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Physicochemical, Sensory, Rheological Properties and Glycemic Index of Fresh Date Ice Cream

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Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study, managed the literature searches and performed the statistical analysis. Authors MAL and SK managed production of the tested ice creams and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aim: The aim of this study was to formulate and develop a low calorie and low glycemic index (GI) soft ice cream by using mixture of sucrose and date.
Methods: Five different formulations of ice cream were produced by using different proportions of sucrose and date. Physicochemical characteristics, hedonic sensory evaluations and GI determination of products were carried out following conventional methods.
Results: Replacement of sucrose with date resulted in a significantly higher viscosity (.000) and brix (.034) degree with a higher overrun and melting rate, in a dose dependent manner. Sucrose free ice creams had significantly lower caloric value from (143.03 to 113.51 Kcal) and GI from 79.06±4.0 to 72.51±4.61 as compared to date free those of sucrose based formulation indicating a 29.52% and 6.55% reduction, respectively.
Conclusion: We concluded that substitution of sucrose with date is may be a choice to produce a low calorie and glycemic index ice creams with no impeding effect on physicochemical and sensory properties.

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Keywords: Glycemic index; date; ice cream; overrun; melting rate.

1. INTRODUCTION

Ice cream is the most popular frozen dessert all over the globe. It is a combination of milk, sweetener, stabilizer, emulsifier and flavoring agents, egg products, coloring additives and hydrolyzed products of starch [1].

Wide types of sweeteners have been used in ice cream formulation. For both economic and rheologic reasons, sucrose is the most frequently used sweetener in ice cream production. However, it has many disadvantages due to its high glycemic index (GI) which is correlated with metabolic syndrome, diabetes mellitus (DM), obesity, hypertension, ischemic heart diseases and dental caries [2]. Therefore, in recent decades, artificial sweeteners have been widely suggested to be substitutes for sucrose. Although, these compounds produce little or no calories but a variety of safety issues has been raised including carcinogenicity, teratogenicity and interference with some metabolic or vascular diseases.

Date is one of the most nutritious fruits which contain many minerals such as potassium, zinc, manganese, iron and also vitamins A, B and E. Date is low in fat and protein but rich in sugars, mainly fructose and glucose. Palm sugar contains 25% sucrose and 50% glucose. In aqueous environments, the sucrose content converts to glucose and fructose [3] .There is 125 kilo-calorie of energy in each 100 grams of fresh date which is one fourth of equivalent grams of sugar [4].

Nowadays, to adapt a healthy life style, there is an increasing trend for consumption of healthy diets with low sucrose and low glycemic index. Therefore many researchers in food technology have been focusing on possibility of introducing new food products with fewer calories. A global increase in production and consumption of ice cream, as a highly nutritive dessert, parallels with increased trend in prevalence of DM, obesity and ischemic heart diseases [5,6]. This product has been widely accepted by children and other age groups and has been included in food basket of many families in different countries. Production of an ice cream with a relatively lower calorie value and GI will be partly helpful in impeding occurrence of life style related diseases. The aim of the current study was to examine GI, rheology, sensory and physicochemical characteristics of soft ice cream formulated with different proportions of sucrose and date and to introduce a novel date based ice cream.

2. MATERIALS AND METHODS

2.1 Preparation of Ice Cream

To prepare different treatments of ice creams, 500 ml of skimmed milk with 1.5% fat, 8% solid non fats dry matter was pasteurized and mixed with 120 g cream powder, 80 g full cream milk powder containing 30% fat, 1g of guar gum and locust bean gum as emulsifier and 0.9 gram of vanilla. It was then homogenized by a stirrer (Heidolph RZR 2012 control, Japan) with 800 rpm for one minute. As shown in Table 1, varying proportion of date (yellow date and sucrose (su) was added to make five different ice cream formulations followings: (1) treatment A(TA) 18.6 g(su), (2) treatment B(TB) 13.95 g (su) and 4.65 g date, (3) treatment C (TC) 9.3 gram (su) and 9.3 g of date, treatment D(TD) 4.65 g (su) and 13.95 g date and treatment E(TE) 18.6 g date without any sucrose. All the treatments were

homogenized at 70ºC and 85 Pascal. The mixture was pasteurized for thirty seconds at 80ºC. The mix was incubated at 10-15ºC for 20 minutes and kept on 4ºC for 12 hours.

