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Replacing Cane Sugar With Variable Increments of Dextrose and Cerelose Sugar in the Ice Cream Mix, and Its Effect Upon the Physical and Chemical Properties of Ice Cream at Different Serving Temperatures

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W. H. E. Reid, R. J. Cooley, and W. S. Arbuckle

INTRODUCTION

The effect of the different constituents of the ice cream upon the physical and chemical properties of the resultant ice cream differs considerably. Sugar is an important ingredient in ice cream and has a marked effect upon the physical properties, particularly when the ice cream is served at different temperatures.

The object of this investigation was to acquire technical data relating to the effect of different sugars upon the physical and chemical properties and crystalline structure of ice cream when served at different temperatures.

The chemical nomenclature of the sugars used in this investigation other than sucrose is: Royal Dextrose, which is the anhydrous form of dextrose containing a preponderating amount of beta-anhydrous dextrose and the remainder is alpha-anhydrous dextrose; and Cerelose, which is the dextrose alpha-hydrated form.

REVIEW OF LITERATURE

Newkirk (1)† stated that corn sugar, chemically known as dextrose, was not intended to be used as a substitute for cane sugar. He maintained that the ice cream trade desired dextrose on account of its lack of sweetness, stating that because the average ice cream consumer demanded a certain body which was produced only by the use of sugar, refined dextrose would result in the desired body of ice cream without making the latter too sweet.

Hutchinson (2) reported that dextrose was much more quickly absorbed through the stomach walls than was sucrose, cane sugar. This absorption took place within 20 minutes and sup-

This investigation has been aided in part by a grant from the Corn Products Sales Company and appreciation is expressed for such assistance.
†See Bibliography

plied the body with energy, relieved fatigue, and gave additional strength and stamina very quickly.

Flood (3) substantiated these assimiliation findings when he stated that dextrose is the most readily absorbed of all the sugars.

Dahlberg (4) found that increasing the amount of sugar in ice cream improved the texture and lessened the amount of ice formed, due to the presence of a more concentrated solution.

Reid (5) observed that as the sugar content of the ice cream was increased, the freezing point was lowered and a smoother texture was obtained. Combs (6) recommended that dextrose, because of its greater bulk in relation to its sweetness, could be substituted for a part of the serum solids at little or no extra cost. Turnbow and Raffetto (7) suggested that if large quantities of corn sugar were used, there would be a greater probability of sandiness, since there was less water available to keep the lactose in solution. They recognized that an increase in total solids would make the ice cream smoother and pointed out that sugar is the best suited ingredient to increase for this objective.

Corbett (8) stated that replacing one-fourth of the sucrose in low-lactose ice cream mixes with dextrose tended to prevent the ice cream from having a dry body.

Mack (9) worked with high-fat and high-total-solids ice creams and recommended the replacement of part of the sucrose with dextrose to prevent the ice creams from having a crumbly texture and to improve melting qualities. Tracy and Corbett (10) compared to the melt down qualities of all-sucrose ice creams with ice cream in which one-quarter of the sucrose was replaced with dextrose and reported that the dextrose ice cream melted down slightly more rapidly than the all-sucrose, though the percentage loss in weight at 60 to 90 minutes was rarely more than two to five per cent greater. The dextrose mixes were found to give as desirable a melt down as did the sucrose mixes. Hunziker (11) compared dextrose to sucrose, mentioning that it was of lesser sweetness, less expensive in the ice cream mix, the cheapest source of total solids, of greater preserving power, and more readily assimilated in the body.

Brainerd (12) found that smoothness depended upon the amount and fineness of division of solids present, other than those in true solution. He concluded that the keeping qualities of ice cream depended upon the stability of the mix. Reid and

Hales (13) used the petrograph microscope to identify crystalline and non-crystalline materials as they existed in the ice cream. They noted that the structure of ice cream was affected by an increase in per cent fat, solids-not-fat, sugar, and gelatin; that the texture of the resultant ice cream was changed from a coarse condition to a fine crystalline physical structure; that fine texture in ice cream is associated with the presence of uniform angularly shaped ice crystals and jagged tapering air-cell boundaries. Hunziker (14) reported that sweetened condensed milk is smooth or sandy according to the size of sugar crystals.

Anthony and Lund (15) found that dextrose delayed the occurrence of sandiness and that lactose was much more soluble in a dextrose-sucrose mixture than in combination with sucrose alone. Combs and Erb (16) found that dextrose had little or no effect in preventing the occurrence of sandiness. Reid, Drew, and Arbuckle (17) reported that sandiness did not become apparent in ice cream with 13.5 per cent serum solids even when held at serving temperatures ranging from 6 to 18 degrees Fahrenheit for three weeks. Microscopic examination of the ice creams indicated that as the percentage of fat, serum solids, sugar, or gelatin increased, the ice crystals appeared relatively smaller.

Bradley and Dahle (18) showed that the texture of ice cream improved and the ice crystals were smaller when a low freezing temperature was used and the ice cream hardened in a short period of time.

Frandsen, Rovner, and Luithly (19) found that 50 per cent of the cane sugar used in the manufacture of ice cream could be satisfactorily replaced with dextrose. Corbett and Tracy (20) made consumer tests with dextrose ice cream, replacing one-quarter of the sucrose with dextrose. Dextrose sugar had no detrimental effect upon the flavor of ice cream, which, from the standpoint of body preference, met with practically the same favor as did the all sucrose product. Masurovsky (21) pointed out that dextrose is not as sweet as sucrose and therefore its use in sherbets is more valuable from the standpoint of palatability.

Tracy (22) found that consumers preferred an ice cream with medium to high sugar content. Baumann (23) recorded that half of his group of consumer-judges preferred a 16 per cent sugar content in ice cream as compared to a 12 per cent sugar content. Roberts and Stoltz (24) conducted a quantity consumer preference experiment and found that equal numbers of consumers preferred each of the sugar samples one sucrose and

the other part-dextrose. Quantity consumption of 15 and 17 per cent sugar ice creams was the same.

Reid (25) reported that when the sugar content of ice cream was increased from 8 to 16 per cent, the hardness and melting time was decreased. Combs and Bele (26) found that as sugar content increases in ice cream, the hardness decreases. They concluded that ice creams containing cerelose must be held at a colder temperature for serving than ice creams containing only sucrose sugar.

Bierman (27) recommended that the dipping temperature be lowered one degree Fahrenheit for each per cent of increase in sugar over 15 per cent because of the greater softness of ice cream of higher sugar content. He (28) dipped 1,200 gallons of ice cream and concluded that there was a variation in dipping losses when different serving temperatures were used. Since dextrose depresses the freezing point of mixes to a greater extent than sucrose does, it naturally follows that somewhat lower dipping temperatures should be maintained for dextrose ice creams than for all-sucrose ice creams.

Tracy and Corbett (10) recognized the difference in hardness between all-sucrose and part-dextrose ice creams and found that dipping losses for dextrose ice cream were slightly higher when dipping was done at the same temperature; but when the dipping temperature for the dextrose ice cream was lowered approximately one degree Fahrenheit for each per cent of dextrose, the dipping loss was comparable to that of the sucrose ice cream.

Reid and Arbuckle (29) found that the serving temperature is a factor of great importance in determining consumer acceptance of ice creams and sherbets. Ice creams with high sugar content and pronounced flavor were more desirable at a lower serving temperature than were the mildly flavored ice creams with low sugar contents. Ice creams at 18 degrees Fahrenheit were described as too sweet and the flavor pronounced. Little difference was found in the stability of ice creams served at high or low temperatures.

PROCEDURE

The mixes used in this investigation were prepared from the same ingredients, which included cream, whole milk, dry milk solids, Dextrose, Cerelose, sucrose and gelatin. The mixes were pasteurized at 150 degrees Fahrenheit for 30 minutes,

homogenized at 2,500 pounds pressure by a two-stage homogenizer, aged from four to six hours, and frozen in a Vogt continuous freezer.

The surface tension of the mixes was determined by the application of the De Nouy apparatus. A Beckman glass electrode pH meter was used in determining the pH.

After the ice creams were frozen and hardened, they were tempered in commercial ice cream cabinets at the desired temperatures for 12 to 24 hours before they were judged. The ice creams reached the desired temperature in that time.

The judges were asked to place the ice creams with respect to flavor, body and texture preference and to make a final placing. Each sample was judged at temperatures of 4, 8, 12 and 16 degrees Fahrenheit. In addition, five samples of each series were judged at the same temperature and ranked 1st, 2nd, 3rd, 4th and 5th. The judges were not informed as to the composition or the temperature of the ice creams. Both men and women served as judges.

Two and one-half gallon cans of each ice cream was dipped at temperatures of 4, 8, 12, and 16 degrees Fahrenheit, respectively, using a size No. 24 (Zeroll type) disher. The ice creams were weighed and the average weight of the dishers was calculated. It should be observed that the bulk and brick ice creams were drawn from the freezer at an overrun of 100 and 90 per cent respectively and not on a basis of total solids per gallon of ice cream.

Five pints of each sample of ice cream were used from each series for stability observations. The ice creams were tempered at 4, 8, 12, and 16 degrees Fahrenheit. These samples were placed in a cabinet having a temperature of 83 to 85 degrees Fahrenheit, which is similar to summer conditions of ice cream in the home. While the samples were being exposed for 90 minutes, still photographs were taken every ten minutes and moving photographs every four seconds. Observations were made on the final melt down residue of the fifteen ice creams.

The crystalline structure of the ice creams at each of the four temepratures was studied by making macroscopic and microscopic photographs of each sample. Sections of the ice creams, five to ten microns in thickness, were made with a modified microtone and placed on a glass slide using oil with a refractory index of 1.42. The photomicrographs were taken under the low-power objective. All sections were prepared and photographed at approximately -10 degrees Fahrenheit.

EXPERIMENTAL DATA

The composition of the mixes used in this investigation is presented in Table 1.

Table 1.—The Composition of the Different Mixtures and the Overrun of the Ice Cream.

Fat	Serum Solids	Sucrose	Corn Sugar	Kind of Corn Sugar	Gelatin	Total Solids	Overrun	
							Per Cent	
Per Cent	Per Cent	Per Cent	Per Cent		Per Cent	Per Cent	Bulk	Brick
				Series 1				
12.00	11.00	14.00	0.0	Dextrose	.30	37.30	100.00	90.00
12.00	11.00	10.00	2.0	Dextrose	.30	35.30	100.00	90.00
12.00	11.00	10.00	4.0	Dextrose	.30	37.30	100.00	90.00
12.00	11.00	10.00	6.0	Dextrose	.30	39.30	100.00	90.00
12.00	11.00	10.00	8.0	Dextrose	.30	41.30	100.00	90.00
				Series 2				
12.00	11.00	14.00	0.0	Cerelose	.30	37.30	100.00	90.00
12.00	11.00	10.00	2.0	Cerelose	.30	35.30	100.00	90.00
12.00	11.00	10.00	4.0	Cerelose	.30	37.30	100.00	90.00
12.00	11.00	10.00	6.0	Cerelose	.30	39.30	100.00	90.00
12.00	11.00	10.00	8.0	Cerelose	.30	41.30	100.00	90.00
				Series 3				
10.00	13.00	14.00	0.0	Dextrose	.30	37.30	100.00	90.00
10.00	13.00	10.00	2.0	Dextrose	.30	35.30	100.00	90.00
10.00	13.00	10.00	4.0	Dextrose	.30	37.30	100.00	90.00
10.00	13.00	10.00	6.0	Dextrose	.30	39.30	100.00	90.00
10.00	13.00	10.00	8.0	Dextrose	.30	41.30	100.00	90.00

Table 2 shows the chemical and physical properties of the different mixtures. The acidity varied from .22 to .26 per cent, decreasing as sugar content increases and increasing in the presence of lower fat, higher serum solids content. The pH varied from 6.3 to 6.5. The surface tension varied from 47.3 to 54.3 dynes, which shows that increased amounts of sugar and decreased fat but higher serum solids content tends to influence surface tension. The specific gravity ranged from 1.0544 to 1.1232.

Table 3 shows the freezing data from the different mixes. The ammonia temperature ranged from -4 to -11.5 degrees Fahrenheit, while the drawing temperature of the ice cream varied from 23 to 20 degrees Fahrenheit, depending on the sugar content of the mix. In general, the data show that the time required to fill the different sized containers decreased as the total solids of the mix increased. As the sugar content increased, the body of the ice cream appeared slightly soft; however, adequate firmness was obtained by lowering the temperature of the refrigerant.

Table 2.—The Chemical and Physical Properties of the Different Ice Cream Mixtures.

Sample Number	Acidity Per Cent	pH	Surface Tension in Dynes	Specific Gravity Per Cent
		Series 1		
1	.23	6.5	48.4	1.0924
2	.23	6.5	47.3	1.0873
3	.23	6.5	48.8	1.0940
4	.22	6.5	47.9	1.0983
5	.22	6.5	47.9	1.1110
		Series 2		
1	.23	6.5	53.6	1.0987
2	.22	6.5	49.9	1.0860
3	.23	6.5	50.6	1.0926
4	.22	6.5	52.1	1.0970
5	.22	6.5	54.3	1.1000
		Series 3		
1	.26	6.3	50.6	1.0544
2	.25	6.4	51.3	1.0777
3	.25	6.4	51.3	1.0789
4	.24	6.4	51.3	1.1232
5	.24	6.5	52.8	1.0951

Table 3.—The Effect of Composition on the Freezing Properties of the Different Ice Cream Mixtures

Sample Number	Ammonia Temperature Degrees F.	Drawing Temperature Degrees F.	Time to Fill Containers: Pints Seconds	Gallons Seconds	2½ Gallons Minutes	2½ Gallons Seconds
			Series 1			
1	-6	23	8		2	50
2	-5	22	8	54	2	33
2	-5	21.5	8	54	2	39
4	-4	21	8	56.7	2	44
5	-4	20	8	54	2	42
			Series 2			
1	-7	23	8	56	2	16
2	-7	23	7	43	1	55
3	-9	22		43	1	50
4	-9	21	6	42	1	50
5	-9	20.5	6.5	46	2	00
			Series 3			
1	-9	22	8	50	2	30
2	-10	22	8	52	2	20
3	-11	21	8	52	2	15
4	-11	20.5	7.5	48	2	05
5	-11.5	20	7.3	48	2	06

To obtain the same consistency in body when dextrose and cerelose ice creams were drawn at the freezer, the drawing temperature of the dextrose ice cream averaged four-tenths of one degree Fahrenheit lower than that of the cerelose ice cream. Dextrose and cerelose have a similar effect in depressing the freezing point.

