Utilization of Buttermilk in Low Fat Ice Cream Making

Amira M. El-Kholy; A. M. Abou El-Nour; M. S. El-Safty and Safaa M. Mokbel
Dairy Department, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt

Received: *20/10/2014*

Abstract: Performance of sweet buttermilk as a replacement of buffaloe's skim milk one of low fat ice cream mix ingredients making were investigated. All mixes and resultant ice cream were evaluated for their chemical, physical and rheological as well as the sensory quality attributes. The specific gravity (SPG) of ice cream mix increased significantly ($p<0.05$) with the increasing of buttermilk ratios. The weights per gallon (WPG) of different mixes are closely related to their specific gravity. All low fat treatments had significantly higher ($p< 0.05$) SPG and WPG as compared to control full fat (T1). Titratable acidity increased parallel with the replacement ratio. However pH values of low fat ice cream were slightly decreased as the percentages of substitution increased. The freezing point of the mix decreased significantly ($p<0.05$) with low fat ice cream compared to full fat ice cream (T1). The apparent viscosity and plastic viscosity, consistency index of the control low fat ice cream mix and other low fat treatments tended to be lower than that of full fat ice cream (T1) during the aging process up till 4 hours. Whereas, during aging process, it was noticed that all values of apparent viscosity, plastic viscosity, yield stress and consistency coefficient index of all treatments were increased with prolonged the aging period. Ice cream made by replacing 75% and 100% of buffaloe's skim milk with sweet buttermilk exhibited the lowest specific gravity and weight per gallon as compared to low fat ice cream treatments. Specific gravity and weight per gallon were inversely proportional to changes occurring in the overrun. Substituting buffaloe's skim milk by sweet buttermilk caused an obvious decrease in the melting down rate (%) of ice cream. As buttermilk ratio used in ice cream making increased as the body & texture and flavour scores were enhanced during all freeze storage period. It could be concluded that substitution of buffaloe's skim milk with sweet buttermilk produced ice cream with improving flavour intensity and became more smoother, creamy appearance and high acceptability compared to control low fat. Such product can be applied for home of health concise and care of milk fat.

Keywords**:** Ice cream, Buttermilk, Low fat ice cream

INTRODUCTION

Ice cream is a highly nutritive, complex food matrix. Milk fat has been recognized as a critical parameter for the formation and support of structural characteristics of ice cream as well as for the perceived textural quality and flavour perception (Dresselhuis *et al*., 2008 and Turgut & Cakmacki, 2009). Lowering of the fat content brings a host of body & textural problems and flavour defects (Hatchwell, 1994 and Chantal *et al*., 1996). Addition of emulsifiers or blends of stabilizers and emulsifiers or fat replacers to an ice cream mix improving the sensory and physical properties of low fat and nonfat ice cream (Marshall and Arbukle, 1996; Bear *et al*., 1999; Azzam 2003). Buttermilk is characterized by a fat composition rich in milk fat globule membrane (MFGM) components, such as phospholipids and various lipoproteins **(**Vyas *et al.*, 2002). The high content of phospholipids in buttermilk makes this dairy ingredient interesting for use as a functional ingredient because of the emulsifying properties of phospholipids (Wong and Kitts, 2003; Morin *et al*., 2006).

Sweet buttermilk, as a source of milk solids not fat was used successfully in ice cream making, because its very cheap price besides its advantage of improving the texture, body and foam properties of product leading to smooth body and better overrun (Mahran *et al.* 1976; Fikry *et al*., 1994 and EL-Dieb *et al*., 1995). Among the numerous advantages of the use of milk solids from buttermilk are not a decrease in the amount of waste disposal and improved economics, but also improved flavour and texture of the final product (Mayes *et al*., 1994; Schoenfuss and McGregor, 1997).

Therefore, the present study was carried out to investigate the effect of replacing buffaloe's skim milk one of low fat ice cream mix ingredients with sweet buttermilk on the chemical composition, physical and sensory properties of low fat ice cream and to monitor the changes of ice cream quality during freezing storage.

MATERIAL AND METHODS

Materials:

Fresh buffaloe's milk (9.4 % SNF and 6 % fat) was obtained from a private farm in Ismailia Governorate, and was separated to obtain cream and skim milk. Sweet buffaloe's s buttermilk (9% TS and 0.5 % fat) was obtained by churning sweet buffaloe's cream. Skim milk powder (97% TS, Grade A- low heat – spray dry process) product by West Farm Foods, USA. Commercial grade crystalline sugar (sucrose) was obtained from the local market. Sodium carboxy methyl cellulose (CMC) was obtained from Misr Food Additives- MIFAD**,** Egypt.

