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Organoleptic and Physical Properties of Ice Cream made from Hydrolysed Lactose Reconstituted Milk

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ABSTRACT

Partially hydrolysed lactose reconstituted milk (HLRM) (about 50% and 75% lactose hydrolysis) was used in ice cream making. A control mix was also manufactured from fresh buffalo's milk.

Mixes containing HLRM showed higher viscosity and whipping ability and yielded an ice cream of higher overrun and better organoleptic properties than the control. The higher level of lactose hydrolysis was more effective in the above properties.

Manufacturing of ice cream from mixes made using HLRM of about 75% hydrolysed lactose allowed the sucrose contents of mixes to be reduced by 12·5% to 25% of the sucrose used in control mixes without significant effects on the properties of the product.

INTRODUCTION

Ice cream production has increased rapidly in recent years in many countries of the world. Quality and physico-chemical properties of ice cream are greatly affected by the milk ingredients used for making ice cream.

Sandy texture is one of the main defects in ice cream. This defect is due entirely to fairly large lactose crystals which are slow to dissolve (Arbuckle, 1972). The high lactose content of the mix favours the development of this defect. To overcome this defect, low lactose milk has been used in ice cream

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making. The use of delactosed products in ice cream making increased the mix viscosity and improved the quality of the resultant ice cream (Young *et al.*, 1982). Steinsholt & Bredevein (1977) showed that the use of ultrafiltered skim milk as a source of low lactose milk solids non fat (MSNF) for ice cream making, caused a reduction in the quality of the product. They showed that ice cream with MSNF from ultrafiltered skim milk appeared to be harder, possess a higher density, a lower viscosity and a lower score for consistency compared with samples produced on the basis of dried skim milk. Arbuckle (1972) observed that the use of low lactose skim milk for making ice cream enabled one to increase the mix milk solids non fat without incidence of sandiness and with improved body and texture properties. From a nutritional point of view, there are several reasons for milk allergy, of which lactose intolerance is an essential factor (Mann, 1981). The object of this work was to evaluate the organoleptic and physical properties of ice cream made using hydolysed lactose reconstituted milk in mix preparation.

MATERIALS AND METHODS

Materials

Milk
Fresh buffalo's milk and fresh cream (60% fat) were taken from the Dairy Laboratory, Food Science Department, Faculty of Agriculture, Zagazig University. Skim milk powder was obtained from the Misr Milk and Food Company, Egypt.

Stabiliser
A stabiliser, IC 107, was obtained from Milkyland Company, Egypt.

Lactozym
A liquid commercial β-galactosidase preparation containing 3000 LAU/ml derived from the yeast *Kluyveromyces fragilis* was obtained from NOVO Industries, Denmark.

Sweetener
Cane sugar was used as a sweetener.

Preparation of hydrolysed lactose milk

Skim milk powder was reconstituted in warm water (40°C) to contain 11% SNF. Reconstituted skim milk (RSM) was heated to 71°C for 15 s and

rapidly cooled to 37°C. The milk was incubated with lactozyme at a level of 1 ml (3000 LAU)/kg until the desired degree of lactose hydrolysis had been achieved. (It was found from pilot experiments that incubating RSM with lactozyme at a level of 1 ml (3000 LAU)/kg milk gave degrees of lactose hydrolysis of 50·2 and 75·3% after 45 and 70 min at 37°C, respectively.) Lactose and its hydrolysed products were estimated according to Nickerson *et al.* (1976).

Preparation of ice cream mixes

First trial

In this trial four different mixes were prepared as follows.

The first mix was prepared from fresh buffalo's milk and used as a control.
The second mix was prepared from reconstituted skim milk.
The third mix was prepared from 50% hydrolysed lactose reconstituted milk HLRM standardised.
The fourth mix was prepared from 75% HLRM.

All mixes were standardised to contain 6% fat, 11% MSNF, 16% sugar and 0·4% stabiliser. Ice cream was made according to Khalafalla *et al.* (1975). Ingredients were mixed well, heated to 75°C for 30 min, cooled to 5°C and aged at this temperature for 8 h. Then mixes were frozen in an ice cream freezer machine type Espiessoer 233 F 20070 Guardamiglio Milano, Italia, at the Zagazig Agriculture Secondary School.

