FACTORS AFFECTING FAT LOSSES IN ICE CREAM PROCESSING

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Joshua W. Kearney, Jr.

1952

SIS

This is to certify that the

thesis entitled

Factors Affecting Fat Losses
in Ice Cream Processing

presented by

Joshua W. Kearney

has been accepted towards fulfillment
of the requirements for

M.S. degree in Dairy

Joseph A. Meiser Jr.
Major professor

Date December 2, 1952

O-169

FACTORS AFFECTING FAT LOSSES IN ICE CREAM PROCESSING

By

Joshua W. Kearney, Jr.

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Dairy

1952

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to the following:

Dr. Earl Weaver, Professor and Head of the Department of Dairy, for placing the facilities of the department at the writer's disposal.

Dr. J. A. Meiser, Assistant Professor of Dairy, under whose direction this work was done, for his helpful suggestions and constructive criticism throughout the course of this investigation, and for his invaluable assistance in the preparation of this manuscript.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Formerly ice cream was considered a confection rather than a staple article of our diet, but recently for many people ice cream has become a regular item of their daily diet. Consequently, the manufacture and sale of ice cream must be controlled as rigidly as milk. Most states and progressive municipalities have set up standards and regulations that insure the consumer a safe and wholesome ice cream. These standards and regulations are closely patterned after those which have successfully improved the quality of milk.

Ice cream standards as enacted in most statutes specify a minimum percentage of butterfat for all flavors. In many instances it is desirable to exceed these values by as much as three or four per cent, thus composition control from a legal standpoint is not a problem. However, the greatest percentage of this Nation's ice cream volume is placed on the market possessing a butterfat content that meets or slightly exceeds these minimum standards. It is exceedingly possible that marginal values such as these may sometimes fall below the legal standards. Although these violations may be unintentional, the product if discovered by enforcing agencies must be confiscated and proper legal action taken. Thus, to avoid unfavorable publicity and to maintain one's reputation, it is essential that manufacturers understand how processing procedures may give rise to compositional control problems.

REVIEW OF LITERATURE

Although many articles have been published relative to the analysis of ice cream, out of this numerous list only a few publications located to date deal with the effect of processing or handling practices on the fat content of the mix or of the frozen product.

MacBride (1925), investigating the Mojonnier testing of ice cream, called attention to the fact that the Mojonnier method for ice cream analysis gave a lower fat test with the frozen product than it did with the ice cream mix. The differences which he noted ranged from 0.1 to 0.6 per cent. The cause of these differences was thought to be churning in the freezer. The differences themselves were eliminated by placing a quantity of ice cream, in the frozen condition, into tared stoppered Mojonnier fat extraction flasks, allowing it to attain room temperature prior to weighing.

Crowe (1930), investigating the testing of ice cream for butterfat, stated that ice cream when once frozen churns extremely easy when the sample is mixed for analysis. He further stated that the ice cream must be melted below 27° C. to prevent melting of the fat and that the fat must not be churned before testing for the fat content.

Bird and Johnson (1931) studied the effect of processing, handling and testing procedures on the fat content of ice cream. They compared the fat content of ten mixes and the finished ice cream made from these mixes. The experiment is summarized as follows:

Samples of ice cream mixes were taken from the holding vat after homogenization, whereas frozen ice cream was obtained at the time batches were pulled from the freezer. Representative samples of retail material were obtained with a dipper from the packer when it was from one-third to two-thirds full.

When ice cream was sampled in the frozen condition, the fat tests agreed within 0.20 per cent or less with the analyses of the mixes, however the tests made on ice cream sampled in the frozen condition were lower in all cases than the mix analyses. No churning in the freezer was indicated when the mix, the ice cream, and the scrapings from the freezer wall and dasher were analyzed.

Johnson and Ormond (1937), in studying some of the factors influencing the fat content of ice cream mix and the corresponding finished product,found that excessive shaking of melting ice cream samples used for analysis caused fat separation which produced erratic variations in the tests with a tendency toward low results. The variations ranged from 0.05 per cent fat to as high as 0.50 per cent with an average of about 0.20 per cent. Also, vigorous agitation of the ice cream mix in the holding tank caused a concentration of fat and solids in the top layer of the mix and a reduction in the lower layer. Therefore, the accumulated foam layer had to be stirred into the ice cream and the agitation stopped just before drawing the mix to the freezer. They further concluded that condensation of moisture in the standardized ice cream mix and in the ice cream during freezing caused a fat reduction especially when the relative humidity was high, and when the frozen ice cream was delivered from the freezers to metal hoppers. Finally, the adding of color and flavor at the freezer caused a definite loss which could be calculated.

