifier /Stabilizer
C	70	8	18	-	-	2	1.4	0.1	0.5
PDS	70	8	9	9	-	2	1.4	0.1	0.5
TDS	70	8	-	18	-	2	1.4	0.1	0.5
PDP	70	8	9	-	9	2	1.4	0.1	0.5

C: Control, PDS: Partial substitution of granular sugar with date liquid sugar (50%), TDS: Total substitution of granular sugar with date liquid sugar, and PDP: Partial substitution of granular sugar by date pulp (50%)

Milk analysis

The fat, protein, lactose, minerals, and moisture of milk were determined by Lacto Star (Gerber, Germany).

Ice cream manufacturing

The ice cream was prepared according to the four formulations presented in Table 1. The granular sugar was used for the control group. Date pulp (3rd grade Kabkab) and date liquid sugar (Brix=70) for sugar replacement, were purchased from Shahd Babe Pars Company, Tabriz, Iran.

Dry ingredients including: Skim milk powder (Pegah, Iran), whey powder (Pegah, Iran), granular sugar, and emulsifier/stabilizer (Palsgaard® Extrulce 379, Denmark) were added to the previously heated milk (45°C) and mixed. The mixtures were homogenized (at 70°C) and pasteurized at 80°C for 1 min. Then they were cooled to 15°C and stored for 16 h at 4°C for aging. All ice cream mixes were flavored with vanilla extract prior to freezing at 0.4% (V/V). The soft ice cream was made from the mixtures by ice cream maker (Moulinex, Italy 03051 410). Then, they were divided into weights of 120 g and packed in plastic containers and transferred to a -30°C hardening freezer, and held for 48 h. Ice cream samples were stored at -18°C until further analysis. The manufacturing process was similar for all treatments. The production process was done in triplicate.

Determination of pH and acidity

The pH of ice cream samples was measured using a glass electrode pH meter (Methrohm AG, Herisau, Switzerland). Titratable acidity of samples was determined by titration with NaOH 0.1N, and reported as the percentage of lactic acid/100 g of ice cream (AOAC, 2000).

Determination of density, apparent viscosity, and overrun

The density of ice cream samples was determined at 20°C using Pycnometer (Brand, England). The apparent viscosity of the melted ice cream was determined at 4°C using a rotational Brookfield Viscometer DV-II (Brookfield, USA) at the speed of 20 rpm at 30 s using a spindle #5 (LV model, Brookfield, USA), and was expressed in centipoises (cp) (Özer *et al.*, 1997).

The overrun of the product was determined according to the following equation (Dervisoglu and Yazici, 2006):

$$\text{Overrun (\%)} = \frac{(\text{ice cream volume} - \text{mix volume})}{\text{mix volume}} \times 100$$

Determination of total anthocyanin content

Total anthocyanins were determined according to Hwang *et al.* (2009). Exactly 2 ml of samples (2 g of dates) was mixed with 2 ml acidified methanol (containing 100 g/kg HCl) and centrifuged at 3000 × g for 10 min. The supernatant (1 ml) was added to 9 ml HCl (Merck, Germany) 1 mol equiv/L. The optical density was measured at 520 nm. Total anthocyanin content was calculated as below:

$$\text{Anthocyanin content (mmol/ml)} = \text{Absorbance}_{520} \times 101 \times 18.89$$

Determination of total phenolic content

The total concentration of phenols in the samples was measured according to Hwang *et al.* (2009) using Folin-Ciocalteu (F-C) colorimetric method. About 5 g of an ice cream, date, and date liquid sugar were extracted in 25 ml of methyl alcohol (Merck, Germany). After 12 h refrigeration, the extracts were filtered (Whatman No. 4) and used for the determination of phenolics and DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity.

Extracts (0.2 ml) were mixed with 1.8 ml of distilled water, 1 ml of F-C reagent (Sigma-Aldrich, USA), and 2 ml of 20% sodium carbonate (Merck, Germany). The mixture was kept at 25°C for 20 min and the absorbance was measured at 735 nm. Different concentrations of gallic acid (GA) (0, 0.1, 0.25, 0.5, 0.75, and 1 mg/ml) were used for calibration curve and the results were expressed as mg GA equivalent/100 g of sample. All measures were obtained in triplicate.

