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A study of Massachusetts ice cream

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A STUDY OF MASSACHUSETTS ICE CREAM

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Massachusetts Ice Cream

By

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INTRODUCTION.

The ice cream industry in the United States has grown steadily since its humble beginning in about 1851 to the present time. During the years from 1910 to 1930 there was an annual increase in production of over two hundred million gallons, which in 1930 reached a total production of over three hundred twenty-four million gallons.

The per capita consumption of ice cream has likewise increased. In 1910 there were 1.04 gallons consumed per capita and in 1929 there were 3.0 gallons consumed. The following figures give the per capita consumption of ice cream in the New England States and their rank in the United States according to per capita consumption and also a few of the leading ice cream consuming states.

State.	Gals. Consumed per capita 1930	Rank.
Maine	2.82	22
Vermont	2.88	20
New Hampshire	2.38	28
Massachusetts	3.49	8
Rhode Island	2.43	27
Connecticut	2.99	19
Dist. of Columbia	7.03	1

State.	Gals. Consumed per capita 1930.	Rank.
Pennsylvania	5.38	2
Wisconsin	4.21	3
Delaware	3.91	4
Illinois	3.75	5
California	3.73	6
New Jersey	3.62	7
New York	3.29	14
United States	2.82	

Although Massachusetts ranks eighth among the States of the Union in the number of gallons of ice cream consumed per capita there are still possibilities of increasing this amount.

The average person, however, has no way of telling whether ice cream is wholesome or safe, and must place confidence in state legislation, public health agencies and the reputation of the manufacturer.

The ice cream maker is entrusted with the production of one of the most nutritious and delicious foods in the American diet. The increasing demand for ice cream as a food for children and for the sick makes it imperative that the ice cream maker take every possible precaution to produce a safe product. He

should use every effort to increase the popularity of his product by offering to the public ice cream that merits its confidence. This means that ice cream must contain not only the proper proportion of ingredients and have a smooth texture and pleasing flavor, but it must be made from the best grade of raw products and handled with all sanitary precautions.

In my judgment, a law providing for a definite percentage of milk fat in ice cream is necessary because of the importance now ascribed to this ingredient in ice cream. Its presence imparts a smoothness and richness to the ice cream not obtained by the use of any other ingredient. The use of small amounts of milk fat lessens the food value of ice cream and brings about unfair competition between the manufacturers. A milk fat standard not only protects the consumers' dollar but puts the manufacturers on an equal basis.

At the present time California is probably the only State that requires that ice cream contain a definite amount of food value per gallon. This law was the result of the incorporation of excessive amounts of air in ice cream by some manufacturer. California now requires 1.6 pounds of food solids per gallon of

ice cream. What people want is food value as well as a pleasing taste, and through the working of this law they are assured of a definite amount of food solids.

The increasing consumption of ice cream is bringing it under the observation of health officers. For some time a chemical standard has existed and some States are contemplating the establishment of a bacteriological standard for ice cream. A chemical standard protects against adulteration but not against lack of sanitation.

Until recently the thought of bacteria in ice cream held little attention. The bacterial content of milk has for years been used as a criterion of quality. A common idea has been held by many that the temperature necessary to keep ice cream in a frozen condition was too low for bacteria to live. This, of course, is a mistake. Ice cream which is made of poor quality ingredients and is carelessly handled and processed in unsterile utensils will contain numerous viable bacteria. Therefore, a bacterial standard is needed.

Pathogenic bacteria will survive for varying periods of time. According to Mitchell[40] B. typhosus

survived in ice cream for twelve to thirty-nine days. Prucha and Beaman[50] found that B. typhosus survived for two years and four months at 40 degrees F. and they made this statement, "At the end of one year about one germ out of every thousand survived, and at the end of two years one germ out of every ten thousand survived."

It now is an accepted fact that numerous outbreaks of disease, such as typhoid fever, diphtheria, scarlet fever, diarrhoea and other intestinal disturbances have definitely been traced to contaminated ice cream.

Although most of the bacteria in ice cream, as in milk, are harmless the conditions responsible for large total numbers are the conditions most likely to result in the presence of harmful types or objectionable products of growth.

Bacteriological standards, as well as chemical standards, have been almost universally accepted for milk. Standards of this type are being considered as a means of improving the quality of ice cream. Already some States of the Union have adopted bacteriological standards for ice cream and they are helping to improve the product.

