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Evaluating Doum (*Hyphaene thebaica* L.) Fruit Extract as a Functional Ingredient in Formulas for Ice Cream

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Abstract: Doum (*Hyphaene thebaica* L.) fruits are rich in healthy nutrients such as dietary fiber, phenolic compounds and antioxidant activity. The present study aimed to explore possibility of using doum fruit extracts (DFE) in preparing functional ice cream. Different concentrations of aqueous extracts (10, 20, 30 and 40% w/v) from doum fruit powder were incorporated -into formulations of healthy ice cream as functional additives. The functional ice cream was evaluated for physicochemical properties (specific gravity, pH, titratable acidity, weight of gallon, viscosity, freezing point, overrun and melting resistance), color parameters, sensory properties and microbial analysis. The obtained results indicated that water substitution with DFE was associated with increase in total solids, fiber as well as ash content. Doum fruit extracts led to an increase in the specific gravity of mixes as well as elevated the overrun and strengthened the melting resistance of the final product. The obtained results indicated that total solids, fiber, ash and carbohydrates were increased, while protein and fat were reduced with increased concentrations of DFE. The increasing concentration of Doum fruit extracts in the ice cream formula increased the specific gravity, weight per gallon, viscosity and freezing point but decreased the pH value. Furthermore, a decrease in overrun values was observed in ice cream supplemented with different concentrations of DFE compared to the control sample. Concerning ice cream color, L* value decreased with supplementation, the color of the ice cream became darker and high a* value. The quality of all sensory criteria of color & appearance, body and texture, flavor as well as overall acceptability of the ice cream supplemented with doum fruit extract was evidently better than that of the control, which was made with water replacement. Scores of sensory attributes increased with the addition of doum fruit extract up to 40%. The total plate counts and molds & yeasts of supplemented ice cream with DFE decreased with increasing the DFE concentration. The psychrophilic and coliform bacteria counts were not detected in all ice cream samples. The results of this study suggest that using DFP in the production of healthy and functional ice cream not only gives a sweet taste, but can also be used as a potential source for dietary fiber and a natural antioxidant.

Key words: Doum (*Hyphaene thebaica* L.) fruit extracts · Functional ice cream · Physical properties · Antioxidant activity · Sensory characteristics

INTRODUCTION

The Doum (*Hyphaene thebaica* L.) palm desert tree belongs to Arecaceae family. It is widely distributed in some parts of Africa and commonly alongside the Nile River in Egypt and Sudan [1]. Doum fruits rich in total phenolics content, are known for their medicinal value in the treatment of several health conditions, such as hypertension and diabetes mellitus [2].

Doum fruit is a good source of essential minerals such as potassium, sodium, calcium, magnesium and phosphorus [1]. Furthermore, Doum fruit contains

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B-complex vitamins, carbohydrates and fiber, which are essential for good nutrition. The aqueous extract of Doum fruit shows antioxidant and anticancer activities. These activities are likely due to the substantial amounts of water-soluble phenolic compounds [3, 4]. Ice cream is a popular frozen dairy product throughout the world and there are many types of ice cream that differ according to additives and manufactured methods [5]. Ice cream is sweetened frozen food typically eaten as a snack or dessert, it is usually made from dairy product, such as milk and cream and often combined with fruits or other ingredient and flavors and it have high consumption for all people, especially in children [6].

Ice cream is a dairy product of high caloric and nutritional density, with lower contents of natural antioxidants and dietary fiber. Currently, consumer awareness and attention have been directed to foods rich in dietary fibers, natural antioxidants, minerals, vitamins, natural colorants, low cholesterol, low calories and free of artificial ingredients, etc. Ice cream is considered a complicated colloidal food system which in its frozen form is composed of air cells, ice crystals and moderately combined fat globules distributed in a continuous freeze-concentrated aqueous phase comprising proteins, polysaccharides and minerals particularly calcium, but also potassium and sodium [7].