The data relating to the effect of composition and serving temperature on consumer preference are based on observations of approximately 300 different men and women. Three thousand, four hundred and sixty-five records were made on flavor, body, texture and final placings of these fifteen different ice creams.

Series 1.—The Relation of Sucrose-Dextrose Sugar Combinations to the Consumer Preference of Ice Creams at Different Serving Temperatures.

Figure 1 shows the final placings of medium fat, low serum solids ice creams varying in sucrose-dextrose sugar combina-

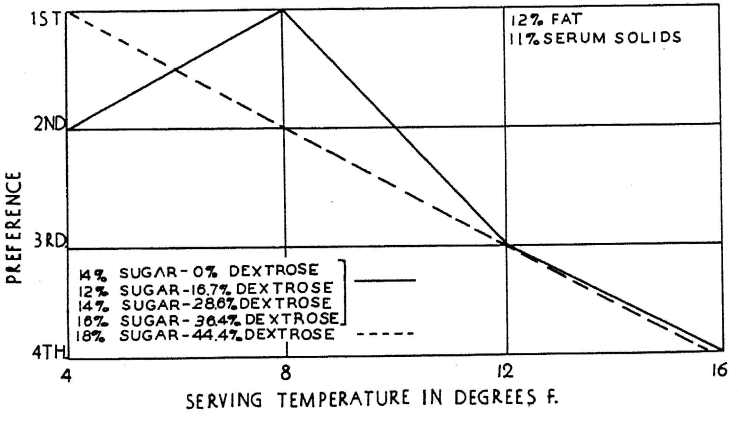


Fig. 1.—The effect of serving temperature upon consumer preference of medium fat-low serum solids ice cream varying in sucrose-dextrose sugar combination.

tions at different serving temperatures. Flavor, body and texture preference coincided with the final placings. Ice creams containing as much as 16 per cent sugar, in which sucrose was replaced by dextrose to the extent of 36.4 per cent, were preferred at eight degrees Fahrenheit, while ice cream with higher sugar content was preferred at four degrees Fahrenheit. Twelve and 16 degrees Fahrenheit were considered to be the least preferable serving temperatures for all sucrose-dextrose combina-

tions. Table 4 presents specific comments made by the judges.

Table 4.—The Effect of Ice Cream Serving Temperature Upon Consumer Preference.

Sugars Per Cent		Serving Temperature	Number of	Consumer Comments
Sucrose	Dextrose	Degrees F.	Judges	
14	...	4	116 women	Typical ice cream; desirable flavor; too hard.
		8	98 women	Desirable richness and hardness; body too firm.
		12	109 women	Typical flavor and serving temperature; too sweet.
		16*		
10	2	4	79 women	Too cold.
		8	104 women	Serving temperature too low; body too firm; flavor good.
		12	124 women	Desirable temperature; open texture
			24 men	Typical flavor.
		16	79 women	Too warm; body too soft
10	4	4	107 women	Typical ice cream; too cold; close texture; body is too firm.
			28 men	Typical ice cream.
		8	129 women	Desirable richness, flavor intensity and temperature; smooth mellow body.
			28 men	Typical ice cream
		12	140 women	Desirable flavor and temperature
			24 men	Typical ice cream
		16	104 women	Typical ice cream although too warm and too soft.
10	6	4	43 women	Flavor typical and desirable; too cold
		8	25 women	Typical ice cream; desirable temperature; pronounced flavor.
		12	24 men	Desirable richness, temperature and flavor.
		16*		
10	8	4	120 women	Desirable flavor intensity; medium-close texture.
		8	77 women	Typical flavor
		12	77 women	Too sweet; too warm.
		16	77 women	Too sweet; too warm; body is too soft.

*No single comment made by at least 50 per cent of the judges. (Composition of mix 12 per cent fat, 11 per cent serum solids).

Figure 2 shows the flavor, body and texture preferences and final placing of ice creams shown in Figure 1 when served at

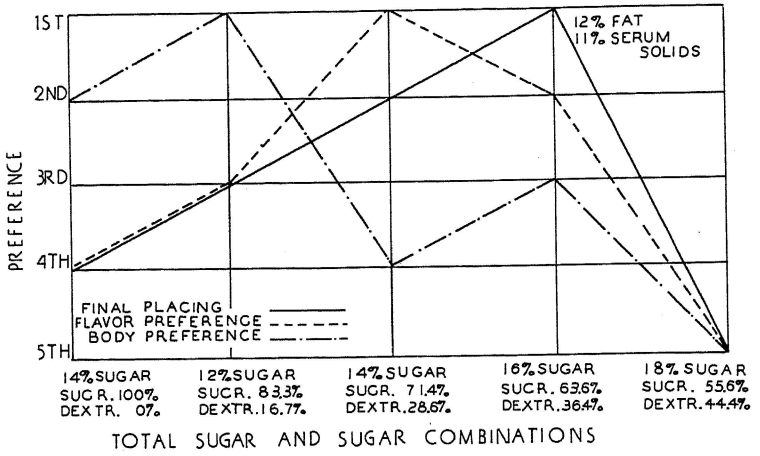


Fig. 2.—The effect of different sugar combinations upon consumer preference for ice cream at 8 degrees Fahrenheit.

eight degrees Fahrenheit. The texture preference coincides with the final placing. Figure 3 shows the same ice creams as Figure 2 when served at 12 degrees Fahrenheit. The 16 per cent sugar

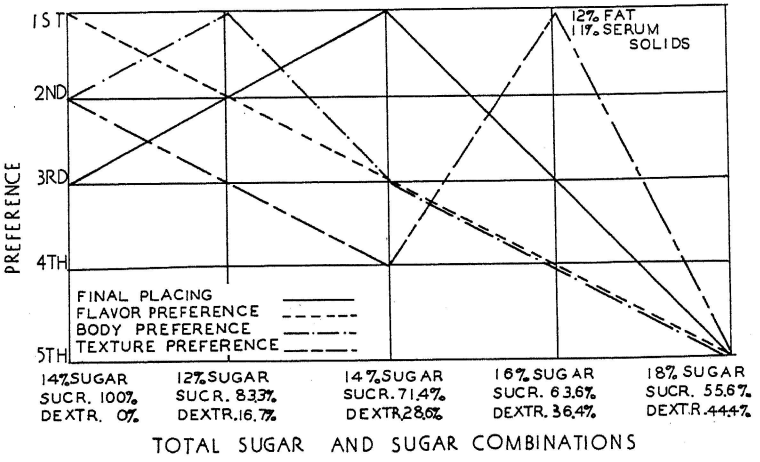


Fig. 3.—The effect of different sugar combinations upon consumer preference for ice cream at 12 degrees Fahrenheit.

content was preferred in the final placing at eight degrees Fahrenheit, whereas preference was for the 14 per cent sucrose-dextrose sugar combination ice cream when the serving temperature was increased to 12 degrees Fahrenheit. This may be due to the fact that the colder ice cream shocked the taste buds so it is more difficult for them to recognize the sensation of flavor. A more pronounced flavor is therefore desired at lower

temperatures. The consumers, in making their final placings, preferred the sucrose-dextrose sugar combination in the all-sucrose ice cream at both eight and twelve degrees Fahrenheit.

Series 2. The Relation of Sucrose-Cerelose Sugar Combinations to Consumer Preference of Ice Cream at Different Serving Temperatures.

A comparison of sucrose-dextrose and sucrose-cerelose sugar combinations in ice cream with regard to final placing at different serving temperatures is shown in Figure 4. When ice cream containing 12 per cent fat and 11 per cent serum solids has

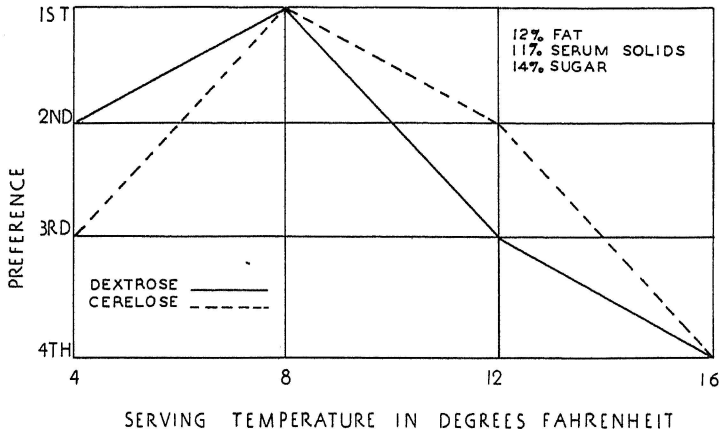


Fig. 4.—A comparison of dextrose and cerelose sugars by consumer preference for ice cream having 28.6 per cent replacement of sucrose by dextrose or cerelose.

a sugar content of 14 per cent in which 28.6 per cent of the sucrose is replaced by either dextrose or cerelose, the preferred serving temperature is eight degrees Fahrenheit. Dextrose ice cream is apparently preferred at a slightly lower temperature than the cerelose ice cream as the second preference was for four degrees Fahrenheit as compared to the second preference for cerelose ice cream at 12 degrees Fahrenheit. The serving temperature of 16 degrees Fahrenheit was least desirable to the judges.

Figure 5 shows the flavor and body preference for the cerelose ice cream which is given a final placing in Figure 4. The flavor of the ice cream is more desirable at four degrees Fahrenheit, while the body is more desirable at eight degrees Fahrenheit. Final placing was also given for the ice cream at eight degrees Fahrenheit.

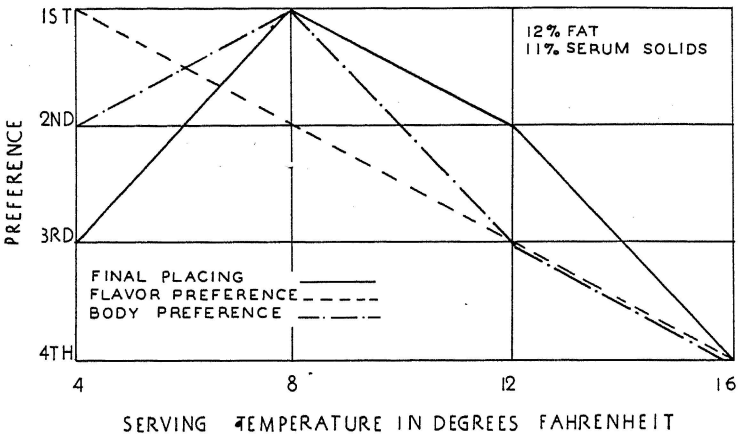


Fig. 5.—The effect of low serving temperature upon consumer preference of medium fat-low serum solids ice cream having 28.6 per cent replacement of sucrose by cerelose.

Table 5 records specific comments made by the judges when 50 per cent or more so commented. Figure 6 presents a comparison of preferences for ice cream on the basis of sex. Men and women recorded their final placings for ice creams varying in total sugar and in sucrose-cerelose combinations. In both cases, sucrose-cerelose combinations were preferred to the all-sucrose ice cream. Ice cream having 18 per cent total sugar

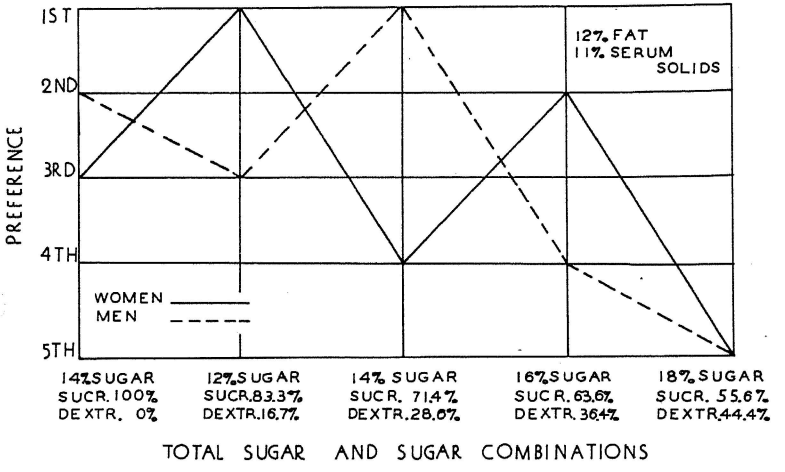


Fig. 6.—The effect of replacing variable increments of sucrose with cerelose upon consumer preference of ice creams of different sugar contents at 8 degrees Fahrenheit.

Table 5.—The Effect of Ice Cream Serving Temperature Upon Consumer Preference.

Sugars		Serving	Number	
Per Cent		Temperature	of	Consumer Comments
Sucrose	Cerelose	Degrees F.	Judges	
14	0	4*		
		8	30 women	Typical ice cream; desirable temperature; body mellow, smooth
			27 men	Typical ice cream; too cold.
		12*		
		16*		
10	2	4*		
		8	30 women	Typical ice cream; desirable richness, flavor and temperature; smooth, mellow body.
		12*		
		16*		
10	4	4	38 women	Too cold
		8	30 women	Typical ice cream; desirable flavor and temperature; smooth mellow body; medium-close texture.
		12	36 women	Desirable richness; smooth, mellow body.
		16	38 women	Too warm.
10	6	4*		
		8	30 women	Typical ice cream; desirable richness, flavor and temperature; smooth, mellow body.
		12*		
		16*		
10	8	4	43 women	Unnatural flavor; desirable richness; good temperature.
		8	30 women	Unnatural flavor
		12*		
		16*		

*No single comment made by at least 50 per cent of the judges. (Composition of mix: 12 per cent fat, 11 per cent serum solids).

with a 44.4 per cent replacement of sucrose by cerelose was least desired by both the men and women judges.