Aside from bacteria content there are also other factors to consider in a study of the quality of ice cream. Turnbow and Raffetto[64] state that texture, more often than any other factor listed on the score card, is a source of complaint. Only a discerning individual may decide when an ice cream is off flavor, but anyone can tell when it is rough or sandy.

Inasmuch as there are certain defects that can readily be noticed by the average consumer in the body and texture of ice cream a study of them is important. Turnbow and Raffetto[64] list the body and texture defects as follows: Doggy, coarse, weak, sticky, watery, sandy, lumpy, fluffy, buttery, icy and crumbly. The flavor defects are also important since they are at times so outstanding that they become offensive even to the average consumer.

This study was undertaken:

1st. To determine as accurately as possible the quality of New England ice cream.

2nd. To compare it with ice cream from other districts.

3rd. To furnish information which will aid the manufacturer and public health worker in the

setting up of a minimum standard for ice cream.

REVIEW OF PREVIOUS WORK.

Judkins[35] found that none of the plants in New England could guarantee to sell to their dealers five-gallon cans of vanilla ice cream that would weigh within one pound of each other. He also found it would require extreme vigilence to abide by a minimum weight per gallon law. The plants as a whole using the hopper system were turning out ice cream having the most uniform weight.

Smith and Gunness[60] found the commercial ice cream of New England to have a fat content of approximately 12 percent, they also found that more emphasis should be placed on the sanitary aspect of the manufacture of ice cream. Refrigeration in many plants was found to be inadequate.

The shrinkage of ice cream when dished from bulk containers averaged about one-third of its original volume according to Hillips[51]. He also concluded that the ice cream spoon was the most practical dishing tool.

The work of some investigators in other States on factors that affect the quality of ice cream will also be reviewed.

Davis[14] came to the conclusion that hemolytic streptococci remain alive in ice cream for at least

eighteen days without any appreciable diminution in number or virulence.

According to Mitchell[40] B. typhosus survived in ice cream from twelve to thirty-nine days. Prucha and Beaman[50] found that B. typhosus survived for two years and four months at 40 degrees F.

The following table shows the number of cases of the various diseases that have been traced to ice cream and gives the authority for each investigation.

Disease	Cases	Investigator
Scarlet Fever	*Epidemic	Buchanan[6]
" "	116	Ramsey[52]
Typhoid	*Epidemic	Turner[63]
"	"	Munro[44]
"	25	Hope[30]
"	19	Barras[4]
"	29	Cummings[10]
"	118	Delepine[12]
"	20	Russell-Trivol[59]
"	350	Lumsden[36]
"	75	"

*The exact number of cases not available.

Disease	Cases	Investigator.
Typhoid	57	Waterman[65]
"	42	"
"	128	Hamilton[29]
Diphtheria	402	McCoy & Others[41]
"	6	" "
"	9	" "
Diarrhoea	146	Henry[33]
"	18	Collinridge[9]
Unknown	40	Hamilton[29]
Gaertner Group	52	Robertson[54]
Enteritidis	67	Peacock[49]
Scarlet Fever	9	Ramsey[52]
"	3	"
"	100	A. J.P.A.[55]
"	1051	"

Fabian[19] found the number of bacteria per gram in ice cream ranged from 26,597 to 15,006,622. In ice cream other than vanilla Hammer[30] found the number of bacteria per c. c. ranging from 130,000 to 40,850,000. Samples of ice cream that were sent into the annual ice cream scoring contest held each year from 1921 to 1927 were studied for bacterial content and according to Fay and Martin[21] the number ranged from 2,000 to 47,000,000.

The number of bacteria in ice cream is extremely variable due primarily to variations in the quality of the materials used and the care taken in the manufacture and handling. Under very good conditions of production the count may be as low as 1,000 per c. c. while with careless methods it may be in the millions.

The work of Newman and Reynolds[46] includes the following table giving the bacterial content of various ingredients.

Ingredient.	Average Bacteria per gram.
Eggs, frozen yolks	250,000
Eggs, fresh	200,000
Eggs powdered	4,000,000
Milk Evaporated	400
Skim Milk Sweetened Condensed	609,000
Powdered skim milk	75,000
Skim milk evaporated	100,000
Gelatine	250
Gums	8,000
Improvers	5,000
Sugar	250
Cocoa syrup	2,500
Cocoa powdered	5,000

According to Fay and Olsen[22] milk and cream proved to be responsible for over 99 percent of the bacteria that were present before pasteurization. It is not unusual to find millions of bacteria per cubic centimeter in cream. When such a product goes into the mix, even a pasteurizing efficiency of 99 percent cannot elliminate high count ice cream.