Dairy products are not a good source of fibers; however they could provide an alternative vehicle for the development of fibers enriched foods [8]. The functional properties of many fruits or plants, especially their potential use as novel nutraceuticals in functional foods are being investigated. In recent years, use of some ingredients having nutritional and physiological properties such as some fruits, probiotics, alternative sweeteners, dietary fibers, natural antioxidants in ice cream manufacture has increased due to interest of consumers to healthier and functional foods [9].

The inclusion of natural additives in ice cream has shown an increase due to the increasing demand for functional and flavored ice creams by consumers [10]. The fruits added to the ice cream provide some nutritional benefits owing to their natural antioxidants, minerals, vitamins, fiber and natural colorants, together with a low amount of cholesterol and fat [11].

Ice cream is one of the most consumed dairy products in the world [12] but the commercial ice cream available is generally poor in natural antioxidants like vitamin C, natural pigments and polyphenols. Practically, the possibility to improve the nutritional value of ice cream using ingredients with health benefits is valuable, focusing on natural antioxidants, natural pigments, vitamins, low fat and free from synthetic additives such as fruit and vegetables [13].

Improvement of the nutritional attributes of ice cream using ingredients with health benefits, focusing on natural antioxidants, natural colorants, vitamins, low fat and freedom from synthetic additives in light of consumer expectations [14]. Recently, research has been concerned with healthy foods that have functional properties and are high in nutraceuticals [15].

The aqueous extract of doum fruit contains high levels of fiber, phenols and flavonoids and possesses significant antioxidant and anticancer activities. This is due to the substantial amount of water-soluble phenolic compounds [3]. Among several advantages of using fruit fibre in ice cream production can be the improvement of the structure of ice cream due to their fibrous framework and melting properties, reduction of recrystallization, resulting in prolonged shelf life and enhancement of the ice cream viscosities, allowing freezing at higher overrun, causing no negative effect on the ice crystal sizes and leading to a more homogenous air bubble formation in the ice cream [16, 17]. The inclusion of phenolics or phytochemicals in ice cream and similar frozen dairy products could give nutraceutical value and improve sensory properties, stability and microbial safety [18]. The aqueous extract of doum fruit contains high levels of phenols and flavonoids and possesses significant antioxidant and anticancer activities. This is due to the substantial amounts of water-soluble phenolic compounds [17]. The aim of this study was conducted to demonstrate the possibilities of utilizing Doum fruit extracts as fiber and antioxidant supplements to produce functional ice cream with acceptable physicochemical properties and good sensory attributes.

MATERIALS AND METHODS

Materials: The Doum (*Hyphaene thebaica* L.) palm fruit in a crushed form was obtained from a local market in Tanta city, El- Ghrbia Governorate. Skim milk powder (SMP) (96.7% TS, 0.8% fat and 33.4% protein) made in USA was obtained from MIFAD (Misr for Milk and Food Co., Cairo, Egypt. The cream (54% fat) was obtained from the Faculty of Agriculture Kafr El-Sheik University. Commercial grade cane sugar was purchased from Sugar and Integrated Industries Company, Giza, Cairo. Carboxymethyl cellulose (CMC/ Sigma) was used as a stabilizer. Vanilla (local market) was used to flavor the control ice cream. All analytical grade chemicals used were purchased from El-Gomhouria Co., Cairo, Egypt.

Preparation of Doum Fruit Extracts (DFE): Water extracts of doum powder are prepared at a concentration of 10% 20% 30% and 40% (W/W). The doum fruit extract was made by soaking doum powder in distilled water for 12 hours at room temperature. Each extract was drained through one layer of cheese cloth. The obtained extract was filtered with Whatman filter paper No. (1), to remove fine particles and stored at 4°C until used.

