MINERAL CONTENTS AND PHYSICAL, CHEMICAL, SENSORY PROPERTIES OF ICE CREAM ENRICHED WITH DATE FIBRE

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ABSTRACT

Date samples of Amber cultivar straining from Medina region (Saudi Arabia) were analysed for their chemical compositions and physicochemical properties of date fibre in the present study. Fibre rich date pieces were found to contain 80.2 g/100 g total dietary fibre, 16.32 g water/g sample water-holding capacity while 9.50 g oil/g sample oil-holding capacity. It can be stated from these results that fibre content of date is a valuable dietary fibre source and used in food production as an ingredient. Effects of the addition of date fibres at different concentrations (1, 2, 3 and 4%) were investigated on the physical, chemical, sensory properties and mineral content of ice cream in the present study. It was found that elemental composition of ice cream samples was affected significantly by the addition of date fibre concentrations ($p<0.05$) and the rates of K, Mg and Zn especially increased in the samples depending on the content of date fibre while the content of Ca and P decreased. It was determined from the sensory results that ice cream sample containing date fibre in the rate of 1 and 2% received the highest score from panellists.

- Keywords: date fibre, ice cream, elemental composition, nutraceutical ingredient -

INTRODUCTION

Dietary fibre as a class of compounds includes a mixture of plant carbohydrate polymers, both oligosaccharides and polysaccharides (cellulose, hemicelluloses, pectic substances, gums, resistant starch, inulin) that may be associated with lignin and other non-carbohydrate components (polyphenols, waxes, saponins, cutin, phytates, resistant protein; ELLEUCH *et al.*, 2011). Over the last decades, knowledge on dietary fibre has increased considerably, both in the physiological and analytical areas. Health benefits of dietary fibre are associated with bowel function, reduced risk of coronary heart diseases, type 2 diabetes and improved weight maintenance (AGOSTONI *et al.*, 2010; HAUNER *et al.*, 2012; WESTENBRINK *et al.*, 2012). In addition, dietary fibre can provide a multitude of functional properties when they are incorporated in food systems. Several advantages of using fruit fibres in ice cream production are improvement in body due to the fibrous framework and melting properties, reduction of cold impression, reduction of recrystallization causing prolonged shelf-life, and enhancing mixed viscosities allowing freezing at higher overrun, causing no negative effect on the ice crystal sizes, and leading to a more homogenous air-bubble formation (ANONYMOUS, 2000; DERVISOGLU and YAZICI, 2006). Thus, fibre addition contributes to the modification and improvement of the texture, sensory characteristics and shelf-life of food due to their water binding capacity, gel-forming ability, fat mimetic, anti-sticking, anti-clumping, texturising and thickening effects (DELLO STAFFOLO *et al.*, 2004; GELROTH and RANHOTRA, 2001; THEBAUDIN *et al.*, 1997, chap. 23; SOUKOULIS *et al.*, 2009). There is little data dealing with the study of the functionality of dietary fibre in ice creams (SOUKOULIS *et al.*, 2009). Date (*Phoenix dactylifera* L.) provides a good source of dietary fibre content, is also considered to be a commercially important agricultural commodity as well as vital element of the daily diet and a nutritious food in the Arabian world (KHAN *et al.*, 2008; AL-FARSI and LEE, 2008) generally being consumed fresh or processed into various products (SINGH *et al.*, 2013). Annual production rate of date all across the world in 2010 was about 7.91 million tons, which increased in the rate of 6.6% in when compared to 2009 (FAO, 2011; AHMED *et al.*, 2013). Different varieties of date vary in their chemical composition especially in sugars and dietary fibre (MUSTAFA *et al.*, 1986; AHMED *et al.*, 1995; RAHMAN and AL-FARSI, 2005; SINGH *et al.*, 2013). The importance of date in human nutrition comes from its rich composition of carbohydrates (70-80%), salts and minerals, dietary fibres, vitamins, fatty acids, antioxidants, amino acids and protein (EL-BELTAGY *et al.*, 2009; AL-SHAHIB and MARSHALL, 2003; EL-NAGGA and ABD EL–TAWAB, 2012; AL-FARSI *et al.*, 2005, 2007; BIGLARI *et al.*, 2008; HONG *et al.*, 2006; MANSOURI *et al.*, 2005; VAYALIL, 2002; KCHAOU *et al.*, 2013). In fact, date fruit has been used in traditional medicine as immune system stimulator (PURI *et al.*, 2000), and as treatment for various infectious diseases (DUKE, 1992; MARTÍN-SÁNCHEZ *et al.*, 2013).

