THE INFLUENCE OF THE SOURCE OF FAT AND SERUM SOLIDS ON THE OVERRUN AND QUALITY OF ICE CREAM

THESIS FOR THE DEGREE OF M. S.

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THESIS

The Influence of the Source of Fat and Serum Solids on the Overrun and Quality of Ice Cream

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Thesis

Respectfully submitted to the Faculty of the Michigan State College in partial fulfillment of the requirements for the degree of Master of Science.

by

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THESIS

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INTRODUCTION

Ice cream is a manufactured article made largely from milk products. The manufacturer is not particularly limited in his choice of ingredients providing the products are clean and wholesome. He may select, therefore, the ingredients that can be purchased at least expense.

Aside from the economic consideration the manufacturer must keep in mind also the important item of quality. It is on this point that good will and permanent relations are best attained with the public. Though it is doubtful that the public in general can accurately judge and discriminate on the basis of quality it would not be wise to attempt building a business on such a supposition.

When considering a problem dealing with reconstitution of materials, it is well to be reminded that the invention of the homogenizer has been responsible for practices leading to such choice, and while the work presented here is not intended as a problem of homogenizing, this phase is intimately related to work of this sort. The homogenizer made available to the industry butter and skim milk products as new sources of material from which to build a mix. Accordingly it is extensively used for just this purpose.

REVIEW OF LITERATURE

Recently there have been a number of investigations conducted on the use of butter in ice cream. Dahle (1) made a comparison of ice cream prepared from frozen cream, butter, and butter oil. His conclusions were that, provided the cream was of high quality, the ice cream from the various products were identical, but if the cream was fair to poor in quality better results were secured by storing it as sweet cream butter. He also stated that "Ice cream of best quality is prepared from fresh cream of highest quality although good results can be secured with butter of high quality".

Wright (2) observed that substitution of butter for cream in part, or wholly, noticeably retarded the final whip. Wright further observed that a 14 per cent fat ice cream mix, deriving all its fat from butter, could not be homogenized without feathering.

Clutter (3) studied some of the factors that influence overrun and quality of ice cream. He observed that when butter is used in place of cream in the mix a normal yield was not obtained. A greater viscosity was noted and the fat globules were found to be distributed in uniformly larger clusters.

In a series of this experiment skim-milk powder and water was used instead of whole milk and the percentage of solids-not-fat was increased. This resulted in a greater yield, which suggested that percentage of milk-solids-not fat has a marked effect upon yield. The fat being in an unprotected state was given as the reason for the peculiar behavior of the butter mixes.

Caulfield and Martin (4) substituted butter for sweet cream in ice cream mixes and also report a destruction of whipping properties. These investigators were of the opinion that the churning process and not the treatment the cream receives prior to churning is largely responsible.

The influence of the use of butter on the freezing properties of ice cream mix was studied by Whitaker (5) who reports a decrease in freezing quality when butter is used that was churned from the same lot of cream as was used in the check lot. He ascribes this as probably due to loss in lecithin during the churning process, believing that lecithin improves whipping quality.

Contrary to the results of Wright (2), Clutter (3), Whitaker (5), and Caulfield and Martin (4) in regard to the influence of butter on overrun, Hening and Dahlberg (6), while studying the effect of certain salts on the physical properties of ice cream mixes observed that when mixes were prepared using either unsalted butter, skimmilk powder, and water, or unsalted butter, skimmilk powder, skimmilk and enough water to mix and dissolve the gelatin and salts, the mixes were unusually viscous, but whipped very easily.

In all the investigations where viscosity studies were made there was a general agreement that mixes made with butter as the fat source were high in this property.

In an attempt to disclose the reason why mixes made with butter as the fat source did not yield as good whipping properties as sweet cream mixes Whitaker (5) suggests the loss of lecithin due to the churning process as being the responsible factor. Contrary to this theory is the work of Caulfield and Martin (7) who found the lecithin from soybeans a deterrent to overrun in an ice cream mix. Button (8) likewise found that egg yolk lecithin deterred overrun. Button (8) further found that the increased whipping ability and greater stability in the freezer of mixes containing egg yolks were produced by the egg protein.

Fat is generally accepted as an overrun deterrent. Gregory and Manhart (9) state that "although the milk fat content of an ice cream mix is of great importance as affecting other qualities and properties of ice cream it has no beneficial influence in obtaining overrun. A high overrun can be obtained from mix without fat, but in order to produce a product that is of good quality and smooth to the taste, a fair amount of milk fat must be used". Williams (10) says "Overrun in ice cream making is not increased by the fat. It is often thought that since fat increases the viscosity of a mix, it should also result in producing a higher overrun; but the fact is that the fat is an overrun deterrent". Lucas and Mook (20) observed that each two per cent increase in fat decreased overrun approximately 10 per cent.

Sommer and Horrall (21) explain the whipping ability of ice cream mix by saying that "as more and more air is whipped into a fixed quantity of mix the distance between the air cells becomes thinner and thinner. Finally a point is reached where the walls consisting of partially frozen ice cream mix become so thin with the addition of more air that some of them break and no additional air can be incorporated". The condition in which the fat is present is explained by these investigators as being an important factor in relation to the strength of the air cells formed. They state that the presence of fat weakens the cell walls because milk serum does not adhere to fat with a force equal to the cohesion of the serum. When the fat is in large globules or clusters of globules the strength of the walls is correspondingly lowered, because of the lessened amount of serum in the cross section of the walls where these fat masses are present.

The Effect of Milk Solids Not Fat on Overrun   The colloidal properties of the plasma solids of the mix are responsible for whipping properties. Mojonnier and Troy (11) state that "a mix high in milk solids not fat and comparatively low in fat takes on overrun much more readily than in the reverse case. Of great importance in their influence upon overrun are the proportions of the various constituents that make up the total solids".

The interrelationship of the combined effects of fat and serum solids on fat clumping has been studied. Doan (12) explains this phenomenon as being due to an interfacial tension effect.

"Fat and water interfaces give rise to relatively high interfacial tensions and since the magnitude of this free energy can be diminished by a decrease in surface area, and a decrease in surface area can be brought about by coalescence of the fat globules into larger units, the globules must exhibit some tendency to thus come together and unite. Indeed, in pure water the globules would undoubtedly follow this procedure until ultimately a layer of fat and a layer of water would be formed presenting the smallest interface possible. In milk, however, there are opposing forces which act to neutralize the interglobule attraction. The free energy represented by the fat globule-water interface may be reduced in another way from that represented by reduction of surface area, namely, by adsorption of surface tension active substances present in the water, or in case of milk, in the plasma. Colloids as a class are capable of lowering energy at surfaces and in milk enough evidence is at hand to prove practically that adsorption of the colloids takes place to a considerable extent. By mathematical means Troy and Sharp have arrived at a thickness of 19 m u for the adsorbed layer, although they consider this figure somewhat high. In any case adsorption occurs and free energy is decreased, although evidently not entirely done away with since the fat globules in normal milk tend to aggregate into clumps due to a slight attraction remaining. However, no coalescence takes place, either because the tendency has been so greatly overcome that it is insufficient to do more than attract the globules together, or because the adsorbed layer prevents an intimate contact of the globules. The latter idea is more logical."

Doan (12) found that the clumping of small fat globules in homogenized mixtures of normal milk and cream to be greatly stimulated by increases in the pressure used in homogenization. The ratio of the amount of plasma solids to the amount of fat in the mixtures processed was a limiting factor in the fat clumping phenomenon. There was a critical ratio above which no clumping was obtained, but below which clumping was pronounced. Due to many factors which are difficult to control, it was not possible to establish a definite value for the critical ratio, since the mechanics of the homogenizer, individuality in the physical properties of different samples, the fat concentration of the mixtures and other undefined factors influence the value.

Doan (12) found the critical ratio to be between .6 and .85 for mixtures compounded from raw products warmed to 38° C (100° F) and a fat concentration from eight to 18 per cent.

While working with ice cream mixes Dahle (13) found that clumping occurred in mixes having a serum solids to fat ratio ($\frac{SS}{F}$) of 1.25.

The effect of butter on clumping, viscosity, and overrun is presented by Dahle (13) in the following table.

Source of fat in mix	Clumping noted	Viscosity in centipoises	Minutes to reach 100 per cent overrun
Butter	Very prominent	276.4	12.39
Cream	Very evident to prominent	121.4	10.79

The mixes used in this trial contained 12 per cent fat and 10 per cent serum solids, a ratio of serum solids to fat of ($\frac{10}{12}$) or .83.

In view of the fact that the fat and serum solids ratio has been found to influence the physical properties of the mix the following table has been constructed to compare the ratio of some of the experimental mixes employed by various investigators who used butter as a source of fat in making up their mixes:

Table showing fat to s.s. ratio of mixes reported using butter as a source of fat.

Experiment	Per cent Fat	Per cent S S.	Ratio ($\frac{S\ S}{F}$)
Clutter (3)1 Table IV	14.0	7.3	.52
" 2 " V	15.2	6.2	.41
Caulfield & Martin (4)	12.0	10.0	.83
Whitaker (5)	10.0	10.0	1.00
Dahle (13)	12.0	10.0	.83
Dahlberg & Hening (6)	12.0	10.0	.83

Effect of Butter on Quality There have been only a few investigations conducted on the use of butter as affecting quality. Dahle (1) made a comparison of ice creams prepared from frozen cream, butter, and butter oil. His conclusions were that, providing the cream was of high quality, the ice creams from the various products were identical, but if the cream was fair to poor in quality better results were secured by storing it as sweet cream butter.

Source of Serum Solids Williams (14) states that "the quantity and quality of milk solids not fat used in the manufacture of medium grade ice cream are major factors determining its outstanding physical properties. Textural properties of ice cream are affected to a very large extent by the character of milk solids not fat, which in turn may be related to the source or form of milk solids not fat used. Quality of ice cream varies according to different forms of dried milk of the same type and that the heat treatment employed in the preparation of dried skim milk is a factor that is fundamentally beneficial. The data from these investigations show conclusively ice cream made from spray dried skim milk which had been forewarmed to 181° F for 30 minutes prior to drying was decidedly preferable to ice cream made from unsweetened condensed skim milk.

Tracy (15) made a comparison between the ice cream mixes which contained superheated and plain condensed milk. He found that the superheated condensed milk increased the viscosity and also increased the overrun.

Hening (16) found that high heat treated skim milk, or skim milk with skim milk powder added, whipped to a higher overrun than condensed skim milk which had only been heated to a temperature of 145 - 150° F.

Effect of Aging When a mix is aged an improvement in whipping property and texture is usually observed. Sommer (17) states that aging is beneficial, through some physical property that cannot be explained by either viscosity or surface tension, but is probably due to hydration of colloids.

Hening (16) while working with experimental mixes where fat was excluded, found that aging improved the whipping properties of skim milk and skim milk powder serum solids mixes without gelatin, but no marked improvement which could be attributed to aging occurred in the solids mixes made from commercially condensed skim milk and the serum solids from fresh whole milk which was condensed and separated in the laboratory.

Hening believes this difference between whipping properties of the fresh and aged skim milk plus skim milk powder serum solids mixes might be accounted for by the fact that the powder does not become thoroughly dissolved immediately and, as the mixture ages, some water adsorption takes place.

Hening (16) observed no difference in the body and texture of ice cream frozen from the fresh and aged mixes under factory conditions.

The value of aging is discounted by some investigators. Dahle and Keith (18) noted that four hours of aging produced the desired overrun in practically the same time on the average as did 24 hours of aging. The body and texture of the ice cream from these mixes were found to be the same.

Olson (19) reports that mix which must be aged to secure the desired swell is a slow mix to whip even when aged. He states that a properly balanced mix does not need more aging than is required to cool the fat globules.

PURPOSE OF EXPERIMENT

The work herein reported was done with the purpose of studying the effect on overrun and quality of ice cream secured by substituting butter for varying amounts of cream as the fat source and substituting skim milk powder for varying amounts of plain condensed skim as the source of serum solids.

The specific object of this experiment consisted in,

1. Determination of the effect on the whipping properties of the ice cream mix of substituting unsalted butter for sweet cream as the source of fat.
2. Determination of the influence of the source of fat on the quality of the resulting ice cream.
3. Study of the effect of aging the mixes of the butter series 48 hours as compared with 24 hours to determine the influence on whipping properties and quality.
4. Study of the influence on quality and overrun of using skim milk powder in place of plain condensed skim as a source of serum solids in ice cream mixes.

PLAN OF EXPERIMENT

The Mixes

Part I.

Seven mixes in each series were used in conducting the experiment herein reported. All the mixes were made so as to contain the same percentage of ingredients except the amount of butter and cream that was used to make a 10 per cent mix. This variation was effected by the replacement of cream by butter. The mixes were made from these ingredients in the following amounts.

	Butter	Cream
Mix No. I		100%
" " II	5%	95%
" " III	10%	90%
" " IV	20%	80%
" " V	50%	50%
" " VI	80%	20%
" " VII	100%	

Part II.

Six mixes in each series were used in conducting this phase of the experiment. All the mixes were made so as to contain the same percentage of ingredients except the amounts of skim condensed and skimmilk powder that was used to build up the solids to 10.5 per cent. The milk products from which the fat was derived were held to a constant source by standardization.

Skim condensed and skimmilk powder were added to bring up the serum solids to 10.5 per cent. The following percentages of each were used.

Mix No. I	100% condensed	0	skim powder
" " II	80% "	20	" "
" " III	60% "	40	" "
" " IV	40% "	60	" "
" " V	20% "	80	" "
" " VI	0 "	100	" "

Table I.

Calculated Composition of Experimental Mixes (Part I.).

Mix No.	Per cent Fat	Per cent M.S.N.F.	Per cent T.S.
I.	10.00	10.49	35.04
II.	10.00	10.48	35.03
III.	9.99	10.48	35.03
IV.	9.97	10.48	35.01
V.	10.00	10.47	35.02
VI.	9.99	10.45	35.00
VII.	10.00	10.44	35.00

Table II.

Analysis of Materials used in Experimental Mixes

Materials	Per cent Fat	Per cent M.S.N.F.	Per cent Total Solids
Sweet Cream	36.0	5.72	41.72
Butter	84.0	1.00	85.00
Whole Milk	3.5	8.685	12.185
Skim Milk		9.00	9.00
Skimmilk Powder	1.3	96.7	98.00
Sugar			95.00
Gelatin			90.00

The amounts of each ingredient used were found to be those shown in Table III.

Table III.

Composition of Mix (Part I).

Ingredient	Mix Number 1	2	3	4	5	6	7
Butter		.26775	.5355	1.07145	2.6775	4.284	5.328
Sweet Cream	9.9	9.234	8.568	7.2405	3.2625		
Whole Milk	26.04	26.4397	26.838	27.63	30.0015	24.966	
Skimmilk						6.6915	30.6135
Skimmilk Powder	1.9575	1.9575	1.9575	1.9575	1.9575	1.9575	1.9575
Sugar	6.6285	6.6285	6.6285	6.6285	6.6285	6.6285	6.6285
Gelatin	.2475	.2475	.2475	.2475	.2475	.2475	.2475
Vanilla	.225	.225	.225	.225	.225	.225	.225
Fat Source: Butter		5%	10%	20%	50%	80%	100%
Fat Source: Cream	100%	95%	90%	80%	50%	20%	
Weight of Exp. Mix	45.	45.	45.	45.	45.	45.	45.

Table IV.

Calculated Composition of Experimental Mixes (Part II).

Mix No.	Per cent Fat	Per cent M.S.N.F.	Per cent Total Solids
I.	10.005	10.49	34.99
II.	10.01	10.5	35.01
III.	10.01	10.5	35.01
IV.	10.01	10.5	35.01
V.	10.01	10.5	35.01
VI.	10.01	10.5	35.01

Table V.

Analysis of Materials Used in Mixes (Part II).

Materials	Per cent Fat	Per cent M.S.N.F.	Per cent Total Solids
Sweet Cream	36.0	5.76	41.76
Whole Milk	3.5	8.60	12.10
Condensed Skim		27.00	27.00
Skimmilk Powder		98.00	98.00
Gelatin			90.00
Sugar			95.00

The amount of each ingredient necessary to give the desired composition was found to be those shown in Table VI.

Table VI.

Composition of Mixes in Part II.

Ingredients		Mix Number				
	1	2	3	4	5	6
Cream	10.80	10.81	10.81	10.81	10.81	10.81
Milk	17.55	17.54	17.54	17.54	17.54	17.54
Condensed skim	9.54	7.65	5.73	3.82	1.90	
Skim powder		.5	1.066	1.59	2.11	2.66
Sugar	6.62	6.62	6.62	6.62	6.62	6.62
Gelatin	.24	.24	.24	.24	.24	.24
Vanilla	.22	.22	.22	.22	.22	.22
Weight Exp. Mix	45.00	45.00	45.00	45.00	45.00	45.00
Addition S.Solids Source (Skimmilk Powder		20%	40%	60%	80%	100%
(Skim Con-	100%	80%	60%	40%	20%	

PREPARATION OF MIXES

Part I.

The butter used was manufactured from sweet, pasteurized cream and was controlled to a moisture content of 14 per cent. The cream used was standardized to 36 per cent, was sweet and freshly pasteurized. The skimmilk powder was fresh and was checked by the Mojonnier method from time to time to determine the average test.

The ingredients were carefully weighed on scales sensitive to 0.05 of a pound. The sugar, gelatin, and skimmilk powder were all carefully weighed, and then thoroughly mixed before being added to the cream, milk, and butter.

The cream, milk, and butter mixtures after being carefully weighed, were heated to 90 - 100° F. in ten gallon cans. After the butter had completely melted, the sugar, gelatin, and skimmilk powder mixture was added and stirred into the mixture. The cans were placed in a vat and the water heated by direct steam. A stirring rod was used to agitate the mixes while heating to the pasteurization temperature.

An accurate thermometer was used to check the temperature of each can. The mixes were heated to 145 - 150° F. and held at this temperature for 30 minutes. After pasteurization the mixes were taken directly to the creamery and homogenized at a pressure of 2500 pounds at a temperature of 140 - 145° F. As the mixes came from the homogenizer they were immediately cooled to 45 - 50° F. over a small surface cooler. A special apparatus was constructed by which the entire contents of each can was emptied into the homogenizer. The homogenizer was completely drained. after each mix had passed through. Samples of the mix were taken at this time for analysis and the mixes were placed in the refrigerator at 35 - 40° F. until the aging period was completed.

Aging Six series of Part I were aged 24 hours before freezing and another six series were aged for 48 hours. The temperature of aging was fairly uniform at 35 - 40° F.

