TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR,
College Station, Texas

BULLETIN NO. 656 AUGUST 1944

THE UTILIZATION OF SKIM MILK IN THE ICE CREAM MIX

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E04-844-4500-L180

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This bulletin presents information upon the preparation and use of a concentrated skim milk product in the manufacture of ice cream. The method which proved most successful consisted of coagulating skim milk at a temperature of 94 to 96°F. with dilute hydrochloric acid. The whey was drained when sufficient acid had been added to produce an acidity in the whey of 0.45 to 0.48 per cent. After the whey had been drained the curd was disintegrated by passing it through the screen bottom of the drain rack. The curd was dissolved by adding five pounds of sodium bicarbonate per 100 pounds of casein and heating to 150°F. for 30 minutes. Skim milk was added to the dissolved casein to produce a finished product containing 16 per cent solids. The product was standardized by the addition of skim milk to 16 per cent solids content according to the Pearson square method or to a Baume reading of 7.2 at 60° Fahrenheit. The method used differs from methods heretofore described in that the quality and composition control was based upon the use of the acidity tester, a casein test and the hydrometer. The preparation was simplified by completing the entire process by the use of a cheese vat as the major piece of equipment. Disintegration and heating the curd brought about more rapid dissolving. The heating period reduced the bacterial count of the finished product to fifty thousand or less. The use of skim milk instead of water to standardize the finished product to 16 per cent solids content offered a means of conserving additional non-fat milk solids. An analysis showed that the approximate composition of the finished product was as follows: 84.0 per cent water, 16.0 per cent total solids including 13.8 per cent protein, 2.0 per cent lactose and 1.5 per cent ash. The cost of manufacture excluding labor was approximately one and one-half cents per pound solids.

The product prepared in this manner was used to supply 10 to 50 per cent of the serum solids content of various ice cream mixes. The data indicate that 37.5 per cent of the serum solids can be supplied by the concentrated skim milk in a 10 per cent fat, 8 per cent serum solids ice cream containing butter as a source of fat. When cream was used as a source of fat, 10 per cent of the serum solids needed could be furnished by the concentrated skim milk product in a 10 per cent fat, 8 per cent serum solids mix. In a 12 per cent fat, 9.6 per cent serum solids mix, 20 per cent of the serum solids could be supplied by the concentrated skim milk; and in a 12 per cent fat, 11 per cent serum solids mix, the concentrated skim milk could be used to furnish 50 per cent of the serum solids needed.

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THE UTILIZATION OF SKIM MILK IN THE ICE CREAM MIX

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The possibility of utilizing delactosed milk products as a source of solids in the ice cream mix has been recognized for many years especially in plants which do not possess the facilities for the conversion of skim milk into skim milk concentrates. Much of the ice cream produced in Texas is manufactured in small plants that carry on mixed operations in which skim milk is available at nearly all times. Nevertheless, many of these small plants continue to purchase the condensed milk and milk powder used in ice cream mixes rather than utilize available skim milk for this purpose. Lack of acceptance of concentrated delactosed milk products by the industry has been primarily due to inadequate methods of preparation and control. A satisfactory method would permit the more efficient use of surplus skim milk in human food channels rather than its present use for feeding livestock. It would also facilitate the storage of temporary surpluses of skim milk for use in periods of shortages. This bulletin presents such a method whereby small dairy plants can produce a concentrated skim milk product for utilization in the manufacture of ice cream.

LITERATURE CITED

Experimental work conducted upon the manufacture of delactosed milk solids for use in ice cream indicates that this product offers a possible method for utilizing skim milk solids. Several methods for the preparation of a low lactose skim milk product have been suggested, but no simple standard method for its preparation and use has been developed.

Hall and Houtz (4) were apparently the first to study the possibilities of the use of acid casein as a source of serum solids in ice cream. The object of their investigations was to develop a method for raising the serum solids content of ice cream without the development of sandiness. They found that moist acid casein dissolved with sodium bicarbonate could be used in ice cream with satisfactory results. Turney and Turney (7) patented a process for producing a casein ice cream filler. The casein curd was precipitated by pepsin, rennin or acid, and then semi-dissolved by the addition of lime, soda bicarbonate and sugar. Zoller (9) patented a process for the preparation of an unhydrolized alkali caseinate to be used with the regular mix ingredients.

Corbett and Tracy (2) produced a low lactose milk by the addition of Hygell, a carbo bean derivative, that caused the separation of the curd and whey in skim milk.

Bird, Sadler and Iverson (1) found that ice cream mix made with sodium caseinate supplying from 2.5 to 5 per cent serum solids whipped more

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rapidly to a higher maximum overrun, had a smoother more desirable body and texture, was more uniform in melting and had slightly better flavor than ice cream made with other serum solids concentrates. Watts (8) found that the use of 4 per cent casein solids in the mix gave more satisfactory results from the standpoint of flavor, body and texture, whipping ability and melting quality than higher casein contents. He reported that the whipping properties of the ice cream mix were greatly increased by the use of casein solids. Teichert (5) made an extensive study of the manufacture and use of acid casein in ice cream and concluded that acid casein could be used as a desirable source of serum solids for the manufacture of ice cream. In an 11 per cent serum solids ice cream mix, as much as 4 per cent serum solids could be supplied as acid casein with satisfactory results.

