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Effect of Fat Replacement by Doum Palm Fruits on Frozen Yoghurt Quality

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Abstract: The effect of adding Doum palm (*Hyphaene thebaica*) powder (0, 25%, 50%, 75% and 100% as fat replacement) was examined in respect of physicochemical, rheological and sensory properties of low and fat free frozen yoghurt. Increasing Doum palm powder increased the mixture specific gravity, weight per gallon and freezing point but decreased pH value. A proportional relation between the added ratios of Doum palm fruit powder and the apparent viscosity of the produced frozen yoghurt mixes. Also, the resultant frozen yoghurt prepared with replacement of fat with Doum palm fruit powder had higher specific gravity, weight per gallon but slightly lower ($p>0.05$) overrun. The melting resistance of Doum frozen yoghurt showed a positive proportional with replacement levels of Doum palm powder at the first 15 min. Doum frozen yoghurt had the highest content of acetaldehyde and diacetyl. Frozen yoghurt containing 100% Doum palm powder was organoleptically superior followed by that of 75% and 50% Doum palm powder respectively.The overall results cleared that, it is possible to produce good quality frozen yoghurt with superior flavour, good body/ texture and with attractable appearance/ colour by replacing fat with 75% and /or 100% Doum palm fruit.

Key words: Frozen yoghurt · *Hyphaene thebaica* · Doum palm fruit · Frozen dairy products

INTRODUCTION

Frozen yoghurt is a complex fermented frozen dairy dessert that combines the physical characteristics of ice cream with the sensory and nutritional properties of fermented milk products [1]. Frozen yoghurt can be regarded as a healthy alternative to ice cream [2] for people suffering from obesity, cardiovascular diseases and lactose intolerance due its low fat content (3.5 – 6%) and reduced lactose concentration, which depends on the kind and duration of fermentative step [3]. In addition, frozen yoghurt is expected to present acceptable quality of flavour, body, texture, cooling effect, viscosity, whipping ability and freezing properties of dairy frozen desserts [4].

Frozen yoghurt can be made either by fermentation of ice cream mix with lactic acid bacteria (often mixed cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*) or by blending yoghurt with ice cream mix [5, 6] reported that production of lactic acid exceeding 0.4% LA in frozen yoghurt may lead to excessive viscosity of the product. The preferred pH and acidity for frozen yoghurt were reported as 5.5 and 0.4% LA respectively [7,8] suggested keeping maximum acidity in frozen yoghurt to 0.47%; beyond which there was loss observed in sensory qualities. Frozen yoghurt can be made from different sweeteners, stabilizers, flavours and sources of milk solids not fat according to the attempts of making low calories or low fat frozen yoghurt [9].

Recently, consumers have directed their interest towards low fat frozen desserts as they associate them with a reduced risk of obesity, coronary heart diseases and diabetes. By decreasing the fat content in frozen dairy product formulation, quality attributes such as viscosity, creaminess, melting and flavour are affected [10].

Doum palm fruit (*Hyphaene thebaica*) is one of the desert member of family Palmae. It is common in Egypt, West India, several parts of Africa and known as Doum or gingerbread palm because the plant has the taste and the consistency of gingerbread [11, 12]. In Egypt, the Doum palm has been cultivated since ancient times. The outer layer of the fruit is edible and can be prepared either in sliced or in a powder form, which is further dried then added to food as flavouring agent [13]. Utilization of Doum palm fruit (*Hyphaene thebaica*) in its powder form was applied in some food products as a source of fiber, stabilizer and minerals as well as for its potential healthy effect [14]. Research on the fruit pulp of *Hyphaene*

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thebaica showed that it contains nutritional trace minerals, proteins and fatty acids, in particular the nutritionally essential linoleic acid [15] It is listed as one of the useful plants of the world that supplies human with dietary fibres, carbohydrates and anti-hyper tension substances [16]. Doum fruit (*Hyphaene thebaica*) is a good source of potent antioxidants [12]. Also, aqueous Doum palm extracts increased the viability and activity of some certain dairy starter cultures which used in the manufacture of some dairy products especially probiotics [17].

The aim of the present study was to investigate the possibilities of utilizing Doum palm fruit powder as a fat replacer to produce low or fat free frozen yoghurt with acceptable rheological and sensory attributes.