Preparation of Ice Cream: The processing of ice cream treatments was carried out in the Department of Dairy Science Department, Faculty of Agriculture, Kafr El-Sheikh University according to the procedure described by Arbuckle [19] using the formulas illustrated in Table 1. The control of ice cream mix was standardized to contain 6% fat, 12% solids not fat (SNF), 15% sugar, 0.15% CMC and 0.01% vanilla powder. Skimmed milk powder, CMC and sugar were mixed together in order to make a "dry mixture". Then, the water (or doum fruit extract was used at concentration of 10%, 20%, 30% and 40 % in the mixes as a substitute for the water which is used to dissolve the ingredient) was mixed with the cream to prepare the "liquid mixture". After that, the liquid mixture was heated in a water bath to 30-40°C and the dry mixture was slowly added to the liquid mixture with a gentle stirring. The attained mixture was blended by using a mixer for 1 min at speed 1, pasteurized in a double boiler at 80°C for 15 min, cooled to 4°C and doum fruit extracts were added by substituting with 10, 20, 30 and 40%, respectively. As shown in table 1, the formulated ice cream batches were basically calculated as 10% fat, 11% non-fat solids and 14% sugar taking in mind that doum fruit extracts as sweetening components after determining the percentage of sugar in Brix. The degree of sweetness in ice cream treatments was established by subtracting the added doum fruit sugars from the theoretical amount of sucrose. The obtained pasteurized mixtures were aged in the refrigerator at 4°C for 20 hours. Afterwards, the mixes were frozen in horizontal batch freezer (Taylor Co. USA). The frozen ice cream samples were packaged in plastic cups (100 ml) and immediately, frozen at −18°C in a freezing cabinet for at least 24 hours before assessment.

Physiochemical Properties of Ice Cream: The specific gravity of the mix and the final ice cream was determined according to Winton [20] at 20°C. The pH values of ice cream mix samples were measured by using a digital pH meter (Jenway pH meter, Jenway Limited, England). The titratable acidity of mixes was determined according to Richardson [21]. Weight per gallon was determined according to Marshall *et al*. [22]. The freezing point of ice cream was determined according to the FAO manual [23]. The viscosity of the ice cream was evaluated at 20°C using a Brookfield Brookfield viscometer (Model DV-III+ (Brookfield Engineering Laboratories, Inc., MA, USA), equipped with a SC -21 spindle according to Hegedusic *et al*. [24].

The overrun of the final product was determined as follows [25]:

Overrun = (Weight of unit mix - weight of equal volume of ice cream) / (weight of equal volume of ice cream) × 100. The viscosities of the ice creams were determined using a Brookfield viscometer (Model DV-II, Brookfield, Engineering Laboratories, Stoughton, MA, USA) at a temperature of 5°C ± 0.5 °C. The readings were made at 12 rpm with spindle number 3 and the results were expressed in centipoises [25].

Chemical Composition: Total solids, protein, fat, ash, total soluble solids (TSS) and fiber content were determined according to the recommended methods of AOAC [26]. Total carbohydrate content was calculated by difference, TSS content was measured using a refractometer (Abbe Hergestellt in der DDR, Germany) at 20°C with values expressed as Brix according to AOAC [26].

Determination of Total Phenolics, Flavonoid Contents and Antioxidant Activity: The total phenolic content as mg GAE/100g of the doum fruit extracts was determined by Folin-Denis reagent according to the method of Zilic *et al.* [27]. Total flavonoid content as mg Qer/100g was determined according to the method of Siddhuraju and Becker [28]. Antioxidant activity was determined by scavenging the radical 1, 1-diphenyl-2-picrylhydrazyl (DPPH) as described by Tadolini *et al*. [29].

Color Measurements of Ice Cream: The color of ice cream samples was measured a colorimeter with (Model Hunter Lab Color Flex). The L*, a* and b* values were recorded, with L denoting lightness on a 0–100 scale from black to white; a, red (+) or green (-); and b, yellow (+) or blue (-) [30].

Microbiological Analyses: Total plate counts, moulds & yeasts, psychrophilic and coliforms bacteria determination were carried out according to APHA [31].