Series 3. The Relation of Sucrose-Dextrose Sugar Combinations to Consumer Preference of Low-Fat, Medium-Serum Solids Ice Cream at Different Serving Temperatures

Figure 7 shows the flavor and body preference and final placing of sucrose-dextrose combination ice creams containing 10 per cent fat and 13 per cent serum solids. The total sugar content of 14 per cent contains 28.6 per cent dextrose. Body preference is at four degrees Fahrenheit and flavor at 12 degrees Fahrenheit. Since the final placing is also at 12 degrees Fahrenheit, it appears that flavor of ice cream is more important to the consumer than the body. The serving temperature of 16 degrees Fahrenheit was least desirable for both flavor and body.

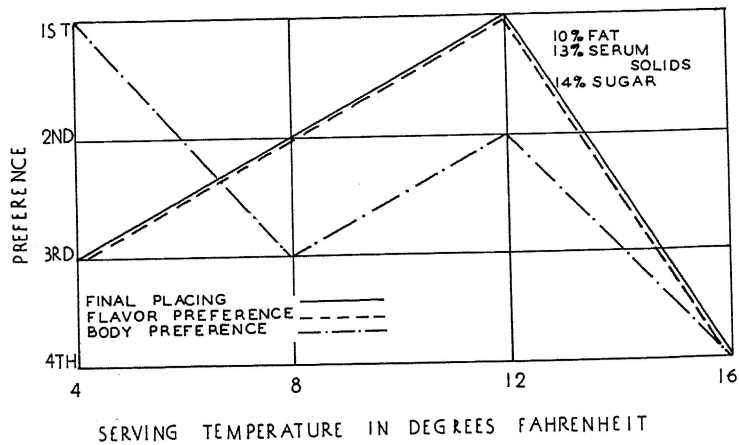


Fig. 7.—The effect of serving temperature upon consumer preference for low fat-medium serum solids ice cream having 28.6 per cent replacement of sucrose by dextrose.

When the five different ice creams in Series 3 were judges for flavor and body preference and final placing, at eight degrees Fahrenheit, the sucrose-dextrose sugar combinations were preferred as is shown in Figure 8. The ice cream containing only sucrose was given third preference for both body and flavor and final placing. Comments made by the judges in regard to serving temperature, flavor body and texture are shown in Table 6.

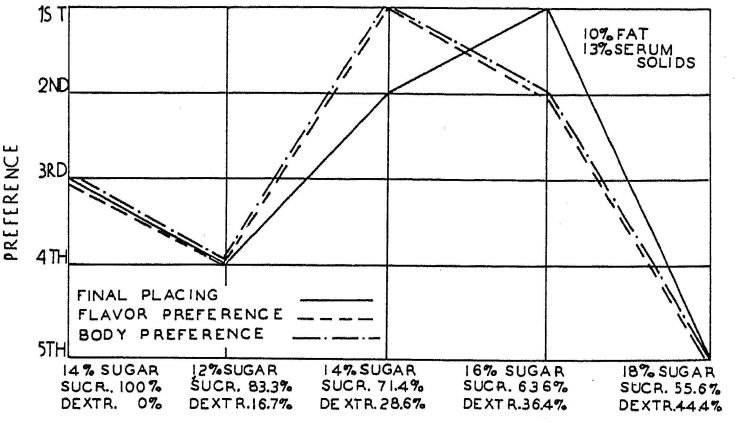


Fig. 8.—The effect of sugar combinations in low fat-medium serum solids ice cream upon consumer preference at 8 degrees Fahrenheit.

Table 6.—The Effect of Ice Cream Serving Temperature Upon Consumer Preference.

Sugars Per Cent		Serving Temperature	Number of	Consumer Comments
Sucrose	Dextrose	Degrees F.	Judges	
		4*		
14	0	8	40 women	Serving temperature; too cold
		12*		
		16*		
10	2	4*		
		8	40 women	Typical ice cream; too cold
		12*		
		16*		
10	4	4	14 women	Desirable; too cold
		8	54 women	Typical ice cream; desirable richness; smooth, mellow body.
		12	14 women	Lacks sweetness; pronounced flavor; desirable temperature.
		16	14 women	Too warm; body too soft.
10	6	4*		
		8	40 women	Desirable flavor; smooth, mellow body
		12	24 men	Desirable temperature.
		16*		
10	8	4*		
		8*		
		12*		
		16*		

*No single comment made by at least 50 per cent of the judges. (Composition of mix: 10 per cent fat, 13 per cent serum solids).

Figure 9 presents the effect on consumer preference of variation in ice cream composition with regard to fat, serum solids, and cane-corn sugar combinations. Flavor, body and final preference coincide. With fat and serum solids constant at 12 and 11 per cent respectively, the ice cream having 28.6 per cent of the sucrose replaced by dextrose was preferred over the sucrose-cerelose ice cream. With the total sugar and sucrose-dextrose

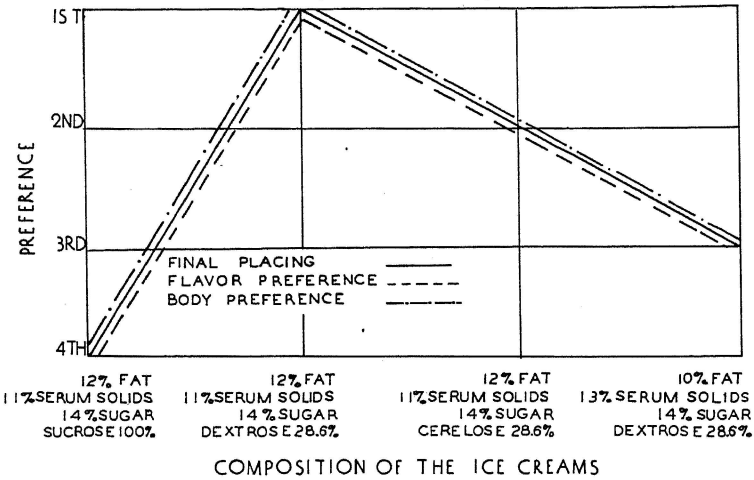


Fig. 9.—The effect of variable percentages of fat, serum solids and sugar upon consumer preference of ice cream at 12 degrees Fahrenheit.

sugar combinations constant, the medium fat—low serum solids ice cream was preferred to the low fat—medium serum solids ice cream. Of the four ice creams, the three cane-dextrose sugar combinations were preferred to the all-sucrose ice cream despite a reduction in fat content with a corresponding increase in serum solids in the sample receiving third preference. Apparently the sugar combination of cane and dextrose sugars plays a more important role in consumer preference than a 2 per cent fat or serum solids variation.

Series 1 and 3. The Relation of Fat and Serum Solids Variation to Consumer Preference of Ice Cream at Different Serving Temperatures.

Figure 10 indicates that the desirable serving temperature for ice cream varies with its composition. The 12 per cent fat, 11 per cent serum solids ice cream was preferred at eight degrees Fahrenheit. When the fat percentage was reduced to 10 per cent and the serum solids content increased to 13 per

cent, the serving temperature of 12 degrees Fahrenheit was preferred. This increase in serving temperature preference may be due to the property of butterfat to carry flavor. Therefore, when the amount of butterfat is reduced, a higher temperature is required to cause the remaining flavor to become apparent. In both of these ice creams, the total sugar content included 28.6 per cent dextrose.

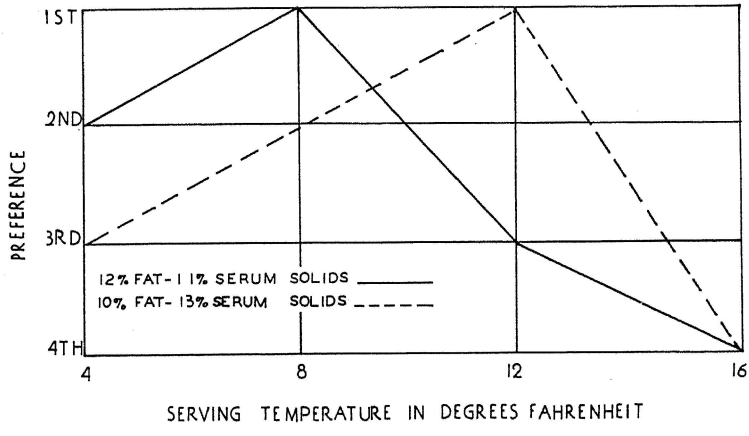


Fig. 10.—The effect of variable percentage of fat and serum solids upon consumer preference of ice cream at different serving temperatures.

Figure 11 shows the effect of different percentages of fat and serum solids upon consumer preference of ice cream of different sugar compositions at eight degrees Fahrenheit. The

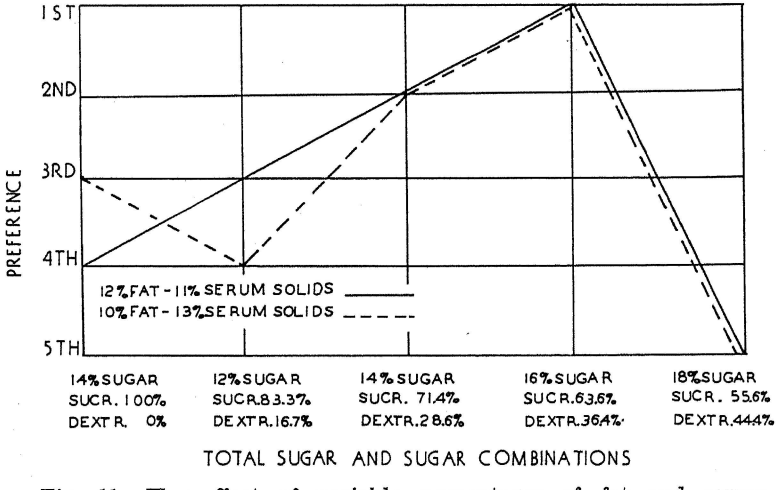


Fig. 11.—The effect of variable percentages of fat and serum solids upon consumer preference for ice cream at different sugar compositions at 8 degrees Fahrenheit.

first three placings were given the sucrose-dextrose ice cream in preference to the all-sucrose ice cream when 12 per cent fat was present in two of the three samples. Specific comments by the judges regarding these ice creams are found in Tables 4 and 6.

Figure 12 shows that a medium fat, low serum solids ice cream having a total sugar composition of 14 per cent, of which 28.6 per cent is dextrose, was preferred by women at a lower serving temperature. This placing difference may indicate that men prefer sweeter ice cream since a higher serving temperature intensifies flavor. Men and women stated that the ice creams at 16 degrees Fahrenheit were the least desirable.

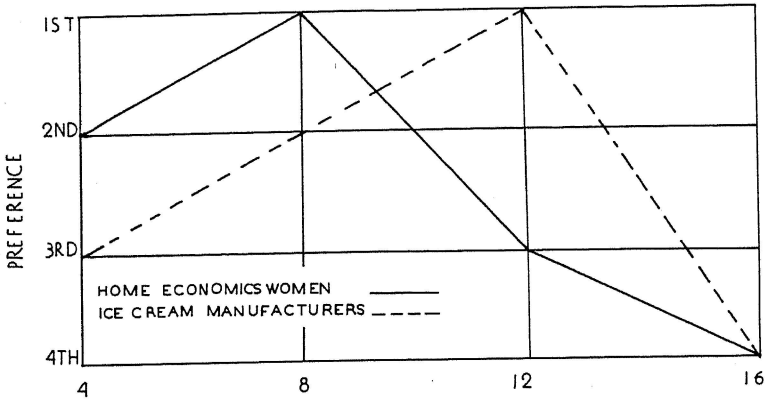
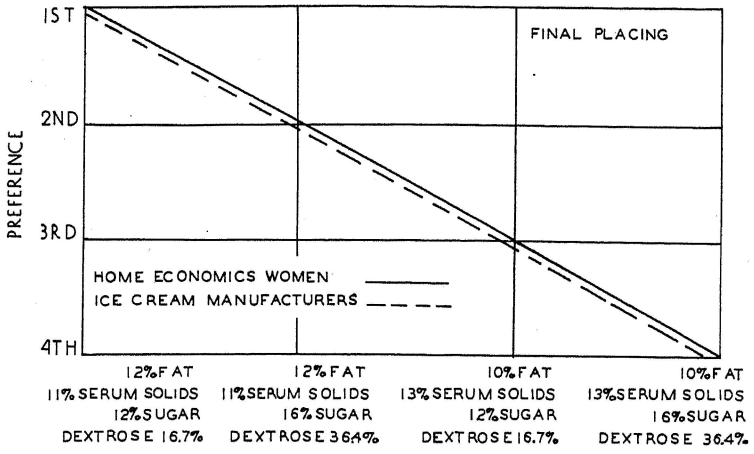


Fig. 12.—The variation in consumer preference for serving temperatures in medium fat-low serum solids ice cream having 28.6 per cent replacement of sucrose by dextrose.

Series 1, 2 and 3. The Variation in Consumer Preference of Ice Creams of Different Compositions.

Figure 13 shows that the sex of the ice cream judge is not an important factor in consumer preference when four different ice creams are judged at 12 degrees Fahrenheit. Two of the ice creams contained only the one variable factor—that of dextrose sugar which was increased from 12 to 16 per cent. The women preferred the flavor in the ice creams varying in fat and serum solids and containing the larger percentage of sugar. Tables 4 and 6 present the actual comments on each of these ice creams as offered by 50 per cent or more of the judges.

Figure 14 shows another close correlation between sexes as consumer and preference judges. It is apparent that the sex of the ice cream consumer is not important in the selection of ice creams.



