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MANUFACTURE OF LOW FAT PREBIOTIC ICE MILK

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ABSTRACT: *Nine batches of ice milk were made to study the effect of replacing milk fat with two types of inulin (Frutafit HD® and Frutafit Tex®) on the quality of ice milk. Control vanilla ice milk mix containing 4% fat, 13% milk solid not fat, 15% sucrose and 0.5% stabilizer was prepared. The other 8 batches were made by replacing 25,50,75 and 100% of milk fat with either Frutafit HD® or Frutafit Tex®, respectively. Obtained results indicated that replacement of milk fat with two types of inulin did not affect the acidity and pH-values of ice milk mixes, while, increases the specific gravity, weight per gallon and viscosity of all mixes and specific gravity, weight per gallon, overrun and melting resistance of ice milk. This increase was proportional to the rate of replacement. Ice milk batches those made by replacing milk fat with Frutafit HD® were not significantly different (P> 0.05) from corresponding batches those made by replacing milk fat with Frutafit Tex®. Increasing the rate of replacing milk fat with Frutafit HD® up to 50% increased the overrun and improved the acceptability of the resultant ice milk, while increasing the rate of the replacement to 75 and 100% decreased the overrun and the scores of organoleptic properties of ice milk. Ice milk batches made with Frutafit HD® gained higher scores of organoleptic than the corresponding batches those made by Frutafit Tex®. Organoleptic scores of ice milk batches those made with Frutafit Tex® decreased as the storage period advanced.*

Replacement of milk fat with both types of inulin did not affect(P> 0.05) the ash, total protein and total solids content of ice milk, while it is caused an obvious increase in carbohydrate contents and decrease of calorific values and fat contents of the resultant ice milk.

The obtained results indicated that, total solids, total protein, ash and carbohydrate contents, titratable acidity, pH value and calorific values did not change in ice milk samples during the storage period, in the freezer for 10 weeks.

Key words: *Low fat, Ice milk, prebiotic, inulin, fat repalcers.*

INTRODUCTION

Inulin is a linear non-digestible polysaccharide of β-(2-1) linked fructose residues with a terminal glucose residue unit (Tarrega and Costell, 2006). It has been used as fat or sugar replacer, a low caloric bulking agents and as a textureising and water binding agent (Tungland and Meyer, 2002 and Kip *et al.*, 2006). Inulin has been shown to induce crucial physiological and nutritional effects such as hypotriglyceridemia, hypoinsulinemia, improved mineral absorption and stimulation of immune function and reducing the colon cancer (Bosscher *et al.*, 2006; Huebner *et al.*, 2007 and Villegas and Costell, 2007).

In view of the aforementioned the objectives of this study were to evaluate the possibility of making a good quality prebiotic low fat ice milk by replacing milk fat with inulin, which is a prebiotic. We may investigate the effect of using inulin on the quality of ice milk and to monitor the chemical, physical and sensory changes during the storage of ice milk.

MATERIALS AND METHODS

Ingredients:

Fresh bulk buffalo's milk (obtained from the herd of Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt. Cream was obtained by separating fresh buffalo's milk in the pilot plant of Department of Dairy Science and Technology, Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt. Two types of inulin, Frutafit HD® (as fat and sugar replacer) (Average Chain Length 8-13 monomers) and Frutafit Tex®

(as fat replacer) (Average Chain Length ≥ 22 monomers) were gratefully provided by Sensus, Borchwerf, the Netherlands. Sucrose and Vanilla were obtained from local market, Stabilizer (Mercol IC) was obtained from Meer Corporation, North Bergen, NJ, USA.

Manufacture of ice milk:

It was concerned to investigate the effect of replacing milk fat with inulin which is a carbohydrate-based fat replacer and a prebiotic on the quality of ice milk. Therefore, nine ice milk treatments were made. Vanilla ice milk mixes were prepared according to the method of Khader *et al.* (1992) with the following composition: 4% Fat, 13% milk solid not fat, 15% sucrose, 0.5% stabilizer. Control ice milk was made containing 4% milk fat, the other eight ice milk treatments were made by replacing 25, 50, 75 and 100% of the amount of milk fat with either Frutafit HD® or Frutafit Tex® ,respectively. All treatments were heat treated at 69°C for 30 min, cooled and then aged over night at 4°C. Vanilla was added prior to freezing and ice milk mixes were frozen in a batch-type freezer (Cattabriga, Bolongia, Italy). The frozen ice milk was packaged in plastic cups, hardened for 24 hr and stored at -20 ± 2°C for 10 wk. Each ice milk treatment was analyzed when fresh (0 time) and every two weeks for chemical and sensory evaluation. The whole experiment was performed in triplicate.

