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Preparation of Functional Frozen-Yoghurt Using Fat Replacer and Sweetener Substitutes

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Abstract

Frozen yoghurt is a popular dairy product which generally it gathers the properties of ice cream as a preferable, delicious, and refreshing product beside the nutritive values of yoghurt. Now a day; many researchers produced frozen yoghurt with different attitudes. This research dealt with using a fat replacer (Etenia 457) and a sweetener (Sativoside) to produce low fat and low calories functional frozen yoghurt. Control and four treatments were prepared using 0, 25, 50, 75 and 100% of fat replacer and sweetener to achieve CY, F1, F2, F3 and F4, respectively. Chemical and physical properties as well as organoleptic properties evaluation were carried out. The values of fat content and calories were lower in the treated samples when compared with control one. The rat of decreases were parallel with the increase of fat replacer and sweetener ratios. Pronounced differences were also observed in the values of specific gravity, overrun; where specific gravity and viscosity values were increased with the increases of additives while overrun was decreased. The organoleptic evaluation indicated that the sample F1 which contain 25% fat replacer and sweetener had the best and favorite properties as well as total scores among all other treatment.

Keywords: Frozen-yoghurt, fat replacer, sweetener, low calories;

1. Introduction

Early, at the last few decades, frozen-yoghurt is coming very popular in western countries in the form of a soft product. It known as a yoghurt-ice-cream or a dairy frozen dessert which combines the sour taste of yoghurt with the attributes and refreshing of ice cream. Survival of yoghurt cultures in frozen yoghurt has great importance for the therapeutic image of the product, as yoghurt has been a healthful product with high biological value and probable benefits to the immune system by destruction of bacterial cells, lactose digestion, regularity of intestinal flora, detoxification of harmful products, reduction of carcinogenic end products, and suppressing the multiplication of food-sourced pathogens [1,2]. Frozen-yoghurt dessert can be regarded as a healthy alternative to ice cream for people suffering from obesity, cardiovascular disorders, and lactose intolerance, due to the product's low fat as well as reduced lactose contents [3]. On a large view; frozen-yoghurt has been used as a carrier of probiotic organisms, enabling the organisms to maintain their viability in low pH and low storage temperature (−29°C). In addition, frozen-yoghurt is expected to present acceptable quality of flavor, body, texture, cooling effect, viscosity, whipping ability, and freezing properties of dairy frozen desserts [4]. In 2017; Nagendra et al [5] recognized that frozen-yoghurt has become the base for development of other innovative products such as frozen flavored yoghurt desserts, frozen yoghurt novelties on a stick, or as sandwiches. Probiotic organisms such as *Bifidobacterium* spp. and *L. acidophilus* have been successfully added in frozen-yoghurt. The product may be made as soft-serve or hard variant, and being

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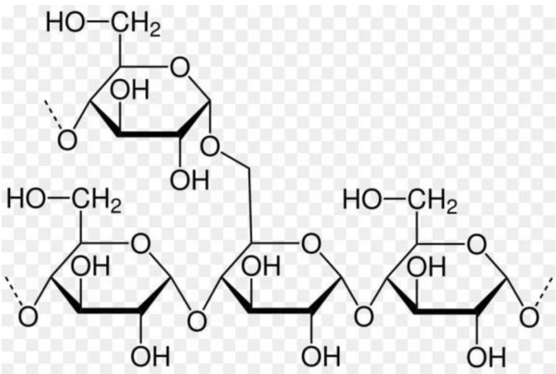
low-fat. Many investigations were done to produce a new product frozen-yoghurt as it considered as a healthier alternative to ice cream. [1,5-10]. For the methods of its preparation; in the last decades; Davidson et al [11] and Mahdian et al [12], showed that frozen-yoghurt can be produced either by 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.

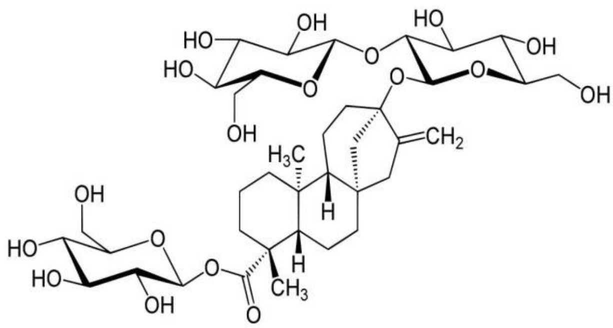
A recent general attitude is reduced the calories and lactose contents as well as fat content in the dairy products. Most common attitude was using fat replacers or sweeteners in dairy products. They were including inulin, maltodextrin, polydextrose, milk proteins, soy proteins, dietary fibers, stevia and honey and starches [7, 10, 13, 16].

Etenia™ is E-number free and can be declared starch and Maltodextrin in Europe and maltodextrin in the rest of the world. The Product is easy to add when processing dairy and bakery products or Emulsified low-fat spreads. It has unique thermo reversible gelling Characteristics, and performs more like hydrocolloids [14]. Etenia™ can be used in fat reduced cake mixes and dough. It is one of its kind thermo-reversible amylopectin type hydrocolloids that builds texture only when the product is cooled, hence Etenia™ 457 is completely shear and heat stable during processing and the product is still liquid when it is filled in the packaging: it needs 16-24 hours at 1-4°C to build texture.