Part II.

The mixes in this part of the experiment were made from cream, whole milk, and sugar, with varying amounts of skim milk powder and skim condensed to furnish the same amount of serum solids. The cream used was standardized to 36 per cent fat, and the milk used, to 3.5 per cent fat. Equal quantities of cream, milk, and sugar were used in each mix. Since the skim milk powder and skim condensed varied in amounts of each used, the difference in weight was supplied by water.

The skimmilk powder used was made by the spray process and was of high quality. The condensed skim milk used was made by a local dairy and was fresh. The history of the treatment received by the skim milk powder is not known, but the condensed skim milk was made from fresh skim milk that had been preheated to 140° F., and held for 30 minutes. It was condensed at 135° F. in a vacuum until it had reached a concentration of 32 per cent serum solids. The serum solids content was standardized to 27 per cent at which it was calculated for the mixes.

These mixes were handled in the same manner throughout the manufacturing process as the mixes in Part I. The mixes were aged for a period of 24 hours before freezing.

Freezing Process The mixes were handled in a manner similar to the methods employed in commercial practice. The freezer was cooled to freezing temperature by allowing the brine to circulate through the jacket. The mix was poured into the freezer and was frozen to the proper consistency as determined by the eye and a "Draw-rite" attachment. At this point the brine was entirely shut off while the mix was permitted to whip to its maximum swell. No effort was made to keep the brine temperature constant for different series, but the brine was kept at practically the same temperature throughout the freezing of each series. The brine valve was kept completely open during the freezing period and no attempt was made to measure the flow.

A United States fifty quart batch brine freezer was used. Forty pounds of mix was used from each batch and all were of the same temperature when poured into the freezer. Overrun tests were made with a Mojonnier tester at minute intervals, beginning at the second minute of the freezing process. When the overrun reached ninety per cent two quart samples were drawn for scoring and melting tests. The mixes were allowed to whip until the maximum overrun was reached after which it was drawn. The freezer was flushed with cold water and allowed to drain before the next operation was begun. This method of procedure was followed for each series of mixes.

Judging the Quality As the quality of the commodity is the greatest governing factor in determining its desirability, it was considered important to study the influence of the source of material on the body and texture of the ice cream made from these mixes. The samples for this purpose were taken at the same degree of overrun in order that this factor should not have an influence on the consistency. Each batch was scored for body and texture. The samples were judged by two judges and the results arranged according to the degree of the defects exhibited.

Melting Properties The melting properties are particularly related to the body and texture of the ice cream. For the purpose of studying the melting properties bricks of ice cream from each series were melted on a screen in a room at constant temperature. The melted portions were weighed at regular intervals. The melting properties were further studied by observing the air cells formed on a card board base. From this study it was possible to secure an accurate idea of the effect of the source of materials on the properties of the mix, and especially on the relative strength of the film surrounding the air cells.

The Effect of Source of Fat on Fat Clumping In microscopic studies made of mixes with butter as a source of fat, fat clumping has been found. Photomicrographic pictures were made of slides prepared from a 10 per cent dilution of the mix in water.

Description of Tests Made and Observed A check was made on the following for each series of trials and results were systematically recorded.

Cream Tests. The cream used was standardized to 36 per cent fat and tested by the Babcock method to check the accuracy of the standardization.

Pasteurization The temperature during pasteurization was observed by means of a dairy thermometer graduated to read to two degrees Farenheit. Each thermometer was tested for accuracy against one known to be accurate. Regular observations of the thermometers enabled accurate control of the temperature during the process of heating, holding, and cooling.

Viscolization Each mix was poured into a separate receiving tank immediately after the holding period was completed. The temperature was permitted to fall to 145° F. at which the mix was viscolized with a pressure of 2500 pounds. The mix was cooled immediately and removed to the refrigerator.

Temperature and Time of Aging The temperature of aging was noted by means of a thermometer suspended in one can of the mix. The temperature of the refrigerator was observed to range from 35 - 40° F. One-half of the series of Part I were aged in this room for 24 hours and the other six series were aged 48 hours. The six series of Part II were all aged 24 hours before freezing.

Butterfat and Total Solids Test After the mixes were assembled and the processing was complete they were tested by the Mojonnier method for butterfat and total solids content. The procedure used was followed in detail as outlined by the manufacturers of the Mojonnier machine.

Overrun It was especially desirable in this experiment to determine the rate of overrun as well as the maximum swell obtainable. For this purpose a Mojonnier Overrun Tester was used, and beginning with the second minute of freezing, the overrun was recorded at minute intervals until the cream was drawn from the freezer.

The Mojonnier test is based on the difference in weight between equal volumes of ice cream mix and the frozen product. The overrun cups were adjusted and determinations made for each mix according to directions given by Mojonnier and Troy (Technical Control of Dairy Products) 1922, 464.

Scoring the Ice Cream Samples for scoring were taken from the freezer at approximately 90 per cent overrun and immediately taken to the hardening room where they were left for two weeks and then scored. The samples were scored for body and texture. No attempt was made to score for flavor, as this would vary with the quality of butter used. In scoring the samples twenty-five points were allowed for body and texture. The scoring in all cases was done by Professor Lucas of the Dairy Department and the writer.

Melting Test The method followed was similar to those used previously at this station. A large screen about three feet wide by eight feet long was made, and placed in a room in which the heat was controlled to 88°F. All outdoor air currents were excluded. In order to measure the melting, tared pans were placed underneath the screen to catch the drip from each brick. The screen used was large enough to accommodate all the samples from one series.

The bricks of ice cream were left in the hardening room for at least a week. In conducting the melting test the sample bricks were removed to the melting room where they were hurriedly stripped of the carton, except for one side which was used as a base, after which the bricks were quickly weighed and placed in order on the screen. The drip was caught in the tared pans and was weighed at definite intervals. This test gave very significant results.

Photographic Work The photographic work was done by the college photographer. Photographs were made of the base upon which the bricks were melted as it was thought of interest to show the variation in the way the air cells retained their shape under adverse conditions. The size of the air cells left on this base after melting gave a good indication of strength of the emulsion made from the various mixes.

Photomicrographs were made of the various mixes of one series of Part I. The slides were prepared by diluting one cubic centimeter of mix in nine cubic centimeters of water and transferring one drop to a glass slide. A thin cover glass was carefully placed over this drop, care being used to not inclose air. By placing this glass slide on the camera and carefully adjusting the focus until the fat globules could be seen in Brownian movement, some very good pictures depicting the fat clusters were obtained.

Viscosity Tests A Mojonnier-Doolittle Viscosimeter was used to determine the basic viscosity. To reduce the mixes to give basic viscosity readings they were agitated for one minute in a malted milk mixer, the air being permitted to escape before the test was made.

The Mojonnier-Doolittle instrument is a modification of the torsion viscosimeter devised by Doolittle in 1893. A metal sphere, fastened to a dial, is suspended by a wire, about 25 inches long, from the top of a goose-neck support which extends from the base of the instrument. The wire fastens into a knurled nut at the top. The metal sphere is lowered into the liquid to be tested until it is completely covered. The dial is then turned clockwise through one revolution, stopping with zero degree in line with the pointer. The dial is held in place by means of a lug and a trip. When ready to make the determination, the trip is released, Due to the torque on the wire, the cylinder will revolve back to the zero point and continue in the same direction a certain distance, depending on the viscosity of the liquid. The degrees at which the dial stops represents the viscosity of the sample, expressed in degrees of retardation.

During the operation of these tests a temperature of 60° F. was maintained.

Surface Tension Test A surface tension test was made on each sample of a series which showed characteristic whipping properties. A Du Nuoy Micro Torsion balance was used. The apparatus was carefully cleaned and standardized with double distilled water before being used.

The Micro Torsion balance consists essentially of a stand provided at the top with a fine steel wire stretched between end supports. One end of the wire is tightly clamped, the other being attached to a worm wheel controlled by a thumb-screw. To the worm wheel is also attached a pointer which moves over a metal scale graduated in degrees. To the middle of the wire is clamped a hollow, light steel lever with a hook in the outer end. A stirrup is attached to this hook carrying a carefully made loop of platinum-iridium wire with a periphery exactly 4 c m in length.

In making the test a watch glass was thoroughly cleaned and filled with the mix to be tested, then placed on a platform that was raised by means of an adjusting screw until the platinum loop just made contact with the mix. The pointer, having been previously set at zero, the torsion of the wire was gradually increased by means of the thumbscrew controlling the worm gear, until the loop of the wire tore loose from the liquid. The number of degrees was read from the scale and converted into dynes per c m. The tests were made at 23.5° C.

Table VII a

Showing Composition of Mixes in Experiment (Part I)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
I.	1.	10.04	36.03	.22	21.53	11.49
	2.	10.32	35.56	.22	21.06	10.74
	3.	10.24	35.86	.22	21.36	11.12
	4.	10.07	35.81	.22	21.31	11.24
	5.	9.82	35.93	.22	21.43	11.61
	6.	10.31	35.41	.21	20.91	10.60
	7.	10.15	35.75	.22	21.25	11.10
II.	1.	10.25	35.58	.21	21.08	10.80
	2.	10.23	36.07	.215	21.57	11.34
	3.	10.14	36.23	.215	21.73	11.46
	4.	10.27	36.09	.22	21.59	11.32
	5.	10.13	36.16	.22	21.66	11.53
	6.	10.16	36.35	.22	21.85	11.69
	7.	10.70	36.09	.22	21.59	11.34
III.	1.	10.26	35.62	.21	21.12	10.96
	2.	10.12	36.02	.21	21.52	11.40
	3.	9.94	36.46	.21	21.96	12.02
	4.	10.06	36.00	.21	21.50	11.44
	5.	9.99	36.05	.21	21.55	11.56
	6.	10.34	36.50	.21	22.04	11.71
	7.	10.45	36.30	.21	21.80	11.35

Table VII a (Cont.)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
IV.	1.	10.14	36.14	.21	21.64	11.50
	2.	10.01	35.63	.21	21.13	11.12
	3.	10.13	35.27	.21	20.77	10.64
	4.	10.03	35.54	.21	21.04	11.01
	5.	9.98	35.45	.21	20.95	10.97
	6.	9.80	35.70	.21	20.20	10.40
	7.	10.23	35.74	.21	21.24	11.01
V.	1.	10.25	36.07	.21	21.52	11.27
	2.	10.16	35.73	.21	21.18	11.02
	3.	10.04	36.03	.215	21.48	11.44
	4.	10.04	35.67	.21	21.12	11.08
	5.	10.13	35.73	.215	21.18	11.05
	6.	10.07	35.85	.21	21.30	11.23
	7.	9.93	35.64	.21	21.09	11.16
VI.	1.	10.02	36.03	.21	21.48	11.46
	2.	10.02	36.02	.21	21.47	11.45
	3.	10.03	36.02	.21	21.47	11.44
	4.	9.99	35.99	.21	21.44	11.45
	5.	10.02	36.05	.21	21.50	11.48
	6.	10.03	36.07	.21	21.42	11.39
	7.	10.14	36.07	.21	21.42	11.28

Table VII b

Showing Composition of Mixes in Experiment (Part I)

(48 hours aging)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
I.	1.	10.27	35.86	.22	21.33	11.06
	2.	10.15	35.04	.22	20.49	10.34
	3.	10.14	36.01	.22	21.46	11.32
	4.	10.35	36.03	.22	21.48	11.13
	5.	10.00	36.04	.22	21.49	11.49
	6.	10.29	36.07	.22	21.42	11.13
	7.	10.29	36.02	.22	21.47	11.18
II.	1.	10.01	36.05	.215	21.50	11.49
	2.	9.99	36.09	.21	21.44	11.45
	3.	10.23	36.01	.21	21.46	11.23
	4.	9.98	35.90	.215	21.35	11.37
	5.	10.06	35.98	.21	21.43	11.37
	6.	10.08	36.02	.21	21.48	11.40
	7.	9.93	36.03	.21	21.48	11.55
III.	1.	10.03	35.97	.21	21.42	11.39
	2.	10.10	35.83	.21	21.28	11.18
	3.	9.96	36.03	.21	21.48	11.52
	4.	9.87	35.86	.21	21.31	11.44
	5.	10.02	36.15	.21	21.60	11.58
	6.	9.97	36.03	.21	21.48	21.51
	7.	10.03	35.96	.21	21.41	11.38

Table VII b (Cont.)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
IV.	1.	10.01	35.98	.21	21.43	11.42
	2.	10.03	36.03	.21	21.48	11.45
	3.	9.88	35.88	.21	21.33	11.45
	4.	9.94	36.00	.215	21.45	11.51
	5.	10.10	35.83	.21	21.28	11.18
	6.	10.08	36.00	.215	21.45	11.37
	7.	9.96	35.87	.21	21.32	11.36
V.	1.	10.10	35.83	.21	21.28	11.18
	2.	9.89	36.06	.21	21.51	11.62
	3.	10.06	35.89	.21	21.34	11.28
	4.	9.90	36.10	.21	21.55	11.65
	5.	10.13	36.03	.21	21.48	11.35
	6.	9.89	35.96	.21	21.41	11.52
	7.	10.10	36.33	.21	21.77	11.67
VI.	1.	9.99	36.02	.21	21.47	11.48
	2.	10.01	36.04	.21	21.49	11.48
	3.	9.97	36.07	.21	21.52	11.65
	4.	10.02	36.16	.21	21.61	11.59
	5.	10.00	35.96	.21	21.41	11.41
	6.	10.04	35.90	.21	21.35	11.31
	7.	10.02	35.68	.21	21.13	11.11

Table VII c

Showing Composition of Mixes in Experiment (Part II)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
I.	1.	10.10	35.43	.22	20.98	10.88
	2.	10.06	35.37	.21	20.82	10.76
	3.	10.11	36.01	.20	21.46	11.35
	4.	10.83	35.44	.21	20.89	10.06
	5.	10.10	35.27	.21	20.72	10.62
	6.	10.02	35.36	.21	20.81	10.79
II.	1.	10.10	36.03	.215	21.48	11.38
	2.	9.86	35.83	.21	21.28	11.42
	3.	9.96	35.67	.22	21.12	11.16
	4.	10.03	36.16	.21	21.61	11.58
	5.	10.26	35.30	.215	20.75	10.70
	6.	10.05	35.50	.21	20.95	10.90
III.	1.	10.12	36.13	.215	21.58	11.46
	2.	10.14	35.97	.21	21.42	11.28
	3.	10.20	36.24	.215	21.69	11.49
	4.	10.08	35.84	.21	21.29	11.16
	5.	10.13	36.05	.21	21.50	11.37
	6.	10.86	36.26	.21	21.71	10.85

Table VII c (Cont.)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
IV.	1.	10.00	35.32	.20	20.77	10.77
	2.	9.86	35.40	.21	20.85	10.99
	3.	9.98	35.45	.21	20.90	10.92
	4.	9.87	35.26	.20	20.71	10.84
	5.	10.03	35.83	.20	21.28	11.25
	6.	10.14	36.16	.21	21.61	11.47
V.	1.	10.18	35.43	.20	20.88	10.70
	2.	10.13	35.69	.205	21.14	11.01
	3.	10.16	35.07	.20	20.52	10.36
	4.	10.07	35.73	.21	21.18	11.11
	5.	10.08	35.35	.21	20.80	10.72
	6.	10.02	35.27	.21	20.72	10.70
VI.	1.	10.45	36.30	.215	21.75	11.30
	2.	10.56	36.25	.215	21.70	11.14
	3.	10.44	36.31	.215	21.76	11.32
	4.	10.58	36.38	.215	21.83	11.34
	5.	10.49	36.29	.22	21.74	11.25
	6.	10.37	35.56	.215	21.01	10.64

Results

Part I.

(Effect of Source of Fat)

Overrun

By using varying amounts of butter to replace cream as the source of fat in the mix, it was found in an average of six trials with mix aged 24 hours prior to freezing, that where butter replaced cream to the extent of 80 to 100 per cent of the fat, such mixes gave rise to quicker whipping than was obtained in mixes where pasteurized cream was used as the fat source.

Table VIII was constructed to show the average overrun secured per minute during the freezing operation conducted on these mixes. The overrun as secured during each minute of freezing is tabulated in the appendix.

By platting overrun against time as shown by Graph I, it was found that the cream mix used in this experiment produced a curve characteristic of a slow whipping mix. The overrun rose slowly, but gradually, until the end of a sixteen minute period, at which time the average overrun was 89 per cent.

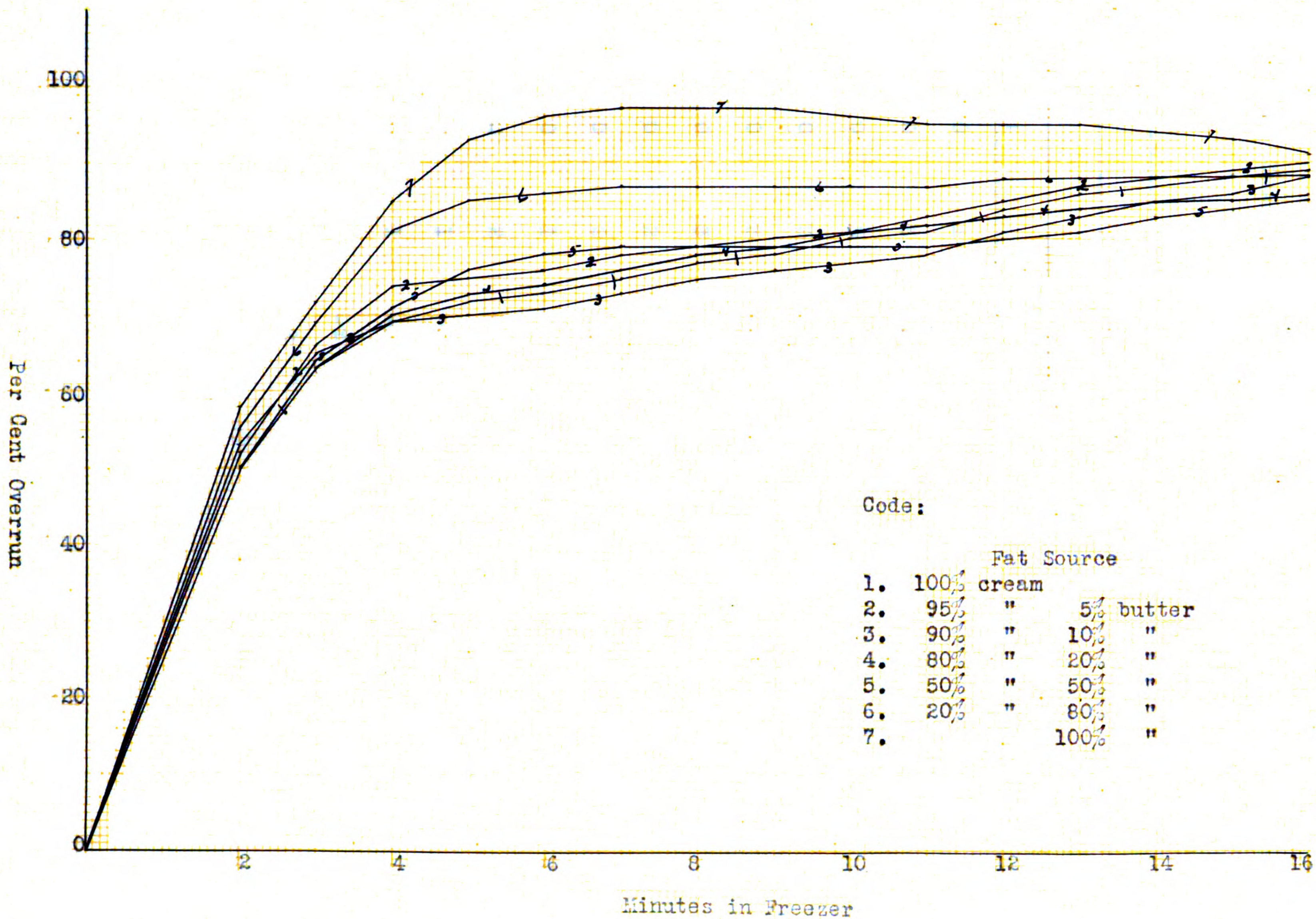
Table VIII. Showing Average Overrun per Minute During Each Minute of Freezing for the Six Series of Mixes Aged 24 Hours.