Physical and chemical analysis:

Overrun of the ice milk was determined according to the method of Arbuckle (1986). The specific gravity of ice milk mixes and ice milk samples was determined according to Winton (1958). Weight per gallon of ice milk mixes in kilogram (Kg) was directly calculated according to Arbuckle (1986). The melting resistance of ice milk was determined according to Reid and Painter (1933). The viscosity of ice milk mixes were measured using coaxial cylinder viscometer (Bohin V88, Sweden).

Chemical analysis:

Fat content, titratable acidity and pH values were determined according to Ling (1963). The pH value was measured using pH- meter (Jenway LTD, Felsted Dunmow, Essex, UK). Total solids, ash and total protein were determined according to the Official Method (A.O.A.C., 2007). Carbohydrate was calculated by difference.

Total energy of ice milk was calculated based on conversion factors as follows; protein 4, carbohydrate 4 and fat 9 and expressed as kcal / 100 g ice milk.

Sensory evaluation:

Ten panelists from the Staff members and graduated students at the Department of Dairy Science and Technology, Department of Food Science and Technology, Faculty of Agriculture, Menoufia University evaluated the organoleptic properties of each batch of vanilla ice milk at zero time and at the 4th, 8th and 10th week of storage period according to score sheets described by Kebary and Hussein (1997).

Statistical analysis:

Data were analyzed using the completely randomized block design and 2 × 3 factorial design. Newman-Keuls Test was used to made the multiple comparisons (Steel and Torrie, 1980) using Costat program. Significant differences were determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Some ice mix properties:

Titratable acidity of ice milk mixes were not significantly ($P > 0.05$) different from each other, which means that replacement of milk fat with both types of inulin did not have significant ($p > 0.05$) effect on the titratable acidity of ice milk mixes (Table 1).

Changes in pH values of low fat ice milk mixes were shown in (Table 1). There were no significant ($p > 0.05$) differences among the ice milk mixes, which means replacement of milk fat with both types of inulin did not affect significantly ($p > 0.05$) the pH values of ice milk mixes.

Replacement of milk fat with inulin caused a marked ($p \leq 0.05$) increase in viscosity (Table 1). This increase was proportional to the rate of the replacement of milk fat with both types of inulin. The increase of viscosity by adding inulin could be attributed to the capacity of inulin to retain water (Soukoulis *et al.,* 2009), the interaction of inulin with milk protein that can lead to an increase in the molar mass (Scaller-Povolny and Smith, 2001) and the formation of small aggregates of microcrystals that are able to retain water (Gonzalez-Tomas *et al.,* 2008). These results are in accordance with those reported by Arcia *et al.* (2010), Debon *et al.* (2010) and Cruz *et al.* (2013). Ice milk mixes those made by replacing milk fat with inulin (Frutafit Tex®) exhibited higher viscosity than corresponding ice milk mixes made with inulin (Frutafit HD®). These results might be due to the longer chain of (Frutafit Tex®) than those of (Frutafit HD®), which subsequently increasing the viscosity of the resulting ice milk mixes. (Wada *et al.,* 2005).

Replacement of milk fat with inulin caused a marked ($p \leq 0.05$) increase in specific gravity and weight per gallon (Table 1). This increase was proportional to the rate of the replacement of milk fat with both types of inulin. These results could be attributed to the higher specific gravity of both inulin types than that of fat, which consequently increase the specific gravity of ice milk mixes. The specific gravity and weight per gallon of ice milk mixes made with inulin (Frutafit HD®) were not significantly ($p > 0.05$) different from those of corresponding ice milk mixes made with inulin (Frutafit Tex®). These results might be due to that both inulin types havé similar specific gravity. These results agreement with those reported by Tarrega and Costell (2006), Naskar *et al.* (2010) and Cruz *et al.* (2013).

Table (1): Effect of replacing milk fat with inulin on some properties of ice milk mixes.

