THE EFFECT OF THE USE OF CORN SYRUP SOLIDS OF DIFFERENT DEXTROSE EQUIVALENTS ON THE QUALITY AND PROPERTIES OF ICE MILK

by

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INTRODUCTION

Ice milk is a product similar to ice cream in character but it generally contains an extra two percent of non-fat milk solids and its fat content is reduced from 10-12% to 2-7%. There are several merits in ice milk besides being less expensive than ice cream. It is relatively low in fat and calorie content. It is a frozen food recommended by physicians and dietitians. Ice milk serves in the preparation of milk drinks, such as malts and shakes, which are palatable products of a lower fat content than those made with ice cream.

The total production of ice milk in the United States in 1961 was 144,740,000 gallons. Hard ice milk production was 79,883,000 gallons and soft ice milk production was 64,857,000 gallons. The three leading states ranked in order of total production of ice milk are: California, Illinois, Ohio, (1).

The Federal standards for composition of ice milk are as follows (12):

a)	Milk fat	min. 2.0%	max. 7.0%
b)	Total milk solids	min. 11.0%	
c)	Stabilizer		max. 0.5%
d)	Weight per gallon	min. lbs. 4.5	
e)	Food solids per gallons	min. lbs. 1.3	

The state standards for milk fat vary from a minimum of 2.0-4.0% and a maximum of 5.0-10.0%. Twenty-five states have a minimum butterfat standard of 2.0-3.0%; twenty-one states specify 3.1-4.0%. One state requires over 4.1% and six states do not have a minimum fat standard. Five states have a maximum of 4.0-5.0%; seven states specify 5.1-6.0%; six states have over 6.1%

and 15 states do not have a maximum fat standard.

The percentage of total milk solids required by state standards is 10-14%. Most states have a maximum of 0.5% stabilizer with the exception of Illinois which has a maximum of 1.0% and Washington with a maximum of 0.6%. The minimum weight per gallon according to state standards varies from 4.2 to 5.0 lb. and the minimum food solids per gallon is 1.0 to 1.5 lb. (12).

There are 2 types of ice milk available, hard ice milk with an overrun of 70-100% and soft serve ice milk with 30-50% of overrun.

This experiment was undertaken to obtain further information on the effect of different types of corn syrup solids, when used in combination with sucrose on the properties and quality of ice milk and to check consumer acceptance of the ice milks in which the different sweeteners were used.

REVIEW OF LITERATURE

Corn Syrup Solids in Ice Cream and Related Products

Corn sweeteners were used first in ice cream during World War I when sucrose was in short supply. Improvements in corn product technology have continued since World War II with the result that today the use of corn syrup or corn syrup solids can be considered as a desirable practice in the production of quality ice cream and related products.

Various types of corn sweeteners are available in both liquid and solid form. Their production is accomplished by stopping the hydrolysis of the corn starch, the end product of which is dextrose or corn sugar. After the purifying, decolorizing and refining, the resulting product is called corn syrup. The dry form of corn syrup (CS) is known as corn syrup solids (CSS) (24). These materials are classified according to the degree to which complete conversion to dextrose has been accomplished. According to Frandsen (12) there are 4 types:

a) Low conversion 30-37 DE[1]

b) Regular conversion 38-49 DE

c) Intermediate conversion 50-57 DE

d) High conversion 58-higher DE

Table 1 shows the approximate carbohydrate composition of corn sweeteners of various DE on dry basis.

TABLE 1

Typical carbohydrate composition of commercial corn sweeteners

Type	DE	Mono	Di	Per cent saccharides Tri	Tetra	Penta	Hexa	Hept	Higher
Dextrose	100	100	-	-	-	-	-	-	-
High conversion	60	36	20	13	9	6	4	3	9
Regular "	42	18	14	12	10	8	7	6	25
Low "	24	8	8	7	7	6	5	5	54

According to Drusendahl (6), the primary purpose of CSS in ice cream and related products is to improve the body and texture. Since CSS are neutral in flavor and low in sweetening value, they may be used to build up

[1]DE = Dextrose equivalent. The dextrose equivalent is a measure of reducing-sugar calculated as dextrose and expressed as percentage of the total dry substance. Pure dextrose has a DE of 100. Corn syrup and CSS are available in the range of 28-62 DE.

the solids of the mix. Caulfield (3) pointed out that through the use of CSS the total solids content of the ice cream mix may be increased to 40 per cent or more and at a minimum cost.

Drusendahl (8) reported that the incorporation of the proper type and amount of CSS in ice cream aids in producing a fine texture, firm and chewy bodied ice cream. There are several reasons why CSS can do this. Higher percentages of high molecular weight sugar produce a firmer texture and it is possible to build a higher total solids in ice cream without danger of lactose crystallization or "sandiness". Mixes containing all CSS have a higher freezing point than mixes containing all sucrose which makes it possible to draw a dry-stiff ice cream from the freezer. The same author recognized that corn sweetener has more sweetening power when used in combination with sucrose than when used alone.

According to Drusendahl (10) low DE CSS has smaller quantities of monosaccharides and disaccharides, which depress the freezing point less than sucrose. Tharp (24) reported that many investigators have demonstrated that the use of low conversion CSS is equal and sometimes, superior to the regular conversion products. On the other hand, Caulfield (3) recommended regular CSS for use in ice cream over high conversion CSS for the following reasons:

a) "Regular CSS has a low sweetening value and hence may be used at the rate of 2 lb of CSS for each pound of cane or beet sugar replaced without increasing the sweetness of the mix."
b) "Regular CSS contains a relatively high percentage of dextrins and higher sugars. These materials are starch-like in character.

They can combine with water of the mix and hence tend to improve the body and texture of ice cream."