GENERAL PROCEDURES

The ice cream mix used in this study was prepared under commercial conditions in the Michigan State College Creamery. The composition of the mix was as follows: 12 per cent milk fat; 10.9 per cent milk solids-not-fat; 15 per cent sugar and 0.30 per cent gelatin.

The ingredients used in compounding the mixes were as follows:

1,487.5	pounds	of	3.5% milk
518.0	"	"	50% cream
134.0	"	"	skim milk powder
270.0	"	"	cane sugar
73.0	"	"	corn sugar
86.0	"	"	Sweetose
7.8	"	"	gelatin

With but one exception, the above ingredients were used throughout the study. The exception was a butter mix compounded as follows:

135.00	pounds	of	butter
087.25	"	"	skim milk powder
135.00	"	"	sugar
2.00	"	"	Dricoid
538.50	"	"	water

Processing the mixes. The mixes were prepared in 2,600 pound quantities and pasteurized at 160°F for thirty minutes into a 300 gallon Creamery Package Series B Steam Vapor pasteurizing vat. At the end of the pasteurization period, the mixes were homogenized in a Cherry Burrell Superhomo Homogenizer Model A 350C. The pressures used in homogenizing the mixes were 2,000 pounds per square inch on the first stage and 700 pounds per square inch on the second stage. Following homogenization, the mixes were cooled in a Creamery Package, plate type, heat exchanger. Immediately after cooling, the mixes were stored into a Pfaudler 600 gallon storage tank and held at 40°F.

Following aging, at 40°F for 24 hours, the mixes were removed from the storage tank and frozen in a 40 quart Creamery Package Fort Atkinson Direct Expansion Ice Cream Freezer. The mixes were frozen until the Draw-rite Controller read 6 amperes, at which time the ammonia was shut off. The temperature of the ice cream at this point was approximately 23.5° F. The ice cream was permitted to whip until an overrun of 90 percent was reached. At this point, the ice cream was drawn from the freezer and placed in the hardening room at -10°F.

Sampling and Analytical Method. Samples of the ice cream mix were taken directly from the flow of mix as the product passed over the cooler during the processing. Samples from the storage tank were taken from the top of the tank with a long handle dipper and those from the bottom were taken from the outlet valve. The ice cream samples were taken as the ice cream came from the batch freezer. All samples were collected in half pint milk bottles, sealed with sanitary caps and stored at 40°F until analyzed.

All analyses were made at room temperature. To insure proper mixing, the bottles containing the samples were rotated gently. Precautions were taken to agitate the samples as little as possible to prevent the churning of the samples. Five gram samples were immediately taken after mixing in lots of four by means of the Mojonnier 5 ml. pipettes. The pipettes were inserted to approximately one-third the depth of the liquid and the required amount drawn into the pipette. Following the procedures outlined by Mojonnier and Troy (1922), the samples were tested for fat and total solids.

PLAN OF EXPERIMENT

For a number of years there has been a belief among ice cream manufacturers that ice cream always tests lower in fat than the mix from which it was made. It was thought that the freezing operation caused a shrinkage in the fat content. From the previous assumption, there was a need for knowledge concerning the difference in fat between the ice cream mix and the finished product. A review of the literature disclosed only limited information regarding the variation in fat of the ice cream mix and the ice cream. Most of the available information had to do with testing of the ice cream for butterfat.

It was the purpose of this study to determine, if possible, the causes of any irregularities in the fat content which might result from processing and handling of the mix and of the frozen ice cream. Thus, this investigation was limited to the study of processing methods and their effect on the composition of the finished product. The mix used throughout the study was prepared according to the same formula, thereby eliminating any influence which may be attributed to change in the mix composition.

