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# The Relation of Dry Skim Milk to Several of the Physical and Chemical Properties of Whipped Cream

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## ABSTRACT

In this experiment the physical properties of whipped cream were improved by the addition of dry skim milk. Dry skim milk added to cream for whipping purposes increased the viscosity and the acidity of the cream but had little influence on its surface tension. The foaming ability and viscosity of fluid skim milk were increased when dry skim milk was added to it, whereas the surface tension was slightly reduced. Of four different types of whippers used, the air whipper proved to be most satisfactory. The addition of six per cent of dry skim milk decidedly improved the whipping properties, flavor, body and texture of whipped cream. The flavor, body and fat clumping of cream was largely dependent upon the whipper used. Sugar markedly influences the physical properties of whipped cream. The data also showed that pasteurized cream was satisfactory for whipping purposes; aging of cream for twenty-four hours was essential and that a whipping and aging temperature of forty-two degrees Fahrenheit was most satisfactory.

## ACKNOWLEDGMENT

The authors wish to express their appreciation to the American Dry Milk Institute, Chicago, Illinois, whose cooperation made this research project possible.

# The Relation of Dry Skim Milk to Several of the Physical and Chemical Properties of Whipped Cream

W. H. E. Reid and W. C. Eckles*

## INTRODUCTION

The use of cream for whipping purposes has, until recent years, been of little importance to the milk distributing plant. Because of large increases in consumption and improvements in the methods of manufacturing and storage, it now occupies a prominent place in the industry. With the increased demand for whipped cream, many new problems have arisen, especially because of the limited time during which this product could be stored, or held before it was consumed. Normally the structure of whipped cream is easily impaired during storage and it soon collapses, resulting in much of the material draining to the bottom of the container.

Some investigators have shown that the whipping properties of cream and ice cream mixtures are markedly influenced by the percentage of solids-not-fat. Others have shown that drainage of whipped cream may be due to insufficient water absorbing colloids and material that will retain the moisture. Dry skim milk serves as an excellent source of serum solids because it is high in nutritive value, very wholesome, relatively inexpensive, available during all seasons of the year and has splendid keeping qualities. It seems logical, therefore, to assume that a considerable amount of dry skim milk could be used advantageously in the manufacture of whipped cream.

The purpose of this investigation was to determine the relative influence of dry skim milk on several of the physical and chemical properties of cream prior to and subsequent to its being whipped and to give consideration to factors other than the serum solids-not-fat content, which are also influential in the production of a whipping cream possessing desirable qualities.

## REVIEW OF LITERATURE

Dahlberg and Henning (1925) found that two distinct and simultaneous changes occur when cream is whipped. These are the incorporation of air and the formation of fat clumps. They

*The data presented in this bulletin were taken from a paper submitted by the junior author in partial fulfillment of the requirements for the degree of Master of Arts in the Graduate School of the University of Missouri, 1933.

state that fat clumps form a heterogeneous network in which the serum is held, that this gives the whipped cream rigidity or stiffness, and that aging usually increases the viscosity and improves the whipping properties of cream. Factors contributing to the improvement of whipping properties gave reductions in overrun and decreased the amount of drainage. They assume that the milk proteins help stabilize the incorporated air by surface adsorption.

Associates of Rogers (1928) state that the fat globules and their aggregates gather on the liquid-air interface or films, producing a piling up effect that results in quite a rigid structure. They state that viscigene, like many other protein materials that are protective, enhance aggregation and whipping properties. They also state that increases in acidity decrease the viscosity but have little effect on the whipping properties.

Palmer (1923) states that whipped cream is an air-in-water emulsion, the aqueous phase being a concentrated oil-in-water type of emulsion and that the methods of improving the whipping quality of cream are either increasing the viscosity of the hydrophyllic colloids present or adding them in great amounts in the form of other materials.

Doan (1929) found that normal variations in the acidity of cream had little influence on the whipping properties of the cream.

Sanman and Ruehe (1930) found that increases in acidity up to .35 per cent were influential in promoting the whipping of cream.

Babcock (1922), Henning (1924), and Dahlberg and Henning (1925) found that pasteurization is usually detrimental to whipping properties of cream, although some pasteurized creams whipped nearly as effectively as raw cream and in most cases produced a greater overrun.

Baldwin and Combs (1931) show that pasteurized cream whipped in a shorter time than raw cream.

Tracy and Ramsey (1931) state that heating to temperatures of 170 degrees Fahrenheit or below does not affect the whipping properties of cream. Pasteurization of whole milk, the cream of which is to be used for whipping purposes, is more harmful than the pasteurization of the separated cream. Reduced temperatures gave the desired aging effect in a shorter time.

Babcock (1922), Henning (1924), Dahlberg and Henning (1925) and Reid (1928) agree that a cream of 30 to 35 per cent of butterfat is best for whipping purposes, that aging is necessary to produce a cream that will whip well, and that the maximum

improvement due to aging is completed after 48 hours but the greatest improvement occurs during the first 24 hours.

Sommer (1927) advanced the theory that cream whipped better if it had had time for part of the serum to be drawn from the solution by the fat. Greater serum adsorption occurs at low temperatures due to the kinetic energy of the particles being reduced, and the greater the adsorption the better the resultant whipped cream.

Melich (1909) found that some salts, milk powders and sugar promote whipping.

Glabau (1932) shows that the greatest overrun occurs in the presence of low whipping temperatures and that sugar increases the time required to whip and reduces the overrun.

Reid and McCroskey (1930) show that increasing the solid content by the addition of either gelatin or dry skim milk, in combination or when used separately, gave a whipped cream more rigid in body. By the addition of either or both of these materials the drainage could be reduced.

## PROCEDURE

Throughout this investigation attempts were made to study the influence of variable factors one at a time. Practices were followed that would eliminate so far as possible those factors which did not contribute to the point under study.

The cream used for the investigation was from the milk of the University dairy herd and was obtained direct from a surface cooler after having been pasteurized and separated. It was standardized by diluting with the milk from which the cream had been obtained. Spray process dry skim milk of the highest quality obtainable was added to the standardized cream in the form of a cold paste at 42 degrees Fahrenheit (5.55 degrees Centigrade) unless otherwise stated. The different creams were aged and all chemical and physical determinations were made at a constant temperature of 42 degrees Fahrenheit.

All cream was whipped at 42 degrees Fahrenheit in batches of 500 cubic cntimeters.

The relation of the dry skim milk to the chemical and physical properties of the treated cream and the resultant whipped cream were compared on the basis of:

1. Titratable acidity of the cream prior to whipping.
2. Viscosity of the cream prior to whipping, using the MacMichael Viscosimeter.

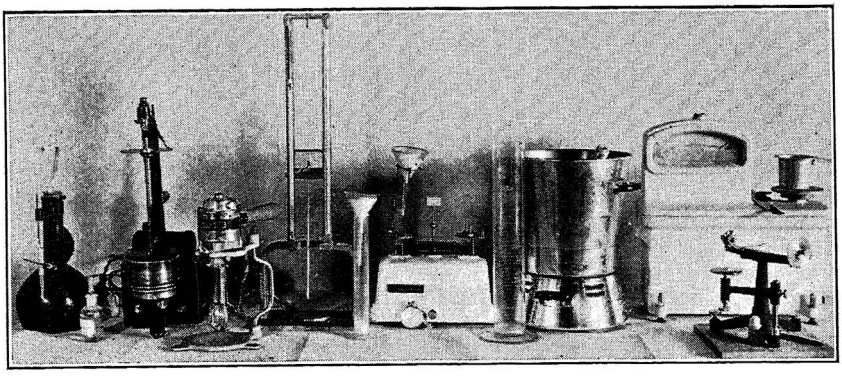

Fig. 1.—Part of the apparatus used in the study.

3. Surface tension of the cream prior to whipping, using the du Nouy apparatus.
4. Time required to whip.
5. Percentage of overrun or volume increase due to whipping.
6. Relation of whipping to body (resistance and condition).
7. Texture and microscopic examination.
8. Relation of whipping to drainage properties.
9. Flavor
10. Color.

## EXPERIMENTAL DATA

### Methods of Adding Dry Skim Milk To a Cream To Be Used For Whipping Purposes and The Influence of Aging On Its Chemical and Physical Properties

1. *Heating to 90 degrees Fahrenheit (32.22 degrees Centigrade).* —A 32 per cent cream that had aged for 24 hours was heated to 90 degrees Fahrenheit (32.22 degrees Centigrade) and the dry skim milk added. The treated cream was then quickly cooled to 42 degrees Fahrenheit.

Chemical and physical determinations were made on the cream immediately after cooling to the aging temperature and after 2, 4, and 6 hours of aging. The different batches of the cream were then whipped with the egg beater whipper and the resultant whipped cream compared.

