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Evaluation Of Low Calories Ice Cream Properties Prepared By Using Fat Replacer And Sweetener

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Abstract

Producing **ice** cream suitable for individual people is a recent demand. Low calories or reduced fat-ice-cream has great request for avoiding obesity and heart diseases. In the present research; **Etenia 457** was used as fat replacer while **Sativoside**was used as sweetener at different levels (0, 25, 50, 75 and 100%) to achieve five treatments, namely C, T_1, T_2, T_3 and T_4 respectively. Maltodextrin and Sorbitol (1:2 W/V) as bulking agent were also added. The obtained results showed no clear variations in the total solids, protein and ash contents or acidity percent and pH values between control and treatments. However, there were great differences in fat contents and calories values. On another side; the specific gravity values were decreased as a result of using the fat replacer and sweetener. Viscosity was increased with the increase of the additives in the formulation. Large variations in the values of melting resistance degrees were noticed, and control sample had the favorite properties of melting behavior. There had little lower flavor scores in treatments and slight deterioration in body & texture properties .For all total acceptability; T_1 samples (25% replacements) gained the higher scores (99 points) followed by T_2 ,T_3 and then T_4 which gained 86 points. So, it could be prepared ice cream sample with acceptable properties by using 25% Etenia 457 and 25% Sativoside to be more suitable for individual people.

Keywords: Ice cream; low calories; low fat; fat replacers; sweeteners

Introduction

Nowadays, it can be noticed that consumers are more aware of the connection between their diet and Health. Earlier, ice cream was considered as a food for enjoyment, rather than a basic food, but by increasing incomes and health consciousness, value addition has witnessed a significant increase over the past few years. (El-Batawy et al., 2019). Ice cream is a complex food consist of small air cells dispersed in a partially frozen continuous aqueous phase. (Zaky et al., 2019 and Desouky 2021).The major ingredients of the Ice cream formula- backbone are sweetener, stabilizer and/or emulsifiers, beside milk fat, milk solids-not- fat.

Lactose is the main carbohydrate in milk and other dairy products, it is present at approximately 7.3% in ice cream (Karaman et al., 2014). It is characterized by low water solubility and when it presents in combination with sucrose; especially; in frozen dairy products, it crystallizes faster than sucrose (Sormoli, et al., 2013), resulting to grittiness (Abbasi&Saeedabadian, 2015 and El-Batawy et al., 2019).So, a recent attitude is reduced the calories and lactose contents in ice cream to produce a healthy and functional products more suitable for individual people and have less defects. Sugar contributes a main and sweet taste to ice cream, and thus has a crucial regulating effect on the overall taste sensation. The ability of sugar to lower the freezing point has a significant influence on the hardness/ softness of final frozen desserts.

To produce ice cream which is sufficiently low in calories as well as to provide a refreshing frozen dessert for diabetics and individual peoples; it is necessary to reduce or remove the sugar content. There are some trends to consider in making

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compositional adjustments which will minimize the effect of these differences. When sucrose, which is used generally (about 15 %), is to be replaced by intense sweetener, the requirement is in ppm only. Hence, there are two expected problems. The first is to compensate for the total solids to prevent weak body and related defects. This can be generally achieved by use of low-calorie bulk fillers/ bulking agents such as poly-dextrose and maltodextrin etc. However, use of bulking agents will result in a somewhat hard product since they lower the freezing point far less than sucrose. . On average, the calorific value of ice cream is 200 kcal/100g. (Dharaiya&Suneeta, 2014).

On another view ; Nutritional Education and Labeling Act (NLEA) in 1993, described new several modifying terms could be used such as reduced fat, light, low fat and nonfat, or no-fat which could be used in conjunction with the word ice cream. (Lincoln &Guba, 2011). Nowadays, consumers are interested in consuming low-fat foods; consequently, many fat replacers are utilized in low-fat ice cream that can mitigate textural and sensory defects caused by reducing fat content. The fat replacers used to replace fat in food system are named fat mimics or called mimetics or fat analogs. Fat mimics are based on carbohydrate, protein, and /or fat and they have energy values from 0 to 38 kJ/g (0-9 kcal/g), they have the characteristics of fat but have less energy (Miraglio, 1995; Trgo et al 1999 and Zoulias et al., 2002).