Experimental procedures

1- Preparation of different ice cream mixes:

Ice cream mixes were prepared by mixing the ingredients (Table 1). Six treatments were carried out. The mix of control formula full fat ice cream from buffaloe's milk was standardized to give 8% fat, 10% milk solid not fat, 15% sugar and 0.2% CMC (T1). Treatment (2) was standardized to give 2% fat, 12% milk solid not fat, 15% sugar and 0.2% CMC and served as control low fat ice cream. Other four treatments were made by substituting (SM) with sweet buttermilk (BM) at different ratios as follow: 25% (T 3), 50% (T4), 75% (T 5) and 100% (T 6). The mixes heated at 75˚C for 5 min. cooled to 4˚C and aged at that temperature for 4 hours prior to freezing. The mixture (2 Kg mix for each treatment) was frozen in an ice cream freezing machine (Taylor-mate Model 156, Italy). The resultant ice cream was packaged in cups (100 ml), and put in deep freezer at -18˚C for hardening according to Marshall and Arbuckle (1996).

Methods of analysis:

The ice cream mix was analyzed for titratable acidity according to the official method A.O.A.C. (1990), pH using digital pH meter (Jenway pH meter, Jenway Limited, England). Specific gravity (Winton, 1958), weight per gallon (Burke, 1947), freezing point (FAO Laboratory Manual, 1977), Viscosity and rheological parameters were carried out using Digital Rheometer model DV- lll+ (Brookfield Engineering Laboratories, Inc., MA, USA) equipped with a Sc_4.21 spindle.. Measurements were made at temperature of 5°C in shear rate ranging from 9.3 to 93 S^{-1}. All rheological properties were performed in duplicates.

The resultant ice cream were analyzed for overrun (Marshall and Arbuckle 1996), melting resistant (Bhanumurthi *et al*., 1972), specific gravity (Winton, 1958), and weight per gallon (Burke, 1947).

Sensory evaluation:

The sensory evaluation for resultant ice cream were carried out by 10 of the staff members of the Dairy Dept. for , flavour (45 points), body and 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 (1998) under windows software version 6.311 and least significant difference (LSD) test were employed to determine significant difference at ($p<0.05$).

RESULTS & DISCUSSION

Properties of ice cream mix:

The changes in specific gravity (SPG) and weight per gallon (WPG) of different ice cream mixes as influenced by fat content and different amounts of buttermilk are presented in Table (2). The specific gravity of ice cream mix increased significantly ($p<0.05$) with the increasing of buttermilk ratios. Investigation indicates that the specific gravity of a mix may vary from 1.0544 to 1.1232 (Marshall and Arbuckle, 1996). The control treatment (T1) showed the lowest specific gravity among all treatments. The weights per gallon of different mixes are closely related to their specific gravity. All low fat treatments had significantly higher ($p<0.05$) SPG and WPG as compared to control one (T1). This may be due to the higher percent of SNF and lower fat contents of these treatments as compared to full fat one. Similar findings were observed by Khalil and Embaby (2012). Also it was noticed that using different ratios of BM had no significance effect on SPG and WPG of different low fat ice cream mixes. Similar findings were noticed by Badawi *et al*. (2010) who attributed that to similar chemical composition of skim milk and buttermilk.

The acidity % and pH values are related to composition of the mix, an increase in SNF raises acidity and lowers the pH. Table (2) represents the acidity% and pH values of ice cream mixes as affected by using different amounts of buttermilk. It was observed that titratable acidity increased parallel with the replacement ratio. Ice cream mixes containing 75% and 100% sweet buttermilk (T5, T6) had higher ($p<0.05$) total acidity than the control full fat ice cream (T1). Titratable acidity of low fat ice cream mixes were not significantly different ($p<0.05$) from each other, which means that using BM with different amounts had no significant effect on the titratable acidity of low fat ice cream mixes. From the same Table, it was found that control full fat ice cream had higher pH value than other low fat treatments. This may be correlated with the high SNF of low fat treatments as compared with control one**.** However pH values of low fat ice cream were slightly decreased as the percentages of substitution increased. This may be due to the similar pH values of BM and SM used in ice cream making. Similar trends were found by Mahran *et al*. (1976) and Badawi *et al.* (2010). The changes in the acidity of different ice cream mixes showed an opposite trend for pH values. The freezing point of prepared mixes ranged from -2.28 of control full fat (T1) to -2.31 of low fat ice cream mixes. This can be attributed to the differences in solids not fat (SNF). The freezing point of the mix decreased (Table 2) significantly ($p<0.05$) with low fat ice cream compared to full fat ice cream (T1). Generally, the freezing point is depressed as the serum phase concentration is increased or as the solutes molecular weight is decreased (Hartel, 2001). Similar findings were reported by Ohemes *et al*. (1998) and El- Kholy (2005) they stated that when fat removed from ice cream and replaced with non fat milk solids or other dissolved substances, the freezing point was lowered. Using buttermilk causing slight decrease, but not significant ($p<0.05$), for the freezing point of treatments T3:T6. Similar findings were reported by Azzam (2003) who found that increasing the substitution of SNF by dried buttermilk to 50% caused a decrease of freezing point of the resultant ice cream.