MATERIALS AND METHODS

Materials: Fresh buffalo's milk (9% SNF and 6% fat) was obtained from a private farm in Ismailia Governorate and was skimmed into cream (50% fat) and fresh skim milk which were used in frozen yoghurt making. Skim milk powder (Grade A- low heat - spray process-pasteurized) manufactured by West farm Foods (96% total solids), U.S.A. Carboxy methyl cellulose (CMC) stabilizer, Oxford Ingredients, India. Direct Vat Starter (DVS) yoghurt culture was obtained from CHR Hansen? s laboratories, Denmark, under commercial name type (FD-DVS-YC-X11) containing *Streptococcus thermophiles* and *Lactobacillus delbrueckii* ssp. *Bulgaricus* in the amount of 50 unit/250 cm^3 of the processed milk, which corresponded to 2% of activated working starter. Sugar and Doum palm (*Hyphaene thebaica*) in a crushed form were purchased from local market.

Methods

Technological Methods

Preparation of Doum Palm Fruit Powder: Doum palm (*Hyphaene thebaica*) were prepared in a powder form by milling in a blinder laboratory mill type (Moulinex blender, France). Doum palm powder had the values of 7.5%, 53.54%, 6.3% and 12.79% for moisture, total sugars, ash and crude fiber, respectively.

Preparation of Low or Fat Free Doum Frozen Yoghurt: Doum frozen yoghurt mixes were manufactured according to Gooda *et al*. [18]. Mixes composition and formulations are shown in Tables (1) and (2) respectively. The mixes were divided into 5 parts. The control mix formula was standardized to give 4% fat, 11% milk solids not fat, 15% sugar and 0.2% CMC. The other four parts (mixes) were made by replacing fat by Doum fruit powder at levels 25,

Table 1: Selected composition of Doum frozen yoghurt mix formulas.

	Formula No				
	%				
Composition	Control	T2	T3	T4	T5
Fat	4	3	2	1	0
Solids not fat	11	11	11	11	11
Sugar	15	15	15	15	15
Stabilizer	0.2	0.2	0.2	0.2	0.2
Doum palm powder	0	1	2	3	4
Total solids	30.2	30.2	30.2	30.2	30.2

Table 2: Formulations of Doum frozen yoghurt mixes

	Formula No.				
	g/kg				
Ingredients	Control	T2	T3	T4	T5
Cream (50% fat)	80	60	40	20	0
Buffaloes skim milk (9% SNF)	725. 1	734. 3	743.4	752.5	761.6
Skim milk powder (96% SNF)	42. 9	42.9	43	43.1	43.2
Sugar	150	150	150	150	150
CMC	2	2	2	2	2
Doum palm powder (92.5% TS)	-	10.8	21.6	32.4	43.2

50, 75 and 100%. The ingredients (Fresh skim milk, cream, skim milk powder, Doum powder, stabilizer) of 5 mixes were divided into 2 parts (A and B); sweeteners (sucrose) were added to the first portions (A). Both portions were heat treated at 80°C for 10min, then portions (A) rapidly cooled to about 10°C before being mixed with fermented portions (B). The second portions (B) were cooled to 42°C, inoculated with yoghurt starter culture and incubated at the same temperature till the pH of ~ 5.5 was obtained, then removed from the incubator and cooled to 10° C. Finally, the two portions (A and B) were combined and mixed well, individually, then aged at 5±1°C for 4 hr. The mixtures (2Kg mix for each treatment) were frozen in an ice cream freezing machine (Taylor-mate Model 156, Italy). The resultant frozen yoghurt was packaged in cups (100 ml) and put in deep freezer at -18°C for hardening according to Marshall and Arbuckle [19] for 24 hr before analysis and stored for 1 month. Also, samples of DFY were evaluated after 15 and 30 days of hardening for sensory and acetaldehyde and diacetyl content. The whole experiment was carried out in triplicates.

Analytical Methods: Moisture, crude fiber, total sugars and ash content of Doum powder were determined according to AOAC [20]. Doum frozen yoghurt (DFY) mix was analyzed for titratable acidity according to AOAC [20], pH using Adwa pH meter (AD 1200 Professional Bench Meters, Adwa Instruments Kft, Hungary), Specific gravity according to Winton [21], weight per gallon according to Burke [22], freezing point (FAO Laboratory Manual, [23] viscosity and some rheological parameters were carried out using a Brookfield Digital Rheometer model DV-III+ (Brookfield Engineering Laboratories, Inc., MA, USA), equipped with a SC_4-21 spindle. Measurements were made at temperature of 10°C in shear rate ranging from 23.3 to 232.5 S^{-1}. All rheological properties were performed in duplicates.

The resultant Doum frozen yoghurt (DFY) were analyzed for overrun according to Marshall and Arbuckle [19] melting resistant Tharp *et al*. [24], specific gravity Winton [21] and weight per gallon Burke [22]. Acetaldehyde and diacetyl content were determined according to Lee and Jago [25].