The nature of this study was divided into sections. Consequently, each section was devoted to determining the butterfat and total solids in ice cream at various stages of processing as follows:

I. Variation in the fat content of the ice cream mix passing over the cooler. Samples of the ice cream mix were taken as follows:

   A. The first mix over the cooler.

   B. When one-half of the mix was over the cooler.

   C. When two-thirds of the mix was over the cooler.

   D. The last mix over the cooler.

II. Distribution of butterfat in ice cream mix during storage.

   For this experiment, the storage tank was used. Samples were taken from the top and bottom of the storage tank as follows:

   A. From the top of the tank prior to agitation.

   B. From the bottom of the tank prior to agitation.

   C. From both the top and bottom of the tank following thirty minutes agitation.

III. The effect of agitation on the fat test of the mix.

   For this experiment the storage tank was used. Samples were taken from the top and bottom of the storage tank as follows:

   A. Prior to agitation.

   B. Following two minutes agitation.

   C. Following five minutes agitation.

EXPERIMENTAL

<u>Variation in the fat content of ice cream mix passing over the cooler</u>. In order to ascertain what reasonable variation might occur in the analyses of mix taken at different points in the manufacturing procedure, the mix was analyzed for fat and total solids as the product passed over the cooler. The samples were taken off the cooler as follows: Of the first mix out of the pasteurizing vat; after one-half of the mix was out of the vat; after two-thirds of the mix was out of the pasteurizing vat; and of the last mix out of the pasteurizing vat. The samples were tested for percentage of butterfat and total solids as previously described.

The ice cream mixes analyzed were compounded from cream and butter as the source of milk fat. Cream is used primarily because it is the best source from which to secure concentrated milk fat. However, when cream is not available, the milk fat may be secured from butter or butter oil. The materials used and the formula adopted vary with the individual manufacturer; consequently, both cream and butter mixes were analyzed.

The data presented in Tables I and II indicated that ice cream mix was not a homogeneous mixture as it passed over the cooler. The percentage of butterfat in the mix coming from the pasteurizing vat was in an ascending order

D. Following ten minutes agitation.

E. Following twenty minutes agitation.

IV. The effect of aging the mix on the composition.

For this experiment three cans of mix (ten gallons each) were set in the ante-room of the ice cream hardening room. The cans of mix were tested after one, two and five days as follows:

A. The top of the can.

B. After pouring off the top five gallons of mix.

C. The combined contents of the can.

V. Analysis of ice cream from the freezer as compared to that remaining on the dasher.

For this experiment, the batch freezer was used. Ice cream samples were taken from the first and fifth batches of ice cream as follows:

A. From the ice cream coming from the freezer.

B. From scraping off the dasher.

with the first mix from the vat testing lowest and the last mix testing highest. Butter mixes, which are the most difficult to process, exhibited the greatest variation in butterfat content.

Evidently there was a concentration of liquid butterfat on the top of the mix during pasteurization. This fat layer remained at the top of the mix even though the agitator of the pasteurizing vat was running. Since the ice cream mix passed from the bottom of the vat through the homogenizer over the cooler, the first mix to reach the cooler would possess the lowest percentage of butterfat. The largest variation in fat was observed when the butter mixes were processed.

The solids-not-fat content varied inversely to the fat with the exception of the first mix over the cooler. These data indicated that the solids-not-fat were concentrated in the middle section of the pasteurizing vat. The possible explanation of this may be attributed to the mix ingredients, since a portion of the milk solids-not-fat was supplied by roller process skim milk powder containing 97 per cent milk solids. The mixing of liquids, or liquids and powder, so that the end product is homogeneous presents a problem. The ice cream manufacturers attempt to overcome this obstacle by the use of an agitator. Since the force of an agitator is not always great enough to force sufficient solids to the top of the vat for a uniform distribution throughout, a low percentage of solids-not-fat may exist at the top of the pasteurizing vat.

The explanation for the decreased solids-not-fat in the bottom of the tank may be attributed to the position and force of the agitator. The agitator blades are located near the floor of the pasteurizing vat. The sweep of the agitator blades forces the solids upward, but not completely to the top of the vat. Therefore, a low percentage of solids is found at the bottom of the vat. Though, the agitator has done much to aid the ice cream manufacturers in their efforts to secure a homogeneous mix, it must be concluded that incorporation problems still exist.

TABLE I

VARIATION IN THE FAT CONTENT OF
ICE CREAM MIX PASSING OVER THE COOLER

BUTTER MIX

FAT BATCH I.

Sample No.	Sample Taken From	Triplicate Determination % Fat			Average %	*Variation %
I.	First Mix over Cooler	11.46	11.48	11.41	11.45	
II.	1/2 of Mix over Cooler	11.65	11.65	11.65	11.65	+0.20
III.	2/3 of Mix over Cooler	11.65	11.67	11.69	11.67	+0.22
IV.	Last Mix over Cooler	11.70	11.73	11.70	11.71	+0.26

FAT BATCH II.