Teichert, et al., (6) in a preliminary study, described a method for the preparation of acid casein for use in ice cream. Dilute hydrochloric acid was added to skim milk to form an acid curd. The curd thus formed when washed and drained contained 29 to 32 per cent solids. The curd was dissolved for use in the ice cream mix by the addition of sodium carbonate or sodium bicarbonate. The most satisfactory results were secured when the pH of the dissolved curd was adjusted to 6.5 to 7.2. Studies indicated that this product could be used to supply up to 40 per cent of the serum solids content of an average commercial mix. The mixes showed exceedingly rapid whipping ability and a high maximum overrun. The finished ice cream possessed a slight curd flavor, and the body was criticized as being gummy. Freeman (3) made suggestions for the use of casein in the ice cream mix, as prepared by the method described by Teichert, et al., and suggested that the casein could be held at 45°F. for 3 to 5 days, and that the addition of 0.2 per cent sodium propionate as a preservative made possible storage at 45°F. for 3 to 4 weeks. The recommended method of incorporating the casein into the ice cream mix was to prepare a 20 per cent solids product by mixing the casein in sufficient water to which had been added 0.25 pound of baking soda for each 10 pounds of curd used. Several hours were required for the casein to dissolve, and then it was added to the balance of the mix at 120°F. as the mix was being pasteurized. Objections to the use of casein to supply more than 40 per cent of the serum solids were: an impaired flavor, a chewy or pasty body and difficult control of overrun due to excessive rapidity of whipping.

PLAN OF INVESTIGATION

The general plan of this investigation was to design an economical, simple and rapid method for the production of a concentrated skim milk solids product of uniform composition and desirable flavor for use as a source of serum solids in ice cream. Also a comparison of various testing procedures was made in order to establish a simple practical method of determining the solids content of the concentrated product. A study was made to determine the extent that the concentrated skim milk could be used as a source of solids for various ice cream formulas, and also its

effect upon the properties of the ice cream mix and the flavor, body and texture, melting properties, consumer acceptance and keeping qualities of the finished ice cream. This investigation was conducted under controlled conditions which closely simulated those of the commercial plant.

METHODS

The Manufacture of the Concentrated Skim Milk Product

The method of manufacturing the skim milk solids used in this investigation was perfected after observations were made of various procedures. Various lots of skim milk were placed in a cheese vat and adjusted to various temperatures between 90 and 100°F. in order to determine the most desirable precipitating temperature. The casein content of the skim milk was determined to provide a basis for the control of the composition in the finished product. A comparison was made of the characteristics of the curds produced by the use of hydrochloric, sulfuric, acetic and lactic acids as precipitating agents. One volume of concentrated acid was diluted with nine volumes of water. The dilute acid was slowly added to the milk with gentle stirring until a clean separation of the whey and curd had taken place. The acidity of the whey was adjusted to various levels between 0.43 and 0.52 per cent, and a comparison was made with the pH values of the whey at each adjustment in order to determine the titratable acidity at pH 4.6, the point of complete precipitation of the casein. When the desired acidity was reached, the whey was drained and the curd was disintegrated and different lots dissolved by the use of various amounts of different dissolving agents. A comparison was made of sodium bicarbonate, sodium carbonate and a commercial alkali for dissolving the curd. The acidity of different lots of the finished product was adjusted to various levels between 0.2 and 0.6 per cent, and the pH values were taken at each adjustment in order to determine the acidity that produced the most desirable product.

The Walker casein test was used because it offers a simple method of composition control that can be used in any plant. In conducting this test a 9 ml. sample of the skim milk was pipetted into a white cup, and one ml. of a one per cent phenolphthalein solution was added. This was titrated with N/10 sodium hydroxide until a fairly deep pink color was produced. Then two ml. of neutral 40 per cent formalin were added which turned the sample white. The reading was taken from the burette, and then the alkali required to turn the sample a fairly deep pink again after the addition of the formalin was determined and recorded. One ml. of N/10 sodium hydroxide was considered equal to 1.63 per cent casein in the milk.

The acidity determination of the whey was made with the Mann's acidity test[2] in which the acid is calculated as lactic acid. A 17.6 ml. sample was titrated with N/10 sodium hydroxide using phenolphthalein as an indicator. The acidity on the finished product was made by the same method with the exception that a 9 gram sample was weighed on a torsion balance for the determination.

[2]According to A.O.A.C. Methods of Analysis. Fifth Edition.

The solids content of the finished product was determined by three different methods: the hydrometer method, a modified Bidwell Sterling method and by drying the sample in a vacuum oven until constant weight was reached. The hydrometer used had a Baumé scale for heavier than water liquids, from 0 to 25, graduated to read at 60° Fahrenheit.

The Bidwell Sterling solids determination was made by using a 10 gram sample and a receiving tube which was graduated from 0 to 10 ml. in 0.1 ml. divisions.

Five gram samples were used for drying in the vacuum oven until a constant weight was reached. The procedure followed was that recommended by A.O.A.C. methods of analysis for condensed milk. The samples were accurately weighed on an analytical balance into aluminum solid dishes. The samples were placed in a vacuum oven at 100° C. until most of the moisture was driven off. Then the samples were heated at 100° C. under 25-inches vacuum until each sample had reached a constant weight. This method gave consistent results on duplicate samples, and the result secured was considered the correct solids content of the product.

The Use of the Concentrated Skim Milk Product in the Ice Cream Mix

In order to determine the extent to which the concentrated skim milk product could be used as a source of serum solids in commonly used ice cream formulas, a number of mixes of various compositions were prepared. The mixes used in this investigation were prepared from the same source of ingredients, and the only difference between mixes, within the same series, was that variable increments of the concentrated skim milk product were used as a source of serum solids. The total solids content was constant for mixes within each series. The mixes were made of cream or butter, as the sources of fat, sodium alginate, as stabilizer, cane sugar, spray process skim milk powder, skim milk and the concentrated skim milk product. Various amounts of the concentrated skim milk product were used to replace milk powder as a source of serum solids. The following series of mixes were studied.

Series I. Mixes in this series contained 10 per cent fat, 8 per cent serum solids, 15 per cent sugar and 0.3 per cent stabilizer. The fat was supplied by butter and the serum solids were supplied by skim milk powder and skim milk. The concentrated skim milk product was used to furnish 0, 25, 37.5 and 50 per cent of the serum solids required.