Table 1: Formulas of ice cream prepared with different concentrations of DFP extract

	Doum fruit extract concentrations				
Ingredients	Control	10%	20%	30%	40%
Skimmed milk powder (96.7% TS)	66.60	66.60	66.60	66.60	66.60
Cream (54% fat)	125.80	125.80	125.80	125.80	125.80
Sugar	150.0	120.60	91.24	61.86	32.48
Stabilizer	2.5	2.5	2.5	2.5	2.5
Vanilla	0.1	-	-	-	-
Water	655.0	-	-	-	-
DFP extract	-	684.5	713.86	743.24	772.62

Sensory Evaluation: The sensory characteristics for the control and supplemented ice cream samples were assessed by a test panel of 10 panelists of the staff members of the Food Science and Technology department, Faculty of Home Economic, Al-Azhar Univ. for flavor (45 points), body & texture (35 points) color & appearance (10 points), melting resistance (10 points) and overall acceptability as described by Salama [32]. The ice cream samples were taken out of the frozen storage period at -18°C after 24h post hardening and promptly offered to the panelists.

Statistical Analysis: The data obtained from three replicates were Statistically analyzed of products and performed by one-way analysis of variance and test significant differences tests (ANOVA) using the SPSS statistical package program and differences among the means were compared using the Duncan's Multiple Range test SPSS, 20. A significant level of 0.05 was chosen.

RESULTS AND DISCUSSION

Physicochemical Properties of Doum Fruit Extracts: Table 2 shows the contents of total soluble solids (TSS), titratable acidity, pH value, phenolic compounds, total flavonoids and antioxidant activity of the aqueous extraction of doum fruits at different concentrations and skimmed milk powder. From the obtained data, it could be noted that TSS increased from 4.31° Brix in 10% doum fruit extract to 17.23° Brix in doum fruit extract 40%. The pH values of different concentrations of doum fruit extracts showed a slight decrease with an increasing concentration of doum fruit. Titratable acidity of doum fruit aqueous extracts were 0.23%, 0.25%, 0.29% and 0.33% in 10, 20, 30 and 40% concentrations, respectively.

Total aqueous extractable phenolic compounds of DF were 18.23 mg/100g and increased to 72.48 mg/100g by increasing the concentration from 10% to 40%. The same trend was observed in total flavonoids, which increased with each increment in DF concentrations. Aboshora *et al*. [1] found that doum fruit extracts contain high levels of phenols and flavonoids and possess significant antioxidant and antibacterial activities. The highest AA% was recorded in doum fruit extract at 40% (79.88%), followed by 30% DFE (60.32%) and 20%, which recorded 39.87%. In this respect, Mohamed *et al*. [33] indicated that the antioxidant activity increased with the increase in concentration and the consumption of doum plant, which would exert several beneficial effects by the value of its antioxidant and antimicrobial activities. The aqueous extract of doum fruit contains high levels of phenols and flavonoids and possesses significant antioxidant and anticancer activities. This is due to the substantial amount of water-soluble phenolic compounds [3]. From the results, it can concluded that doum fruit extracts can serve as a potential source of natural antioxidants and antibacterial agents, which can help to prevent diseases related to oxidative stress and pathogenic bacteria specially when incorporated in popular foods such as ice cream.

Chemical Composition of Ice Cream Formulas Supplemented with Different Concentration of DFE: As shown in Table 3, the total solids of the doum fruit extract ice cream as a replacement of water were increased significantly with increasing the concentration of doum fruit extracts. The highest mean value was (35.70%) in the sample containing 40% DFE and the lowest (32.35%) was recorded in the control sample. These results agree with Guler-Akin *et al*., [34] who reported that the dry matter content (%) of the ice-cream slightly increased with the addition of carob extract. The results revealed that there were decreases in proteins with an increase the concentration of doum fruit extracts (4.93% in control sample to 3.95% in the ice cream sample containing 40% DFE). The highest fat (4.62%) content was detected in the control, while the carbohydrate content was slightly lower in the control compared to the samples supplemented with DFE.