Treatments▫	Acidity	pH value	Specific gravity	Weight per gallon (Kg)	Viscosity (m pas)
C*	0.230^{A}	6.63^{A}	1.1132^{E}	4.214^{E}	137.3^{I}
T_1	0.233^{A}	6.61^{A}	1.1138^{CD}	4.217^{CD}	168.8^{H}
T_2	0.232^{A}	6.59^{A}	1.1143^{CB}	4.229^{CB}	247.8^{F}
T_3	0.235^{A}	6.61^{A}	1.1148^{AB}	4.221^{AB}	465.8^{D}
T_4	0.238^{A}	6.58^{A}	1.1153^{A}	4.222^{A}	538.3^{B}
T_5	0.228^{A}	6.60^{A}	1.1138^{CD}	4.217^{D}	182.7^{G}
T_6	0.230^{A}	6.62^{A}	1.1146^{CB}	4.220^{CD}	257.8^{E}
T_7	0.232^{A}	6.59^{A}	1.1149^{CB}	4.221^{B}	486.4^{C}
T_8	0.235^{A}	6.58^{A}	1.1153^{A}	4.222^{A}	585.9^{A}

▫ Each value in the Table was the mean of three replicates.
• For each effect the different letters in the same column means the multiple comparisons are different from each other, letter A is the highest mean followed by B, C,...etc.
* Significant at 0.05 level ($p \leq 0.05$).
* C = Control ice milk made with 4% milk fat.
T_1, T_2, T_3 and T_4 = Ice milk prepared by replacing 25, 50, 75 and 100% of milk fat with inulin (frutafit HD®), respectively.
T_5, T_6, T_7 and T_8 = Ice milk prepared by replacing 25, 50, 75 and 100% of milk fat with inulin (frutafit Tex®), respectively.

Some ice milk properties:

Overrun of all ice milk made by both types of inulin was higher than that of control ice milk (Table 2). It has been reported that adding inulin during the manufacture of ice milk improved the whipability (Arbuckle, 1986 and Rajasckaran and Rajor, 1989). Overrun of ice milk made by replacing milk fat with both types of inulin increased significantly ($p \leq 0.05$) by increasing the rate of replacement up to 50%, while increasing the rate of replacement to 75 and 100% caused a significant reduction of overrun (Table 2). These results could be attributed to the increase of viscosity, which consequently suppress the ability of ice milk to retain the air in ice milk. These results are in agreement with those reported by Chang and Hartel (2002) and Sofjan and Hartel (2004). Overrun of ice milk treatments those made with inulin (Frutafit HD®) were not significantly ($p > 0.05$) different from those of corresponding treatments made with inulin (Frutafit Tex®) (Table 2). These results are in agreement with those reported by Naskar *et al.* (2010) and Meyer *et al.* (2011).

Specific gravity and Weight per gallon of ice milk made by replacing milk fat with inulin are presented in Table (2). Both specific gravity and weight per gallon followed similar trends. Replacement of milk fat with both types of inulin caused a pronounced increase of specific gravity and weight per gallon of the resultant ice milk (Table 2). This increase was proportional to the increase of the rate of replacement. Control ice milk exhibited the lowest of specific gravity and weight per gallon, while treatments T_4 and T_8 those made by replacing 100% of milk fat with both types of inulin exhibited the highest specific gravity and weight per gallon. These results could be attributed to the higher specific gravity of inulin than milk fat which subsequently increase the specific gravity of the resultant ice milk. Ice milk treatments those made by replacing milk fat with inulin (Frutafit HD®) were not significantly ($p > 0.05$) different from those made with inulin (Frutafit Tex®) which means that the type of inulin did not have a significant effect on specific gravity and weight per gallon of the resultant ice milk. These results are in agreement with those reported by Tarrega and Costell (2006), Naskar *et al.* (2010) and Cruz *et al.* (2013).

Table (2): Effect of replacing milk fat with inulin on some properties of ice milk.