Caulfield (3) further reported that the majority of the investigators agree that the use of CSS in ice cream at the rate of 4.0-5.0% with 13.0-12.0% sucrose may be expected to affect the mix and finished product as follows:

a) "There will be no significant effect on the acidity, protein stability or whipping ability of the mix.

b) The viscosity of the mix may be increased slightly.

c) Flavor of the ice cream will be equal to but no better as a rule than ice cream containing only sucrose.

d) The body and texture scores of the ice cream containing CSS will usually average 0.5 points or more higher than comparable ice cream containing only sucrose if all other factors affecting the body and texture of the ice cream are properly controlled.

e) The melting quality of the ice cream will not be impaired by the use of CSS."

Young (27) studied the use of a regular conversion product 42 DE and a low conversion product 24 DE in ice cream. Percentages of sucrose and corn sweetener were varied and the effects of the variations on flavor score, body and texture score and resistance to heat stock were noted. Sweetener was varied in two ways. In one series, the total sweetener was varied between 15.0 and 19.0% by increasing the corn sweetener in 2.0% steps while sucrose was decreased in 1.0% steps. In another series, the total sweetener was added at levels of from 0 to 6.0%.

TABLE 2

Typical recommended formulas for packaged, hardened ice milk or frozen desserts (10)

	Per cent					
Fat	2	2	4	4	6	6
Solid-non-fat	13.5	14.0	12.0	13.5	12.0	12.5
Sucrose	11.5	10.0	11.5	10.5	12.0	10.5
28 DE CSS	10.0	—	10.0	—	8.0	—
36 DE CSS	—	9.0	—	8.0	—	8.0
Stabilizer and emulsifier	0.5	0.3	0.5	0.3	0.5	0.3
Total solids	36.5	35.3	38.0	36.3	38.5	37.3

Within each series, body and texture scores increased with an increase in the corn sweetener level. The limiting factor in the use of CSS was its adverse effect on the flavor scores of the ice cream examined. This shows that when more than 25.0% of the total sweetener was made up of CSS, the ice cream was evaluated as having a higher unnatural sweetener flavor and the flavor score decreased. Excessively high levels of CSS tend to mask the flavor of vanilla ice cream. A further finding of this study was a decrease in body and texture scores after heat shock became less as the amount of CSS was increased. The 24 DE product exerted slightly more protective action than did the 42 DE product.

Kenney (17) evaluated ice cream containing various levels of CSS having several conversion values, ranging from a DE of 15 to dextrose itself. After four weeks of storage the ice cream containing the low DE CSS had the highest body and texture score, followed by the regular conversion CSS, high conversion CSS, dextrose, and all-sucrose ice creams. The most significant finding in these studies was the ability of low conversion CSS to impart to the ice cream additional protection from heat shock damage.

Relative Sweetener Values

Since there is no chemical test for sweetness, it can be determined only by taste, and this varies with the individual perception to sweetness. Many factors also affect the sweetness such as temperature, concentration of two or more sugars, presence of non-sugar substances, as well as other factors. Best informed technical authorities (10) accept the sweetness values of the various corn sweeteners as submitted in the following table.

TABLE 3

Sweetness value of various corn sweeteners (10)

Types of syrups	DE content	Total solids	Approx. dry basis	Sweetness liquid basis
OK low conversion (Lo Dex)	36	79.93	52	42
OK regular (Reg CSU)	42	80.27	60	48
OK Silver Sweet (Dual Conversion)	43	80.27	63	50
OK High-Dextrose (Intermediate)	54	81.07	68	55
OK Hi-Sweet (Enzyme converted)	63	81.80	80	65
OK Malto-Dextrin	25	96.0	30	--
OK Dri-Sweet 28 (Dried CSU)	28	96.0	35	--
OK Dri-Sweet Reg. (Dried CSU)	42	97.0	60	--
Corn Sugar (Hydrous Dextrose)	92	92.0	80	--

Soft Serve Ice Milk

Soft ice milk is a term that has been applied to those products which are marketed in a soft form and are ready for consumption shortly after they are drawn from the freezer.

Drusendahl (7) and Tharp (25) reported that a high quality soft serve product must meet certain criteria. These requirements are a smooth texture, a firm, chewy body, resistance to heat shock; and they must be refreshing. These objectives can be obtained by reducing the serum solids and sugar content of the mix for several reasons: First; conditions are not always suitable for ideal freezing due to the condition of the equipment, inexperiencedoperators, and temperature of the mix. Since water freezes easier than any other portion of the mix, the product is colder and more refreshing due to its low total solids content. Second; by keeping the solids-non-fat content to a normal range a much cleaner, better flavored finished product is obtained. Mild flavors such as vanilla, will not be masked and after the product is eaten, it will not leave a serum solids or condensed milk flavor, but will taste clean and refreshing.

Sheuring (21), Sheuring and Rossi (22), Tracy (26), Tharp (25), and Frandsen (12) are in agreement in formulating the soft serve ice milk. Typical formulas recommended by these investigators are given in Table 4.

Sheuring (20) and Tharp (25) have demonstrated that a higher level of corn sweeteners such as 25-30% can contribute off-flavors to the product as well as cause a masking of the vanilla flavor.

Frazeur (13) considers three major problems in the manufacture of soft serve ice milk; formulation, stiffness, and dryness. Special care must be exercised to avoid the churning of the milk fat when whipping is prolonged

TABLE 4

Fresh-frozen confection (semi-solid served direct from freezer)

	Per cent			
Butterfat	2.5	4.0	5.0	6.0
Solid-non-fat	13.5	12.5	12.5	12.0
Cane sugar	11.0	11.5	12.0	12.5
Corn syrup solids	6.0	5.0	4.0	3.0
Stabilizer and emulsifier	0.5	0.5	0.5	0.5
Total solids	33.5	33.5	34.0	34.0

in the soft serve freezer. He has demonstrated that the use of a good emulsifier such as polyoxyethelene is most effective in producing dryness and stiffness.