A desirable whipped cream was produced from each batch but the best results were acquired when the cream had aged 4 hours

TABLE 1.—THE EFFECT OF AGING ON THE CHEMICAL AND PHYSICAL PROPERTIES OF CREAM SUBSEQUENT TO THE ADDITION OF DRY SKIM MILK

| Aged Hours | Acid Per Cent | Surface Tension Dynes | Viscosity Centipoises | Time to Whip | | Overrun Per Cent | Penetration M. M. | Cu. centimeters drained from 20 gms. | | Texture | Body |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 Hr. at 68°F | 24 Hrs. at 42°F. | | |
| 0 | .29 | 54.12 | 99 | 5 | 5 | 101 | 25 | 4 | 1.5 | Close, medium, uniform cells | Medium |
| 2 | .31 | 52.70 | 109 | 7 | 5 | 99 | 13 | 2 | 11.5 | Close, medium, uniform cells | Good |
| 4 | .31 | 54.80 | 141 | 7 | 10 | 103 | 11 | 1 | 2 | Close, medium, uniform, velvety | Good |
| 6 | .33 | 56.26 | 146 | 5 | 5 | 90 | 17 | 2 | 2.5 | Close, medium, uniform, velvety | Medium to good |

TABLE 2.—THE INFLUENCE OF AGING AND TEN PER CENT OF DRY SKIM MILK ON THE SURFACE TENSION[1] OF A THIRTY-TWO PER CENT CREAM

| Aged Hours | Normal Dry Skim Milk | | | Low Lactose Dry Skim Milk | | |
|---|---|---|---|---|---|---|
| | 32 Per Cent Cream Control | Dry Skim Milk Added Immediately | Dry Skim Milk Added After 24 Hrs. of Aging | 32 Per Cent Cream Control | Dry Skim Milk Added Immediately | Dry Skim Milk Added After 24 Hrs. of Aging |
| 0 | 50.56 | 64.09 | | 49.85 | 50.56 | |
| 2 | 46.29 | 55.54 | | 49.85 | 50.56 | |
| 4 | 50.56 | 50.56 | | 50.56 | 52.70 | |
| 6 | 49.13 | 51.98 | | 49.85 | 52.70 | |
| 8 | 51.89 | 55.54 | | | | |
| 10 | 51.98 | 53.41 | | | | |
| 12 | 49.85 | 53.41 | | 53.41 | 51.27 | |
| 24 | 51.98 | 54.12 | 51.27 | 53.41 | 51.27 | 50.56 |
| 26 | 51.27 | 53.41 | 50.56 | | | |
| 28 | 50.56 | 52.70 | 59.39 | 54.12 | 53.41 | 53.41 |
| 32 | 51.27 | 53.41 | 54.83 | 51.98 | 52.70 | 50.56 |
| 36 | 53.41 | 53.41 | 52.70 | 53.41 | 51.27 | 54.12 |
| 72 | | | 53.41 | 51.98 | 54.12 | 50.56 |

1 Surface tension expressed in dynes.

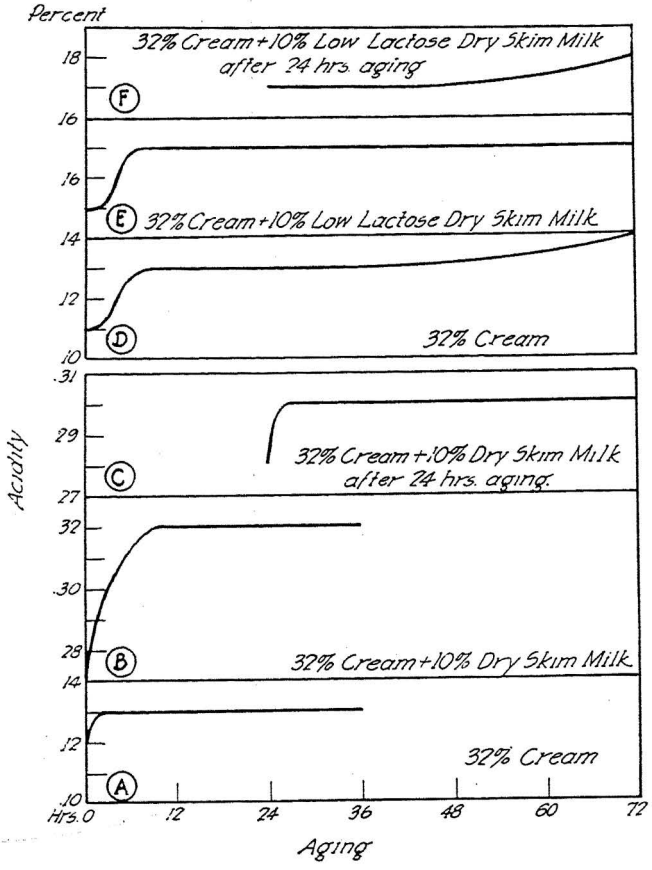


Fig. 2.—The Effect of Normal and Low Lactose Dry Skim Milk and Aging on the Acidity of Cream.

or longer subsequent to the addition of the dry skim milk. Table 1 shows the results of the various periods of aging following the addition of the dry skim milk. As this method of adding the dry skim milk acted unfavorably on the chemical and physical properties of the cream, due to the heating and cooling, it was discontinued in all later experiments.

2. *Dry Skim Milk Added at 42 Degrees Fahrenheit (5.55 Degrees Centigrade).*—Ten per cent of dry skim milk in the form of a cold paste was added to 32 per cent cream received direct from the surface cooler at a temperature of 42 degrees Fahrenheit.

Both low lactose and normal dry skim milk were used and treated identically. A control sample of 32 per cent cream was

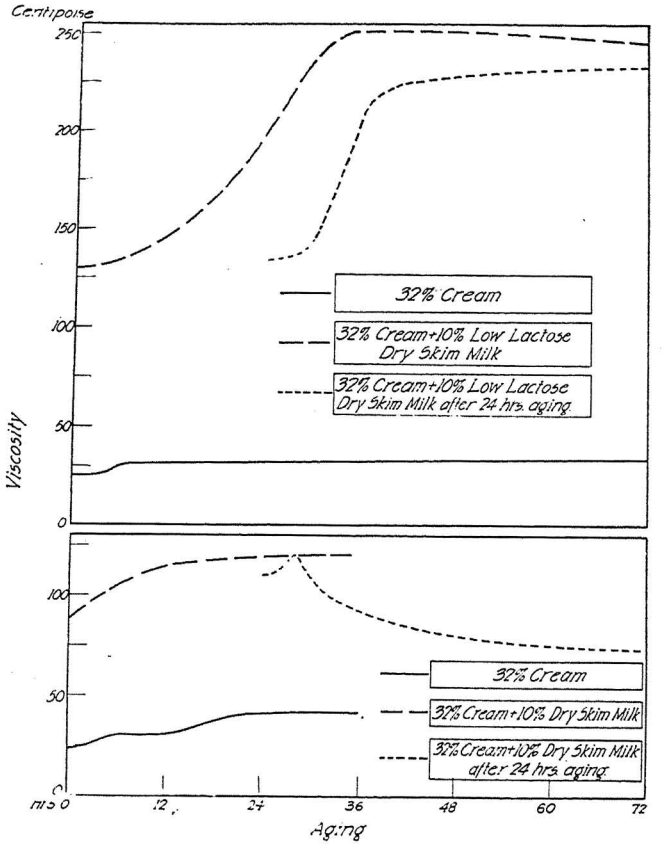


Fig. 3.—The Effect of Normal and Low Lactose Dry Skim Milk and Aging on the Viscosity of Cream.

kept for both of the dry skim milks for direct comparison. In other samples the addition of the dry skim milk was delayed until the cream had aged 24 hours.

Determinations for acidity, surface tension and viscosity were made with definite frequency during the aging period. The influence of aging and of the addition of the dry skim milk on the surface tension are shown in Table 2 and on acidity and viscosity in Figures 2 and 3 respectively.

The data show that the addition of the dry skim milk had little effect on the surface tension of the cream. The addition of 10 per cent of dry skim milk caused an increase in acidity of 0.15 per cent in the case of the normal dry skim milk and an increase of

0.04 per cent in the case of low lactose dry skim milk. The acidity increased more rapidly in cream that contained dry skim milk than in normal cream due to the increased amount of lactose which was converted into lactic acid. The greatest increase in acidity occurred in all batches during the first 6 hours of aging. When the addition of the dry skim milk was deferred 24 hours the increase in acidity was not as marked as when added to the unaged cream, Figure 2.

The viscosity of the cream was markedly increased by the addition of 10 per cent of dry skim milk regardless of the kind of powder or the time it was added. When normal dry skim milk was added at the time of standardization, the greatest increase occurred during the first 12 hours of aging, followed by a slight increase during the second 12 hours. When the addition of the dry skim milk was deferred 24 hours after standardization, as in the instance of the normal dry skim milk, there was an increase in viscosity for several hours followed by a gradual decrease, Figure 3.

When low lactose dry skim milk was added, greater increase in viscosity was observed than in the instance of the normal dry skim milk. The increase continued during the first 36 hours of aging. The later work was conducted with normal dry skim milk.

## The Influence of Variable Increments of Dry Skim Milk On The Chemical and Physical Properties of Skim Milk, Particularly Its Foaming Ability

The object of this part of the investigation was to study the effect of dry skim milk in the absence of butterfat.

Skim milk from fresh whole milk that had been pasteurized, separated and cooled was used. A control sample and samples containing 2, 4, 6, 8, 10 and 12 per cent of dry skim milk were prepared and aged for 24 hours. Previous to whipping, with the egg beater whipper, determinations were made for chemical and physical properties of the skim milk. The rigidity of the whipped skim milk could not be obtained because of insufficient body resistance in all samples.