Treatments▫	Overrun	Specific gravity	Weight per gallon (kg)	Melting Resistance		
				First 60 min	Next 30 min	Last 30 min
C*	62.13^{E}	0.6431^{E}	2.430^{E}	37.8^{E}	46.8^{E}	15.4^{E}
T_1	64.65^{D}	0.6502^{CD}	2.457^{CD}	36.5^{D}	45.3^{D}	18.2^{D}
T_2	70.09^{A}	0.6571^{CB}	2.484^{CB}	35.5^{C}	44.5^{C}	20.0^{C}
T_3	68.13^{B}	0.6723^{AB}	2.541^{AB}	33.9^{B}	42.1^{B}	24.0^{B}
T_4	66.08^{C}	0.6802^{A}	2.571^{A}	32.8^{A}	40.6^{A}	26.6^{A}
T_5	65.18^{D}	0.6513^{CD}	2.462^{CD}	37.3^{D}	45.6^{D}	17.1^{D}
T_6	69.81^{A}	0.6558^{CB}	2.479^{CB}	34.9^{C}	43.8^{C}	21.3^{C}
T_7	67.25^{B}	0.6698^{B}	2.532^{CB}	33.6^{B}	42.5^{B}	23.9^{B}
T_8	66.36^{C}	0.6782^{A}	2.564^{A}	32.8^{A}	40.8^{A}	26.4^{A}

▫ , * See Table (1).

Melting Resistance of the resultant ice milk is expressed in Table (2) as the loss in weight percent of the initial weight. Replacement of milk fat with two types of inulin caused an obvious ($p \leq 0.05$) decrease in the rate of melting ice milk at 60 min and the next 30 min which means that increasing the melting resistance of the resulting ice milk. The increase of melting resistance was proportional to the rate of replacing milk fat with both types of inulin (Table 2). This increase in melting resistance might be due to the increase of viscosity and the higher water holding capacity of inulin which bind higher amount of water and left lower amount of free water that can be melted faster than the bound water, which consequently increases the melting resistance of the resulting ice milk (Villegas and Costell, 2007 and Torres *et al.*, 2010). Melting resistance of ice milk treatments made with replacing milk fat with inulin (Frutafit HD®) were not significantly different from those made by replacing milk fat with inulin (Frutafit Tex®). The melting resistance of all ice milk treatments after the last 30 min had contradictory trend of these of the first 60 min. These results are in agreement with those reported by Kebary and Hussein (1997) and Mousa *et al.* (2008).

All ice milk treatments were not significantly ($p > 0.05$) different from each other in titratable acidity and pH value which means that replacement of milk fat with both types of inulin did not have significant ($p > 0.05$) effect on the titratable acidity of ice milk treatments (Tables 3, 7). Titratable acidity and pH value of all ice milk treatments did not change significantly ($p > 0.05$) during the storage period. Similar results were reported by Badawi *et al.* (2010).

Total solids, total protein and ash contents of ice milk treatments made with the addition of inulin were not significantly different ($p > 0.05$) from that of control ice milk which means that replacement of milk fat with both types of inulin did not affect significantly ($p > 0.05$) the total solids content of the resultant ice milk. Total solids, total protein and ash contents of all ice milk treatments did not change significantly ($p > 0.05$) during storage period (Tables 4, 7). These results are in accordance with those reported by Badawi *et al.* (2008) and Kebary *et al.* (2009).

Fat content of all ice milk treatments did not change significantly($P > 0.05$) as the storage period progressed (Tables 5, 7). These results are in accordance with those of Kebary and Hussein (1999) and Badawi *et al.* (2008). As expected fat content of ice milk decreased significantly ($p \leq 0.05$) by replacing milk fat with both types of inulin (Tables 5, 7). There was negative correlation between the fat content and the rate of replacement, which means that fat content of the resulting ice milk decreased as the rate of replacing milk fat with both types of inulin was increased. Control ice milk contained the highest fat content while treatment T_4 and T_8 those made by replacing 100% of milk fat with the two types of inulin contained the lowest one of fat content. Similar results were reported by Hussein *et al.* (2004) and Badawi *et al.* (2008) and Hussein (2008).Ice milk treatments those made by replacing milk fat with inulin (Frutafit HD®) were not significantly ($p > 0.05$) different from those made with inulin (Frutafit Tex®) (Tables 5,7).

