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EFFECT OF REPLACING SKIM MILK POWDER WITH OAT FLOUR ON THE QUALITY OF ICE MILK

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ABSTRACT: *The possibility of making good quality ice milk by substituting the skim milk powder (SMP) with oat flour at different levels was investigated. Four treatments of ice milk were prepared. The first was control (C), skim milk powder was used to supply the milk solids not fat in the control, while in T1, T2 and T3 treatments skim milk powder (SMP) was replaced with oat flour at the rate of 25, 50 and 75%, respectively. Oat flour was used for its physiological features, being soluble dietary fiber (B-glucans), prebiotic properties and as bulking & texturizing agent. Results revealed that specific gravity, weight per gallon, viscosity and freezing point of the mix were increased significantly (P ≤ 0.05), while acidity was decreased as the percent of oat flour increased. The same trend concerning whipping ability, overrun and melting resistance of resultant ice milk were increased significantly (P ≤ 0.05) with increasing oat flour up to 50% then decreased. On the other hand, specific gravity and weight per gallon of the resultant ice milk were decreased significantly (P ≤ 0.05) with increasing oat flour up to 50%. The resulting ice milk with 50% oat flour show the higher content in both essential and non essential amino acids except methionine. Fibers and some minerals such as: iron, zinc, selenium and manganese were increased, but potassium was decreased. The organoleptic properties of the final product showed that ice milk made with different level of oat flour improved the body & texture and melting resistance than the control which made with SMP without any adverse effect on it's flavour. From this study we can conclude that ice milk with high nutritional value and good organoleptic properties could be successfully made using oat flour as a substitute of SMP with level up to 50% with reducing the percentage of stabilizer from 0.3% to 0.1%, while treatment made with 75% of SMP substitution does not require any stabilizer.*

Key words: **Ice milk, skim milk powder, oat flour.**

INTRODUCTION

Consumption of frozen desserts has increased in Egypt. Ice milk is composed of mixing of air, water, milk fat, non-fat milk solids (NFMS), sweeteners, stabilizers, emulsifiers and flavours. An ice milk mix is the unfrozen blend of the ingredients used to supply these constituents, except the air and flavoring materials. The demand for functional foods is growing rapidly all over the world due to the increase awareness of the consumers on

the impact of food health, (Stoon, 2002). Logical developments and changes in marketing, economic condition has encouraged the development of a wide range of ingredients that are available from numerous sources. Dairy products, which furnish the milk fat and NFMS have essential roles in ice cream and related products.

Oat flour is used as food ingredient for variety of reasons including for fat and sugar replacement as a low calorie bulking agent and as texturising agent (Hui Ru *et al.*, 2002). It is also used for its physiological features of being soluble dietary fiber and having prebiotic properties (Emst and Feldhein, 2000 and Causey *et al.*, 2000).

The objective of this study was to evaluate the possibility of making good quality ice milk made by substituting the skim milk powder with oat flour at levels of 25%, 50% and 75%.

MATERIALS AND METHODS

1-Materials:

Cream (40% fat) and skim milk were prepared from fresh buffaloe's milk, which was obtained from the herd of Faculty of Agric., Minufiya University, Shibin El-Kom, while skim milk powder was from Poland. The gross composition of raw dairy ingredients used for ice milk making is given in Table (1). Sucrose and vanilla were from local market. Carboxy methyl cellulose (CMC) was obtained from Mifad, Co., . White flakes oat from Malta was ground to flour, sieved through 50 mesh screen, dried at 45°C to about 5% moisture and stored in glass containers at 5°C until used. Its composition was 94.80% T.S., 7.1% oil, 19.2% protein (N x 5.45%), 2.69% Ash, 58.81% carbohydrate, 7% fiber, iron (7.0 mg / 100 g), potassium (337.1 mg / 100 g), manganese (4.81 mg / 100 g), selenium (0.134 mg / 100 g) and zinc (2.43 mg / 100 g).

Table (1). Gross composition of raw dairy ingredients used for ice milk making.