However, such a valuable nutrient is generally discarded or used in animal feeding. A serious economic loss can be experienced unless such a useful fruit and its products are used in human diet and food since it is rich in bioactive compounds, which can be extracted and used as value added materials. Development of new food products using date flesh is the topic of very limited number of studies. The objective of the present study is to characterize and evaluate the functional properties of the us date fibre (DF) taking into account the quality and nutritional content of ice cream.

MATERIALS AND METHODS

Materials

Cows' milk and cream were obtained by the Research and Application Farm of Atatürk University. Amber dates were purchased from the palm garden in Medina city of Saudi Arabia. Sugar, salep and emulsifier (mono- and diglycerides) were obtained from local markets. Skim milk powder was supplied by Pınar Dairy Products Co. (Turkey).

Preparation of date flour

Date fibre concentrates were extracted from the Medina cultivar 'Amber' as described previously (ELLEUCH *et al.*, 2008). DF from whole fruits were extracted in boiling water for 15 min, using a magnetic stirrer. After solubilisation of the sugars (sucrose, glucose and fructose), date fibres and pits were recovered through filtration using a 0.2 mm sieve. The pits were then removed. The fibres were concentrated by successive rinsing (water at 40°C) and filtration until the residue was free of sugar as described. The residues obtained were pressed dried, in oven at 65°C for 24 h and milled in a Mill Laboratory at 2890 rpm, then at 5000 rpm until they could pass through a 0.2 mm sieve to recover the date fibre concentrate, and stored at -18°C for subsequent physicochemical analyses and incorporation studies.

Chemical composition

Moisture content was determined according to the Association of Official Analytical Chemists (AOAC, 1997) method. Ash was analysed by combusting the sample in a muffle furnace at 550°C for 4 h. The residue was dissolved in HNO_3 and the mineral constituents (Ca, K, Na, Mg, P and Fe) were determined using an inductively couple plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT, USA). The Bligh and Dyer method (HANSON and OLLEY, 1963) was used to determine the lipid content. Protein content was determined by micro kjeldahl method (AOAC, 1990) and expressed as: % N_2x6,23. Total sugars were extracted through ethanol (80%) (NINIO *et al.*, 2003). After centrifugation, the supernatant was collected and the total sugar content was analysed using phenol/sulphuric acid reagent (DUBOIS *et al.*, 1956). The total phenolic content was analysed according to the Folin-Ciocalteu method developed by AL-FARSI *et al.* (2005). The extract (200 μL) was mixed with 1.5 mL of Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) for 5 min at room temperature. 1.5 mL of aqueous sodium bicarbonate (60 g/L) was added and the mixture was vortexed and allowed to stand at room temperature. After 90 min, the absorbance was measured at 725 nm. The total phenol concentration was expressed as the mean ± SD as mg of gallic acid equivalent (mg GAE) per 100 g of fresh weight of date for two replicates. AOAC enzymatic-gravimetric official method (991.43; AOAC, 1995) was used to determine dietary fibres while dry matter content, fat, ash, acidity (°SH) and pH of ice cream samples were determined as in DEMIRCI and GUNDUZ (1994). Mineral contents (Ca, K, Na, P, S, Mg, Fe, Mn, Zn, Ni) of ice cream samples were determined using an Inductively couple plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT, USA) and following the method described by GULER (2007). Samples were decomposed in a microwave oven (Berghof speed wave MWS-2, Eningen, Germany). For this purpose, about 0.5 g ice cream sample was weighed into the digestion vessels, added concentrated nitric acid (10 mL) and digestion process was realized over each sample at 210°C and under 176 psi pressure for 10 min. After cooling, the carousels were removed from the oven, 30% hydrogen peroxide (2 mL) was added to samples and then second digestion was applied at 195°C and under 95 psi pressure for 5 min. The vessels were immediately closed after the addition of oxidants. At the end of the digestion process, the samples were diluted in with distilled water to an appropriate concentration and filtered through Whatman No. 42 filter paper. All diluted digests were eventually analysed using an Inductively couple plasma spectrophotometer (ICP-OES).

Water and oil holding capacities, and pH of fibre

Water and oil holding capacities (WHC and OHC) of the fibres were determined according to the methods of MAC-CONNELL *et al.* (1997) and CAPREZ *et al.* (1986), respectively. WHC and OHC values represented the amount of water and oil absorbed per gram of sample, respectively. pH of DF was measured using a pH meter (WTW 340-1) and following the method described by SUNTHARALINGAM and RAVINDRAN (1993).