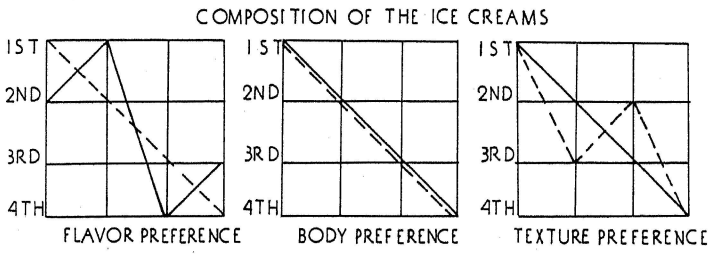


Fig. 13.—The effect of different percentages of fat and serum solids upon consumer preference for ice cream varying in sugar combinations at 12 degrees Fahrenheit.

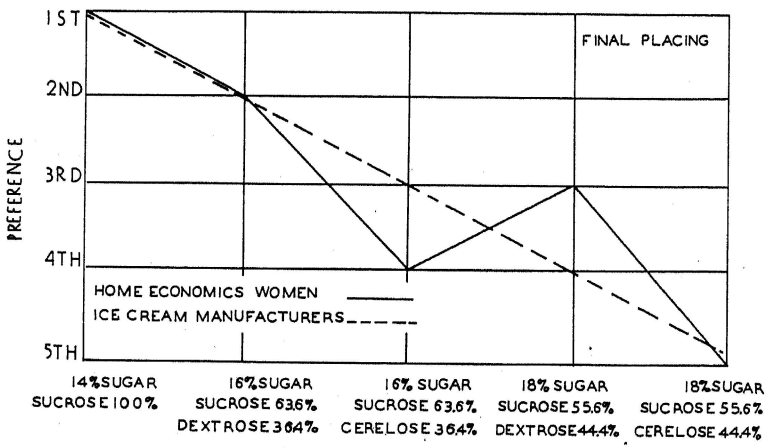


Fig. 14.—The effect of consumer taste upon preference for ice cream having sucrose replacements by dextrose and cerelose at 4 degrees Fahrenheit.

The Relation of Composition of the Mix and Different Serving Temperatures to the Texture of Ice Creams

Figures 15 to 18, inclusive, indicate that serving temperatures has very little effect upon texture, although the texture appears more defined at the lower temperatures. It was noted that increased increments of sugar gave a slightly finer texture, but there appears to be little difference in the effect of various sugar combinations. Ice creams with increased increments of sugar did not maintain their firmness of body at the higher serving temperatures, the body appeared somewhat sticky and the microscopic relief was slightly coarse. These defects were not apparent at lower serving temperatures.

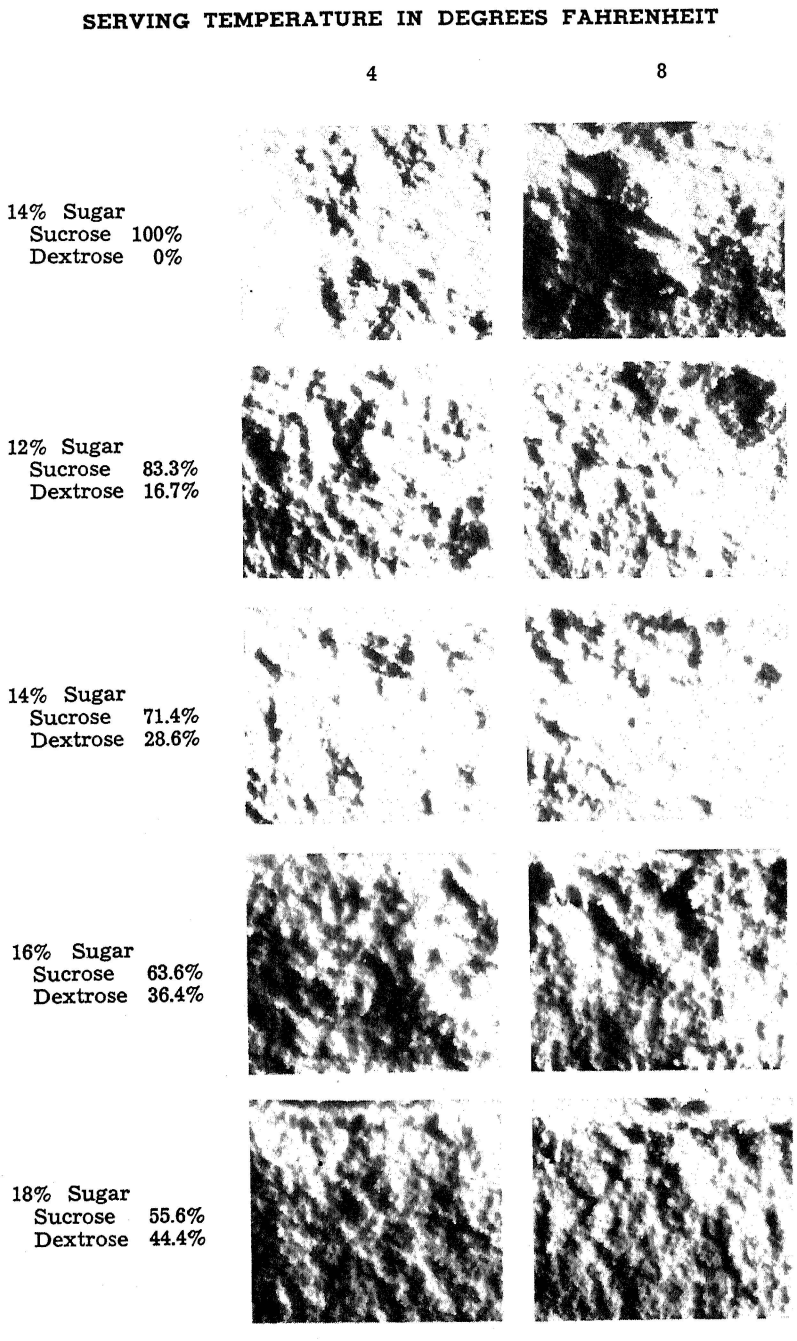


Fig. 15.—The effect of variation in sugar content and serving temperature upon the texture of medium fat, low serum solids ice cream.

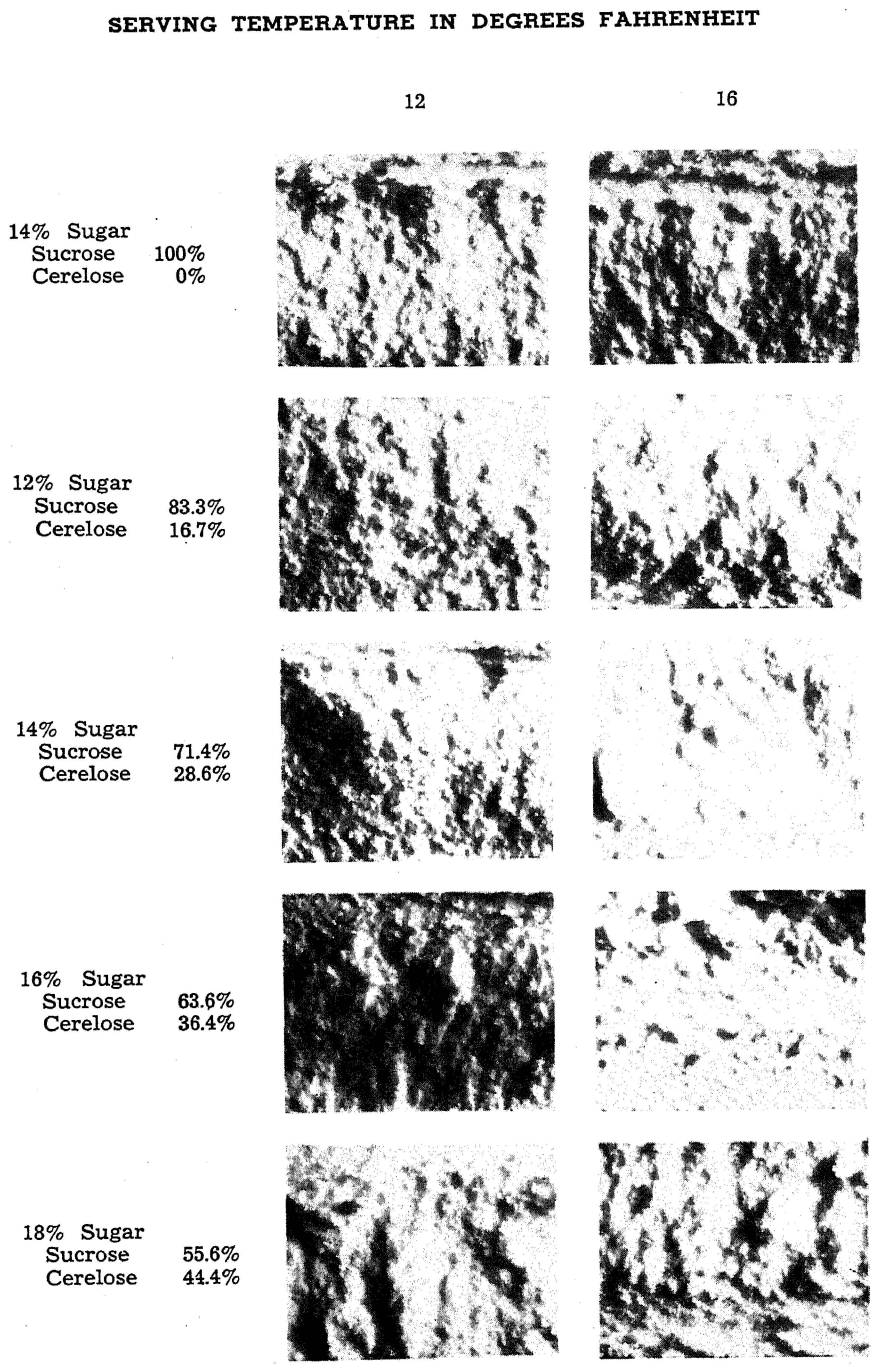


Fig. 16.—The effect of variation in sugar content and serving temperature upon the texture of medium fat, low serum solids ice cream.

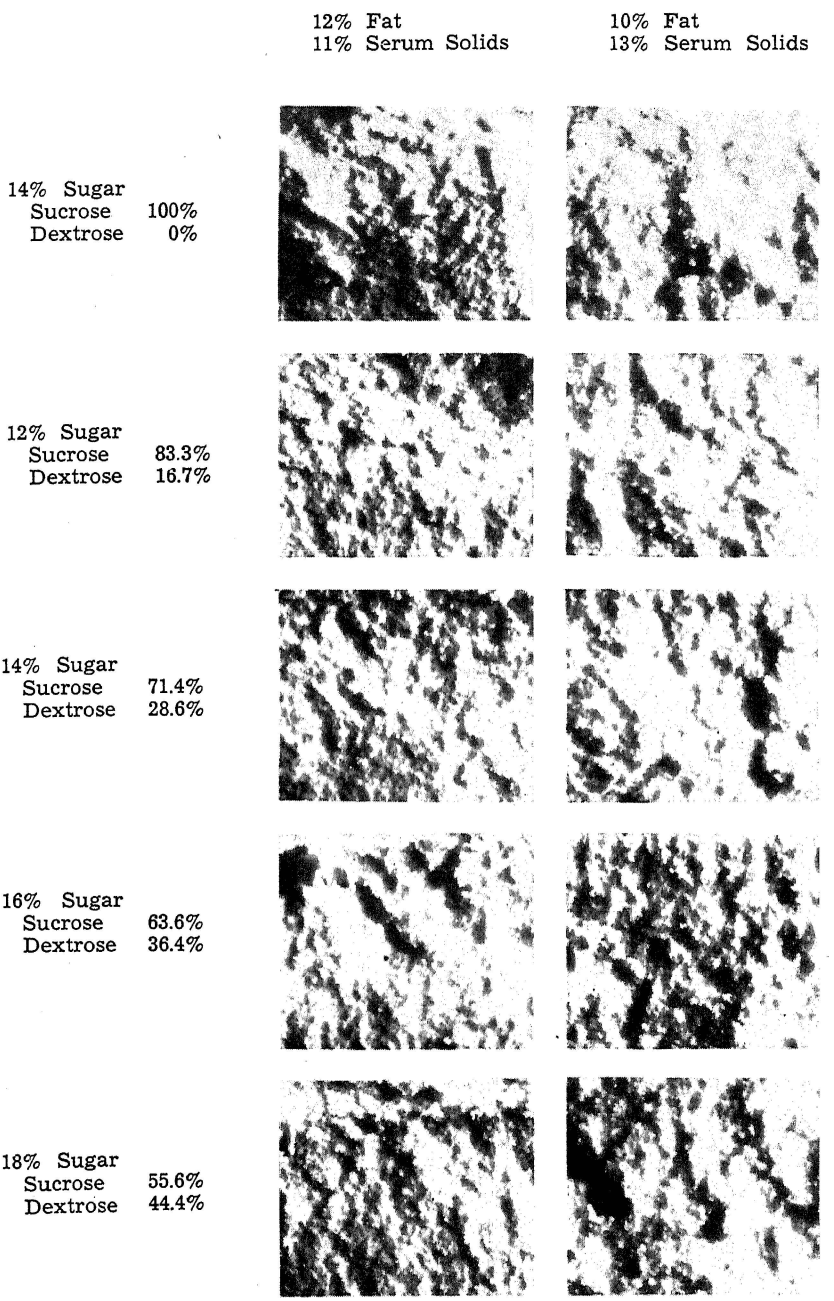


Fig. 17.—The effect of variation in sugar, fat and serum solids content upon the texture of ice cream.