Table 2: Physico-chemical properties of skimmed milk powder and doum fruit aqueous extracts

		Concentrations of doum fruit extracts (DFE)			
Properties	Skimmed milk powder	10%	20%	30%	40%
TSS (°Brix)	ND	4.31[d]	8.63[c]	13.76[b]	17.23[a]
pH	6.62[a]	4.86[b]	4.84[b]	4.82[c]	4.80[c]
Acidity (%)	1.24[a]	0.23[d]	0.25[c]	0.29[c]	0.33[b]
Total phenolic (mg GAE/100g)	ND	18.23[d]	36.44[c]	54.49[b]	72.48[a]
Total flavonoids (mg Quercetin/100g)	ND	1.35[d]	2.59[c]	3.92[b]	5.66[a]
AA (%)	ND	20.65[d]	39.87[c]	60.32[b]	79.88[a]

In a row, values have the same superscript letters are not significantly different at 5% level

ND: not determined AA= Antioxidant activity

Table 3: Chemical composition of ice cream prepared from different concentrations of DFE

		Concentration of doum fruit extracts			
Ingredients	Control	10%	20%	30%	40%
TS	32.35±0.12[d]	32.67±0.13[d]	33.48±0.19[c]	34.29±0.13[b]	35.70±0.21[a]
Protein	5.56±0.14[a]	5.33±0.08[ab]	5.14±0.02[c]	4.77±0.11[d]	4.36±0.13[e]
Fat	4.62±0.06[a]	4.17±0.14[b]	3.91±0.11[c]	3.85±0.02[d]	3.78±0.12[de]
Ash	0.93±0.10[de]	0.98±0.12[d]	1.66±0.12[bc]	1.86±0.13[b]	2.74±0.14[a]
Fiber	0.11±0.13[e]	0.23±0.13[d]	0.26±0.15[c]	0.32±0.11[ab]	0.35±0.12[a]
Carbohydrates	21.13±0.17[e]	23.05±0.11[d]	25.12±0.12[c]	27.32±0.18[b]	29.07±0.15[a]
Antioxidant activity (%)	15.66±0.07[e]	26.32±0.08[d]	28.46±0.11[c]	32.87±0.05[b]	36.49±0.09[a]

Results are expressed as mean values ± standard deviations

In a row, means having the same superscript letters are not significantly different at 5% level

Regarding the fiber content of supplemented ice cream, the results in the same table indicated that supplemented ice cream with DFE had higher fibers content than control ice cream and fiber content an increased as the concentrations of DFE increased. The highest mean value was 0.35% for sample with 40% DFE. Also, increasing the DFE concentration caused increase in ash from 0.93% in the control sample to 2.74% in the sample containing 40% DFE. Results show an increase in the total solids, ash and carbohydrates of doum fruit extract in all treatments, compared to the controls, due to the higher content of total solids, ash and carbohydrates in the doum fruit, while the protein and fat content of the ice cream decreased. The antioxidant activity (DPPH) of ice cream supplemented with different DFE concentrations increased comparing with control. Inhibition of DPPH by ice cream samples containing 40% doum fruit extract was 36.49%. Doum fruit powder is rich in phenolic compounds. Supplementation of the doum fruit extracts into ice cream may supply phenolic antioxidants in important amounts. The incorporation of doum fruit extracts at different concentrations provided significant diffusion of phenolic substances into the ice cream and the total phenolic content values of ice cream samples increased. Similar results were reported by Ismail *el al*. [35], who remarked that ice cream enriched with doum fruit syrup had high antioxidant activity which rose with increasing the addition level.

Physical Properties of Ice Cream Supplemented with Different Concentration of DFE: The effect of doum fruit extracts as functional ingredients on some properties of ice cream is presented in Table 4. Specific gravity as well as weight per gallon of ice cream increased with the increasing the concentration of added PF extracts. These results might be due to the higher specific gravity of PDF compared with that of milk fat. These results are in agreement with those reported by El-Kholy [36]. The pH values of ice cream supplemented with DFE showed a slight decrease and acidity increased as a result of increasing the concentration of doum fruit extract compared to control ice cream, a pattern which was associated with the high acidity of doum fruit extract.