Most common fat replacers used in ice cream include inulin, maltodextrin, polydextrose, milk proteins, soy proteins, dietary fibers, and starches. Reduced fat ice cream is a nutritionally altered product (compared to ice cream) which contains 25% less fat as compared to conventional ice cream. Light ice cream has one-third fewer calories or half the amount of fat of that found in regular ice cream. In another view, low-fat-ice-cream contains less than 3 g fat per serving. But fat free, no fat, or nonfat ice cream is a product contains less than 0.5 g fat per serving. With these changes in descriptors, the total milk solids requirements of 20% still apply and all other aspects of ice cream described above still apply. As suggested by some authors, the fat content can influence the size of the ice crystals. Fat globules could mechanically impede the ice crystal growth (Trgo et al., 1999). Since each type of fat exhibits a specific polymorphism function of its triacylglycerol.

According the above introduction; reduce fat and low calories in ice cream may affect the properties of the final product. So, the current article dealt with using a fat replacer (Etenia 457) and a natural sweetener (Stiviosiode) to prepared low fat and low calories ice cream more suitable for individual people. This study was discussed their effects on the physicochemical and sensory properties.

Four treatments beside control sample were achieved. Control formula of ice cream mix contained 10% fat, 12% sugar, 11% SNF, 0.5% CMC and 0.5% vanilla.

Experimental:

Materials:

- Fresh buffalo skim milk; commercial table - sugar and liquid vanilla extract were obtained from the local market of Damietta, while skim milk powder produced by Poland and fresh buffalo Cream (50% fat) were obtained from Carrefour of Cairo, Egypt.

- Etenia 457 (as fat replacer) **was** obtained from Evebe company, Bucharest Ing Stefan Hepites, while**Sativoside** (as sweetener) **was** obtained from Food-chem. company ,YuexingInt, , China

- Maltodextrin powder as a bulking agent was obtained from Sigma Aldrich company, China, and liquid Sorbitol (70%) wereobtained from Jining Fortune, Biotech company, China.

-Sodium carboxy methyl cellulose) which produced by Jining Fortune, Biotech company,Shandong, China , was used as stabilizer.

Experiments:

- Preparation of low calories & low fat ice cream samples:

Control sample of vanilla ice cream mix was prepared to contain 10% fat, 12% sugar, 11% SNF, 0.5% CMC and 0.5% vanilla according to the method of Arbuckle (1986) which advanced by David *et al*. (2017). Etenia 457 and Sativoside were added at four levels (25, 50, 75 and 100%) to each. Maltodextrin and Sorbitol (1:2 W/V) were added also to the mix by the same levels (25, 50, 75 and 100%) to achieve four treatments beside control, namely C, T_1, T_2, T_3 and T_4 respectively. (Table 1). All mixes were heated at 85ºC for 5 min, then cooled and aged at 5ºC all night. In the next day, the whipping processing was carried for all mixes after adding 0.05% vanilla. The final product was packed in PVC cups.

Table (1): The formula (1kg/100kg mix) of low calories & low fat ice cream mix by using different levels of fat replacer and sweetener.

Ingredients	Level of replacement (%)				
	0 (C)	25 (T_1)	50 (T_2)	75 (T_3)	100 (T_4)
Cream (50% fat, 4.5% SNF*)	19.31	14.48	9.65	4.85	00
Liquid skim milk (0.5% fat, 9% SNF)	61.96	61.96	61.96	61.96	61.96
Dried skim milk (95% DM**)	6.65	6.67	6.69	6.71	6.73
Sugar	12	9.00	6.00	3.00	0
Stabilizer (CMC***)	0.5	0.5	0.5	0.5	0.5
Etenia 457	0	0.25	0.50	0.75	1
Stiviosiode	0	0.02	0.05	0.07	0.1
Sorbitol (70%)	0	2.57	8.08	14.57	18.20
Maltodextrin	0	1.60	4.52	7.446	9.70
Total	100	100	100	100	100

*SNF: Solids not fat **DM: Dry matter ***CMC: Sodium carboxy methyl cellulose

All treatments were achieved in triplicates.

Analytical Method:

1-Chemical analysis:

Dry matter, protein, fat, ash contents as well as acidity percent were determined as described in AOAC (2012). The carbohydrates were calculated by difference according to (Pellet and Sossy, 1970) using following equation: % Carbohydrate = 100 – Sum of (%Protein + %Fat + %Ash). The pH value of samples was measured by using laboratory pH meter (Acumen portable AP61, Fisher Scientific) in 10 ml of samples as described by AOAC (2012) - Total Energy:

Caloric value was calculated using the figures of Renner &Renz-Schauen (1986) as follow:

1g Fat = 9.3 Kcal; 1g Protein = 4.1 K Cal; 1g Carbohydrate = 4.1 Kcal.

2-Physical properties

Specific gravity is the ratio of the density of component or a material at 20ºC compared to the density of water. It determined according to Khalil &Blassy (2011).