Sensory Evaluation: The sensory evaluation for the resultant DFY were carried out by 8 staff members from the Dairy Department, for flavour (45 points), body &texture (30 points) and appearance & colour (25 points).

Statistical Analysis: All obtained data were subjected to the statistical analysis and analysis of variance by the procedure of general linear model using CoStat [26] under windows software version 6.311 and least significant difference (LSD) at ($p<0.05$).

RESULTS AND DISCUSSION

Physicochemical Properties of DFY Mixes: The use of Doum palm powder in replacement of fat increased considerably ($p< 0.05$) the specific gravity and weight per gallon of the mixes (Table 3). Hussein and Aumara [27] stated that the specific gravity of mixes was closely related to their weight per gallon. On the other hand, the results revealed that there were no significant differences ($p> 0.05$) in titratable acidity between DFY mixes and control. Whereas, the pH values showed a slight decrease ($p> 0.05$) as a result of increasing the percentage of Doum palm powder level, while (T5) which fat was completely replaced with Doum palm powder showed lower pH values ($p< 0.05$) as compared with control and treatment(T2: 25% Doum palm powder). Moreover, freezing point of all DFY mixes increased significantly ($p< 0.05$) as the substitution level with Doum palm increased.

The viscosity of frozen dessert mix before freezing is considered a very important attribute as it affects the body and texture of the finished product Minhas *et al*. [28]. The replacement of fat by Doum palm powder in frozen yoghurt mixes significantly (p□ 0.05) affected the apparent and plastic viscosity values (Table 4). The addition of Doum palm fruit caused a significant (p□ 0.05) increase in apparent viscosity and plastic viscosity along the aging period at 5° C for 4 h.The apparent viscosity values of frozen yoghurt mixes significantly (p□ 0.05) increased as Doum palm ratios increased. This increment trend may be attributed to the increased levels of Doum palm powder, which may be due to its high content of fiber, which are characterized by its high water holding capacity Vani and Zayas [29] and Abd El- Rashid and Hassan [14]. The replacement of 75% of fat (T4) by Doum palm powder recorded the highest significant (p□ 0.05) increase in apparent viscosity and plastic viscosity in fresh and through aging time.

Physicochemical Properties of Resultant DFY: Replacement of fat with Doum palm powder increased significantly ($p< 0.05$) the specific gravity and weight per gallon of resultant frozen yoghurt (Table 5).

Table 3: Physicochemical properties of Doum frozen yoghurt mixes made with Doum palm powder as a fat replacer

	Formula No.				
Properties	Control	T2	T3	T4	T5
Specific gravity (gm /cm ^{3})	1.1027^e	1.1081^d	1.1137^c	1.1191^b	1.1247^a
Weight / gallon (Kg)	5.012^e	5.037^d	5.062^c	5.087^b	5.112^a
Acidity (%)	0.45^a	0.45^a	0.46^a	0.47^a	0.48^a
pH value	5.63^a	5.63^a	5.61^{ab}	5.60^{ab}	5.58^b
Freezing point (°C)	-2.17^d	-2.25^c	-2.30^b	-2.36^a	-2.37^a

T2, T3, T4 and T5 different mixes containing 25, 50, 75 and 100% Doum palm powder respectively.

*a, b, c, d & e: means with the same letter among the treatments are not significantly different ($p<0.05$).

Table 4: Rheological parameters of reduced fat and fat free mixes of Doum frozen yoghurt during different aging period at 5±1°C

	Formula No.*					
AgingTime	Control	T_2	T_3	T_4	T_5	Mean
Apparent Viscosity (m Pas)						
0 hour	34	40.4	52.8	72.8	48	49.6^c
2 hours	55.2	55.4	60.0	73.6	55.5	59.94^b
4 hours	55.4	56.4	62.0	78.0	56.8	61.72^a
Mean	48.2^E	50.73^D	58.26^B	74.8^A	53.43^C	
Plastic viscosity (m Pas)						
0 hour	25	28.8	33.4	47.9	35.8	34.18^c
2 hours	41.1	41.2	41.6	53.9	40.1	43.58^b
4 hours	42.0	43.7	45.0	56.1	41.6	45.68^a
Mean	36.03^E	37.9^D	40.0^B	52.63^A	39.16^C	

T2, T3, T4 and T5 different mixes containing 25, 50, 75 and 100% Doum palm powder respectively.