Rheological Characteristics:

The changes of the rheological characteristics of different ice cream mixes as affected by using different amounts of buttermilk were illustrated in Table (3). The attained results shows that the apparent viscosity and plastic viscosity, consistency index of the control low fat ice cream mix and other low fat treatments tended to be lower than that of full fat ice cream (T1) during the aging process up till to 4 hours. From the same Table, data referred to that replacing of buffaloe's skim milk with buttermilk had significant ($p<0.05$) positive effect on the rheological characteristics such as apparent viscosity, plastic viscosity, consistency coefficient index. This may be due to the milk fat globule membrane content of buttermilk which acts as a natural emulsifying agent. A pronounced ($p<0.05$) increase in viscosity was observed for treatment (T6) which made from 100% BM comparing to other low fat treatments during aging period. During aging process, it was noticed that all values of apparent viscosity, plastic viscosity, Yield stress and consistency coefficient index of all treatments were increased with prolonged the aging period. There effects were remarkable with aging process up till to 4 hours. This increase may be due to gel formation and increasing the amount of water hydration (Marshall and Arbuckle, 1996).

Table (1): The ingredients used in making Ice cream mixes.

Ingredients	The mix specification					
	T1	T2	T3	T4	T5	T6
Buffaloe's skim milk (0.5% fat, 9% SNF)	64.2	74.9	56.2	37.5	18.7	-
Buttermilk (0.5 fat, 9% SNF)	-	-	18.7	37.5	56.2	74.9
Skim milk powder (97% SNF)	3.5	6.3	6.3	6.3	6.3	6.3
Cream(45% fat, 4.95% SNF)	17.1	3.6	3.6	3.6	3.6	3.6
Sugar	15	15	15	15	15	15
CMC	0.2	0.2	0.2	0.2	0.2	0.2

Table (2): Effect of substituting buffaloe's skim milk by different percentages of sweet buttermilk on some properties of Ice cream mix (average of three replicates)

Properties	Ice cream (mix)					
	T1	T2	T3	T4	T5	T6
Specific gravity (gm/cm^3)	1.0854^b	1.1022^a	1.1023^a	1.1023^a	1.1024^a	1.1025^a
Weight per gallon (Kg/gallon)	4.934^b	5.011^a	5.011^a	5.011^a	5.012^a	5.012^a
Acidity%	0.19^b	0.20^{ab}	0.20^{ab}	0.21^{ab}	0.22^a	0.22^a
pH	6.47^a	6.44^{ab}	6.43^b	6.42^b	6.42^b	6.41^b
Freezing point (-°C)	-2.28^a	-2.31^b	-2.31^b	-2.31^b	-2.31^b	-2.31^b

T1: control full fat, T2: control low fat, T3: 25% BM, T4: 50% BM, T5: 75% BM, T6: 100% BM.
*a and b: means with the same letter among the treatments are not significantly different ($p < 0.05$).

Table (3): Effect of substituting buffaloe's skim milk with different percentages of buttermilk on the rheological characteristics of ice cream mix during aging period at 5ºC.

Time	Treatments						Mean
	T_1	T_2	T_3	T_4	T_5	T_6	
Apparent Viscosity (m Pas)							
0 hour	257	159	167	176	185	197	190.16^c
2 hours	299	188	199	206	211	220	220.55^b
4 hours	320	212	245	237	255	259	254.66^a
Mean	292^A	186.44^F	203.66^E	206.33^D	217^C	225.33^B	
Plastic viscosity (m Pas)							
0 hour	156	129	131	134	137	141	138^c
2 hours	183	152	155	158	160	162	161.66^b
4 hours	201	175	179	183	186	188	185.38^a
Mean	180.11^A	152^F	155^E	158.33^D	161^C	163.66^B	
Yield stress (N/m^2)							
0 hour	3.45	3.42	3.48	3.55	3.63	3.72	3.54^c
2 hours	4.49	3.71	3.75	3.79	3.82	3.85	3.90^b
4 hours	4.52	3.96	3.98	4.03	4.08	4.11	4.11^a
Mean	4.15^A	3.69^F	3.73^E	3.79^D	3.84^C	3.89^B	
Consistancy coefficient index (m Pas)							
0 hour	149.3	101.3	104.3	105.75	108.2	110.4	113.20^c
2 hours	200	133	139	144	148	151	152.5^b
4 hours	247	156	164	173	177	182	183.16^a
Mean	198.76^A	130.10^F	135.76^E	140.91^D	144.40^C	147.80^B	
Flow behavior index							
0 hour	0.551	0.574	0.571	0.567	0.563	0.565	0.565^a
2 hours	0.540	0.571	0.569	0.566	0.562	0.560	0.561^b
4 hours	0.530	0.560	0.559	0.553	0.550	0.548	0.550^c
Mean	0.450^E	0.568^A	0.566^B	0.562^C	0.558^D	0.557^D	