Stevia rebaudiana (*Bertoni Asteraceae*) is a per ennial herb native to Paraguay and Brazil. The plant is used



all over the world as it possesses medicinal and commercial importance. It contains a significant amount of important nutrients and minerals necessary for regulating and maintaining various metabolic processes in the body [42]. The leaves of *S. rebaudiana* are extensively studied as a source of high potency sweet tasting. Natural constituents of the plant are Ent-kaurene diterpene glycosides. Stevia can use as sweetener in producing of lot of food as a sugar substitute. It is a plant growing in South America, China, and South Korea. The plant is named as sugar plant. The sugar Rebaudioside A (Reb A) (stevia l glycoside) is effective matter of stevia. It is 250–300 times sweeter than sucrose [43].



Recently, Abbas et al. [16] used Etenia 457 as fat replacer and Sativoside as sweetener to prepared ice cream. So, the main target of this research is prepared frozen-yoghurt samples using Etenia 457 as a fat replacer and adding Sativoside as a sugar replacer. Four treatments as well as control samples were achieved. In first treatment (F1); 25% of Etenia 457 was used as well as 25% Sativoside. In the other three treatments, 50, 75 and 100 % of both ingredients were used respectively to current F2, F3 and F4.

2. Materials and Methods

2.1 Materials:

Fresh buffalo skim milk was obtained from the local market of Damietta, while skim milk powder and fresh buffalo cream (50% fat) was purchased from Carrefour of Cairo, Egypt. Commercial artisan yoghurt starter obtained from local market of Damietta; was used for fermentation.

Etenia 457 as a fat replacer was obtained from Evebe Company, Bucharest Ing Stefan Hepites; while **Sativoside** (as sweetener) was obtained from Foodchem company, Yuexing Int., China.

Bulking agents (Maltodextrin powder and liquid Sorbitol, 70%) which produced by Sigmaaldich Company, China; were used to improve the texture properties. Sodium carboxy methyl cellulose as a stabilizer was obtained from Jining Fortune, Biotech company, Shandong, China.

2.2 Methods

2.2.1 Experiments

Yoghurt starter culture was activated by fermenting the buffalo milk with natural yoghurt culture. Milk was heated at 90°C for 5 min and cooled to 45±1°C. Afterwards, it was inoculated with 1% activated yoghurt starter culture and incubated at 40±1°C (~3 hrs.) according to David et al. [15].

Every mix of frozen-yoghurt was obtained from two equal parts, the first one was the yoghurt coagula, while the second part was the completing part which contain all ingredients needed to make the final mix. The mix of control frozen-yoghurt (CY) contain 12% sucrose, 10% fat, 11% SNF, 0.5% CMC and 0.5% vanilla-extract. The fat and sugar contents were reduced in the following treatments by using fat replacer &sweetener. Etenia 457 and Sativoside were added at five levels (0, 25, 50, 75 and 100%). to achieve five final treatments, namely CY, F1, F2, F3 and F4 respectively. Maltodextrin and Sorbitol (1:2 W/V) as bulking agent were added also to the mixes by the same levels. The formula was presented in Table (1). All the mixes were heat treated at 85ºC for 5 min. then cooled to 5ºC. The mixes were aged at 5ºC, overnight, then adding vanilla. Thereafter, the cooled yoghurt was added at the level of 1:1 (yoghurt: mix). All ingredients were well mixed, and the processes was completed according to Isik et al. [7]. Manufactured by Bmeqile™ (Commercial Ice Cream Machine) Product model mq-L22, Production date 10.08.2013, Production number 80130610004, Made in China. The treatments were achieved in triplicates.

Table (1): The formula (1kg/100kg mix) of frozen-yoghurt mix by using different levels fat replacer and sweetener.

Ingredients	Treatments				
	CY	F1	F2	F3	F4
Cream (50%fat, 4.5% SNF)	20	15	10	5	00
Liquid skim milk (0.5% Fat, 9% SNF)	14	14	14	14	14
Dried skim milk (95%DM)	3.5	3.5	3.5	3.5	3.5
Sucrose	12	9.00	6.00	3.00	00
Stabilizer (CMC)	0.5	0.5	0.5	0.5	0.5
Etenia 457	00	0.25	0.50	0.75	1.00
Stiviosiode	00	0.02	0.05	0.07	0.10
Sorbitol (70%)	00	5.35	11.05	16.652	22.20
Maltodextrin	00	2.38	4.40	6.528	8.70
Yoghurt	50	50	50	50	50
Total	100	100	100	100	100

SNF: Solids not fat; DM: Dry matter; CMC: Sodium carboxy methyl cellulose; CY: without additives (control); F1, F2, F3 and F4: 25, 50, 75 and 100 % replacement.

2.2.2 Chemical analysis:

Dry matter, protein, fat, ash contents as well as total acidity were determined as described in AOAC [17]. The carbohydrates were calculated by difference according to Pellet and Sossy [18]. The pH value of samples was measured by using laboratory pH meter (Acumen portable AP61, Fisher Scientific) in 10 ml of samples as described also by AOAC [17]. Caloric value was calculated using the figures of Renner & Renz-Schauen [19] as follow: 1 g Fat = 9.3 Kcal; 1 g Protein = 4.1 Kcal; 1 g Carbohydrate = 4.1 Kcal.

2.2.3 Physical properties estimation:

Specific gravity was determined according to Khalil and Blassy [20].