Hard Ice Milk

Drusendahl (9) reported that consumers prefer to buy ice milk for reasons of economy or their desire for a low caloric or low fat product. According to Sheuring (19), the ratio of milk proteins to fat in ice milk is well balanced for both children and adults. Children are more interested in the refreshing qualities while adults are primarily concerned with the low cost and low caloric features of ice milk.

Gaskins (14) concluded that in the manufacture of a good ice milk, two factors must be considered: First; the product must be of high quality, that is, it must have the necessary body, texture and flavor qualities. Second; the ice milk must have a low carbohydrate content, a reasonably low total calorie content and furnish adequate amounts of proteins. The same author reported that for food to carry its proper protein load, it must contain 2.33 g of protein per 100 calories of food. Ice cream contains less than the required amounts. Ice milk desserts made with protein concentrates have a protein content substantially in excess of the 2.33 g standard. Properly prepared milk protein concentrates are pleasant to the taste and serve nutritional and functional purposes.

In the following table compiled by Keeney (16) is shown the calories in ice milk of different fat percentages.

TABLE 5

Calorie content of ice cream and ice milk (16)

% fat in ice cream or ice milk	Calories	
	In one pint at 80% overrun	In one ounce
12	612	60
10	565	55
6	474	46
3	413	40

According to Dahlberg (4) the calorie content of ice milk is about two-thirds of that of ice cream. Only one-fourth of the calories of ice milk are derived from the fat as compared with one-half of the total calories in ice cream. Sherbets have more calories than ice milk, but only a small proportion is derived from fat, as indicated in the following table.

TABLE 6

Calories per serving (one-third pint) of ice cream, ice milk and sherbert (4)

Product	Calories per serving	% of calories from fat
Ice cream 100 gr	206	52
Ice milk 100 gr	134	27
Sherbet 130 gr	177	16

Typical Formulas for Ice Milk Mix. When ice milks are to be used for hardened products the following formulas given by different investigators are recommended:

TABLE 7

Recommended formulas for hard ice milk

Ingredients	Keeney (16)		Dahle (5)		Brown (2)	Frandsen (12)	
			Per cent				
Fat	3.0	6.0	4.0	6.0	3.5	4.0	6.0
Serum solids	13.5	12.5	14.0	13.0	12.0	11.3	12.0
Cane sugar	13.0	12.0	13.0	13.0	11.5	13.2	15.0
Corn syrup solids	5.0	5.0	5.0	5.0	7.0	7.0	—
Stabilizer	0.4	0.4	0.4	0.4	0.7	0.4	0.5
Emulsifier	0.1	0.1	0.1	0.1	—	—	—
Total solids	35.0	36.0	36.5	37.5	34.7	35.9	33.5

Advantages and Disadvantages of Ice Milk (5).

Advantages:

a) Cheaper product.

b) Fewer calories for the diet minded person.

1. Calories per lb in 12% ice cream 967

2. Calories per lb in 4% ice milk 717

c) Makes it possible to make larger and thicker milk shakes and malts.

d) Less trouble due to churning in soft serve products.

Disadvantages:

a) Increases inventory.

b) Increases records and bookkeeping.

c) More stockroom space needed.

d) More hardening room space needed.

Two investigators (5) (14) have concluded that there is danger of sandiness for the following reasons:

a) because of high serum solids used (13-14%)

b) amount of lactose present in solution is higher than in ice cream despite the use of less fat.

The amount of lactose in solution or concentration of lactose in the water of the mix is as follows:

a) Ice milk (4-14-18-0.5) = 10.63% of lactose

b) Ice milk (4-13-16-0.5) = 9.5% of lactose

c) Ice cream (12-11-15-0.3) = 8.7% of lactose.

The same authors (5) (14) suggested several practices to reduce the danger of sandiness; (a) increase of CSS and reduction of serum solids,

(b) use of low lactose milk concentrates or sodium caseinate, (c) no danger when served soft from the freezer.

Another defect in ice milk mentioned by Kenney (16), which occurs when a large amount of CSS is used, is a pronounced off flavor described as "caramel-like" or "unnatural sweetener".

According to Dahle (5), the titratable acidity of ice milk is higher than in ice cream because of higher serum solids: (a) ice milk with 14% serum solids has 0.246 titratable acidity, (b) ice cream with 11% serum solids has 0.193 titratable acidity.

Dahle (5) and Frandsen (12) reported that the overrun for ice cream may range from 80-90% for bulk ice milk 70-80%, for packaged ice milk 70% and for soft serve ice milk 30-50% depending on the total solids content.

Dahle (5) has calculated the weight per gallon of ice milk with different overrun as follows:

% overrun	30	40	50	60	70	80
Weight per gallon (lb)	7.07	6.57	6.13	5.75	5.41	5.11

The cost of ice milk and ice cream proportioned by Dahle (5) are presented in Table 8.

Composition of Ice Milk Mixes

Butterfat. The most desirable range of butterfat is from 3.0 to 6.0%. Body and texture problems may occur if the fat content is lowered much below 3.0% (12). The product tends to be coarse, weak and icy. If the fat is high, the product may be too rich and less palatable in addition to presenting freezing difficulties involving possible fat separation during the freezing process (16).