The data in Table 3 indicated that the viscosity of supplemented ice cream increased gradually as the concentration of PDF extract increased, whereas control showed the lowest viscosity. The increase in the viscosity of ice cream containing PDF extracts may be due to its high content of fiber which is characterized by its high water holding capacity [37]. From the obtained data,

Table 4: Physical properties of ice cream supplemented with different concentrations of DFP extracts

		Formulations of ice cream with different concentration of DFE			
Parameters	Control	10	20	30	40
			Ice cream mix		
Specific gravity (g/cm^3)	1.06±0.03^e	1.104±0.05^d	1.114±0.04^c	1.133±0.05^b	1.141±0.03^a
pH value	6.44±0.01^a	6.42±0.02^b	6.40±0.00^b	6.38±0.04^c	6.34±0.03^{cd}
Titratable acidity	0.217±0.09^e	0.221±0.12^d	0.234±0.94^c	0.253±0.08^b	0.321±0.05^a
Weight / gallon (Kg)	4.41±0.11^e	4.43±0.13^d	4.51±0.06^c	4.61±0.14^b	4.68±0.13^a
Viscosity (Cp) at 10°C	436.21±0.04^e	457.32±0.03^d	488.33±0.02^c	496.67±0.04^b	530.09±0.05^a
Freezing point °C	- 2.22±0.17^e	- 2.18±0.04^d	- 2.15± 0.02^c	- 2.10±0.11^b	- 2.00±0.14^a
			Ice cream resultants		
Specific gravity (g/cm^3)	0.724±0.09^e	0.783±0.02^d	0.792±0.04^c	0.806±0.01^b	0.859±0.02^a
pH value	6.38±0.06^a	6.36±0.12^b	6.34±0.13^{bc}	6.30±0.09^d	6.23±0.11^e
Titratable acidity	0.238±0.16^e	0.243±0.12^d	0.262±0.11^c	0.288±0.03^b	0.313±0.05^a
Weight / gallon (Kg)	3.42±0.01^d	3.62±0.08^c	3.65±0.01^c	3.71±0.03^b	3.78±0.02^a
Overrun (%)	49.56±0.13^a	44.73±0.14^b	41.48±0.12^c	35.32±0.09^d	30.83±0.11^e

Results are expressed as mean values ± standard deviations

In a row, means having the same superscript letters are not significantly different at 5% level

Table 5: Melting resistance (loss % at 20°C) of ice cream containing different concentration of DFE

	Melting resistance (loss % after)			
Treatments	10 min	20 min	30 min	40 min
Control	10.66	15.13	35.47	46.45
10%	9.13	13.52	33.18	43.76
20%	7.25	12.47	30.30	40.32
30%	5.48	10.16	28.42	39.28
40%	4.52	9.33	27.19	38.46

the control sample had an average of 436.21 p as compared with 496.67 and 530.09 cp for the samples containing 30 and 40% DFE. The replacement of water by DFP extract at 40% recorded the highest significant ($p<0.05$) increase in viscosity in both the fresh and ageing period. Fiber addition causes the binding of free water hence flow rate get reduced and consistency coefficient as well as viscosity enhanced [38].

Overrun is associated with the amount of air incorporated during the ice cream manufacturing process [39]. The control sample of ice cream had the highest overrun (49.56%), whereas ice cream containing 40% DFE recorded the lowest value of overrun (30.83%). The decrease in the overrun, which was observed by increasing the DFP extract ratio, could be attributed to the obvious increase in mix viscosity. In a similar study, overrun of cactus pear pulp ice cream decreased when specific gravity increased [40]. As well as, the specific weight and viscosity, increased in most treatments as compared to the control due to the increase in the rate of total solids. While the overrun decreased in all treatments due to the increased viscosity, which led to the difficulty of air entering the product. The reduction in the overrun of ice cream containing Doum powder may be due to its effect on elevating viscosity [37].