Carbohydrate content of all ice milk treatments did not change significantly ($p > 0.05$) throughout the storage period. These results are in agreement with those reported by Salama and Hassan (1994) and Kebary and Hussein (1999). Carbohydrate content of all ice milk treatments increased by substituting milk fat with both types of inulin. There was positive correlation between carbohydrate content of ice milk treatments and the rate of replacing milk fat with both types of inulin, which means carbohydrate content of ice milk treatments increased as the rate of replacement of milk fat with inulin was increased. Treatments T_4 and T_8 those made by replacing 100% of milk fat with inulin contained the highest carbohydrate content, while control ice milk contained the lowest carbohydrate content. These results are in agreement with those reported by Kebary and Hussein (1999). Ice milk treatments those made by replacing milk fat with inulin (Frutafit HD®) were not significantly ($p > 0.05$) different from corresponding treatments those made with inulin (Frutafit Tex®) (Tables 5, 7).

Table (3). Effect of replacing milk fat with inulin on titratable acidity and pH value during storage the frozen storage for 10 weeks (-20°C).

Treatments[a]	Titratable acidity (%) of ice milk samples (weeks)				pH value of ice milk samples (weeks)			
	0	4	8	10	0	4	8	10
C*	0.230	0.231	0.236	0.236	6.63	6.60	6.56	6.55
T_1	0.233	0.235	0.235	0.240	6.61	6.58	6.54	6.51
T_2	0.232	0.232	0.237	0.241	6.59	6.57	6.52	6.50
T_3	0.235	0.238	0.240	0.240	6.61	6.55	6.52	6.50
T_4	0.238	0.238	0.240	0.240	6.58	6.56	6.56	6.50
T_5	0.228	0.231	0.235	0.238	6.60	6.60	6.53	6.50
T_6	0.230	0.231	0.230	0.232	6.62	6.59	6.52	6.48
T_7	0.232	0.232	0.236	0.239	6.59	6.60	6.58	6.53
T_8	0.235	0.233	0.237	0.240	6.58	6.57	6.53	6.50

[a], * See Table (1).

Table (4). Effect of replacing milk fat with inulin on total solids, total protein and ash contents (%) during the frozen storage for 10 weeks(-20°C).

Treatments[a]	Total solids content (%) of ice milk samples (weeks)				Total protein content (%) of ice milk samples (weeks)				Ash content (%) of ice milk samples (weeks)			
	0	4	8	10	0	4	8	10	0	4	8	10
C*	33.13	33.02	32.93	32.18	5.46	5.40	5.44	5.42	1.22	1.21	1.19	1.18
T_1	33.02	32.91	32.73	32.06	5.42	5.42	5.38	5.40	1.22	1.18	1.18	1.19
T_2	32.98	32.65	32.43	32.23	5.38	5.40	5.33	5.30	1.24	1.20	1.20	1.22
T_3	33.01	32.77	32.75	32.75	5.40	5.38	5.35	5.39	1.27	1.24	1.23	1.22
T_4	32.92	32.76	32.63	32.56	5.32	5.36	5.34	5.34	1.28	1.26	1.26	1.24
T_5	33.22	32.93	32.65	32.09	5.40	5.36	5.38	5.36	1.20	1.20	1.18	1.18
T_6	33.01	32.73	32.46	32.23	5.40	5.38	5.41	5.32	1.24	1.21	1`.21	1.21
T_7	33.16	32.86	32.33	32.08	5.38	5.38	5.33	5.37	1.28	1.26	1.26	1.25
T_8	32.93	32.42	32.40	32.13	5.35	5.31	5.36	5.35	1.28	1.25	1.24	1.24

[a], * See Table (1).

Table (5). Effect of replacing milk fat with inulin on ash, carbohydrate and total calories during the frozen storage for 10 weeks (-20°C).

Treatments[■]	Fat content (%) of ice milk samples (weeks)				Carbohydrate content (%) of ice milk samples (weeks)				Total calories (k. calori / 100 g) of ice milk samples (weeks)			
	0	4	8	10	0	4	8	10	0	4	8	10
C*	4.0	4.0	3.9	3.9	22.35	22.41	22.5	21.78	148.14	147.24	145.96	143.00
T_1	2.9	2.9	3.0	2.9	23.44	23.41	23.37	22.67	141.54	141.42	140.20	137.48
T_2	2.0	2.0	2.0	1.9	24.22	24.05	23.90	23.81	137.30	135.80	126	133.54
T_3	1.0	1.0	1.0	0.9	25.36	25.05	25.17	25.24	132.04	131.62	122.94	130.62
T_4	0.1	0.1	0.1	0.1	26.14	26.04	25.93	25.88	126.74	126.50	125.98	125.78
T_5	2.9	2.8	2.9	2.9	23.80	23.51	23.39	22.85	142.90	140.68	139.38	137.14
T_6	2.0	2.0	1.9	1.9	24.37	24.14	23.94	23.80	137.08	136.08	134.50	133.58
T_7	1.0	1.0	1.0	0.9	25.40	25.20	23.74	24.56	133.02	131.32	125.28	127.90
T_8	0.1	0.2	0.1	0.1	26.10	25.76	25.70	25.44	127.60	125.18	125.14	124.06