	Minutes of Freezing														
Lot No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I.	50	63	69	72	73	75	77	78	80	81	84	86	87	88	89
II.	52	66	74	75	76	78	79	80	81	83	85	87	88	89	90
III.	53	65	69	70	71	73	75	76	77	79	81	83	85	86	88
IV.	50	63	70	73	74	76	78	79	81	82	83	84	85	85	86
V.	50	64	71	76	78	79	79	79	79	79	80	81	83	84	85
VI.	55	69	81	85	86	87	87	87	87	87	88	88	88	88	88
VII.	58	72	85	93	96	97	97	97	96	95	95	95	94	93	91

Table IX. Showing the Influence of the Source of Butterfat on Overrun

Minutes in Freezer	Influence on Overrun						
	Batch Number						
	1	2	3	4	5	6	7
2	0	2	3	0	0	5	8
3	0	3	2	0	1	6	9
4	0	5	0	1	2	12	16
5	0	3	-2	1	4	13	21
6	0	3	-2	1	5	13	23
7	0	3	-2	1	4	12	22
8	0	2	-2	1	2	10	20
9	0	2	-2	1	1	9	18
10	0	1	-3	1	-1	7	16
11	0	2	-2	1	-2	6	14
12	0	1	-3	-1	-4	4	11
13	0	1	-3	-2	-5	2	9
14	0	1	-2	-2	-4	1	7
15	0	1	-2	-3	-4	0	5
16	0	1	-1	-3	-4	-1	2

Chart I. Showing the per cent Overrun by Minutes for Part I. (24 hour aged group)



Code:

	Fat Source		
1.	100% cream		
2.	95% "	5% butter	
3.	90% "	10% "	
4.	80% "	20% "	
5.	50% "	50% "	
6.	20% "	80% "	
7.		100% "	

Table IX. Showing the Influence of the Source of Butterfat on Overrun

Minutes in Freezer	Influence on Overrun						
	Batch Number						
	1	2	3	4	5	6	7
2	0	2	3	0	0	5	8
3	0	3	2	0	1	6	9
4	0	5	0	1	2	12	16
5	0	3	-2	1	4	13	21
6	0	3	-2	1	5	13	23
7	0	3	-2	1	4	12	22
8	0	2	-2	1	2	10	20
9	0	2	-2	1	1	9	18
10	0	1	-3	1	-1	7	16
11	0	2	-2	1	-2	6	14
12	0	1	-3	-1	-4	4	11
13	0	1	-3	-2	-5	2	9
14	0	1	-2	-2	-4	1	7
15	0	1	-2	-3	-4	0	5
16	0	1	-1	-3	-4	-1	2

The curve platted from freezing the mixes containing five per cent of butterfat from butter and 95 per cent from cream was of similar character, but whipped with slightly more ease and reached a maximum of 90 per cent overrun in the 16 minute period.

When 10 per cent of the fat was secured from butter and 90 per cent from cream, a curve of the same type as case one was obtained, but a slight decrease throughout was noted. The maximum which was secured at the end of the period was 88 per cent.

In the 20 per cent butter and 80 per cent cream fat source mixes the resulting overrun curve compared closely with the cream mix curve for the first 11 minutes of freezing; from this point on, the overrun failed to increase at a rate comparable with the check lot and at 16 minutes averaged its maximum of 86 per cent overrun.

The type of overrun curve secured from freezing the mixes made with butter as the source of 50 per cent of the fat differed from those in which less butter was used. These mixes whipped to a greater overrun for the first nine minutes than the control mixes exhibited for the first nine minutes, from whence they failed to increase in proportion to that obtained in the cream mix. The maximum overrun of these mixes was secured at the end of the period, but only averaged 85 per cent. The characteristic of this curve was its fairly rapid rise succeeded by a failure to respond to whipping for a considerable period. This was followed by a slight increase in swell toward the end of the period.

Mixes of number 6 which contained 80 per cent fat from butter and 20 per cent from sweet pasteurized cream whipped to from a curve of sim-

Table VII c

Showing Composition of Mixes in Experiment (Part II)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
I.	1.	10.10	35.43	.22	20.98	10.88
	2.	10.06	35.37	.21	20.82	10.76
	3.	10.11	36.01	.20	21.46	11.35
	4.	10.83	35.44	.21	20.89	10.06
	5.	10.10	35.27	.21	20.72	10.62
	6.	10.02	35.36	.21	20.81	10.79
II.	1.	10.10	36.03	.215	21.48	11.38
	2.	9.86	35.83	.21	21.28	11.42
	3.	9.96	35.67	.22	21.12	11.16
	4.	10.03	36.16	.21	21.61	11.58
	5.	10.26	35.30	.215	20.75	10.70
	6.	10.05	35.50	.21	20.95	10.90
III.	1.	10.12	36.13	.215	21.58	11.46
	2.	10.14	35.97	.21	21.42	11.28
	3.	10.20	36.24	.215	21.69	11.49
	4.	10.08	35.84	.21	21.29	11.16
	5.	10.13	36.05	.21	21.50	11.37
	6.	10.86	36.26	.21	21.71	10.85

Table VII c (Cont.)

Batch & Mix No.		Butterfat %	Total Solids %	Acidity %	Total Milk Solids	Total M.S.N.F.
IV.	1.	10.00	35.32	.20	20.77	10.77
	2.	9.86	35.40	.21	20.85	10.99
	3.	9.98	35.45	.21	20.90	10.92
	4.	9.87	35.26	.20	20.71	10.84
	5.	10.03	35.83	.20	21.28	11.25
	6.	10.14	36.16	.21	21.61	11.47
V.	1.	10.18	35.43	.20	20.88	10.70
	2.	10.13	35.69	.205	21.14	11.01
	3.	10.16	35.07	.20	20.52	10.36
	4.	10.07	35.73	.21	21.18	11.11
	5.	10.08	35.35	.21	20.80	10.72
	6.	10.02	35.27	.21	20.72	10.70
VI.	1.	10.45	36.30	.215	21.75	11.30
	2.	10.56	36.25	.215	21.70	11.14
	3.	10.44	36.31	.215	21.76	11.32
	4.	10.58	36.38	.215	21.83	11.34
	5.	10.49	36.29	.22	21.74	11.25
	6.	10.37	35.56	.215	21.01	10.64

Results

Part I.

(Effect of Source of Fat)

Overrun

By using varying amounts of butter to replace cream as the source of fat in the mix, it was found in an average of six trials with mix aged 24 hours prior to freezing, that where butter replaced cream to the extent of 80 to 100 per cent of the fat, such mixes gave rise to quicker whipping than was obtained in mixes where pasteurized cream was used as the fat source.

Table VIII was constructed to show the average overrun secured per minute during the freezing operation conducted on these mixes. The overrun as secured during each minute of freezing is tabulated in the appendix.

By platting overrun against time as shown by Graph I, it was found that the cream mix used in this experiment produced a curve characteristic of a slow whipping mix. The overrun rose slowly, but gradually, until the end of a sixteen minute period, at which time the average overrun was 89 per cent.

Table VIII. Showing Average Overrun per Minute During Each Minute of Freezing for the Six Series of Mixes Aged 24 Hours.

	Minutes of Freezing														
Lot No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I.	50	63	69	72	73	75	77	78	80	81	84	86	87	88	89
II.	52	66	74	75	76	78	79	80	81	83	85	87	88	89	90
III.	53	65	69	70	71	73	75	76	77	79	81	83	85	86	88
IV.	50	63	70	73	74	76	78	79	81	82	83	84	85	85	86
V.	50	64	71	76	78	79	79	79	79	79	80	81	83	84	85
VI.	55	69	81	85	86	87	87	87	87	87	88	88	88	88	88
VII.	58	72	85	93	96	97	97	97	96	95	95	95	94	93	91

Chart I. Showing the per cent Overrun by Minutes for Part I. (24 hour aged group)

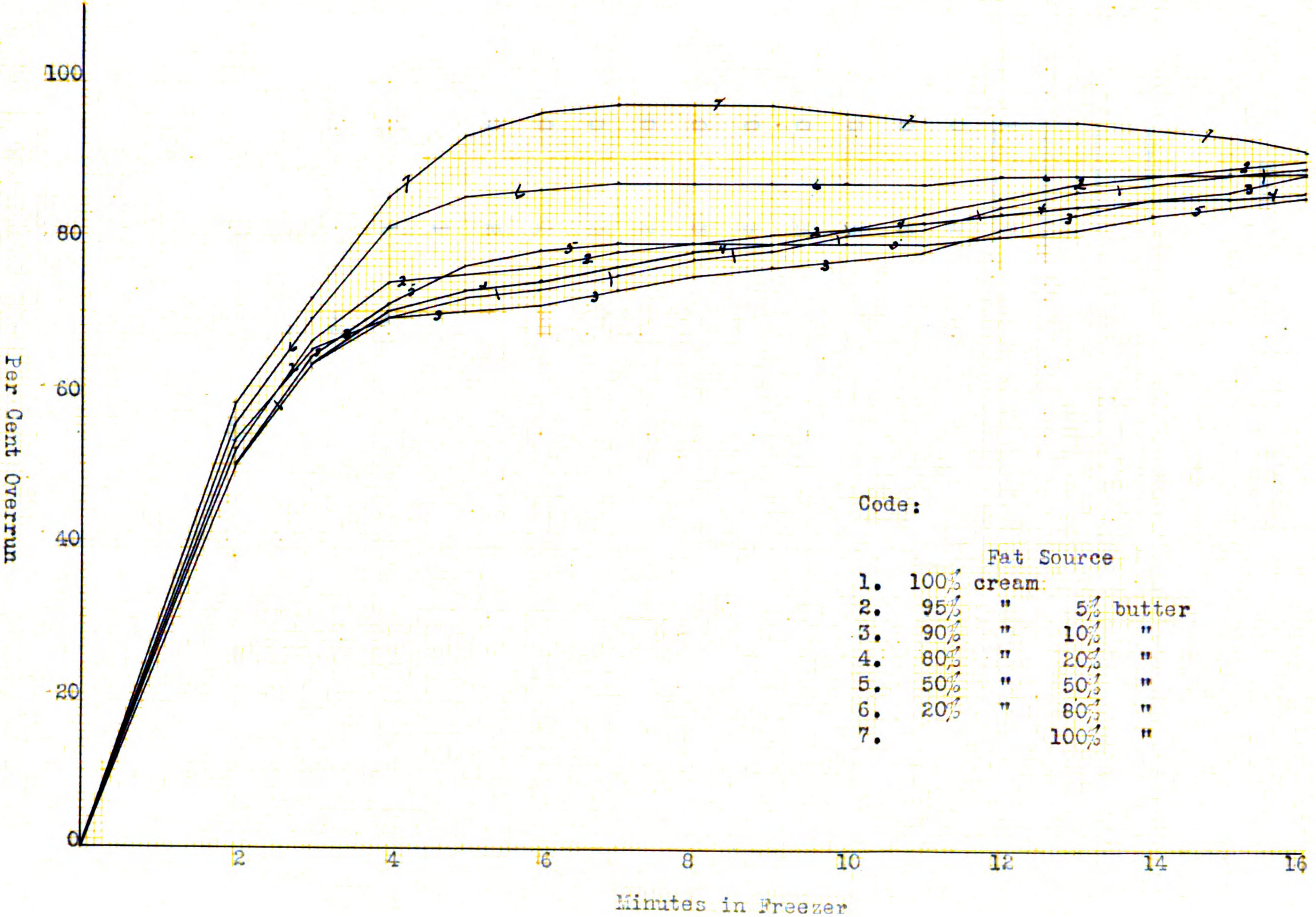


Table IX. Showing the Influence of the Source of Butterfat on Overrun

Minutes in Freezer	Influence on Overrun						
	Batch Number						
	1	2	3	4	5	6	7
2	0	2	3	0	0	5	8
3	0	3	2	0	1	6	9
4	0	5	0	1	2	12	16
5	0	3	-2	1	4	13	21
6	0	3	-2	1	5	13	23
7	0	3	-2	1	4	12	22
8	0	2	-2	1	2	10	20
9	0	2	-2	1	1	9	18
10	0	1	-3	1	-1	7	16
11	0	2	-2	1	-2	6	14
12	0	1	-3	-1	-4	4	11
13	0	1	-3	-2	-5	2	9
14	0	1	-2	-2	-4	1	7
15	0	1	-2	-3	-4	0	5
16	0	1	-1	-3	-4	-1	2

The curve platted from freezing the mixes containing five per cent of butterfat from butter and 95 per cent from cream was of similar character, but whipped with slightly more ease and reached a maximum of 90 per cent overrun in the 16 minute period.

When 10 per cent of the fat was secured from butter and 90 per cent from cream, a curve of the same type as case one was obtained, but a slight decrease throughout was noted. The maximum which was secured at the end of the period was 88 per cent.

In the 20 per cent butter and 80 per cent cream fat source mixes the resulting overrun curve compared closely with the cream mix curve for the first 11 minutes of freezing; from this point on, the overrun failed to increase at a rate comparable with the check lot and at 16 minutes averaged its maximum of 86 per cent overrun.

The type of overrun curve secured from freezing the mixes made with butter as the source of 50 per cent of the fat differed from those in which less butter was used. These mixes whipped to a greater overrun for the first nine minutes than the control mixes exhibited for the first nine minutes, from whence they failed to increase in proportion to that obtained in the cream mix. The maximum overrun of these mixes was secured at the end of the period, but only averaged 85 per cent. The characteristic of this curve was its fairly rapid rise succeeded by a failure to respond to whipping for a considerable period. This was followed by a slight increase in swell toward the end of the period.

Mixes of number 6 which contained 80 per cent fat from butter and 20 per cent from sweet pasteurized cream whipped to from a curve of similar character to that of number five, but was quicker to rise and maintained a higher level throughout. A maximum overrun of 88 per cent was obtained at the end of a 12 minute interval.

Where all of the fat was derived from butter a rapid swell was obtained, with the maximum overrun of 97 per cent secured in 7 minutes. The maximum swell was maintained for three minutes after which a slight decrease occurred.

The influence on overrun as affected by the fat source is further shown by table IX. In this table the overrun secured in the cream mixes was considered as the base or zero and the influence was figured and tabulated as the positive or negative difference.

A characteristic tendency peculiar to the various mixes was that where cream was the major fat source a slow whipping mix was secured that took swell gradually until the end of the whipping period. The mixes in which the cream was largely or wholly substituted by butter as the fat source whipped in air rapidly and practically remained at a constant overrun.

The results secured were not in accord with those previously secured by other investigators in studies on the effect of butter on the whipping properties of ice cream. It was thought probable that the higher serum-solids-to-fat $\left(\frac{S.S.}{F}\right)$ ratio employed in this experiment was the reason for the difference.

Although an equal amount of fat and serum solids were present in all of the experimental mixes it is probable that the butterfat from butter is incapable of reestablishing the same colloidal condition that is present in the cream with the consequence that a greater amount of serum solids is left in suspension. The greater amount of serum solids left in suspension would likely have the same effect on whipping properties during freezing temperatures, as a larger percentage of serum solids present, or as a smaller percentage of fat interference. The result would theoretically be a mix of greater whipping properties. Such a phenomenon seemed evident in this phase of the experiment.

Effect on Quality

In scoring the experimental mixes a value was not placed on flavor, as flavor would be influenced by the quality and amount of butter and cream used. It was noticeable to the judges that whenever an off flavor was present in the butter it could be detected when small amounts were used as a source of fat.

The chief aim of the experiment was to note the effect of butter on the physical properties and as this involves body and texture these were the only qualities scored.

Table X shows all of the scores on body and texture in the 24 hour aged group of Part I. The samples of the mix, made entirely of cream, were somewhat soggy in body. The ice cream having five and ten per cent of the fat supplied by butter scored slightly higher and seemed to be improved in body and texture. The ice cream carrying 20, 50, 80, and 100 per cent of the fat from butter varied in coarseness in respect to the amount added.

The samples containing 10 per cent of butter as the source of fat ranked highest in score, while the sample having butter as the sole source of fat ranked the lowest.

Table X. Showing Scores on Body and Texture of Ice Cream

	Mix Number and Fat Source						
Series No.	1	2	3	4	5	6	7
		5% butter	10% butter	20% butter	50% butter	80% butter	100% butter
	100% cream	95% cream	90% cream	80% cream	50% cream	20% cream	
1	20.5 soggy	20.5 soggy	23 good	22 good	22 good	21 fair	18 coarse
2	22 fair	22 fair	23 good	22 fair	22.5 mellow	21 fair	21 sl.coarse
3	22 fair	22.5 mellow	22 mellow	21.5 sl. coarse	21.0 sl. coarse	21 sl.coarse	20 coarse
4	18 soggy	22 fair		21.5 sl. coarse	20.5 sl. coarse	19 coarse	18 coarse
5	20 soggy	20 soggy	23 good	22 fair	21.0 sl. coarse	20 coarse	18 coarse
6	22 fair	22.5 mellow	22 mellow	21.5 sl. coarse	21.5 sl. coarse	21.5 fair	20.5 coarse
Average	21.3	21.6	22.6	21.7	21.4	20.6	19.25

It appeared from the results obtained that the body and texture of ice cream is benefitted by the use of a small amount of butter as the source of fat. The mixes containing 10 per cent of fat from butter proved to be the best in body and texture. Ice cream made with butter as the entire fat source was not entirely desirable from the standpoint of these properties.