Table 1. Components of soft and date ice cream

Components of ice cream in 100 g	Treatment A	Treatment B	Treatment C	Treatment D	Treatment E
Milk* (ml)	58.01	58.01	58.01	58.01	58.01
Sucrose (g)	18.6	13.95	9.3	4.65	0
Dry milk powder** (g)	9.3	9.3	9.3	9.3	9.3
Cream powder(g)	14	14	14	14	14
Emulsifier and Stabilizer(g)***	0.22	0.22	0.22	0.22	0.22
Date(g)	0	4.65	9.3	13.95	18.6

The milk used contained 1.5% fat, 8% dry material, 3.3 gram (g) protein and 4.9 g carbohydrate. **Dry milk powder contained 30% fat. * PGX-1 stabilizer from Germantown Mfg. Co., Broomall,PA, USA.*

2.2 Physicochemical Assessments

Ice cream overrun assessment was performed using weight method [7]. According to Table 2determination of total protein and fat were performed by Kjeldahl (AOAC; 930.33) and Gerber methods (AOAC 952.06), respectively [8].

Table 2. Ingredients of soft and date ice cream

Treatments / Constituent	Treatment A	Treatment B	Treatment C	Treatment D	Treatment E
Fat*	6.67	4.21	4.02	6.23	6.30
Protein*	4.50	6.20	6.73	6.67	5.47
Total sugar*	16.25	17.07	15.31	12.50	13.03
Total calorie	143.03	130.97	124.34	132.75	113.51

Data are expressed as gram per 100 ml of ice cream.

Melting test was conducted as proposed by Lee and White [9]. Briefly, all the treatments were stored at -18ºC before carrying out the melting test. Ice cream samples (100.0 ± 2.0 g) were placed on a 1-1 mesh and maintained in a controlled temperature chamber set at 25ºC, under constant humidity of 50%. The dripped volume was measured every 5 minutes for 60 minutes. The weight of the material passing through the screen was recorded and used to determine the melting rate (g/minute).

The viscosities of the ice creams were measured at 15ºC using a digital Brookfield Viscometer (Physical, Anton Paar GmbH and Graz, Austria). Before measuring the viscosity, the samples were stirred gently to remove air from the mixtures. Caloric content of each treatment was calculated using food analysis software (Nutritionist 4, Nutrition Marker Plus).

2.3 Sensory Evaluation

The sensory evaluation tests were performed with volunteers according to a previously described method [10] by in house panelists (n = 26) The sensory evaluations were repeated consecutively for all the samples with a 15 minutes time gap to perform mouth

washing by the volunteers. The panelists were requested to rank between '0' as uncharacterized intensity, and '5' as very strong intensity.

2.4 Measurement of Glycemic Index

To measure GI, ten volunteers (2 men and 8 women) were recruited in the study. Inclusion criteria were: normal health according to a complete physical examination by a physician, normal fasting and post-prandial glucose levels and not receiving any medications or food supplements during past three months.

The volunteers were requested to maintain overnight fasting for ten hours. To calculate reference glycemic response, the participants were then asked to take 50 g pure glucose in 150 ML drinking water and their plasma glucose was tested for two hours and in 15 minutes intervals. The blood glucose levels were determined by capillary blood glucose analyzer (Beurer, Art-Nr.463.00, and Germany).The experiments were repeated for two consecutive days using 61.5 g of soft ice cream (TA), 76.9 g of a sample date ice cream (TB) to provide ice creams with 50 gram of carbohydrate in each test meals. Then, related curves were drawn based on obtained blood glucose levels and the area under curve was measured from 0 to 120 minutes by numerical integration for of all samples. Finally, GI was calculated by using following equation:

Glycemic index= area under glycemic increase curve in 0 to 120 minutes for consumed ice cream / area under glycemic increase curve in 0 to 120 minutes for standard sample.

2.5 Ethical Considerations

All the participants had written an informed consent. The study was approved by the medical ethics committee of the Tabriz University of Medical Sciences, Tabriz, Iran. The study was registered at national randomized clinical trial directory.

2.6 Statistical Analysis

All the assessments were repeated three times. Data were first examined by Kolmogorov-Smirnov test to ensure normality. They were then expressed as mean± SDV .Comparison within each group were done by one way analysis of variance followed by the Tukey's test. All the analysis were performed using SPSS software, version 17.1(SPSS, Chicago, Illinois, USA).