■, * See Table (1).

Table (6). Effect of replacing milk fat with inulin on organoleptic score of ice milk.

Treatments[■]	Flavour (50)				Body & texture (40)				Melting quality (10)				Total scores (100)			
	Storage period (weeks)															
	0	4	8	10	0	4	8	10	0	4	8	10	0	4	8	10
C*	43	42	41	41	35	35	34	33	8	8	8	8	86	85	83	82
T_1	44	43	43	41	36	36	36	35	8	8	8	7	88	87	87	83
T_2	45	43	43	42	37	37	36	35	8	8	8	8	90	88	87	85
T_3	42	42	41	40	35	34	32	32	7	7	8	7	84	83	81	79
T_4	42	40	40	38	35	33	31	30	7	7	8	7	82	80	79	75
T_5	43	43	38	36	36	35	30	28	8	7	6	6	87	85	74	70
T_6	43	43	38	36	36	35	29	27	8	7	6	6	85	84	73	69
T_7	40	40	35	34	33	33	28	26	7	7	5	5	80	80	68	65
T_8	40	40	35	34	32	32	27	25	8	7	5	5	80	79	67	64

■, * See Table (1).

Table (7). Statistical analysis of some ice milk properties.

Ice milk properties	Effect of treatments										Effect of storage period (weeks)				
		Multiple comparisons●										Multiple comparisons●			
	Mean squares	C♦	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Mean squares	0	4	8	10
pH values	3.362	A	A	A	A	A	A	A	A	A	0.2131	A	A	A	A
Titratable acidity (%)	10.2102	A	A	A	A	A	A	A	A	A	3.326	A	A	A	A
Total solids (%)	8.336	A	A	A	A	A	A	A	A	A	0.945	A	A	A	A
Protein (%)	1.3645	A	A	A	A	A	A	A	A	A	0.136	A	A	A	A
Fat (%)	43.29*	A	B	C	D	E	B	C	D	E	26.34	A	A	A	A
Ash (%)	13.521	A	A	A	A	A	A	A	A	A	5.324	A	A	A	A
Carbohydrate (%)	18.431*	E	D	C	B	A	D	C	B	A	1.680	A	A	A	A
Calorific value	597.635*	A	B	C	D	E	B	C	D	E	122.244	A	A	A	A
Organoleptic properties:															
Flavor	33.231*	B	AB	A	C	D	D	D	F	F	45.666*	A	A	B	C
Body and texture	31.313*	B	AB	A	C	D	D	E	F	F	30.749*	A	A	B	C
Melting properties	1.708	A	AB	A	AB	AB	B	B	BC	C	2.333	A	A	A	A
Total scores	152.583*	B	AB	A	C	D	D	DE	F	F	156.999*	A	A	B	C

♦ See Table (1).

● For each effect the different letters in the same row means the multiple comparisons are different from each other, letter A is the highest mean followed by B, C, ... etc.

* Significant at 0.05 level ($p \leq 0.05$).

Total calories of all ice milk treatments did not change significantly ($p > 0.05$) as the storage period progressed. Replacement of milk fat with inulin caused a significant ($p \leq 0.05$) reduction of calorific value of the ice milk treatments. This reduction was proportional to the rate of the replacement (Tables 5, 7). On the other hand, ice milk treatments those made from the same milk were not significantly different from each other ($p > 0.05$) which might be probably due to the amount added from inulin are the same. These results are in agreement with those of Kebary and Hussein (1999).