Evaluation of antioxidant activity using the DPPH method

The extract (0.3 ml) obtained in the previous step was mixed with 1.2 ml methanol and 1.5 ml DPPH solution in methanol (0.5 mmol/L). After 90 min of reaction at room temperature, the sample absorbance was measured at 515 nm (Singh *et al.*, 2002). Methanol was applied as a blank. The DPPH scavenging activity was calculated as shown below:

$$\% \text{DPPH scavenging} = \frac{\text{absorbance}_{\text{control}} - \text{absorbance}_{\text{sample}}}{\text{absorbance}_{\text{control}}} \times 100$$

Determination of the reducing power of ice cream, dates, and date liquid sugar

An aliquot of 0.1 ml of each extract was mixed with 0.5 ml of phosphate buffer (0.2 M, pH = 6.6) and 0.5 ml of 0.01% potassium ferricyanide (Merck, Germany). The mixture was incubated at 50°C for 20 min. After cooling, 0.5 ml trichloroacetic acid (1%) was added and the

mixture was centrifuged (30 min at 7000 × g). The supernatant was diluted with distilled water (1+1) and then mixed with 0.2 ml ferric chloride solution (0.001%), and the absorbance was read at 700 nm. Butylated Hydroxytoluene (BHT) was used as a standard and the reducing power was reported as BHT equivalent/100 g of sample (Ferreira *et al.*, 2007).

Sensory analysis

The sensory analysis of ice cream samples was carried out after 2 weeks of storage by twenty trained panelists (10 men and 10 women, age 30-45 years), using a 5 point scale as follows:

5 = Really like

4 = Like moderately

3 = Neither like nor dislike

2 = Dislike moderately

1 = Dislike really

Panelists were asked to evaluate the color, flavor, and texture. Samples were offered in plastic cups, coded with 3-digit numbers. Assessors were nonsmokers and regular consumers of dairy products. All panelists were asked to rinse their mouths with distilled water between samples.

Statistical analysis

All experiments were done in triplicate. Data were

subject to analysis of variance (ANOVA) and Duncan's multiple range tests using an SPSS package (SPSS 16 for Windows, SPSS Inc., Chicago, IL, USA). The Kruskal-Wallis test was used for sensory data analysis. P-values less than 0.05 were considered statistically significant.

Results

Analysis of raw materials

Some physical and chemical properties of raw milk, date, and date liquid sugar are summarized in Table 2.

The glucose (G) was a predominant carbohydrate in date, followed by fructose (F) and sucrose.

Physicochemical properties of ice creams

The results obtained from the physicochemical properties of all ice cream formulations are shown in Table 3. The partial replacement of sugar with date liquid sugar or date pulp did not have a significant effect on pH and acidity ($P > 0.05$) while complete replacement of granular sugar by date liquid sugar, significantly decreased the pH and increased the acidity ($P < 0.05$), which may be due to the different acids in the date.

According to the results, no significant difference ($P > 0.05$) in the overrun and density of ice creams was

Table 2: The chemical properties of milk, date pulp, and date liquid sugar

Parameters	Milk	Date pulp	Date liquid sugar
Fat (%)	3.36 ± 0.63	-	-
Protein (%)	3.71 ± 0.38	-	-
Solid non-fat (SNF) (%)	10.46 ± 1.15	-	-
Lactose (g/100 g)	5.59 ± 0.62	-	-
Glucose (g/100 g)	-	32.92 ± 0.64	34.42 ± 1.28
Fructose (g/100 g)	-	30.53 ± 0.20	31.10 ± 1.51
Sucrose (g/100 g)	-	8.96 ± 0.98	8.38 ± 2.46
Glucose/Fructose (G/F)	-	1.08 ± 0.01	1.11 ± 0.33
Minerals (%)	0.66 ± 0.18	-	-
Moisture (%)	86.18 ± 1.78	-	-
Freezing point (°C)	-0.59 ± 0.07	-	-

The data are presented as mean±SD

Table 3: Physicochemical properties of all ice cream formulations

Formulas	Dry matter (%)	Fat (%)	pH	Acidity (g/L)	Density (g/L)	Viscosity (cp)	Overrun (%)
C	38.74 ± 4.22 ^a	10.53 ± 1.76 ^a	6.48 ± 0.08 ^a	1.53 ± 0.68 ^a	868 ± 32 ^a	926.00 ± 11.00 ^a	100 ± 0.00 ^a
PDS	36.52 ± 5.03 ^a	10.84 ± 2.11 ^a	6.39 ± 0.21 ^a	1.57 ± 0.31 ^a	820 ± 43 ^a	932.67 ± 13.01 ^a	100 ± 0.00 ^a
TDS	37.66 ± 6.16 ^a	10.58 ± 1.36 ^a	5.90 ± 0.01 ^b	2.47 ± 0.95 ^b	838 ± 69 ^a	1616.00 ± 16.10 ^b	100 ± 0.00 ^a
PDP	37.91 ± 3.95 ^a	10.29 ± 1.85 ^a	6.32 ± 0.02 ^a	2.11 ± 0.19 ^a	835 ± 85 ^a	2164.33 ± 15.04 ^c	100 ± 0.00 ^a