Ingredients	T.S %	Fat %	T.P %	Ash %	Lactose %
Buffaloe's milk	16.90	7.00	4.15	0.91	4.84
Cream	47.43	40.00	2.88	0.65	3.90
Fresh skim milk	9.18	0.1	3.69	0.81	4.58
Skim milk powder	96.0	0.60	35.60	8.30	51.50

I- Experimetal procedures:

Mixtures of fresh buffaloe's skim milk (9.18 T.S), skim milk powder (96.00 T.S) and fresh cream 40% fat were prepared to give 6% fat, 12% milk solids not fat (MSNF) in the mix. Cane sugar, stabilizer and vanillin were added to the mix at the ratio 16.0, 0.3 and 0.03% respectively control treatment (C). The oat flour (OF) was used to replace 25,50 and 75% of skim milk powder in the prepared mixes T1, T2 and T3 respectively. The formula of ice milk mixes is presented in Table (2).

Table (2). Formula of ice milk mixes made by replacing skim milk powder with different levels of oat flour.

Raw materials	Ice milk mixes			
	C*	T_1	T_2	T_3
Fresh skim milk (kg)	1.574	1.579	1.574	1.574
Fresh cream (kg)	0.375	0.375	0.375	0.375
Skim milk powder (kg)	0.144	0.108	0.72	0.36
Oat flour (kg)	–	0.36	0.72	0.108
Cane sugar (kg)	0.40 (16%)	0.40 (16%)	0.40 (16%)	0.40 (16%)
(CMC)** (kg)	0.075 (0.3%)	0.075 (0.3%)	0.025 (0.1%)	–
Vanilla	0.03	0.03	0.03	0.03
Total (kg)	2.493	2.493	2.491	2.493

C* = Control ice milk made with 3% skim milk powder as a source of milk solids not fat.

T_1, T_2, T_3 = Ice milk samples made by substitution skim milk powder with oat flour at the rate of 25, 50 and 75%, respectively.

CMC**= Carboxy methyl cellulose.

II- Mix preparation and freezing :

Ingredients were mixed together, then shifted slowly to the standardized milk at 45 to 60°C under vigorous agitation to prevent lumping according to the method of Khader *et al.* (1992). All mixes were heat treated at 85°C for 10 min., then rapidly cooled to 5°C and aged at 5°C overnight. Vanilla was added prior to freezing and ice milk mix was frozen in a batch-type freezer (Taylor, Model, 103, Italy). The resultant ice milk treatments were packed into plastic cups (120 cm^3) covered and stored at -18°C in a harding room for eight weeks. Each batch was about two and half kilogram (kg). Three replicates were done for every treatment.

2-Methods of analysis:

Determination of total solids, oil, milk protein (total nitrogen × 6.38), protein of oat flour (total nitrogen × 5.45), ash and fiber contents were estimated as in A.O.A.C (2000). Fat content, titratable acidity were determined according to Ling (1963). Carbohydrate content was calculated by difference according to Guzman *et al.* (1999). Minerals contents were determined according to Shoale *et al.* (1997), using Atomic Absorption (Perken Elemer Emission Spectrophotometer, USA). The samples were hydrolyzed with 6N HCl according to Allen *et al.* (1997). Free amino acids were determined according to Block *et al.* (1958), using Automatic Amino Acid Analyzer, AAA 400, Ingos Ltd. Specific gravity (Winton, 1958). Weight per gallon (Burke, 1947). Freezing point (FAO, 1997), using an electronic thermometer (Wheatson 650, Type-K, Chromel-Alvmel). Viscosity of ice milk was measured according to Morison and Mackary (2001), using coaxial cylinder viscometer (Bohlin 88, Sweden) attached to a work station loaded with software V88 viscometry programme. The system (C30) was filled with the ice milk sample at a refrigerator temperature (4-6°C) and measurement of shear stress and the viscosity was carried out in the up mode at shear rates from 27 $^{1}/_{5}$ to 208 $^{1}/_{5}$. The whipping ability was carried out as given by El-Neshawy *et al.* (1988). The overrun and melting resistance were determined according to Sommer (1951) and Arbuckle (1986), respectively.

Organoliptic properties:

Scoring card was used for the sensory evaluationof the produced ice milk by 15 panelists from the Dairy Sci. & Tech. Dept. staff , for flavour (50 points), body and texture (35 points), melting quality (10 points) and colour (5 points).