Scores of flavour, body & texture and the total scores of organoleptic properties of all ice milk treatments followed similar trends. Fresh ice milk treatments were not significantly($P > 0.05$) different from each other and the control treatment. Ice milk treatments made by replacing milk fat with inulin (Frutafit Tex®) exhibited more creaminess property than other treatments, which might be due to the long chain of this type of inulin (Guggisberg *et al.,* 2009). Although many ice milk treatments were accepted by the panelists, the most acceptable treatments were T_1, T_2 those made by replacing 25 and 50% of milk fat with inulin (Frutafit HD®). Treatments T_1, T_2 gained the highest scores followed by control treatment that was not significantly different from T_1. Ice milk treatments those made by replacing milk fat with inulin (Frutafit HD®) gained higher scores than corresponding treatments those made by replacing milk fat with inulin (Frutafit Tex®) (Tables 6, 7). These results could be attributed to the low scores gained by ice milk treatments those made by replacing milk fat with inulin (Frutafit Tex®) as the storage period progressed especially after the fourth week up to the end of storage period. These results might be due to the progressive aggregation of inulin crystals especially the long chain inulin, which consequently influence the sensory quality of the resultant ice milk (Tungland and Meyer, 2002 and Torres *et al.,* 2010). Total scores of organoleptic properties of all ice milk treatments did not change significantly($P > 0.05$) during the first four weeks then decreased as the storage period progressed up to the end of the storage period (Tables 6,7). These results might be due to the low scores gained by ice milk treatments made with inulin (Frutafit Tex®) especially after the four weeks of the storage period. These results are in agreement with those reported by Zedan *et al.* (2001) and Kebary *et al.* (2004).

It could be concluded that replacement of milk fat with inulin caused an obvious increase in melting resistance and reduction in calorific value and this effect was proportional to the rate of the replacement. Increasing the rate of the replacement of milk fat with inulin (Frutafit HD®) till 50% increased overrun and improved the acceptability of the resultant ice milk, while increasing the replacement rates to 75 and 100% decreased the overrun and scores of organoleptic properties of the resultant ice milk. Therefore it could be recommended that it is possible to replace till 50% of milk fat with inulin (Frutafit HD®) without determintal effects on ice milk quality

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تصنيع المثلوج اللبنى المنخفض الدهن والداعم للحيوية

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الملخص العربى :

اهتمت الدراسة فى هذا الجزء بدراسة تأثير إستبدال دهن اللبن بنسب مختلفة بواسطة الإنيولين على الخواص الكيميائية والريولوجية والحسية للمثلوج اللبنى حيث تم تصنيع ٩ معاملات وكان تركيب المعاملة الكنترول كالتالى :

٤% دهن لبنى + ١٣% جوامد صلبة لبنية لا دهنية + ١٥% سكر + ٠.٥% مثبت . أما باقى الثمانية معاملات فقد تم تصنيعهم بنسب إستبدال ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% من دهن اللبن إما بنوع إينولين Frutafit HD® أو بنوع إينولين Frutafit Tex® .

وتم تخزين المعاملات فى الفريزر لمدة ١٠ أسابيع حيث أخذت عينات وهى طازجة وعند ٤ ، ٨ ، ١٠ أسابيع من التخزين وذلك لإجراء التحليلات الكيماوية والريولوجية والحسية عليها . ولقد أوضحت أهم النتائج المتحصل عليها بعد تحليلها إحصائيا مايلى :