T1: control full fat, T2: control low fat, T3: 25% BM, T4: 50% BM, T5: 75% BM, T6: 100% BM.
**a, b & c and A, B, C, D, E &F: means with the same letter among the treatments and storage period respectively are not significantly different ($p<0.05$)

Ice cream properties:

Specific gravity is one of the important physical properties of ice cream; it gives some information about the quality of the resultant ice cream such as body and texture, incorporated air and melting quality. Generally incorporation of air in ice cream mix during the pre-freezing process decreased the specific gravity of ice cream and consequently to its weight per gallon. It was noticed that full fat ice cream had lower ($p<0.05$) values of specific gravity and weight per gallon as compared to low fat ice cream treatments (Table 4). This may be due to the high contribution of fat to the stability of air phase of ice cream during freezing and whipping (Goff *et al*., 1999). Similar trend were found by El- Kholy (2005) & Khalil and Blassy (2011). Ice cream made by replacing 75% and 100% of buffaloe's skim milk with sweet buttermilk exhibited the lowest specific gravity and weight per gallon as compared to low fat ice cream treatments. These results in agreement with those reported by Badawi *et al*., (2010).This could be attributed to the extent of milk fat globule membrane which causes higher whipping ability in the mix during the pre-freezing process (El-Dieb, 1995). Specific gravity and weight per gallon were inversely proportional to changes occurring in the overrun (Mahran *et. a.l*., 1984, Jangiou and Moosavi, 2004; Rad *et al*., 2005 and Abbas 2006). The changes of overrun% of different ice cream treatments as affected by using different amount of buttermilk are shown in Table (4). The results referred to that full fat ice cream, treatment (T1), had significantly ($p<0.05$) higher overrun % than that of control low fat ice cream treatment (T2). This may be due to the high contribution of fat to the stability of air phase of ice cream during pre-freezing and whipping (Goff *et al*., 1999). Substituting of buffaloe's skim milk with sweet buttermilk caused a pronounced ($p<0.05$) increase in the overrun % of low fat ice cream being 48.36, 50.60 and 51.65% for treatments (T4), (T5) and (T6) respectively. However, ice cream made by substituting 25, 50, 75 and 100% of buffaloe's skim milk with sweet buttermilk were significantly ($p<0.05$) different from each other, while they exhibited the highest overrun as compared to control low fat ice cream (T2). The positive relationship between the overrun and the ratio of substituting buffaloe's skim milk by sweet buttermilk may be attributed to higher phospholipids and fat globule membrane in buttermilk which have good emulsifying and higher whipping ability. These results are in agreement with those reported by Mostafa et *al*. (2001); Azzam (2003) and Badawi *et al*. (2010). It might be observed from the same table that overrun in the resulting ice cream increased proportionally to the decrease of their specific gravity.