** a, b & c and A, B, C, D & E: means with the same letter among the treatments and aging period respectively are not significantly different ($p<0.05$).

Table 5: Physicochemical properties of resultant Doum frozen yoghurt made with Doum palm powder as a fat replacer

	Formula No.*				
Properties	Control	T2	T3	T4	T5
Specific gravity (g / cm^3)	0.716^e	0.723^d	0.730^c	0.733^b	0.737^a
Weight / gallon (Kg)	3.254^e	3.286^d	3.318^c	3.332^b	3.350^a
Overrun (%)	53.92^a	53.32^a	52.56^a	52.49^a	52.43^a

T2, T3, T4 and T5 different mixes containing 25, 50, 75 and 100% Doum palm powder respectively.

*a, b, c, d & e: means with the same letter among the treatments are not significantly different ($p<0.05$).

Table 6: Melting resistance (loss%) of Doum frozen yoghurt made with Doum palm powder as a fat replacer within 60 min

	Melting resistance (loss%) after				
Treatments	15 min	30 min	45 min	60 min	Mean**
Control	5.2	33.6	66.2	93.8	49.7^D
T2	2.8	34.9	66.8	93.9	49.6^D
T3	2.6	39.2	70.1	94.2	51.52^C
T4	2.4	42.1	72.9	95.2	53.15^B
T5	2.2	44.7	75.6	95.6	54.52^A
Mean**	3.04^d	38.9^c	70.32^b	94.54^a	

T2, T3, T4 and T5 different mixes containing 25, 50, 75 and 100% Doum palm powder respectively.

** a, b, c & d and A, B, C & D : means with the same letter among the treatments and melting down duration respectively are not significantly different ($p<0.05$).

Table 7: Effect of replacing fat of frozen yoghurt by Doum palm powder on acetaldehyde and diacetyl (ppm) during storage at - 18°C

	Formula No.*					
Storage period (day)	Control	T_2	T_3	T_4	T_5	Mean**
Acetaldehyde (ppm)						
1	17.72	17.74	19.50	20.40	20.70	19.21^{c}
15	37.89	38.24	40.03	42.32	43.90	40.47^{b}
30	40.52	42.50	44.03	44.91	45.08	43.40^{a}
Mean**	32.04^{C}	32.82^{C}	34.52^{B}	35.87^{A}	36.56^{A}	
Diacetyl (ppm)						
1	2.28	2.83	7.28	8.39	8.41	5.83^{c}
15	7.25	10.05	11.86	13.39	13.78	11.26^{b}
30	9.27	10.28	12.83	13.94	14.55	12.17^{a}
Mean**	6.26^{D}	7.72^{C}	10.65^{B}	11.90^{A}	12.24^{A}	

T2, T3, T4 and T5 different mixes containing 25, 50, 75 and 100% Doum palm powder respectively.

** a, b & c and A, B, C & D : means with the same letter among the treatments and storage period respectively are not significantly different ($p<0.05$).

Table 8: Sensory evaluation of reduced fat and fat free Doum frozen yoghurt made with Doum palm powder as fat replacer during storage at -18°C

	Storage period (day)			
Treatments*	1	15	30	Mean**
Flavour (45 points)				
Control	42	41	40	41 ^{C}
T 2	44	44	43	43.66 ^{B}
T 3	44	44	43	43.66 ^{B}
T 4	44	44	44	44 ^{AB}
T 5	44.9	44.9	44	44.6 ^{A}
Mean**	43.78 ^{a}	43.58 ^{a}	42.8 ^{b}	
Body& Texture (30points)				
Control	29	29	28	28.66 ^{A}
T 2	29	29	29	29 ^{A}
T 3	29.9	29	29	29.3 ^{A}
T 4	29.9	29	28	28.96 ^{A}
T 5	29	29	28	28.66 ^{A}
Mean**	29.36 ^{a}	29 ^{ab}	28.4 ^{b}	
Colour & appearance (25 points).				
Control	24.9	24	23	23.96 ^{B}
T 2	24.9	24	23	23.96 ^{B}
T 3	24.9	24	24	24.30 ^{AB}
T 4	24.9	24.9	24	24.60 ^{AB}
T 5	24.9	24.9	24.9	24.9 ^{A}
Mean**	24.9 ^{a}	24.36 ^{ab}	23.78 ^{b}	
Total acceptance (100 points)				
Control	95.9	94	91	93.63 ^{C}
T 2	97.9	97	95	96.63 ^{B}
T 3	98.8	97	96	97.26 ^{AB}
T 4	98.8	97.9	96	97.56 ^{AB}
T 5	98.8	98.8	96.9	98.16 ^{A}
Mean**	98.04 ^{a}	96.94 ^{b}	94.98 ^{c}	

T2, T3, T4 and T5different mixes containing 25, 50, 75and 100% Doum palm powder respectively.