If contaminated equipment and inefficient methods are used in manufacturing ice cream, even though the ingredients of the mix are of high quality, the finished product will be of an inferior grade.

All equipment in the ice cream plant is a source of contamination and must be so considered.

Hammer and Cosa[30] in studying the contamination of a freezer by adding sterile water to the freezer and then operating at about the same speed, capacity etc., as in freezing ice cream found that the bacteria counts of the water ranged from 300 to 141,500, whereas, according to Ellenberger[17] the bacterial count of a thoroughly steamed freezer was from 10 to 55. Fay[24] reported a case where before freezing the count of the mix was 26,000, and after

625,000. This may be due, to some extent, to the breaking up of the bacterial clumps.

According to work done by Fabian[20] bacterial contamination of ice cream from the air is insignificant.

The employees in the ice cream plant are one of the sources of bacteria in the finished product. The organisms from this source are more objectionable because of the possibility of pathogenic types. The extent of contamination depends principally on the personal habits of the employees.

Fay[23], Olsen[23] and Fabian[20] all agree that 150 degrees F. for 30 minutes is the most desirable pasteurizing temperature, for ice cream mix.

Homogenization of the mix has some effect on the bacterial content of the ice cream. In nearly every case there is an increased number of bacteria in the mix after homogenizing, according to the plate count. Fay and Olsen[23] say this increase reaches 26 percent, yet a majority of investigators believe this increase is more apparent than real. It is due to the breaking up of the clumps of bacteria. Of course, unsterile equipment will always increase the bacteria count. The homogenizer should be taken apart

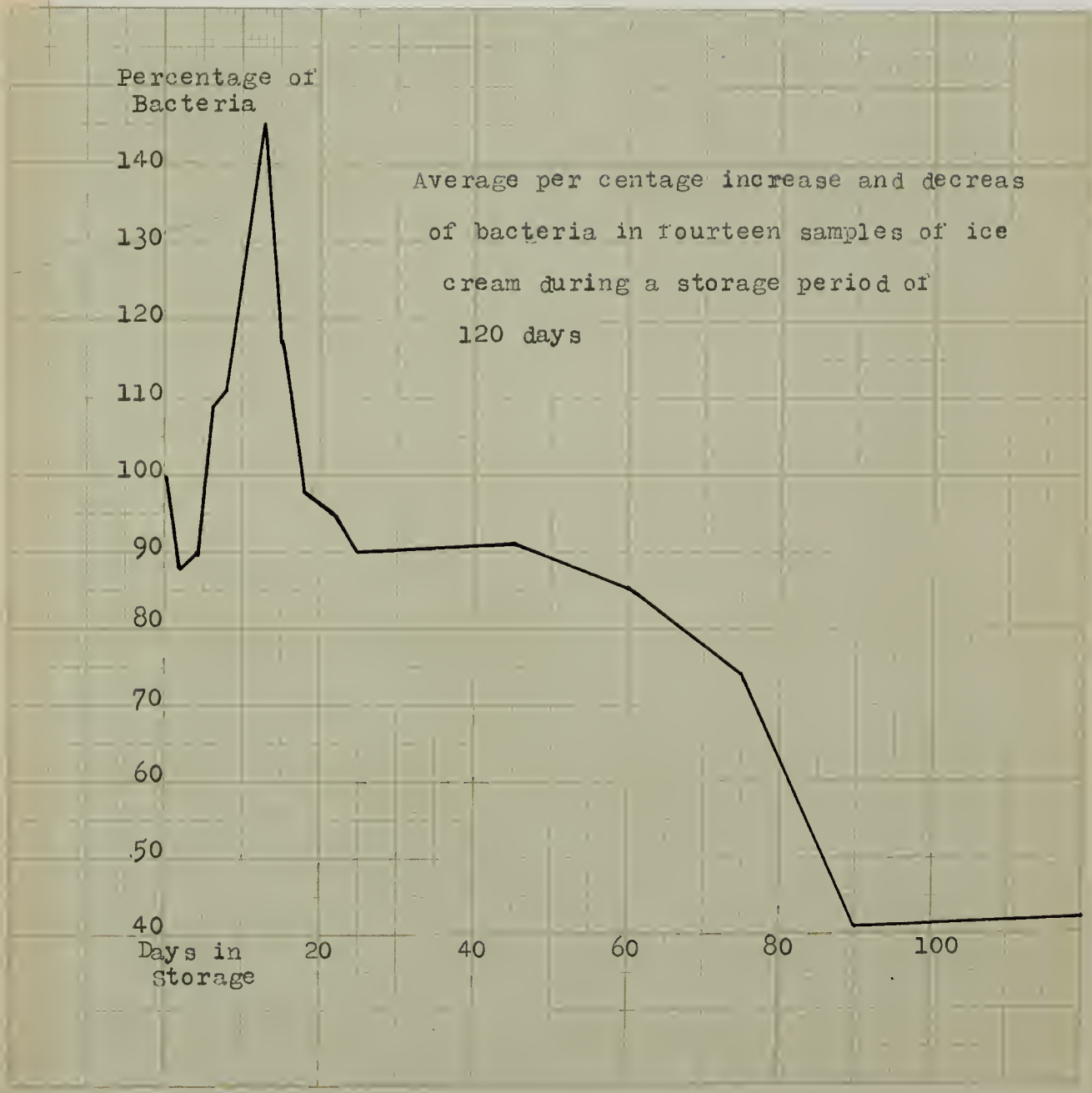
and parts coming in contact with the mix should be thoroughly scrubbed and sterilized.