Statistical analysis:

Factorial design and completely randamized design were block used to analyze all the data and Newman Keuls test was followed to make the multiple comparisons (Steel and Torri, 1980) using Costat program. Significant differences were calculated at ($p \leq 0.05$).

RESULTS AND DISCUSSION

Mix properties:

Acidity of ice milk mix was decreased significantly ($p \leq 0.05$) by substituting skim milk powder (SMP) with oat flour (Tables 3 and 7). This decrease of acidity was proportional to the rate of SMP replacement with oat flour, which means negative correlation between the acidity of ice milk and the rates of replacement. This decrease may be due to that oat flour has lower protein content and higher fiber content than SMP.

Specific gravity and weight per gallon of the ice milk mix were increased significantly ($p \leq 0.05$) as the replacement with oat flour increased (Tables 3, 7). These results are in agreement with those reported by Salem *et al.* (2003).

Table (3). Effect of replacing of skim milk powder with oat flour on ice milk mixes properties.

Properties	Treatments*			
	C	T_1	T_2	T_3
Titratable acidity (%)	0.200	0.196	0.190	0.188
Specific gravity (g/cm^3)	1.073	1.098	1.109	1.128
Weight / gallon (kg)	4.062	4.157	4.199	4.271
Viscosity (cp)•	93	240	418	501
Freezing point (°C)	-2.2	-1.50	-0.70	-0.10
Whipping ability (%)				
After: 5 min	14.72	18.94	20.35	10.89
10 min	35.50	38.82	39.86	30.69
15 min	45.00	49.66	53.65	43.76
20 min	43.23	46.49	50.68	40.82

*See Table (2) for details.
• Shear rate (49 cp).

Viscosity of ice milk mix was increased significantly ($p \leq 0.05$) by replacing of SMP with oat flour (Tables 3, 7). Treatment T_3 which did not have carboxy methyl cellulose (CMC) was increased 5 time than control treatment , which have CMC (0.30%). This increase in viscosity may be due to the nature of dietary fiber found in oat flour (beta-glucan) which had exceptional water binding capacity and ability to enhance viscosity (Wang *et al.*, 1998). These results are in line with the finding of Salem *et al.* (2003). Also, Soukulis and Rontogianni (2009) reported that the use of dietary fiber (as in oat flour) may be important in ice cream formulation as it may furnish many functional characteristics including: (a) Increase of mixes viscosity. (b) Improvement of textural characteristics. (c) Increasing of melting resistance.

The freezing point of ice milk mixes was increased significantly ($p \leq 0.05$) by using oat flour (Tables 3, 7). These results agree with those of Omar (1983), who mentioned that the freezing point of ice cream was lowered by increasing the percentage of milk solids not fat which contained lactose and minerals. The freezing point of ice cream is dependent on soluble constituent in mix. (Arbuckle, 1986).

The whipping ability of ice milk mix increased when part of the skim milk powder was replaced up to 50% by oat flour (Tables 3, 7). This could be attributed to the high soluble fiber beta-glucan, protein, and carbohydrates content of oat flour which act as stabilizer (Soukulis and Rontogianni, 2009). Increasing oat flour up to 75% decreased whipping ability than replacement

of 25% and 50% but till higher than control. This decrease may be due to the higher viscosity of 75% replacement which increased five times than control .

Ice milk properties:

It is clear from Tables (4, 7) that specific gravity and weight per gallon of the resultant ice milk were decreased gradually ($p \leq 0.05$) by replacing of SMP by 25% up to 50% with oat flour, then increased by 75% of replacement. This might be due to the increase of overrun. This high overrun could be due to the increase of viscosity and high whipping ability of T_1 and T_2 mixtures, which were made by substituting 25% and 50% of SMP with oat flour.

The overrun percentage of the resultant ice milk was increased ($p \leq 0.05$) significantly by increasing the replacements of SMP by oat flour up to 50%, then decreased (Tables 4, 7). This increase in overrun at replacing ratio of 25 and 50% with oat flour might be due to the better functional properties of beta-glucan fiber found in oat flour, which act as a stabilizer (Blomsma, 1997). However, treatment T_3 gave the lowest percentage overrun. The decrease in the overrun which was observed by increasing the replacement ratio of SMP with oat flour to 75% and which prepared without using stabilizer CMC could be attributed to the over high increase of viscosity. These results are in line with the finding of El-Nagar and Kuri (2001), Salem *et al.* (2003) and Soukulis and Rontogianni (2009).