Ice cream manufacture

The ice cream samples were prepared in the Pilot Plant of Food Engineering Department, Agriculture Faculty, Atatürk University. Initially, the fat ratio of cows' milk was adjusted to 6% by adding cream. Then, the milk was divided into five equal parts of 2 kg. For each mix, skim milk powder (125 g), sugar (405 g), salep (stabilizer) (16.2 g), emulsifier (mono- and di-glycerides) (6.75 g) were added to each mix. Then prepared date fibres were added at four different concentrations: 1, 2, 3 and 4% to mixture weight. The mixes were pasteurized at 85°C for 25 min and stored at 4°C for 24 h. Then, they were iced in ice cream machinery (-5°C; Ugur Cooling Machineries Co., Nazilli, Turkey) and hardened at -22°C for 24 h and stored at -18°C and used for physical, chemical, mineral and sensory analyses. Ice cream samples were produced in duplicate.

Ice cream analysis

Physical measurements. Overrun was determined using a standard 100 mL cup, according to the equation [(volume of ice cream)-(volume of mix)/volume of mix×100] given by JIMENEZ-FLOREZ *et al.* (1993). First dripping and complete melting times were measured according to GUVEN and KARACA (2002) 25 g of tempered samples were left to melt (at room temperature, 20°C) on a 0.2 cm wire mesh screen above a beaker. First dripping and complete melting times of the samples were accepted to be seconds. The viscosities of the ice cream mixes were determined at 4°C using a digital Brookfield Viscometer, Model DV-II (Brookfield Engineering Laboratories, Stoughton, MA, USA). Before measuring the viscosity, the samples were stirred gently to remove the air from the mixes (AKIN *et al.*, 2007). The color analyses (L*, a* and b* values) of the ice cream mix were carried out using in Minolta colorimeter (Chroma Meter, CR-200, Osaka, Japan; ANONYMOUS, 1979). The colorimeter was calibrated using a white reference plate before measurements. Light source for the colorimeter was standard daylight (C) and the standard observer was 2°.

Sensory evaluation

Eight professional panellists from the Food Engineering Department of Atatürk University, Erzurum, Turkey, participated in the study to determine some properties using a score test for flavour, body and texture, color and appearance, resistance to melting and general acceptability. Hardened ice cream samples were tested at a serving temperature of -10°C and scored their sensory characteristics in a scale ranging from 1 (poor) to 9 (excellent). Warm water and bread were also provided to the panellists to cleanse their palates between samples. All panellists were non-smokers, had prior testing experience with a variety of dairy products including milk, cheese and ice cream and had previously used flavour profile procedures adapted from ROLAND *et al.* (1999).

Statistical analysis

All statistical analysis was performed using SAS for windows (SAS, 1998). Analysis of variance was performed using the routine Proc ANOVA. Significant treatment was separated using Duncan's Multiple Range Test (DUZGUNES *et al.*, 1987).

RESULTS AND DISCUSSION

Physical and chemical characteristics of date fibre

Dry matter, fat, acidity (°SH) and pH values of milk, skim milk powder and cream used in the production of the ice cream are given in Table 1. Date and date fibre were analyzed for moisture, ash, fat, total sugars, color, total phenolic content, WHC and OHC (Table 2). Date fibres are rich in protein (9.01 g/100 g). Earlier, EL-LEUCH *et al.* (2008) reported 9 g/100 g protein contents for Tunisian dates and similar to the present work. Presence of high protein content in fruit fibres (11.6-14.4 g/100 g) is reported in the literature (BRAVO and SAURA-CALIXTO, 1998; SAURA-CALIXTO, 1998). In the present study, calcium, sodium, potassium and magnesium contents of date fibre were measured to be 1925, 56.5, 981 and 1807 mg/kg, respectively. AHMED *et al.* (2013) reported that the sodium content was significantly lower than other minerals (55-86 mg/kg); however, the fibres were rich in potassium. The Barhee cultivar possessed exceptionally higher amount of potassium (2600 mg/kg), and the maximum sodium was found in Owadi cultivar. These results are significantly different from the reported values for date flesh (EL-LEUCH *et al.*, 2008). The variation could originate from the cultivar, and agro-climatic as well as environmental conditions.

Table 1 - The gross chemical, physical properties and mineral contents of raw milk, skim milk, cream.