Sample No.	Sample Taken From	Triplicate Determination % Fat			Average %	*Variation %
I.	First Mix over Cooler	10.66	10.60	10.60	10.60	
II.	1/2 of Mix over Cooler	11.44	11.44	11.40	11.43	+0.83
III.	2/3 of Mix over Cooler	11.87	11.88	11.85	11.86	+1.26
IV.	Last Mix over Cooler	12.07	12.06	12.08	12.07	+1.47

*Variation from test of first mix over cooler.

TABLE I (Continued)

VARIATION IN THE SOLIDS CONTENT OF
ICE CREAM MIX PASSING OVER THE COOLER

BUTTER MIX

SOLIDS BATCH I

Sample No.	Sample Taken From	Triplicate Determination % Solids			Average %	*Variation %
I.	First Mix over Cooler	37.40	37.63	37.46	37.49	
II.	1/2 of Mix over Cooler	38.82	38.76	38.53	38.70	+1.21
III.	2/3 of Mix over Cooler	38.75	38.68	38.58	38.67	+1.18
IV.	Last Mix over Cooler	37.42	37.63	37.56	37.53	+0.04

SOLIDS BATCH II.

Sample No.	Sample Taken From	Triplicate Determination % Solids			Average %	*Variation %
I.	First Mix over Cooler	40.09	40.04	40.15	40.09	
II.	1/2 of Mix over Cooler	41.49	41.81	41.67	41.65	+1.56
III.	2/3 of Mix over Cooler	41.88	41.79	41.60	41.65	+1.56
IV.	Last Mix over Cooler	40.94	40.46	40.73	40.67	+0.58

*Variation from test of first mix over cooler.

TABLE II

VARIATION IN THE FAT CONTENT OF
ICE CREAM MIX PASSING OVER THE COOLER

CREAM MIX

FAT BATCH I.

Sample No.	Sample Taken From	Triplicate Determination % Fat			Average %	*Variation %
I.	First Mix over Cooler	11.20	11.23	11.20	11.21	
II.	1/2 of Mix over Cooler	11.22	11.23	11.21	11.22	+0.01
III.	2/3 of Mix over Cooler	11.23	11.25	11.24	11.24	+0.03
IV.	Last Mix over Cooler	11.32	11.30	11.31	11.31	+0.10

FAT BATCH II.

Sample No.	Sample Taken From	Triplicate Determination % Fat			Average %	*Variation %
I.	First Mix over Cooler	12.18	12.17	12.13	12.16	
II.	1/2 of Mix over Cooler	12.23	12.22	12.21	12.22	+0.06
III.	2/3 of Mix over Cooler	12.26	12.28	12.27	12.27	+0.11
IV.	Last Mix over Cooler	12.33	12.29	12.28	12.30	+0.14

*Variation from test of first mix over cooler.

TABLE II (Continued)

VARIATION IN THE SOLIDS CONTENT OF
ICE CREAM MIX PASSING OVER THE COOLER

CREAM MIX

SOLIDS BATCH I.

Sample No.	Sample Taken From	Triplicate Determination % Solids			Average %	*Variation %
I.	First Mix over Cooler	38.73	38.35	38.46	38.51	
II.	1/2 of Mix over Cooler	39.83	39.70	39.70	39.74	+1.23
III.	2/3 of Mix over Cooler	40.10	40.30	40.20	40.20	+1.69
IV.	Last Mix over Cooler	38.80	38.47	38.63	38.60	+0.09

SOLIDS BATCH II.

Sample No.	Sample Taken From	Triplicate Determination % Solids			Average %	*Variation %
I.	First Mix over Cooler	40.27	39.31	39.67	39.75	
II.	1/2 of Mix over Cooler	40.26	40.37	40.42	40.35	+0.6
III.	2/3 of Mix over Cooler	40.88	40.79	40.69	40.79	+1.04
IV.	Last Mix over Cooler	40.29	39.26	40.03	39.89	+0.14

*Variation from test of first mix over cooler.

__Distribution of butterfat in ice cream mix during storage.__ Ice cream mix, though homogenized, may exhibit fat separation during post-processing storage. In order to obtain more complete information as to the degree of separation that may occur during storage and the effect of drawing the ice cream mix from the storage tank before starting the agitator or running a sufficient time, a study of the ice cream mix in the storage tank was undertaken.

For these data, the storage tank was used. The ice cream mix was processed as previously described and allowed to stand for twenty-four hours in a 600 gallon cold wall tank. Samples were taken from the top and bottom of the tank before agitation and after agitation for thirty minutes. The results of this observation are reported in Table III.