Hammer and Saunders[32] say that the bacterial increase during aging is due to insufficient cooling after homogenization and also to lack of stirring the mix during the aging period. A temperature of 45 degrees F. should be reached before aging begins.

The freezing process is the next step in the manufacture of ice cream and, according to the plate count this is similar to the homogenizing process, in the effect on bacterial content. In freezing there are two sources of increasing the count. The freezer itself is a source of contamination. Even if a sterile freezer is used in freezing the ice cream the plate count may indicate an increase in the number of bacteria in the ice cream, but this, no doubt, is due to the breaking up of the clumps of bacteria.

Most investigators have agreed that the bacteria count of ice cream during the hardening period is decreased slightly; then a slight increase, followed by a gradual decrease (Ellenberger)[17].

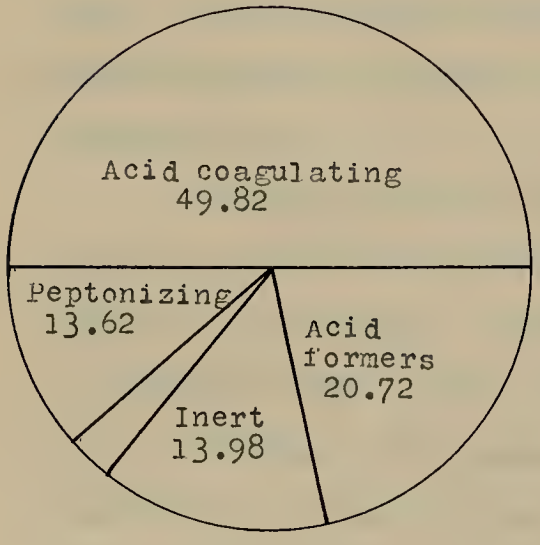
Hammer and Goss[30] studied the effect of softening and rehardening ice cream. They found that


Percentage of Bacteria
140
130
120
110
100
90
80
70
60
50
40
Days in Storage
20
40
60
80
100
Average per centage increase and decreas of bacteria in fourteen samples of ice cream during a storage period of 120 days

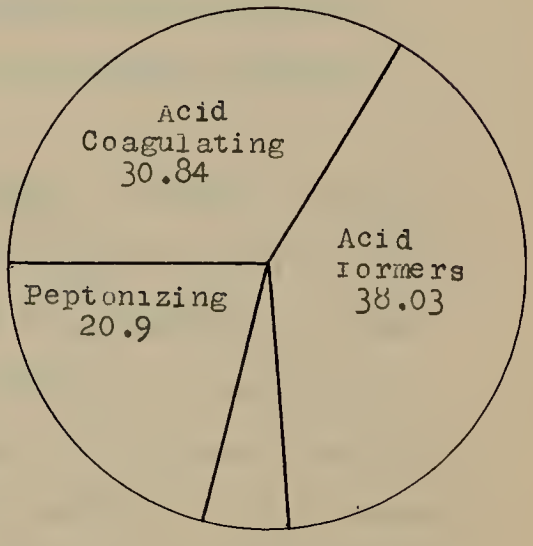
an increase in bacteria seemed to be more common in ice cream which was only slightly softened while a decrease followed pronounced softening.