TABLE 8

Cost of ice milk and ice cream (5)

Ingredients	Cost per lb	4.0% ice milk	10.0% ice cream	12.0% ice cream
	cents	dollars	dollars	dollars
Fat	80	3.20	8.00	9.60
Serum solids	18	2.34	2.16	1.98
Sugar	9	1.53	1.53	1.53
Stabilizer	60	.30	.24	.18
Total cost		7.37	11.93	13.29
Cost/gal/mix		.64	1.085	1.20
Cost/gal/frozen product at 70% overrun		.39	.63	.70

Serum Solids. The serum solids are important from the standpoint of building body and texture. Increasing the serum solids content tends to counter balance the loss of total solids due to the decrease in the amount of butterfat used. The percentage of serum solids in the ice milk is usually 12-14% (12).

Sugar. CSS are a key ingredient in the manufacture of good ice milk. Since CSS are only about 50% as sweet as cane sugar, the total carbohydrate and total solids content of the mix can be built up without causing the ice milk to be too sweet (16).

Stabilizer and Emulsifier. Stabilizers are used in amounts ranging from 0.2 to 0.4%. Emulsifiers are used in amounts ranging from 0.1-0.2% to provide smoothness, desirable whipping properties, melting resistance and firmness (12).

EXPERIMENTAL PROCEDURE

In this experiment two basic mixes of different compositions were used. One series consisted of 4 individual mixes of the following composition:

a) Control mix was calculated to test 4.0% fat, 13.0% serum solids, 15.0% sucrose, and stabilizer and emulsifier in amounts recommended by the manufacturer.

b) Same as control except for the sweetener, which consisted of 12.0% sucrose plus 5.0% CSS (28 DE).

c) Same as control except for the sweetener, which consisted of 12.0% sucrose plus 5.0% CSS (36 DE).

d) Same as control except for the sweetener, which consisted of 12.0% sucrose plus 5.0% CSS (42 DE).

The second series consist of 4 individual mixes of the following composition:

a) The control mix was calculated to test 6.0% fat and mixes (b), (c) and (d) were the same as in the first series except for fat content which was increased from 4.0 to 6.0%.

Ingredients Used

The ingredients used in these mixes were fresh sweet cream, 40.0% fat, whole milk, 4.0% fat, non fat dry milk 97.0% solids, sucrose, CSS, and stabilizer and emulsifier.

Composition of CSS used are presented in Table 9 (10).

TABLE 9

Composition of corn syrup solids (10)

Ingredients	Low conversion	Low conversion	Regular conversion
		Per cent	
Dextrose equivalent (DE)	28	36	42
Dextrose monosaccharide	9.3	14.1	18.5
Maltose disaccharides	8.6	11.7	13.9
Trisaccharides	8.0	10.3	11.6
Higher saccharides	74.1	63.9	56.0
Total solids	97.0	79.7	80.3

Processing the Ice Milk

Fifty lb mixes were made by weighing the ingredients into 10 gallon milk cans. The pasteurizing temperature used throughout these trials was 165 F for 30 min followed by homogenization at pasteurization temperature using a 2 stage homogenizer with 800 lb pressure on the outlet valve and 2500 lb on the inlet valve, followed by cooling to 40 F. The mixes were aged for 48 hours and frozen in a 40-quart batch type freezer. Color and flavor in proper amounts were added at the freezer. The amount of overrun and the temperature of the mix, while in the freezer were taken at 1 min intervals after the first 2 min and samples of the finished ice milk were taken in 4 oz cups and pint containers for consumer tests.

Samples of the mixes were taken immediately after the cooling operation for laboratory determinations. The following tests were made on the mixes: fat and total solids by the Mojonnier method (15). Acidity tests were made on the mix by titrating a 9 g sample with N/10 NaOH using phenolphthalein as an indicator (15). A Bechman Zeromatic, model 96 potentiometer was used for the pH determinations. Viscosity determinations were made using a Brookfield synchrolectric viscosimeter at 20 C (68 F) and the results expressed as centipoises. Melt down determinations were made by placing a 4 oz sample of ice milk on a screen, supported on a funnel and observations were made on the time melting started and the final melt down time.

Consumer Preference Tests

The 4 oz cups of the frozen ice milk marked with ○ (control mix), □ (28 DE), △ (36 DE) and ⊕ (42 DE) were distributed to patrons of the dairy sale counter. The pint samples marked in the same manner were submitted to a selected group of individual consumers who examined the sample in their homes. The participants were requested to examine the sample and fill out a questionnaire indicating their preference for the various samples.

The results of the consumer preference studies were tested for significance by the Friedman two-way analysis (18). When the Friedman test indicated significance at the .05 level, the individual observations were examined to determine which of the 4 different mixes were preferred, using the following formula to determine the number of times one sample of ice milk must be ranked over another sample to be significant at the .05 level: $\frac{N + 1.96 \; N}{2}$ where N = number of observations (23).

The results were summarized and used as a basis for evaluating the preference for the various ice milks.

The following is a sample of the questionnaire used.

CONSUMER PREFERENCE STUDY ON FROZEN DESSERTS

You are invited to participate in a Consumer Preference Study on Ice Milk. Will you taste the four samples identified by a ○, □, △, ⊕ and supply the following information by placing an X in the appropriate column.

	○	□	△	⊕
Flavor				
Too high				
Too low				
About right				
Like very much				
Acceptable				
Dislike				
Overall rank				
Body and Texture				
Smooth				
Coarse or icy				
Like very much				
Acceptable				
Dislike				
Overall rank				
Sweetness				
Too sweet				
Lacks sweetness				
About right				
Like very much				
Acceptable				
Dislike				
Overall rank				

RESULTS

Results of the Chemical Analysis and Other Tests of Ice Milk Mixes

Fat and Total Solids. The results of the butterfat and total solids test made on 24 experimental batches of ice milk mix are presented in Tables 10 and 11.