Apparent viscosity of mixes were determined using a Bohlin coaxial cylinder viscometer (Bohlin Instrument Inc., Sweden) attached to a workstation loaded with software V88 viscometer programmed. The system C30 was filled with the ice milk mixture at the measurement temperature of 20°C. The viscosity was carried out in the up mode at shear rate ranging from 34 to 270 1/s. Apparent viscosity was expressed as mPa [21].

Overrun was measured by comparing the weight of mix and ice milk in a fixed volume container by using a 250 ml beaker. The overrun percentage was determined according to Arbuckle [22] by using the following equation:

$$On\ \% = 100\ (Wm - Wic)/Wic$$

Where:

On (%) is the overrun percentage

Wm (g) is the weight of a given volume of mix

Wic (g) is the weight of same volume of frozen yoghurt.

The melting rate test was carried out according to the method of El-Nagar et al. [13] with some modifications. Forty grams of cubic cut sample was placed on the screen, which was mounted on a beaker. The weight of the collected sample in the beaker was recorded at min 15, 30 and 45 of melting. The ratio of these values to the initial weight was calculated. Of melting, the ratio of these values to the initial weight of samples was calculated.

2.2.4 Organoleptic properties evaluation:

Sensory properties of frozen-yoghurt samples were evaluated by a panel of 15 trained, expert, and specialized judges from the staff members of the dairy department, Faculty of Agriculture, Damietta University. Samples were taken out from frozen storage (-18ºC) after 24 hours past of hardening and promptly offered to the panelists. The samples were coded with three-digit random numbers in odorless plastic cups with all the orders of servings completely randomized. The applied arbitration card suggested by Kaul et al. [23] was used. Flavor scores were 50 points, body & texture scores were 40 while melting quality scores were 10 degrees.

2.2.5 Statistical analysis:

Statistical analysis was performed according to SAS Institute [24] using General Linear Model (GLM) with main effect of treatments. Duncan's multiple range was used to separate among means of three replicates at $P \leq 0.05$.

3. Results and Discussion

3.1 Chemical properties:

Chemical characters of frozen-yoghurt mixes containing different levels of fat replacer and sweetener are presented in Table (2). It could be noticed that the replacements had no significant or clear differences in dry matters and total protein contents among the different treatments. The values of dry matters were 34.70, 34.92, 35.84, 35.84 and 35.77% for control and F1, F2, F3 and F4 samples respectively. Early, Arbuckle, [25] mentioned that the total solids content of both control and experimental samples was standardized to 37%.

Their corresponding values for protein contents (Table 2) were 4.00; 4.00; 3.90; 4.01 and 4.00%. These results were in agreements of Milani & Koooheki,[8]; Mahrous & Abd–Salam,[9]; Nagendra et al. [5] and Arslaner et al. [10].

For ash contents, it could be noticed a slight decrease in their contents with increasing the ratio of supplements added in the blend. These decreases may be due to lower ash content in ingredients compared with control as mentioned in Table (2). Their values were 1.401; .095; 0.900, 0.840 and 0.800 % in CY, F1, F2, F3 and F4 samples respectively. The main factor in frozen-yoghurt quality is pH value. As shown in the same table; no clear variations were observed in the pH values between the treatments and control. Their values were 6.15; 6.20; 6.28; 6.33 and 6.40 in the same order for CY and F1, F2, F3 and F4. The same trend was noticed for acidity percent; where control sample possessed 0.22% lactic acid while F1, F2, F3 and F4 samples had 0.22; 0.24; 0.25 and 0.26 % in the same order. These results were paralleled with findings of Isik et al. [7], Senaka et al. [26]; Abd El- Aziz et al. [27]; Abbas et al. [28]; Zaki et al. [29]; Batawy et al. [30] and Abbas et al. [16]. In A study of Isik et al. [7], the preliminary consumer preference was performed to determine the favorite pH value. The results showed that 69% of the panelists preferred the sample having a pH value of 5.2 in comparison to the sample with pH 4.8. As the preference of the panelists was statistically significant ($P<0.05$). However, Chandan & Kilara [31], prepared frozen yoghurt with a blend of 90% ice milk mix and 10% plain yoghurt. The pH of most popular frozen yoghurt is around 6 and it tastes more like ice milk/cream with a hint of yoghurt.

Table (2): Effect of different levels of fat and sweetener replacers on the chemical properties and caloric value of the resultant low-fat Frozen-yoghurt.

Parameters	CY	Treatments*				SEM	P-value			
		F1	F2	F3	F4		T	L	Q	C
DM%	34.693[d]	34.913[c]	35.836[a]	35.836[a]	35.766[b]	0.004	0.001	0.001	0.001	0.001
Fat%	9.766[a]	7.433[b]	5.00[c]	3.866[d]	0.100[e]	0.036	0.001	0.001	0.001	0.001
Protein%	4.00[a]	4.00[a]	4.01[a]	4.06[a]	4.00[a]	0.021	0.001	0.001	0.001	0.001
Ash%	1.400[a]	0.983[b]	0.903[c]	0.836[d]	0.803[e]	0.002	0.001	0.001	0.001	0.001
Cal. V	160.20[a]	130.90[b]	100.30[c]	70.80[d]	30.100[e]	0.000	0.001	0.001	0.001	0.001
pH value	6.143[e]	6.196[d]	6.276[c]	6.320[b]	6.403[a]	0.006	0.001	0.001	0.359	0.531
TA%	0.213[c]	0.216[c]	0.240[b]	0.246[b]	0.256[a]	0.002	0.001	0.001	0.771	0.107

- See foot table (1) ; DM%: Dry matter; Cal V : Caloric value (Kcal/100g); TA: Titratable acidity; T = treatment; L = linear response; Q = quadratic response; C = cubic response.

a,b,c,d Means within a row with different superscript letters are significantly different (P<0.05).