Analysis	Milk	Skim milk powder	Cream
Dry matter (%)	11.37	95.17	63.76
Fat (%)	3.5	1.00	65.00
Ash (%)	0.67	-	-
Acidity (°SH)	5.81	-	13.98
pH	6.40	-	4.95
Minerals (mg kg⁻¹)			
Ca	1224.00		
K	1397.00		
Mg	91.67		
P	869.54		
Na	327.90		
Fe	13.56		

- Not determined.

Table 2 - Chemical and physical properties of date fibre and date.

Chemical analysis	Date	Date fibre
Moisture (g/100 g)	13.61±0.11	3.87±0.13
Ash (g/100 g)	1.79±0.07	2.06±0.04
pH	6.00±0.21	5.71±0.02
Protein (g/100 g)	1.23±0.16	9.01±0.75
Fat (g/100 g)	3.41±0.03	0.98±1.21
Total sugars	78.20	0
Total phenolic content[c]	186±2.30	0.73±0.01
Total dietary fibre (g/100 g)	8.75±0.96	80.2±1.06
Minerals (mg kg^{-1})		
Ca	23.40±0.51	1925±1.84
K	428±0.14	981±2.04
Mg	84.51±0.22	1807±0.82
P	90.19±1.36	1325±0.51
Na	17.65±0.12	56.5±0.05
Fe	2.03±0.07	24.82±1.36
Physical Analysis		
L*	23.8±0.04	61.08±0.05
a*	11.0±0.03	6.35±0.01
b*	8.9±0.07	14.72±0.01
WHC[a]	-	16.32±0.47
OHC[b]	-	9.50±0.23

[a]Water holding capacity (g water/g, sample);
[b]Oil holding capacity (g oil/g, sample);
[c]g/100 g of DF concentrates;
L* = lightness; a* = redness (+) and blueness (–); b* = yellowness.

Date contains high proportions of total dietary fibre (80.2 g/100g) similarly to those reported in Deglet-Nour and Allig (two varieties of date) between 88 and 92%, respectively (EL-LEUCH *et al.*, 2008). In addition, the contents of dietary fibre in dried apricots, prunes, figs, and raisins were 7.7, 8.0, 12.2, and 5.1 g/100 g, respectively (CAMIRE and OUGHERTY, 2003; MARLETT *et al.*, 1994; VINSON, 1999). Thus, dates and their by-products serve as good sources of fibre compared with syrups and other fresh and most dried fruits. In addition, these DF contents are close to levels measured for DF preparations from apple (Liberty cultivars) (89.8%), but notably higher than those of other fruit DF concentrates reported for grapefruit, lemon, orange, apple and mango (28-78.2%) (FIGUEROLA *et al.*, 2005; VERGARA-VALENCIA *et al.*, 2007), grape skins (54.1–64.6%) (BRAVO and SAURA-CALIXTO, 1998; SAURA-CALIXTO, 1998), citrus peel (57%; CHAU and HUANG, 2003), or fibre from lime peels (66.7% and 70.4%; UBANDO *et al.*, 2005) and mango peel (71%; LARRAURI *et al.*, 1996).

WHC was found to be 16.32 (g water/g, sample) in date fibre in the present study. WHC in of date fibres was reported to be significantly higher than those of fruit and vegetable fibres (FEMENIA *et al.*, 1997; GAN and LATIFF, 2011; LOPEZ *et al.*, 1996; VERGARA-VALENCIA *et al.*, 2007; AHMED *et al.*, 2013), but similar to those found in date (15.5 g/g, dry matter) by ELLEUCH *et al.* (2008). OHC is another functional property of some ingredients used in formulated food. In general, date fibre showed significantly higher OHC (9.5 g oil/g, sample) when compared to other fruit and vegetable derived fibres (GAN and LATIFF, 2011; VERGARA-VALENCIA *et al.*, 2007). The highest OHC was observed for Allig cultivar (9.9 g oil/g sample) followed by ELLEUCH *et al.* (2008). Higher OHC of date fibre indicated that it could be used as an ingredient to stabilize foods with a high percentage of fat (ELLEUCH *et al.*, 2008; AHMED *et al.*, 2013). The mean L*, a* and b* values were found to be 61.08, 6.35 and 14.72, respectively. This could be due, on the one hand, to the wash operations during the extraction and concentration of DF and, on the other hand, to the solubility of pigments responsible for the dark units of color. ELLEUCH *et al.* (2008) reported that L*, a* and b* values were 61.92, 7.11 and 14.85, respectively for Allig, which are convenient with the present study. GOÑI *et al.* (2009) informed that PP associated with polysaccharides and proteins in cell walls are significant constituents of date fibre. Table 2 shows date fibre polyphenol (PP) contents (0.73 g/100 g).