3. RESULTS AND DISCUSSION

3.1 Effects of Replacing Sucrose with Date on Physicochemical Properties of Products

Viscosity or resistance to flow is the most important feature of ice cream mixture. It was found that ice cream samples with no sucrose TE had the highest viscosity. As shown in Table 3, this sample had relatively high viscosity as compared to TA. This seems reasonable since changing type of sweetener has been known to influence viscosity of ice creams. Also, monosaccharide such as glucose and fructose produce high osmolality solutions due to their solubility and hydrophilic characteristic and have capacity to make hydrogen bonds with water molecules by a hydroxyl group [11]. Which in turn augments viscosity of ice cream mixtures.

Table 3. Physicochemical and rheology properties of soft and date ice cream

Treatments / Variable	Treatment A	Treatment B	Treatment C	Treatment D	Treatment E	P Value
Viscosity(PA·s)	0.63±0.85 (a)	0.20±0.12 (b,c)	0.27±0.16 (a,c)	0.52±0.37 (a)	0.83±0.64 (a,d)	0.00
Brix (ºBx)	35.00± 0.50 (a)	36.00± 5.51 (a)	39.00±1.00 (a)	40.00± 0.29 (a)	42.00± 1.00 (b)	0.03
Over run (%)	53.37±0.76 (a)	54.33±1.20 (a)	56.18±0.74 (b)	58.08±1.07 (b)	62.04±1.00 ()	0.00

Date are presented as mean± SD and analyzed with one way analysis of variance. Different letters represent statistical significance among different treatment using the Turkey test.

It is suggested that a very low overrun is associated with soggy configuration while an increased overrun results in a puffy tissue [12]. As shown in Table 3, we found significant change in percentage of overrun among all the treatments with the lowest percent (53.37±0.76) in TA and the highest percent (62.04±1.00) in TE. Although, many factors affect overrun including viscosity, fat, emulsifier, stabilizer contents and processing conditions, viscosity has been reported to be an important factor [12]. A higher viscosity observed in ice creams with lower sugar contents (TA), lower viscosity with no added sugars (TE) implies that ice creams with high sucrose have relatively lower overrun

As shown in Fig. 1, ice cream melting rate showed an increasing trend in proportional to amount of used date. Also, the ice creams with low overruns melted slowly. A lower melting resistance in the ice creams with high overruns is mainly attributed to a reduced rate of heat transfer across air bubbles [13]. It has been reported that sugars with lower molecular have a decreased melting resistance as compared to those with higher molecular weight [14]. It was concluded that the slower thawing of the ice creams produced with sucrose was associated to the size and molar weight of the chains of this disaccharide [15,16].

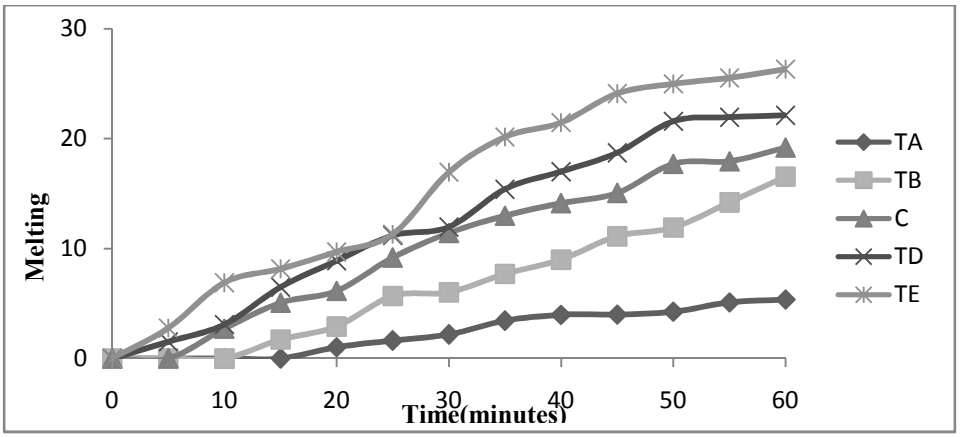

Fig. 1. Melting rates (g/minute) of ice creams during two hours period.