- لم تختلف نسبة الحموضة و الـ pH لمخاليط المثلوج اللبنى عن بعضها وهذا يدل على أن إستبدال دهن اللبن لم يؤثر معنويا على حموضة مخاليط المثلوج اللبنى .
- أدى إستبدال دهن اللبن بواسطة الإنيولين إلى زيادة ملحوظة فى لزوجة مخاليط المثلوج اللبنى وهذه الزيادة كانت تتناسب طرديا مع معدل الإضافة . والعينات التى حدث فيها إستبدال دهن اللبن بالإنيولين (Frutafit Tex®) أظهرت لزوجة أعلى عن المخاليط التى تم إستبدال دهن اللبن فيها بالإنيولين (Frutafit HD®) .
- أدى إستبدال دهن اللبن بواسطة الإنيولين إلى زيادة ملحوظة فى الكثافة النوعية والوزن بالجالون لمخاليط المثلوج اللبنى وهذه الزيادة كانت تتناسب طرديا مع معدل الإضافة. ولم تختلف الكثافة النوعية والوزن بالجالون للمخاليط المصنعة بإنيولين بكلا نوعى من الإنيولين.
- حدثت زيادة فى الريع للمثلوج اللبنى بإستبدال دهن اللبن بنوعى الإنيولين بزيادة معدل الإستبدال حتى ٥٠% بينما أدى زيادة الإستبدال عن ذلك ١٠٠% إلى إنخفاض ملحوظ فى الريع . ولم يختلف الريع فى العينات المصنعة بإنيولين (Frutafit Tex®) عن تلك المصنعة بإنيولين (Frutafit HD®) .
- أدى إستبدال دهن اللبن بنوعى الإنيولين إلى زيادة واضحة فى الكثافة النوعية والوزن بالجالون للمثلوج اللبنى بزيادة معدل الإستبدال. ولم تختلف الكثافة النوعية والوزن بالجالون للعينات المصنعة بكلا النوعى من الإتيولين.
- أدى إستبدال دهن اللبن بنوعى الإنيولين إلى زيادة المقاومة للإنصهارحيث كانت هناك علاقة طردية بين زيادة المقاومة للإنصهار ومعدل الإستبدال . ولم تختلف المقاومة للإنصهار للعينات المصنعة بكلا النوعى من الإتيولين.

- لم تختلف جميع المعاملات عن بعضها فى نسب الحموضة وقيم الـ pH أى أن إستبدال دهن اللبن بنوعى الإنيولين لم يُؤثر على نسب الحموضة وقيم الـ pH وكذلك أيضاً لم تختلف نسب الحموضة وقيم الـ pH أثناء فترات التخزين .
- لم تختلف نسب الجوامد الصلبة الكلية و البروتين الكلى والرماد فى الكنترول عن العينات المنخفضة فى نسبة الدهن معنويا وهذا يدل أن إستبدال الدهن بالإنيولين لم يُؤثر على نسب الجوامد الصلبة الكلية والبروتين الكلى والرماد للمثلوج اللبنى . ومن ناحيةٍ أخرى لم تتأثر نسب الجوامد الصلبة والبروتين الكلى والرماد معنوياً فى كل المعاملات بمرور فترات التخزين . ولم تختلف نسب الجوامد الصلبة الكلية والبروتين الكلى والرماد فى العينات المصنعة بإنيولين (Frutafit Tex®) عن تلك المصنعة بإنيولين (Frutafit HD®) .
- أدى إستبدال دهن اللبن بكلا النوعى من الإنيولين إلى إنخفاض نسبة الدهن والقيمة السعرية بينما أدى إلى زيادة نسبة الكربوهيدرات .
- اتخذت الخواص الحسية المختلفة (النكهة ، القوام ، التركيب ، المجموع الكلى) نفس الاتجاهات تقريباً . ومن ناحيةٍ أخرى فقد حصلت العينة T_1, T_2 المصنعة بإستبدال ٢٥ ، ٥٠% من دهن اللبن على أعلى الدرجات . والعينات المصنعة بإستبدال دهن اللبن بإنيولين (Frutafit HD®) على درجات أعلى من تلك المصنعة بإستبدال دهن اللبن بإنيولين (Frutafit Tex®) . حيث لم تتغير الدرجات الممنوحة لكل المعاملات معنوياً أثناء الأربع أسابيع الأولى من التخزين ثم بدأت هذه الدرجات فى الانخفاض بنهاية فترات التخزين .
- مما سبق يتضح أن إستبدال دهن اللبن بالإنيولين أدى إلى زيادة واضحة فى المقاومة للإنصهار وإنخفاض القيمة السعرية و هذا التأثير إزداد بزيادة معدل الإستبدال . وإزداد الريع فى المعاملات المصنعة حتى نسبة إستبدال ٥٠% بواسطة إنيولين (Frutafit HD®) بينما زيادة معدل الإستبدال عن ذلك إلى ١٠٠% أدى إلى خفض الريع والخواص الحسية للمثلوج اللبنى . ولهذا من الممكن أن نوصى بأنه يمكن إستبدال حتى ٥٠% من دهن اللبن بواسطة إنيولين (Frutafit HD®) بدون حدوث أى تأثير معنوى على جودة المثلوج اللبنى .