Apparent viscosities of mixes were determined using a Bohlin coaxial cylinder viscometer (Bohlin Instrument Inc., Sweden) attached to a workstation loaded with software V88 viscometery 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 (Atallah and Barakat, 2017).

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 (1986) 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 ice milk.

For the melting rate test; a 2.5mm iron wire mesh screen (Analysensieb, Retsch, D-5657 Haan, and Germany) was used. The test was carried out according to the method of El-Nagar *et al*. (2002) 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.

Statistical analysis

Statistical analysis was performed according to SAS Institute (2009) using General Linear Model (GLM) with main effect of treatments. Duncan's multiple range was used to separate among means of three replicates at $P \leq 0.05$.

Organoleptic evaluation

Sensory properties of ice cream samples were evaluated by a panel of 25 trained, expert and specialized judges from the staff members of the dairy department, Faculty of Agriculture, Damietta University, Egypt. Ice cream 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*., 1982) was used. Flavor scores were 50 points, body & texture scores were 40 while melting quality scores were 10 degrees.

Results and Discussion

Chemical composition of low-calories and low-fat ice cream mix:

Chemical characters of ice cream mixes containing different level of fat replacer and sweetener are presented in Table (2). It could be noticed that these replacements had no significant or clear differences in dry matter and total protein among all treatments. The values of dry maters were 35.49, 35.32, 34.80, 34.84 and 34.77% for C, T_1, T_2, T_3 and $T_{4,}$ respectively. However, their corresponding values for protein contents were 4.00, 3.9, 3.88, 4.11 and 4.02% for C, T_1, T_2, T_3 and $T_{4,}$ respectively. For ash content, it could be observed that it was slightly decreased with increasing the ratio of supplements added in the blend. This decrease may be due to lower ash content in ingredients compared with control as mentioned in Table (2). These values were 1.201, 0.095, 0.93, 0.90 and 0.84% in C, T_1, T_2, T_3 and T_4, respectively. The data were in agreement with that of Arbuckle, 1972

There were great differences and pronounced variations in fat contents, carbohydrate, and calories. Fat contents were pronouncedly varied where control samples contained 9.7%. This value was decreased to be 7.2, 4.8, 3.2 and 0.1% in T_1, T_2, T_3 and T_4, respectively. These variations are logic as the replacement of milk fat with fat replacer and so achieve the target of this study.

For caloric values, there were significant changes in their numbers. Control sample supplied 177.3 Kcal/100g sample, while T_4 supplied 60.30 Kcal/g samples only. The other treatments had intermediate values of calories where T_1 supplied 150.5 Kcal/g sample, T_2 supplied 125.2 Kcal/g sample however T_3 had 95.1 Kcal/g sample. So, it can be observed that the aim of this research was achieve and it can prepare low calories ice cream.

No clear variations were observed in the pH values between the treatments and control. Their values were 6.45; 6.44; 6.44; 6.46 and 6.50 for C, T_1, T_2, T_3 and T_4, respectively. The same trend was noticed for acidity percent; where C sample possessed 0.23% lactic acid while T_1, T_2, T_3 and T_4 had 0.23; 0.24; 0.25 and 0.26% in the same order. These results were paralleled with findings of Dagdemir*et al*. 2004; Abd El-Aziz *et al*., 2015; Abbas *et al*., 2019 and El-Batawy*et al*., 2019.

Person correlations coefficients between different chemical properties of low-calorie ice cream mix are presented in Table (4). There are significant relationships between different chemical properties of low calorie ice cream mix (P<0.01) except those between fat and protein contents, dry matter and protein contents, ash and protein contents, protein content and caloric value, pH value and acidity as well as pH value with caloric value, fat, protein and ash contents showed non-significant associations (P>0.05). Additionally, negative relationships were detected between all chemical properties of low calorie ice cream mix except those between pH value and acidity as well as dry matter content with caloric value, fat, protein and ash contents; fat content with ash and caloric value; protein content with ash, pH value and acidity; ash content with caloric value. Negative relationships indicated that increase the first variable will resulted in a decrease in the second one and vice versa.

Table (2): Effect of different replacements level of milk fat and sweeteners on chemical properties of low-fat and low-calories ice cream mix.