Formulations of the ice creams were as followings: TA=18.6 gram sucrose added to soft ice cream / 0 gram date. TB=13.95 gram sucrose added to soft ice cream / 4.65 gram date.TC=9.3 gram sucrose added to soft ice cream / 9.3 gram date. TD=4.65 gram sucrose added to soft ice cream/ 13.95 date/.TE=0 gram sucrose added to soft ice cream / 18.6 gram date.

3.2 Effects of Replacing Sucrose with Date on Glycemic Index and Caloric Measurement

Young, apparently healthy adults with average age of 23.3± 4.16 years were included to do this test. Mean body mass index of the participants was 23± 4.37. The mean GI of ice Cream formulated with or without sucrose was calculated as 79.06± 4.01 and 72.51±4.61, respectively (Fig. 2). In addition, mean calorie value of these two ice creams was 143.03 and 113.51.

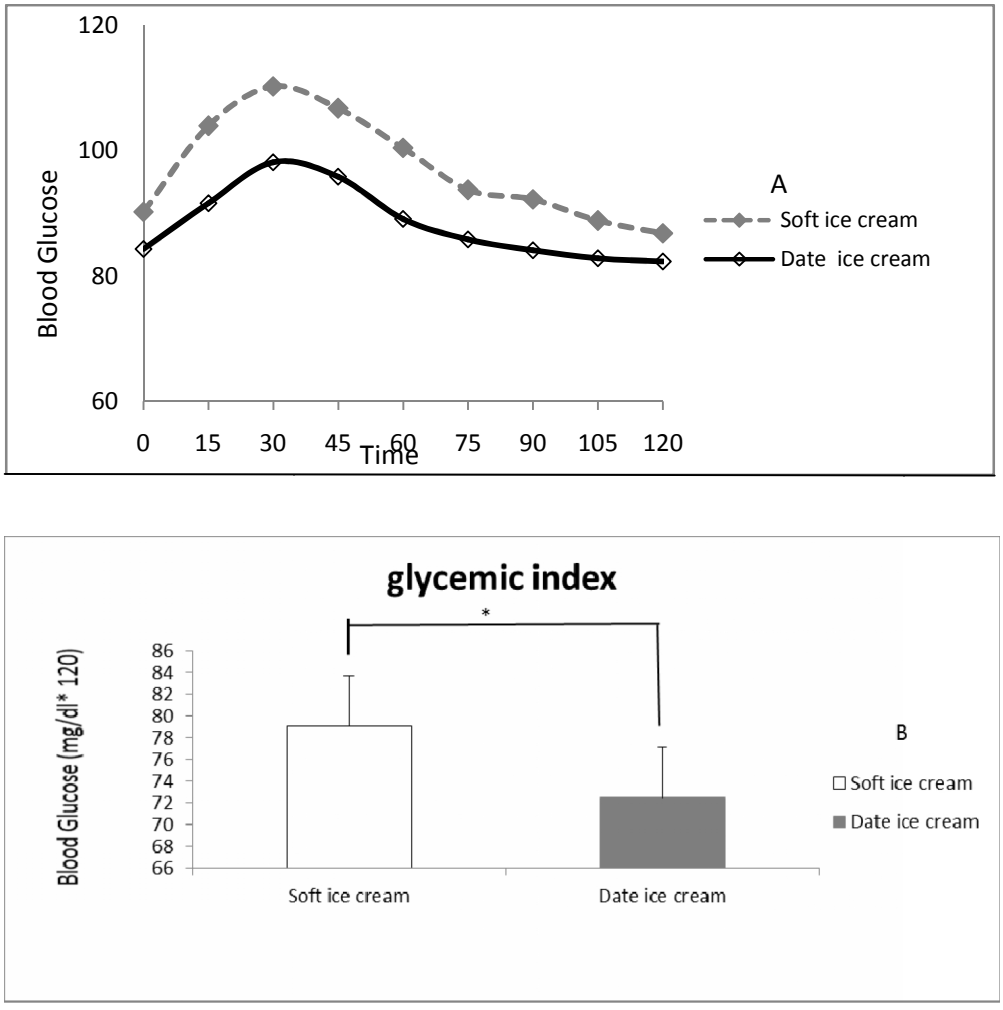

Fig. 2. (A) Trend of blood glucose response during 120 minutes after consumption of the twice ice cream formulation (B) glycemic index of soft and date ice cream. A single asterisk indicate p value less than 0.05

Level of post-prandial blood glucose is affected by both amount and type of carbohydrate consumed. Accumulative data elucidated a positive correlation between increased dietary GI, amount of calory and risk for coronary heart disease [5]. Judging from the remarkable reduction in caloric value and GI of date based Ice Creams (TD and TE) and in line with

previous reports [17-19], we suggested that substitution of date with sucrose brings a new relatively healthy choice for food basket of families with high risk of life style related diseases including DM.