Effect on Resistance to Melting

It will be noted from Table XI that the average melting during a three hour exposure of 88° F. for each of the various ice cream lots ranging from one to seven was as follows: 16.2 oz., 16.2 oz., 15.56 oz., 15.7 oz., 16.53 oz., 16.92 oz., and 16.35 oz. The ice cream remaining on the screen at the end of the period was as follows, in the same order: 3.05 oz., 2.9 oz., 3.34 oz., 3.3 oz., 2.97 oz., 2.45 oz., and 2.45 oz.

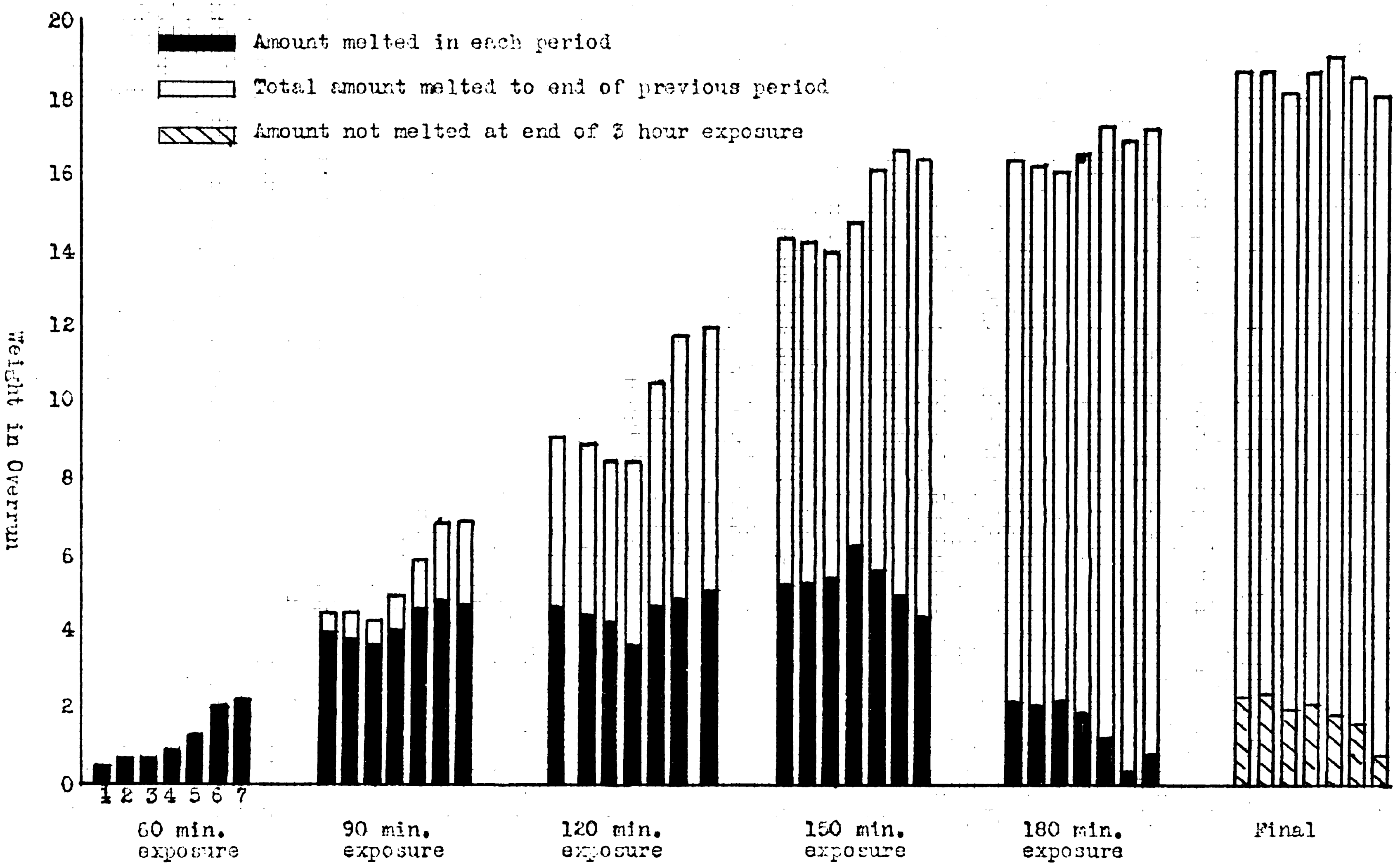
The amount of melting during the first 60 minutes of exposure showed the most direct difference in melting resistance. There was a close relationship between the amount of butter supplied as the fat source and the ease with which the ice cream was melted. The ice cream containing butter as the major fat source had low melting resistance as compared with the bricks from the cream mixes. The cream samples in some instances produced no melting during the first 60 minute period.

At the end of the 90 minute period there was practically the same relationship in regard to melting as was noted at the close of the 60 minute period; the samples containing the most butter showing the lowest resistance.

Table XI. Showing Average Melting During a Three Hour Exposure at 88° F.

Time of Exposure		60 min.	90 min.	120 min.	150 min.	180 min.	
Lot No.	Wt. of Brick	Melting recorded during Exposure Interval					Total Melting
I.	19.25	.43 oz.	2.70 oz.	4.45 oz.	5.77 oz.	2.85 oz.	16.20 oz.
II.	19.1	.87	3.20	4.20	5.03	2.90	16.20
III.	18.9	.70	4.06	3.84	4.30	2.66	15.56
IV.	19.0	1.30	3.43	4.01	3.80	3.10	15.70
V.	19.4	1.65	4.30	4.27	4.30	2.01	16.53
VI.	19.37	2.45	4.30	4.87	4.60	.70	16.92
VII.	18.8	2.40	4.35	4.60	4.23	.77	16.35

Chart II. Result of Melting Tests on Mixes of Part I (24 hour aged group at 88° F.)



At the end of the 120 minute period no relationship could be detected in regard to melting resistance and the fat source by considering the weight of leakage recorded. During this period the difference in the type of melting was best noted. The leak from the ice cream in which butter constituted from 20 to 100 per cent of the fat source was observed to break down into fluid mix, while the remaining bricks were found to break down in sections of foam and to remain in this condition on the surface of the leakage caught in the tared pans.

Between the 120 minute and 150 minute exposure period the bricks proportionally high in cream as the fat source melted more freely than during the preceding periods and also showed greater melting than the samples high in butter as the fat source.

The melting during the last 30 minute period decreased considerably over the preceding one, due to the small amount remaining on the screen. During this period the whole mass was observed to be melted; but due to its foamy consistency, especially noted with the cream source samples, the entire amount did not drop to the pans. This remaining protion was permitted to dry for further observation and for photographic work. Plates 1, 2, 3, 4, 5, 6 and 7 are photographs of the dry bases secured from the melting test. A direct relationship was found between the size of air cells formed and the amount of butter used as the fat source.

Chart II gives a graphic representation of the rate of melting just described. Each series of columns represents the set of samples for the period indicated on the graph. The columns are so arranged as to have the sweet cream mix at the left and the samples with increasing amounts of butter placed successively to the right.

The black portion of the bar represents the melted portion for the period indicated, while the white portion is accumulative and is indicative of the total amount melted previous to the period indicated. The cross-bar columns represent the unmelted portion that had not gone through the screen at the end of the exposure period. Tables are constructed in the appendix to show the amount of melting of each brick tested.

The results obtained by the melting test would indicate that a mix made from butter as the main source of fat is not capable of producing as strong cell walls as are secured from mixes where cream constitutes the fat source. This is further brought out by the microscopic study to conform to the theory set forth by Sommer and Horrall (22) as quoted in the Review of Literature. The cell walls in the cream mixes had sufficient strength to retain the small air cells present in the frozen ice cream; while those from the high butter mixes condensed into larger bubbles which were both evident in the melting process and on the dried cardboard base.

Photomicrographic Results

The microscope and camera were used to denote and record the effect of reconstituting butter-fat from butter into the ice cream mix.

Several methods of preparing slides were used, but the one which proved most satisfactory was the water dilution method described in the procedure.

Under the microscope pronounced clumping was observed in the mixes containing butterfat from butter in varying amounts. There was apparently a direct relationship between the amount of butter added and the degree of fat clumping. When cream supplied all of the fat in the mix no clumping was detected.

Plates 8, 9, 10, 11, 12, 13 and 14 are photomicrographs that are fairly representative of a number of observations made of mixes with varying amounts of cream and butter required to make 10 per cent fat mixes.

Table XII was constructed to show the fat source and the ratio of fat to serum solids employed in the mixes of this experiment as well as to indicate the degree of fat clumping secured under these conditions. The amount of fat clumping is shown by the number of plus signs in the last column of Table XII. Four plus signs signify a high degree of clumping and one sign, a fair amount.

Table XII. Showing the Effect of Fat Source on Fat Clumping.

Mix No.	Fat Source Butter	Fat Source Cream	Per cent Fat	Per cent Serum Solids	Ratio SS/Fat	Clumping
1		100%	10	10.5	1.05	–
2	5%	95%	10	10.5	1.05	+
3	10%	90%	10	10.5	1.05	+ +
4	20%	80%	10	10.5	1.05	+ + +
5	50%	50%	10	10.5	1.05	+ + +
6	80%	20%	10	10.5	1.05	+ + + +
7	100%		10	10.5	1.05	+ + + +

The fat clumping in the presence of a relatively high serum solids content would indicate that the adhesive power of the fat and serum solids was lower than the cohesive power of either the fat or the serum solids plasma. This would bear out the theory that a greater amount of serum solids is permitted to remain in the plasma of the high butter mixes, thus allowing for enhanced whipping properties, at least during the early stages of freezing.

The high degree of fat clumping explains the lack of cell wall strength and the poor melting properties exhibited by the mixes high in butter as the fat source. This is in accord with the theory advanced by Sommer and Horrall (22).

Influence of Aging 48 Hours

Effect on Overrun Table XIII was constructed to show the average overrun obtained per minute during the freezing of six series of mixes aged 48 hours. A higher overrun was secured in the mixes containing butter as the major fat source than was obtained in those mixes of the 24 hour aged group. The mixes made with 100 per cent of cream as the fat source and that where five per cent of the fat was secured from butter showed no increase over the 24 hour aged group. There was a more direct influence apparent on the ease of securing overrun with the mixes made from increasing amounts of butter as the fat source. Table XIV shows the difference in the average overrun of the same mixes in the 24 and 48 hour groups. Mix 5, containing equal amounts of fat from butter and cream showed the greatest increase in whipping property due to aging while the mixes, one and two showed no appreciable change.

Table XV shows the influence of the source of butter-fat supplied. The mixes in which butter was used in appreciable amounts as the fat source in the 48 hour group exhibited a greater effect on the whipping

Chart III. Showing the per cent Overrun by Minutes for Part I (48 hour aged group)

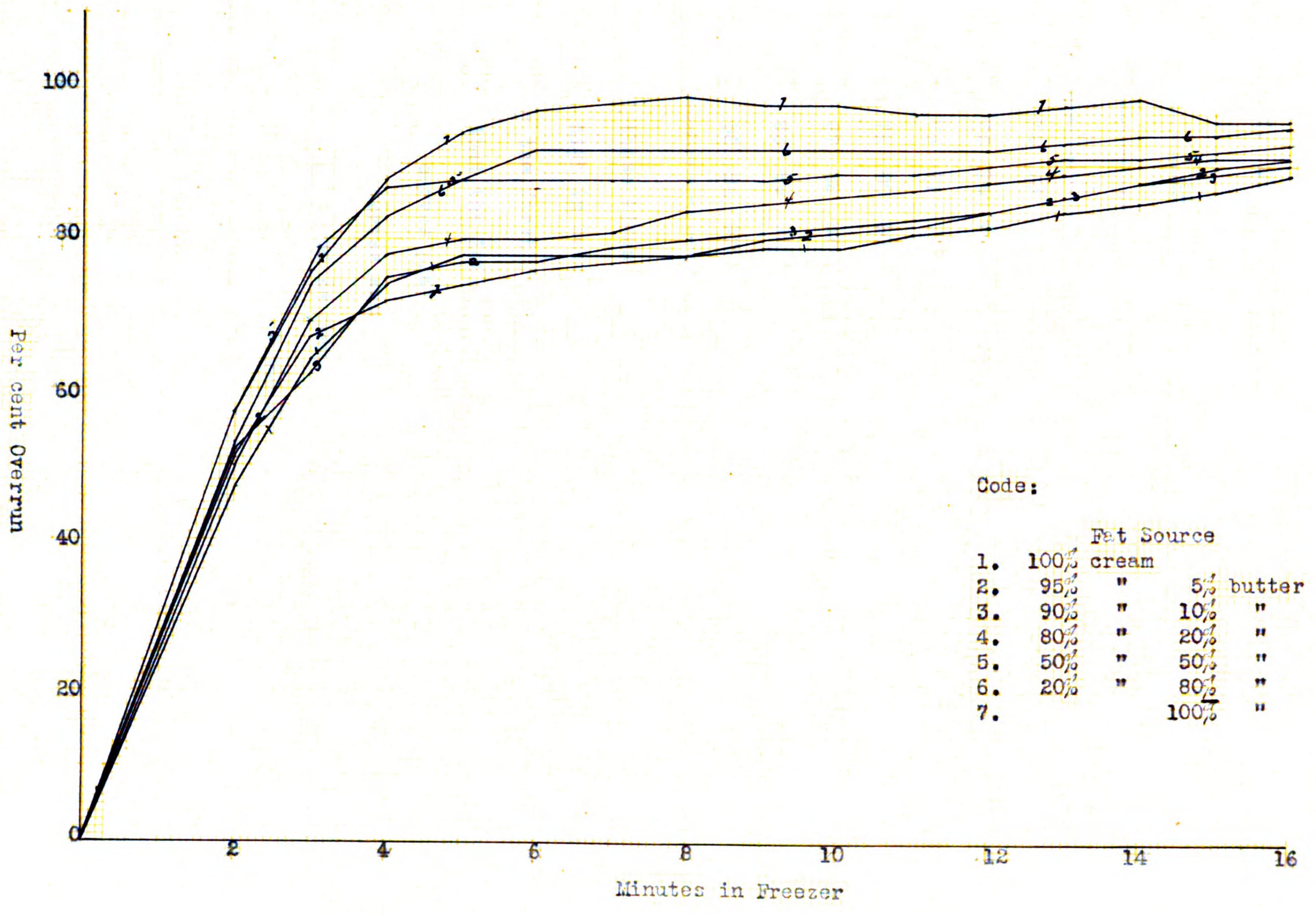


Table XIII. Showing Average Overrun per Minute

(Average of Six Mixes, Aged 48 Hours)

Mix	Minutes in Freezer														
No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	47	64	74	78	78	78	78	79	79	81	82	84	85	87	89
2	51	67	72	74	76	77	78	80	81	82	84	86	88	90	91
3	52	62	75	77	77	79	80	81	82	83	84	86	88	89	90
4	60	69	78	80	80	81	84	85	86	87	88	89	90	91	91
5	57	79	87	88	87	88	88	88	89	89	90	91	91	92	93
6	53	74	83	89	92	92	92	92	92	92	92	93	94	94	95
7	57	76	88	94	97	98	99	98	98	97	97	98	99	96	96

properties of those mixes than was evident in the 24 hour aged group. In the mixes, high in butter as the fat source overrun is taken on very readily during the first few minutes of the freezing process and it is at this stage that the influence of the fat source was most pronounced.

The overrun curves platted from the 48 hour aged mixes are shown on Graph III. The curves secured were very similar in character to those drawn from the mixes aged 24 hours, but show a more pronounced difference as affected by the influence of the fat source. In this group there was a close relationship between the amount of butter used as the fat source and the amount of overrun secured. There was also a close relationship between the amount of butter used as the fat source and the rapidity with which swell was secured.

Table XIV. Showing Influence on Overrun by Aging 48 Hours as Compared with 24 Hours

Lot No.	I			II			III			IV			V			VI			VII		
Time in	Per cent Overrun and Difference per Minute of Freezing when Aged 24 and 48 Hours																				
Minutes	24 hr.	48 hr.	-	24 hr.	48 hr.	-	24 hr.	48 hr.	-	24 hr.	48 hr.	-	24 hr.	48 hr.	-	24 hr.	48 hr.	-	24 hr.	48 hr.	-
2	50	47	-3	52	51	-1	53	52	-1	50	50	0	50	57	7	55	53	-2	58	57	-1
3	63	64	1	66	67	1	65	62	-3	63	69	6	64	79	15	69	74	5	72	76	4
4	69	74	5	74	72	-2	69	75	6	70	78	8	71	87	16	81	83	2	85	88	3
5	72	78	6	75	74	-1	70	77	7	73	80	7	76	88	12	85	89	4	93	94	1
6	73	78	5	76	76	0	71	77	6	74	80	6	78	87	9	86	92	6	96	97	1
7	75	78	3	78	77	-1	73	79	6	76	81	5	79	88	9	87	92	5	97	98	1
8	77	78	1	79	78	-1	75	80	5	78	84	6	79	88	9	87	92	5	97	99	2
9	78	79	1	80	80	0	76	81	5	79	85	6	79	88	9	87	92	5	97	98	1
10	80	79	-1	81	81	0	77	82	5	81	86	5	79	89	10	87	92	5	96	98	2
11	81	81	0	83	82	0	79	83	4	82	87	5	79	89	10	87	92	5	95	97	2
12	84	82	-2	85	84	-1	81	84	3	83	85	5	80	90	10	88	92	4	95	98	3
13	86	84	-2	87	86	-1	83	86	3	84	89	5	81	91	10	88	93	5	95	99	4
14	87	85	-2	88	88	0	85	88	3	85	90	5	83	91	8	88	94	6	94	96	2
15	88	87	-1	89	90	1	86	89	3	85	91	6	84	92	8	88	94	6	93	96	3
16	89	89	0	90	91	1	88	90	2	86	91	5	85	93	8	88	95	7	91	96	5

<u>Effect on Quality</u> The quality of body and texture was materially influenced by aging an added 48 hour period. The influence of aging is shown by table XVI. All of the scores were found to be increased over those from mixes aged 24 hours prior to freezing. The greatest increases in scores were found in the samples from the No. 1 and No. 7 mixes. In this group sample No. 3, containing 10 per cent of fat from butter, again averaged the highest score, and the No. 7 sample, made with 100 per cent of butter as the source of fat was also again the lowest in score. The difference in the score between the highest and the lowest was not as great in the 48 hour aged mixes as in the 24 hour aged group, ranging 3.45 in the former and 2.18 points in the latter. The samples made with cream as the major fat source ranked well above those having butter as the major fat source. The bottom column of Table XVI shows the difference in score of the ice cream made from the 24 and 48 hour mixes.