Melting Resistance: Melting resistance of ice cream was expressed as the loss in weight percent of the initial weight of the tested samples. The melting resistance of ice cream showed a positive proportionality with the added quantity of Doum powder in ice cream that subsequently caused soggy body and low overrun. Sogginess contributes to high melting resistance [41]. The results in table 5 suggest that the use of Doum fruit extracts as a replacement for water in ice cream caused a decrease in the melting resistance. It can be said that the doum fruit extract, which has a high amount of fiber, absorbed the water and the melting of ice cream was retarded. Similar to this work, the addition of high fiber-containing persimmon puree [42] and cape gooseberries [43] to ice cream resulted in better melting characteristics due to the effect of dietary fiber on the water-holding capacity. Hussein and Aumara [44] stated that, the differences in melting resistance are mainly due to the differences in the freezing points of the mixes.

Color Parameters of Ice Cream Supplemented with Different Concentrations of Doum Fruit Extracts: Incorporation of doum fruit extracts caused a change in the color of the final ice cream products, as shown in Table 6. Due to the dark brownish color of doum fruit

Table 6: Color attributes of ice cream supplemented with different concentrations of DFE

Treatments	L*	a*	b*
Control (0%)	83.72	0.84	22.16
10%	78.35	2.89	20.34
20%	74.58	3.78	19.78
30%	66.49	5.39	18.39
40%	61.34	7.26	16.51

Table 7: Sensory properties of ice cream supplemented with different concentrations of doum fruit extract during frozen storage period at -18°C

Treatments	Frozen storage period (days)	Color & appearance (10)	Flavor (45)	Body & texture (35)	Melting resistance (10)	Overall acceptability (100)
Control (0%)	0	8.66±0.22	42.11±0.18	31.53±0.12	8.26±0.15	90.56±0.08
	15	8.31±0.17	39.94±0.17	31.01±0.16	8.07±0.12	87.33±0.12
	30	8.11±0.15	39.80±0.19	30.22±0.14	7.86±0.09	85.99±0.03
10%	0	9.03±0.19	44.10±0.16	33.57±0.16	8.14±0.21	94.94±0.22
	15	8.93±0.13	43.32±0.18	33.24±0.18	8.00±0.23	93.49±0.14
	30	8.58±0.21	42.16±0.15	32.66±0.12	7.66±0.19	91.06±0.17
20%	0	9.13±0.18	44.00±0.11	34.36±0.07	8.00±0.15	95.39±0.23
	15	8.95±0.16	43.78±0.14	34.12±0.11	7.58±0.11	94.43±0.15
	30	8.88±0.18	43.22±0.13	34.00±0.19	7.39±0.16	93.49±0.14
30%	0	9.33±0.11	45.00±0.09	34.42±0.04	7.78±0.20	96.53±0.15
	15	9.32±0.14	44.83±0.16	34.27±0.09	7.63±0.12	96.05±0.18
	30	9.20±0.12	44.16±0.18	34.18±0.15	7.45±0.05	94.99±0.22
40%	0	9.46±0.24	46.00±0.06	34.86±0.11	7.46±0.12	97.78±0.13
	15	9.33±0.19	45.93±0.21	34.77±0.13	7.33±0.23	97.36±0.19
	30	9.39±0.23	44.88±0.17	34.29±0.16	7.21±0.24	95.77±0.17

Results are expressed as mean values ± standard deviations

Table 8: Microbial analysis of ice cream supplemented with different concentrations of DFE ($\times 10^2$ cfu/g)

Treatments	Total plate count	Moulds & Yeasts	Psychrophilic	Coliform bacteria
Control	32.64±0.21^a	7.33±0.26^a	ND	ND
10%	29.78±0.18^b	5.42±0.22^b	ND	ND
20%	24.66±0.09^c	3.67±0.19^c	ND	ND
30%	20.39±0.14^d	2.86±0.12^d	ND	ND
40%	16.58±0.20^e	1.59±0.17^e	ND	ND