The results in Table III indicated that fat separation had taken place in the ice cream mix during the twenty-four hour storage period. The percentage of fat in the samples taken prior to agitation from the top of the storage tank averaged 12.60 percent; whereas the samples from the bottom averaged 11.81 percent, a difference of 0.79 percent. After agitating the mix for thirty minutes, the difference was reduced to 0.01 percent.

The solid content of the mix during storage as shown in Table III indicated a tendency for the solids to settle to the bottom of the tank. The percentage of solids taken from the top of the storage tank without agitation averaged 39.48 per cent; whereas the samples from the bottom averaged 41.75 per cent, a difference of 2.27 per cent. Agitation for thirty minutes reduced the difference to 0.02 per cent.

Separation presents a problem from a composition control standpoint, since the quality of the finished ice cream depends to a great extent upon proper mixing and blending of the ingredients used in compounding the ice cream mix.

TABLE III

DISTRIBUTION OF BUTTERFAT IN MIX
AFTER HOLDING 24 HOURS IN STORAGE TANK

Sample	Triplicate Determination % Fat			Average %	*Variation %
Top of Mix in Storage Tank	12.59	12.63	12.59	12.60	
Bottom of Mix in Storage Tank	11.77	11.85	11.81	11.81	-0.79
AFTER THIRTY MINUTES AGITATION					
Top of Mix in Storage Tank	12.09	12.11	12.12	12.11	
Bottom of Mix in Storage Tank	12.09	12.08	12.18	12.10	-0.01

DISTRIBUTION OF TOTAL SOLIDS IN MIX
AFTER HOLDING 24 HOURS IN STORAGE TANK

Sample	Triplicate Determination % Solids			Average %	*Variation %
Top of Mix in Storage Tank	39.40	39.58	39.46	39.48	
Bottom of Mix in Storage Tank	41.76	41.80	41.69	41.75	+2.27
AFTER THIRTY MINUTES AGITATION					
Top of Mix in Storage Tank	40.15	40.24	40.17	40.17	
Bottom of Mix in Storage Tank	40.15	40.24	40.19	40.19	+0.02

*Variation from test of mix in the top of storage tank.

The effect of agitation on the fat test of the ice cream mix. Previous experiments showed agitation prior to drawing the mix into the freezer to be essential for a uniform composition. In order to determine how much agitation is necessary, samples were taken from the top and bottom of the storage tank following twenty-four hours standing as follows: before agitation, after two minutes, five minutes, ten minutes and twenty minutes agitation.

Results in Table V indicated, as the agitation process continued, the percentage of fat at the top of the tank decreased with the time of agitation; while the percentage of fat at the bottom of the tank increased with the time of agitation. The percentage of fat continued to decrease at the top and increase at the bottom of the tank with the agitation until the tank had been agitated for thirty minutes. At this point, the variation in fat between the top and bottom of the tank was approximately 0.01 per cent indicating a uniform mixture.

The percentage of solids followed an inverse pattern of the fat. The top of the tank increased in solids while the bottom decreased. After agitating the mix for thirty minutes, the difference between the top and bottom was reduced to 0.02 per cent.

Study of the results in Table V indicates that there is a concentration of butterfat at the top of the mix during standing. When the agitator is started, the layer of fat is partially incorporated into the mix. As the agitation process proceeds, the fat and solids are thoroughly incorporated throughout the mix until a complete uniformity is obtained after thirty minutes agitation. Therefore, for a uniform ice cream, the mix should be agitated for at least thirty minutes prior to drawing the mix into the freezer.

TABLE IV

THE INFLUENCE OF AGITATION UPON
THE DISTRIBUTION OF FAT IN THE MIX

Sample	% Fat (Top)			% Fat (Bottom)			Average %		Variation % of Bottom from Top
							Top	Bottom	
Non-Agitated	12.90	12.92	12.87	11.32	11.35	11.42	12.89	11.36	-1.53
Two-Minute Agitation	12.77	12.80	12.79	11.54	11.61	11.58	12.79	11.57	-1.22
Five-Minute Agitation	12.57	12.60	12.55	11.71	11.73	11.78	12.57	11.74	-0.83
Ten-Minute Agitation	12.38	12.49	12.44	11.88	11.87	11.88	12.44	11.88	-0.53
Twenty-Minute Agitation	12.27	12.29	12.28	11.97	12.0	11.98	12.28	11.98	-0.30