TABLE 10

Butterfat content of 24 experimental mixes

Mix	Series 1 (4.0% fat)			Series 2 (6.0% fat)		
Trial No.	1	2	3	4	5	6
			Per cent of fat			
a Control 15% suc[a]	4.68	4.15	3.96	5.88	6.12	5.98
b 12% suc + 5% 28 DE	3.51	4.13	4.05	5.80	6.28	6.04
c 12% suc + 5% 36 DE	3.89	4.08	4.05	5.81	6.25	6.04
d 12% suc + 5% 42 DE	3.40	3.98	4.08	5.85	6.12	6.02
mean fat %		3.99			6.01	

[a] suc = sucrose

The butterfat content as determined by the Mojonnier method in all the trials except No. 1 was very close to the calculated percentages. The first series had a range of 3.4 to 4.68% fat and the mean was 3.99%. The second series had a range of 5.80 to 6.28% fat and the mean was 6.01%.

There was considerable variation in the total solids content of the mixes in Series 1. In the first series this variation ranged from a low of 32.43 to a high of 36.62%. In Series 2 with one exception (control batch, Trial 6) the variation was less than 1.68 points, ranging from a

TABLE 11

Total solids content of 24 experimental mixes

Mix	Series 1 (4.0% fat)			Series 2 (6.0% fat)		
Trial No.	1	2	3	4	5	6
	Per cent of total solids					
a Control 15% suc[a]	32.67	32.43	32.47	36.75	35.56	34.01
b 12% suc + 5% 28 DE	34.45	34.77	34.54	35.92	36.57	36.46
c 12% suc + 5% 36 DE	33.79	33.93	35.67	36.65	36.37	36.52
d 12% suc + 5% 42 DE	34.67	34.63	36.62	36.28	36.95	35.27
mean total solids %		34.21			36.21	

[a]suc = sucrose

low of 34.01 to a high of 36.95%. The mean for the first series was 34.21% and for the second 36.21%.

Acidity and pH. Tables 12 and 13 present the results of the titratable acidity and pH tests on the 24 experimental mixes.

TABLE 12

Per cent titratable acidities of 24 experimental mixes

Mix	Series 1 (4.0% fat)			Series 2 (6.0% fat)		
Trial No.	1	2	3	4	5	6
	Per cent of acid					
a Control 15% suc[a]	0.23	0.23	0.23	0.23	0.23	0.23
b 12% suc + 5% 28 DE	0.23	0.23	0.23	0.23	0.23	0.23
c 12% suc + 5% 36 DE	0.23	0.23	0.24	0.23	0.23	0.23
d 12% suc + 5% 42 DE	0.23	0.23	0.24	0.23	0.23	0.23
mean titratable acidity %		0.23			0.23	

[a]suc = sucrose

TABLE 13

pH values of 24 experimental mixes

Mix	Series 1 (4.0% fat)			Series 2 (6.0% fat)		
Trial No.	1	2	3	4	5	6
		pH			pH	
a Control 15% suc[a]	6.35	6.40	6.40	6.40	6.35	6.35
b 12% suc + 5% 28 DE	6.35	6.40	6.40	6.35	6.30	6.35
c 12% suc + 5% 36 DE	6.35	6.40	6.35	6.35	6.30	6.30
d 12% suc + 5% 42 DE	6.35	6.40	6.35	6.30	6.30	6.40
mean pH for all mixes		6.37			6.33	

[a] suc = sucrose

The titratable acidities of all mixes in Series 1 and 2 were .23%, except two in Series 1 which were .24%. The pH values of all mixes ranged between a pH of 6.3 to 6.4 The mean pH for all mixes in Series 1 was 6.37 and Series 2 was 6.33.

Viscosity Test. The results of the viscosity tests on the 24 mixes are presented in Tables 14, 15, 16 and 17. With the exception of Trial No. 1 viscosity tests were made on the fresh mixes and after 24 hr of aging.

In Table 15 figures are presented showing the effects of aging on the viscosity of the fresh mix and the mixes after aging for 24 hr at 40 F.

TABLE 14

Viscosity values of fresh mixes and after 24 hr of aging

Mix		Series 1 (4.0% fat)			Series 2 (6.0% fat)		
Trial No.		1	2	3	4	5	6
		Degrees centipoise (00 omitted)					
a Control 15% suc[b]	fresh	--[a]	111	74	56	86	50
	aged	114	115	72	74	84	56
b 12% suc + 5% 28 DE	fresh	--	112	126	81	104	80
	aged	142	111	119	94	112	84
c 12% suc + 5% 36 DE	fresh	--	120	150	92	108	72
	aged	102	101	116	94	124	90
d 12% suc + 5% 42 DE	fresh	--	121	106	95	100	78
	aged	120	100	114	98	126	98

[a]not determined

[b]suc = sucrose

TABLE 15

Increases or decreases in viscosity of experimental mixes after aging 24 hr (average 3 trials)

Mixes	Series 1 (4.0% fat)	Series 2 (6.0% fat)
	Centipoise	
a Control 15% suc[a]	+ 780	+ 733
b 12% suc + 5% 28 DE	+ 500	+ 833
c 12% suc + 5% 36 DE	-2840	+1203
d 12% suc + 5% 42 DE	- 217	+1633

[a]suc = sucrose

In Series 1 (4.0% mixes) the control mix and the mix containing 12.0% sucrose + 5% 28 DE increased 780 and 500 degrees centipoise, respectively, after aging 24 hr, while the 36 DE and 42 DE decreased 2840 and 217 degrees centipoise, respectively. In Series 2 all the mixes increased in viscosity during the 24 hr aging period. These increases were from 733 degrees centipoise in the control mixes to 1633 degrees centipoise in the 42 DE mixes.