C: Control, PDS: Partial replacement (50%) of granular sugar with date liquid sugar, TDS: Total replacement of granular sugar with date liquid sugar, and PDP: Partial replacement (50%) of granular sugar with date pulp. The data are presented as mean±SD. Means in the same column with different superscript letters indicate significant differences ($P < 0.05$) between treatments

Table 4: Total phenolic and anthocyanin content, DPPH scavenging activity, and the reducing power of ice cream samples

Formulas	Total phenols (mg GA/100 g)	Anthocyanin (mmol/ml)	DPPH scavenging (%)	Reducing power
C	1.95 ± 0.16 ^a	190.65 ± 0.64 ^a	18.14 ± 0.29 ^a	0.23 ± 0.60 ^a
PDS	4.24 ± 0.06 ^b	267.23 ± 10.32 ^b	18.14 ± 0.29 ^a	0.23 ± 0.60 ^a
TDS	6.71 ± 0.60 ^c	312.22 ± 7.27 ^c	34.80 ± 0.23 ^c	1.53 ± 0.03 ^c
PDP	6.58 ± 0.95 ^c	390.24 ± 6.26 ^d	41.45 ± 1.17 ^d	1.63 ± 0.01 ^d

DPPH: 2,2-diphenyl-1-picrylhydrazyl, C: Control, PDS: Partial replacement of granular sugar with date liquid sugar (50%), TDS: Total replacement of granular sugar with date liquid sugar, and PDP: Partial replacement (50%) of granular sugar with date pulp. The data are presented as mean±SD. Different letters in the same column are significantly different ($P < 0.05$)

seen.

Viscosity is one of the most important properties of an ice cream, which is necessary for good texture and resistance to melting. Replacing sucrose with dates (pulp or liquid sugar) increased the ice cream viscosity. The lowest value of viscosity was seen in the control sample while by total replacement of sugar with date liquid sugar, the highest viscosity value was obtained ($P < 0.05$).

Phenolics, anthocyanin and antioxidant content

Total phenolics and anthocyanin content of ice creams, DPPH scavenging activity, and the reducing power of samples are summarized in Table 4. Sugar replacement with date (pulp/liquid sugar) significantly increased the total phenols and anthocyanin content of ice creams ($P < 0.05$). Thus, the control group had the lowest phenolic and anthocyanin content ($P < 0.05$).

Sensory analysis

The findings obtained from the sensory evaluation are shown in Fig. 1. The effect of adding dates on the colour of the ice cream depended on their concentration since the partial replacement of sugar with date pulp or liquid sugar had no significant effect on colour ($P > 0.05$) while the complete replacement with date liquid sugar significantly decreased the color score ($P < 0.05$), that could be due to the brownish color of the date liquid sugar. Similar results were observed by adding date fiber to ice cream (Yangilar, 2015).

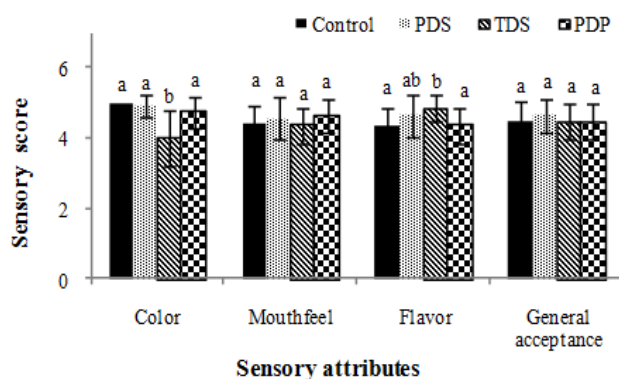


Fig. 1: Effect of sugar replacement with date (pulp/liquid sugar) on the sensory profile (mean±SD) of ice creams. PDS: Partial replacement (50%) of granular sugar with date liquid sugar, TDS: Total replacement of granular sugar with date liquid sugar, and PDP: Partial replacement (50%) of granular sugar with date Pulp. Different superscript letters in each sensory attribute indicates significant differences ($P < 0.05$) among treatments

All ice creams had a similar mouth feeling ($P > 0.05$). Adding date liquid sugar significantly improved the flavor of ice creams ($P < 0.05$). The scores for flavor significantly increased with the increase in the date liquid sugar concentration. But, the addition of date pulp had no effect on the scores of flavor ($P > 0.05$). Panelists preferred the flavor of ice cream samples made with 18% date liquid sugar.