Table (4). Effect of replacing skim milk powder with oat flour on the resultant ice milk properties.

Properties	Treatments			
	C	T_1	T_2	T_3
Specific gravity (g/cm^3)	0.740	0.734	0.722	0.785
Weight/gallon (kg)	2.801	2.800	2.733	2.972
Overrun (%)	45.00	49.66	53.65	43.76
Melting resistance loss%:				
At 25 °C after 15 min	–	–	–	–
30 min	5.77	5.07	3.02	–
45 min	11.20	10.65	7.20	4.46
75 min	36.90	35.07	33.62	30.26

See Table (2) for details.

The increase in melting resistance of the resultant ice milk was proportional to the amount of oat flour used (Tables 4, 7). This increase could be attributed to the high water hydration capacity of the oat flour and soluble fiber beta-glucan content. These results are in accordance with those reported by Soukulis and Rontogianni (2009). The control ice milk showed lower melting resistance than the rest of ice milk treatments made with replacement of SMP with oat flour. This may be due to their lower freezing

point compared with other treatments supplemented with oat flour, which caused observed decrease in the rate of melting. These results are in line with Arbuckle (1986), who stated that using low lactose products in ice cream making caused some influence on the rate of melting.

Data presented in Table (5) show that the effect of substituting 50% of SMP with oat flour on the essential and non-essential amino acids. It is clear that ice milk made with oat flour had higher content in both total non-essential and total essential amino acids content except methionine compared with ice milk made without oat flour (control). These results are in accordance with those reported by Matz (1991).

Table (5). Effect of substitution of skim milk powder with oat flour on amino acids content of ice milk.

Amino acids*	Control	T_2
Essential amino acids (E.A.A):		
Luc	1.442	1.786
Iluc	0.609	0.762
Lys	0.685	0.906
Met	0.343	0.177
Phe	0.312	0.643
Thr	0.641	0.745
Trp	ND	ND
Val	0.446	0.910
Total E.A.A	4.478[b]	5.929[a]
Non essential amino acids (N.E.A.A.):		
Ala	0.540	0.673
Asp	1.276	1.534
Glu	2.738	3.328
Gly	0.321	0.474
His	0.361	0.478
Pro	0.267	0.343
Ser	0.804	0.976
Tyr	0.433	0.582
Arg	0.258	0.390
Total N.E.A.A	6.998[b]	8.778[a]

* g/100 g of ice milk "on dry matter".
T_2 = Ice milk made with 50% substitution of skim milk powder with oat flour.
ND = Not determined.

The results in Table (6) indicate a remarkable increase in fibers and minerals (zinc, selenium, iron and manganese) contents in ice milk made with 50% substitution of SMP with oat flour.

Table (6). Concentration of crude fibers % and some mineral elements (mg / 100 g) of ice milk "on dry weight basis".

Constituents	Treatments	
	Control	T_2
Fibers %	–	0.27
K	559.90	508.42
Zn	4.84	4.94
Fe	12.45	20.66
Se	0.10	0.11
Mn	0.42	3.45

T_2 = Ice milk made with 50% substitution of skim milk powder with oat flour.

Organoleptic quality:

The organoleptic scoring of ice milk as affected by skim milk powder replacement with different levels of oat flour are illustrated in Fig.1. It is obvious that ice milk made with oat flour gained higher body & texture and melting properties scores than control which made with skim milk powder without any adverse effect on it's flavour. This could be attributed to the high water-holding capacity of the dietary fiber (B-glucans) of oat flour. The high water-holding of the oat flour aids in smoothing the texture and gives the body to the finishes product (Arbuckle, 1986). Also, Fernandz-Garcia and McGregor (1997) reported that the oat fiber gave the best results for plan yoghurt in terms of flavour quality scores. These results are in agreement with Salem *et al* (2003). Sensory evalution of the resultant ice milk showed that all treatments were acceptable for flavour body & texture and melting quality during 4 weeks of storage period at -18°C.