Physical and chemical characteristics of ice cream samples

The results of some physical, chemical analyses and mineral contents of ice cream samples are given in Tables 3 and 4. The dry-matter content of control sample was lower than other samples at statistically significant levels ($p<0.05$). The dry matter rates of ice cream increased with the addition of DF concentration. The highest fat and acidity ratios were found to be in control sample (4.63%). pH values of ice

Table 3 - Some chemical and physical properties of ice cream samples with date fibre.

Analysis	C	DF1	DF2	DF3	DF4
Moisture (%)	33.15±0.02a	33.32±0.29b	33.49±0.10a	33.63±0.36b	34.05±0.01c
Ash (%)	0.89±0.01a	0.92±0.01ab	0.95±0.01b	1.06 ±0.02c	1.10±0.01c
Fat (%)	4.63±1.41d	4.17±0.14c	4.15±0.03c	3.91±0.01b	3.86±0.02a
Acidity(°SH)	8.99±0.00e	6.23±0.02a	6.38±0.01b	6.54±0.01c	6.73±0.02d
pH	6.20±0.02e	5.62±0.02d	5.56±0.01c	5.23±0.03b	5.09±0.01a
L*	83.33±0.01d	82.26±0.04d	80.27±0.03c	77.64±0.91b	75.45±0.07a
a*	1.62±0.05a	2.54±0.04b	2.73±0.01c	3.21±0.04d	3.90±0.01e
b*	9.15±0.02a	9.20±0.01a	11.60±0.14b	12.40±0.01c	12.50±0.02c
Overrun (%)	40.51±0.00e	39.32±0.21d	37.20±0.01c	32.24±0.19b	29.87±0.06a
Complete melting time (s)	0.43±0.02b	0.50±0.00c	0.46±0.02b	0.35±0.01a	0.38±0.00a

Mean values followed by different letters in the same row are significantly different ($p<0.05$).
C: Control (without date fibre); DF1: ice cream with made date fibre 1% (w/w); DF2: ice cream with date fibre 2% (w/w); DF3: ice cream with date fibre 3% (w/w); DF4: ice cream with date fibre 4% (w/w).

Table 4 - Elemental composition (mg kg^{-1}) of the ash in ice cream with date fibre.

Concentrations of minerals	C	DF1	DF2	DF3	DF4
Ca	1844.36±12.72e	1623.25±2.82d	1547±2.12c	1481.40±2.12a	1514.06±7.77b
K	1669.56±21.20a	1913.06±4.15b	1939.18±1.33bc	2043.46±80.63cd	2135.46±49.95d
Na	537.68±6.37b	572±0.04c	690±0.70d	528.5±0.70a	573±0.01c
P	1100.86±0.01c	1257.05±4.24d	1019±2.12b	1100±0.71c	1006±2.82a
S	875.24±1.41a	938.50±17.67b	980±0.70c	1015±7.07d	1103±2.12e
Mg	159.31±1.39a	161.32±1.15a	164.78±0.72b	171.06±0.12c	183.33±1.59d
Fe	10.82±0.24a	11.17±0.05b	14.73±0.02c	21.02±0.01d	29.65±0.22e
Mn	0.32±0.01b	0.35±0.07c	0.26±0.02a	0.30±0.01b	0.40±0.01d
Zn	57.84±0.86a	70.82±0.95b	84.03±0.89c	91.13±1.36d	94.56±3.93d
Ni	0.97±0.06a	1.20±0.14b	1.14±0.01ab	1.70±0.01c	1.61±0.01c

Mean values followed by different letters in the same row are significantly different ($p<0.05$).
C: Control (without date fibre); DF1: ice cream with made date fibre 1% (w/w); DF2: ice cream with date fibre 2% (w/w); DF3: ice cream with date fibre 3% (w/w); DF4: ice.