Series II. In this series the mixes contained 10 per cent fat, 8 per cent serum solids, 15 per cent sugar and 0.3 per cent stabilizer. The fat was supplied by 40 per cent cream, and the serum solids were supplied by skim milk powder and skim milk. The concentrated skim milk solids product was used to furnish 0 and 10 per cent of the serum solids required.

Series III. Mixes in this series contained 12 per cent fat, 9.6 per cent serum solids, 15 per cent sugar and 0.25 per cent stabilizer. The fat was supplied by 40 per cent cream, and the serum solids were supplied by skim milk powder and skim milk. The concentrated skim milk product was used to furnish 0, 15, 20 and 25 per cent of the serum solids required.

Series IV. This series of mixes contained 12 per cent fat, 11 per cent serum solids, 15 per cent sugar and 0.25 per cent stabilizer. The fat was supplied by 40 per cent cream, and the serum solids were supplied by skim milk powder and skim milk. The concentrated skim milk product was used to furnish 0, 25, 37.5 and 50 per cent of the serum solids required.

The above mixes were made in 50 pound lots in 10 gallon cans and were pasteurized at 160° F. for 30 minutes. Each mix was homogenized at the pasteurization temperature with a single stage homogenizer set at 2500 pounds pressure. The mixes were cooled to 40° F., and aged at this temperature for approximately 12 hours. A 40 quart batch freezer was used to freeze 45 pounds of each mix. Overrun determinations were taken at one minute intervals, and the ammonia was turned off when the ice cream reached a temperature of approximately 25° Fahrenheit.

Those mixes that proved most desirable when frozen on the batch freezer were prepared and frozen on a continuous freezer.

The flavor, body and texture, melting properties, consumer acceptance, dipping properties and keeping quality studies of the ice cream of different composition were made on samples drawn at 100 per cent overrun.

The viscosity of the different mixes was determined at 70° F. by the use of a pipette that delivered 100 ml. of water at 100° F. in 34 seconds. The viscosity was expressed in comparison with water. The ice creams were observed for flavor and body and texture after the samples had been stored at 0° F. for one week. Texture studies were made by breaking a half pint sample and observing the broken inner surface. The melting studies were made by tempering a one pint sample of each ice cream at 0° F. for 24 hours, and then exposing it on a wire gauze to a temperature of 85° F. for a 60-minute period. At the end of the exposure period, the ice creams were photographed, and the amount melted was determined by weight.

The most desirable ice cream of each series was dipped after it had been tempered at 6° Fahrenheit. The average weight per disher was calculated. The consumer acceptance of each ice cream was determined from the flavor and body and texture preferences of a group of 15 consumers composed of housewives, food specialists and creamerymen. Samples of each ice cream were held at 0° F. and examined weekly for keeping quality.

Those mixes that proved most desirable were manufactured and handled on a commercial basis by the College Creamery.

RESULTS

The results presented in Table 1 show the effect of precipitating temperature upon the character of the curd produced. Precipitating temperatures above 96° F. produced a tough, rubbery, lumpy curd, and temperatures below 94° F. produced a soft, fine, flaky curd which was easily lost in the whey. The most satisfactory curd was formed at precipitating temperatures of 94 to 96° Fahrenheit.

Table 2 shows the results of using various acids in precipitating fresh skim milk. The acidity of the skim milk had an effect upon the amount of acid required to produce the desired coagulation. It was found that, by

Table 1. Effect of Precipitating Temperature Upon the Yield and Character of the Curd

Precipitating temperature	Calculated yield of 20 per cent solids curd per cwt. of skim milk	Actual yield of 20 per cent solids curd per cwt. of skim milk	Character of curd
Degrees F.	Lbs.	Lbs.	
90	14.5	13.5	Soft, fine, flaky
92	15.5	14.7	Fine, flaky
94	15.5	15.0	Granular, firm
96	14.5	14.0	Granular, firm
98	16.5	16.0	Firm, slightly lumpy
100	15.5	15.0	Tough, rubbery, lumpy

adding starter to the skim milk and developing the acidity to 0.35 to 0.40 per cent, the amount of acid required to produce the desired coagulation could be decreased approximately 50 per cent, but there was a large solids loss in the whey, and the curd was soft and fine when this was done. The results indicate that sulfuric acid produced the most desirable curd whereas the hydrochloric acid produced a satisfactory curd with a superior flavor. The other acids used were less desirable because of the amount of acid required, the excessive loss of solids in the whey, or the production of a curd that was difficult to handle.

The results showed that there was a relation between the final acidity of the whey, the pH of the whey and the character of the curd produced. When the acidity of the whey was 0.50 per cent or above, the pH value of the whey was 4.5 or below, and the curd formed was slick and slightly sticky. When the acidity of the whey was 0.45 per cent or below, the pH

Table 2. Use of Various Acids for Precipitating Curd from Fresh Skim Milk

Acid (One volume concentrated acid diluted with nine volumes water)	Ratio of Acid to Skim Milk for desired coagulation	Solids remaining in whey, Percent	Characteristics of curd
Hydrochloric	1 : 25.5	6.6	Desirable color and flavor, medium fine, slightly flaky
Sulfuric	1 : 53.3	6.9	Slight off-flavor, flocculent, very desirable for handling
Lactic	1 : 22.2	7.6	Desirable color, slight off-flavor, medium fine
Citric	1 : 25.0	6.8	Desirable color and flavor, medium fine
Acetic	1 : 20.0	6.7	Light desirable color, desirable flavor, soft curd
Starter developed acidity to 0.40 per cent plus hydrochloric acid	1 : 52.0	7.3	Desirable color and flavor, fine, soft curd

value of the whey was 4.7 or above, and the curd formed was soft and easily broken. The best curd was produced when the final acidity of the whey was 0.48 per cent, and the pH value of the whey was 4.6. The final acidity of the whey affected the character of the curd more than it did the composition or yield of the curd. The results further indicated that the acidity test could be used as a basis for determining the correct amount of acid to be added for the production of the most desirable curd.