From the foregoing results it could be concluded that oat flour can be used to replace SMP required in formulating ice milk up to 50% level. Such replacement permite to reduce the stabilizer from 0.3% to 0.1% only, While treatment made with 75% skim milk powder does not require any stabilizer .

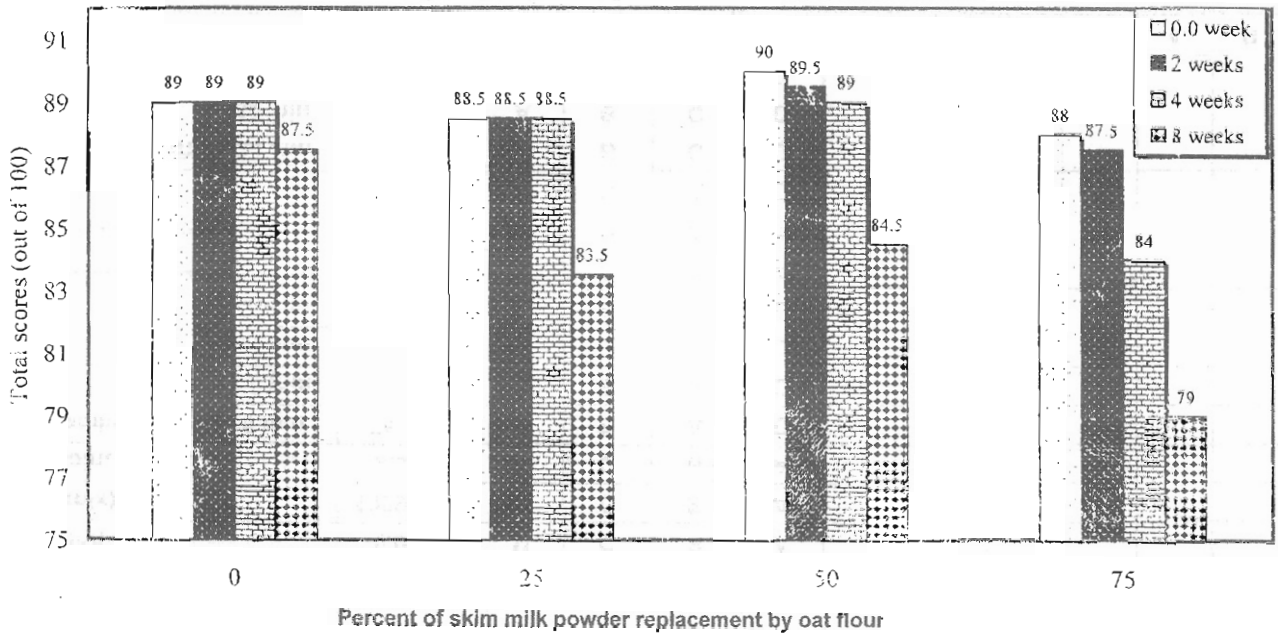

Fig. (1). Effect of replacing skim milk powder with oat flour on total scores of organoleptic properties (out of 100) on ice milk stored at -18°C for 8 weeks.

Table (7). Statistical analysis of ice milk properties made with different replacement levels of skim milk powder with oat flour.

Ice milk Properties	Effect of treatments					Effect of storage period (weeks)				
	Multiple comparisons*					Multiple comparisons*				
	Mean squares	C♦	T_1	T_2	T_3	Mean squares	0	2	4	8
Acidity %	0.008*	A	AB	BC	C					
Specific gravity (mix)	0.054*	D	C	B	A					
Weight/gallon (mix)	0.023*	D	C	B	A					
Viscosity (mix)	1009.000*	D	C	B	A					
Freezing point (mix)	2.528*	D	C	B	A					
Whipping ability After: 5 min	55.114*	C	B	A	D					
10 min	51.109*	C	B	A	D					
15 min	61.654*	C	B	A	D					
20 min	54.716*	C	B	A	D					
Specific gravity (ice milk)	0.023*	B	B	C	A					
Weight/gallon (ice milk)	0.031*	B	B	C	A					
Overrun (ice milk)	61.654*	C	B	A	D					
Melting resistance after: 30 min	20.103*	A	B	C	D					
45 min	29.864*	A	B	C	D					
75 min	23.681*	A	AB	B	C					
Total organoleptic scores	41.797*	A	A	A	B	45.547*	A	A	A	B

♦ See Table (2). * Significant at 0.05 level.