TABLE IV

THE INFLUENCE OF AGITATION UPON
THE DISTRIBUTION OF FAT IN THE MIX

Sample	% Fat (Top)			% Fat (Bottom)			Average %		Variation % of Bottom from Top
							Top	Bottom	
Non-Agitated	12.90	12.92	12.87	11.32	11.35	11.42	12.89	11.36	-1.53
Two-Minute Agitation	12.77	12.80	12.79	11.54	11.61	11.58	12.79	11.57	-1.22
Five-Minute Agitation	12.57	12.60	12.55	11.71	11.73	11.78	12.57	11.74	-0.83
Ten-Minute Agitation	12.38	12.49	12.44	11.88	11.87	11.88	12.44	11.88	-0.53
Twenty-Minute Agitation	12.27	12.29	12.28	11.97	12.0	11.98	12.28	11.98	-0.30

TABLE IV (Continued)

THE INFLUENCE OF AGITATION UPON
THE DISTRIBUTION OF SOLIDS IN THE MIX

Sample	% Solids (Top)			% Solids (Bottom)			Average %		Variation % of Bottom from Top
							Top	Bottom	
Non-Agitated	39.33	39.29	39.30	41.97	41.90	41.88	39.31	41.92	+2.61
Two-Minute Agitation	39.37	39.40	39.39	41.79	41.83	41.87	39.39	41.83	+2.44
Five-Minute Agitation	39.50	39.54	39.51	41.64	41.60	41.66	39.52	41.63	+2.11
Ten-Minute Agitation	39.67	39.72	39.70	41.57	41.54	41.5	39.70	41.53	+1.83
Twenty-Minute Agitation	39.37	39.40	39.41	40.39	40.70	40.51	39.39	40.53	+1.14

The effect of aging the mix on the composition. There is a common practice among ice cream manufacturers to store ice cream mix in cans. This experiment was carried out to see if can storage of ice cream mix has any effect on the mix composition. For these data, three-ten gallon cans containing mix were placed in storage at 40°F. for prescribed periods. The samples for analysis were obtained following one, two, and five day holding periods. The samples were taken as follows: from the top of the can; then the top five gallons of mix were poured off and samples were taken from the bottom half of the mix remaining in the can; then, the two halves were combined and a sample taken.

An examination of results in Table IV indicates that fat separation had occurred within the cans up to the second day of storage. Following the second day, there was little or no change in the mix composition. The percentage of fat taken from the can after one day storage averaged 12.51 per cent for the top, 11.84 per cent after removal of the top half, and 11.92 per cent for the combined contents of the can. The difference in percentage between the top and combined contents of the can was 0.59 per cent, whereas the combined contents of the can differed from the mid-point of the can by a minus 0.07 per cent. Samples from the can after two and five days storage showed the same variation, 0.51 per cent for the top of the can and 0.14 per cent successively from the combined contents of the can.

As the storage period increased, the solids from the top of the can decreased; whereas the solids from the mid-point of the can increased for the first day, decreased for the second day and increased for the fifth day.

The data presented indicates that there is a separation of ice cream mix when stored in cans prior to freezing. The separation reaches its peak following two days storage, after which there is practically no change. The solids of the mix seem to decrease from the top of the can and increase at the mid-point.

TABLE V

DISTRIBUTION OF BUTTERFAT IN MIX
AFTER STORAGE IN TEN GALLON CANS

Sampled After 1 Day	Triplicate Determination % Fat			Average %	*Variation %
Top	12.53	12.49	12.50	12.51	+0.59
After Removal of Top Half	11.87	11.80	11.85	11.84	-0.07
Combined Content of Can	11.99	12.01	11.97	11.92	

Sampled After 2 Days	Triplicate Determination % Fat			Average %	*Variation %
Top	12.49	12.50	12.50	12.50	+0.51
After Removal of Top Half	11.85	11.87	11.83	11.85	-0.14
Combined Content of Can	12.00	11.98	11.99	11.99	

Sampled After 5 Days	Triplicate Determination % Fat			Average %	*Variation %
Top	12.47	12.44	12.47	12.46	+0.51
After Removal of Top Half	11.83	11.81	11.80	11.81	-0.14
Combined Content of Can	11.94	11.97	11.95	11.95	

*Variation from test of combined can contents.