Second trial

Mixes were prepared from 75% HLRM, as previously mentioned, with the same composition except that two levels of sugar were added to the mix, being 12% and 14%. Control mix was made from the same milk containing 16% sugar. Mixes were treated as in the first trial. Resultant ice cream from all mixes was stored at −15°C for 30 days. All treatments were carried out in triplicate.

Examination of mixes and resultant ice cream

Mixes were examined for titratable acidity as suggested by Arbuckle (1972), specific gravity according to Winton (1958) and viscosity using a Hoppler viscometer according to Tabias & Tracy (1950).

The whipping ability test of ice cream mix was carried out using a food mixer according to Hughes (1967). The ice cream mix was placed in the bowl of the mixer and cooled to 0°C using an ice and salt mixture. The mixes were

then whipped at the maximum speed. The specific volume (cm^3/g) was measured at different intervals of time during whipping. The temperature of the mix was maintained below 5°C.

The resultant ice cream samples were examined for specific gravity Burke (1947), overrun (Sommer, 1951) and melting properties according to Thomas & Comps (1944). The samples were also organoleptically examined according to Arbuckle (1977). Standard deviation was calculated according to Snedecor (1961).

RESULTS AND DISCUSSION

Partial lactose hydrolysis in ice cream making

Effect on mix properties

Table 1 indicates that using HLRM had no marked effect on either specific gravity or titratable acidity of the different mixes. These results could be explained on the basis that all mixes contained the same percentage of fat, MSNF and sugar.

Khalafalla *et al.* (1975) found that ice cream mixes having similar composition showed no differences in acidity and specific gravity.

On the other hand, mixes containing partially hydrolysed lactose milk showed higher viscosity than mixes containing either untreated RSM or buffalo's milk (control).

The increase in the viscosity of the mixes was proportional to the degree of lactose hydrolysis. Smith *et al.* (1984) studied the effect of various sweeteners on the viscosity of ice cream mixes. They reported that fructose and glucose structure aqueous systems more than sucrose. They also stated that sweeteners which contain a large amount of glucose increase the structure. Smith *et al.* (1985) found that the increase in structure from changes in arrangement of water molecules around the sugar molecules could result in differences in the extent of hydration and increase the viscosity.

Table 1 also shows that whipping ability (as determined by the specific volume) of mixes containing partially hydrolysed lactose milk was higher than those containing both untreated RSM and buffalo's milk (control). Also, the specific volume of the mixes increased with increasing whipping time up to 10 min, then decreased. Arbuckle (1977) reported that whipping ability of ice cream mix is dependent on composition, efficiency of whipping mechanism and viscosity of the mix. Since the whipping mechanism and composition of the experimental mixes were constant, it can be stated that differences in the whipping ability of mixes could be due to the higher

TABLE 1
Effect of Partial Lactose Hydrolysis on some Properties of Ice Cream Mixes

Properties	*Control*		*Degree of lactose hydrolysis (%)*					
			0·0		*50*		*75*	
	X	*SD*	*X*	*SD*	*X*	*SD*	*X*	*SD*
Specific gravity (g/cm^3)	1·11	0·081	1·11	0·076	1·106	0·067	1·11	0·084
Acidity (%)	0·17	0·012	0·17	0·010	0·18	0·009	0·18	0·009
Viscosity (Cp)	618	112	615	134	658	160	692	115
Whipping ability[a] after a whipping time (min) of								
0	0·904	0·118	0·904	0·071	0·9040	0·117	0·904	0·081
2	1·32	0·163	1·27	0·169	1·398	0·149	1·42	0·110
5	1·47	0·164	1·38	0·145	1·589	0·141	1·69	0·121
10	1·77	0·271	1·45	0·191	1·814	0·203	1·94	0·192
20	1·31	0·269	1·32	0·248	1·401	0·296	1·43	0·217

[a] Specific volume, cm^3/g.
X = average.
SD = standard deviation.