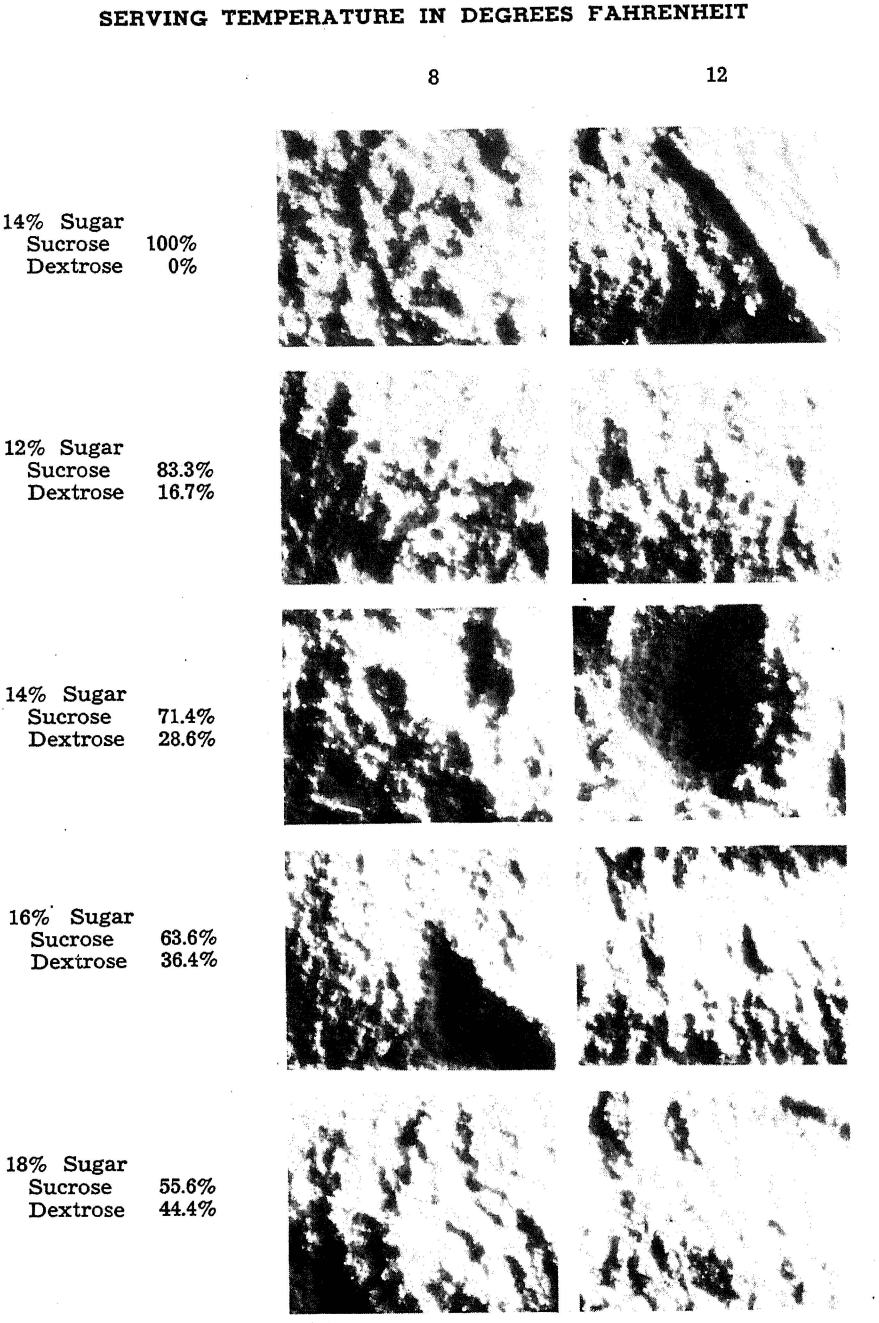


Fig. 18.—The effect of variation in sugar content and serving temperature upon the texture of medium fat, low serum solids ice cream.

The Relation of the Composition of the Mix to the Internal Structure of Ice Creams

Microphotographs of the texture of the ice creams studied in this investigation, Figures 19 to 21 inclusive, indicate that added increments of dextrose sugar increase the average size of the ice crystal. The increase in ice crystal size was only 46.13 per cent as great when cerelose sugar was used. The relationship of increased ice crystal size with increased increments of sugars was not found in lower fat, higher serum solids mixes.

Figures 19 to 21 also show that added increments of sugar caused the amount of matrix or unfrozen material between the ice crystals to increase and caused a greater dispersion of the ice crystals which resulted in a somewhat more moist ice cream. Increased increments of dextrose increased the distance between ice crystals 104.91 per cent in the 12 per cent fat and 11 per cent serum solids ice cream and only 78.04 per cent in the 10 per cent fat and 13 per cent serum solids ice cream. Cerelose increased the amount of unfrozen material only 28.23 per cent as much as did dextrose.

The largest ice crystals found in the dextrose ice creams measured 8.03 microns. This size is considerably below Hunziker's (11) scale of crystal size which are 12 to 15 microns to cause a slightly mealy body.

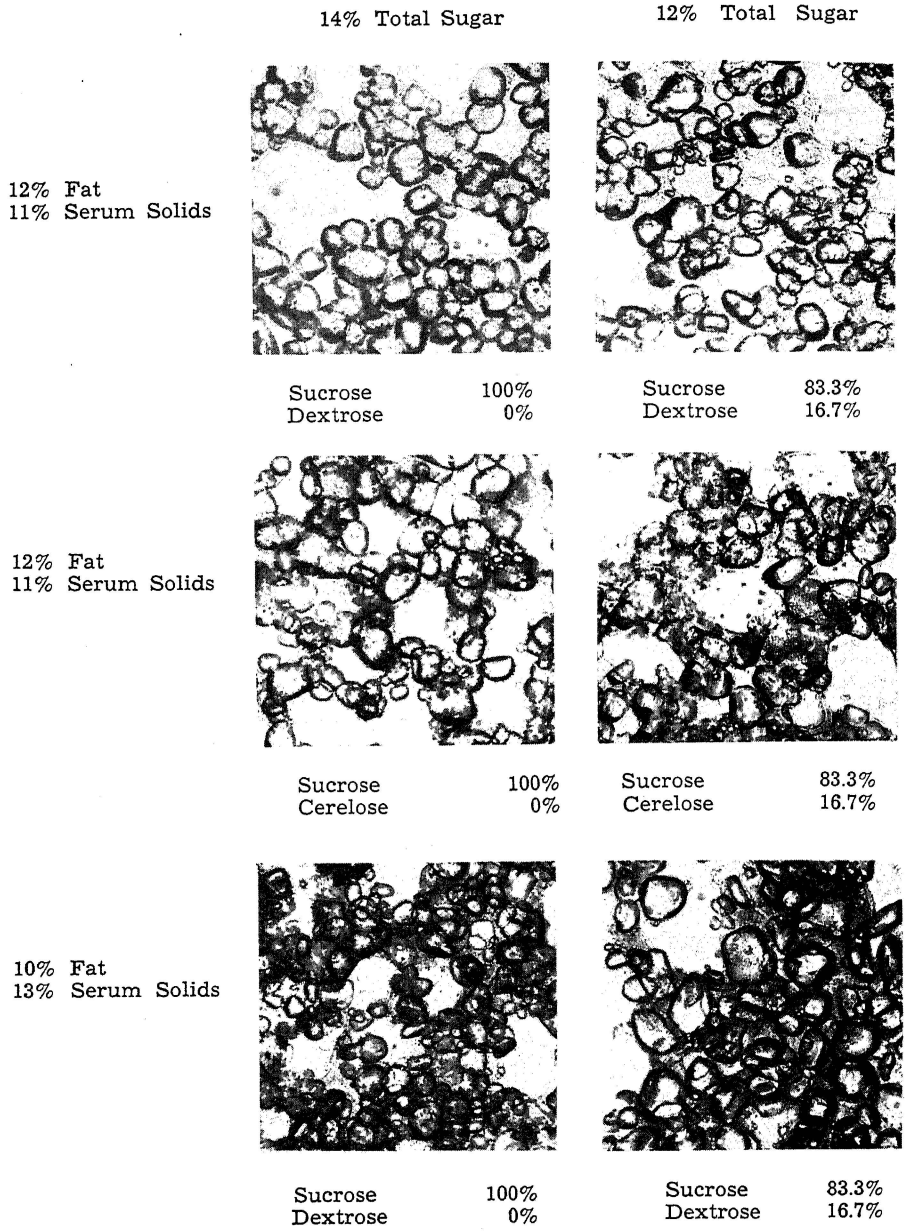


Fig. 19.—Microphotographs showing effect of variation in sugar, fat and serum solids upon the internal structure of ice cream.

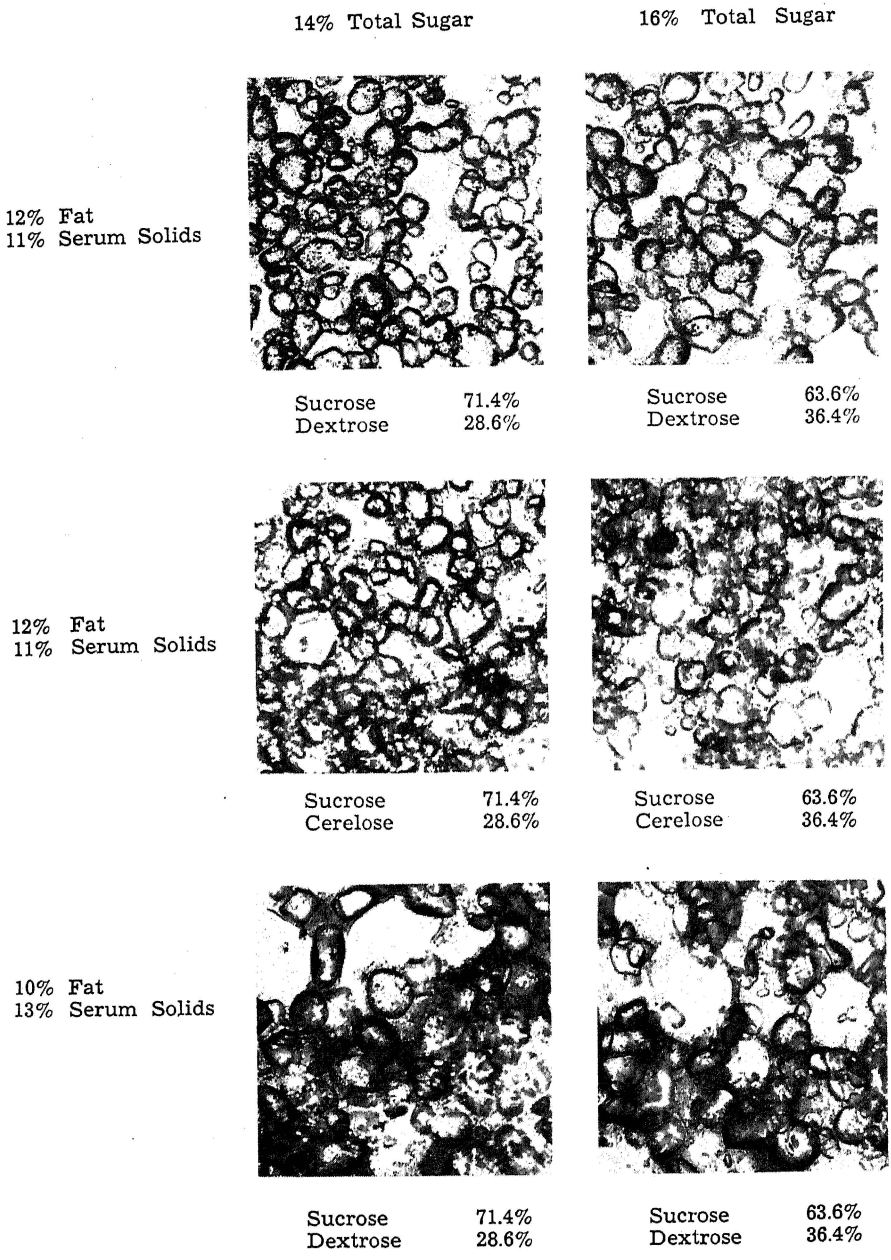
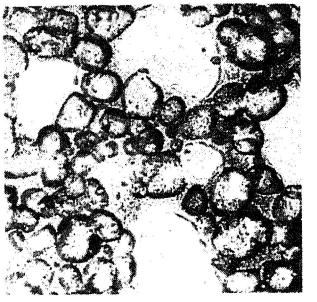


Fig. 20.—Microphotographs showing effect of variation in sugar, fat and serum solids upon the internal structure of ice cream.

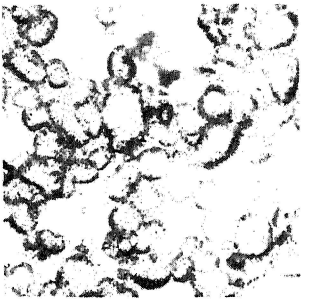
18% Total Sugar

12% Fat
11% Serum Solids



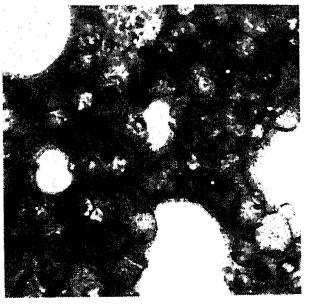
Sucrose 55.6%
Dextrose 44.4%

12% fat
11% serum solids



Sucrose 55.6%
Cerelose 44.4%

10% Fat
13% Serum Solids



Sucrose 55.6%
Dextrose 44.4%

Fig. 21.—Microphotographs showing effect of variation in sugar, fat and serum solids upon the internal structure of ice cream.

The Relation of the Composition of the Mix and Different Serving Temperatures to the Stability of Ice Creams

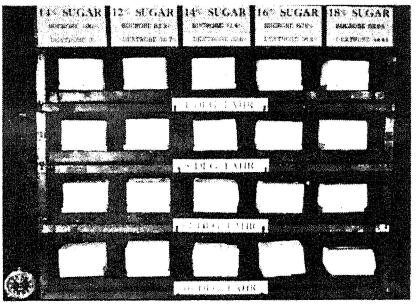
Figures 22 to 25 show that the serving temperature appears to be insignificant in relation to ice cream stability; while fat and serum solids content of the mix appear to be more important in influencing the stability than the amount or kind of sugar combination. Melt down occurred first in the 10 per cent fat and 13 per cent serum solids series when compared to the two 12 per cent fat and 11 per cent solids series. However, greater differences in type of melt down was observed between the two 12 per cent fat and 11 per cent serum solids series where the only variables were dextrose and cerelose sugars.