*a, b & c and A, B, & C : means with the same letter among the treatments and storage period are not significantly different ($p<0.05$).

Abd El- Rashid and Hassan [14] indicated that, the specific gravity depends on the formula components as well as mix ability to hold the air bubles and overrun percent in the resultant ice cream. On the other hand, the overrun of DFY containing different levels of of Doum palm powder decreased slightly (p> 0.05) with increasing level of fat replacement. Mahran *et al*. [30] concluded that the specific gravity of ice cream is inversely related to changes in the overrun. Furthermore, the overrun values in frozen yoghurt treatments was observed to be between 53.92 and 52.43% without any significant (p> 0.05) differences among the treatments. This means that, making frozen yoghurt by replacing fat with Doum palm powder did not affect significantly (p>0.05) the overrun.

Melting resistance was expressed as the loss in weight percent of the initial weight of the tested samples. The melting resistance (low melting ability) of Doum frozen yoghurt (Table 6) showed a positive proportional with replacement levels of Doum palm powder at the first 15 min. Whereas, treatments (T5), (T4) and (T3) respectively melted more rapidly than did the whole fat control frozen yoghurt at min 30 and 45. These results suggested that the use of Doum palm as a replacement of fat in frozen yoghurt caused a significant (p□ 0.05) decrease in the melting resistance. Hussein and Aumara [27] stated that, the differences in melting resistance are mainly due to the differences in the freezing points of the mixes. Treatment (T2) having 25% of Doum palm powder was evaluated to be the closet product to control because of similar melting trends. Sofjan and Hartel [31] reported that ice cream with higher overrun melt more slowly. Also, they found that air acted as good insulation, slowing the rate of heat transfer in ice cream and thus decreasing melting rate.

Acetaldehyde and diacetyle content of the resultant frozen yoghurt (DFY) made with Doum palm fruit as a replacement of fat increased significantly (p< 0.05) as compared with control frozen yoghurt (Table 7) when fresh and along the storage period. This increment was proportional with increasing ratios of Doum palm powder. These may be due to high mineral, digestible and non-digestible fibers contents of Doum palm fruits, which enhance the viability of starter culture Aumara and Hassan [32] and consequently starter culture activity. Moreover, the data (Table 7) revealed that, acetaldehyde and diacetyl contents increased significantly through the storage period up to 30 days.

Sensory Evaluation: The results obtained revealed a significant (p< 0.05) differences were observed between control frozen yoghurt and treatments made with fat replacement by Doum palm powder (Table 8). Control frozen yoghurt was of a significantly lower (p< 0.05) flavour and overall acceptance score among all Doum frozen yoghurt. The body & texture of all frozen yoghurt treatments compared well with each other and no significant (p> 0.05) differences were observed. The results (Table 8) indicated that body & texture of the experimental frozen yoghurt tended to be smooth without any defects. Frozen yoghurt prepared with 50% (T3), 75% (T4) and 100% (T5) replacement of fat by Doum palm powder were characterized by creamy colour, acceptable flavour and described with soft body & texture and higher (p< 0.05) scores of sensory parameters as compared with control. The degree of significant was more pronounced (p< 0.05) in Doum frozen yoghurt with 100% (T5) Doum powder replacement which was the most preferred sample by the panelists. Such trend was based on the highest scores of sensory parameters given by the panelists and statistical analysis. Doum palm fruit flesh possesses good functional properties as its high water and/or oil absorption capacity Aboshora *et al*. [33]. Water absorption characteristics represent the ability to associate with water, while oil absorption characteristics reflects emulsifying capacity. Kaur *et al*. [34] reported that the ability of flours to absorb water and/or oil may help to improve binding structure, enhance flavour retention and improve mouthfeel. Generally, total acceptance score decreased significantly (p< 0.05) as the storage period progressed.

The foregoing results indicated that Doum palm fruit powder can be used to replace up to 75% and 100% of fat in frozen yoghurt mixes without any adverse effect on flavour, body & texture and colour & appearance when fresh or as storage progressed.

CONCLUSION

Finally, frozen yoghurt with good physicochemical and sensory properties could be made by replacing fat with 75% and 100% Doum palm fruit powder. Using of Doum palm fruit in the manufacture of frozen yoghurt not only gave a sweet taste, but also can be used as the flavouring and colouring (golden) agents.

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