Due to the rapidity with which the structure of the whipped skim milk disintegrated, the usual drainage procedure could not be followed. As a substitute for such, the time that elapsed during the drainage of 10 cubic centimeters of liquid from a 30-gram sample of each of the whipped skim milks was recorded, Table 3. This

TABLE 3.—THE INFLUENCE OF VARIABLE INCREMENTS OF DRY SKIM MILK ON THE CHEMICAL AND PHYSICAL PROPERTIES OF NORMAL SKIM MILK

| Dry Skim Milk Added Per Cent | Acid Per Cent | Surface Tension Dynes | Viscosity Centi-poises | Time to Whip | | Over-run Per Cent | Time to Drain 10 cc. | | Body | Texture | Color | Flavor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | Min. | Sec. | | | | |
| 0 | .15 | 55.9 | 5.3 | 0 | 58 | 350 | 18 | 12 | Weak, Very fluffy | Very large cells | White | Normal |
| 2 | .20 | 55.54 | 5.8 | 1 | 12 | 330 | 27 | 0 | Weak, fluffy | More even cells | White | Slightly sweet |
| 4 | .22 | 54.12 | 6.7 | 1 | 19 | 367 | 16 | 0 | Slight resistance | Medium uniform cells | Glossy white | Sweet |
| 6 | .25 | 56.6 | 8.4 | 1 | 40 | 392 | 14 | 6 | Low resistance | Medium uniform cells | Very glossy white | Very sweet |
| 8 | .28 | 56.4 | 8.5 | 1 | 56 | 356 | 12 | 0 | Low resistance | Uniform cells | Very glossy white | Very sweet |
| 10 | .32 | 54.4 | 9.6 | 2 | 18 | 350 | 12 | 24 | Very weak | Large cells | Very glossy white | Coats mouth |
| 12 | .36 | 53.41 | 13.4 | 2 | 15 | 356 | 7 | 0 | Very weak | Large not uniform | Very glossy white | Coats mouth |

determination was conducted at 42 degrees Fahrenheit.

Increasing the dry skim milk content up to 8 per cent imparted a more desirable body and texture to the whipped skim milk. However, additional increments produced an inferior product. Figures 4, 5, 6 and 7 are typical of the variations found in texture and air cell structure due to the variable increments of dry skim milk used.

Increased increments of the dry skim milk were accompanied by an increased acidity, viscosity, overrun and time required to whip. The drainage determinations show that increased increments of the dry skim milk caused the formation of a structure that broke more rapidly. This was probably due to the increase in density. It is evident that the increase in viscosity was due to the large amount of soluble and suspended material added to the batches in the form of dry skim milk.

A variation in the color of the batches containing different increments of the dry skim milk was not noticeable but greater amounts of the dry skim milk than 4 per cent imparted a very glossy appearance to the whipped skim milk.

### The Use of Four Common Types of Cream Whippers

This study was conducted to determine the influence that different types of whippers had upon several of the physical properties of whipped cream, particularly when dry skim milk was added.

A 32 per cent cream and a cream containing 25 per cent of butterfat to which 6 per cent of dry skim milk had been added were used. Both creams were aged for 24 hours at 42 degrees Fahrenheit. The dry skim milk was added, as a cold paste, before aging. The 32 per cent cream had an acidity of 0.15 per cent, a viscosity of 34 centipoises and a surface tension of 52.7 dynes per centimeter. The acidity of the 25 per cent cream was 0.22 per cent, the viscosity 33.5 centipoises and the surface tension 52 dynes per centimeter. Figures 8, 9, 10 and 11 show the different types of whippers that were used.

The data, Tables 4 and 5, show that the air whipper produced a whipped cream having the most desirable flavor, gave greater overrun and required the shortest whipping time.

The egg beater whipper produced a whipped cream that was more resistant and from which less material drained. In the instance of the 32 per cent cream, however, the whipped cream had a greasy taste which was apparently due to the partial churning and the fat clumping resulting from the excessive agitation which is typical of this kind of whipper.

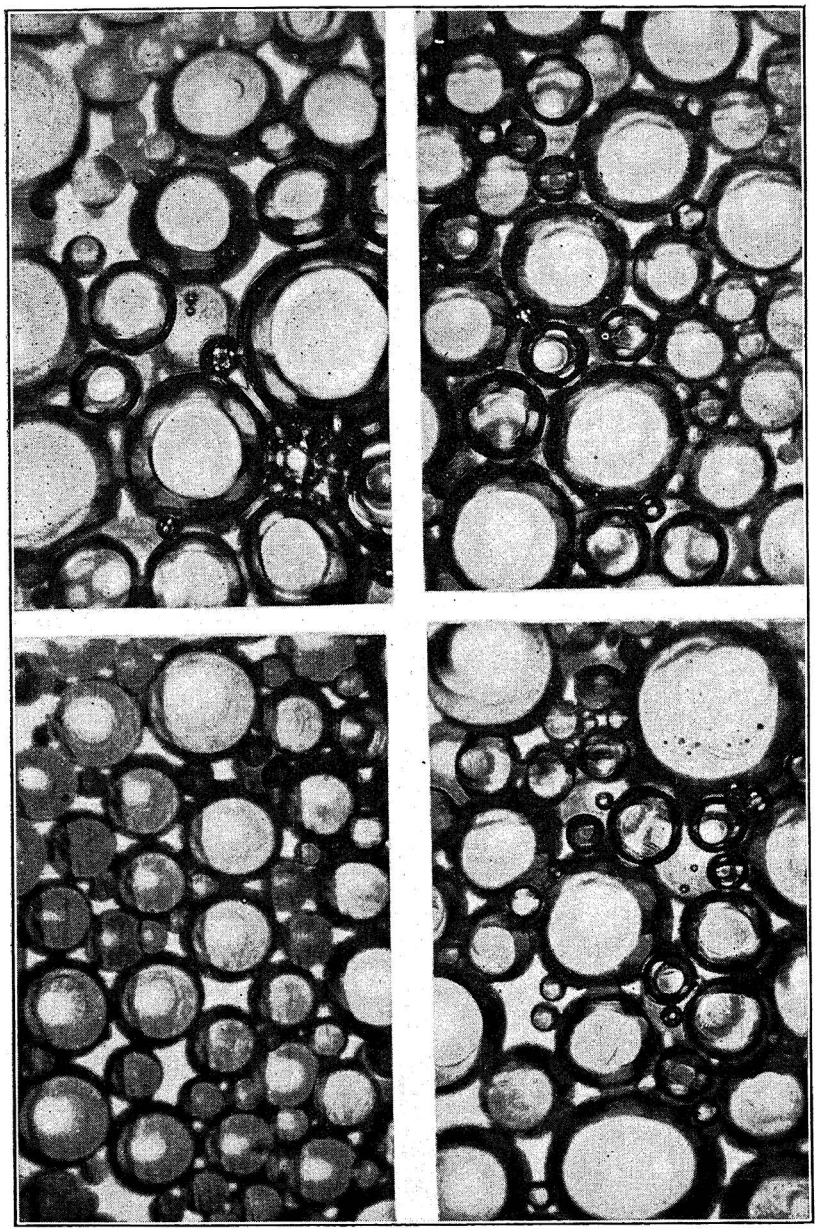

Fig. 4.—Normal Whipped Skim Milk.

Fig. 5.—Whipped Skim Milk containing 4 Per Cent of Dry Skim Milk.

Fig 6.—Whipped Skim Milk Containing 8 Per Cent of Dry Skim Milk.

Fig. 7.—Whipped Skim Milk containing 12 Per Cent of Dry Skim Milk.

Fig. 8.—The Air Whip.

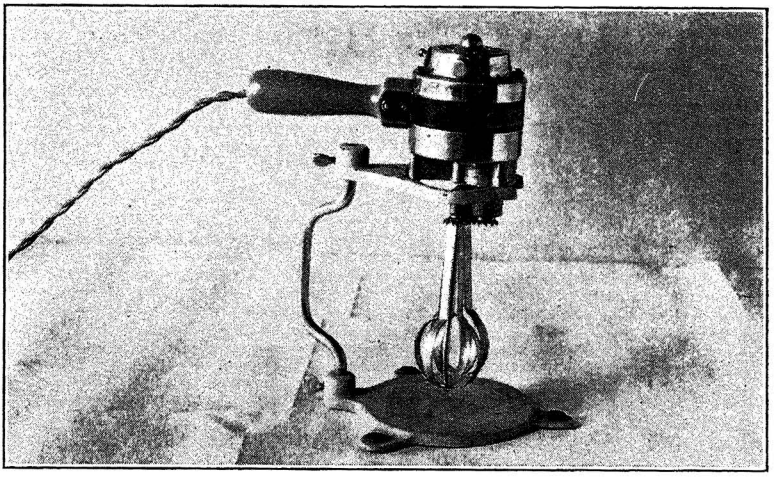

Fig. 9.—The Egg Beater Whipper.

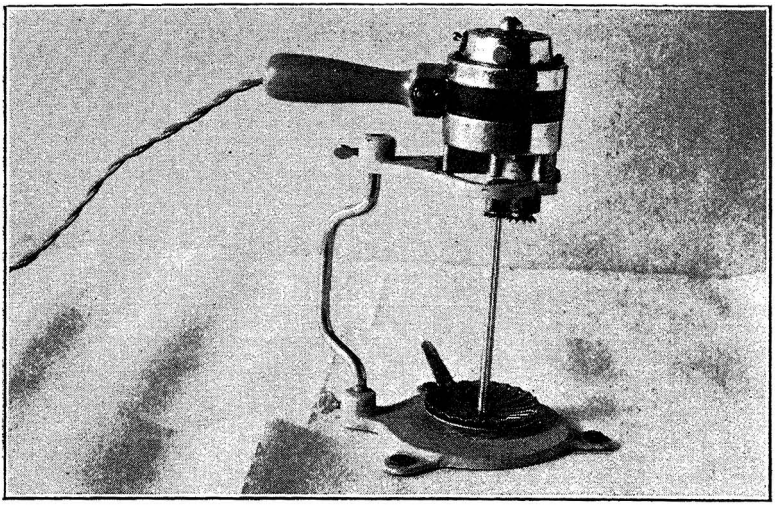

Fig. 10.—The Turbine Whipper.