3.3 Effects of Replacing Sucrose with Date on Sensory Properties

Sensory evaluations were conducted to determine relevance of date as a natural sweetener as presented Fig. 3, different amounts of date and sucrose did not result in difference in the color of the products. Substitution of sucrose with date decreased flavor, tissue and mean liking scores of the products. The suitability of taste, texture and mean liking was relatively higher (.000) in TC as compared to other ice creams.

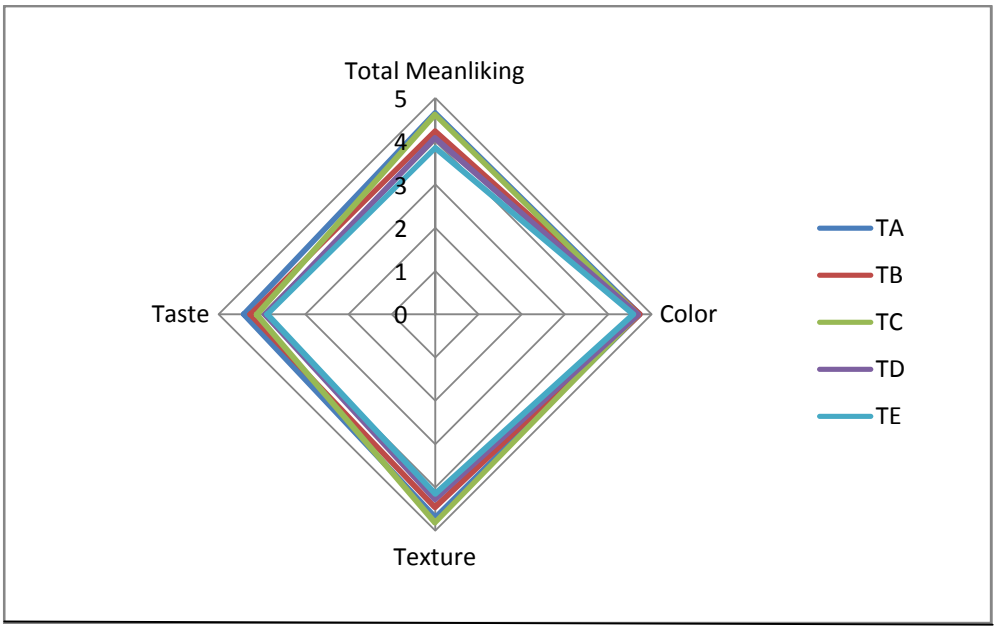

Fig. 3. Sensory properties of soft and date ice cream. Formulations of the ice creams were as followings: TA=18.6 gram sucrose added to soft ice cream / 0 gram date. TB=13.95 gram sucrose added to soft ice cream / 4.65 gram date.TC=9.3 gram sucrose added to soft ice cream / 9.3 gram date. TD=4.65 gram sucrose added to soft ice cream/ 13.95 date/.TE=0 gram sucrose added to soft ice cream / 18.6 gram date.

The sweetening power and persistence of sweet taste by date are affected by several factors such as concentration, ingredients and temperature of ice cream. It has been described that addition of very high concentrations of date to many food products negatively influences mean liking of those products [20]. It is concluded that sensory characteristics of the ice creams were related to both amount of date used and its interactions with other components of the products.

4. CONCLUSION

In conclusion, the current study has shown that application of date, as a natural sweetener, has a positive impact on producing an ice cream with remarkably low calorie and GI without

impeding effect on physicochemical and sensory properties of the ice creams. We believe that this sweetener can be used for production of proper food samples with low calorie and low GI. Although date is a natural compound, ensuring their safety in terms of allergic potency and any unexpected adverse effects on human health warrants further studies.

ETHICAL APPROVAL

All authors hereby declare that specific national laws were followed where applicable. All experiments have been examined following a study proposal approved by the ethics committee of the Tabriz University of Medical Sciences, Tabriz, Iran.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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