In comparing sodium bicarbonate, sodium carbonate and a commercial alkali as curd dissolving agents, it was found that it required an amount of sodium bicarbonate equal to approximately one per cent of the weight of the 20 per cent curd or 5 per cent of the weight of the casein. For sodium carbonate or the commercial alkali, it required 0.5 per cent of the weight of the 20 per cent curd or 2.5 per cent of the weight of the casein. The flavor and body were somewhat superior in the product prepared by the use of sodium bicarbonate or the commercial alkali, but the adjustment of the acidity of the finished product proved to be more important than the kind of dissolving agent used. The curd was not completely dissolved until enough alkali had been added to produce a pH value of 6.0 or greater. Some undissolved curd remained whenever the pH value was less than 6.0. A study of the relation of acidity and pH value of the finished product to the flavor and body characteristics showed that the most desirable product had an acidity of 0.40 to 0.45 per cent or a pH value of 6.4 to 6.6. Acidities above 0.50 per cent resulted in an acid flavor in the finished product, and acidities below 0.40 per cent resulted in a salty or alkaline flavor in the finished product.

The results of the various methods used to determine the solids content of the product are shown in Table 3. The hydrometer readings ranged

Table 3. The Results Obtained by Various Methods Used to Determine the Soilds Content of the Concentrated Skim Milk Product

Lot	Vacuum oven method*	Bidwell Sterling method	Hydrometer method
Number	Per cent solids	Per cent solids	Degrees Baume
1	13.2790	13.5	6.0
2	15.4777	15.0	7.0
3	15.8466	16.0	7.1
4	16.0666	16.0	7.2
5	16.7103	16.5	7.5
6	16.8928	17.0	7.6
7	17.5431	17.5	7.9
8	18.3891	18.5	8.3
9	18.7425	18.5	8.4
10	19.6460	19.5	8.9

*Official A. O. A. C. method for total solids.

from 6.0 to 8.9° Baumé on products that varied from 13.3 to 19.6 per cent solids. Within this range each 0.2 degree variation in the hydrometer reading represented about 0.4 per cent change in the solids content of the product. The hydrometer method was the simplest and most rapid and seemed to be best for use under plant conditions. The Bidwell Sterling method produced fairly accurate results, but was not as simple or rapid as the hydrometer method. These methods gave results within 0.5 per cent of the correct solids content.

Detailed Procedure for the Manufacture of the Concentrated Skim Milk Product

The equipment used in the manufacturing process consisted of a cheese vat, cheese vat strainers, wooden paddle, 1000 ml. graduated measure, two 3-gallon pails, a drain rack having a screen bottom with 10 squares per inch, an acidity tester and a hydrometer. Figures 1 and 2 show the equipment used. In this investigation a 200 gallon cheese vat and a 50 gallon cheese vat were available. When 1500 pounds of skim milk or less were used the curd was dissolved in the 50 gallon cheese vat. When more than 1500 pounds of skim milk were used, the curd was dissolved in the larger vat. The wooden paddle was used to gently agitate the milk as the acid was added, and the graduated measure provided an accurate means for measuring the acid. The pails facilitated handling the curd and the screen bottom drain rack provided a means for draining and disintegrating the curd. Fresh skim milk was placed in the cheese vat, the casein content was determined, and the milk was adjusted to a temperature of 94 to 96° Fahrenheit. One volume of concentrated hydrochloric acid was diluted with nine volumes of water. This dilution should be made in a glass container, and the acid should be poured into the water in making the dilution. The acid solution was slowly added to the milk with gentle agitation until a clean separation of the curd and the whey had taken place. Usually it required about 200 ml. of concentrated acid or approximately two quarts of the acid solution per 100 pounds of skim milk. The acid required was added in small portions and between each addition the milk was gently agitated. After the precipitation of the casein had begun to occur, smaller portions of the diluted acid were added until the acidity content of the whey was 0.45 to 0.48 per cent as determined by titration using the Mann's acidity test. The precipitation of the casein was considered complete when the acidity of the whey had reached 0.45 to 0.48 per cent, and cold water was run into the vat to cool the curd and whey to 85° F. in order to prevent the formation of hard curd particles. The curd was allowed to settle for 5 to 10 minutes, and then the whey was drained. The curd was washed once with 80 to 85° F. water, and placed upon the drain rack and allowed to drain until it reached the calculated weight of 20 per cent solids curd as determined from the casein test of the skim milk. Results showed that approximately 3 per cent of the casein was lost in the process. This meant that the casein recovered was 0.06 to 0.1 per cent less than the casein test showed. The drain rack was so constructed that it and the curd could be

removed and weighed upon a platform scale in order to determine when draining was complete. Upon completion of the draining process, the curd was disintegrated by forcing it through the screen bottom of the drain rack. The disintegrated curd was spread to a uniform depth in the cheese vat. Sodium bicarbonate at the rate of 5 to 6.25 pounds per 100 pounds of casein was weighed out, sufficient water was added to dissolve and the solution was sprinkled evenly over the surface of the curd. The curd and soda were thoroughly mixed and allowed to set about 30 minutes. The curd was agitated frequently, and the temperature of the curd was gradually raised to 145° to 150° F. by heating the water in the jacket of the vat. When the curd reached this temperature, sufficient skim milk heated to 150° F. was added to produce a product with a 16 per cent solids content, as calculated by the Pearson square method. The solids content of the finished product was standardized to 16 per cent by the addition of skim milk because it was found that finished products having higher than 16 per cent solids were viscous, gelatinous, dissolved less readily in the mix and were difficult to handle during cooling and storage. The skim milk was considered to contain 9 per cent solids and the curd 20 per cent solids. After the skim milk was added the acidity was adjusted to approximately 0.40 per cent by the addition of the necessary amount of soda. This gave a pH of approximately 6.4 for the finished product. The temperature was maintained at 145° to 150° F. for 30 minutes, and then the product was drained through a bucket strainer, cooled over a surface cooler and stored in 10 gallons cans at 40° F. until used in the ice cream mix. The entire process was completed within a period of two hours. The finished product kept well for seven to ten days when stored at 40° Fahrenheit.