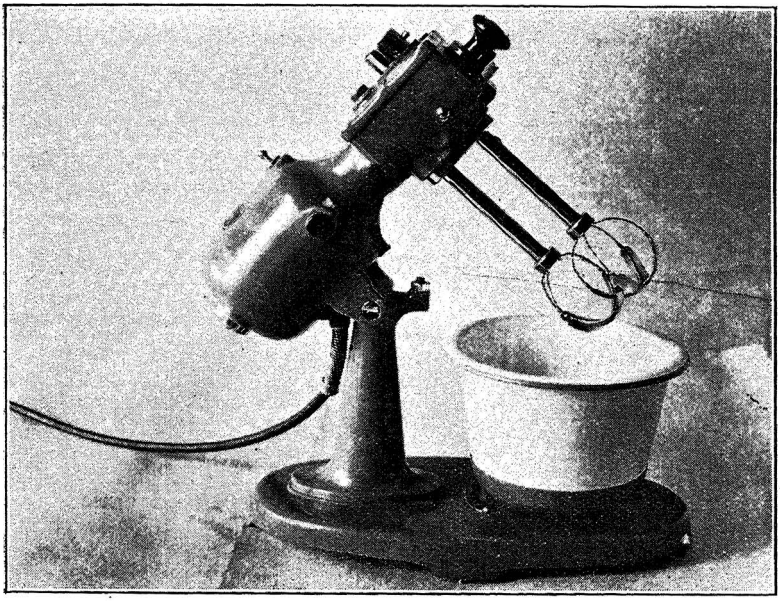

Fig. 11.—The Kitchen Aid Whipper.

TABLE 4.—THE INFLUENCE OF DIFFERENT TYPES OF WHIPPERS ON THE WHIPPING PROPERTIES OF A THIRTY-TWO PER CENT CREAM AND THE RESULTANT WHIPPED CREAM

| Type of Whipper | Time to Whip | | Over-run | Pene-tration | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|
| | Min. | Sec. | Per Cent | MM. | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| Air | 2 | 48 | 287 | 19 | 7 | 8 | Desirable, resistant | Cells close, medium, uniform | Rich, creamy | Light cream |
| Egg Beater | 2 | 56 | 139 | 2 | 4 | 11 | Heavy, very resistant | Very close small air cells | Rich, greasy | Rich cream |
| Kitchen Aid | 10 | 12 | 114 | 32 | 13 | 15 | Lacking resistance | Smooth, close, uniform, velvety | Rich greasy | Cream |
| Turbine | 6 | 20 | 137 | 27 | 8 | 15 | Very weak | Smooth, uniform, velvety | Rich creamy | Light cream |

TABLE 5.—THE EFFECT OF DIFFERENT TYPES OF WHIPPERS ON THE WHIPPING PROPERTIES OF A TWENTY-FIVE PER CENT CREAM AND THE RESULTANT WHIPPED CREAM

| Type of Whipper | Time to Whip | | Over-run | Pene-tration | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|
| | Min. | Sec. | Per Cent | MM. | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| Air | 2 | 16 | 181 | 23 | 5 | 13 | Desirable, Resistant | Medium close | Rich, sweet, creamy | Light cream |
| Egg Beater | 4 | 49 | 109 | 23 | 6 | 13 | Less desirable, med. resistant | Very uniform | Greasy, sub-merges sweetness | Rich cream |
| Kitchen Aid | 16 | 10 | 88 | 38 | 10 | 14 | Less desirable, lacks resistance | Uniform | Greasy, sub-merges sweetness | Cream |
| Turbine | 7 | 27 | 93 | 34 | 13 | 18 | Less desirable, very weak | Uniform | Sweet, rich butterfat | Light cream |

The air whip produced the most desirable whipped cream when a cream containing 25 per cent of butterfat and 6 per cent of dry skim milk was used.

The turbine whipper used by several other investigators was not satisfactory and proved less desirable than either the egg beater or air whipper.

The colors of the whipped creams were quite similar except when using the egg beater whipper which gave a more intense butterfat color. The partial churning of butterfat causes an intensification of the color of whipped cream.

## The Effect of Variable Increments of Dry Skim Milk On The Chemical and Physical Properties of a Thirty-Two Per Cent Cream And The Resultant Whipped Cream

The dry skim milk was varied from 0 to 12 per cent in increments of 2 per cent. The cream used was 32 per cent butterfat. This phase of the investigation was divided into two parts on the basis of the type of whippers used, i. e., the air whip and the egg whipper.

1. *Variable increments of dry skim milk using the air whip.*— The dry skim milk was added to the fresh pasteurized 32 per cent cream in the form of a cold paste at 42 degrees Fahrenheit (5.55 degrees Centigrade) and aged for 24 hours. Determinations for acidity, surface tension and viscosity were made at the expiration of the aging period. The overrun was calculated from the weight of the cream before and subsequent to whipping. The drainage was obtained by allowing the material from a 30 gram sample of the whipped cream to drain into a graduated cylinder. The weighed samples were placed in glass funnels in the neck of which was placed a small portion of steel wool. The body rigidity was determined by the penetration of a plunger having a displacement area of 1.55 square inches, and weighing 67.74 grams, when placed on the surface of a container filled with the whipped cream.

Table 6 shows the effect of the variable increments of the dry skim milk on the chemical and physical properties of the 32 per cent cream and the resultant whipped cream when the air whip was used. Graphs A, B and C respectively of Figure 12 show the influence of variable increments of the dry skim milk on the viscosity and acidity of the cream and the influence on the overrun of the whipped cream.

TABLE 6.—THE EFFECT OF VARIABLE INCREMENTS OF DRY SKIM MILK ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A THIRTY-TWO PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE AIR WHIPPER IS USED

| Dry Skim Milk Per Cent | Surface Tension Dynes | Time to Whip | | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Color | Flavor |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Sec. | | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| 0 | 51.98 | 1 | 50 | 29 | 7 | 12 | Medium resistant | Large cells, fluffy | Light cream, dull | Rich, creamy |
| 2 | 51.27 | 2 | 5 | 34 | 10 | 12.5 | Medium resistant | Medium cells, fluffy | Light cream, glossy | Rich, sweet, creamy |
| 4 | 49.85 | 1 | 50 | 19 | 4 | 11 | Desirable, resistant | Small cells, uniform, velvety | Very glossy | Rich, sweet creamy |
| 6 | 50.56 | 1 | 36 | 10 | 3 | 9 | Very desirable, resistant | Small cells, uniform, close, velvety | Very bright gloss | Very rich, sweet, creamy |
| 8 | 51.27 | 1 | 47 | 32 | 9 | 15 | Medium resistant | Uniform, close, velvety | Very bright gloss | Very rich, sweet, creamy |
| 10 | 49.85 | 2 | 19 | 36 | 4 | 14 | Medium resistant | Velvety, some large cells | Cream, very glossy | Very sweet, coats mouth |
| 12 | 50.56 | 1 | 51 | 43 | 7 | 17 | Lacks resistance, soggy | Velvety, large cells | Cream, very glossy | Very sweet, coats mouth |

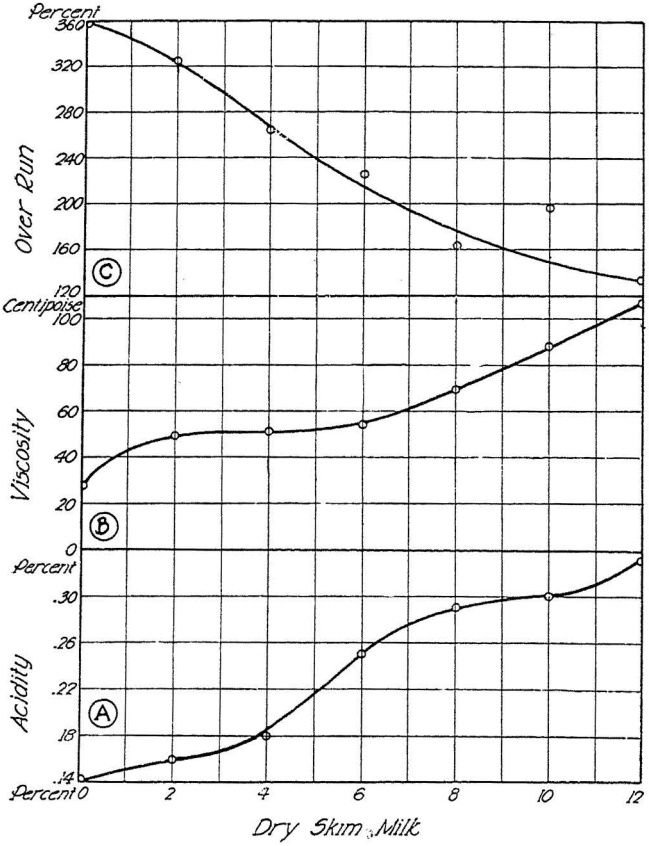


Figure 12.—The Influence of Variable Increments of Dry Skim Milk on the Acidity, Viscosity and Overrun When Using the Air Whip.

A very desirable whipped cream was produced from batches containing 6 per cent or less of dry skim milk. The addition of increments of the dry skim milk exceeding 8 per cent resulted in a whipped cream that was less desirable than the control batch. The viscosity and acidity were increased with each additional increment of dry skim milk while the overrun was consistently reduced. The texture, body and drainage properties were improved by the addition of the dry skim milk up to 6 per cent. Figures 13 to 16, inclusive, are typical of cell structure and texture of the respective whipped creams when the air whip was used.