The use of dextrose sugar in ice cream tended to give a melt down in which masses of mix sluffed off the sample, while the characteristic cerelose melt down appeared as smoother, less viscous, more glistening ice cream. Ice cream containing sucrose only possessed melt down characteristics between those of the dextrose and cerelose ice creams. There seems to be a greater difference in the type and rapidity of melt down between the ice creams.

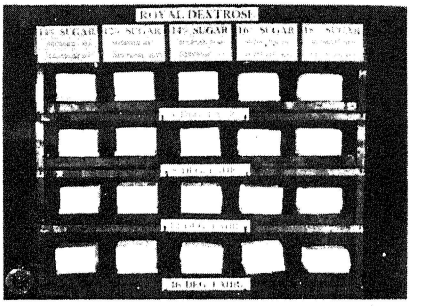
The ice creams containing a portion of dextrose sugar and having 14 per cent total sugar were more stable at the four serving temperatures studied than the ice creams having 14 per cent total sucrose sugar. Figure 25, 10 minute exposure, shows that ice cream having six per cent cerelose and 10 per cent sucrose began to melt before ice creams to which four per cent dextrose was added to the 10 per cent sucrose base. This would tend to indicate that the stability of dextrose ice cream is somewhat greater than the stability of cerelose ice creams. However, the stability difference is insignificant since very little melt down occurred within the first half hour of exposure. The stability of most ice creams containing dextrose was greater than that of ice creams containing only sucrose.

Corn Sugar: Dextrose

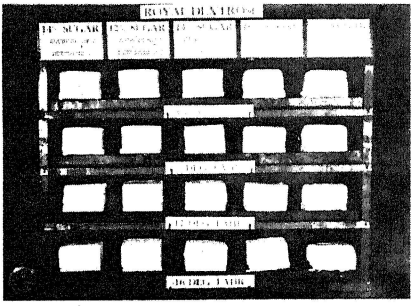
12% Fat 11% Serum Solids



Original Ice Cream



Exposed 10 Minutes



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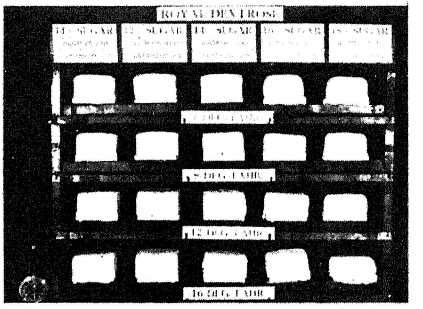
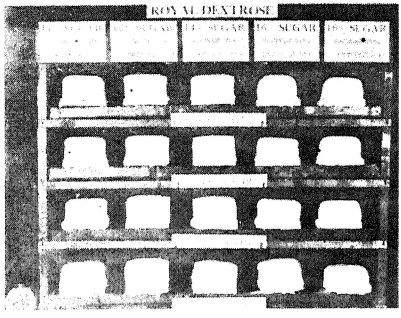


Exposed 30 Minutes

Fig. 22.—The relation of sugar content to the stability of medium-low serum solids ice cream.

Corn Sugar: Dextrose

12% Fat 11% Serum Solids



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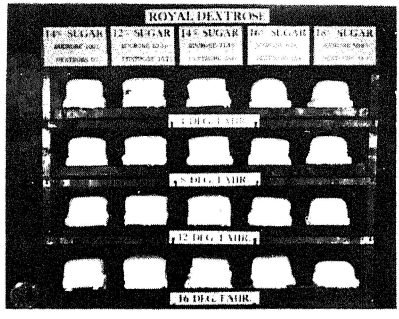
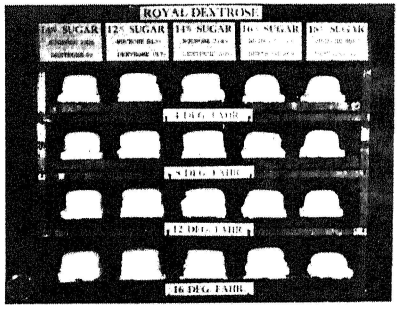


Exposed 50 Minutes



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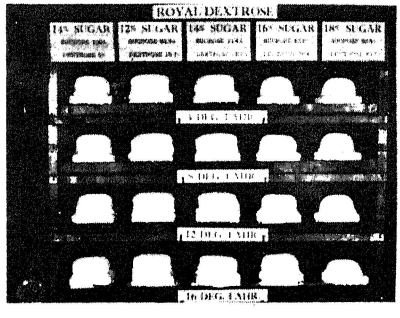

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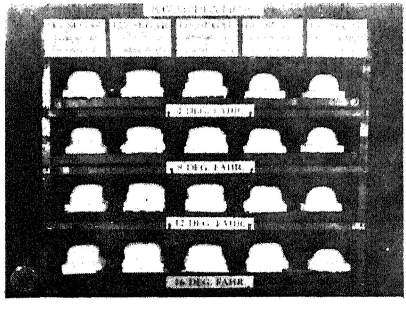
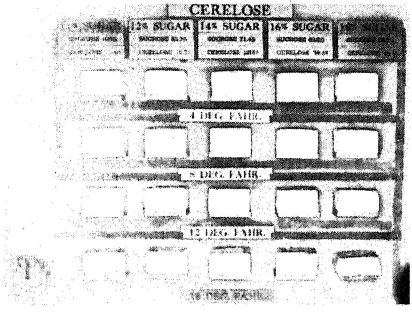


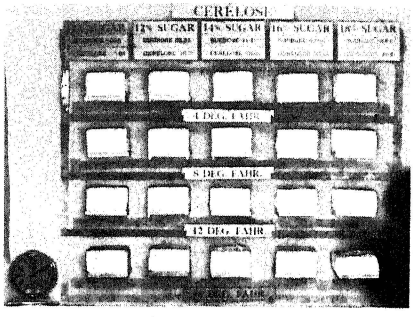
Exposed 80 Minutes

Corn Sugar: Cerelose

12% Fat 11% Serum Solids



Original Ice Cream



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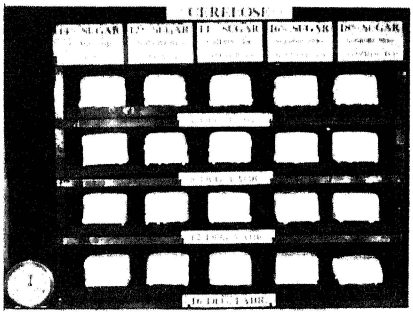

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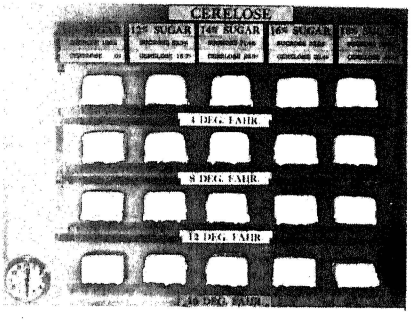
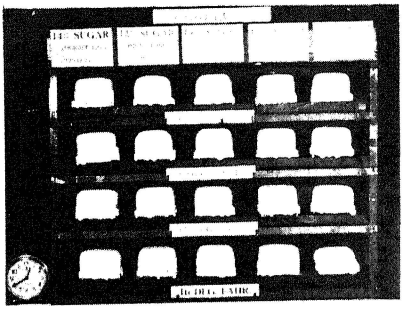


Exposed 30 Minutes

Fig. 23.—The relation of sugar content to the stability of medium fat-low serum solids ice cream.

Corn Sugar: Cerelose

12% Fat 11% Serum Solids



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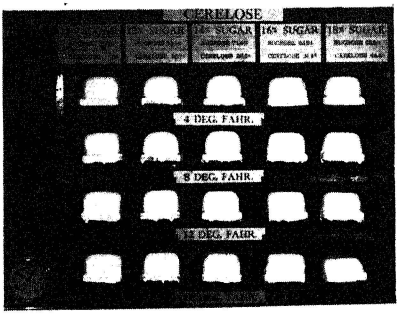

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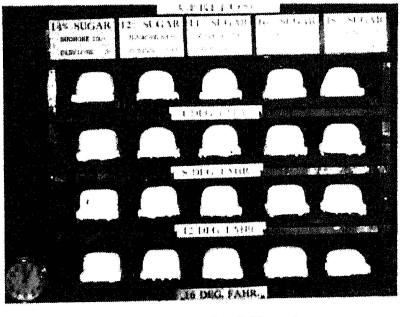

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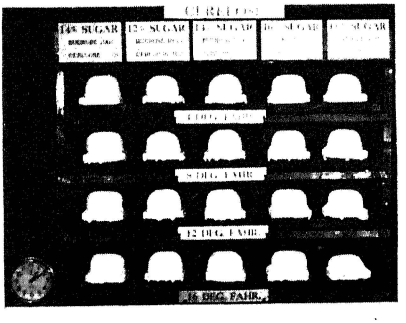

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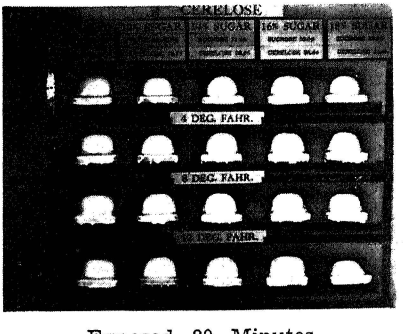
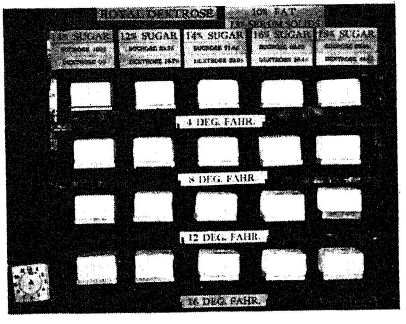


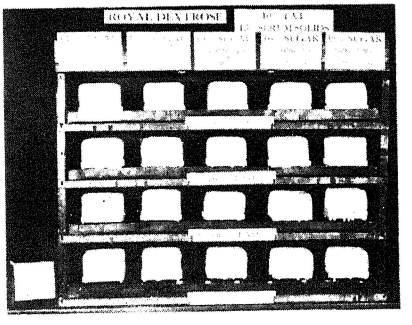
Exposed 80 Minutes

Corn Sugar: Dextrose

10% Fat 13% Serum Solids



Original Ice Cream



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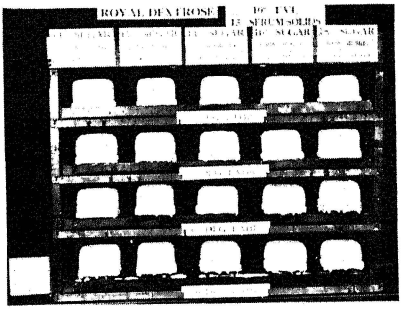

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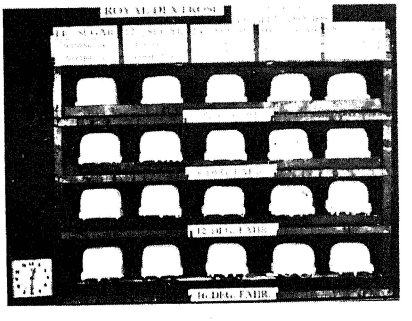
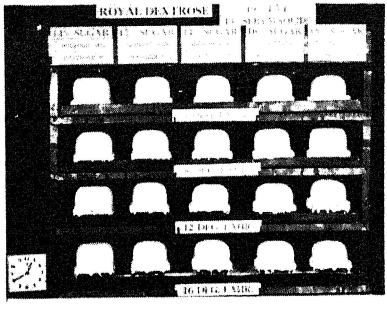


Exposed 30 Minutes

Fig. 24.—The relation of sugar content to the stability of low fat-medium serum solids ice cream.

Corn Sugar: Dextrose

10% Fat 13% Serum Solids



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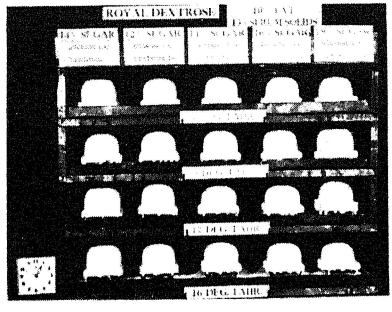
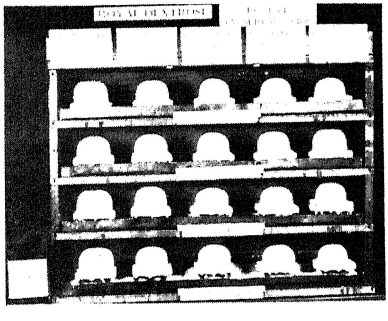
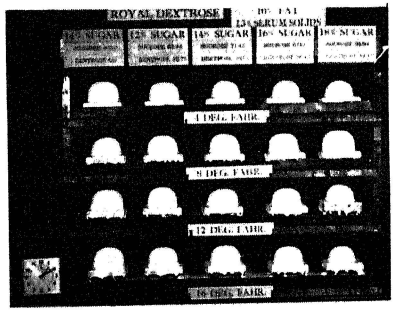


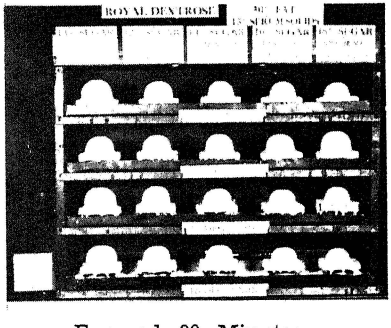
Exposed 50 Minutes



Exposed 60 Minutes



Exposed 70 Minutes



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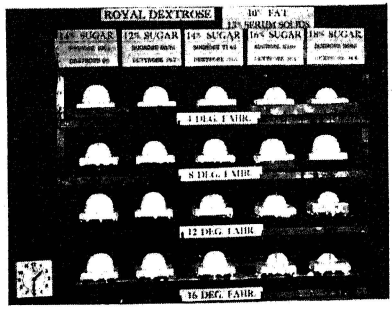