TABLE V (Continued)

DISTRIBUTION OF TOTAL SOLIDS
IN MIX AFTER STORAGE IN TEN GALLON CANS

Sampled After 1 Day	Triplicate Determination % Solids			Average %	*Variation %
Top	38.55	38.52	38.48	38.52	-1.30
After Removal of Top Half	39.29	39.37	39.41	39.35	-0.47
Combined Content of Can	39.87	39.9	39.88	39.82	

Sampled After 2 Days	Triplicate Determination % Solids			Average %	*Variation %
Top	38.59	38.64	38.72	38.65	-1.22
After Removal of Top Half	39.54	39.49	39.55	39.53	-0.34
Combined Contents of Can	39.84	39.81	39.80	39.87	

Sampled After 5 Days	Triplicate Determination % Solids			Average %	*Variation %
Top	38.64	38.78	38.69	38.70	-1.08
After Removal of Top Half	39.0	39.13	39.21	39.11	-0.67
Combined Contents of Can	39.72	39.84	39.78	39.78	

*Variation from test of combined can contents.

__Analysis of ice cream from the freezer as compared to that remaining on the dasher.__ This experiment was designed to determine if there is a building up of fat on the dasher as the freezing process continues. For these data, samples were collected from the first and fifth batches of the ice cream as the ice cream came from the freezer. Samples were also collected from the dasher at the end of the first and fifth run. The results of this experiment are reported in Table VI.

An examination of the results in Table VI revealed a lowering of the fat content of frozen ice cream as successive batches are drawn from the freezer. This is offset by a continued building up of the fat around the dasher as the freezing process continues. From the data obtained, the average percentage of fat for the first batch, both the frozen ice cream and the scraping from the dasher was 12.01 per cent; whereas the samples collected from the fifth batch showed an average percentage of fat of 11.98 per cent for the frozen ice cream and 12.05 per cent for the scraping from the dasher, a difference of .04 per cent which indicates that the fat builds up around the dasher as the freezing process continues.

TABLE VI

ANALYSIS OF ICE CREAM FROM THE FREEZER
AS COMPARED TO THAT REMAINING ON THE DASHER

Sample Frozen Ice Cream	% Fat			Average %	Variation %
First Batch	12.0	12.03	12.01	12.01	
Fifth Batch	11.98	11.97	11.99	11.98	-0.03
SCRAPING FROM DASHER					
First Batch	12.01	12.01	12.03	12.01	
Fifth Batch	12.03	12.05	12.06	12.05	+0.04

Sample Frozen Ice Cream	% Solids			Average %	Variation %
First Batch	39.64	39.61	39.67	39.64	
Fifth Batch	39.65	39.62	39.69	39.65	+0.01
SCRAPING FROM DASHER					
First Batch	39.67	39.61	39.65	39.64	
Fifth Batch	39.67	39.63	39.65	39.65	+0.01

DISCUSSION

Since the percentage of butterfat in frozen ice cream is lower than that of the original mix, it indicates a loss of butterfat during the processing procedure. This experiment was designed to determine at what step or steps this loss occurred.

Analysis of mix coming from the pasteurization vat through the homogenizer indicated that ice cream mix is far from being a uniform mixture. The butterfat content varied from a low of 0.10 per cent for a cream mix to a high of 1.47 per cent for a butter mix. The total solids content varied inversely to the fat with the exception of the first mix over the cooler.

Secondly, the distribution of butterfat in the storage tank was not uniform. Analysis of results in Table III indicated that a separation of butterfat occurred after holding the mix for twenty-four hours in the storage tank. The difference between the samples taken from the top and bottom of the storage tank was in one instance as high as 1.53 per cent. Further, the results indicated that the total solids tend to settle to the bottom of the storage tank upon storage for twenty-four hours. The difference between the samples taken from the top and bottom of the storage tank was 2.27 per cent.

The use of cans as a method of storage for ice cream mix indicated a fat separation taking place within the cans. The results in Table IV indicated that this separation reached its peak at the end of the second day of storage. The difference in percentage of fat of samples taken from the top of the can and mid-point of the same can as compared to the combined contents of the can was 0.59 and minus 0.07 per cent respectively, for the first day of storage; whereas the samples taken the second and fifth days from the top and mid-point exhibited an 0.51 per cent and minus 0.14 per cent from the combined contents of the can. The solids at the top of the can tend to vary inversely with the storage period from the combined contents of the can; whereas the solids at the mid-point of the can tend to increase.

Agitation to insure uniformity of the mix held in vats or cans is essential. Samples were collected from the top and bottom of the storage tank after zero, two, five, ten, twenty and thirty minutes agitation. The results in Table V indicate that the percentage of butterfat at the top of the tank decreased inversely with the agitation; whereas at the bottom of the tank the percentage of fat increased with the time of agitation. After thirty minutes agitation, the variation in percentage of fat between the top and bottom of the tank was less than 0.01 per cent. The solids increased at the bottom of the tank with the time of agitation, until at the end of thirty minutes agitation, the difference between the top and bottom of the tank was 0.02 per cent.