The following chart from Ellenberger[17] shows the bacterial content of ice cream during the storage period.

A study of the groups of bacteria found in summer ice cream and winter ice cream was made by Ayers and Johnson[2] with the following results:



Summer Months



Winter Months.

A comparison of the above shows that the percent of alkali and peptonizing groups are larger in winter, but actually there were smaller numbers of bacteria in ice cream during the winter season on account of a lower total number of bacteria during cold weather.

The inert group is of little interest because they produce no apparent change in milk,

and in all probability the same is true in ice cream.

The alkali forming group of bacteria is made up of organisms capable of producing an alkaline reaction and no other apparent change in litmus milk during 14 days at 30 degrees C. This group does not include bacteria which produce an alkaline reaction together with visible signs of peptonization.

The peptonizing group is probably the most interesting if not the most important group of bacteria in ice cream. This group consists of what are commonly known as the putrefactive bacteria, or those that attack the proteins decomposing them into less complex organic bodies. Bacteria of this class are usually considered undesirable in articles of food and it is to some of them that intestinal troubles are sometimes attributed.

The importance of the colon aerogenes group in determining the quality of ice cream is a question that is still debated to some extent. A number of investigators have found that a majority of these organisms have as their source the hands of the operators. A recent article by Buice, Schested and Nienst[8] reported 337 tests made on the hands of 251 food

handlers. They found 67.7 percent of the total number showing lactose fermenting aerobes, 8.4 percent of the total proving to be of intestinal origin. Close attention to personal hygiene would reduce the danger of contamination.

From the above material, we should be able to observe one point which seems to be well established: We should do everything in our power to keep the number of bacteria in ice cream down to the very minimum.

According to Fabian[19] it is possible and desirable to produce ice cream with a plate count of not more than 100,000 bacteria per gram. A low bacteria count in ice cream is very important because of the increased safety and desirability of the product.

Fay and Olsen[23] say: "Ice cream can be produced under commercial conditions having a bacteria count of less than 25,000 and in many cases less than 10,000 per gram."

As early as 1910 Buchan[7] suggested a bacteriological standard for ice cream. He says: "Ice cream should not contain more than 1,000,000

organisms per cubic centimeter capable of growing on nutrient agar." Hoy[23] after analyzing 115 samples of ice cream concluded that the high percent of samples containing 100,000 bacteria or less per gram indicated that this figure would not be unfair to the Kansas producer as a bacterial standard.

The following States have a standard requiring that ice cream shall not contain over:

California	150,000	bacteria per c. c.
Idaho	150,000	" " "
Connecticut	100,000	" " "
Pennsylvania	250,000	" " "
Iowa	250,000	" " "

The Iowa standard refers to pasteurized foods only.

Several states have the same standard but others have a standard varying between the two mentioned. Just what effect the varying percentages of fat may have in connection would be difficult, if not impossible, to determine. The manufacture of rich ice cream must affect the selling price and this increase would probably cut sales. There is another advantage of low fat ice

cream inasmuch as such ice cream carries an increased amount of skim milk solids, thus stimulating the production and sales of skim milk concentrates. The proponents of high fat ice cream hold that the increased quality of the resulting ice cream increases sales.

Nelson and Reid[48] conclude that the fat content of ice cream has no effect upon its hardness, but that the rate of melting increased with decreased percentages of fat in a uniform manner. They also state that considerable difference in the body, texture and flavor was introduced by the increased percentages of fat and that a mix containing 10 percent fat appears to result in the most desirable ice cream. Ice cream with 14 percent or more fat gave a pronounced butter fat after-taste and a coating of grease in the mouth.

Williams[67], Campbell[67], Washburn[66], and Baer[3] agree that ice cream with high fat content is often preferred to ice cream with low percent of fat.

The amount of butter fat to use is governed by many factors, such as price, legal standards and customer preference. It would be difficult to suggest

an amount of fat which would fit all cases according to Doble[11] and Sommers[61].

Butter fat should be in balance with the serum solids of the mix to give the best results. It is often possible to obtain a high quality of ice cream from a mix lower in fat content than another mix of higher fat content, if the proper balance between the fat and serum solids is maintained. Butter fat probably has more effect on the properties of ice cream than any other constituent. According to Mack[39] the flavor improves with additional increments of fat until about 16 percent is reached. Above that concentration it is doubtful if further increases improve flavor.