In Table 16 figures are presented to show the effect of the (DE) of the 3 CSS used in these experiments on the viscosity of the mixes.

TABLE 16

Increase in viscosity of fresh and aged mixes containing CSS over that of the control mix (average 3 trials)

	Series 1		Series 2	
Mixes	fresh	aged	fresh	aged
		Centipoise		
a Control 15% suc[a]	000	000	000	000
b 12% suc + 5% 28 DE	+2650	+2370	+2433	+2533
c 12% suc + 5% 36 DE	+4250	+ 630	+2663	+3133
d 12% suc + 5% 42 DE	+2100	+1103	+2700	+3600

[a] suc = sucrose

According to the figures in Table 16, all experimental mixes in both series had an increase in the viscosity compared with the control mix. The viscosity values ranged from 2100-4250 degrees centipoise for the fresh mixes and 630 to 2370 degrees centipoise for the aged mixes in the first series, and 2433 to 2700 centipoise for the fresh mixes and 2533 to 3600 degrees centipoise for the aged mixes in the second series.

In Table 17 is presented the effect of fat content of the mixes on the viscosity of the experimental mixes.

TABLE 17

Effect of fat content on viscosity, centipoise increase in 6.0% fat over 4.0% fat mixes (average 3 trials)

Mixes	4.0% fat fresh and aged	6.0% fat fresh	6.0% fat aged
		Centipoise	
a Control 15% suc[a]	000	2850	2897
b 12% suc + 5% 28 DE	000	3067	2700
c 12% suc + 5% 36 DE	000	4437	394
d 12% suc + 5% 42 DE	000	2250	400

[a]suc = sucrose

Figures presented in Table 17 show an increase in viscosities of the 6.0% fat mixes over that of the 4.0% fat mixes. In the fresh mixes the viscosities increased 2250 degrees centipoise for the 42 DE mix to 4437 degrees centipoise for 36 DE mix. The increases in viscosity of the aged 6.0% fat mixes were from 394 in the 36 DE mix to 2897 for the control.

Melt Down Time and Volume of Melt Down. The results of melt down time and volume for the 24 experimental mixes of ice milk are presented in Table 18.

According to the figures in Table 18, the first drop appeared in 10-12 min in the first series and 29-31 min in the second series. The appearance of the last drop varied from 47-49 min in the first series and 81-82 min in the second series. The 6.0% fat ice milk were more resistant to melting than the 4.0% fat mixes. Factors other than the type and amount of sugar such as the kind and amount of stabilizer may have some influence on melting. The variation in the volume of liquid and foam of 24 ice milks

TABLE 18

Mean melt down time and volume for 24 experimental mixes

Mixes	Series 1 Time of appearance of: first drop	Series 1 Time of appearance of: last drop	Series 2 Time of appearance of: first drop	Series 2 Time of appearance of: last drop
	min	min	min	min
a Control 15% suc[a]	10	48	29	81
b 12% suc + 5% 28 DE	12	49	31	82
c 12% suc + 5% 36 DE	12	47	29	81
d 12% suc + 5% 42 DE	10	47	31	82
	Volume of melt down at 30 min			
	liquid & foam	liquid	liquid & foam	liquid
	ml	ml	ml	ml
a Control 15% suc	35	12	22	—
b 12% suc + 5% 28 DE	37	9	15	—
c 12% suc + 5% 36 DE	39	9	12	—
d 12% suc + 5% 42 DE	39	10	6	—
	Volume of melt down when completely melted			
	liquid & foam	liquid	liquid & foam	liquid
	ml	ml	ml	ml
a Control 15% suc	63	18	78	6.1
b 12% suc + 5% 28 DE	69	13	83	4.8
c 12% suc + 5% 36 DE	68	14	81	5.9
d 12% suc + 5% 42 DE	66	16	80	5.4

[a]suc = sucrose

at the end of 30 min and at the end of melting was affected by the size of air bubbles in the foam. No attempt was made to determine the effect of CSS on the amount of foam.

Freezing Time, Drawing Temperature and Per Cent Overrun. In Table 19 are presented the freezing time, drawing temperature and the per cent overrun on 24 experimental mixes.

The figures in Table 19 show that the drawing temperature varied from 23 to 24 F except for the 22 F in the second trial drawing temperature of

TABLE 19

Showing freezing time, drawing temperature and per cent overrun obtained when experimental mixes were frozen in a batch freezer

	Series 1				Series 2			
Trial	1	2	3	mean	4	5	6	mean
a Control 15% suc[a]								
Temp F	24	24	23	23.66	22	23	23	22.66
Time (min)	7	9	9	8.33	8	7	8	7.66
Overrun %	76	90	75	80.12	80	89	93	87.33
b 12% suc + 5% 28 DE								
Temp F	23.5	24	22	23.16	24	23	23	23.33
Time (min)	11	8	7	8.66	6	7	7	6.66
Overrun %	70	80	80	81.25	90	90	89	89.66
c 12% suc + 5% 36 DE								
Temp F	24	23	23	23.33	23	23	23	23
Time (min)	9	8	6	7.66	7	6	9	7.33
Overrun %	70	88	69	75.66	90	95	85	90
d 12% suc + 5% 42 DE								
Temp F	24	22	23	23	23	23	23	23
Time (min)	7	8	6	7.66	7	6	9	7.33
Overrun %	71	88	63	74	89	82	85	85.33

[a]suc = sucrose

the first series when 42 DE CSS was used. In the second series the variation in temperature was the same as the first series with the exception of the control mix in the fourth trial.