Results are expressed as mean values ± standard deviations ND: Not detected

In a column, means having the same superscript letters are not significantly different at 5% level

extract, the color intensity of ice creams increased with increasing doum fruit extract concentrations. The L* (lightness) values of samples decreased with an increase in doum fruit extract concentration. The L* value of control ice cream was 83.72, whereas the color of the sample containing 40% DFE was 61.34. The color of the ice cream samples became darker with the increased concentrations of doum fruit added and this change was accepted by panelists. Both the L* value (lightness) and + b* value (yellowness) decreased with the addition of DFE, while the a* (redness) values increased as DFE concentrations increased in ice cream as compared with the control The highest a* value was shown by ice cream sample supplemented with 40% DFE and the lowest by the control. According to Sagdic *et al*. [45], phenolic substance addition caused a significant change in the color characteristics of ice creams compared with the control sample.

Sensory Evaluation of Ice Cream Supplemented with Different Concentrations of DFE: Table 7 shows the sensory evaluation scores of doum fruit extract-ice cream samples as compared to the control ice cream during storage periods (0, 15 and 30 days) at -15°C. All the ice cream samples that were supplemented with DFE received high scores for total evaluation in terms of sensory characteristics. Regarding the color and appearance scores, the highest scores were recorded for the ice cream

sample supplemented with 40% of DFE (9.46), followed by 30% DFE (9.33), while the lowest scores were detected for the control ice cream sample (8.66).

The flavor of the ice cream samples containing 40% DFE showed the highest score (46.00) followed by 30% DFE (45.00), while the lowest scores were detected in control ice cream (42.11).

The overall acceptability of the ice cream samples containing 20, 30 and 40% DFE showed the highest scores (95.39, 96.53 and 97.78, respectively) as compared to the ice cream sample (90.56).

The overall results showed that, it is possible to produce good quality ice cream with superior flavor, good body / texture and an attractable appearance / color by replacing the water, which is used for dissolving the ingredients, with doum fruit extracts with different concentrations (10, 20, 30 and 40%). Similar results were observed by Abd El-Rashid and Hassan [37], who reported that ice cream prepared in the presence of 3 % doum powder was characterized by creamy color, acceptable flavor and a description of soft body & texture with good nutritional value of fiber and higher scores of sensory parameters.

The ice cream containing 30 and 40% was the most preferred by the panelists. The results obtained revealed that the 40% DFE replacement in ice cream formulas improved the body & and texture as compared to the control sample. All sensory scores decreased during storage and the lowest values were recoded after 30 days of storage in all ice cream samples.

Microbiological Characteristics of Ice Cream Supplemented with Different Concentrations of DFE: Microbiological characteristics of ice cream with different concentrations of DFE are presented in Table 8. The highest value of total plate count was obtained for control ice cream (32.64×10^2 cfu/g), while the lowest value was obtained for ice cream supplemented with 40% DFE (16.58×10^2 cfu/g). Increase the doum fruit extract concentrations led to a decrease the total plate count of ice cream. Molds & yeasts counts showed the same trend since they decreased from 7.33×10^2 cfu/g in the control sample to 1.59×10^2 cfu/g in the ice cream sample with 40% DFE.

Also, it is observed that the psychrophilic and coliform counts could not be detected in all treatments.

From the obtained data, it could be observed that ice cream samples supplemented with DFE showed higher antibacterial activity than control. In this respect, Singh *et al.* [46] reported that phenolic compounds cased cell death via: a) disrupt membrane proteins b) degradation of the cytoplasmic membrane c) degradation of the cell wall d) interaction with membrane-integrated enzyme. Aqueous doum palm extracts showed antibacterial and antifungal activities against undesirable bacteria and fungi [44].

CONCLUSION

The physical and sensory properties of ice cream can be improved by incorporating DFE up to 40%. In addition, DFE can be used to produce a functional ice cream rich in bioactive components including fiber and natural antioxidants due to the presence of phenolic and flavonoids compounds which have healthy benefits. Therefore, could be used as good source of antioxidants for making ice cream with good nutritional and functional properties.

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