TABLE 2
Effect of Partial Lactose Hydrolysis on Some Properties of Ice Cream

Properties	*Control*		*Degree of lactose hydrolysis* (%)					
			0·0		*50*		*75*	
	X	*SD*	*X*	*SD*	*X*	*SD*	*X*	*SD*
Specific gravity (g/cm^3)	0·644	0·605	0·672	0·073	0·632	0·081	0·621	0·062
Overrun (%)	82	13	72	14	83	12	84	12
Melting resistance as % drainage at 30°C after:								
30 min	18	1·1	26	1·6	18	1·4	17	1·9
60 min	37	6·3	43	6·9	36	8·7	35	6·3
90 min	73	4·1	75	7·5	72	7·9	71	5·6

X = average.
SD = standard deviation.

viscosity of the mixes containing HLRM which allows early incorporation of the air into the mix. El Fak (1975) and Metwally *et al.* (1979) showed that the whipping ability of ice cream mix was in proportion to its viscosity.

Effects on ice cream properties

Table 2 shows that ice cream made from untreated RSM showed higher specific gravity and lower overrun than that made from buffalo's milk (control).

However, using 50% or 75% HLRM led to a decrease in the specific gravity and an increase in the overrun. This effect was more pronounced when ice cream was made from a mix containing 75% HLRM. These results could be explained on the basis that hydrolysed lactose milk increased the mix viscosity, which, in turn, increased the whipping ability, resulting in high overrun and low specific gravity.

Filchakova (1974), Wielinga (1977) and Metwally (1979) found similar trends in normal ice cream.

Table 2 shows that RSM reduced the melting properties of ice cream compared with the control. But when 50% and 75% HLRMwere used in ice cream making, it increased the melting resistance of the product to make it comparable, or even more resistant, than the control. This was more noticeable in 75% hydrolysed lactose milk. These results could be due to the increase in mix viscosity resulting from hydrolysed lactose milk. Similar results were obtained by Frandson & Arbuckle (1961).

Organoleptic properties

Table 3 shows that ice cream made from untreated RSM gained lower score points (especially for body and texture) than the control. In addition, a sandy texture was observed in the product. However, ice cream made from mixes containing 50% or 75% HLRM was characterised by improved flavour, smooth texture and good melting properties during storage. Moreover, HLRM imparted considerable sweetness. Similar results were obtained by Huse *et al.* (1984). The results could be explained on the basis that hydrolysis of milk sugar controls the formation of large lactose crystals which cause the sandy texture. In addition, hydrolysis of lactose to glucose and galactose lowers the freezing point of the mix and this, in turn, decreases the size of ice crystals (Arbuckle, 1972).

In the light of these results, it could be concluded that ice cream made from a mix containing 75% HLRM was characterised with improved body and texture but the product showed relatively higher sweetness compared with that of the control. Therefore, it was found desirable to evaluate the possibility of reducing sugar levels in the mixes.

TABLE 3
Effect of Partial Lactose Hydrolysis on Organoleptic Properties[a] of Ice Cream during Storage at −15°C

Storage period (days)	Properties	Maximum score points	Control	Degree of lactose hydrolysis (%)		
				0·0	50	75
Fresh	Flavour	(45)	42	36	41	42
	Body and texture	(30)	27	18	28	29
	Melting	(5)	4	3	5	5
	Colour	(5)	5	5	5	5
	Total	(85)	78	63	79	81
15	Flavour	(45)	41	35	49	41
	Body and texture	(30)	25	16	28	29
	Melting	(5)	4	3	4	4
	Colour	(5)	5	5	5	5
	Total	(85)	75	59	77	79
30	Flavour	(45)	40	32	40	40
	Body and texture	(30)	25	15	27	28
	Melting	(5)	4	2	4	4
	Colour	(5)	5	5	5	5
	Total	(85)	74	54	76	77

[a] Averages of five judges.

Sucrose levels in ice cream mixes made using hydrolysed lactose RSM

The influence of reducing the level of sucrose added to the mix on the organoleptic and physical properties of ice cream made using 75% HLRM was investigated.