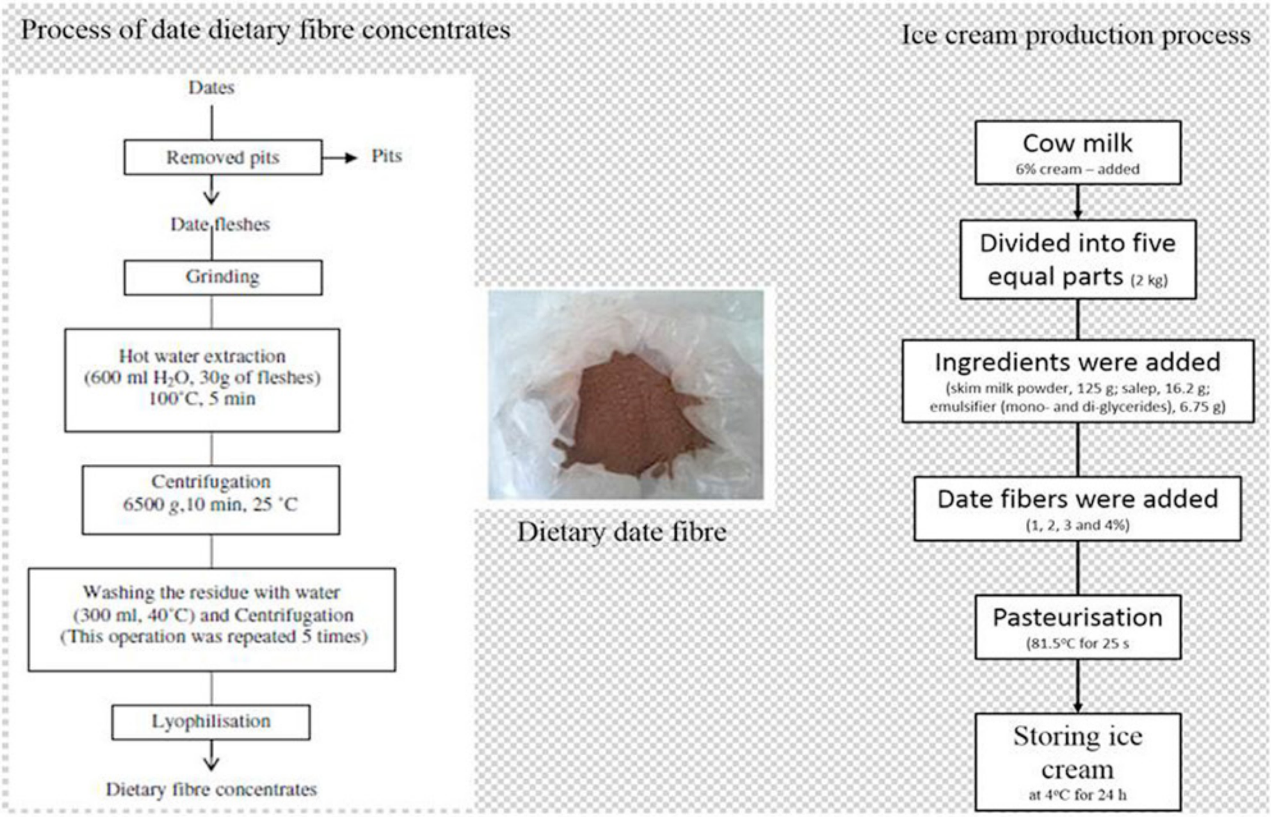

Fig. 1 - The obtain of date fibre and production of ice cream.

cream samples were not statistically different maybe due to pH of date (6.00).

Viscosity is one of the most important properties of an ice-cream mixture since it can result in a desirable body and texture in ice creams. Therefore, the measurement of viscosity is important to know the effect of DF on the characteristics of ice-cream mixtures. It could be seen in the present study that the addition of DF significantly ($p<0.05$) affected the viscosity behaviour of ice cream samples (Fig. 1). Viscosity of ice-cream samples increased significantly by adding DF (3 and 4%). As shown in Fig. 1, the lowest and highest viscosity rates value were obtained in DF1 sample the sample with 4% DF. The control sample had an average of 5175 viscosity. Similar results were reported in grape wine lees added in ice cream by HWANG *et al.* (2009), in frozen yogurt by GUVEN and KARACA (2002), in Cape gooseberry (*Physalis peruviana* L.) added in ice cream by ERKAYA *et al.* (2012) and the citrus fibre added in ice cream mixes by DERVISOGLU and YAZICI (2006).

Ice cream color was affected by the addition of DF. The date fibre had a brownish color. Ice cream fortified with date fibre had significantly higher a* and b* values and lower L* values compared to the control sample. Lightness (L*) values of ice cream samples were closer to each of dietary fibre but with DF1 and DF2 samples, it was found to be significantly higher than the other samples (Table 3). All samples had negative a* values and DF3 and DF4 samples had close but significantly higher values than other samples. Increase in the concentration of date fibre contributed to the color values of the samples ($p<0.05$). The addition of date fibre increased the b* values of all samples. The lowest b* value was obtained in DF1 samples while the highest b* was obtained in the DF4 samples. DERVISOGLU and YAZICI (2006) reported that the addition of citrus fibre increased the color properties similarly to the results of present study.