Discussion

The G and F were the main sugars in the date. Sahari *et al.* (2007) also reported that the G (16.41-54.23 g/100 g) and F (12.62-43.31 g/100 g) were predominant sugars in thirty-four date varieties. Al-humaid *et al.* (2010) also reported the same results and added that sucrose was not detected in most varieties of palm in Saudi Arabia. The sugar content of date, might considerably change with variety, soil, and climatic conditions (Hulme, 1970), but generally, it is an excellent source of readily available sugars (Ahmed *et al.*, 1995) which are easy to digest in human cells and useful for getting the energy for metabolic processes. The G/F ratio in the present study was 1.08. Due to higher concentrations of G, the G/F ratio in this product is usually higher than one. Ahmed *et al.* (1995) reported a G/F ratio of 1-1.2 in various species of date.

The results indicated a concentration dependent effect of the sugar substitution percent on the acidity of ice cream. Similar results were expressed by Abdollahzadeh *et al.* (2018), in which the acidity of yogurt increased by increasing the concentration of date extract to 12%. In the present study, it was found that replacing sugar with date did not have a significant effect on the ice cream density and overrun, but increased the viscosity. Ozdemir *et al.* (2008) showed that sucrose substitution with honey, high F corn liquid sugar, and G liquid sugar could decrease the overrun of the ice cream. Gohari Ardebili *et al.* (2005) reported that 50% replacement of sugar with date palm increased the overrun percentage of an ice cream; however, with the increasing replacing rate, the overrun percent decreased. They also expressed that the ice cream viscosity increased with increasing the date concentration. Similar findings were observed by adding cape gooseberry to ice cream (Erkaya *et al.*, 2012). The increase of viscosity in samples can be explained by the high content of dietary fiber in date.

Replacing dates with sugar increased the amount of phenolic compounds in ice cream. The use of date pulp had a greater effect on the phenolic and anthocyanin content of an ice cream than the date liquid sugar ($P < 0.05$). The thermal process used to make the liquid sugar seems to decompose some phenolic compounds (Shahidi and Naczki, 2003). Many studies have reported different amounts of phenolic compounds in dates (Al-Farsi *et al.*, 2005; Biglari *et al.*, 2008). The amount of phenolic compounds varies depending on the variety and the growth stage (Singh *et al.*, 2012).

Anthocyanin, phenolic, and flavonoid contents of dates is responsible for their antioxidant activity (Matsumoto *et al.*, 2002; Mansouri *et al.*, 2005; Al-Turki *et al.*, 2010). Accordingly, total phenol (28.9 ± 0.8), reducing power (1.72 ± 0.002), anthocyanin content (586.68 ± 20.23) and DPPH scavenging activity (82.08 ± 1.31) of date pulp were significantly higher than the liquid sugar (4.10 ± 0.06 , 1.65 ± 0.04 , 180.27 ± 8.1 , and 1.65 ± 0.04 , respectively) ($P < 0.05$). As date liquid sugar concentration increased, the reducing power and DPPH

scavenging activity of ice cream also increased ($P < 0.05$). The antioxidant activity of phenolics is a result of their redox activity, which can absorb and neutralize free radicals, quench singlet and triplet oxygen, or decompose peroxides (Osawa, 1994; Brewer, 2011). Al-humaid *et al.* (2010) also reported the antioxidant activity of date in camel milk.

All samples received high scores for general acceptability in terms of flavor, mouthfeel, and colour and no marked off-flavor was reported. Ozdemir *et al.* (2008) revealed that the partial substitution of sucrose with G syrup, honey, and high F corn syrup had a better effect on sensory properties of an ice cream than the complete substitution. Milani and Koocheki (2011) showed that as date syrup concentration increased (0-50%), the sensory (flavor, texture, and total acceptability) scores of the frozen yogurt decreased.

Dates are one of the most important agricultural products in Iran, and every year large quantities of this valuable product are wasted due to the lack of proper treatment. Dates are a good source of natural antioxidants and their use in different foods may help them to become a functional food. Adding dates (pulp/liquid sugar) to ice cream increases the amount of phenolic compounds, antioxidant properties, and flavor of ice cream. Partial replacement (50%) of sugar by date pulp was revealed to have a greater antioxidant effect than a complete replacement by date liquid sugar. However, no adverse effect of dates on the sensory attributes was observed; thus, partial replacement (50%) of sugar with date pulp in ice cream production is recommended.

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