CY: without additives (control); F1, F2, F3 and F4: 25, 50, 75 and 100 % replacement.

It could be notice also that some markets prepared frozen-yoghurt from 100% plain yoghurt with stabilizers, corn syrup solids, and emulsifiers; it usually has a pH 4.5 or below. Our finding was in agree with data of Arslaner et al. [10].

For the main target of the present study; there were great variations in fat contents and pronounced differences in calories values. Table (2) presented the fat contents; it could be notice that control samples contained 9.8 %. This value was decreased to be 7.5, 5.0, 3.9 and 0.1 % in F1, F2, F3 and F4 samples respectively. These reduces were logic as the replacement of milk fat with fat replacer. For caloric values; there were also significant changes in their numbers as showed in Table (2) and Figure (1). Control sample supplied 160.2 Kcal/ 100g sample; while F4 sample supplied 30.10 Kcal/g samples only. The other treatment had intermediate values of calories where F1 sample supplied 130.9 Kcal/g sample; F2 sample possessed 100.3 Kcal/g sample however F3 sample had 70.8 Kcal/g sample. So, it can be observed that the aim of this research was achieve and it can prepare low calories product for the individual consumers.

Descriptive statistics for chemical properties of resultant low-calorie frozen yoghurt were recorded in Table (3). Means along with standard deviations were 35.409±0.517, 5.233±3.391, 3.986±0.074, 0.985±0.224, 98.460±46.993, 6.268±0.095, and 0.234±0.018 for dry matter, fat, protein, ash % as well as caloric number, pH value and acidity %, respectively. It was clearly appearing that fat content and caloric value were coupled with the highest coefficient of variations, which indicated that there were higher variations between the experimental groups compared to the other chemical properties of resultant low-calorie ice cream mix.

Table (3): Descriptive statistics for chemical properties and caloric value of the resultant low-fat Frozen-yoghurt.

Parameters*	Mean	S.D	C.V	Range
DM%	35.409	0.517	1.462	1.160
Fat%	5.233	3.391	64.806	9.700
P%	3.986	0.074	1.864	0.300
Ash	0.985	0.224	22.749	0.601
Cal. V	98.460	46.993	47.728	130.100
pH value	6.268	0.095	1.516	0.270
TA	0.234	0.018	7.701	0.050

•See foot table (1) ; S.D: Standard deviation; C.V: Coefficient of variations varied; DM%: Dry matter; Cal. V: Caloric value (Kcal/100g); P%: Protein; TA: Titratable acidity.

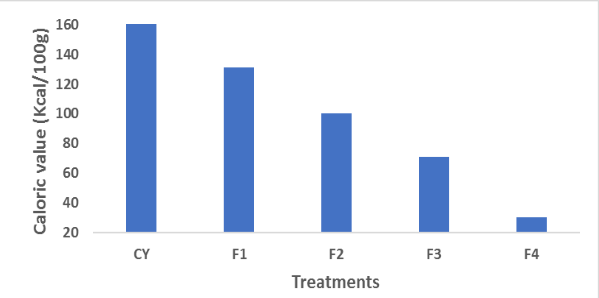


Figure (1). Caloric value (Kcal/100g) of low-fat and low-calories of frozen-yoghurt

CY: without additives (control); F1, F2, F3 and F4: 25, 50, 75 and 100 % replacement.

The results in Table (4); showed that adding different replacements level of fat replacer and sweetener had highly significant effect (P<0.001) on chemical properties of resultant low calories frozen-yoghurt and they were linearly, quadratically and cubically (P<0.001) affected by different replacements level of fat and sweetener except acidity as it affected only linearly (P<0.001). In connection to dry matter content, there are significant differences between control treatment and all other treatment (P<0.05). Meanwhile, non-significant differences were detected between the treatments with levels of 50% and 75% fat replacer and sweetener (P>0.05). To comparing control treatment with other treatment, it is clearly appearing that there are significant differences in fat and ash content as well as caloric value, being the highest in control treatment and began to decrease gradually with increasing the levels of milk fat and sweeteners. With regard to protein content, significant differences were showed between the treatment with the level of 50% fat replacer and sweetener and the other treatment. In contrast, non-significant differences were observed between the control treatment and the treatments with the levels of 25%, 75% and 100% of supplements (P>0.05). Regarding the acidity content, the minimum content was recorded in the control treatment, while the maximum one was detected in the treatment with the level of 100% of supplements (P<0.05), trivial difference were observed between the treatment with the levels of 50% and 75% (P>0.05).

Table (4): Person correlations between different chemical properties of the resultant low-fat and low-calories Frozen-yoghurt.

Items	TA	pH value	Cal. V	Ash	P%	Fat%	DM%
DM%	0.934***	0.870***	-0.843***	-0.849***	-0.206	-0.836***	1
Fat%	-0.958***	-0.995***	0.994***	0.855***	-0.045	1	
P%	-0.018	0.065	-0.127	0.035	1		
Ash	-0.817***	-0.855***	0.854***	1			
Cal. V	-0.965***	-0.997***	1				
pH value	0.978***	1					
TA	1						

*** P<0.001.

DM%: Dry matter; Cal. V: Caloric value (Kcal/100g); P%: Protein; TA: Titratable acidity.