Overrun and melting time are associated with the amount of air incorporated during the manufacturing process. These features can define the structure of the end final product since the presence of air gives the ice cream an agreeable light texture and influences the physical properties of melting and hardness of the end product (SOFJAN and HARTEL, 2004; CRUZ *et al.*, 2009; DAGDEMIR, 2011). All ice cream samples had normally lower overrun values (29.87-40.51%) than those reported in literature (80-120%). Although the rate of DF lowered the overrun values of the ice-cream samples, control samples had higher overrun values than the DF added samples (Table 3). Since the viscosity of ice cream increased in DF added samples, it was possible that less air was incorporated in the ice cream mix with DF during batch freezing, which resulted in lower overrun than for control (without DF). The decrease of overrun values for ice creams with DF was in agreement with the results indicated in literature (DERVISOGLU *et al.*, 2005; TEMIZ and YESILSU, 2010). EL-SAMAHY *et al.* (2009) reported that the decrement of overrun in ice cream containing concentrated cactus pear pulp might be attributed to increment of mix's viscosity that extremely affects whipping rate of mixes. HWANG *et al.* (2009) reported that the overrun values of ice-cream samples decreased significantly when grape wine lees was added. It was found by SUN-WATERHOUSE *et al.* (2013) that overrun rate of ice – cream containing green kiwi fruit was 90.5% and higher than that found in the present study. However, similar results with the present study were found with Cape gooseberry (*Physalis peruviana* L.) added in ice cream by ERKAYA *et al.* (2012).

As can be seen in Table 3, the complete melting times of the ice cream samples were significantly longer for DF4 samples (0.50 g min^{-1}) and the period got longer as the fibre content increased. This is due possibly to some compounds existent in DF4, which have the ability of water absorption. AKIN *et al.* (2007) reported that the decrease in melting rate of ice cream with inulin might originate from its ability to reduce the free movement of water molecules. DF (3 and 4%) concentration affected the first dripping times positively (Fig. 2). Results of the present study indicated that the first dripping times were prolonged as the fibre contents increased in the ice cream samples ($p<0.05$). It was found by DERVISOGLU and YAZICI (2006) that citrus fibre samples extended dripping times. These findings were similar to those in the present study. Statistically significant differences ($p<0.05$) were found in terms of major element contents such as Ca, K, Mg and S between the samples except for Mn concentration in all ice cream samples. Dairy products are known to be excellent sources of Ca, P and Mg and supply dietary fibre a significant amount of calcimine, a bioavailable form (MCKINLEY, 2005). Addition of date fibre lowered Ca content of the samples in the present study (Table 4). The highest Ca was found to be 1844.36 mg/kg in control samples. Mg and S values of ice cream samples increased with the addition of date fibre ($p<0.05$). Increasing K in human diet may provide protection from hypertension in people who are sensitive to high levels of Na. The highest rate of S and Na was fibre detected in the samples with 4% and 2% DF to be 1103 and 690 mg/kg, respectively, while the lowest rates were 875.24 in control and 528.5 mg/kg with 3% DF, respectively. Elements like Fe, Zn and Mn are classified as micro-nutrients. The addition of DF significantly increased Fe, Zn and Mn contents of the ice-cream samples ($p<0.05$). Similar results were reported by ERKAYA *et al.* (2012) in Cape gooseberry (*Physalis peruviana* L.) added ice cream samples. It can be suggested by considering such a result that date fibre may be a good source to enhance dairy products such as ice-cream, which is poor in minor elements like Fe and Zn. WU *et al.* (2005) reported that Zn acts as a non-enzymatic antioxidant, so that its consumption helps to prevent oxidative damage of the cell. The ice cream sample with 4% DF had the highest Zn content (94.56 mg/kg).

Sensory evaluations

Results of the sensory evaluation of the ice cream samples on a scale from 1 (poor) to 9 (excellent) are shown in a radar plot in Fig. 3. Fortifying ice cream with DF had a significant effect on all sensory properties except sweetness. All the fibre-enriched samples received lower scores for total evaluation in terms of sensory characteristics ($p<0.05$). Ice cream enriched with up to