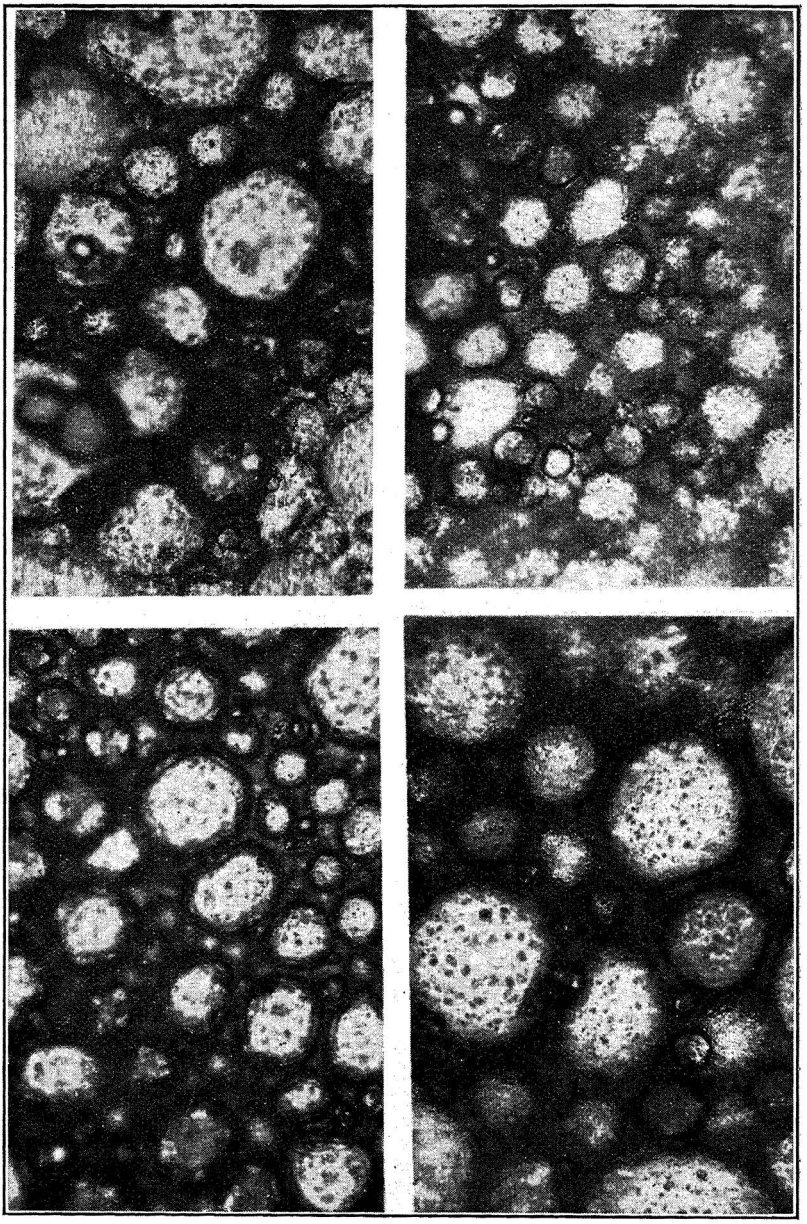

Fig. 13.—Control-32 Per Cent Whipped Cream Using Air Whip.

Fig. 14.—32 Per Cent Whipped Cream Containing 4 Per Cent of Dry Skim Milk.

Fig. 15.—32 Per Cent Whipped Cream Containing 6 Per Cent of Dry Skim Milk.

Fig. 16.—32 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

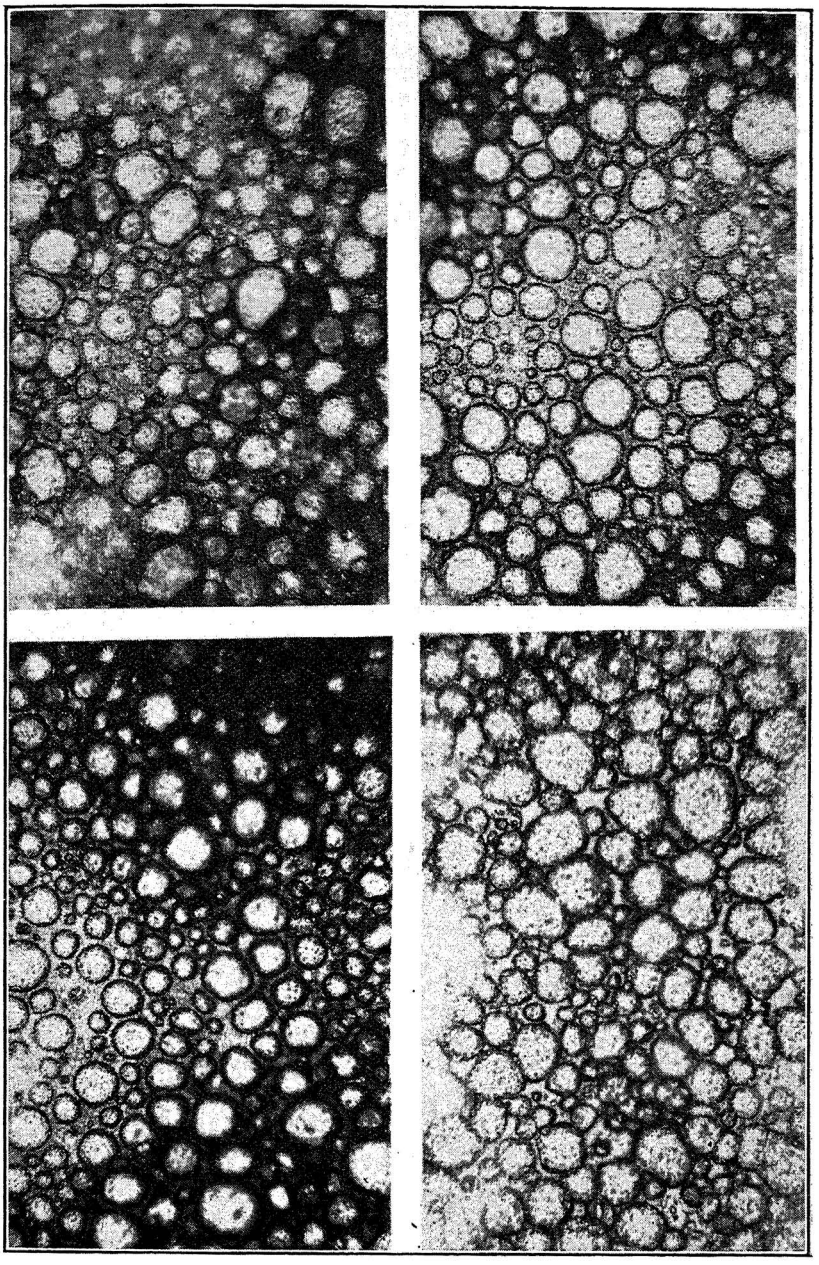

Fig. 17.—Control-32 Per Cent Whipped Cream Using Egg Beater Whipper.

Fig. 18.—32 Per Cent Whipped Cream Containing 4 Per Cent of Dryl Skim Milk.

Fig. 19.—32 Per Cent Whipped Cream Containing 6 Per Cent of Dry Skim Milk.

Fig. 20.—32 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

TABLE 7.—THE EFFECT OF VARIABLE INCREMENTS OF DRY SKIM MILK ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A THIRTY-TWO PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE EGG BEATER WHIPPER IS USED

| Dry Skim Milk Per Cent | Surface Tension Dynes | Time to Whip | | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Sec. | | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| 0 | 50.56 | 2 | 13 | 35 | 4.5 | 15 | Medium resistant | Close, smooth | Greasy, creamy, rich | Light cream |
| 2 | 49.85 | 2 | 13 | 24 | 3 | 8 | Medium resistant | Close, smooth, uniform | Greasy, creamy, rich | Light cream |
| 4 | 47.72 | 2 | 31 | 17 | 3 | 12 | Desirable, resistant | Close, velvety | Rich, slightly sweet | Rich cream, glossy |
| 6 | 48.43 | 2 | 39 | 7 | 5 | 10 | Desirable, resistant | Very close, velvety | Rich, sweet, fat submerged | Rich cream, glossy |
| 8 | 47.00 | 2 | 53 | 48 | 3 | 11 | Medium resistant | Very close, velvety | Sweet richness, good | Rich cream, very glossy |
| 10 | 48.43 | 3 | 8 | 30 | 3 | 10 | Heavy, lacks resistant | Few large cells, velvety | Rich, very sweet, coats mouth | Creamy, very glossy |
| 12 | 49.85 | 3 | 38 | 49 | 5 | 8 | Heavy, soggy, weak | Few large cells, velvety | Very sweet coats mouth | Creamy, very glossy |

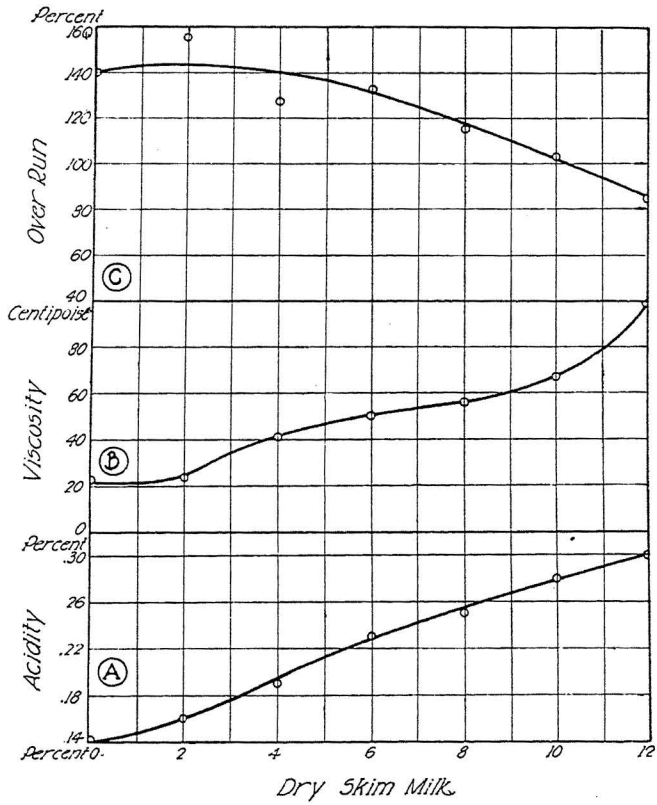


Figure 21.—The Influence of Variable Increments of Dry Skim Milk on the Acidity, Viscosity and Overrun When Using the Egg Beater Whipper.