Parameters	Control	Replacement level of milk fat and sweeteners				*SEM*	*P-value*			
		25%	50%	75%	100%		*T*	*L*	*Q*	*C*
DM%	35.303^{a}	35.280^{a}	34.673^{b}	34.826^{ab}	34.446^{b}	0.178	0.024	0.003	0.945	0.931
Fat%	9.733^{a}	7.300^{b}	4.700^{c}	3.233^{d}	0.106^{e}	0.091	0.001	0.001	0.478	0.001
P%	4.066^{a}	3.866^{b}	3.820^{b}	4.076^{a}	4.016^{a}	0.044	0.006	0.456	0.006	0.007
Ash%	1.167^{a}	0.943^{b}	0.916^{b}	0.910^{b}	0.820^{c}	0.017	0.001	0.001	0.001	0.001
Cal. V	177.30^{a}	150.50^{b}	125.20^{c}	95.10^{d}	60.30^{e}	0.001	0.001	0.001	0.001	0.001
pH value	6.446	5.763	6.433	6.456	6.493	0.295	0.405	0.420	0.490	0.182
Acidity	0.226^{d}	0.230d^{c}	0.236^{c}	0.246^{b}	0.260^{a}	0.002	0.001	0.001	0.036	0.99

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).

DM%: Dry matter; Cal. V: Caloric value (Kcal/100g); P%: Protein % (T.N. X 6.38).

T1 :25 % ,T2 : 50 %, T3 75%,T4 100%

Table (3): Descriptive statistics for chemical properties of low-fat and low-calorie ice cream mix.

Parameters	Mean	S.D	C.V	Range
DM%	34.906	0.435	1.248	1.700
Fat%	5.014	3.430	68.42	9.700
Protein%	3.969	0.127	3.21	0.490
Ash%	0.951	0.122	12.84	0.401
Caloric Value(Kcal/100g)	121.680	42.453	34.88	117.000
pH value	6.318	0.520	8.23	2.060
Acidity%	0.240	0.013	5.45	0.040

S.D: Standard deviation; C.V: Coefficient of variations varied; DM%: Dry matter.

Means along with their standard deviation for chemical properties of low-calorie ice cream mix are recorded in Table (3). Means ± standard deviations were 34.906±0.435, 5.014±3.430, 3.969±0.127, 0.951±0.122, 121.680±42.453, 6.318±0.520 and 0.240±0.013 for Dry matter, fat, protein, ash, caloric value, pH value and acidity, respectively. Coefficient of variations varied between 1.248 % for dry matter content to 68.42 % for fat content, which indicated that there were higher variations in fat estimates between the experimental groups compared to the other chemical properties of low-calorie ice cream mix.

Table (4): Person correlations between different chemical properties of low-fat and low-calorie ice cream mix.

Items	DM%	Fat	P%	Ash	Cal. V	pH value	Acidity
DM%	1	0.930***	0.025	0.791***	0.901***	-0.585**	-0.874***
Fat%		1	-0.086	0.902***	0.995***	-0.391	-0.970***
Protein%			1	0.269	-0.176	0.512	0.286
Ash%				1	0.877***	-0.003	-0.802***
Caloric value (Kcal/100g					1	-0.400	-0.984***
pH value						1	0.448
Acidity%							1

**: $P<0.01$; ***: $P<0.001$; DM%: Dry matter.

Physiochemical Properties:

The physicochemical characteristics of ice cream mix and the final ice cream containing fat replacer (Etenia 457) and sweetener (Sativoside) at three levels are presented in Table (5).

Specific gravity:

The specific gravity of the ice cream samples fortified with different ratios of Etenia 457 and Sativoside were presented in Table (5) . Its value for control was 1.302. This value was reduced to be 1.203, 1289, 1233 and 1248 for T1, T2, T3 and T4 in order. It could be noticed that the specific gravity values were decreased because of using the fat replacer and sweetener. These data were in accordance with those obtained by Abd El-Aziz et al., 2015; Abbas et al., 2019 and El-Batawy, 2019 .

Viscosity:

Table (5) revealed that viscosity values were increased with an increase of fat replacer and sweetener in the Ice cream formulation. Mixes containing Etenia 457 and Sativoside seemed to be more viscous than control. Its value for control was 14 Mpa while their values researched to 16, 20, 21 and 23 Mpa for T_1, T_2, T_3 and T_4, respectively. Guinard*et al.*, 1997 had been reported that ice cream mixes show a non-Newtonian pseudo plastic flow due to behavior of aggregated fat globules and the presence of polysaccharide stabilizers, meaning that viscosity is decreased with increased shear rate. It has been suggested that hardness of ice cream is inversely related to fat content because fat reduction increases ice crystals in low-fat ice cream and probably causes to a harder texture in ice cream thus it is expected that the hardness of the low-fat ice cream be higher than that of regular ice cream with equivalent formulation. Any differences in hardness may also be correlated to changes in freezing points as a result of higher solute concentrations. On another side; Goff and Smith (1999) observed an increase in the viscosity vs. decrease in the freezing point of reduced-fat ice cream containing inulin. According to

Aime*et al*. (2001), consistency coefficients were positively correlated with the apparent viscosity values (r2 = 0.910); so, the greater viscosity values obtained for samples containing (milk protein concentrate) may be the result of higher consistency coefficients for these samples. However, Ozdemir*et al*. ;2003 ,Alvarez *et al*., 2005; Dervisouglou*et al*., 2005; Herald *et al*., 2008; Alfaifi&Stathopoulos 2009 &2010 and El-Batawy*et al*., 2019 recommended the obtained data

Table (5): Effects of different replacements level of milk fat and sweeteners on physical properties of resultant low-fat and low-calorie ice cream.