Results in Table (4) showed the person correlations between different chemical properties of resultant low-calories frozen-yoghurt. It is clearly appearing there are pronounce significant relationships between different chemical properties of resultant product (P<0.001) except those between dry matter and protein contents, fat, and protein contents as well as protein content with ash, caloric value, pH value and acidity showed non-significant associations (P>0.05). Furthermore, the inverse relationships were detected between all chemical properties of resultant mix. Meanwhile, the positive relationships were observed between dry matter content with pH value and acidity; fat content with ash content and caloric value; protein content with ash content, caloric value, pH value and acidity; ash content with caloric value; pH value and acidity. The present data were parallel with Guner et al. [32] and Ramesh, [33].

3.2 Physical properties:

Table (5) reflected the physical properties of low fat &low calories frozen yoghurt. It clear that specific gravity (SG) and viscosity values were increased as level of additives increased. The values of SG were 1.201, 1.210, 1.233, 1.248 while the values of viscosity were 14.00, 15.00, 17.00, 18.00 CP for CY, F1, F2, F3 and F4 in order. However, the percent of overrun were decreased with the increased of replacements. Their values were 68; 67, 60, 52 and 50% respectively. It could be observed also large variations in the values of melting resistance degrees. Control sample had the best and favourite properties of melting behaviour; however, these properties where be unacceptable and were deteriorated in the treated frozen Yoghurt samples. After 5 min Control sample possessed 2.542% while F1, F2, F3 and F4 samples gained 4.923, 5.890, 6.897 and 70.74%. While after 10 min the values become 18.234, 39.471, 39.980, 38.342 and 48.890% for CY, F1, F2, F3 and F4 samples, respectively. The corresponding values after 15 min researched 36.891, 62.335, 66.876, 50. 439 and 70.560% in the same order. In 1999, Roland et al. [34] reported that low fat ice cream samples containing milk protein concentrate had higher melting rates than the samples of 10% fat. While Muse and Hartel [35] (2004) recorded no significant difference between melting resistance of samples and the different type and ratios of fat replacers (p>0.05) but the melting resistance of samples containing inulin was a bit more with the maximum value being associated with 2% inulin sample. Fat destabilization is the most important parameter affecting ice cream melting rate. Fat destabilization is related to viscosity and ice cream ingredients. Herald et al. [36] (2008) reported that increasing ice cream mix viscosity resulted in lower melting rate and improved product smoothness.

Table (5): Effects of different replacements level of fat replacer and sweetener on physical properties of the resultant low-fat and low-calories Frozen-yoghurt.

Parameters	Treatments					SEM	P-value			
	CY	F1	F2	F3	F4		T	L	Q	C
Specific gravity	1.201e	1.260a	1.223d	1.233c	1.248b	0.002	0.001	0.001	0.001	0.001
Viscosity	14.00d	12.00e	17.00c	18.00b	20.00a	0.002	0.001	0.001	0.001	0.001
Overrun%	68.00a	67.00b	60.00c	52.00e	58.00d	0.002	0.001	0.001	0.001	0.001
Melting, % after										
5 min	2.54e	4.92d	5.89c	6.89b	7.75a	0.001	0.001	0.001	0.001	0.001
10 min	18.23d	39.47e	39.98c	48.34b	52.90a	0.004	0.001	0.001	0.001	0.001
15 min	36.89e	62.33c	66.87b	50.43d	70.55a	0.001	0.001	0.001	0.001	0.001

T = treatment; L = linear response; Q = quadratic response; C = cubic response.
a,b,c,d Means within a row with different superscript letters are significantly different (P<0.05).
CY: without additives (control); F1, F2, F3 and F4: 25, 50, 75 and 100 % replacement.

Descriptive statistics for physical properties of resultant low-calories frozen-yoghurt are recorded in Table (6). Means along with standard deviations were 1.23±0.02, 16.20±2.95, 61.00±6.14, 31.33±24.83, 5.60±1.86, 39.78±12.33 and 57.42±12.73 for Specific gravity, Viscosity, overrun %, melting after 5 min, melting after 10 min, and melting after 15 min, respectively. It is clearly appearing that melting at different time sampling coupled with the highest coefficient of variations, which indicated that there were higher variations between the experimental groups compared to the other physical properties of resultant low-calorie frozen yoghurt.

Table (6): Descriptive statistics for physical properties of the resultant low-fat and low-calories Frozen-yoghurt.

Parameters	Mean	S.D	C.V	Range
Specific gravity	1.23	0.02	1.699	0.06
Viscosity	16.20	2.95	18.25	8.00
Overrun%	61.00	6.14	10.06	16.00
Melting, % after				
5 min	5.60	1.86	33.27	5.21
10 min	39.78	12.33	30.99	34.68
15 min	57.42	12.73	22.17	33.67

S.D: Standard deviation; C.V: Coefficient of variations varied.