An analysis of the 16 per cent concentrated skim milk product showed that the approximate composition was as follows: 84.0 per cent water, 16.0 per cent total solids including 13.8 per cent protein, 2.0 per cent lactose and 1.5 per cent ash. The acidity was 0.40 per cent and pH value was 6.4. The standard plate bacteria count was below 50 thousand on the finished product.

The Results of Using the Concentrated Skim Milk Product in the Manufacture of Ice Cream

In this part of the investigation 14 experimental ice cream mixes were prepared and frozen on a batch freezer, and those which proved most desirable were frozen on a continuous freezer. Partial replacements of skim milk powder at various levels depending upon the composition of the mix were made by using the concentrated skim milk solids product.

Table 4 shows the composition of the different mixtures used in the investigation.

The data on the acidity, viscosity and whipping properties of the different ice cream mixes are presented in Table 5. The use of various amounts of the concentrated skim milk product to replace the skim milk powder had little effect upon the acidity. Increased amounts of the concentrated skim milk product in the mix resulted in a marked decrease in the viscosi-

Table 4. The Composition of the Different Ice Cream Mixtures

Mix No.	Fat	Serum Solids		Sugar	Stabilizer	Total solids
		Powdered and skim milk	Concentrated skim milk solids			
	Percent	Percent	Percent	Percent	Percent	Percent
	(Butter)		Series I			
1	10.0	8.0	0.0	15.0	.30	33.30
2	10.0	6.0	2.0	15.0	.30	33.30
3	10.0	5.0	3.0	15.0	.30	33.30
4	10.0	4.0	4.0	15.0	.30	33.30
	(Cream 40%)		Series II			
5	10.0	8.0	0.0	15.0	.30	33.30
6	10.0	7.2	0.8	15.0	.30	33.30
			Series III			
7	12.0	9.6	0.0	15.0	.25	36.85
8	12.0	8.2	1.4	15.0	.25	36.85
9	12.0	7.7	1.9	15.0	.25	36.85
10	12.0	7.2	2.4	15.0	.25	36.85
			Series IV			
11	12.0	11.0	0.0	15.0	.25	38.25
12	12.0	8.3	2.7	15.0	.25	38.25
13	12.0	7.0	4.0	15.0	.25	38.25
14	12.0	5.5	5.5	15.0	.25	38.25

Table 5. The Effect of the Use of Various Amounts of Concentrated Skim Milk Product Upon the Properties of the Different Ice Cream Mixtures

Mix No.	Fat	Serum Solids	Serum Solids Supplied by Concentrated Skim Milk	Acidity	Viscosity	Time required to whip to 100 percent overrun	
	Percent	Percent	Percent	Percent		Min.	Sec.
	(Butter)		Series I				
1	10.0	8.0	0.0	.12	4.7	6	40
2	10.0	8.0	25.0	.13	2.4	5	00
3	10.0	8.0	37.5	.13	2.1	4	00
4	10.0	8.0	50.0	.13	1.7	4	15
	(Cream 40%)		Series II				
5	10.0	8.0	0.0	.20	2.4	6	25
6	10.0	8.0	10.0	.18	1.7	5	20
			Series III				
7	12.0	9.6	0.0	.16	5.5	9	10
8	12.0	9.6	15.0	.16	3.0	7	15
9	12.0	9.6	20.0	.16	2.0	6	00
10	12.0	9.6	25.0	.14	1.9	3	45
			Series IV				
11	12.0	11.0	0.0	.20	17.3	10	15
12	12.0	11.0	25.0	.22	1.7	4	30
13	12.0	11.0	37.5	.24	2.1	4	15
14	12.0	11.0	50.0	.24	2.3	4	00

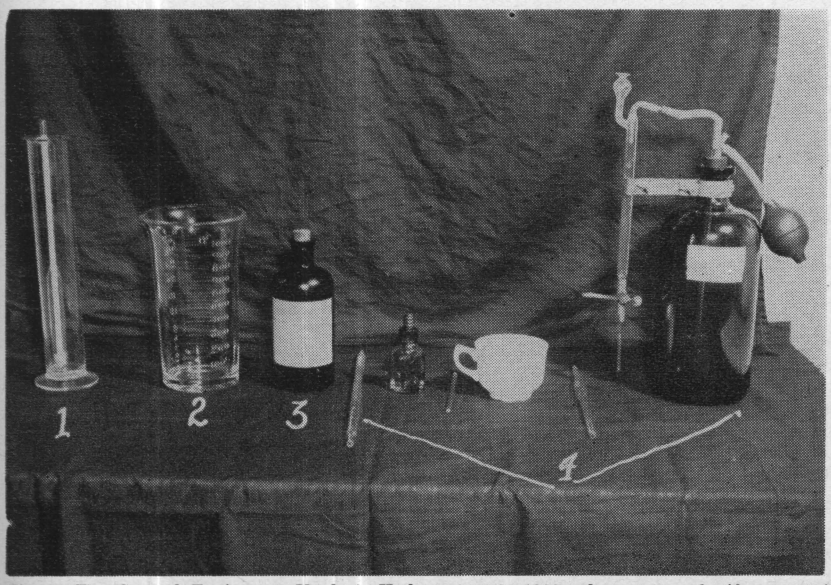

Fig. 1. The Control Equipment Used. 1. Hydrometer, 2. 1000 ml. measure, 3. 40 per cent formalin, 4. Acidity test apparatus.