Parameters	Control	Replacement level of milk fat and sweeteners				*SEM*	*P-value*			
		25%	50%	75%	100%		*T*	*L*	*Q*	*C*
Specific gravity	1.301[a]	1.203[b]	1.288[c]	1.232[d]	1.247[e]	0.002	0.001	0.001	0.001	0.001
Viscosity (Mpa)	16.00[c]	14.00[d]	20.00[b]	20.00[b]	23.00[a]	0.002	0.001	0.001	0.001	0.001
Overrun%	67.00[a]	65.00[b]	62.00[c]	59.00[d]	55.00[e]	0.002	0.001	0.001	0.001	0.001
Melting resistance (loss%) after:										
5 min	2.50[e]	4.92[d]	5.89[c]	6.89[b]	7.73[a]	0.001	0.001	0.001	0.001	0.001
10 min	17.29[d]	17.29[d]	36.98[c]	39.34[b]	55.56[a]	0.001	0.001	0.001	0.001	0.001
15 min	33.88[d]	33.88[d]	49.21[c]	50.54[b]	70.54[a]	0.149	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).T1 :25 % ,T2 : 50 %, T3 75%,T4 100%

This result agreed with Alizadeh et al. (2014) who indicated that the stevia addition increased the overrun ration of soft ice cream. But, the overrun ration of plain with stevia was the lowest compared to other samples. In most of studies regarding fat replacers in low-fat ice cream, researchers had preferred to Keep overrun of samples constant because it affects other physical properties in ice cream such as melting behavior and hardness. Yilsay et al. (2006) also reported that substitution of 6% whey protein fat replacer (Simplesse®100) for milk fat decreased the overrun in low or fat-free Ice cream mixes. Also, Similarly, et al. (2009) used maze maltodextrin (N-Lite™ D, Germany) as bulking agent. They incorporated it at high levels (6% for low-fat Ice cream or 8% for non-fat Ice cream). They not Iced a decrease in the overrun compared to that of regular Ice cream. In another studies, Maltodextrin as bulking agents are produced by partial hydrolysis of corn starch that have dextrose equivalents value (DE) less than 20 but those with fat-replacing properties are DE<10. Polydextrose acts as a bulking agent and resists gastrointestinal enzymes of human so that it provides only one calorie per gram. Polydextrose is not sweet but is used in frozen desserts because it has some fat sparing properties. Both maltodextrin and poly-dextrose are used in low-fat ice cream as they produce minimal negative effects on production, shelf life and price of final product (Schmidt et al., 1993; Ohmes et al., 1998; Güzeler et al., 2011 and Goff &Hartel, 2013).

Melting resistance:

As shown in Table (5) , it could be noticed large variations in the values of melting resistance degrees. Control sample had the best and favorite properties of melting behavior; however, these properties were deteriorated in the treated samples. After 5 min. C-sample possessed 2.502% while T_1, T_2, T_3 and T_4 gained 4.923, 5.890, 6.897 and 70.74% After 5 min respectively. While after 10 min. the values become 17.291, 37.461, 39.980, 43.942 and 48.567% for C, T_1, T_2, T_3 and T_4 samples in the same order. The corresponding values after 15 min researched 33.881, 66.876, 62.372, 50.541 and 70.543% in the same order.

In an early study, Roland *et al*. (1999) reported that low fat ice cream samples containing MPC had higher melting rates than the samples of 10% fat. While, Muse and Hartel (2004) recorded no significant difference between melting resistance of samples and the different type and amounts 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*. (2008) reported that increasing ice cream mix viscosity resulted in lower melting rate and improved product smoothness. However, Alfaifi and Stathopoulos (2009), mentioned that using WPC as a substitute for egg yolk in Gelato ice cream and increasing the substitution level from 20 to 100% had resulted in decreasing melting rate while increasing product stability. Also, the melting rate for Gelato ice cream of 9% egg yolk and WPI, was lower than no WPI added sample (Alfaifi and Stathopoulos, 2010).