2. *Variable increments of dry skim milk using the egg beater whipper.*--The cream used in this part of the experiment and the procedure practiced was identical with that outlined in Part 1. The only variation was in the type of whipper.

Graphs A, B and C of Figure 21 show the effect of variable increments of dry skim milk on the viscosity and acidity of the cream and the overrun of the resultant whipped cream.

The data, Table 7, show that the results were very similar to those obtained with the air whip. The whipping time, viscosity and acidity were uniformly increased with each additional increment of the dry skim milk while the overrun was consistently decreased. The body and the drainage of the whipped cream were improved with each additional increment of the dry skim milk to

6 per cent inclusive. The texture of the whipped cream was improved with 8 per cent or less of the dry skim milk. Figures 17 to 20 inclusive, show typical structure and air cells of the creams whipped with the egg beater whipper. When 4 per cent or more of dry skim milk was added, the whipped cream acquired a glossy appearance. The flavor of the whipped cream was improved by the addition of increments of the dry skim milk up to 6 per cent as the lactose and protein added submerged the greasy fat taste that is characteristic of cream whipped with this type of whipper.

The data show that 6 per cent of the dry skim milk can profitably be added to cream to be whipped with this type of whipper. Its presence in cream will improve the texture, body, color and flavor and markedly reduce the amount of material drained from the whipped cream.

## The Effect of Variable Increments of Dry Skim Milk On The Chemical and Physical Properties of a Twenty-Five Per Cent Cream And The Resultant Whipped Cream

Preliminary experimentation consisted of decreasing the butterfat content and increasing the solids-not-fat content by the addition of variable increments of dry skim milk. This part of the investigation was conducted on cream containing 25 per cent butterfat and the dry skim milk was increased in increments of 2 per cent from 2 to 12 per cent inclusive. It was found that a whipped cream could be produced from cream containing as little as 25 per cent of butterfat, with at least one of the whippers.

1. *Variable increments of dry skim milk added to a 25 per cent cream using the air whip.*—The data, Table 8, show that a whipped cream considered to be quite satisfactory could be produced from a cream containing 25 per cent of butterfat and 4 to 6 per cent of dry skim milk. Either greater or less amounts of dry skim milk than 4 to 6 per cent were less effective in producing a satisfactory whipped cream.

Figures 22 to 25 inclusive, are typical of the texture and cellular structure of the whipped creams containing 25 per cent of butterfat and variable increments of dry skim milk.

2. *Variable increments of dry skim milk added to a 25 per cent cream using the egg beater whipper.*—Table 9 shows that there was an increase in the acidity, viscosity and time required to whip each additional increment of dry skim milk while the effect upon the

TABLE 8.—THE EFFECT OF VARIABLE INCREMENTS OF DRY SKIM MILK ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A TWENTY-FIVE PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE AIR WHIPPER IS USED

| Dry Skim Milk Per Cent | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Overrun Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| 0 | .13 | 14.75 | 49.85 | 1 | 37 | 312 | 46 | 16 | 20 | Very weak | Coarse, very fluffy | Lacked typical richness | Light cream |
| 2 | .15 | 18.10 | 47.00 | 1 | 45 | 275 | 41 | 14 | 21 | Weak | Fluffy, medium coarse | Lacked typical richness | Light cream |
| 4 | .18 | 19.30 | 48.40 | 2 | 53 | 187 | 39 | 10 | 15 | Weak | Close, uniform, velvety | Sweet, lacked typical richness | Glossy, light cream |
| 6 | .23 | 26.10 | 48.43 | 1 | 42 | 236 | 24 | 19 | 22 | Medium resistant | Close, uniform, velvety | Sweet, rich, desirable | Very glossy |
| 8 | .24 | 30.70 | 49.85 | 3 | 5 | 195 | 22 | 17 | 22 | Weak, soggy | Close, uniform, velvety | Sweet, rich, desirable | Very glossy |
| 10 | .27 | 38.10 | 48.85 | 1 | 51 | 181 | 44 | 22 | 28 | Weak, soggy | Some large cells | Very sweet, coats mouth | Light, very glossy |
| 12 | .31 | 39.80 | 50.56 | 1 | 6 | 194 | 44 | 25 | 25 | Very soggy | Very coarse, irregular | Very sweet, coats mouth | Light, very glossy |

TABLE 9.—THE EFFECT OF VARIABLE INCREMENTS OF DRY SKIM MILK ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A TWENTY-FIVE PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE EGG BEATER IS USED

| Dry Skim Milk Per Cent | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Overrun Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 42°F | | | | |
| 0 | .13 | 14.75 | 49.85 | 3 | 5 | 106 | 49 | 16 | 20 | Weak | Medium, close, uniform | Greasy, lacks richness | Light cream |
| 2 | .15 | 18.10 | 47.00 | 3 | 36 | 106 | 49 | 14 | 21 | Weak | Medium, close, uniform | Greasy, lacks richness | Light cream |
| 4 | .18 | 19.30 | 48.40 | 3 | 39 | 100 | 49 | 10 | 15 | Weak | Medium close, uniform | Sweet, submerges fat taste | Light cream |
| 6 | .23 | 26.10 | 48.43 | 3 | 11 | 89 | 49 | 19 | 22 | Weak | Velvety, close, uniform | Sweet, submerges fat taste | Glossy, light cream |
| 8 | .24 | 30.70 | 49.85 | 3 | 5 | 98 | 49 | 17 | 22 | Very weak | Velvety, close, uniform | Very sweet, lacks fat taste | Very glossy |
| 10 | .27 | 38.10 | 49.85 | 4 | 27 | 100 | 49 | 22 | 28 | Very weak | Coarse, large cells | Coats mouth, very sweet | Very glossy |
| 12 | .31 | 39.80 | 50.56 | 4 | 28 | 82 | 49 | 25 | 25 | Very weak | Coarse, large cells | Coats mouth, Very sweet | Very glossy |

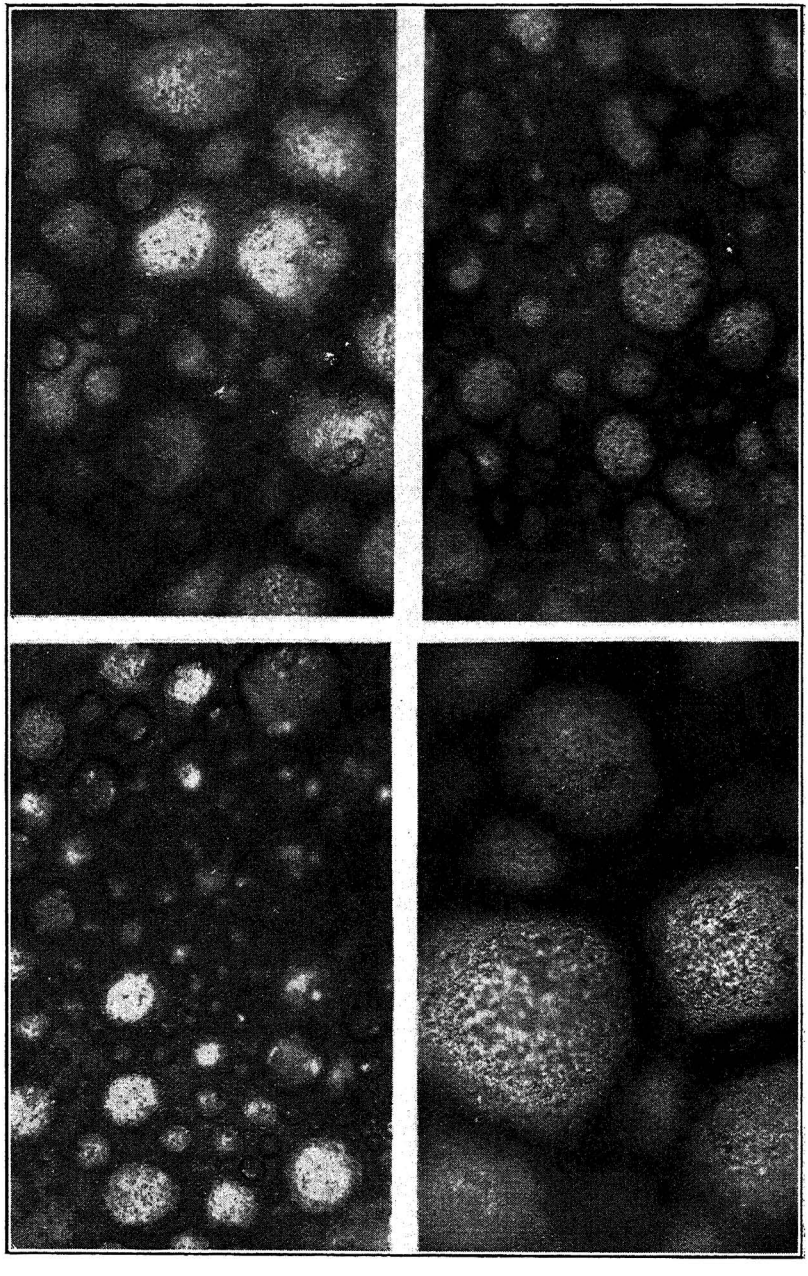

Fig. 22.—Control 25 Per Cent Cream Using Air Whip.

Fig. 23.—25 Per Cent Whipped Cream Containing 2 Per Cent of Dry Skim Milk.

Fig. 24.—25 Per Cent Whipped Cream Containing 6 Per Cent of Dry Skim Milk.