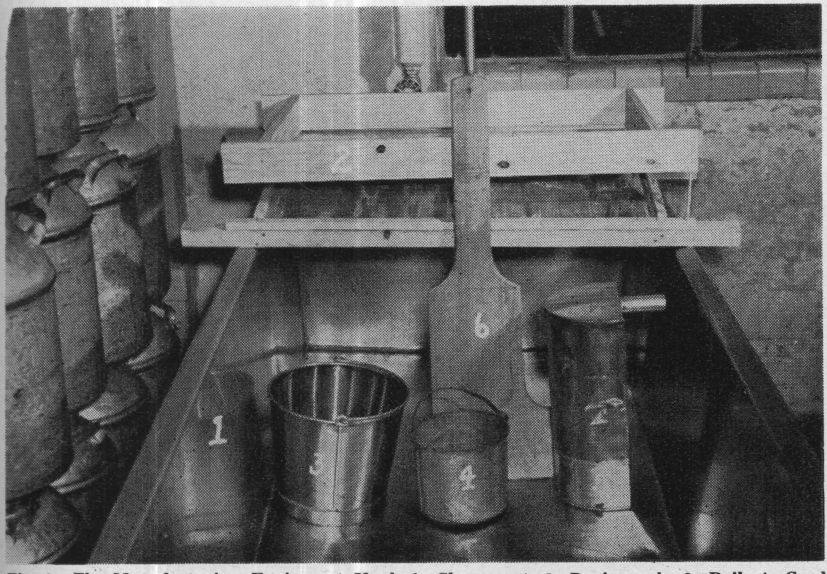

Fig. 2. The Manufacturing Equipment Used. 1. Cheese vat, 2. Drain rack, 3. Pail, 4. Curd Pail, 5. Vat strainer, 6. Paddles.

ty. The time required to secure 100 per cent overrun in the ice cream was also reduced with the use of larger amounts of the concentrated skim milk product. In Series 1 it was possible to use a larger amount of the concentrated skim milk product because the butter and powder decreased the whipping ability of the mixes. Larger amounts of the product could also be used in the mixes of Series 4 because the higher solids content of these mixes decreased the whipping ability. None of the mixes studied possessed excessive whipping properties when frozen on the batch freezer

Table 6. The Flavor, Body and Texture Observations* and the Consumer Preference of the Ice Creams Containing Various Amounts of the Concentrated Skim Milk Product

Mix	Serum solids supplied by the concentrated skim milk product	Flavor observations	Body and texture observations	Numerical rating of flavor, body and texture	Consumer preference of ice cream Percent			
No.	Percent				1st	2nd	3rd	4th
			Series I					
1	0.0	ingredient, cooked	crumbly, coarse	4th	7	7	40	46
2	25.0	lacks fine flavor	crumbly, coarse	3rd	7	13	33	47
3	37.5	desirable, fresh	desirable	1st	47	53	0	0
4	50.0	lacks sweetness	pasty, weak	2nd	33	47	13	7
			Series II					
5	0.0	lacks fine flavor	crumbly, coarse	2nd	20	80	....	....
6	10.0	lacks fine flavor	slightly crumbly	1st	80	20	....	....
			Series III					
7	0.0	lacks fine flavor	crumbly, coarse	3rd	7	13	40	40
8	15.0	lacks fine flavor	coarse, icy	4th	7	13	30	50
9	20.0	desirable, fresh	smooth, fine	1st	53	33	7	7
10	25.0	lacks sweetness, weak	pasty	2nd	13	33	47	7
			Series IV					
11	0.0	lacks fine flavor	fluffy	3rd	0	20	67	13
12	25.0	lacks fine flavor	coarse	4th	0	0	20	80
13	37.5	desirable, fresh	smooth, fine	2nd	27	53	20	0
14	50.0	desirable, fresh	smooth, fine	1st	73	27	0	0

*Observations include only the terms describing the most outstanding characteristics.

except the mix which contained 12 per cent fat, 9.6 per cent serum solids, with 25 per cent of the serum solids supplied by the concentrated skim milk product. When larger percentages than those used in the series studied were supplied by the concentrated skim milk product, the ice cream reached a 100 per cent overrun before it was sufficiently frozen, and it was impossible to control the overrun. These difficulties were not encountered, however, when a continuous freezer was used.

Table 6 presents the description of the flavor, body and texture and the consumer preference of the different ice creams studied. The results show that the use of the concentrated skim milk product produced a more desirable flavor that was described as being clean and fresh, and the body and texture was smooth and fine. In Series 1 and 3, when 50 and 25 per cent, respectively, of serum solids were supplied by the concentrated skim milk product, the flavor was criticized for lacking sweetness, and the body was described as being weak. In all series a coarse bodied ice cream was noted when the smaller amounts of the concentrated skim milk were used.

The consumer acceptance studies showed that in most cases the ice creams that contained the concentrated skim milk product were preferable to those that did not. In the 10 per cent fat, 8 per cent serum solids series of ice cream, where butter was used as a source of fat, the most desirable ice cream was that having 37.5 per cent of the serum solids content supplied by the concentrated skim milk product. In the mixes containing 10 per cent fat, 8 per cent serum solids, with cream as a source of fat, the use of 10 per cent of the serum solids as concentrated skim milk product improved the consumer acceptance of the ice cream. In the 12 per cent fat, 9.6 per cent serum solids series the ice cream that possessed the most desirable consumer acceptance had 20 per cent of the serum solids furnished by the concentrated skim milk product. That ice cream having 50 per cent of the serum solids furnished by the concentrated skim milk product was preferred in the series of mixes that contained 12 per cent fat, 11 per cent serum solids.