Ranadheera*et al*. (2013) found that the last melting times of ice cream samples were around 98.92 and 110.03 min. These results were lower than that of our findings (8700s - 9440s). Alizadeh*et al*. (2014) reported that the addition of stevia decreased the melting ratio in plain ice cream samples containing sucrose. Ranadheera*et al*. (2013) determined the first melting times of ice cream samples made from goat milk. They were around 20.8, and 27.28 min. The fat destabilization values of the samples were around 44.79 and 59.98 %. The fat destabilization of cocoa adding samples was higher than without cocoa. In the same trend, Akbari*et al*. (2019) showed that adding inulin at different levels (2, 3, and 4%) in low-fat ice cream containing 2% fat decreased the hardness compared with the low-fat ice cream without inulin owing to water absorption and decrease of freezing point. Inulin can improve the consistency of the low-fat ice cream mix due to its gelling properties, which consequently can reduce rates of ice crystallization. These observations are comparable with those reported by (El-Nagar *et al*., 2002), who reported that inulin incorporation at 5, 7 and 9% levels to low-fat Ice cream (5% fat) decreased the hardness significantly compared to the low-fat Ice cream.

Table (6): Descriptive statistics for physical properties of physical properties of resultant low-fat, low-calorie ice cream.

Parameters	Mean	S.D	C.V	Range
Specific gravity	1.254	0.038	3.07	0.100
Viscosity (Mpa)	18.60	3.312	17.80	9.00
Overrun%	61.60	4.420	7.17	12.00
Melting resistance (loss%) after:				
5 min	5.58	1.87	33.52	5.24
10 min	33.29	15.05	45.23	3.27
15 min	47.61	13.99	29.39	36.66

SD: standard deviations
CV: Coefficient of variations

Means along with their standard deviation for physical properties of physical properties of resultant low-calorie ice cream are recorded in Table (6). Means ± standard deviations were 1.254±0.038, 18.60±3.312, 61.60±4.420, 5.58±1.87, 33.29±15.05 and 47.61± 13.99 for Specific gravity, Viscosity, protein, overrun percentage melting after 5 min, melting after 10 min and melting after 15 min, respectively. Coefficient of variations varied between 3.07% for Specific gravity to 45.23% for melting after 10 min, which indicated that there were higher variations in after 10 min between the experimental groups compared to the other physical properties of resultant low-calorie ice cream.

The effects of different replacements level of milk fat and sweeteners on physical properties of resultant low-calorie ice cream are represented in Table (6). The present results clearly indicated that there is highly significant effect ($P<0.001$) of adding different replacements level of milk fat and sweeteners on specific gravity, viscosity and over run percentage. Also, they were affected linearly, quadratically and cubically ($P<0.001$) by adding different replacements level of milk fat and sweeteners. Significant differences were observed between the control treatment and the other treatments ($P<0.05$). Minimum estimate of specific gravity was in the treatment with the level of 25% milk fat and sweeteners while the maximum one was in the control treatment. In connection to viscosity estimate, it approximately increased with increasing the levels of milk fat and sweeteners with non-significant differences between the treatments with the levels of 50% and 75% milk fat and sweeteners. In contrasted to viscosity was the overrun percentage, as it was in descending order with increasing the levels of milk fat and sweeteners. With regard to melting estimates at different time sampling, the minimum estimates were showed in the control treatment while, the maximum estimate was in the treatment with the level of 100% milk fat and sweeteners.

Table (7): Person correlations between different physical properties of resultant low-fat, low-calorie ice cream.

Items	Specific gravity	Viscosity	Overrun%	Melting, % after 5 min	10 min	15 min
Specific gravity	1	0.215	0.211	-0.107	-0.107	-0.107
Viscosity (Mpa)		1	-0.904 ***	0.388	0.388	0.388
Overrun%			1	-0.941 ***	-0.972***	-0.966***
Melting resistance (loss%) after:						
5 min				1	0.887 ***	0.858***
10 min					1	0.989***
15 min						1

***: P<0.001

Person correlations between different physical properties of resultant low calorie ice cream mix are presented in Table (7).The present results showed that there were not significant relationships between all different physical properties of resultant low calorie ice cream mix (P>0.05) except those observed between viscosity and over run percentage (P<0.001) also, those between overrun percentage and melting after 5, 10 and 15 min (P<0.05) showed significant associations. In addition, negative relationships were detected between all physical properties of resultant low-calorie ice cream mix except those between viscosities and melting at different time sampling as well as specific gravity with viscosity and over run percentage showed positive associations.