The melting down rate (%) represents the loss in weight of the tested samples during 60 min. High quality product would show a relatively high resistance towards melting. The melting down properties of ice cream constitutes a critical performance parameter for the product, so much so that, these properties contribute towards the quality judgment besides its sensory properties (Tharp *et al*., 1998). The melting down rate of different ice cream treatments as affected by substituting buffaloe's skim milk with different amounts of sweet buttermilk during 45 days of storage was represent Table (5). The control full fat ice cream (T1) took longer time to melt down than control low fat (T2). This may be attributed to the contribution of fat to the structured characteristics of ice cream as well as its reduced heat conductivity (Soukoulis *et al*., 2009). Ice cream containing buttermilk solids showed noticeable decrease in the melting rate of ice cream as compared with control low fat (T2). Substituting buffaloe's skim milk by sweet buttermilk caused an obvious decrease in the melting down rate of ice cream. The melting resistance increased pronouncedly ($p<0.05$) as the ratio of replacement was increased. The lowest low fat ice cream sample was (treatment 6). This may be due to the presence of some constituents in buttermilk and/or the high overrun, when air serves as an insulator and reduced heat transfer (Kebary, 1996). The melting rate decreased gradually with prolonged the freeze storage and this could be due to the decrease of latent heat of ice cream, so it needs more time to melt and accordingly improve the melting quality. Ice cream made by replacing 75 and 100% of buffaloe's skim milk with sweet buttermilk exhibited the highest overrun and had the highest melting resistance, while control low fat ice cream (T2) which exhibited the lowest overrun had the lowest melting resistances. These results are in accordance with those reported by El- Dieb *et al*. (1995); Kebary (1996) and Azzam (2003). On the other hand, the initiation of fluid release was slower for treatments (T6), (T5), (T4) and (T3) respectively. This might be due to its higher emulsion stability than control low fat ice cream (T2), which melts faster. These results are in line with those reported by Fikry *et al*. (1994) and Azzam (2003).

Sensory evaluation:

It was noticed that full fat ice cream (T1) had significant higher flavour, Body & texture, appearance & colour and overall acceptability scores than that of low fat ice cream treatments during all freeze storage periods (Table 6). This may be due to milk fat has been recognized as a critical parameter for the formation and support structural characteristics of ice cream (Turgut and Cakmacki, 2009). This have been interconnected with milk fat functionality including fat destabilization, increased air incorporation and air cell stabilization, lubrication of oral tissue and improvement of mouth sensation (Dresselbuis *et al*., 2008). The panelists cleared that decreasing the fat content of ice cream made it cooler with more watery body & texture with few visible air bubbles (T2). From the same table, it was observed that as buttermilk ratio used in ice cream making increased as the body & texture and flavour scores were enhanced during all freeze storage period. Resultant ice cream became smoother and had creamy appearance with improving flavour intensity by adding (BM**)**. So, treatments (T6, T5) respectively attained higher scores for overall acceptability among other low fat treatments. This might be due to the presence of phospholipids and other milk fat globule membrane and its beneficial effect on whipping ability which caused smooth texture for the resultant ice cream (El-Dieb *et* *al*., 1995). However, prolongation of the storage period lead to less scoring for sensory evaluation of the resulting ice cream. Also, it could be noticed that ice cream treatments containing sweet buttermilk were obviously ($p<0.05$) less scoring than control full fat in fresh and during storage periods while more pronouncedly ($p<0.05$) than control low fat (T2). Similar trend was found by El-Dairy *et al*., (1995) and Awad & Salama (2010) for using buttermilk in ice milk making.

From the foregoing results, it is possibly to make a good quality low fat ice cream with substituting up to 75% or 100% buffaloe's skim milk by sweet buttermilk. In another term, it could be concluded that substitution of buffaloe's skim milk with sweet buttermilk produced ice cream with improving flavour intensity and became more smoother, creamy appearance and high acceptability compared to control low fat. Such product can be applied for home of health concise and care of milk fat.

Table (4): Effect of substituting buffaloe's skim milk by different percentages of buttermilk on ice cream properties (one day after hardening).

Properties	Ice cream					
	T1	T2	T3	T4	T5	T6
Specific gravity (gm/cm^3)	0.699 ^{e}	0.752^a	0.749^a	0.743^b	0.732^c	0.727^d
Weight per gallon (Kg/gallon)	3.178^f	3.419^a	3.405^b	3.378^c	3.328^e	3.350^d
Overrun %	55.28^a	46.47^f	47.17^e	48.36^d	50.60^c	51.65^b

T1: control full fat, T2: control low fat, T3: 25% BM, T4: 50% BM, T5: 75% BM, T6**:** 100% BM.
*a, b, c, d, e & f: means with the same letter among the treatments are not significantly different ($p<0.05$).

Table (5): Effect of substituting buffaloe's skim milk by different percentages of sweet buttermilk on melting down rate (%) of ice cream within 60 min during storage period at -18ºC