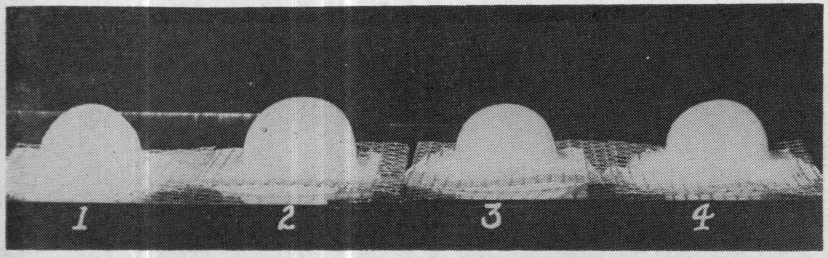

Fig. 3. The Effect of Various Amounts of the Concentrated Skim Milk Product Upon the Melting Qualities of 10 Per Cent Fat, 8 Per Cent Serum Solids Ice Cream (Series 1) Exposed at 85° F. for 60 minutes.

1. **No concentrated skim milk used—56.3 per cent melted.**
2. **25 per cent of serum solids supplied by concentrated skim milk product—65.9 per cent melted.**
3. **37.5 per cent of serum solids supplied by concentrated skim milk product—67.3 per cent melted.**
4. **50 per cent of serum solids supplied by concentrated skim milk product—53.4 per cent melted.**

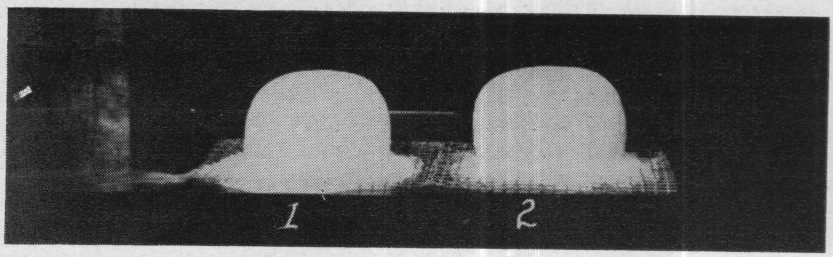

Fig. 4. The Effect of the Use of the Concentrated Skim Milk Product Upon the Melting Qualities of 10 Per Cent Fat, 8 Per Cent Serum Solids Ice Cream (Series 2) Exposed at 85° F. for 60 minutes.

1. No concentrated skim milk used—45.6 per cent melted.
2. 10 per cent of serum solids supplied by concentrated skim milk product—52.0 per cent melted.

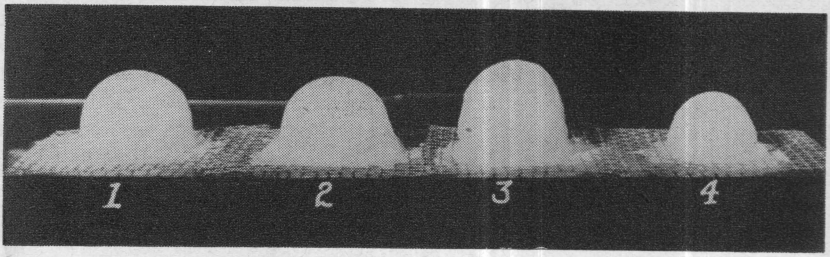

Fig. 5. The Effect of Various Amounts of Concentrated Skim Milk Product Upon the Melting Qualities of 12 Per Cent Fat, 9.6 Per Cent Serum Solids Ice Cream (Series 3) Exposed at 85° F. for 60 minutes.

1. No concentrated skim milk product used—65.5 per cent melted.
2. 10 per cent of serum solids supplied by concentrated skim milk product—70.4 per cent melted.
3. 20 per cent of serum solids supplied by concentrated skim milk product—71.8 per cent melted.
4. 25 per cent of serum solids supplied by concentrated skim milk product—80.5 per cent melted.

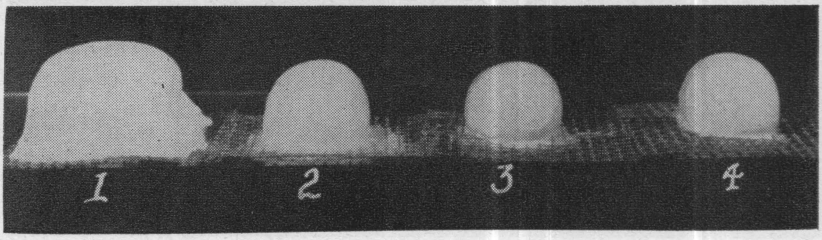

Fig. 6. The Effect of Various Amounts of the Concentrated Skim Milk Product Upon the Melting Qualities of 12 Per Cent Fat, 11 Per Cent Serum Solids Ice Cream (Series 4) Exposed at 85° F. for 60 minutes.

1. No concentrated skim milk product used—25.3 per cent melted.
2. 25 per cent of serum solids supplied by concentrated skim milk product—74.5 per cent melted.
3. 37.5 per cent of serum solids supplied by concentrated skim milk product—75.3 per cent melted.
4. 50 per cent of serum solids supplied by concentrated skim milk product—77.6 per cent melted.

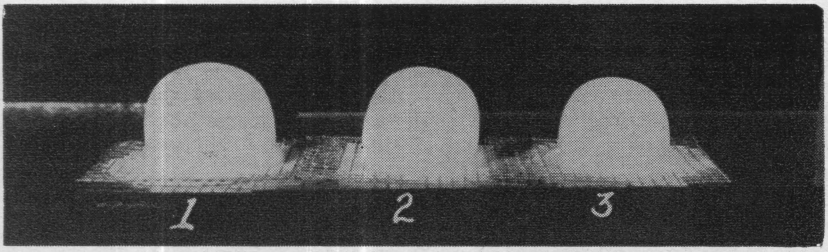

Fig. 7. The Melting Qualities of the Most Desirable Ice Creams From Series 2, 3 and 4. (Frozen on Continuous freezer) Exposed at 85° F. for 60 minutes.