The final tests indicated a building up of fat on the dasher as the freezing process continued and a corresponding reduction in the fat content of the finished ice cream. The average percentage of fat in the frozen ice cream from the first batch was 12.01 per cent and for the fifth batch 11.98 per cent, a difference of 0.03 per cent. The samples from the scraping of the dasher averaged for the first batch 12.01 per cent, and for the fifth batch the average was 12.05 per cent, a difference of 0.04 per cent.

Results of tests on the frozen ice cream and scrapings from the dasher indicated that there is a definite separation of fat within the freezer, and the separated fat concentrates around the dasher. The increased percentage of fat around the dasher accounts for the difference in the fat test between the mix and the frozen ice cream. If the ice cream mix is thoroughly agitated for at least thirty minutes before freezing to insure a uniform composition; the the lowered percentage of fat in the frozen ice cream is due to the separation of fat in the freezer. The separated fat concentrates around the dasher and is removed when the dasher is washed. The fat loss then is in the wash water used to clean the freezer after use.

In preparation of ice cream mixes, the ingredients should be combined in the pasteurizing vat and heated until all of the ingredients are completely suspended and thoroughly mixed. Following pasteurization, homogenizing and cooling, the mix must be collected in a storage vat and thoroughly mixed prior to freezing. Canning directly from the cooler is to be discouraged since considerable variations in the composition of mix as it passes over the cooler has been shown.

Should mix be held for indefinite periods, it must be agitated prior to drawing the mix into the freezer, whether stored in cans or tanks, for approximately thirty minutes to insure complete uniformity. There is, however, a limited extent of agitation, since it is possible to over-agitate, thus causing the mix to churn. If this occurs, the previous processing operations are rendered ineffective. When standardizing ice cream mixes to meet the minimum legal standards for butterfat, an extra 0.2 to 0.3 per cent of butterfat must be added in order that the percentage of butterfat of the frozen ice cream will be within legal limits. The addition of butterfat insures the ice cream manufacturers against losses due to churning in the freezer.

SUMMARY AND CONCLUSIONS

1. Ice cream mix is not a homogeneous mixture as it passes over the cooler. The butterfat passes over in an ascending order, while the solids are inverse of the fat with the exception of the first mix over the cooler.

2. Mixes compounded using butter exhibited greater compositional variation than those utilizing cream.

3. Separation of fat occurs during storage of the mix; the fat concentrates at the top of the mix whereas solids concentrate at the bottom of the mix, this separation reaching its peak after two days storage.

4. Agitation is essential to obtain a homogeneous mixture. The ice cream mix must be agitated whether stored in cans or storage tanks for approximately thirty minutes prior to freezing.

5. As the freezing process continues, there is a build up of butterfat around the dasher and remains in the freezer when the bulk of the ice cream is drawn from the freezer.

6. Mixes must exceed the minimum butterfat standard by 0.2 to 0.3 per cent in order that the frozen product will be within legal limits.

BIBLIOGRAPHY

1. Bird, E. W. and E. A. Johnson

   1931 The effect of processing, handling and of testing procedures on the fat content of ice cream. Iowa Agr. Expt. Sta., Bul. 287.

2. Crowe, L. K.

   1930 Testing ice cream for butterfat. Neb. Agr. Expt. Sta. Bul. 246.

3. Fisher, R. C. and Charles C. Walts

   1925 A comparative study of methods for determining the per cent of butterfat in dairy products. I. Ice Cream. Jour. Dairy Sci. 8: 54-60.

4. Johnson, J. J. and J. I. Ormond

   1937 Some factors influencing fat content in ice cream and the corresponding finished ice cream as determined by the Mojonnier Method. Jour. Dairy Sci., 20: 159-164.

5. Maack, A. C. and P. H. Tracy

   1940 A method for the accurate sampling of ice cream. Jour. Milk Technology. 3: 123-125.

6. MacBride, C. S.

   1925 A detail in Mojonnier testing of ice cream. Intern. Assn. Dairy Milk Inspectors Ann. Rept. 14: 177-178.

7. Mojonnier, T. and H. C. Troy

   1925 The Technical Control of Dairy Products. 2nd Ed. Published by Mojonnier Brothers Co., Chicago, Illinois