Treatments	Storage period (day)				Mean*
	Fresh	15	30	45	
		15 min			
T1	11.40	2.20	1.30	1.10	4.000^F
T2	38.80	4.90	2.30	2.05	12.012^A
T3	32.30	4.55	1.90	1.70	10.112^B
T4	25.40	4.20	1.60	1.45	8.162^C
T5	20.40	4.20	1.20	1.05	6.712^D
T6	18.86	4.30	1.20	1.05	6.352^E
Mean*	24.52^a	4.05^b	1.58^c	1.40^d	
		30 min			
T1	25.70	14.50	9.50	8.50	14.44^F
T2	75.12	41.70	24.45	20.50	40.44^A
T3	64.60	32.90	22.00	18.10	34.40^B
T4	56.86	30.90	16.95	13.50	29.35^C
T5	55.30	21.80	16.34	13.0	26.61^D
T6	55.19	21.50	15.00	12.5	26.04^E
Mean*	55.46^a	27.21^b	17.23^c	14.35^d	
		45 min			
T1	31.02	24.00	20.00	17.25	23.067^F
T2	83.47	75.40	65.23	55.87	69.95^A
T3	81.20	74.90	64.00	53.40	68.375^B
T4	68.60	62.40	59.00	51.20	60.30^C
T5	63.30	55.10	53.00	46.50	47.72^E
T6	60.90	53.00	48.80	44.40	51.77^D
Mean*	60.24^a	57.44^b	51.67^c	44.77^d	
		60 min			
T1	50.30	47.12	42.95	41.34	45.42^F
T2	100	97.67	95.22	94.14	96.76^A
T3	96.00	93.24	90.55	89.42	92.30^B
T4	91.26	88.43	85.61	84.11	87.35^C
T5	86.97	83.65	82.00	80.13	83.19^D
T6	82.85	79.50	76.16	74.88	78.35^E
Mean*	84.56^a	81.59^b	78.75^c	77.34^d	

T1: control full fat, T2: control low fat, T3: 25% BM, T4: 50% BM, T5: 75% BM, T6: 100% BM.
** a, b, c & d and A, B, C, D, E & F : means with the same letter among the treatments and storage period respectively are not significantly different ($p<0.05$).

Table (6): Effect of substituting buffaloe's skim milk with different percentages of sweet buttermilk on scores of sensory evaluations of ice cream during storage period at -18ºC

Treatments	Storage period (day)				Mean*
	Fresh	15	30	45	
Flavour (45 points)					
T1	44.00	43.55	43.00	42.50	43.26^{A}
T2	40.00	39.30	38.50	38.00	38.95^{D}
T3	41.00	40.20	39.50	39.00	39.90^{C}
T4	42.00	40.80	40.00	39.50	41.32^{B}
T5	42.50	41.20	40.80	40.20	41.17^{B}
T6	42.70	42.00	41.50	41.00	41.80^{B}
Mean*	42.03^{a}	41.16^{b}	41.05^{b}	40.03^{c}	
Body& texture (30 points)					
T1	28.00	29.00	29.11	28.80	28.72^{A}
T2	25.00	25.50	25.62	25.30	25.35^{E}
T3	26.00	26.50	26.73	26.20	26.35^{D}
T4	26.50	26.88	27.20	26.60	26.79^{C}
T5	26.72	27.12	27.40	26.72	26.99^{B}
T6	26.84	27.30	27.70	26.74	27.14^{B}
Mean*	26.51^{d}	27.05^{b}	27.29^{a}	26.72^{c}	
Appearance and colour (25 points)					
T1	25.00	25.00	24.00	23.80	24.45^{A}
T2	23.00	23.00	22.50	22.50	22.75^{C}
T3	24.00	24.00	23.40	23.00	23.60^{B}
T4	24.00	24.00	23.50	23.30	23.70^{B}
T5	24.00	24.00	23.52	23.33	23.71^{B}
T6	24.00	24.00	23.52	23.34	23.71^{B}
Mean*	24^{a}	24^{a}	23.40^{b}	23.21^{c}	
Overall acceptability (100 points)					
T1	97.00	97.00	96.11	95.10	96.30^{A}
T2	88.00	87.80	86.62	85.80	87.05^{F}
T3	91.00	90.70	89.63	88.20	89.88^{E}
T4	92.50	91.68	90.7	89.40	91.07^{D}
T5	93.22	92.32	91.72	90.27	91.88^{C}
T6	93.54	93.30	92.72	91.08	92.66^{B}
Mean*	92.54^{a}	92.13^{b}	91.25^{c}	89.97^{d}	

T1: control full fat, T2: control low fat, T3: 25% BM, T4: 50% BM, T5: 75% BM, T6: 100% BM.
** a, b, c & d and A, B, C, D, E & F : means with the same letter among the treatments and storage period respectively are not significantly different ($p<0.05$).

REFERENCES

Abbas, F. M. (2006). The use of transglutaminase catalyzed crosslinking in the manufacture of low fat ice cream. Agricultural Research Journal, Suez Canal University, 6: 87-92.

AOAC (1990). Official methods of analysis 15th ed., Association of Official Analysis Chemists Inc., USA.