The existing results indicated that there are pronounce significant effects of different replacements level of milk fat & sweetener on physical properties of resultant low-calorie frozen-yoghurt. Also, they linearly, quadratically and cubically affected (P<0.05) by different replacements level of milk fat & sweetener. The treatments with the levels of 25% milk fat and sweetener coupled with the highest estimate, while the control treatment coupled with the lowest one (P<0.05). Viscosity estimate was in a gradually increase with increasing the levels of milk fat and sweeteners (P<0.05). With regarded to overrun percentage, it was in descending order from the control treatment till the treatment with 75% fat replacer and sweetener then it began to increase in the treatment with 100%. However, melting estimates at different time sampling were in ascending order with increasing the levels of fat replacer and sweetener (P<0.05) as presented in Table (5).

Results in Table (7) showed the person correlations between different physical properties of resultant low-calorie frozen-yoghurt. The present results showed that there were significant relationships between all different physical properties of resultant low-calories frozen-yoghurt (P<0.05) except those observed between specific gravity, viscosity and over run percentage. The positive relationships were detected between all physical properties of resultant low-calorie frozen-yoghurt except those between specific gravity and overrun percentage, viscosity and over run percentage as well overrun percentage with melting at different time sampling showed negative associations.

Table (7): Person correlations between different physical properties of the resultant low-fat and low-calories Frozen- yoghurt.

Items	Specific gravity	Viscosity	Overrun%	Melting, % after		
				15 min	10 min	5 min
Specific gravity	1	0.021	-0.163	0.594*	0.722**	0.711**
Viscosity		1	-0.814	0.790**	0.670**	0.395
Overrun%			1	-0.821***	-0.761**	-0.274**
Melting, % after						
5 min				1	0.983***	0.735**
10 min					1	0.757**
15 min						1

3.3 Sensory properties:

Organoleptic score of resultant low-calorie frozen-yoghurt are presented in Figure (2). The results showed that there were slight differences among all treatments. The samples containing fat replacer and sweetener had little lower flavour scores than control treatment. The scores of flavours were 49, 48, 47, 47 and 44 points for CY, F1, F2, F3 and F4 samples, respectively. This may be due to the lost or lacking milk fat and its natural flavour. Fat of milk plays a significant role in the flavour because fat acts as a main carrier for important flavour notes. Fat can impact ice cream – yoghurt -flavour in three ways: by contributing to the rich, full, and creamy flavour; by participation in hydrolysis and oxidation reactions; by helping in perception of flavourful volatile ingredients in the final product [37-39]. With regard to body and texture degrees, addition of Etenia 457 and Sativoside to frozen yoghurt formula caused a slight and unobservable deteriorations in body & texture properties of final product. The points of body & texture of control sample were 38 while their value was 38 in F1 sample. Their values began to decrease again to reach 36, 36 and 35 in F2, F3 and F4 samples in order. The melting propertied degrees were varied also. Complete degree of melting quality was showed with the control treatment and the treatment with level of 25% milk fat and sweetener, whereas the treatment with the level of 100 % milk fat and sweetener coupled with the lowest degree. The results were in agreement with Peres et al. [40] and Abbas et al [16].

The F1 sample had the best and favourite melting properties as well as control; they possessed 10 points. Both F2 and F3 gained 9 and 7 points, however F4 had 6 points. El-Batawy et al. [30] recorded a decrease in body & texture properties of the final product. Milk fat is a determinant factor in frozen Yoghurt texture; therefore, reduction of fat in ice cream can lead to textural defects in the final product such as iciness and coarseness brittle body and shrinkage [41].

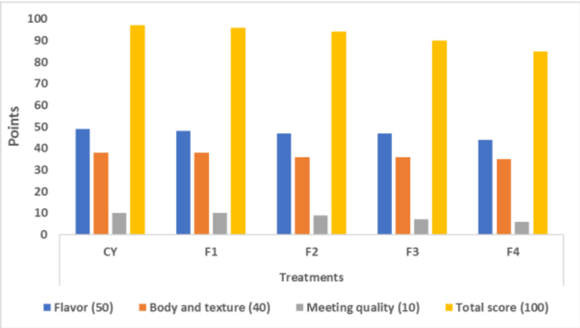


Figure (2). Organoleptic properties (Points) of low-fat and low-calories frozen-yoghurt.
CY: without additives (control); F1, F2, F3 and F4: 25, 50, 75 and 100 % replacement.

For all total acceptability, F1 samples (25% replacements) and control samples gained the higher scores (97 points). The F2 possessed 94 followed by F3 (90 points) and finally F4 sample which possessed 85 points.

4. Conclusion

It could be concluded that the preparing of low fat and calories frozen-yoghurt is be available by using 25% Etenia as fat replacer and 25% Stiviosiode as sweetener.