• 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.

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تأثير استبدال اللبن الفرز المجفف بدقيق الشوفان على جودة المثلوج اللبنى

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الملخص العربى:

يهدف هذا البحث إلى إستخدام دقيق الشوفان كبديل للبن الفرز المجفف فى تصنيع المثلوج اللبنى المحتوى على (٦% دهن و١٢% جوامد لادهنية و٠,٣% مادة رابطة و١٦% سكر) حيث يمتاز دقيق الشوفان بإرتفاع نسبة الألياف الغذائية الذائبة (B-Glucans) ذات الخواص الوظيفية والداعمة للحيوية فضلاً عن كونه مادة مالئة وكعامل مساعد لتحسين صفة القوام والتركيب البنائى للمثلوج اللبنى .

ولقد تم دراسة تأثير هذا الإستبدال بنسب ٢٥% ، ٥٠% ، ٧٥% من اللبن الفرز المجفف على جودة المثلوج اللبنى ومقارنتها بمخلوط المثلوج اللبنى المستخدم فيه اللبن الفرز المجفف كمصدر رئيسى لجوامد اللبن اللادهنية وكانت أهم النتائج المتحصل عليها ما يلى :

١- إستخدام دقيق الشوفان أدى إلى زيادة الوزن النوعى والوزن بالجالون واللزوجة ونقطة التجمد بينما انخفضت الحموضة مع زيادة نسبة الاستبدال بدقيق الشوفان وكانت الزيادة معنوية وذلك بالمقارنة بالعينة الكنترول. كما سبب الإستبدال أيضا زيادة قابلية المخاليط للخفق والنسبة المئوية للربع والمقاومة للإنصهار وأن هذه الزيادة تزيد بزيادة نسبة الإستبدال بدقيق الشوفان حتى ٥٠% استبدال ثم تنخفض بعد ذلك ولكنها كانت أعلى من الكنترول.

٢- انخفض الوزن النوعى والوزن بالجالون للمثلوج اللبنى الناتج مع زيادة نسبة الإستبدال بدقيق الشوفان حتى ٥٠% .

٣- لوحظ زيادة محتوى المثلوجات اللبنية المحتوية على ٥٠٪ دقيق شوفان من الأحماض

الأمينية الضرورية والأحماض الأمينية غير الضرورية ما عدا حمض الميثيونين ، وكذلك بعض الأملاح المعدنية وهى "الحديد والزنك والسلينيم والمنجنيز" والألياف ، بينما حدث انخفاض فى عنصر البوتاسيوم.

٤- من الناحية الحسية كانت جميع العينات مقبولة بدون إستثناء وأرتفعت درجات التحكيم للمثلوج اللبنى المحتوى على دقيق الشوفان وذلك لتحسين خواص القوام والتركيب والمقاومة للانصهار مقارنةً بالعينة الكنترول الخالية من دقيق الشوفان، كما أنه لم يظهر به أى عيوب فى النكهة أو اللون وحتى بعد التخزين على درجة -١٨°م لمدة ٤ أسابيع .

مما سبق يتضح أنه يُمكن استخدام دقيق الشوفان فى صناعة مخاليط المثلوجات اللبنية بنسبة إستبدال من اللبن الفرز المجفف٥٠% يليها ٧٥% للحصول على منتج مرتفع القيمة الغذائية والصحية وذا خواص وظيفية وحسية جيدة حتى بعد تخزينه لمدة ٤ أسابيع على درجة -١٨°م وبدون تأثير غير مرغوب على النكهة أو خواص القوام والتركيب البنائى كما أن استخدام دقيق الشوفان أدى إلى خفض نسبة المثبت المستخدمة فى الصناعة من ٠,٣% إلى ٠,١% فى العينة ذات الأستبدال ٥٠% بينما العينات ذات نسبة الأستبدال ٧٥% لم تحتاج إلى إستخدام المثبت وهذا مهم من الوجهة الإقتصادية فى الصناعة.