Awad, R. A. and Salama W, M. (2010). Using sodium casein ate and buttermilk powder in production of low and free fat ice milk. Proc. 11th Egyptian conference of Dairy Science & Technology. 523-535.

Azzam, M. A. A. (2003). Production of low-calorie ice milk. Journal of Agricultural Sciences. Mansoura University., 28(2): 8139-8150.

Badawi, R. M.; Badran, I. I.; Kebary, K. M. K.; Farag, S.I. and A. Said. (2010). Effect of replacing skim milk powder with dried buttermilk on ice milk quality. 11th Egyptian Conference of Dairy Science & Technology., 511-521.

Bear, R. J.; Krishnolswany, N. and Kosperson, K. M. (1999). Effect of emulsifiers and food gum on nonfat ice cream. Journal of Dairy Science, 82:1416-1427.

Bhanumurthi, J. L.; Trehan, K. S.; Srinivasan, M. R. and Samlik, O. (1972). Viscosity changes in sweetened condensed full cream buffalos milk during storage. Indian Journal of Dairy Science, 25:30-39.

Burke, A. L. (1947). Practical Ice Cream Making. The Olsen Publishing Co., Mailwauke, Wise., USA.

CoStat (1998). User's manual for CoStat version 6031. Cohort software, Berkeley; CA.

Chantal, R. ;Stampanoni, K. ;Patrizia, P. and Susane, S. (1996). The influence of fat, sugar and non-milk fat solids on selected taste, flavour and texture parameters of a vanilla ice cream. Food Quality and preference. 7: 69-80.

Dresselhuis, D. M.; de Hoog, E. H. A.; Cohen Stuart, M. A.; Vingerhoeds, M. H. and Van Aken, G. A. (2008). The occurrence of in mouth coalescence of emulsion droplets in relation to perception of fat. Food Hydrocolloids, 22: 1170-1183.

El-Dairy, S. Y. ; Ibrahim, S. A. and Fikry, S. A. (1995). Substitution of non-fatty milk solids with some by-products in making ice milk. Egyptian Journal of Agriculture Research., 73: 493-500.

El-Dieb, S. M. ;Ramadan, F. A. and Abd El-Ghany, I. H. I. (1995). The use of buttermilk and milk fat globule membrane to improve the body and texture of ice milk. Egyptian Journal of Dairy Science, 23: 249-258.

El- Kholy, A. M. (2005). Some physical, rheological and sensory properties of ice milk containing rolled oats. Journal of Agricultural Science, Mansoura University, 30: 2639-2650.

FAO LAB (1977). Laboratory Manual. FAO Regional Dairy Development and Training Center for the Near East.

Fikry, S. A; Ibrahim, S. A. and El- Dairy, S. Y. (1994). Utilization of sweet buttermilk and fresh skim milk in ice milk making. Egyptian Journal of Dairy Science, 22: 39-50.

Goff, H. D.; Verespej, E. and Smith, A. K. (1999). A study of fat and air structures in ice cream. International Dairy Journal, 9: 817-826.

Hartel, R. W. (2001). Crystallization in Foods (1st) ed. Gaithersburg, Maryland: Aspen Publishers Inc.

Hatchwell, L. C. (1994). Overcoming flavour challenges in low fat frozen desserts. Food Technology, 48: 98-104.

Jangiou, N. and Moosavi, M. A. (2004). A review of the methods to produce low-fat ice cream. International Dairy Federation, Brusseles, Belgium: 412-424.

Kebary, K. M. K. (1996). Viability of *Bifidobacterium bifidum* and its effect on quality of frozen zabady. Food Research International., 29: 431-437.

Khalil, R. A. M. and Blassy, K, I. (2011). The use of modified date pulp fibers in functional low fat ice cream. Egyptian Journal of Dairy Science., 39: 275-283.

Khalil, R. A. M. and Embaby, H. E. (2012). The use of jambul fruit (*Syzygium cumini*) as a source of natural antioxidants in functional low fat ice cream making. Egyptian Journal of Dairy Science, 40: 75-84.

Mahran, G. A. ; El-Ghandour, M. A. ; El-Bagoury, E. H. and Sayed, A. F. (1984). Effect of skim milk powder storage on ice cream quality. Egyptian Journal of Dairy Science. 12: 267-273.

Mahran, G. A. ; Khalafalla, S. M. ;Farahat, S. M. and Fares, F. M. (1976). The use of buttermilk solids in ice cream. Egyptian Journal of Dairy Science, 4: 27-32.

Marshall, R. T. and Arbukle, W. S. (1996). Pages 18, 23, 34, 93, 203 in ice cream 5th ed. Chapman and Hall, New York, NY.