Properties of the mixes

Table 4 shows that reducing the sugar level in the mixes slightly reduced the specific gravity and viscosity of the mixes but did not affect the titratable acidity. Nickerson & Pangborn (1961) found that increasing the level of sugar added to the mix increased its viscosity.

Table 4 also shows that the whipping ability of mixes containing 12% sugar was comparable to that of control, while that containing 14% sugar was higher than the control. Arbuckle (1977) reported that increasing the sugar level in the ice cream mix reduced its whipping ability.

Properties of ice cream

Table 5 shows that ice cream made from mixes containing 75% HLRM and different levels of sucrose showed no remarkable difference in specific

TABLE 4
Some Properties of Ice Cream Mix made from HLRM (75% Hydrolysed Lactose) as Affected by Sucrose Level

Properties	*Sugar level (%)*					
	16 (control)		*12*		*14*	
	X	*SD*	*X*	*SD*	*X*	*SD*
Specific gravity	1·11	0·110	1·10	0·109	1·10	0·128
Acidity	0·175	0·0067	0·178	0·010	0·180	0·016
Viscosity (Cp)	638	806	651	97	672	121
Whipping ability after a whipping time (min) of						
0	0·904	0·092	0·97	0·101	0·906	0·100
2	1·41	0·121	1·39	0·792	1·43	0·131
5	1·598	0·148	1·58	0·166	1·65	1·76
10	1·92	0·197	1·80	0·219	1·94	0·211
20	1·42	0·221	1·41	0·194	1·40	0·209

X = Average.
SD = Standard deviation.

TABLE 5
Some Properties of Ice Cream made from HLRM (of 75% Hydrolysed Lactose) as Affected by Sucrose Level

Properties	*Sugar level (%)*					
	16 (control)		*12*		*14*	
	X	*SD*	*X*	*SD*	*X*	*SD*
Specific gravity	0·632	0·073	0·6361	0·0572	0·6241	0·0811
Overrun (%)	84	14	84	15	85	15
Melting resistance as % drainage at 30°C after:						
30 min	18	0·9	18	7·1	17	7·0
60 min	39	4·7	36	3·2	36	3·0
90 min	72	6·4	71	6·6	70	6·2

X = Average.
SD = standard deviation.

TABLE 6
Organoleptic Properties[a] of Ice Cream made from 75% Hydrolysed Lactose Reconstituted Milk as Affected by Sugar Level

Storage periods (days)	*Property*	*Maximum score points*	*Sugar level (%)*		
			16 (control)	*12*	*14*
Fresh	Flavour	(45)	42	40	43
	Body and texture	(30)	28	27	29
	Melting	(5)	4	5	5
	Colour	(5)	5	5	5
	Total	(85)	79	77	82
15	Flavour	(45)	41	39	42
	Body and texture	(30)	27	27	28
	Melting	(5)	4	5	5
	Colour	(5)	5	5	5
	Total	(85)	77	76	80
30	Flavour	(45)	40	38	41
	Body and texture	(30)	27	27	38
	Melting	(5)	4	4	4
	Colour	(5)	5	5	5
	Total	(30)	76	74	78

[a] Averages of five judges.

gravity, but the overrun was slightly increased in the case of the mix containing 14% sucrose.

On the other hand, it could be also observed that reducing the sugar level of the mix increased the melting resistance of the resultant ice cream. (Nickerson & Pangborn, 1961).

Organoleptic properties of the products

Table 6 shows that ice cream made from the mix containing 14% sucrose gained the highest score points for flavour during storage. Ice cream containing 12% sugar had a satisfactory taste but was less sweet than the control. The textures and colours of all ice cream samples were comparable.

In conclusion, the use of HLRM of about 75% hydrolysed lactose could be recommended. This treatment gave a product with acceptable quality and reduced the sugar content by 12·5%–25% of the sugar used in the control.

REFERENCES

Arbuckle, W. S. (1972). *Ice cream*, (2nd edn), The AVI Publishing Company, Inc., Westport, Connecticut.