1. **10 per cent fat, 8 per cent serum solids—10 per cent serum solids supplied by concentrated skim milk product—57.7 per cent melted.**
2. **12 per cent fat, 9.6 per cent serum solids—20 per cent serum solids supplied by concentrated skim milk product—63.2 per cent melted.**
3. **12 per cent fat, 11 per cent serum solids—50 per cent serum solids supplied by concentrated skim milk product—66.9 per cent melted.**

The melting qualities and the appearance of the melted ice creams are shown in Figures 3, 4, 5, 6 and 7. Figure 3 shows the melting qualities of the ice creams in Series 1. Those ice creams containing the concentrated skim milk product showed smoother more desirable melting qualities. The ice cream with 37.5 per cent of the serum solids content supplied by the concentrated skim milk product melted most rapidly. Figure 4 indicates there was little difference in the melting qualities of the ice creams in Series 2, however, the ice cream containing the concentrated skim milk product melted faster, and the appearance of the melted ice cream was more desirable. Figure 5 shows the melting qualities of the ice creams in Series 3. These ice creams contained 12 per cent fat and 9.6 per cent serum solids. The rate of melting was somewhat greater than for the ice creams in Series 1 or 2 which contained 10 per cent fat and 8 per cent serum solids. Added amounts of the concentrated skim milk product produced a greater increase in the rate of melting in the ice cream of this series than in those of the preceding series.

Figure 6 presents the appearance of the ice creams of Series 4 at the end of the exposure period. There was a decided improvement in the melting properties when the concentrated skim milk product was used to supply a portion of the serum solids, and the melted ice cream was a smooth creamy product very similar in appearance to that of the original mix. Added amounts of the concentrated skim milk product increased the rate of melting which was not considered excessive in any case. The melting qualities of the best ice creams, from Series 2, 3 and 4, when frozen on a continuous freezer, are shown in Figure 7. The melting qualities were very similar to those secured for the ice creams frozen on the batch freezer except the rate of melting was not as rapid for the continuous frozen ice creams.

The results show that in nearly all cases added amounts of the concentrated skim milk product produced more rapid melting, and the appearance of the melted ice cream was more desirable.

The dipping studies showed that the use of the concentrated skim milk as a source of serum solids had very little effect upon the average weight of ice cream secured per disher. The ice cream was of desirable consistency at a temperature of 6° F., but was resistant at temperatures below 0° F. and was pasty and soggy at temperatures above 12° Fahrenheit.

DISCUSSION

The method used in this investigation to prepare a concentrated skim milk solids product for use as a source of serum solids in the ice cream mix differs from other methods heretofore described in that the quality and composition control is based upon the use of the acidity tester, the hydrometer and a casein test. Also the preparation was simplified by completing the entire process in a cheese vat. The curd was more readily dissolved after it had been disintegrated by passing it through the screen bottom of the drain rack. Heating the product brought about more rapid dissolving of the curd and reduced the bacterial count on the finished product. Skim milk instead of water was used to standardize the finished product to 16 per cent solids content thereby offering a means of conserving additional non-fat milk solids.

The use of the hydrometer provided a practical method of estimating the solids content of the finished product, however, it can not be recommended for securing exact results.

The use of the concentrated skim milk product produced a decided decrease in the viscosity of the ice cream mix and a marked reduction in the time required to secure 100 per cent overrun in the finished ice cream. This was apparently due to the presence of sodium salts introduced into the mix through the use of the concentrated product. It was found that the greatest limitation to the use of the concentrated skim milk in the mix was the excessive whipping that was encountered when large amounts of the product were used. When the continuous freezer was used excessive whipping was not a problem because the overrun could be accurately controlled, and the desired drawing temperature of the ice cream could be obtained. The extent to which the concentrated skim milk product could be used as a source of serum solids in ice cream depended upon the composition of the mix. Larger amounts of the product could be used when other ingredients in the mix tended to decrease the whipping qualities. In higher solids mixes, a larger amount of the concentrated skim milk product could be used. Mixes containing larger amounts of the concentrated skim milk product could be more successfully frozen on the continuous type freezer than on the batch type freezer.

The data indicate that when the fat content was supplied by butter in a 10 per cent fat, 8 per cent serum solids ice cream the best product was produced when the concentrated skim milk furnished 37.5 per cent of the serum solids. When cream was used as a source of fat, 10 per cent of the serum solids needed in a 10 per cent fat, 8 per cent serum solids mix could be furnished by the concentrated skim milk product. In a 12 per

cent fat, 9.6 per cent serum solids mix, 20 per cent of the serum solids could be supplied by the concentrated skim milk, and in a 12 per cent fat, 11 per cent serum solids mix the concentrated skim milk could be used to furnish 50 per cent of the serum solids needed.

The results showed that the use of the concentrated skim milk product produced a more desirable flavor and body and texture in the finished ice cream. The flavor was described as fresh, and the body and texture as smooth and fine. When an excessive amount of the product was used the flavor was criticised for lacking sweetness and the body was criticised for being pasty. The consumer acceptance studies showed that in most cases the ice cream that contained the concentrated product were preferable to those that did not. In nearly all cases added amounts of the concentrated product as a source of serum solids produced more rapid but satisfactory melting, and the appearance of the melted ice cream was more desirable. The use of the concentrated skim milk product had little effect upon dipping qualities or keeping qualities of the ice cream studied.

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