Mayes, J. J. ; Urbach, G. ; Sutherland, B. J. (1994). Does addition of buttermilk affect the organoleptic properties of low fat cheddar cheese. Australian Journal of Dairy Technology. 49: 39-41.

Morin, P. ; Pouliot, Y. and Jimenez-Flores, R. (2006). A comparative study of the fractionation of regular buttermilk and whey buttermilk by microfiltration. Journal of Food Engineering. 77:521-528.

Mostafa, M. B. M; Abdel- Malek, R. A. and Okasha, A. I. (2001). Utilization of some dairy by- products in the manufacture of reduced cholesterol frozen yoghurt. Proc. 8th Egyptian Conference of Dairy Science and Technology, pp. 551-561.

Ohemes, 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, 81:1222-1231.

Rad, A. H. ; Ehsani, M. R.; Mousavi, S. M.; Valizadeh, M. and Emam Djomeh, Z. (2005). Improving the quality of low fat ice cream by hydrolyzing of casein micelles with chymosin. Iranian Journal of Agricultural Sciences. 36: 765-773.

Schoenfuss, T. C. and McGregor, J. U. (1997). Improving the flavor of a low fat cheddar cheese with homogenized cream and commercial buttermilk powder. Journal of Dairy Science. 80 suppl. 1:100.

Soukoulis, C.; Lebesi, D. and Tzia, C. (2009). Enrichment of ice cream with dietary fiber: Effects on rheological properties, ice crystallization and glass transition phenomena. Food Chemistry, 115: 665-674.

Tharp, B. W.; Forrest, B.; Swan, C.; Dunning, L. and Hilmoe, M. (1998). Basic factors affecting ice cream melt down. In W. Buchheim (Ed), Ice cream (pp. 54-64). New York : International Thomson publishing.

Turgut, T. and Cakmacki, S. (2009). Investigation of the possible use of probiotics in ice cream manufacture. International Journal of Dairy Technology, 62: 444-456.

Vyas, H. K. ; Astaire, J. C. and Jimenez-Flores (2002). Buttermilk fractionation by microfiltration. Journal of Dairy Science, 85: 1639-1645.

Winton, A. L. (1958). Analysis of Foods 3rd ed., printing John Whiley and Sons Inc., New York.

Wong, P. Y. Y. and Kitts, D. D. (2003). A comparison of the buttermilk solids functional properties to non fat dried milk, soy protein isolate, dried egg white, and egg yolk powders. Journal of Dairy Science. 86:746-754.

استخدام لبن الخض لصناعة مثلوجات قشدية منخفضة الدهن

أميرة محمد الخولى، عاطف محمد ابو النور، محمد سميح الصفتى، صفاء محمود مقبل
قسم الألبان – كلية الزراعة - جامعة قناة السويس – ٤١٥٢٢ الاسماعيلية – جمهورية مصر العربية

تم دراسة تأثير استبدال اللبن الفرز أحد مكونات مخلوط المثلوجات القشدية منخفضة الدهن باستخدام لبن الخض لإنتاج مثلجات قشدية منخفضة الدهن. ولقد اختبرت المخاليط وكذلك المثلوجات الناتجة من حيث بعض خواصها الكيماوية و الطبيعية والريولوجية و كذلك الخواص الحسية. واشارت النتائج الى زيادة الكثافة النوعية والوزن للجالون بزيادة نسبة اللبن الخض.أظهرت مخاليط المثلوجات القشدية المنخفضة الدهن زيادة فى الحموضة وانخفاض فى قيم الـ pH، وكذلك زيادة معنوية فى انخفاض نقطة التجمد. كذلك انخفاض كل من اللزوجة الظاهرية والخصائص الريولوجية لمخاليط المثلوجات القشدية المنخفضة الدهن مقارنة بالتجربة المقارنة الذى يحتوى مخلوطها على ٨% دهن. وقد لوحظ زيادة اللزوجة الظاهرية والخصائص الريولوجية لكل المعاملات بتقدم مدة التعتيق. أدى استبدال ٧٥% و ١٠٠% من اللبن الفرز بواسطة لبن الخض الى زيادة الريع والمقاومة للانصهار بزيادة نسبة الاستبدال ومن حيث الخواص الحسية، اظهرت النتائج انه بزيادة نسبة اللبن الخض المستخدم فى صناعة المثلوجات القشدية أدى الى الحصول على خواص حسية مناسبة من حيث الطعم، والقوام والتركيب اكثر نعومة واكثر تفضيلا لدى المحكمين. لذلك يمكن التوصية بتطبيق صناعة المثلوجات القشدية منخفضة الدهن باستخدام لبن الخض.