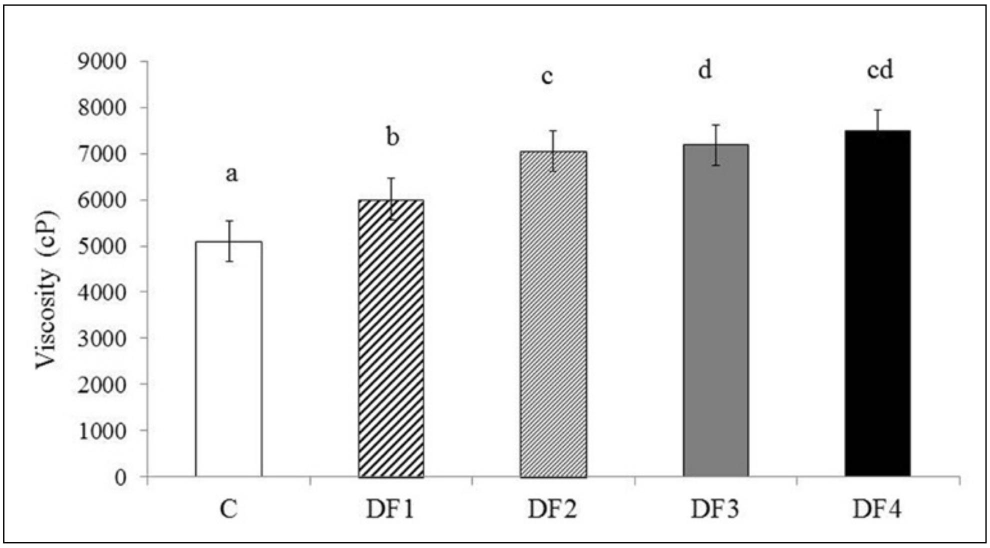

Fig. 2 - Viscosity values of ice cream containing date fibre and control.

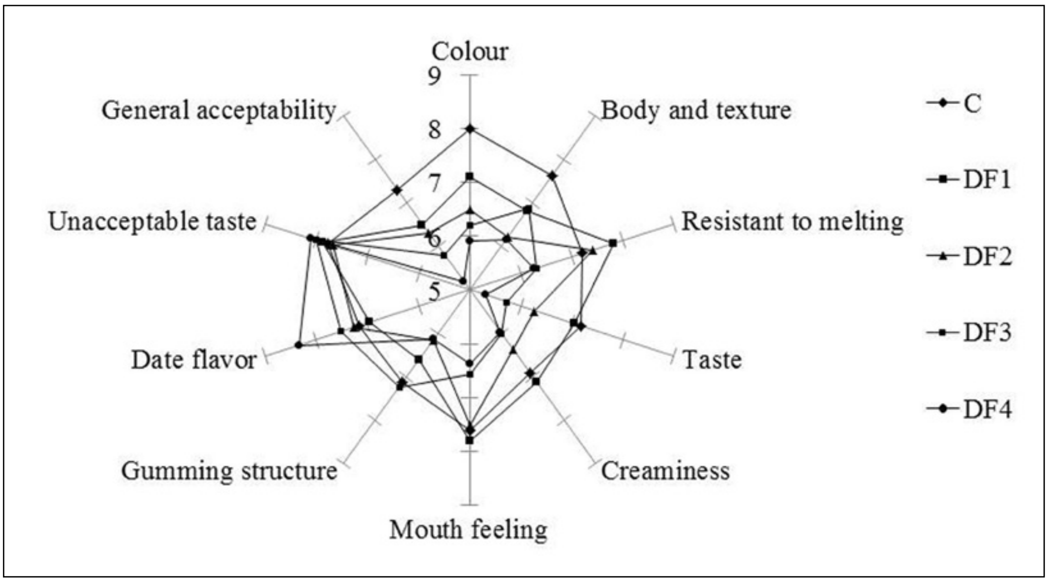

Fig. 3 - Effect of the addition of DF on the sensory profile of ice cream.
C: control; DF1: 1% (w/w) date fibre added; DF2: 2% (w/w) date fibre added; DF3: 3%(w/w) date fibre added; DF4: 4%(w/w) date fibre added.

1 and 2% DF had similar mouth feeling, showed resistant to melting and gave general acceptability ratings as control sample. Panellists preferred the ice cream samples more to the others.

CONCLUSIONS

It can be shown as the results of the present study that fibre of date (especially at 1 and 2%) may be successfully used as a good natural source of nutritive ingredients in ice cream production. The addition of date fibre improved the viscosity, first dripping times, complete melting times and mineral compositions, but had no significant effect on overrun of ice creams. The enrichment of food with date fibres is an effective way to enhance nutritional and physiological aspects and to promote functionality by influencing rheological and thermal properties of the final product.

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Paper Received January 12, 2015 Accepted March 9, 2015