The freezing time varied from 6 to 11 min in the first series. The highest mean of 8.66 min of freezing time was required for the 28 DE CSS and the lower mean freezing times of 8.33, 7.66 and 7.66 for the control, 36 DE and 42 DE mixes, respectively. In the second series the freezing time varied from 6-9 min. The lowest mean of 6.66 min of freezing time was required for the 28 DE CSS and higher mean freezing times of 7.66, 7.33 and 7.33 min for the control, 36 DE and 42 DE mixes, respectively.

The percentage of overrun ranged from 63 to 90 in the first series.

The highest mean was 81.25% for the 28 DE mixes. In the second series the overruns were 90% for the 36 DE and 89.66 for the 28 DE. According to these figures, higher overruns were obtained with 6.0% fat mixes. It appears that the kind of sugar used in these trials had no effect on the freezing time, drawing temperature and per cent overrun.

Consumer Preference Studies

The results of the consumer preference studies are presented in Tables 20 and 21. Table 20 summarizes the results of the Friedman test (18) on the preference of the patrons of the Kansas State University dairy bar for the 24 experimental samples submitted to them and Table 21 presents similar data for the opinions obtained from faculty consumers to whom the samples were submitted.

Consumers were requested to indicate their preference for the different ice milks based on the desirability of flavor, body and texture, and sweetness of the samples which contained sucrose, sucrose and 28, 36, 42 DE CSS, respectively. These data were subjected to the Friedman test for significance. The results of these tests for significance (chi-square test of independence) (23) are presented in Tables 22 and 23.

Opinions expressed by the panel of dairy bar consumers indicated flavor preferences for the 15.0% sucrose ice milk (.05 p .02) and the 12.0% sucrose and 5.0% 36 DE ice milk (.01 p .001) over the other samples in Trial 1 and 4, respectively. There was a preference for the body and texture of the 12.0% sucrose and 5.0% 28 DE ice milk (.05 p .02) in Trial 3. There was no preference for sweetness in the experimental samples except for the 12.0% sucrose and 5.0% 36 DE (.05 p .02) in Trial 6.

TABLE 20

Tests of significance of the 24 experimental mixes
(dairy bar consumers)

Trial	No. of individuals	x^2_r	df	Probabilities	Significance
			Flavor		
1	39	7.915	3	.05 p .02	s
2	34	1.438	3		ns
3	33	2.436	3		ns
4	31	14.342	3	.01 p .001	s
5	30	2.680	3		ns
6	27	3.578	3		ns
			Body and Texture		
1	38	5.566	3		ns
2	27	.111	3		ns
3	31	8.739	3	.05 p .02	s
4	24	6.050	3		ns
5	26	2.158	3		ns
6	24	2.450	3		ns
			Sweeteners		
1	38	4.239	3		ns
2	33	1.345	3		ns
3	34	4.871	3		ns
4	28	3.600	3		ns
5	33	4.845	3		ns
6	30	9.200	3	.05 p .02	s

s = significant

ns = not significant

df = degrees freedom

TABLE 21

Tests of significance of the 24 experimental mixes
(faculty consumers)

Trial	No. of individuals	x^2r	df	Probabilities	Significance
		Flavor			
1	13	.785	3		ns
2	8	1.550	3		ns
3	11	6.709	3	.10 p .05	s
4	4	.675	3		ns
5	9	.126	3		ns
6	8	.326	3		ns
		Body and texture			
1	13	.969	3		ns
2	8	3.150	3		ns
3	11	15.982	3	.01 p .001	s
4	3	8.200	3	.05 p .02	s
5	7	1.629	3		ns
6	7	.771	3		ns
		Sweetness			
1	13	.415	3		ns
2	8	1.350	3		ns
3	11	4.855	3		ns
4	4	3.000	3		ns
5	8	2.250	3		ns
6	8	5.138	3		ns

s = significant

ns = not significant

df = degrees freedom

TABLE 22

Summary of preferences for the different ice milks
(dairy bar consumer)

Trial	Properties	No. of individuals	Significant preferences			
			15% suc[a]	12% suc + 5% 28 DE	12% suc + 5% 36 DE	12% suc + 5% 42 DE
1	Flavor	39	p	np	np	np
	B and tex	38	np	np	np	np
	Sweetness	38	np	np	np	np
2	Flavor	34	np	np	np	np
	B and tex	27	np	np	np	np
	Sweetness	33	np	np	np	np
3	Flavor	33	np	np	np	np
	B and tex	31	np	p	np	np
	Sweetness	34	np	np	np	np
4	Flavor	31	np	np	p	np
	B and tex	24	np	np	np	np
	Sweetness	28	np	np	np	np
5	Flavor	30	np	np	np	np
	B and tex	26	np	np	np	np
	Sweetness	33	np	np	np	np
6	Flavor	27	np	np	np	np
	B and tex	24	np	np	np	np
	Sweetness	30	np	np	p	np

[a]suc = sucrose

p = preference

np = no preference

B and tex = Body and texture

TABLE 23

Summary of preferences of the different ice milks
(faculty consumers)

Trial	Properties	No. of individuals	Significant preferences 15% suc[a]	12% suc + 5% 28 DE	12% suc + 5% 36 DE	12% suc + 5% 42 DE
1	Flavor	13	np	np	np	np
	B and tex	13	np	np	np	np
	Sweetness	13	np	np	np	np
2	Flavor	8	np	np	np	np
	B and tex	8	np	np	np	np
	Sweetness	8	np	np	np	np
3	Flavor	11	np	np	np	p
	B and tex	11	np	np	np	p
	Sweetness	11	np	np	np	np
4	Flavor	4	np	np	np	np
	B and tex	3	np	np	p	np
	Sweetness	4	np	np	np	np
5	Flavor	9	np	np	np	np
	B and tex	7	np	np	np	np
	Sweetness	8	np	np	np	np
6	Flavor	8	np	np	np	np
	B and tex	7	np	np	np	np
	Sweetness	8	np	np	np	np

[a]suc = sucrose

p = preference

np = no preference

B and tex = Body and texture

Choices by the faculty consumers panel indicated that there was a preference for the flavor (.10 p .05) and body and texture of the ice milk in Trial 3. A preference was noted for body and texture (.05 p .02) of the 12.0% sucrose and 5.0% 36 DE ice milk in Trial 4. No preferences were noted for the different types of sweeteners in the percentages used in this experiment.