Table XV. Showing the Influence of the Source of Butterfat on Overrun (48 hour aged group)

Minutes in Freezer	Influence on Overrun Mix Number						
	1	2	3	4	5	6	7
2	0	4	5	3	10	6	10
3	0	3	-2	5	15	10	12
4	0	2	1	4	13	9	14
5	0	-4	-1	2	10	11	16
6	0	-2	-1	2	9	14	19
7	0	-1	1	3	10	14	20
8	0	0	2	6	10	14	21
9	0	1	2	6	9	13	19
10	0	1	3	7	10	13	19
11	0	1	2	6	8	11	16
12	0	2	2	6	8	10	15
13	0	2	2	5	7	9	14
14	0	3	3	5	6	9	14
15	0	3	2	4	5	7	9
16	0	2	1	2	4	6	7

The figures given are the plus and minus differences in overrun as compared with the No. 1 mix, made with cream as the sole fat source.

Table XVI. Showing Scores on Body and Texture of Ice Cream (Mixes Aged 48 Hours)

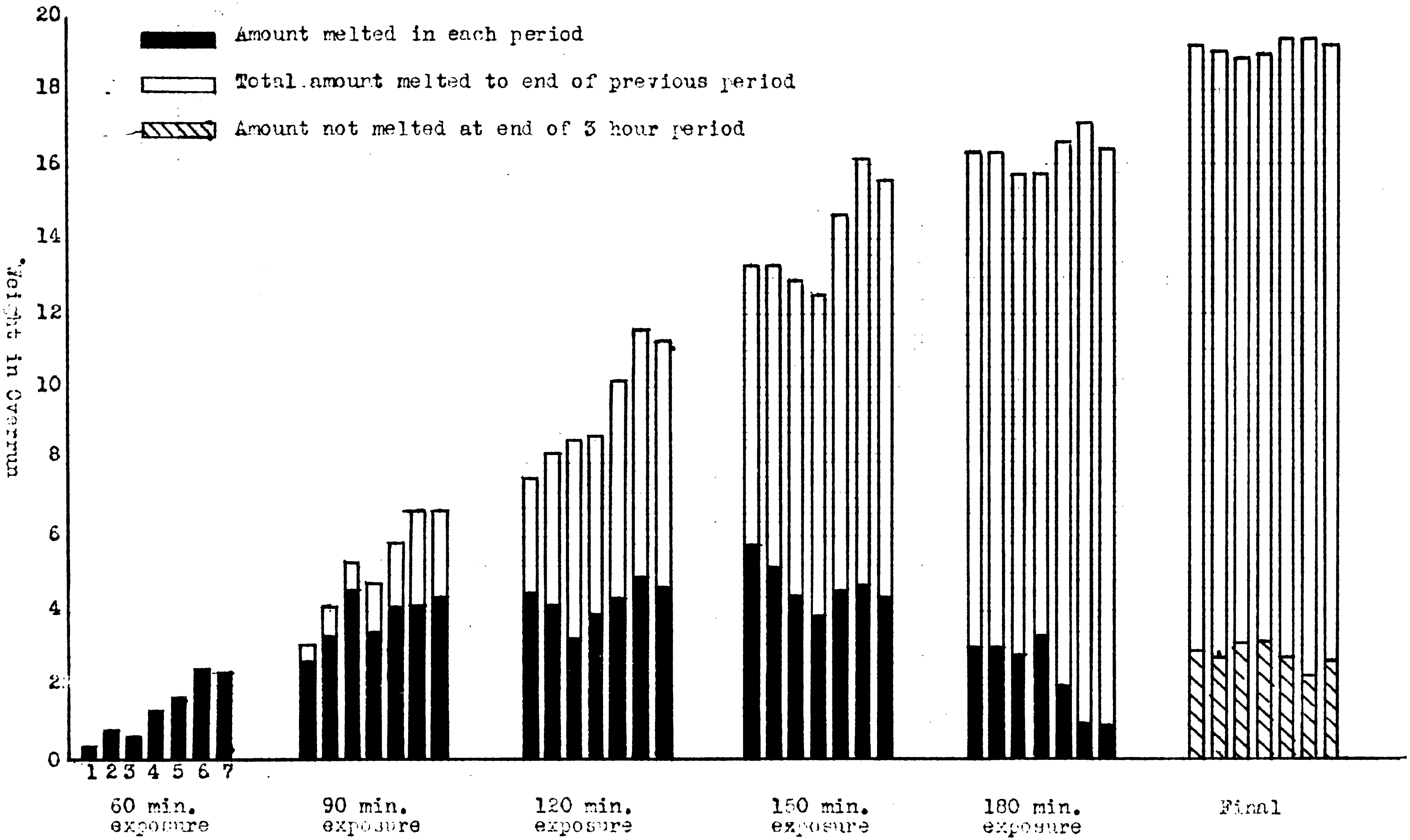
Series No.	Mix Number						
	1	2	3	4	5	6	7
1	23.0 good	23.0 good	23.5 very good	22.0 fair	21.5 sl. coarse	21.0 sl. coarse	20.0 coarse
2	23.0 good	24.0 very good	23.0 very good	22.0 good	21.5 sl. coarse	20.0 coarse	21.0 sl. coarse
3	23.0 good	23.0 good	24.0 very good	23.0 very good	22.5 good	22.0 fair	22.0 fair
4	22.5 good	23.0 good	22.0 good	22.0 good	21.0 sl. coarse	21.0 sl. coarse	20.5 coarse
5	22.5 good	22.0 good	23.0 very good	23.0 very good	22.0 fair	21.0 sl. coarse	21.0 sl. coarse
6	23.0 good	22.5 good	23.0 very good	22.5 very good	22.0 fair	21.5 fair	21.0 sl. coarse
Ave. 48 hr. group	22.8	22.9	23.08	22.4	21.7	21.08	20.9
Ave. 24 hr. group	21.3	21.6	22.6	21.7	21.4	20.6	19.25
Difference	1.5	1.3	.48	.7	.3	.48	1.65

<u>Effect on Melting Resistance</u> Aging 48 hours had no apparent influence on the body of the ice cream as affecting melting resistance. The same melting properties were displayed by both series of mixes. Table XVII and Graph IV demonstrate the melting properties of this series in the same manner as it was illustrated by Graph II and Table XI for the 24 hour aged group. A greater amount of melting was recorded for the 48 hour group than for the 24 hour group. This difference may be accounted for by the fact that it was necessary to turn steam into the room where the 48 hour group was exposed in order to secure the same temperature as was used in the 24 hour group. The higher humidity encountered was very evident.

Table XVII. Showing Average Melting During a Three Hour Exposure at 88° F.

Lot No.	Wt. of Brick	Time of Exposure 60 min.	90 min.	120 min.	150 min.	180 min.	Total Melting
		Melting Recorded during Exposure Interval					
I	18.7	.50 oz.	4.05 oz.	4.60 oz.	5.07 oz.	2.20 oz.	16.40
II	18.7	.73	3.80	4.60	5.10	2.05	16.30
III	18.1	.66	3.70	4.45	5.13	2.11	16.05
IV	18.75	.87	4.01	4.53	5.30	1.85	15.56
V	19.1	1.31	4.51	4.70	5.60	1.13	17.25
VI	18.5	2.03	4.83	4.90	4.90	.31	16.97
VII	19.0	2.20	4.70	5.10	4.40	.90	17.20

Chart IV. Result of Melting Tests on Mixes of Part I (48 hour aged group at 88° F.)



Viscosity

Table XVIII shows the basic viscosity as measured by the Mojonnier Viscosimeter on samples taken from the fifth, sixth and seventh series. The figures presented are relative and are expressed in degrees of retardation. The greater the retardation, the lower is the reading and consequently the greater is the viscosity. After the samples had been agitated for one minute in a malted milk shaker they gave very uniform results and gave check readings varying within one point. The greatest difference in viscosity found was three degrees. No uniform difference was observed that was consistent with the variations observed in overrun and melting resistance.

Table XVIII. Showing Viscosity at 60° F. in Degrees Retardation

Lot No.	Series Number		
	V	VI	VII
I	332	332	332
II	332	333	333
III	335	332	332
IV	333	333	334
V	332	333	333
VI	334	333	332
VII	332	332	333

Surface Tension

An attempt was made to explain the physical properties exhibited by the different mixes through the effect of surface tension as measured by the Du Nuoy Micro Torsion balance. Although extreme precautions for accuracy were observed no results were secured that would indicate that surface tension, as measured by this apparatus, had any effect on whipping properties. Table XIX shows the surface tension of each mix in one series. As no significant results were obtained only one series of mixes was tested.

Table XIX. Showing Surface Tension of Mixes as Obtained with Du Nuoy Micro Torsion Balance

Mix No.	Surface Tension	
	Reading	Dynes
1.	73	50.40
2.	72	49.71
3.	72	49.71
4.	72	49.71
5.	71	49.02
6.	72	49.71
7.	72	49.71

The mixes used for this test were taken from Series I of the 48 hour group.

Results

Part II

(Effect of Source of Serum Solids)

In a manner of attack similar to that employed in the study conducted on the fat source, skimmilk powder made by the spray process was compared with fresh condensed skim in an effort to determine the influence it effects when used in varying amounts in the ice cream mix. The composition of the mixes used and the analysis of materials employed may be found in tables IV, V, VI and VII.

Overrun

The six experimental mixes used in this part of the experiment tend to bear out previous data showing high heat treatment of serum solids as being conducive to aid in securing overrun. By taking overrun tests during each minute of freezing only a small difference was detected in the amount of overrun obtained; nor was there much difference in the rapidity with which overrun was secured. Table XX shows the average overrun secured with six experimental series for each minute of a 16 minute freezing period.

Table XX. Showing Average Overrun Secured for the Six Series of Mixes of Part II at Minute Intervals during Freezing

Lot	Minutes of Freezing														
No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	42	59	69	71	76	78	80	81	83	84	86	87	89	90	91
II	43	60	68	72	74	77	79	81	82	84	86	88	90	91	92
III	40	61	76	78	79	81	82	84	85	85	87	89	90	91	91
IV	43	61	71	76	77	79	81	82	83	84	86	87	88	90	91
V	41	59	72	79	82	82	83	83	84	85	86	88	89	90	91
VI	44	66	76	81	84	85	85	86	87	88	89	91	92	94	94

Table XXI. Showing Influence on Overrun of the Source of Serum Solids

Minutes in Freezer	Mix Number					
	1	2	3	4	5	6
2	0	1	-2	1	-9	-8
3	0	1	2	2	0	7
4	0	-1	9	4	5	9
5	0	1	7	5	8	10
6	0	-2	3	1	6	8
7	0	-1	3	1	4	7
8	0	-1	2	1	3	5
9	0	0	3	1	2	5
10	0	-1	2	0	1	4
11	0	0	1	0	1	4
12	0	0	1	0	0	3
13	0	1	2	0	1	4
14	0	1	1	-1	0	3
15	0	1	1	0	0	4
16	0	1	0	0	0	3

The figures given are the plus and minus differences in overrun as compared with the No. I mix, made with plain condensed skimmilk as the added serum solids source.

The mixes containing skimmilk powder as the entire serum solids source attained overrun more readily than any of the mixes containing smaller amounts of powder. These mixes also maintained a higher overrun throughout the freezing process. There was no difference in the amount of overrun secured in the mixes containing condensed skimmilk, but those containing the higher percentages of skimmilk powder were generally more quick to incorporate overrun.

Graph V was made to illustrate the freezing properties exhibited by the mixes of Part II. It was noted that when 20 per cent of the serum solids were supplied by the use of condensed skimmilk only a very small difference resulted when compared with the curve drawn from the plain condensed mix. When 40 per cent of skimmilk powder was used with 60 per cent condensed skimmilk as the source of added serum solids, a small increase in the overrun during the first 10 minutes was noted. There was an increase in the overrun in the No. IV mix, where 60 per cent of skimmilk powder was used, over the No. I mix, but a decrease compared with No. III. This indicates the air incorporation tendency was not strongly influenced by the source of serum solids. Mix No. V, containing 80 per cent of its serum solids from skimmilk powder as a source of serum solids exhibited whipping properties comparable with those of the No. III mix, also showing a marked increase over that of the condensed skim mix. The curve describing the whipping properties of the No. VI mixes, with the 100 per cent of skimmilk powder, was quicker to rise and maintained a higher level than was exhibited by any of the mixes in which condensed skim was used to build up the serum solids.

Chart V. Showing the per cent Overrun by Minutes for Part II (24 hours aged group)

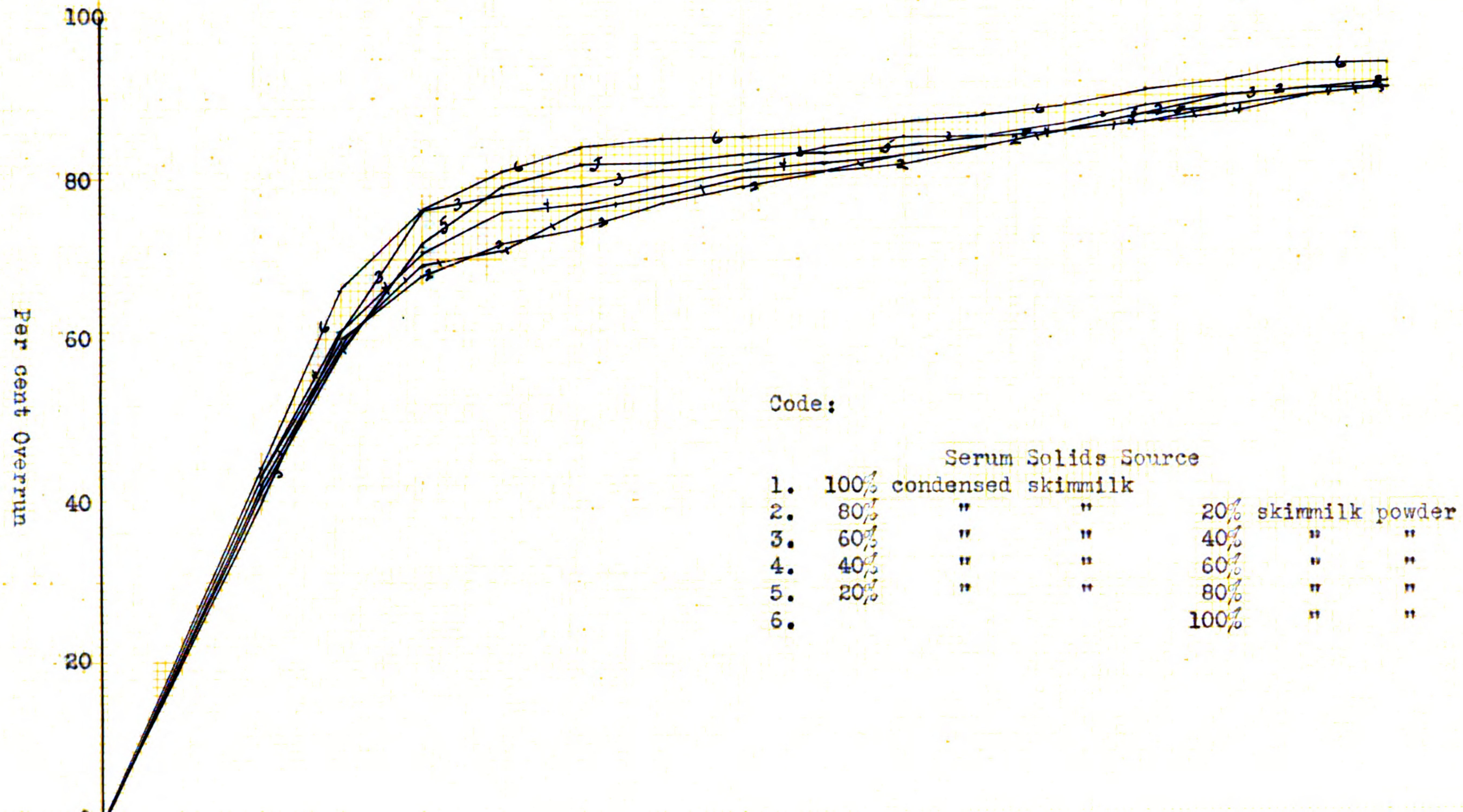


Table XXI was constructed to show the influence on overrun brought about by substituting various amounts of skimmilk powder for plain condensed skimmilk in the mix. The condensed skim mix was used as the base for comparison and the five mixes containing varying amounts of skimmilk powder were compared, the differences being expressed as the positive or negative figure shown on the table. It was observed from this table that all of the skimmilk powder mixes except that containing 20 per cent as the added serum solids source, assumed overrun more readily during the early stages of freezing than did the condensed skim mix.

Quality

No attempt was made to place a score on the ice cream for flavor, nor could a difference be detected in this quality. It was thought of interest to score the body and texture as these qualities are closely related to the physical properties of the mix and thus may be influenced by the type of ingredients supplied in the form of serum solids.

Table XXII gives the scores for each sample secured, as well as an average for each lot of the six experimental series. No influence due to the source of serum solids could be detected. As influencing body and texture, skimmilk powder and condensed skim proved to be equal. The average scores of the six series, containing the various percentages of skimmilk powder and condensed skim as the serum solids source were as follows: (I) 22.875, (II) 22.7, (III) 22.7, (IV) 22.7, (V) 22.875, and (VI) 22.83.