Organoleptic properties

Results in Table (8) and Figure (1), showed the organoleptic scores of the resultant low-calorie ice cream. For flavor grade; the control treatment coupled with the complete degree, while the lowest degree was detected with the treatment that contained the level of 100% fat replacer and sweetener. Body and texture degree showed the same mentioned results approximately. Complete degree of meeting quality was showed with the control treatment and the treatment with level of 25% fat replacer and sweetener.

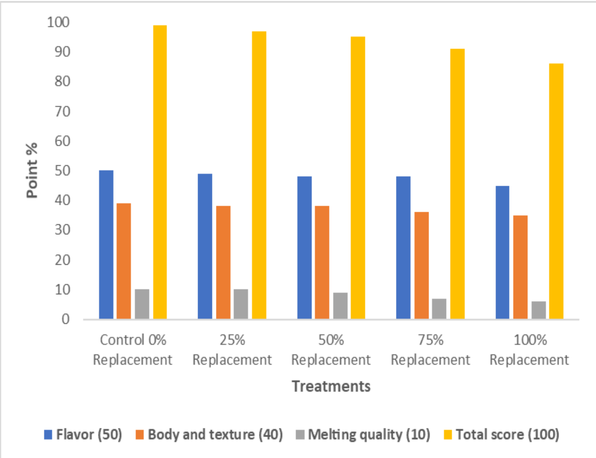

Figure (1). Organoleptic properties of low-fat & low-calories ice cream.

Table (8): Organoleptic evaluation of resultant low-fat, low-calorie ice cream.

Property(degree)	Replacement level of milk fat and sweeteners (%)				
	0	T1	T2	T3	T4
Flavor (50)	50	49	48	48	45
Body and texture (40)	39	38	38	36	35
Melting quality (10)	10	10	9	7	6
Total score (100)	99	97	95	91	86

T1 :25 % ,T2 : 50 %, T3 75%,T4 100%

Generally, the results showed that there were slight differences among all ice cream treatments. The ice cream samples containing fat replacer and sweetener had little lower flavor scores than control treatment. The score of flavors were 50, 49, 48, 48 and 45 points for C, T_1, T_2, T_3 and T_4, respectively.

This may be due to the lost or lacking milk fat and its natural flavor where milk fat plays a significant role in ice cream flavor because it acts as a main carrier for important flavor notes. Fat can impact ice cream flavor in three ways: by contributing to the rich, full and creamy flavor; by participation in hydrolysis and oxidation reactions; by helping in perception of flavorful volatile ingredients in the final product. (Plug & Haring, 1993; Ohmes*et al*., 1998 and Prindiville*et al*., 1999). On the other hand, addition of Etenia 457 and Sativoside to ice cream formula caused a slight deterioration also in body & texture properties of final product. The points of body & texture of control sample was 39 while their value increased to 40 in T_1. Their values began to decrease again to reach 38, 36 and 35 in T_2, T_3 and T_4 in order. The melting propertied degrees were varied also. The T_1 sample had the best and favorite melting properties; it possessed 10 points. Both control and T_3 gained 9 points, however T_3 had 7 while T_4 gained 6 scores. El-Battawy*et al*. (2019) used dried Ice protein concentrate (DRPC) to prepared low lactose Ice cream. They recorded a decrease in body & texture properties of the final product. Milk fat is a determinant factor in Ice cream 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 (Mahdian*et al*., 2013).

For all total acceptability, T_1 samples (25% replacements) gained the higher scores (99 points) and the control one possessed also 99 followed by T_2 (95 points); T_3 (91 points) and then T_4 which gained 86 points.

Actually, partially coalesced fat causes a fat network to form, which stabilizes air bubbles and foam structure in Ice cream and therefore is also essential in improving meltdown behavior (Koxholt*et al*., 2001 and Marshall *et al*., 2003).However, early in another study, Roland *et al*. (1999) evaluated effects of fat replacer's maltodextrin and 352polydextrose on sensory properties of fat-free ice cream (less than 0.05% fat). In their study, Ice cream mixes containing fat replacers were formulated to maintain the sweetness intensity and freezing characteristic of the control Ice cream (containing 10% fat). They showed that the yellowness of the Ice cream containing poly-dextrose was higher compared to that of 10% fat Ice cream whereas Ice cream containing maltodextrin was as white as regular Ice cream. They reported also that Ice creams containing carbohydrate-based fat replacer had significantly better appearance attribute score than Ice cream that contained 0.1% fat and were sweeter than 10% fat Ice cream. Vanilla intensity in fat-free Ice creams was intermediate between 0.1 and 10% fat Ice creams and Ice cream containing poly-dextrose was bitterer than all other samples and had weaker creamy flavor than regular Ice cream. According to some studies it is obvious that the addition of inulin causes a reduction in ice crystals formation in Ice cream texture during storage and can improve sensory properties of ice cream. Conflicting results had been reported by Akin *et al*. (2007) who demonstrated that inulin incorporation did not influence sensory attributes of Ice cream. When inulin is dissolved in water or milk, it has ability to form inulin microcrystals. Interaction of these microcrystals together causes a creamy Texture to form and provides mouth feel similar to that of fat (Niness, 1999 and Franck, 2002).Akbari*et al*. 2016 conducted research on the effect of inulin on the sensory properties of low-fat Ice cream and reported that incorporation of inulin caused to improve flavor in low-fat Ice cream. In an early study, Conflicting results had been reported by Akin *et al*. (2007) who demonstrated that inulin incorporation did not influence sensory attributes of Ice cream. When inulin is dissolved in water or milk, it has ability to form inulin microcrystals. Interaction of these microcrystals together causes a creamy Texture to form and provides mouth feel similar to that of fat (Niness, 1999 and Franck, 2002).