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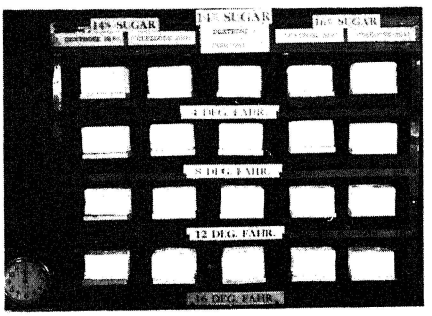
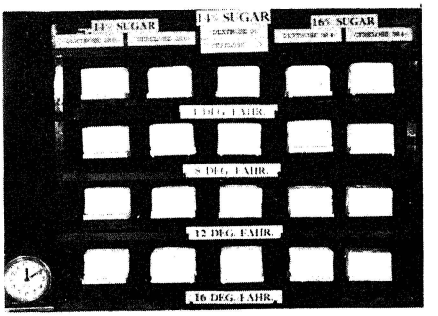
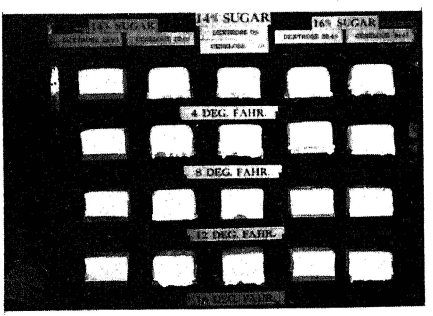


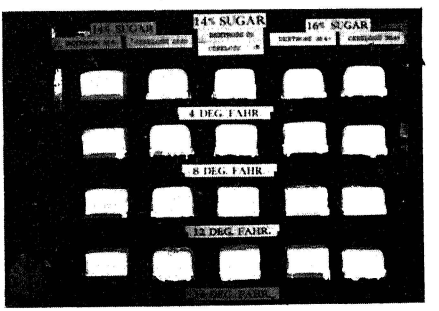
Original Ice Cream



Exposed 10 Minutes

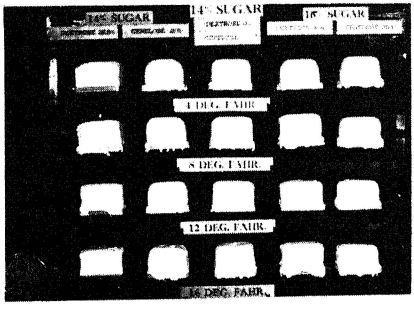


Exposed 20 Minutes

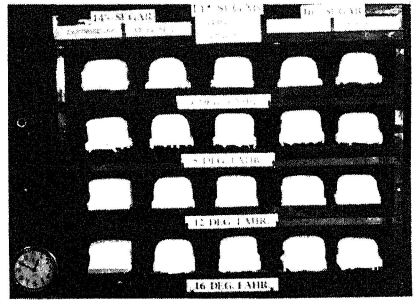


Exposed 30 Minutes

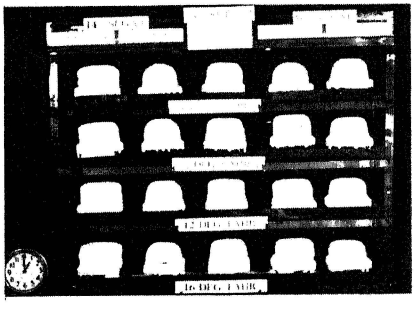
Fig. 25.—A stability comparison of ice cream containing combinations of dextrose, cerelose and sucrose at different serving temperatures.



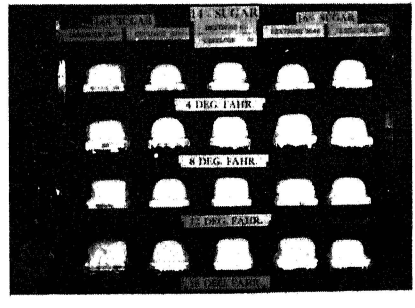
Exposed 40 Minutes



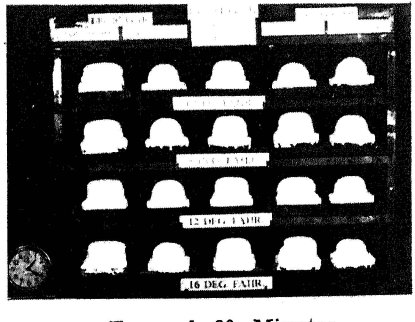
Exposed 50 Minutes



Exposed 60 Minutes



Exposed 70 Minutes



Exposed 80 Minutes

Table 7 presents the temperature of ice creams after an exposure time of one and one-half hours at 80 degrees Fahrenheit. The final temperatures of the melting ice cream increased from the initial serving temperatures which varied a total of 12 degrees Fahrenheit to temperatures that ranged from 25.5 to 27 degrees Fahrenheit at the completion of the melting period.

Table 7.—The Relation of Composition and Serving Temperature to the Final Temperature of Ice Cream After An Exposure Period of One and One-Half Hours at 80 Degrees Fahrenheit.

Fat	Serum Solids	Sucrose	Corn Sugar	Kind of Corn Sugar	Initial Temperatures of the Ice Creams, Degrees F.			
Per Cent	Per Cent	Per Cent	Per Cent		4	8	12	16
			Series 1					
12.00	11.00	14.00	0.0	Dextrose	26	26	26	26
12.00	11.00	10.00	2.0	Dextrose	26	26	26	26
12.00	11.00	10.00	4.0	Dextrose	25	25	25.5	26
12.00	11.00	10.00	6.0	Dextrose	24	24.5	25	26
12.00	11.00	10.00	8.0	Dextrose	24	25	25	26
			Series 2					
12.00	11.00	14.00	0.0	Cerelose	27	27	27	26.5
12.00	11.00	10.00	2.0	Cerelose	26	27	26	26
12.00	11.00	10.00	4.0	Cerelose	26	26	26	26
12.00	11.00	10.00	6.0	Cerelose	24.5	25	26	26
12.00	11.00	10.00	8.0	Cerelose	24.5	25	25.5	26.5
			Series 3					
10.00	13.00	14.00	0.0	Dextrose	22	22	22.5	22
10.00	13.00	10.00	2.0	Dextrose	23	23	24	22
10.00	13.00	10.00	4.0	Dextrose	23	21.5	23	22.5
10.00	13.00	10.00	6.0	Dextrose	23	22	23	23
10.00	13.00	10.00	8.0	Dextrose	24	23	23	23.5

The Relation of the Composition of the Mix to the Residue of Completely Melted Ice Cream

Figures 26 to 28, inclusive, show the fifteen different ice creams after complete melt down has taken place. It is obvious that the different amounts or kinds of sugar combinations in ice creams with low or medium fat and serum solids percentages did not alter the desirable residue of the completely melted ice creams. In the two and four per cent dextrose ice creams having a 12 per cent fat and 11 per cent serum solids base, the flaky residue is characteristic of butterfat.

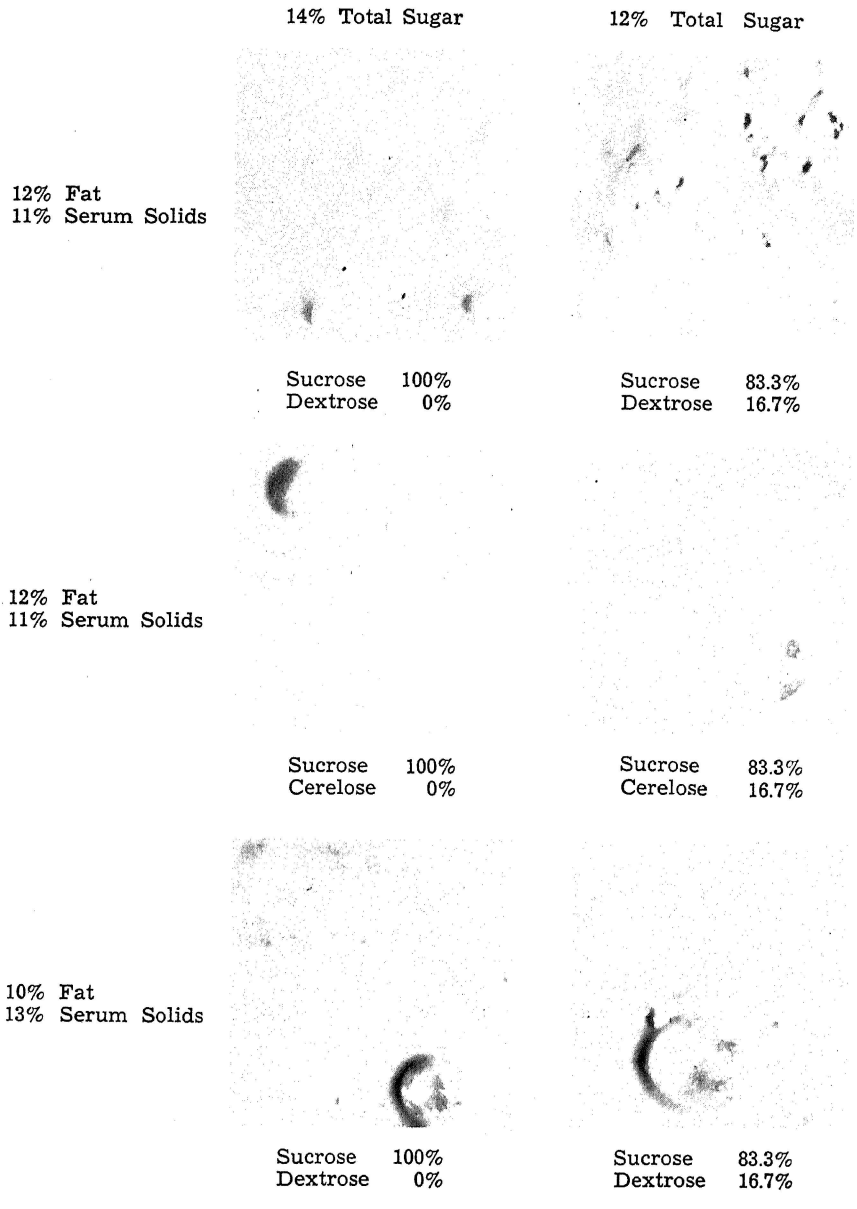


Fig. 26.—Macrophotographs of completely melted ice cream showing effect of variation in sugar, fat and serum solids upon physical appearance.

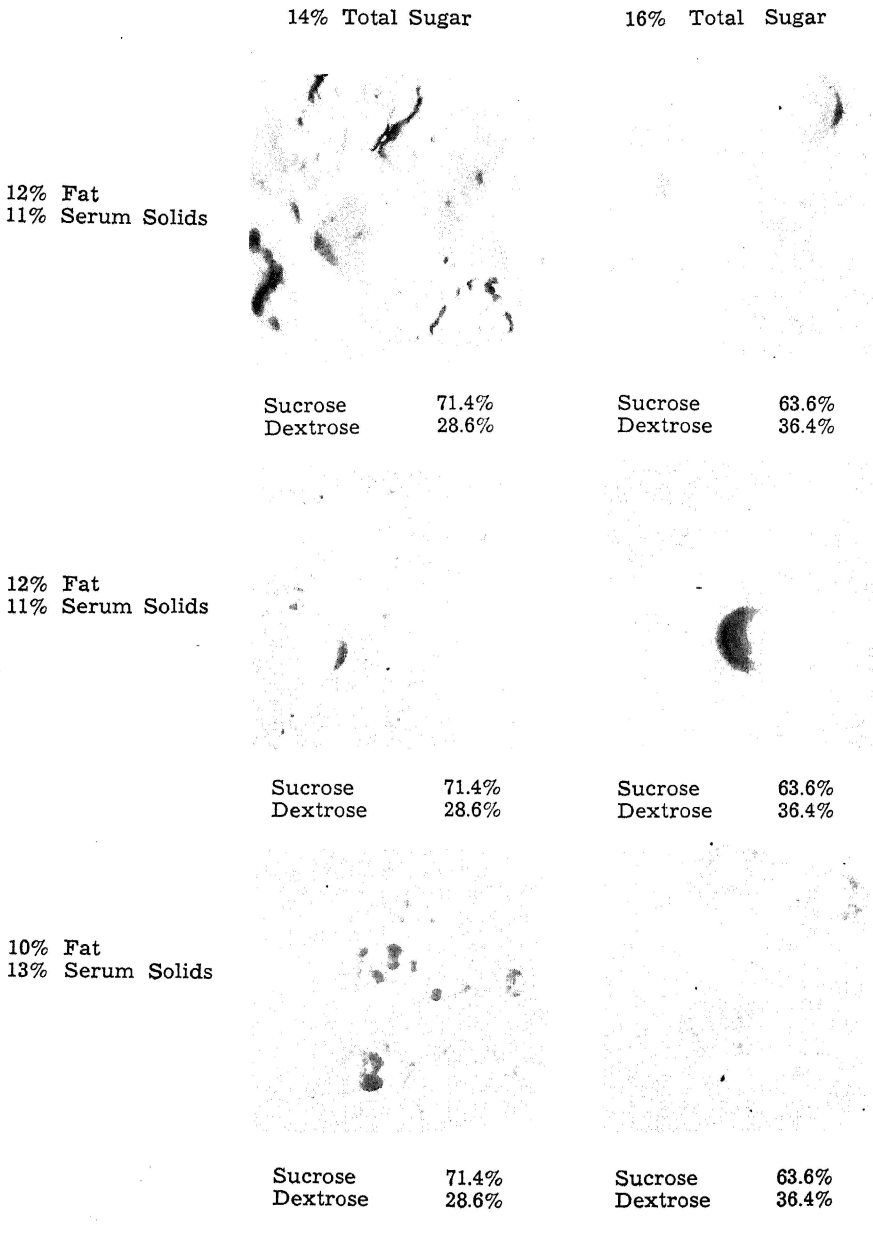


Fig. 27.—Macrophotographs of completely melted ice cream showing effect of variation in sugar, fat and serum solids upon physical appearance.