Table XXII. Showing Scores on Body and Texture of Ice Cream

Series	Mix Numbers and Serum Solids Source					
No.	1	2	3	4	5	6
	100% cond.	20% sk.powd. 80% cond.	40% sk.powd. 60% cond.	60% sk.powd. 40% cond.	80% sk.powd. 20% cond.	100% sk.powd.
1	$23\frac{1}{2}$ mellow	$23\frac{1}{2}$ mellow	23 mellow	23 mellow	23 mellow	23 mellow
2	$22\frac{1}{2}$ good	$22\frac{1}{2}$ mellow	$22\frac{1}{2}$ good	$22\frac{1}{4}$ fair	$22\frac{1}{4}$ fair	$22\frac{1}{4}$ good
3	$22\frac{1}{2}$ good	22 fair	$22\frac{1}{2}$ good	$22\frac{1}{2}$ good	$22\frac{1}{2}$ good	$22\frac{1}{2}$ good
4	$23\frac{1}{2}$ mellow	23 mellow	23 mellow	23 mellow	$23\frac{1}{2}$ mellow	$23\frac{1}{2}$ mellow
5	$22\frac{3}{4}$ good	$22\frac{3}{4}$ good	$22\frac{3}{4}$ mellow	$22\frac{3}{4}$ good	$22\frac{3}{4}$ good	$22\frac{3}{4}$ good
6	$22\frac{1}{2}$ good	$22\frac{1}{2}$ good	$22\frac{1}{2}$ good	$22\frac{3}{4}$ good	23 mellow	23 mellow

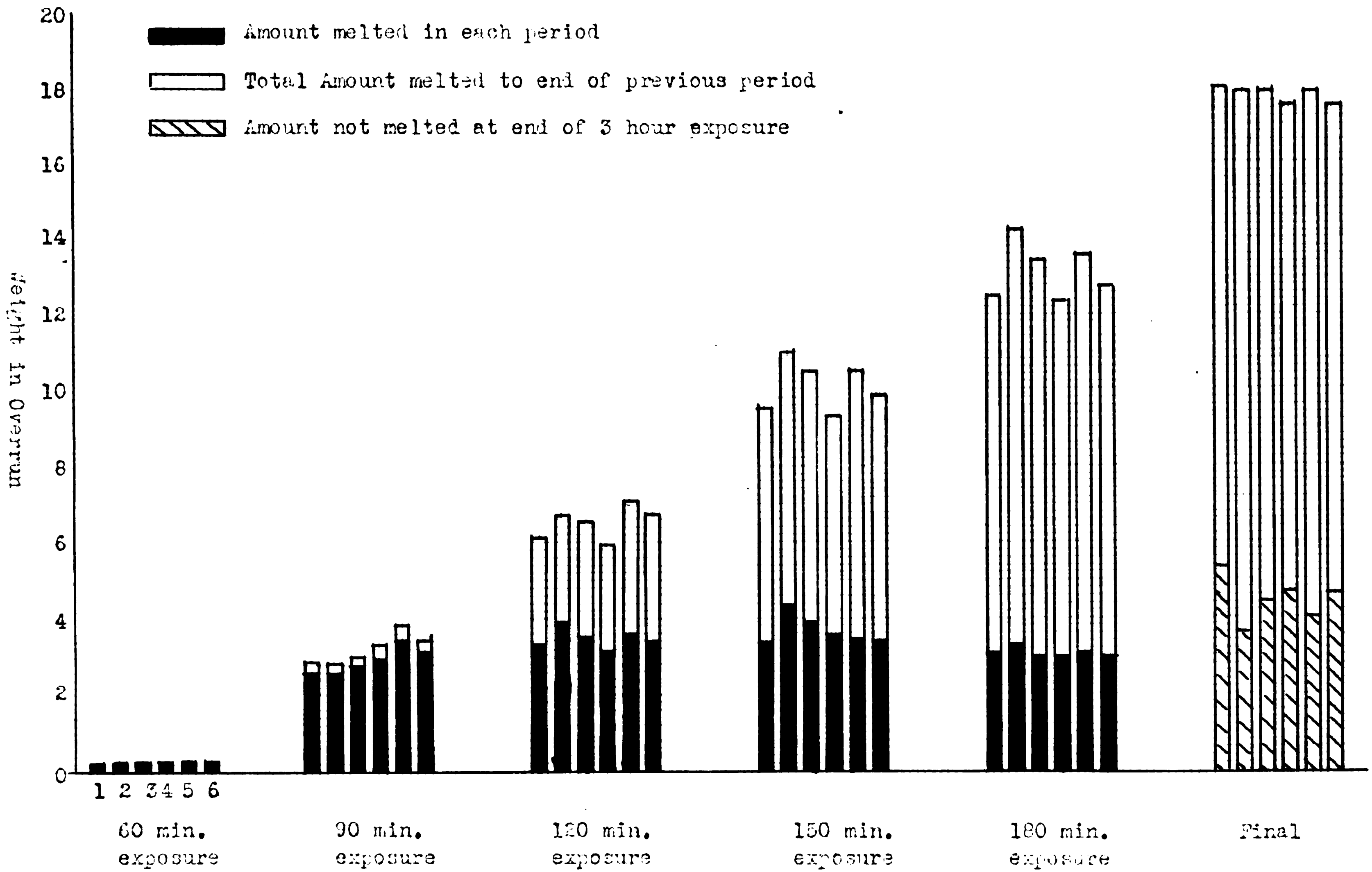
Melting Properties

In melting tests similar to those conducted on the ice cream of Part I, it was found that the ice cream containing condensed skimmilk as the source of the additional required serum solids and that made with skimmilk powder or varying amounts of each had practically the same melting resistance. The samples of this part of the experiment were melted at a temperature of 84° F. Table XXIII and Graph VI show the melting during each period as well as the accumulative results.

Table XXIII. Showing Average Melting during a Three Hour Exposure at 84° F.

Time of Exposure		60 min.	90 min.	120 min.	150 min.	180 min.	Total Melting
Lot No.	Wt. of Brick	Weight of Melted Portion in Ounces					
I.	17.9	.27	2.60	3.30	3.30	3.00	12.6
II.	17.8	.31	2.50	3.90	4.30	3.20	14.2
III.	17.8	.30	2.70	3.55	3.90	2.96	13.4
IV.	17.4	.33	2.93	3.05	3.45	2.90	12.8
V.	17.8	.35	3.50	3.60	3.40	3.03	13.8
VI.	17.4	.30	3.10	3.40	3.30	2.86	12.8

Chart VI. Results of Melting Tests on Mixes of Part II (24 hours aged at 84° F.)



Conclusions

I. The whipping properties of mixes made with a composition of 10 per cent fat and 10.5 per cent serum solids were not appreciably affected by supplying 20 per cent or less of fat from butter. When mixes of this composition contained 80 to 100 per cent of butter as the fat source, mixes of better whipping properties were obtained.

II. The score of body and texture of the ice cream was increased by using 10 per cent of butter as the fat source. No deleterious effects could be detected when 20 per cent of butter was used to supply a portion of the fat. When 50 to 100 per cent of butter was employed as the fat source the body of the ice cream tended toward coarseness.

III. The greater the supply of butter used as the fat source, the lower was the melting resistance and the weaker were the air cell walls.

IV. Microphotographs of diluted portions of the various mixes showed that as the butter percentage of the fat source was increased greater clumping of the fat globules occurred.

V. Aging the experimental mixes 48 hours resulted in better whipping properties than was secured with mixes aged 24 hours. This tendency was more pronounced in the mixes in which butter supplied the major portion of the fat.

VI. When the mixes were aged 48 hours the resulting ice cream showed an improvement in score for body and texture over that of the mixes aged 24 hours. No difference in the melting properties could be detected due to the influence of a longer aging period.

VII. When viscosity tests were made in an effort to explain the difference in the physical properties suggested by the whipping peculiarities encountered, no difference could be found in the basic viscosity as measured by the Mojonnier-Doolittle Viscosimeter. The surface tension of these mixes gave the same value and offered no clue that would explain the variations exhibited.

VIII. Mixes made employing skimmilk powder as the added source of serum solids exhibited better whipping properties than those in which condensed skimmilk was used.

IX. The body and texture of the ice cream made from skimmilk powder and condensed skimmilk apparently were unaffected by the source of serum solids.

X. No differences were exhibited in the melting properties of ice cream made from the condensed skimmilk and the skimmilk powder.

be detected due to the influence of a longer aging period.

VII. When viscosity tests were made in an effort to explain the difference in the physical properties suggested by the whipping peculiarities encountered, no difference could be found in the basic viscosity as measured by the Mojonnier-Doolittle Viscosimeter. The surface tension of these mixes gave the same value and offered no clue that would explain the variations exhibited.

VIII. Mixes made employing skimmilk powder as the added source of serum solids exhibited better whipping properties than those in which condensed skimmilk was used.

IX. The body and texture of the ice cream made from skimmilk powder and condensed skimmilk apparently were unaffected by the source of serum solids.

X. No differences were exhibited in the melting properties of ice cream made from the condensed skimmilk and the skimmilk powder.

Bibliography

1. Dahle, C. D.

Problems in Manufacture of Ice Cream

Pa. Agr. Exp. Sta. Bul. 213, 1927.

2. Wright, K. E.

Lowering Weight-texture Handicaps on Plant-packed Ice Cream

Ice Cream Trade Jour. XXV, No. 2, 49(1929)

3. Clutter, J. A.

What Influences Overrun and Quality?

Ice Cream Trade Jour. XXI, No. 3, 56(1925)

4. Caulfield, W. J. and Martin, W. H.

How Butter Affects Whipping

Ice Cream Trade Jour. XXV, No. 9, 56(1929)

5. Whitaker, Randolph

The Influence of the Use of Butter on the Freezing Properties of Ice Cream Mix

Jour. of Dairy Science XIII, No. 1, Jan. 1930.

6. Hening, J. C. and Dahlberg, A. C.

The Effect of Certain Salts on the Physical Properties of Ice Cream Mixes

Jour. of Dairy Science XII, No. 2, 139 (March) 1929.

7. Caulfield, W. J. and Martin, W. H.
The Use of Egg Yolk in Ice Cream
Jour. of Dairy Science XII, No. 3, 193 (May) 1929.

8. Button, Forest C. and Mueller, William S.
The Use of Dehydrated Egg Products in the Manufacture of Ice Cream
Jour. of Dairy Science XII, No. 4, 320 (July) 1929.

9. Gregory, H. W. and Manhart, V. C.
Factors Affecting Yield of Ice Cream
Purdue University Ext. Bul. 287, 1924.

10. Williams, O. E.
Effect of Composition on Overrun
Creamery and Milk Plant Monthly XI, 100 (1922)

11. Mojonnier and Troy
Technical Control of Dairy Products, pp. 289-449.

12. Doan, F. J.
Some Factors Affecting Fat Clumping Produced in Milk and Cream Mixtures when Homogenized
Jour. of Dairy Science XII, No. 3, 221 (May) 1929.

13. Dahle, C. D.
What Must be Done to Control the Clumping of Fat in the Mix
Ice Cream Trade Jour. XXVI, No. 1, 55 (1930).

14. Williams, O. E.

The Source of Milk Solids Not Fat is an Important Factor

Ice Cream Trade Jour. XXV, No. 9, 86 (1926).

15. Tracy, P. H.

Quality Studies Bring Forth Interesting Facts

Ice Cream Trade Jour. XIX, No. 1, 66-68 (1923)

16. Hening, J. C.

The Effect of Aging on the Properties of Ingredients of the Mix

Ice Cream Trade Jour. XXV, No. 11, 75 (1929).

17. Sommer, H. H.

Why Age the Ice Cream Mix

Ice Cream Trade Jour. XXV, No. 7, 41 (1929).

18. Dahle, C. D. and Keith, J. I.

What Effect Does Aging Have upon the Freezing Qualities of the Mix?

Ice Cream Trade Jour. XXV, No. 11, 76 (1929).

19. Olson, N. E.

Is Aging of the Mix Quite so Necessary as is Claimed?

Ice Cream Trade Jour. XXV, No. 11, 79 (1929).

20. Lucas, P. S. and Mook, D. E.

The Effect of Butterfat on Overrun and Quality of Ice Cream

Michigan Special Bul. 201.

21. Sommer, H. H. and Horrall, B. E.
Whipping Ability of Ice Cream Mix is Explained, New Science for an Old Art.
Wisconsin Bul. 410, p. 25.

A P P E N D I X

Table XXIV. Showing the per cent of Overrun by Minutes for Lot I in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	55	59	54	45	52	34	50
3	73	66	71	54	68	46	63
4	82	65	75	62	79	54	69
5	80	67	76	71	79	59	72
6	80	70	76	72	79	61	73
7	83	74	77	73	79	64	75
8	85	75	79	75	80	67	77
9	86	76	79	77	80	70	78
10	88	79	79	79	80	75	80
11	90	80	81	82	81	76	81
12	94	82	83	84	82	78	84
13	92	84	84	87	84	83	86
14	92	87	85	87	85	85	87
15	93	89	86	87	86	88	88
16	91	88	90	87	87	90	89
Brine Temp.	1.0° F	0.0° F	0.0° F	20° F	1.0° F	1° F	
Temp. of Mix	39° F	39° F	36° F	39° F	37° F	41° F	

Table XXV. Showing the per cent of Overrun by Minutes for Lot II in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	52	55	55	52	60	40	52
3	74	63	69	63	78	59	66
4	80	64	76	71	86	71	74
5	79	67	76	74	82	72	75
6	80	69	78	74	83	74	76
7	81	73	79	74	84	76	78
8	81	75	80	75	84	77	79
9	82	78	81	77	85	79	80
10	83	79	83	78	86	80	81
11	85	82	85	80	86	81	83
12	87	83	86	83	87	83	85
13	89	85	89	85	88	84	87
14	91	86	89	87	89	86	88
15	93	87	90	87	89	87	89
16	94	89	90	87	90	88	90
Brine Temp.	0° F	0° F	1° F	4° F	1° F	-2° F	
Temp.	39° F	39° F	37° F	39° F	37° F	40° F	

Table XXVI. Showing the per cent of Overrun by Minutes for Lot II in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	53	52	53		59	45	53
3	65	60	65		67	66	65
4	74	64	71		67	72	69
5	77	65	73		69	65	70
6	78	69	75		70	63	71
7	80	72	78		72	67	73
8	82	74	79		73	70	75
9	82	75	80		73	71	76
10	83	77	80		74	74	77
11	84	78	81		76	77	79
12	86	81	81		78	80	81
13	87	83	84		80	83	83
14	88	85	85		81	87	85
15	90	87	86		81	88	86
16	93	88	87		84	89	88
Brine Temp.	2° F	0°F	0° F		-1° F	0° F	
Temp. of Mix	39° F	39°F	36° F		37° F	41° F	

Table XXVII. Showing the per cent of Overrun by Minutes for Lot IV in Part I (24 Hour Group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	49	56	53	53	50	40	50
3	62	70	67	62	64	51	63
4	71	75	74	72	69	60	70
5	74	74	80	76	70	63	73
6	77	77	81	77	71	65	74
7	80	80	82	79	71	66	76
8	81	82	83	80	71	70	78
9	83	83	83	82	72	72	79
10	84	85	85	84	72	75	81
11	84	86	87	86	73	77	82
12	85	86	87	87	74	80	83
13	86	85	88	88	76	82	84
14	88	84	90	90	77	83	85
15	88	82	89	90	78	85	85
16	89	82	89	91	79	87	86
Brine Temp.	1° F	-4° F	0° F	0° F	-2° F	0° F	
Temp. of Mix	39° F	39° F	36° F	39° F	37° F	41° F	

Table XXVIII. Showing the per cent of Overrun by Minutes for Lot V in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	53	54	59	54	48	36	50
3	65	63	75	60	67	51	64
4	75	70	79	65	72	67	71
5	78	75	82	67	74	77	76
6	83	76	84	67	73	84	78
7	86	78	84	69	73	83	79
8	86	79	84	71	73	81	79
9	85	81	85	73	74	76	79
10	86	82	85	76	73	73	79
11	85	83	86	77	73	75	79
12	87	84	86	78	73	77	80
13	87	85	87	79	77	80	81
14	88	85	87	81	79	82	83
15	88	86	88	82	80	85	84
16	89	85	88	84	81	86	85
Brine Temp.	0° F	0° F	-1° F	3° F	-1.5° F	6° F	
Temp. of Mix	39° F	39° F	36° F	39° F	36° F	41° F	

Table XXIX. Showing the per cent of Overrun by Minutes for Lot VI in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	57	54	65	60	54	43	55
3	75	62	81	70	70	59	69
4	83	73	92	84	77	75	81
5	88	76	95	93	79	79	85
6	86	78	96	100	81	76	86
7	85	82	97	100	82	76	87
8	86	83	97	102	82	75	87
9	84	83	98	102	81	76	87
10	83	83	98	101	81	76	87
11	83	83	98	101	81	77	87
12	84	85	97	102	81	78	88
13	86	84	96	101	83	79	88
14	86	83	96	100	83	80	88
15	87	82	97	100	83	80	88
16	85	82	97	98	84	80	88
Brine Temp.	2^{o} F	0^{o} F	1^{o} F	4^{o} F	0^{o} F	4^{o} F	
Temp. of Mix	39^{o} F	39^{o} F	36^{o} F	39^{o} F	37^{o} F	41^{o} F	

Table XXX. Showing the per cent of Overrun by Minutes for Lot VII in Part I (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	52	58	72	58	58	50	58
3	70	72	80	68	72	70	72
4	85	77	98	89	81	80	85
5	97	81	105	106	84	84	93
6	100	84	109	112	87	85	96
7	104	83	108	113	87	86	97
8	99	83	108	117	87	86	97
9	100	83	106	117	87	86	97
10	102	82	105	115	87	85	96
11	100	82	102	116	86	86	95
12	98	82	101	116	87	87	95
13	99	82	101	116	87	87	95
14	99	80	100	112	87	87	94
15	97	79	98	108	87	88	93
16	95	78	97	105	88	86	91
Brine Temp.	2° F	0° F	1° F	4° F	0° F	0° F	
Temp. of Mix	39° F	39° F	36° F	39° F	37° F	41° F	

Table XXXI. Showing the per cent of Overrun by Minutes for Lot I in Part I (48 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	45	54	45	46	53	39	47
3	65	73	60	62	68	58	64
4	74	93	72	68	72	66	74
5	78	96	77	74	76	70	78
6	77	90	76	76	78	73	78
7	77	85	74	77	79	75	78
8	77	84	74	78	80	77	78
9	77	84	74	80	80	78	79
10	78	83	75	81	80	80	79
11	78	84	78	81	81	82	81
12	79	85	80	82	84	84	82
13	82	86	82	83	85	86	84
14	81	88	86	84	86	88	85
15	82	88	90	86	88	90	87
16	83	90	92	88	90	92	89
Brine Temp.	3^{o} F	1^{o} F	4^{o} F	-6^{o} F	0^{o} F	-5^{o} F	
Temp. of Mix	36^{o} F	36^{o} F	37^{o} F	34^{o} F	36^{o} F	38^{o} F	