DISCUSSION AND CONCLUSIONS

The use of corn syrup solids in combination with sucrose in ice cream, ice milk and related products has become a general practice in the industry. There are several advantages to be gained by this practice. One advantage is in the lower cost of corn syrup solids over other solids used in the mix. Aside from the reduction in the mix cost, improvement in the body and texture of the product has been demonstrated by several investigators (3) (6) (8). Most of the earlier experimental work related to the use of corn syrup solids in ice cream, however, the same advantages also were found to apply to ice milk.

Results of this experiment indicated that CSS of different DE values could be used successfully as a replacement for part of the sucrose of the ice milk mix. When 5.0% corn syrup solids was used with 12.0% sucrose in 4.0% and 6.0% fat ice milk mixes, no difficulties were experienced in obtaining the desired overrun. The titratable acidities, pH values and viscosities of the control and experimental mixes were quite similar. Some differences were observed in the viscosities and melt down properties of the 4.0 and 6.0% fat mixes. Generally the 6.0% fat ice milk mixes were more viscous and more resistant to melting than the 4.0% fat products.

Differences in viscosities between the individual trials may have resulted from use of different stabilizers. The results of the consumer preference studies indicated that all samples submitted were satisfactory so far as flavor, body and texture and sweetness were concerned. Only in a few instances were differences in the overall quality great enough to be detected by the members of the panel to whom the samples were submitted.

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THE EFFECT OF THE USE OF CORN SYRUP SOLIDS OF DIFFERENT DEXTROSE EQUIVALENTS ON THE QUALITY AND PROPERTIES OF ICE MILK

by

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This experiment was undertaken to obtain further information on the effect of different types of corn syrup solids (CSS) when used in combination with sucrose on the properties and quality of ice milk and to check consumer acceptance of the ice milk in which the different sweeteners were used.

Two basic mixes of 4.0 and 6.0% fat content were studied. The properties of the mixes containing the three types of CSS, 5.0% 28 DE[1], 5.0% 36 DE and 5.0% 42 DE combined with the properties of the control mixes which contained 15.0% sucrose. The titratable acidities, pH values and viscosities of the fresh and aged mixes were determined. The mixes were frozen in a batch freezer and data obtained on the freezing time, drawing temperature, and amount of overrun. Data were collected on the resistance to melting. Samples of the hardened ice milk were distributed to the patrons of the dairy counter and to faculty members for home consumption. The consumers to whom the samples were submitted were requested to fill out a questionnaire and to indicate their preferences for the 4 samples submitted in each trial.

Mojonnier tests for butterfat averaged 3.99% in the first series and 6.01% in the second series; and the averages for the total solids were 34.12% in the first series and 36.21% in the second series.

The data obtained on acidities and pH values indicated that the 3 types of corn syrup solids did not change the acidity and pH of the test mixes from that of the control mix. The freezing time, drawing temperature, and % overrun obtained when the test mixes were frozen were not materially different from those of the control mix.

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[1]DE - Dextrose equivalent

The viscosities of the mixes in which CSS were used in these trials were higher than the viscosities in fresh and aged control mixes. Also the 6.0% fat, fresh and aged mixes were higher in viscosity than the 4.0% fat mixes.

The melting resistance of mix b (12.0% sucrose and 5.0% 28 DE) in the 4.0% fat series was slightly greater than that of the other mixes in this series. In the 6.0% fat series, mixes b (12.0% sucrose and 5.0% 28 DE) and d (12.0% sucrose and 5.0% 42 DE) were more resistant to melting than the other mixes in this series. The time of appearance of the first drop of melt down in the 6.0% fat series was about 3 times greater than that in the 4.0% fat series. The time required for complete melt down in the 6.0% series was about twice as great as it was in the 4.0% series.

The data obtained from 181 judgments from the patrons of the dairy bar and from 53 faculty judgments when analyzed by the Friedman Test for significance did not indicate any significant preference for the samples containing the different corn syrup solids over that for the control except in a few instances. Opinions expressed by the dairy bar consumers indicated flavor preferences for the 15.0% sucrose ice milk (.05 p .02) and 12.0% sucrose combined with 5.0% 36 DE ice milk (.01 p .001) over the other samples in Trials 1 and 4, respectively. There was a preference for body and texture of the 12.0% sucrose and 5.0% 28 DE ice milk (.05 p .02) in Trial 3. There was preference for sweetness for the 12.0% sucrose and 5.0% 36 DE ice milk (.05 p .02) in Trial 6. Choices by the faculty members indicated that there was a preference for the flavor (.10 p .05) and body and texture (.01 p .001) of the 12.0% sucrose and 5.0% 42 DE ice milk in Trial 3. A preference was noted for body and texture (.05 p .02) of the 12.0% sucrose and 5.0% 36 DE ice milk in Trial 4.

The results of these experiments indicate that the use of CSS of 28, 36, 42 DE (in combination with sucrose (12.0% sucrose and 5.0% CSS) in 4.0 and 6.0% fat ice milk mixes resulted in a frozen product which was acceptable to the consumers to whom the samples were submitted. No marked preference for any of the ice milk containing the different corn syrup solids was noted.