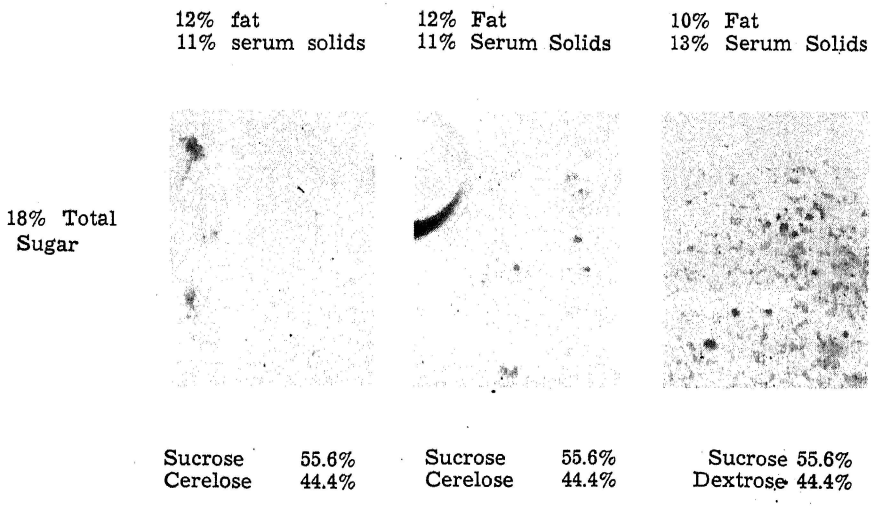


Fig. 28.—Macrophotographs of completely melted ice cream showing influence of variation in sugar, fat and serum solids upon physical appearance.

Fig. 29.—Macrophotographs of completely melted ice cream showing influence of sugar content upon the final residue.

Figure 29 pictures Series 3 after melt down was complete. The size and foaminess of the residue is indicated by bubble structure on the blocks used in the melt down. Increased increments of dextrose tend to decrease the size of the bubbles. The smallest bubbles were present in the control ice cream having 14 per cent sucrose sugar. The largest bubbles occurred in the presence of the lowest per cent total sugar ice cream.

The Relation of Composition of the Mix and Different Serving Temperatures to the Average Weight and Number of Dishers of Ice Cream

Table 8 shows the effect of varying increments of dextrose sugar and different serving temperatures on the average weight and number of dishers of ice cream in two and one-half gallons of ice cream at 100 per cent overrun. It may be noted that the weight of the dishers of ice cream increase slightly with increase in serving temperature. Serving temperature plays an important role in maintaining firmness of body so that lower serving temperatures are desired for ice creams of high sugar content. There appears to be greater uniformity in disher weight increase due to the increase in serving temperature than from the increase in sugar content.

Table 9 represents the same data as Table 8 with the exception that increments of cerelose were used instead of dextrose. Again, the weight of the dishers of ice cream slightly increased as the serving temperature was increased, but only in the case of the lower total sugar content ice creams. Perhaps this may be explained by the fact that the dishers of the higher sugar ice creams were too soft at the higher serving temperatures to be of normal size. The number of dishers obtained per two and one-half gallons ranged from 92 to 124 and normal dipping appeared to depend upon the firmness of ice creams, a factor which can be regulated by serving temperature.

Table 10 presents the effect of added increments of dextrose in a 10 per cent fat and 13 per cent serum solids ice cream upon the dipping properties of the finished product. The weight of the dishers decreased as the serving temperature increased and there was less variation in the average weight of dishers from an increase in sugar content of the ice cream. At the higher serving temperatures, the number of dishers of ice cream per gallon increased with a corresponding decrease in average weights. It is likely that variation in firmness of body caused by increased increments of sugar may be controlled by the maintenance of correct serving temperatures.

Table 8.—The Relation of Ice Cream of Different Sugar Combinations at Different Serving Temperatures to the Average Weight, Number and Physical Characteristics of Dishers of Ice Cream.

Sugars (Per Cent)		Physical Characteristics of the Ice Cream	Serving Temperature in Degrees Fahrenheit							
			4		8		12		16	
Sucrose	Dextrose		Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers
			ozs.		ozs.		ozs.		ozs.	
14.00	0.0		1.569	114	1.657	109	1.658	108	1.725	104
		Comments	Much too hard		Little too hard		Optimum hardness		Rather soft and sticky	
10.00	2.0		1.533	117	1.761	102	1.771	101	1.749	102
		Comments	Too hard for dipping		Hard		Holds shape well		Good for dipping	
10.00	4.0		1.606	111	1.713	105	1.520	118	1.560	115
		Comments	Very hard		Satisfactory for dipping		Optimum hardness		Very easy dipping	
10.00	6.0		1.682	108	1.614	112	1.638	105	1.709	105
		Comments	Rather resistant		Good dipping		Too soft to hold shape		Too soft for dipping	
10.00	8.0		1.600	112	1.600	112	1.670	108	1.600	113
		Comments	Very good dipping		Satisfactory for dipping		Too soft to hold shape		Sticky	

(Composition of mix: 12 per cent fat, 11 per cent serum solids)

Table 9.—The Relation of Ice Cream of Different Sugar Combinations at Different Serving Temperatures to the Average Weight, Number and Physical Characteristics of Dishers of Ice Cream.

Sugars (Per Cent)		Physical Characteristics of the Ice Cream	Serving Temperature in Degrees Fahrenheit							
			4		8		12		16	
Sucrose	Dextrose		Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers
			ozs.		ozs.		ozs.		ozs.	
14.00	0.0		1.849	97	1.493	122	1.657	108	1.923	94
		Comments	Much too hard		Too hard		Slightly sticky		Rather soft for dipping	
10.00	2.0		1.659	107	1.645	109	1.726	104	1.944	92
		Comments	Too hard		Too firm		Good for dipping		Optimum for dipping	
10.00	4.0		1.720	104	1.681	106	1.795	99	1.840	99
		Comments	Much too hard		Little too firm		Too soft for dipping		Far too soft	
10.00	6.0		1.824	99	1.656	106	1.793	100	1.440	124
		Comments	Little too hard		Splendid for dipping		Slightly sticky		Very soft and sticky	
10.00	8.0		1.840	97	1.773	106	1.752	102	1.600	121
		Comments	Satisfactory dipping		Good for dipping		Sticky		Too soft to look right	

(Composition of mix: 12 per cent fat, 11 per cent serum solids)

Table 10.—The Relation of Ice Cream of Different Sugar Combinations at Different Serving Temperatures to the Average Weight, Number and Physical Characteristics of Dishers of Ice Cream.

Sugars (Per Cent)		Physical Characteristics of the Ice Cream	Serving Temperature in Degrees Fahrenheit							
			4		8		12		16	
Sucrose	Dextrose		Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers	Weight of Average Disher	Number of Dishers
			ozs.		ozs.		ozs.		ozs.	
14.00	0.0		1.915	94	1.837	98	1.739	103	1.747	133
		Comments	Much too hard		Dips nicely		Slightly sticky		Too soft to look right	
10.00	2.00		1.920	94	1.773	101	1.872	98	1.725	104
		Comments	Much too hard		Dips nicely		Somewhat gummy		Sticky and no shape	
10.00	4.0		1.894	94	1.720	96	1.734	104	____	___
		Comments	Too hard		Right for dipping		Good dipping		Sticky and too soft	
10.00	6.0		1.934	92	1.934	92	1.816	100	1.843	98
		Comments	Too hard		Splendid dipping		Quite sticky		Much too soft	
10.00	8.0		1.889	95	1.763	102	1.721	105	1.518	120
		Comments	Good for dipping		Tendency to be soft		Sticky		Very soft and no shape	

(Composition of mix: 10 per cent fat, 13 per cent serum solids)

DISCUSSION

The physical and chemical analysis of the different mixtures indicated that a variation in the composition of the mix had little effect upon surface tension, pH and acidity. Specific gravity was increased by an increase in total solids.

The drawing temperature of the ice cream decreased with increased increments of cerelose or dextrose sugar and averaged 0.4 degrees Fahrenheit lower for the sucrose-dextrose mixes. It was found that the time required to fill different sized containers with ice cream decreased with increase in the total solids of the ice cream. Freezing difficulties such as stickiness were not encountered in any of the ice creams having sugar contents as high as 16 per cent of which 36.4 per cent was dextrose or cerelose sugar.

The consumer preference was greatest for the medium fat and low serum solids content ice creams at the serving temperature of eight degrees Fahrenheit. In case the fat percentage was decreased by two per cent and the serum solids content increased by a like amount, consumers preferred the serving temperature of 12 degrees Fahrenheit. These observations suggest that the composition and serving temperature have a decided effect upon the flavor and body of ice cream. In all cases, the flavor became more pronounced and sweeter and the body less resistant as the serving temperature increased from four to 16 degrees Fahrenheit. Increased fat and sugar content also produced a less resistant body.

The serving temperature had considerable effect upon the sweetness of the ice cream. The high sugar content ice creams were judged as too sweet at the higher serving temperatures but as desirable at the lower temperatures. Those ice creams containing a low sugar content were criticized at the lower serving temperatures as lacking in sweetness while they were considered acceptable at the higher temperatures.

Ice creams containing increments of dextrose or cerelose were preferred to ice cream containing sucrose alone. The ice creams containing added increments of dextrose had the highest consumer acceptance when judged at the optimum serving temperatures. In most cases, flavor characteristics were more important than body characteristics in determining the final consumer placings for the ice creams.

Macrophotographs show that serving temperature had very little effect upon texture, however, increased increments of sugar tended to give a slightly finer texture. Little difference

was noted in the effect of the various sugars and sugar combinations upon the texture of ice cream. Microscopic studies of the internal structure of ice cream show that increments of dextrose and cerelose sugar result in the ice crystals becoming larger and farther apart than ice crystals in ice cream composed of sucrose alone. This accounts for the presence of a moist body when increments of dextrose or cerelose are used, since there is more matrix or unfrozen material filling in between the ice crystals. The use of cerelose sugar may be expected to produce a slightly drier body in ice cream since increments of cerelose do not increase the size and distance between the ice crystals as much as do increments of dextrose sugar; therefore, less matrix would be present. This moist body condition disappears at the lower serving temperatures because the matrix is chilled into a less viscous physical state.

The serving temperature had little effect upon the stability of ice cream. Fat and serum solids content affect the stability of ice cream more than the amount or kind of sugar combination. The melt down of ice cream with increments of dextrose resembled fluffy snow that sluffed off the brick in masses of foamy mix, while the sucrose-cerelose ice creams began melting upon a shorter exposure and appeared to have a smoother, less viscous, more glistening melt down. All other factors comparable, the ice cream containing increments of dextrose was the most stable; ice cream containing increments of cerelose, next stable; and those containing sucrose alone, least stable. However, this finding has restricted advantage because very little melt down was observed within the first half hour of exposure.

The amounts or kinds of sugar combinations did not alter the desirability of the residue resulting from a complete melt down of ice cream. Macrophotographs of the slightly flaky residue, characteristic of high fat melt down, is observed in the ice cream containing 12 per cent fat. It is absent in the residue of the ice creams having 10 per cent fat. The appearance of the residue from ice creams containing added increments of dextrose or cerelose is readily acceptable to the consumer.

It was observed that the number of dishers of ice cream dipped from any given volume of ice cream was in inverse proportion to the average weight of the dishers of ice cream. The average weight of the dishers of ice cream increased slightly as the ice creams became softer and less resistant to dipping. This indicates that serving temperature plays an important part in maintaining the desired firmness of body in ice creams

high in sugar content. Apparently there is more uniformity in the average increase in disher weight as influenced by increasing serving temperature than by variation in sugar content. Greater variation in the number of dishers per gallon of ice cream was found in the ice cream containing cerelose than in the ice cream containing dextrose. A two per cent decrease in fat and a like increase in serum solids decreased the average weight of the disher at the higher serving temperatures. The average weight and number of dishers per gallon appear to be affected to a considerable extent by serving temperature.

CONCLUSIONS

1. Composition and serving temperature affected the consumer preference, crystalline structure, stabiltiy and dipping qualities of ice creams in this investigation.

2. Ice cream mixes containing 12 to 18 per cent total sugar with as much as 44.4 per cent of the sucrose replaced with either dextrose or cerelose were readily frozen without difficulty in a continuous freezer.

3. The 12 per cent fat and 11 per cent serum solids ice cream was preferred to the 10 per cent fat and 13 per cent serum solids ice cream. The former ice cream was preferred by the greatest number of consumers at eight degrees Fahrenheit, while the latter ice cream was preferred at 12 degrees Fahrenheit.

4. The higher sugar content ice creams were considered too sweet at the higher serving temperatures but desirable at the lower serving temperature.

5. Consumer preference was influenced more by flavor characteristics than by body characteristics when arriving at the final placings of ice creams. Flavor and body preferences may be partially controlled by proper serving temperatures.

6. Ice creams having sugar content comprised of sucrose-dextrose or sucrose-cerelose combinations ranging from 16.7 to 36.4 per cent replacement of sucrose by either dextrose or cerelose sugar in total sugar contents of 12 to 16 per cent were preferred to ice cream having 14 per cent sucrose sugar.

7. A difference was noted between sucrose or combinations of sucrose and dextrose or cerelose on the texture of ice cream.

8. The ice crystals are larger and farther apart with added increments of dextrose and cerelose in ice cream. Since there is more distance between ice crystals, there is more matrix or unfrozen material surrounding the ice crystals. This may account for these ice creams possessing a more moist body than ice cream composed of sucrose sugar alone. The applica-

tion of a lower serving temperature tends to give greater firmness to the body of ice cream.

9. Composition of ice cream has a greater effect upon stability than serving temperature. The characteristic melt downs of dextrose and cerelose sugars in combination with sucrose are comparable to sucrose melt downs and tend to be somewhat more stable when exposed at 85 degrees Fahrenheit.

10. The appearance of fully melted ice cream is readily acceptable to the consumer when combinations of dextrose and cerelose are used with sucrose.

11. Differences in average weights and numbers of dishers dipped from ice cream varying in sugar composition and combination and serving temperature appear to be less apparent by the maintenance of proper serving temperatures.

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