Table XXXII. Showing the per cent of Overrun by Minutes for Lot II in Part I (48 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	45	60	51	48	55	46	51
3	60	78	65	65	75	60	67
4	68	78	68	69	79	69	72
5	71	76	69	72	85	73	74
6	72	76	70	74	89	75	76
7	74	76	72	76	89	77	77
8	75	77	74	77	89	78	78
9	76	78	77	79	90	80	80
10	78	79	78	80	90	81	81
11	79	81	80	81	90	82	82
12	79	82	83	84	90	86	84
13	82	84	86	85	93	88	86
14	84	86	88	86	94	89	88
15	86	88	91	88	96	90	90
16	87	89	94	90	95	91	91
Brine Temp.	-4° F	1° F	1° F	-3° F	0° F	-4° F	
Temp. of Mix	34° F	36° F	37° F	34° F	36° F	38° F	

Table XXXIII. Showing the per cent of Overrun by Minutes for Lot III in Part I (48 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	55	53	51	54	50	50	52
3	65	69	68	70	71	69	62
4	67	83	74	75	79	74	75
5	68	84	73	78	83	76	77
6	70	82	71	78	86	77	77
7	72	82	74	79	88	78	79
8	73	82	76	80	90	79	80
9	74	84	78	81	90	80	81
10	75	84	80	82	90	81	82
11	76	84	83	83	90	82	83
12	77	85	85	84	91	84	84
13	78	87	87	86	92	86	86
14	79	89	89	87	93	89	88
15	80	90	92	87	95	90	89
16	81	91	94	88	95	92	90
Brine Temp.	-4° F	[illegible]° F	2° F	-4° F	0° F	-4° F	
Temp. of Mix	33° F	36° F	37° F	34° F	36° F	38° F	

Table XXXIV. Showing the per cent of Overrun by Minutes for Lot IV in Part I (48 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	48	55	51	52	52	45	50
3	74	88	61	68	69	63	69
4	79	100	69	73	76	70	78
5	78	100	70	76	80	75	80
6	81	100	71	76	85	80	80
7	81	100	73	77	86	82	81
8	81	100	75	79	86	84	84
9	82	98	77	81	87	85	85
10	83	100	79	81	87	86	86
11	83	99	81	84	88	87	87
12	84	98	84	85	90	87	88
13	84	100	86	86	91	87	89
14	84	101	90	87	92	87	90
15	84	100	92	88	94	86	91
16	83	102	94	90	93	83	91
Brine Temp.	1° F	4° F	2° F	-8° F	-1° F	-4° F	
Temp. of Mix	33° F	36° F	37° F	34° F	36° F	38° F	

Table XXXV. Showing the per cent of Overrun by Minutes for Lot V in Part I (48 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	60	60	52	66	60	42	57
3	77	89	72	87	83	65	79
4	80	101	84	95	91	73	87
5	80	98	87	93	96	77	88
6	80	93	81	95	98	78	87
7	81	93	78	96	98	80	88
8	80	92	79	98	98	82	88
9	80	92	78	98	98	83	88
10	81	93	79	99	97	84	89
11	81	94	81	99	96	86	89
12	82	95	82	99	97	87	90
13	82	95	83	100	97	88	91
14	83	95	85	100	98	88	91
15	83	96	88	101	98	90	92
16	83	96	90	100	98	91	93
Brine Temp.	0° F	2° F	4° F	-3° F	1° F	-4° F	
Temp. of Mix	34° F	36° F	37° F	34° F	36° F	38° F	

Table XXXVI. Showing the per cent Overrun by Minutes for Lot VI in Part I (48 hour group)

	Batch Number						
Minutes	I	II	III	IV	V	VI	Average
2	58	49	44	54	53	60	53
3	80	70	59	76	80	78	74
4	89	80	79	86	86	82	83
5	95	83	88	92	93	85	89
6	98	85	89	93	100	87	92
7	98	86	91	92	102	86	92
8	97	86	91	90	101	86	92
9	97	86	91	91	100	86	92
10	96	87	91	90	103	86	92
11	96	88	91	90	102	87	92
12	96	88	91	90	102	88	92
13	96	90	92	90	102	88	93
14	97	91	92	90	102	90	94
15	98	93	92	89	103	91	94
16	98	93	92	88	104	93	95
Brine Temp.	1° F	4° F	-4° F	-5° F	0°F	-2° F	
Temp. of Mix	33° F	36° F	37° F	34° F	36°F	38° F	

Table XXXVII. Showing the per cent Overrun per Minute for Lot VII in Part I (48 hour group)

	Batch Number						
Minutes	I	II	III	IV	V	VI	Average
2	54	59	54	53	63	60	57
3	79	70	75	68	81	81	76
4	93	84	88	87	86	88	88
5	97	87	96	97	91	95	94
6	101	89	101	101	94	98	97
7	103	90	102	104	94	98	98
8	103	91	101	110	94	95	99
9	102	89	100	110	94	94	98
10	101	89	100	110	93	94	98
11	101	90	99	107	91	94	97
12	101	90	98	103	91	94	97
13	103	91	99	108	92	94	98
14	104	92	99	109	93	94	99
15	102	93	99	104	93	95	96
16	103	94	100	100	93	97	96
Brine Temp.	1° F	0° F	1° F	-6° F	0° F	-5° F	
Temp. of Mix	34° F	36° F	37° F	34° F	36° F	38° F	

Table XXXVIII. Showing the per cent Overrun per Minute for Lot I in Part II (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	44	36	43	49	39	42	42
3	61	53	63	68	56	54	59
4	68	59	76	78	65	66	69
5	71	65	74	80	68	71	71
6	74	70	76	85	74	75	76
7	76	73	77	89	77	77	78
8	77	77	79	91	78	80	80
9	78	79	81	90	78	81	81
10	80	80	84	91	80	83	83
11	81	81	84	93	81	85	84
12	82	82	87	93	83	87	86
13	85	83	87	95	85	88	87
14	87	85	89	96	86	90	89
15	88	87	91	98	87	90	90
16	88	88	93	95	90	91	91
Brine Temp.	-8° F	-4° F	-12° F	-2° F	0° F	4° F	
Temp. of Mix	38°F	36° F	40° F	36° F	38° F	38° F	

Table XXXIX. Showing the per cent Overrun per Minute for Lot II in Part II (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	45	39	40	53	41	43	43
3	59	55	57	70	60	59	60
4	65	62	70	77	67	69	68
5	69	70	73	80	68	71	72
6	72	74	76	82	71	71	74
7	74	76	77	84	76	75	77
8	76	77	81	86	77	77	79
9	77	80	82	88	79	78	81
10	79	82	84	90	80	80	82
11	81	83	86	92	82	82	84
12	82	85	87	94	85	85	86
13	84	87	88	95	87	88	88
14	87	89	90	96	88	90	90
15	88	91	92	95	89	93	91
16	89	92	92	95	90	94	92
Brine Temp.	-8° F	-5° F	-14° F	-3° F	2° F	5° F	
Temp. of Mix	38°F	36° F	40°F	36° F	38° F	38° F	

Table XL. Showing the per cent Overrun per Minute for Lot III in Part II (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	34	32	44	50	40	43	40
3	58	57	63	73	57	62	61
4	68	76	77	85	75	75	76
5	69	74	78	90	78	79	78
6	74	75	78	92	76	78	79
7	77	78	81	92	78	78	81
8	80	80	84	93	79	80	82
9	81	81	86	93	81	82	84
10	82	83	87	94	82	84	85
11	83	84	88	95	84	85	85
12	84	85	89	95	85	86	87
13	85	86	92	95	87	88	89
14	86	87	92	96	89	89	90
15	88	88	93	97	90	91	91
16	88	88	92	95	92	93	91
Brine Temp.	-4° F	-5° F	3° F	-4° F	4° F	7° F	
Temp. of Mix	38° F	36° F	40° F	36° F	38° F	38° F	

Table XLI. Showing the per cent Overrun per Minute for Lot IV in Part II (24 hour group)

	Batch Number						
Minutes	I	II	III	IV	V	VI	Average
2	40	44	38	54	42	42	43
3	59	60	55	73	62	59	61
4	73	64	72	79	68	73	71
5	76	69	79	82	71	79	76
6	78	73	77	84	75	78	77
7	80	75	80	84	77	80	79
8	80	77	82	85	79	82	81
9	81	79	83	86	80	82	82
10	81	80	84	87	81	82	83
11	83	82	85	88	82	84	84
12	84	84	87	88	85	86	86
13	84	87	89	89	87	88	87
14	85	88	90	90	89	89	88
15	87	90	90	93	90	90	90
16	87	92	91	93	90	92	91
Brine Temp.	-9° F	-6° F	-14° F	-4° F	0° F	5° F	
Temp. of Mix	38° F	36° F	40° F	36° F	38° F	38° F	

Table XLII. Showing the per cent Overrun per Minute for Lot V in Part II (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	33	40	44	46	44	37	41
3	47	60	60	68	66	56	59
4	60	69	76	80	69	78	72
5	69	76	82	86	73	92	79
6	73	80	80	89	75	95	82
7	77	81	80	90	77	90	82
8	78	82	81	91	78	85	83
9	79	84	82	91	79	85	83
10	80	85	83	92	80	87	84
11	81	85	84	92	81	88	85
12	82	86	85	93	83	90	86
13	84	87	87	94	84	90	88
14	85	88	88	94	85	92	89
15	86	90	90	95	86	94	90
16	86	92	91	94	87	94	91
Brine Temp.	-6° F	-6° F	5° F	-2° F	0° F	7° F	
Temp. of Mix	38° F	36° F	40° F	36° F	38° F	38° F	

Table XLIII. Showing the per cent Overrun per Minute for Lot VI in Part II (24 hour group)

Minutes	Batch Number I	II	III	IV	V	VI	Average
2	45	50	45	60	45	37	44
3	67	65	64	78	66	56	66
4	74	70	77	85	75	78	76
5	76	75	79	89	79	92	81
6	79	77	83	90	81	95	84
7	80	79	87	90	82	90	85
8	81	80	89	91	83	85	85
9	82	82	89	92	86	85	86
10	83	83	90	93	87	85	87
11	84	86	91	95	88	87	88
12	85	88	91	95	89	88	89
13	87	90	92	97	91	90	91
14	88	92	93	98	92	90	92
15	89	94	95	99	93	92	94
16	90	95	96	97	93	94	94
Brine Temp.	-9° F	-6° F	2° F	-3° F	3° F	7° F	
Temp. of Mix	38° F	36° F	40° F	36° F	38° F	38° F	

Table XLIV. Showing Average Melting During a Three Hour Exposure of 88° F. (Part I, 24 hours aged group)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
I	I	19.0	0.0	1.7	3.1	7.2	4.7	16.7
	II	19.0	0.2	3.2	3.7	6.2	3.4	16.7
	III	18.5	0.2	3.7	3.4	5.1	3.8	16.2
	IV	18.5	0.5	3.9	3.4	5.3	3.6	16.7
	V	19.0	0.9	4.7	3.2	4.5	3.5	16.8
	VI	19.7	1.7	4.7	3.4	6.2	0.9	16.9
	VII	18.8	1.6	5.1	3.3	5.0	1.6	16.6
II	I	19.0	0.7	2.3	4.7	6.3	1.8	15.8
	II	18.3	0.8	2.3	5.2	5.4	2.4	16.1
	III	19.0	0.8	3.7	3.8	5.8	2.0	16.6
	IV	18.9	1.3	4.1	5.0	4.2	2.2	16.8
	V	20.0	1.6	4.4	4.4	4.0	3.4	17.8
	VI	20.0	1.7	4.4	5.1	4.3	2.4	17.9
	VII	19.0	2.0	4.9	7.1	4.0	0.0	18.0
III	I	19.0	0.0	1.3	3.0	7.0	4.0	15.3
	II	19.0	0.3	3.0	3.3	5.2	4.0	15.8
	III	20.0	0.4	4.6	3.0	4.0	3.5	15.5
	IV	19.0	0.9	3.3	3.2	3.8	4.5	15.7
	V	19.0	1.0	5.0	3.5	5.3	1.2	16.0
	VI	18.5	1.5	4.7	3.5	6.0	0.0	15.7
	VII	18.5	1.5	4.7	3.0	6.5	0.0	15.7

Table XLIV. (Continued)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
IV	I	18.5	0.0	3.2	4.1	6.0	2.0	15.3
	II	19.5	1.0	3.5	4.0	5.5	2.5	15.5
	III	Sample lost						
	IV	19.5	3.3	3.5	3.5	2.0	2.0	16.3
	V	20.0	2.1	5.7	4.5	3.7	2.3	16.3
	VI	19.5	4.6	4.0	6.0	2.8	0.0	17.4
	VII	19.0	4.6	4.5	4.0	3.7	0.0	16.8
V	I	20.0	0.8	4.8	5.9	4.0	2.1	16.7
	II	19.8	1.7	4.0	4.1	4.0	2.7	16.5
	III	19.0	1.1	3.5	4.0	3.1	2.9	14.6
	IV	19.0	0.5	2.7	4.5	3.5	4.0	15.2
	V	19.5	2.3	3.0	4.9	5.2	0.8	16.2
	VI	19.0	1.9	4.2	5.2	4.7	0.8	16.8
	VII	18.5	2.6	2.7	4.4	3.0	3.0	15.7
VI	I	20.0	1.1	3.0	5.9	4.1	2.5	16.6
	II	19.0	1.2	3.1	4.8	3.9	2.3	15.3
	III	18.0	1.0	4.8	5.0	3.5	1.1	15.4
	IV	19.0	1.2	3.1	4.5	4.0	2.7	15.5
	V	19.0	2.0	5.0	5.1	3.0	0.9	16.0
	VI	19.5	3.3	4.0	6.0	3.5	0.0	16.8
	VII	19.0	3.2	3.9	5.8	3.2	0.0	16.1

Table XLV. Showing Average Melting During a Three Hour Exposure of 88° F. (Part I, 48 hour aged group)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
I	I	18.5	0.0	3.2	4.5	6.1	2.9	16.7
	II	18.7	0.0	3.7	4.7	6.0	0.9	15.3
	III	18.0	0.3	4.0	3.9	5.9	1.6	15.7
	IV	18.5	0.2	4.2	4.5	6.6	1.0	16.5
	V	18.5	1.2	3.5	4.5	5.1	2.0	16.3
	VI	18.0	2.1	4.5	4.5	5.0	0.0	16.1
	VII	18.5	2.0	4.9	4.3	4.2	0.8	16.2
II	I	19.5	0.4	3.8	4.0	5.3	2.2	15.7
	II	17.5	0.1	2.6	3.7	5.9	2.1	14.4
	III	18.0	0.2	3.0	4.0	5.4	2.5	15.1
	IV	19.0	0.3	3.3	4.7	5.3	2.1	15.7
	V	19.5	0.4	3.9	4.3	5.4	2.3	16.3
	VI	18.0	2.1	4.2	4.3	4.0	1.9	16.5
	VII	18.5	2.3	3.5	4.5	4.7	1.9	16.7
III	I	18.0	0.0	2.8	3.5	6.0	4.0	16.3
	II	19.0	0.0	3.5	3.0	7.0	4.0	17.5
	III	17.5	0.0	2.6	2.4	6.0	4.0	15.0
	IV	19.0	0.0	2.8	3.0	7.0	3.5	16.3
	V	20.0	0.2	3.4	3.0	11.0	0.0	17.6
	VI	18.0	0.9	3.8	4.0	8.0	0.0	16.7
	VII	21.0	0.5	4.6	4.4	7.0	2.0	18.5

Table XLV. (Continued)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
IV	I	18.5	0.0	5.0	4.0	7.0	0.0	16.0
	II	20.0	0.8	3.8	3.0	6.0	3.0	16.6
	III	18.0	0.2	2.6	3.2	7.0	2.0	15.0
	IV	19.0	0.2	3.3	4.0	6.0	2.0	15.5
	V	20.5	0.7	6.3	4.5	5.5	1.0	18.0
	VI	19.0	1.5	4.5	4.0	8.0	0.0	18.0
	VII	19.0	0.5	5.5	3.5	5.5	1.0	16.0
V	I	19.0	1.5	5.0	5.5	3.0	2.0	17.0
	II	18.0	1.8	4.0	7.0	2.7	1.3	16.8
	III	18.5	1.8	5.5	6.0	3.0	1.0	17.3
	IV	19.0	3.2	5.5	5.0	3.0	1.5	18.2
	V	18.0	3.2	5.0	5.5	4.0	0.5	18.2
	VI	19.0	3.0	6.0	7.6	1.5	0.0	18.1
	VII	19.0	4.6	4.0	7.0	2.0	0.0	17.6
VI	I	18.5	1.1	4.5	6.0	3.0	2.0	16.6
	II	19.0	1.7	5.0	6.5	3.4	1.0	17.6
	III	19.0	1.5	4.5	7.2	3.5	1.6	18.3
	IV	18.0	1.3	5.0	6.0	4.0	1.0	17.3
	V	18.5	2.2	5.0	6.5	2.5	1.0	17.2
	VI	19.0	2.6	6.0	5.0	3.0	0.0	16.6
	VII	18.0	3.3	5.5	5.0	3.0	0.0	16.8

Table XLVI. Showing Average Melting During a Three Hour Exposure of 84^{0} F. (Part II, aged 24 hours)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
I	I	18.0	0.1	3.0	3.1	3.8	2.6	12.6
	II	18.0	0.0	2.1	3.9	3.0	2.5	11.5
	III	17.0	0.0	2.5	3.2	3.3	3.0	12.0
	IV	17.0	1.1	3.2	2.9	4.6	3.0	14.8
	V	17.0	0.8	3.5	3.0	3.0	3.5	13.8
	VI	16.3	0.0	3.0	3.0	3.0	3.0	12.0
II	I	18.5	0.5	2.1	3.4	2.8	4.2	13.0
	II	18.0	0.6	2.3	4.1	4.9	4.1	16.0
	III	19.0	0.0	2.8	3.2	3.9	3.9	13.8
	IV	17.0	0.3	2.5	2.7	3.1	3.5	12.1
	V	18.0	0.0	3.5	3.3	3.5	3.5	13.8
	VI	17.0	0.1	3.5	3.5	3.0	3.0	13.1
III	I	18.0	0.3	2.5	3.0	3.8	3.2	13.0
	II	18.0	0.6	3.0	4.2	5.5	2.5	15.8
	III	17.0	0.1	2.4	3.6	5.9	3.0	15.0
	IV	18.0	0.5	2.6	2.7	3.0	4.0	12.8
	V	18.0	0.5	3.2	3.9	3.0	3.5	14.1
	VI	17.8	0.6	3.0	4.6	3.6	2.7	13.5

Table XLVI. (Continued)

Series No.	Lot No.	Weight of Brick	Time Exposed 60 min.	90 min.	120 min.	150 min.	180 min.	Weight of Leak
IV.	I	17.5	0.1	2.3	2.8	3.0	2.4	10.6
	II	18.0	0.3	2.7	3.8	4.5	4.5	15.8
	III	18.0	0.8	3.0	3.8	3.4	2.6	13.6
	IV	17.5	0.0	2.9	3.1	3.0	2.7	11.7
	V	19.0	0.1	3.7	3.8	4.0	3.0	14.6
	VI	17.5	0.2	2.7	3.1	4.4	3.3	13.7
V	I	18.0	0.1	2.2	3.6	3.8	2.6	12.3
	II	18.0	0.0	2.0	4.0	4.0	3.0	13.0
	III	18.0	0.0	2.1	3.9	4.0	3.0	13.0
	IV	17.5	0.0	3.1	3.5	3.9	2.1	12.6
	V	18.5	0.7	3.4	3.2	3.5	2.7	13.5
	VI	18.9	0.4	3.1	3.5	3.0	2.3	12.9
VI	I	16.3	0.5	3.5	4.0	3.5	2.9	14.4
	II	16.8	0.4	3.1	3.5	3.8	2.5	13.3
	III	17.8	0.8	3.7	3.6	2.7	2.3	13.3
	IV	17.6	0.1	3.3	3.4	3.1	3.2	13.1
	V	16.1	0.0	3.8	3.7	3.5	2.0	13.0
	VI	17.3	0.5	3.3	2.7	3.0	2.3	11.8

Photographs of air cells formed on cardboard bases upon melting and drying.