Fig. 25.—25 Per Cent Whipped Cream Containing 10 Per Cent of Dry Skim Milk.

rigidity and surface tension was insignificant. Increasing the amount of dry skim milk decreased the overrun uniformly.

The body of all of the whipped creams was weak and lacked resistance while the texture varied from medium to very coarse as indicated by the drainage.

## The Clumping Or Grouping Of Butterfat Globules Or Their Aggregates On The Surface Of Air Cells In Whipped Creams Prepared With Different Whippers And Containing Variable Increments of Butterfat and Dry Skim Milk

This experiment was divided into two parts, the division being made on the basis of different types of whippers used. All cream used for comparison had been aged and treated in the usual manner. Microscopic photographs were taken of each sample immediately after whipping. The overrun and whipping time for each sample was that normally acquired as determined in previous phases of the investigation.

1. *Egg Beater Whipper.*—Batches of cream containing the following butterfat and dry skim milk contents were used:

Normal 32 per cent cream.

Thirty-two per cent cream containing 12 per cent of dry skim milk.

Normal 25 per cent cream.

Twenty-five per cent cream containing 12 per cent of dry skim milk.

Figures 26 to 29 inclusive, show the clumping of butterfat on the air cells of the whipped creams prepared by this type of whipper from the various batches of cream. The micro-photographs are of portions of air cells at a magnification of X300.

The large clumps of fat in the different photographs indicate that cream whipped by this whipper is partially churned. Fat clumps as large as these are explanations for the pronounced and greasy butterfat taste and more intense color previously noticed.

There were no apparent variations in clumping that could be directly associated with the 12 per cent of added dry skim milk. The slight increases of clumping that are apparent in the batches that contain the dry skim milk can, no doubt, be attributed to the increased whipping time for these samples. This is, of course, indirectly due to the added dry skim milk.

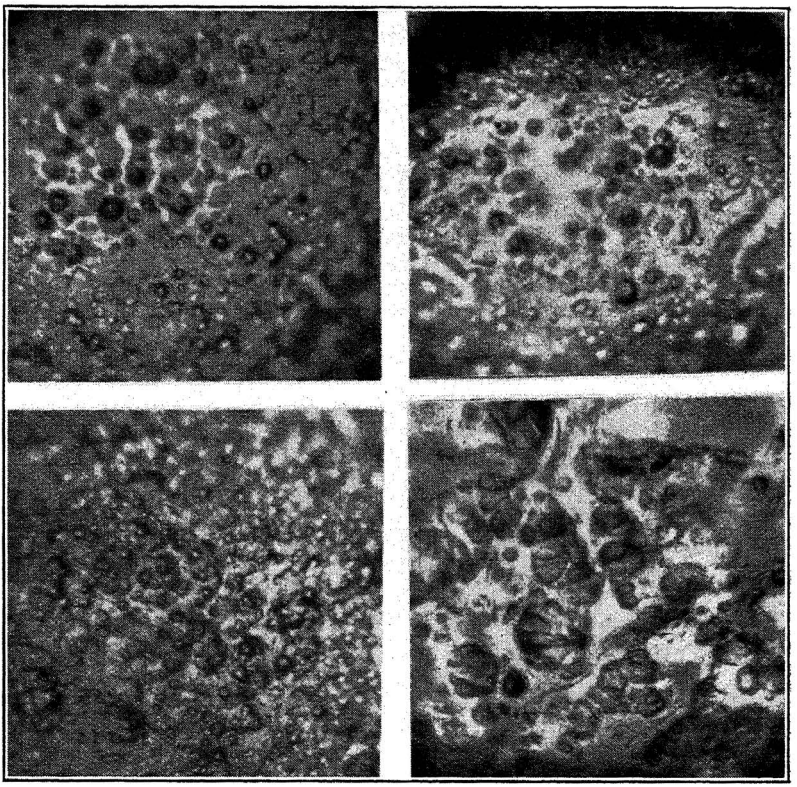

Fig. 26.—Control-25 Per Cent Whipped Cream.

Fig. 27.—25 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

Fig. 28.—Control-32 Per Cent Whipped Cream.

Fig. 29.—32 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

The Clumping of Butterfat on the Surface of Air Cells as Influenced by Different Increments of Butterfat and Dry Skim Milk When Using the Egg Beater Whipper. X300.

2. *Air Whip.*—Batches of cream identical with those in Part 1 were used. The magnification of all the micro-photographs was X300 except Figure 34 which was magnified at X1800.

Figures 30 to 33 inclusive, show typical distribution of the butterfat globules on the face of air cells from the various batches of cream as produced by this particular type of whipper.

All globules in the 32 per cent cream were very evenly distributed over the surface of the air cells with very little clumping or grouping. In the instance of the 25 per cent cream the slight

clumping can be explained by the more vigorous agitation that was required to produce a whipped cream of desirable body and texture. There was no visible evidence of variations in butterfat distribution due to the added dry skim milk in either the 32 or 25 per cent creams.

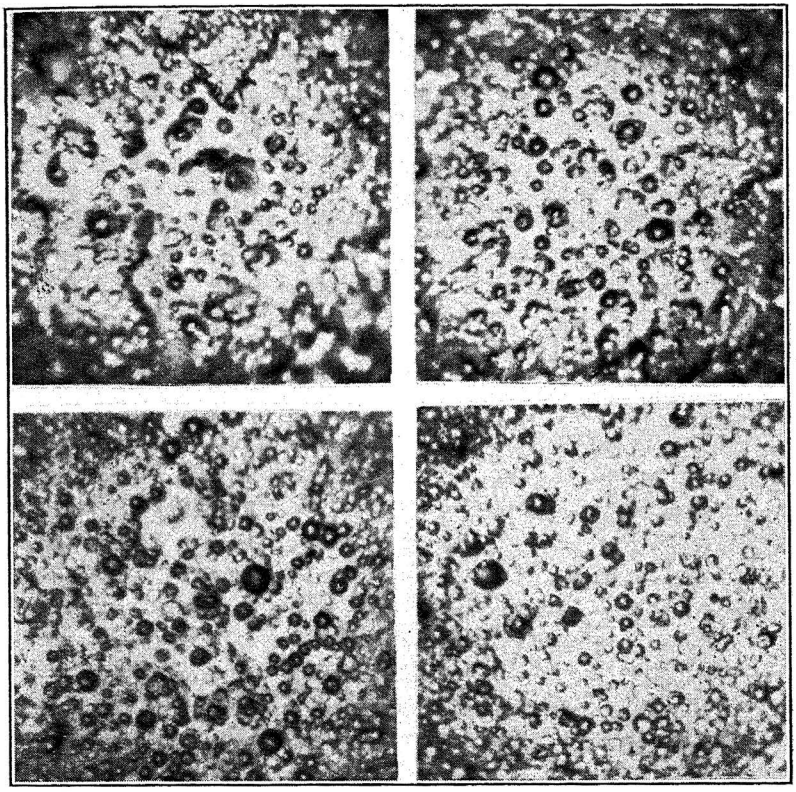

Fig. 30.—Control-25 Per Cent Whipped Cream.

Fig. 31.—25 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

Fig. 32.—Control-32 Per Cent Whipped Cream.

Fig. 33.—32 Per Cent Whipped Cream Containing 12 Per Cent of Dry Skim Milk.

The Distribution of Butterfat Globules on the Surface of Air Cells as Influenced by Different Increments of Butterfat and Dry Skim Milk When Using the Air Whipper. X300.

The theory that butterfat globules and their aggregates form a network that lends stability to a whipped cream, as advanced by Dahlberg and Henning (1925), may apply to the whipped cream prepared with the egg beater whipper, however, it does not apply

to cream whipped with the air whip. The creams whipped by the application of the air whip have a very small per cent of visible globules that touch each other or that tend to form a network. This is clearly illustrated in Figures 30 to 33, inclusive.

It was shown earlier in the investigation that a more desirable whipped cream was produced by this type of whipper than was produced with the egg beater whipper. The entirely different distribution of fat on the air cells, the difference in flavor and color and the differences in overrun indicate that the whipping of cream with these two whippers are entirely different processes.

The air whip apparently produces a whipped cream in which the butterfat globules and the colloidal particles are sufficiently uniform in distribution over the air cell surfaces to result in a very stable structure. The fact that the specific gravity of the butterfat is less than that of the serous membrane forming the cell surface and at the same time offers resistance to the surface tension that is responsible for the breaking of the air cells, would indicate that the greater the fat distribution over the air cell surface, the more resistant the structure would be.

## The Effect of Five Per Cent of Sugar On the Chemical And Physical Properties Of Batches of Cream Containing Variable Increments of Butterfat and Dry Skim Milk

This experiment was divided into two parts on the basis of the type of whipper used.

Five per cent of sugar was added to the following batches of cream before the aging period:

Thirty-two per cent cream.

Thirty-two per cent cream containing 6 per cent of dry skim milk.

Twenty-five per cent cream.

Twenty-five per cent cream containing 6 per cent of dry skim milk.

1. *Air Whip.*—The above mentioned batches of cream were aged normally after the addition of the sugar and dry skim milk and then whipped. The creams, to which the sugar had been added, were compared with the control batches of the cream corresponding to them on the basis of butterfat and dry skim milk, Tables 10 and 11.