Arbuckle, W. S. (1977). *Ice cream.* (3rd edn), The AVI Publishing Company, Inc., Westport, Connecticut.

Burke, A. D. (1947). *Practical ice cream making.* The Olsen Publishing Co., Milwaukee, Wisconsin.

El-Fak, A. M. (1975). *The effect of sugars and casein on the rheological properties of stabilizers.* PhD Thesis, University of Salford, UK.

Filchakova, N. N. (1975). Influence of airphase dispersity on hard ice cream texture. *Bulletin de l'Institute international du froid (1975) Annexe 1974–3,* 321–5; *Dairy Sci. Abs.* **39**, 1188–977.

Francisen, J. H. & Arbuckle, W. S. (1961). *Ice cream and related products.* The Avi Publishing Company, Inc., Westport, Connecticut.

Hughes, E. J. (1967). *Stabilizers in ice cream.* Confidential communication. Unilever Research Laboratory, Welwyn, UK.

Huse, P. A., Towler, C. & Harrer, W. J. (1984). Substitution of non-fat solids in ice cream with whey protein concentrate and hydrolysed lactose. *New Zealand J. of Dairy Sci. and Tech.*, **19**(3), 225–61.

Khalafalla, S. M., Maharan, G. A., Abdel Hamid L. B. & Fares, F. M. (1975). The use of whey solids in ice cream. *Egyptian J. Dairy Sci.*, **3**, 43–50.

Mann, E. J. (1981). Lactose hydrolysed milk and dairy products. *Dairy Industries International,* **46**(9), 17–19.

Metwally, M. M. (1979). *The use of vegetable gums and soy milk in the manufacture of ice cream.* MSc Thesis, Fac. of Agric. Zagazig Univ. Egypt.

Nickerson, T. A. & Pangborn, R. (1961). The influence of sugar in ice cream. III. Effect of physical properties. *Food Technology*, **3**, 106.

Nickerson, T. A., Vujicic, I. F. & Lin, A. Y. (1976). Colorimetric estimation of lactose and its hydrolytic products. *J. Dairy Sci.*, **59**, 386–90.

Smith, D. E., Bakshi, A. S. & Lomauro, C. J. (1984). Changes in freezing point and rheological properties of ice cream mix as a function of sweetener system and whey substitution. *Milch wissenschaft*, **39**, 455.

Smith, D. E., Bakshi, A. S. & Eay, S. A. (1985). Changes in electrical energy requirements to operate an ice cream freezer as a function of sweeteners and gums. *J. Dairy Sci.*, **68**(b), 1349–51.

Snedecor. G. W. (1961). *Statistical methods* (5th edn), The Iowa State University, USA.

Sommer, H. H. (1951). *The theory and practice of ice cream making.* (6th edn). Published by the Author, Madison, Wisconsin.

Steinsholt, A. & Bredevein, J. (1977). *Ultrafiltered and hyperfiltered concentrates as sources of milk solids not fat in ice cream.* Report No. 203 from the Dairy Research Institute, the Agriculture University of Norway.

Tabias, J. & Tracy, P. H. (1950). Basic viscosity of ice cream mixes. *Ice cream trade J.*, **46**, 183. *cf. Dairy Sci. Abs.*, **12**, 428.

Thomas, E. L. & Comps, W. B. (1944). Observations on the use of roller process sweet cream butter milk powder in ice cream. *J. Dairy Sci.*, **27**, 419.

Wielinga, W. C. (1977). Some aspects of stabilization of edible ices. *Voedingsmiddelen technologie*, **10**(21), 12–15. *cf. Dairy Sci. Abs.*, **40**, (1978), 5573.

Winton, A. L. (1958). *Analysis of food.* (3rd edn), John Wiley & Sons, New York.

Young, C. K., Warrenstull, J., Taylor, R. R., Angus, R. C. & Daniel, T. C. (1982). Acceptability of frozen desserts made with neutralized hydrolysed fluid cottage cheese whey. *J. Food Sci.*, **47**, 989–95.