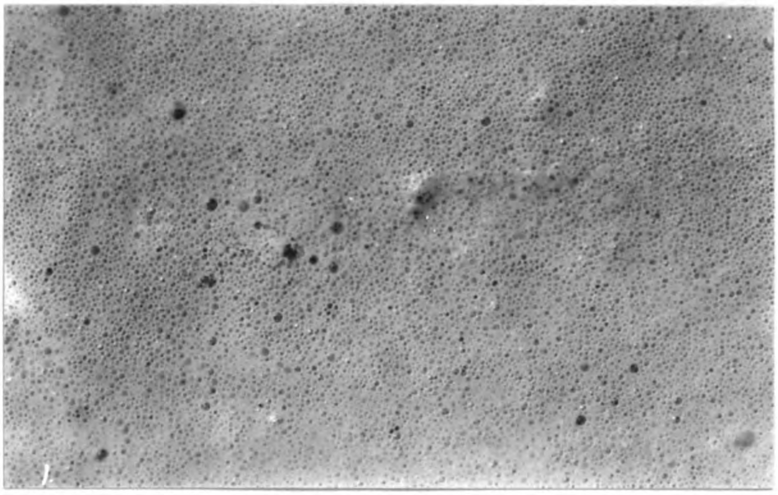


Plate I. Showing the air cell formation of ice cream made with cream as the entire source of fat.

Plate II. Showing air cell formation from melted ice cream made with butter supplying 5 per cent of the fat and cream 95 per cent.

Plate III. Showing air cell formation from melted ice cream made with butter supplying 10 per cent of the fat and cream 95 per cent.

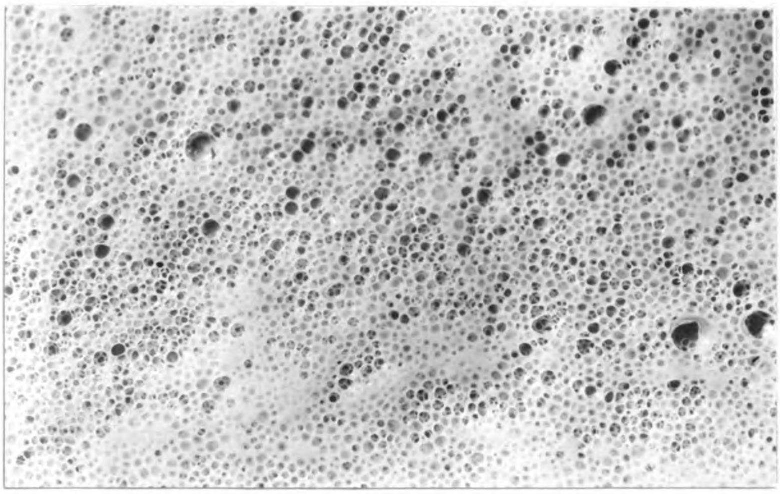


Plate IV. Showing air cell formation from melted ice cream made with butter supplying 20 per cent of the fat and cream 80 per cent.

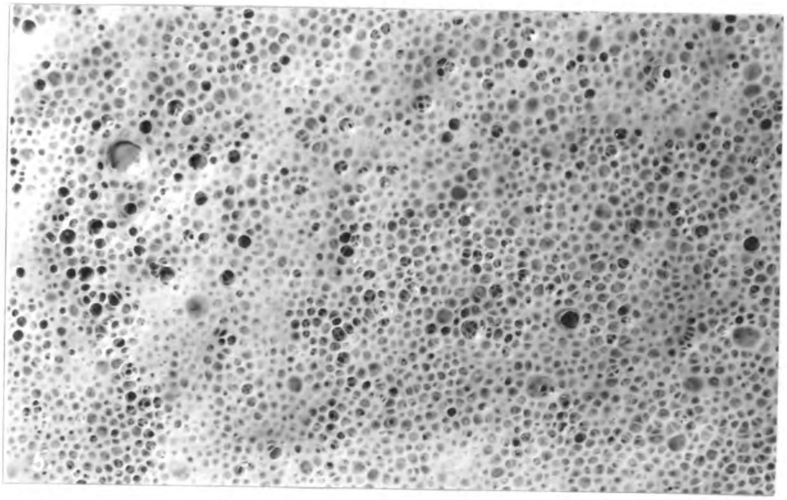


Plate V. Showing air cell formation from melted ice cream made with butter supplying 50 per cent of the fat and cream 50 per cent.

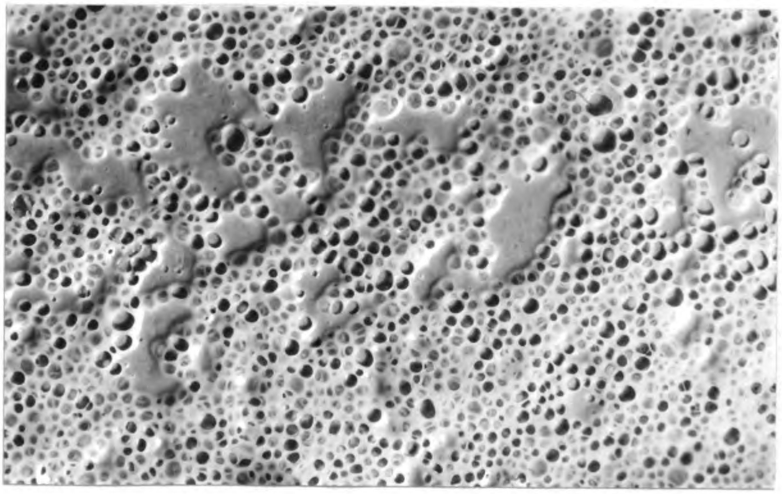


Plate VI. Showing air cell formation from melted ice cream made with butter supplying 80 per cent of the fat and cream 20 per cent.

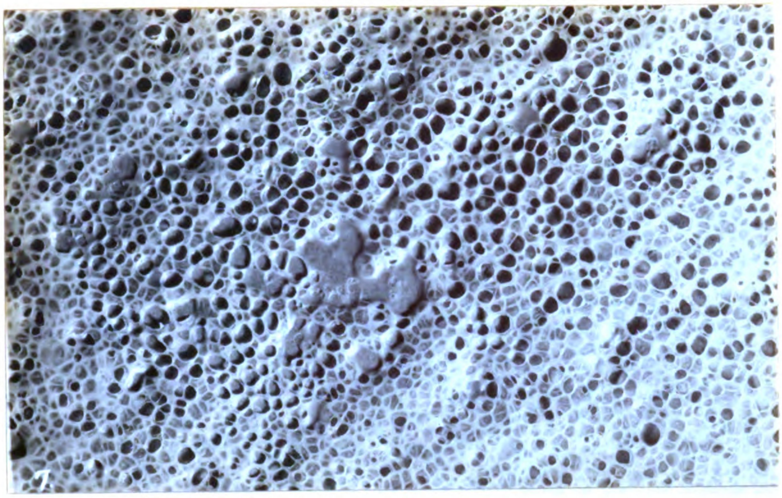


Plate VII. Showing the air cell formation of the ice cream made with butter as the entire source of fat.

Photomicrographs made of 10 per cent water dilutions of each of the mixes used in Part I (Series VI of 48 hour aged group used as illustration).

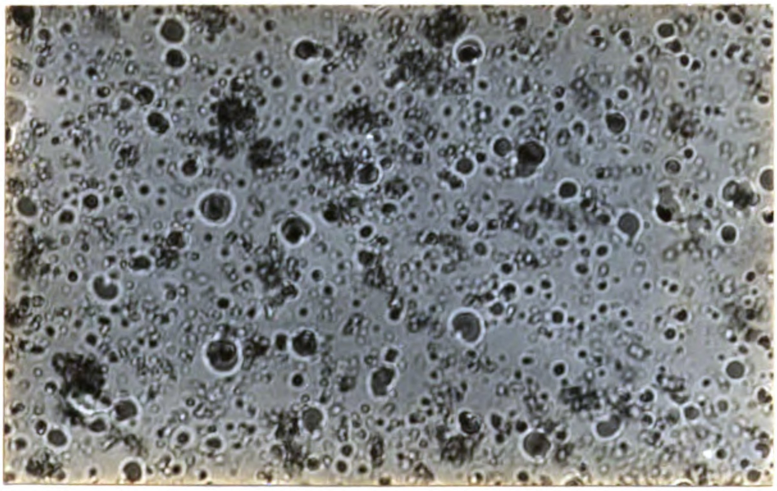


Plate VIII. Showing condition of fat globules as present in Mix I (100% cream used as fat source)

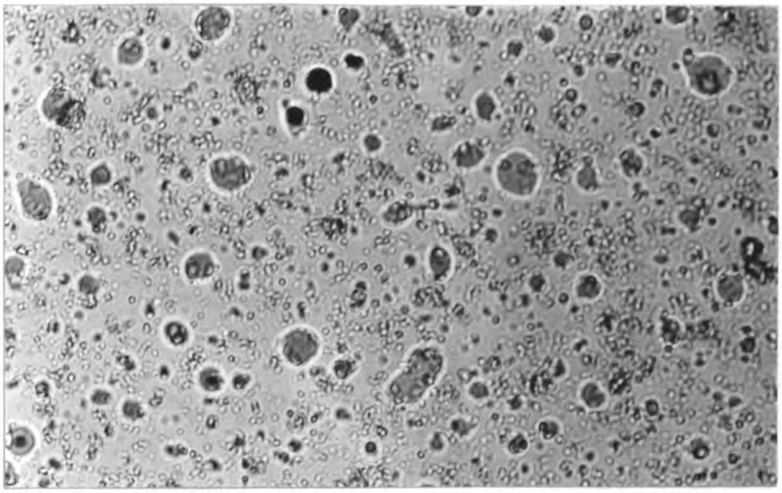


Plate IX. Showing condition of fat globules as present in Mix II (5% butter and 95% cream used as fat source)

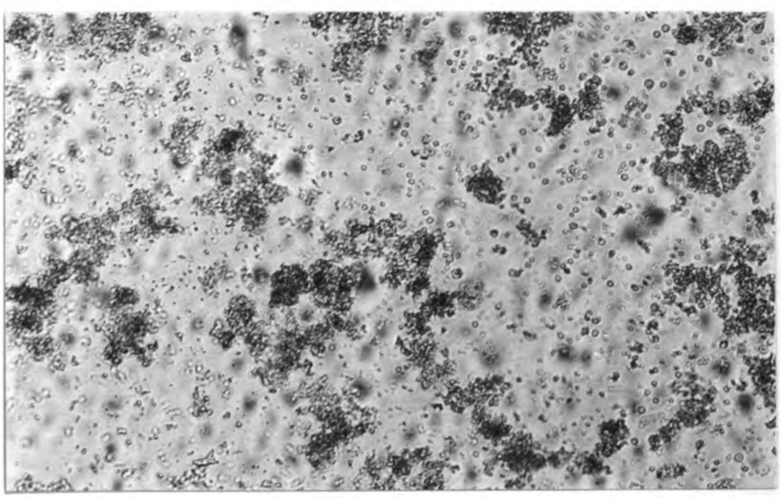


Plate X. Showing condition of fat globules as present in Mix III (10% butter and 90% cream used as fat source)

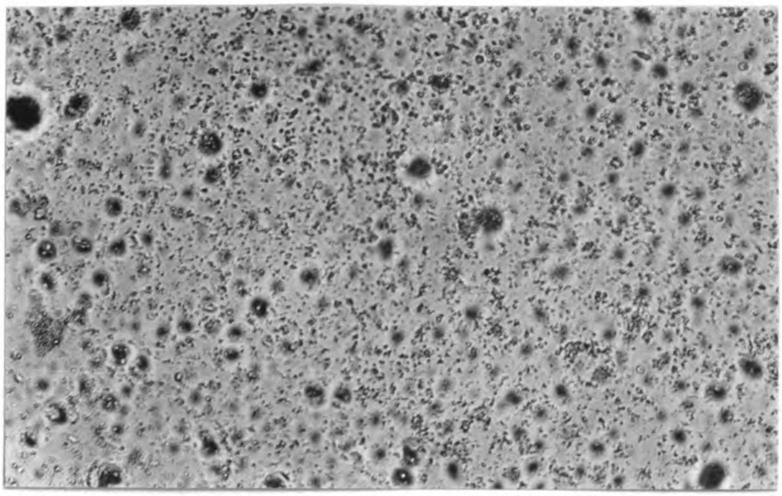


Plate XI. Showing condition of fat globules as present in Mix IV (20% butter and 80% cream used as fat source)

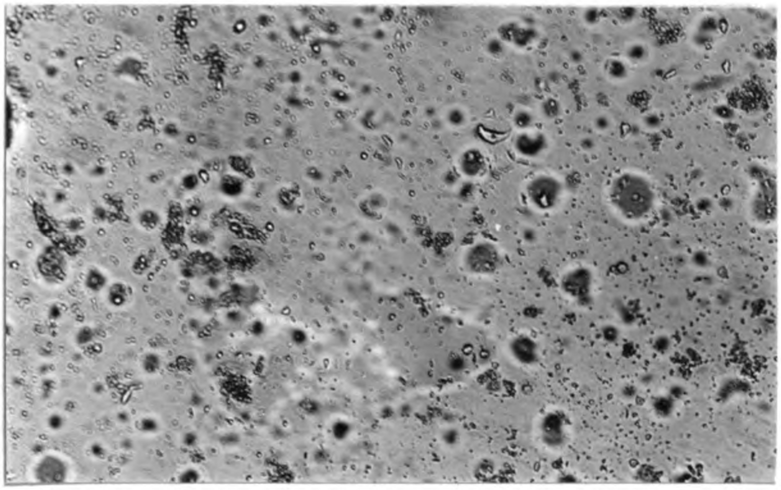


Plate XII. Showing condition of fat globules as present in Mix V (50% butter and 50% cream used as fat source)

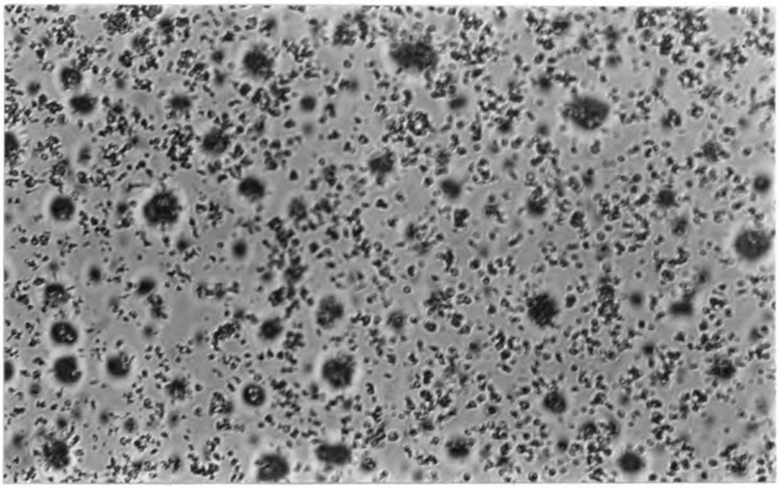


Plate XIII. Showing condition of fat globules as present in Mix VI (80% butter and 20% cream used as fat source)

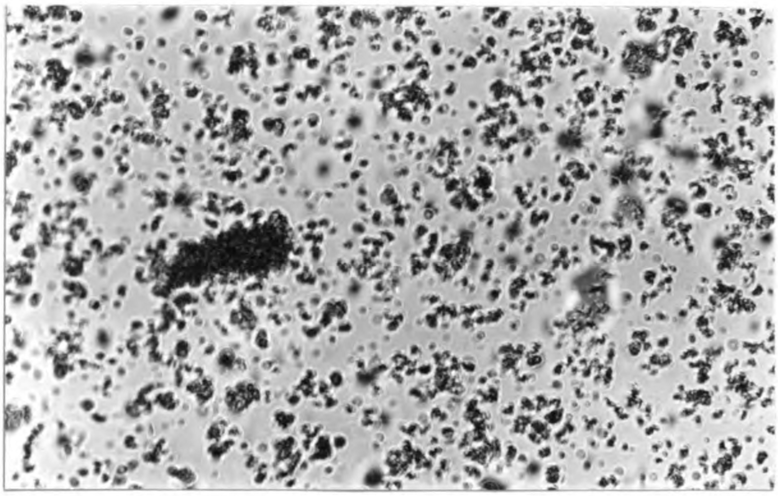


Plate XIV. Showing condition of fat globules as present in Mix VII (100% butter used as fat source)