TABLE 10.—THE EFFECT OF SUGAR ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A THIRTY-TWO PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE AIR WHIPPER IS USED

| Batch | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Overrun Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 48°F. | | | | |
| Control | .14 | 23.90 | 50.56 | 1 | 50 | 358 | 29 | 1 | 12 | Medium resistant | Large, cells, fluffy | Rich, creamy | Light cream, dull |
| Control Plus Sugar | .14 | 26.12 | 49.13 | 1 | 37 | 234 | 9 | 2 | 9 | Resistant, smooth | Medium close, some large cells | Sweet, rich, creamy | Glossy light cream |
| Control Plus 6% D.S.M. | .26 | 56.10 | 48.43 | 1 | 36 | 225 | 10 | 3 | 9 | Resistant, smooth | Uniform, very close, velvety | Very rich, sweet, creamy | Light cream, very glossy |
| Control Plus Sugar 6% D.S.M. | .25 | 52.30 | 47.00 | 1 | 47 | 9 | 4 | 2 | 8 | Very resistant, smooth | Very uniform, velvety close | Very rich, sweet, creamy | Rich cream, very bright glossy |

TABLE 11.—THE EFFECT OF SUGAR ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A TWENTY-FIVE PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE AIR WHIPPER IS USED

| Batch | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Overrun Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 48°F. | | | | |
| Control | .16 | 12.50 | 48.40 | 1 | 37 | 312 | 46 | 16 | 20 | Very weak, lacks resistance | Coarse, very fluffy | Clean lacked richness | Light cream |
| Control Plus Sugar | .15 | 15.90 | 47.70 | 1 | 40 | 275 | 48 | 9 | 14 | Very weak, lacks resistance | Flufly, coarse, irregular cells | Sweet, lacked richness | Glossy, Light cream |
| Control Plus 6% D.S.M. | .28 | 28.40 | 49.13 | 1 | 42 | 236 | 24 | 11 | 22 | Medium resistant | Velvety, uniform close | Sweet, lacks fat richness | Light cream, very glossy |
| Control Plus Sugar Plus 6% D.S.M. | .26 | 29.53 | 48.40 | 1 | 44 | 212 | 19 | 6 | 12 | Medium resistant Slightly soggy | Velvety, uniform close | Very sweet, lacks fat richness | Light cream, very glossy |

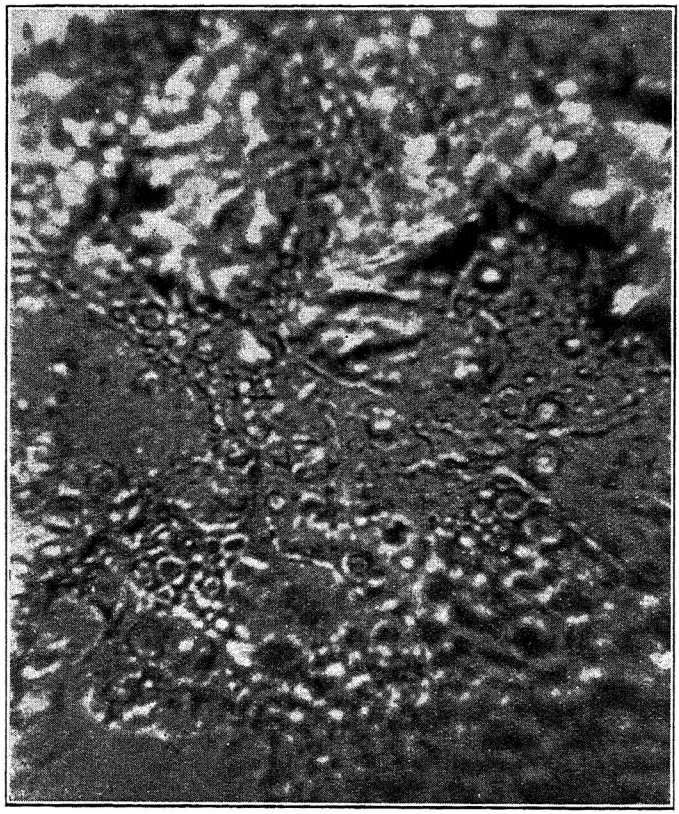

Figure 34.—The distribution of butterfat on the surface of an air cell. Magnification X1800.

The sugar had little influence on the chemical and physical properties of the whipped cream other than the overrun which was reduced. The greatest reduction in overrun as a direct result of the added sugar occurred in the normal cream. The drainage properties, the body and the texture of the respective whipped creams were improved by the addition of the sugar regardless of their butterfat or solids-not-fat content.

The most desirable whipped cream was produced from the batch of cream containing 32 per cent of butterfat and 6 per cent of dry skim milk.

The batch of cream containing 25 per cent of butterfat, 6 per cent of dry skim milk and five per cent of sugar produced a very satisfactory whipped cream. The principal differences between

TABLE 12.—THE EFFECT OF SUGAR ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A THIRTY-TWO PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE EGG BEATER WHIPPER IS USED

| Batch | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Over-run Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| Control | .14 | 23.90 | 50.56 | 1 | 13 | 140 | 35 | 4.5 | 15 | Medium resistant | Very smooth, close | Rich cream, greasy | Rich cream |
| Control Plus Sugar | .15 | 27.26 | 47.00 | 3 | 39 | 146 | 8 | 4 | 10 | Desirable resistant | Close, velvety | Rich, sweet | Glossy, rich cream |
| Control Plus 6% D.S.M. | .26 | 56.80 | 48.43 | 2 | 39 | 135 | 7 | 5 | 10 | Very desirable | Very close, velvety | Sweet, rich, fat submerged | Glossy, rich cream |
| Control Plus Sugar Plus 6% D.S.M. | .25 | 46.67 | 47.70 | 4 | 10 | 134 | 3 | 2 | 12 | Very desirable, heavy | Velvety, very smooth | Very rich sweet | Very glossy, rich |

TABLE 13.—THE EFFECT OF SUGAR ON THE PHYSICAL AND CHEMICAL PROPERTIES OF A TWENTY-FIVE PER CENT CREAM AND THE RESULTANT WHIPPED CREAM WHEN THE EGG BEATER WHIPPER IS USED

| Batch | Acid Per Cent | Viscosity Centipoises | Surface Tension Dynes | Time to Whip | | Over-run Per Cent | Penetration MM. | Cu. centimeters drained from 30 gms. | | Body | Texture | Flavor | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min. | Sec. | | | 1 hr. at 68°F. | 24 hrs. at 42°F. | | | | |
| Control | .13 | 14.75 | 49.85 | 3 | 5 | 106 | 49 | 16 | 20 | Weak | Medium close | Greasy, lacks richness | Cream |
| Control Plus Sugar | .15 | 14.77 | 45.90 | 4 | 47 | 156 | 24 | 12 | 12 | Medium to lacking resistance | Medium close, smooth | Sweet, slight greasy | Glossy |
| Control Plus 6% D.S.M. | .23 | 26.10 | 48.43 | 3 | 11 | 89 | 49 | 19 | 22 | Weak | Close, velvety | Sweet, greasiness submerged | Glossy cream |
| Control Plus Sugar Plus 6% D.S.M. | .25 | 31.80 | 48.43 | 5 | 13 | 128 | 11 | 10 | 12 | Medium resistant | Very close, velvety | Rich sweet | Very glossy cream |

the latter whipped cream and that containing 32 per cent of butterfat were in the drainage properties and flavor.

2. *Egg Beater Whipper.*—The addition of five per cent of sugar to cream containing either 32 or 25 per cent of butterfat did not affect the overrun but always increased the time required to whip.

The body of the whipped cream was improved and the amount of material that drained from the whipped cream was decreased regardless of the butterfat content of the whipped cream. The most marked improvement occurred, however, in the presence of the 6 per cent of added dry skim milk, five per cent of sugar and 25 per cent cream.

A fairly desirable whipped cream could be produced from a 25 per cent cream, with this type of whipper, if 6 per cent of dry skim milk and five per cent of sugar were added before the aging period, Tables 12 and 13.

## SUMMARY AND CONCLUSIONS

1. The addition of dry skim milk to cream used for whipping purposes and subsequently aged is shown to. (1) Increase the viscosity of the cream markedly, the greatest increase occurring during the first 12 hours of aging; (2) Increase the acidity, the greatest increase being effected immediately upon its addition; (3) Have little influence on the surface tension of cream.

2. Dry skim milk may be easily added to a cream for whipping purposes in the form of a cold paste.

3. The addition of dry skim milk to fluid skim milk increases its foaming ability and viscosity and slightly reduces the surface tension.

4. The air whip was found to be the most satisfactory type of whipper, being superior over the egg beater type of whipper because it (1) Gave a more uniformly whipped cream; (2) Produced a larger and more uniform overrun; (3) Required less time to whip; (4) Imparted a superior flavor.

5. The addition of 6 per cent of dry skim milk improved cream for whipping purposes and the resultant whipped cream regardless of the type of whipper used. The improvement was especially noticeable by: (1) Imparting a more desirable flavor; (2) Giving a closer, more uniform and smoother texture; (3) Increasing the resistance of the body and reducing the material that drained from the finished cream; (4) Imparting a more glossy desirable appearance; (5) Promoting a whip in some creams that would otherwise be undesirable for whipping purposes.

6. A desirable whipped cream was produced with the air whip if 4 to 6 per cent of dry skim milk was added to a 25 per cent cream and the normal aging procedure followed. Other whippers failed to produce a desirable body in whipped cream when this butterfat content was used.

7. The intensity of the color, flavor and fat clumping is largely due to the type of whipper used. The whipper producing the greatest agitation during the whipping process intensifies these properties.

8. The more pronounced the clumping, the more greasy and less desirable the flavor in the finished whipped cream.

9. Sugar added to cream before aging improves the flavor of the finished whipped cream, reduces the overrun, improves the body and the amount of material drained from the whipped cream is decreased.

10. This investigation also showed that (1) Pasteurized cream is satisfactory for whipping purposes; (2) Aging ot cream for 24 hours is sufficient to insure proper whipping, if the butterfat content is sufficiently high; (3) A 32 per cent cream proved uniformly satisfactory for whipping; (4) A whipping and aging temperature of 42 degrees Fahrenheit is very satisfactory.

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