Moreover, Adapa*et al*., 2000 added that milk fat reacts with other components to develop the texture, mouth feel, creaminess, and overall sensation of lubricity. With reference to the importance of milk fat in improvement of ice cream structural and sensory properties, adding fat replacers is necessary to low-fat Ice cream because as mentioned above fat replacers can mitigate defects that might arise from fat reduction in the finished product. Ozdemir*et al*. (2003) indicated that panelists preferred the control samples added sugar alcohols as sweetener. A low-fat Ice cream with acceptable organoleptic quality was prepared, by replacing part of the fat using fat replacers' viz. Maltodextrin and Carrageenan, in the Student Training Dairy of College of Food & Dairy Technology, Allahabad Agricultural Institute-Deemed University. A similar finding has shown that 'fat-free' Ice cream with only traces of milk fat could be produced using maltodextrin and traditional sweeteners, but the limit for acceptability of Maltodextrin in Ice cream was 3.5%.

Adapa*et al*., 2000 , mentioned that milk fat reacts with other components to develop the texture, mouth feel, creaminess, and overall sensation of lubricity With reference to the importance of milk fat in improvement of ice cream structural and sensory properties, adding fat replacers is necessary to low-fat ice cream because fat replacers can mitigate defects that might arise from fat reduction in the finished Product. Ice cream hardness was not affected by the addition of low milk fat, anhydrous milk fat, very high melting milk fat and cream but emulsifiers had influence on hardness. Drier product with smoother texture and body was obtained with addition of emulsifier. Melting of 50% ice cream required the longer time for first dripping hence rate of melting was low for very high melting milk fat added Ice cream. Proteins adhered at the surface of water and fat molecules due to emulsifier action that resulted in improving the meltdown property. Emulsifiers caused the agglomeration of fat which in turn finely dispersed and stabilized the air cells (Syed *et al*., 2008). They added that, less milk solids not fat (MSNF) and higher fat contents caused rich mouth coating, but textural attributes were reduced. Increase in fat contents restricted the growth of ice crystals mechanically and smaller crystals formation occurred which affected the rate of melting. Addition of fat had not significantly affected the sweetness, but it caused the reduction in vapor pressure of flavoring chemicals. Fat addition increased the buttery and creamy flavor in contrast to no effect on milky, phenolic, whey-like, and vanilla notes. Caramel flavor was only enhanced with increased MSNF and fat. Decrease in vanilla flavor was not iced when whey protein concentrates were added that could be attributed due to condensation of aldehyde and casein. As the MSNF contents were enhanced, the creamy, phenolic, buttery, and caramel notes were also enhanced. On the other hand, Ice crystals, coldness and meltdown were reduced with MSNF addition. There was an inverse relationship between size of Ice crystals and total solids in a way that total solids might enhanced the viscosity which restricted the diameter of ice crystals .

- Thomas *et al*., 2016, mentioned that fat replacers or mimetic also disrupt or alter the casein matrix in cheese. They are added to the milk and do not interact with the casein network but do fill spaces that otherwise would have been filled with fat in full-fat versions. They are usually used when the fat reduction is ≥50% and these materials are usually starches or denatured whey protein aggregates. They usually have higher moisture holding capacity than casein, so fat mimetics promote higher moisture contents in cheese. Fat replacers and fat mimetics do increase the smoothness and soften the body; however, their excessive use can increase stickiness, decrease shred ability, and may impart undesirable flavors to the cheese. While their use also increases the flow ability of the cheese when heated, the cheese also releases more serum into the food matrix, making the food product soft or soupy.

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