3. References

1. Marshall, R.T.; Goff, H.D. and Hartel, R.W. (2003). Ice Cream. 1st Ed.; Aspen Publishers, New York. https://www.springer.com/gp/book/9781461501633
2. Cruz, A.G.; Antunes, A.E.C.; Sousa, A.L.O.P.; Faria, J.A.F. and Saad, S. M. I. (2009). Ice-cream as a probiotic food carrier. Food Res. Int., 42(9):1233–1239. https://doi.org/10.1016/j.foodres.2009.03.020
3. Inoue, K.; Shiota, K. and Ito, T. (1998). Preparation and Properties of Ice Cream Type Frozen Yogurt. Int. J. Dairy Technol., 51(2):44-50. https://doi.org/10.1111/j.1471-0307.1998.tb02506.xs
4. Tamime, A.Y. and Robinson, R.K. (2007). Background, standards, and marketing of frozen yoghurt: Yoghurt: Science and Technology (Ed. AY Tamime and RK Robinson), 3rd Ed. CRC Press, Boca Raton, FL. pp. 392-393.
5. Nagendra, P.; Ramesh, S. and Chandan, C. (2017). Historical Background, Health Benefits, and Global Trade Science Direct, pp. 3-29. https://doi.org/10.1016/B978-0-12-805134-4.00001-8
6. Guggisberg, D.; Picccinali, P. and Schreier, K. (2011). Effects of sugar substitution with stevia, actilight MT and stevia combinations or palationse MT on rheological and sensory characteristics of low-fat and whole milk set yogurt. International Dairy Journal, 21(9):636–644, https://doi.org/10.1016/j.idairyj.2011.03.010.
7. Isik, U.; Boyacioglu, D.; Capanoglu, E. and Nilufer Erdil, D. (2011). Frozen yoghurt with added inulin and iso-malt. Journal of Dairy Science, 94(4):1647-1656, https://doi.org/10.3168/jds.2010-3280
8. Milani, E. and Koocheki, A. (2011). The effects of date syrup and guar gum on physical, rheological and sensory properties of low-fat frozen yoghurt dessert, Inter. J. Dairy Techn., 64(1):121-129. DOI: 10.1111/j.1471-0307.2010.00631.
9. Mahrous, H. and Rehab Abd-El-Salam (2016). Production of a functional frozen yoghurt fortified with Omega-3 and Vitamin, American J. Food and Nutr.; doi:10.5251/ajfn.2016.6.1.1.10
10. Arslaner A.; M.A. Salik, S. Özdemir and A. Akkose (2019). Yogurt ice cream sweetened with sucrose, stevia and honey: Some quality and thermal properties, Czech J. Food Sci., 37:446–455. https://doi.org/10.17221/311/2018-CJFS
11. Davidson, R.H.; Duncan, S.E. and Hackney, C.R. (2000). Probiotic Culture Survival and Implications in Fermented Frozen Yogurt Characteristics, J. Dairy Sci., 83:666–673. DOI: 10.3168/jds.S0022-0302(00)74927-7c
12. Mahdian, E.; M. Mazaheri Tehrani and M. Nobahari (2012). Optimizing Yoghurt Ice Cream Mix Blend in Soy Based Frozen Yoghurt. J. Agric. Sci. Tech., 14:1275-1284. https://jast.modares.ac.ir/article-23-7697-en.pdf
13. El-Nagar, G.F.; Clowes, G.; C.M. Tudorica; V. Kuri (2002). Rheological quality and stability of yog-ice cream with added inulin, Inter. J. Dairy Techn., 55(2):89-93. DOI:

https://doi.org/10.1046/j.1471-0307.2002.00042.xs

14. Alting, A.C.; F.V. de Velde, M. Kanning; M.J.M. Burgering (2008). Improved creaminess of low-fat yogurt: The impact of amyl maltase treated starch domains, Food Hydrocolloids, 23(3):980-987. DOI: 10.1016/j.foodhyd.2008.07.011
15. David Gomes; K. Szkolnicka; J. Viegas and C.D. Pereira (2017). Lactose free frozen yoghurt: Production and characteristics, Acta Scientiarum Polonorum, Technologia Alimentaria, 16(2):171-179, DOI: 10.17306/J.AFS.0478
16. Abbas, H.M.; Hammad, M.N.F. and Nada B.S. Evaluation of low calories ice cream properties prepared by using fat replacer and sweetener. Egypt. Journal of Chemistry. (Accepted).
17. AOAC (2012). Official Methods of Analysis of the Association of Official Analytical Chemists, 15th Ed. AOAC: Washington, DC. https://doi.org/10.1002/0471740039.vec0284
18. Pellet, P.L. and Sossy, S. (1970). Food composition. Tables for use in the Middle East. Am. Univ. Beirut, Lebanon, 2: 126. https://www.cabdirect.org/cabdirect/abstract/19746700732.
19. Renner, E. and Renz-Schauen, A. (1986). Nährwerttabellen für Milch und Milchprodukte. 557 Seiten (Loseblattsammlung), Verlag B. Renner, Gießen. Preis: 56, DM. https://doi.org/10.1002/food.19870310123s
20. Khalil, R.A.M. and K. I. Blassy (2011). The use of modified date pulp fibers in functional low-fat ice cream. Egyptian J. Dairy Sci., 39:275-283.
21. Atallah, A. A. and H. Barakat (2017). Preparation of Non-Dairy Soft Ice Milk with Soymilk, J. Adv. Dairy Res., 5:2, DOI:10.4172/2329-888X.1000172s
22. Arbuckle, W. S. (1986). Ice cream. 4th Edn., Avi publishing Co. Inc., West Port, Connecticut, pp:207-212.
23. Kaul, V.; Mathur, P. and Murlidharan, R. (1982). Dependency and its antecedents: A review. Indian Educational Review, 17(2):35–46. https://psycnet.apa.org/record/1984-20207-001c
24. SAS; (2004). SAS User's Guide: Statistics Version 8, SAS Institute, Inc., Cary, NC.,USA.
25. Arbuckle, W. S. (1972). Ice Cream. AVI Publishing Company, Inc New York. https://www.abebooks.co.uk/servlet/BookDetailsPL?bi=30557229224&searchurl=an%3Darbuckle%2Bw%2Bs%26sortby%3D20%26tn%3Dice%2Bcream&cm_sp=snippet-_-srp1-_-title1
26. Senaka, R.C.; Evans, C.A.; Adams, M.C.; Baines, S.K. (2013). Production of probiotic ice cream from goat's milk and effect of packaging materials on product quality, Small Ruminant Research, 112:174–180. http://dx.doi.org/10.1016/j.smallrumres.2012.12.020
27. Abd El-Aziz, M.; H.F. Haggag; M.M. Kaluoubi; Laila K. Hassan; M.M. El-Sayed and A.F. Sayed (2015). Physical Properties of Ice Cream Containing Cress Seed and Flaxseed Mucilage's Compared with Commercial Guar Gum. International Journal of Dairy Science, 10(4):160-172. DOI: 10.3923/ijds.2015.160.172.
28. Abbas, H.M.; W.. Ibrahim Abd El-Aziz Nasr, Wafaa Mohamed Zaky and W. Ibrahim El-Desoki (2019). Nutritive Value of Ice Milk Prepared by Chia Seed. World Applied Sciences Journal, 37(6):465-470. DOI: 10.5829/idosi.wasj.2019.465.470.
29. Zaky, Wafaa M.; Abbas, H. M.; W. Ibrahim Abd El-Aziz Nasr and W.Ibrahim El-Desoki (2019). Chia Seeds as Natural Stabilizer and Healthy Ingredient in Ice Milk Preparation. World Journal of Dairy & Food Sciences, 14(1): 52-58. DOI: 10.5829/idosi.wjdfs.2019.52.58.
30. El-Batawy, O.I.; Wafaa M. Zaky and Amal A. Hassan (2019). Preparation of Reduced Lactose Ice Cream Using Dried Rice Protein Concentrate, World J. Dairy & Food Sci., 14(2):128-138. DOI: 10.5829/idosi.wjdfs.2019.128.138s
31. Chandan, R. C. and A. Kilara (2013). Manufacturing Yogurt and Fermented Milks, Copyright © 2013, John Wiley & Sons, Inc., DOI:10.1002/9781118481301
32. Guner, A.; Ardic, M.; Keles, A. and Dogruer, Y. (2007). Production of Yogurt Ice Cream at Different Acidity, Int. J. Food Sci. Technol., 42: 948–952. DOI: 10.1111/j.1365-2621.2006.01315.x
33. Ramesh, C. (2017). Ice Cream and Frozen Desserts, Chandan Ph.D. Chief Editor Consultant, Arun Kilara, DOI: 10.1002/9780470113554.ch74, In book:

Handbook of Food Products Manufacturing, pp.593–633.

34. Roland, A. M.; Lance, G. Phillips and Kathryn, J. (1999). Boor Effects of Fat Replacers on the Sensory Properties, Color, Melting, and Hardness of Ice Cream. *J. Dairy since*, 82(10):2094-2100, https://doi.org/10.3168/jds.s0022-0302(99)75451-2 .

35. Muse, M. R. and R. W. Hartel (2004). Ice Cream Structural Elements That Affect Melting Rate and Hardness, Journal of Dairy Science, 87(1): 1-10. http://dx.doi.org/10.3168/jds.S0022-0302(04)73135-5

36. Herald, T. J.; Aramouni, F. M. and Abu-Ghoush, M. H. (2008). Comparison Study of Egg Yolks and Egg Alternatives in French Vanilla Ice Cream, J. Text. Stud., 39:284-295

37. Plug and Haring (1993). The role of ingredient-flavor interactions in the development of fat-free foods, Trend Food Sci. Technol., 4:150-154.

38. Ohmes, R. L.; Marshall, R. T. and Heymann, H. (1998). Sensory and physical properties of ice creams containing milk fat or fat replacers, Journal of Dairy Science, 81:1222– 1228.

39. Prindiville, E. A.; Marshall, R. T. and Heymann, H. (2000). Effect of milk fat, cocoa butter, and why protein fat replacers on the sensory properties of low fat and nonfat chocolate ice cream, Journal of Dairy Science, 83:2216– 2223.

40. Peres J.; Esmerino E.; da Silva, A.L.; Racowski, I. and Bolini, H. (2018). Sensory profile, drivers of liking, and influence of information on the acceptance of low-calorie synbiotic and probiotic chocolate ice cream, J. Food Sci., 83:1350–1359. DOI: 10.1111/1750-3841.14120.

41. Mahdian, E.; M. Mazaheri Tehrani and M. Nobahari (2013). Optimizing Yoghurt Ice Cream Mix Blend in Soy Based Frozen Yoghurt, J. Agric. Sci. Tech., 14:1275-1284.c

42. Lemus-Mondaca, R.; Vega-Galvez, A.; Zura-Bravo, L. and Ah-Hen, K. (2012). Stevia rebaudiana Bertoni, source of a high-potency natural sweetener: A comprehensive review on the biochemical, nutritional, and functional aspects Food Chemistry, 132(3):1121–1132 DOI: 10.1016/j.foodchem.2011.11.140

43. Alizadeh, M.; Lalabadi, M. A. and Kheirouvris, S. (2014). Impact of using stevia on physicochemical sensory rheology and glycemic index of soft ice cream, Food Nutr. Sci., 5(4):390–396. https://doi.org/10.4236/fns.2014.54047