Lucas and Roberts[37] say that a 10 percent fat ice cream is best with a 10 percent serum solids mix. As the serum solids decrease the fat should increase but not in the exact proportion.

Williams and Campbell[67] state that of 443 sales 56 percent preferred 12 percent serum solids for a 9 or 6 percent serum solids cream.

Fisher[25] in a series of tests found that the serum solids had little effect upon flavor until 12 percent was reached when the flavor of the ice cream deteriorated with additional serum solids.

The body and texture of ice cream was markedly improved by serum solids up to 10 percent, from 10 to 12 percent there was no effect and beyond 12 percent the body became soggy and the texture sandy. Lucas and Roberts[37] state the greatest effect of non-fatty solids of milk and milk products is noted in the quality of the resulting ice cream. A 10 percent fat ice cream carrying 6 percent milk solids not fat is very noticeably deficient in solids. The ice cream is very light, fluffy and coarse in texture. An increase to 8 percent of serum solids improved the cream very appreciably, but not to the extent desired in a good quality product. The cream that carried 10 percent of milk solids not fat scored highest in each case. It possessed smoothness of texture and firmness of body and, after a period of storage, did not sink in the can.

Mack[39] further states that serum solids are high in food value and cheap in cost and solids contribute to the body and texture by making the product more compact and smooth. Therefore, as much serum solids as possible should be added without getting into the danger zone for sandiness. In order to prevent sandiness in ice cream the concentration

of the lactose should be kept below 9 percent in the water of the mix. To keep below this point, according to Lucas and Spitzer[38] the serum solids content should be under 12 percent.

Hall[28] has this to say on the subject, "Comparison of the solubility curves for lactose and the unfrozen water curves for ice cream show that lactose should crystalize from the ice cream when the percentage of serum solids was 12 or more. Microscopic examination of sandy ice cream showed lactose crystals to be present. Mechanical and heat shocks hastened their development. Pasteurization of the mix to thoroughly dissolve all ingredients, low serum solids, high percentages of other solids, and uniform temperature of storage are aids in preventing sandiness."

Turnbow and Raffetto[64] say concerning body and texture defects in ice cream. "If insufficient air is incorporated, a soggy, heavy, doughy body results which is unpalatable and objectionable to the trade. The higher the percentage of solids in the mix, the smoother the product, all other things being equal. A low solids ice cream is prone to be coarse and grainy, although it may be heavy in weight per volume and still may not

be soggy, since the percentage of total solids may be low while food solids per volume are normal because of the percentage of yield obtained. Low solids ice cream mix is quite prone to form ice crystals."

If an excess of milk solids not fat is put into the mix and pasteurized, a super-saturation of lactose will exist. Since lactose is the most insoluble sugar in ice cream, it is the first one to crystalize, forming hard, quite insoluble crystals.

It was observed that the high sugar content ice creams kept fresher in the hardening room and were firmer in body and closer in texture.

According to Mack[39], the practice in the past of adding .5 percent gelatin to the mix resulted in an over stabilized condition in nearly all ice creams. The tendency at present is to reduce the amount of gelatin to the amount actually needed, which depends largely upon strength of the gelatin, fat content of the mix and processing method.

California now has a law requiring 1.6 pounds of total food solids to the gallon of ice cream. Previous to this legislation there had been some agitation for a weight per gallon standard or a yield controll

ing measure. The foods solids per gallon must be considered when establishing a weight standard. The California standard of 1.6 food solids per gallon is a desirable regulation, according to Reynolds.[58]

EXPERIMENTAL PROCEDURE.

The following questionaire was sent to milk inspectors in the cities from which ice cream was secured for this study. The inspectors obtained from the manufacturer the information requested in the questionaire and a pint sample of vanilla ice cream.

Questionaire.

Sample No._____ Date_____

Name of Inspector_____Address_____

Manufacturer's Name_____Address_____

When was this ice cream made?_____

What is your annual output?_____

Do you make your own mix?____If not, who makes it?____

Check the materials that you use in your ice cream:

Milk___Whole Milk Powder___Egg Powder___Cream___Butter__

Raw Eggs___Skim Milk__Gelatin__Gums__Skim Milk Powder___

Cornstarch___List other ingredients used_____

What pasteurization temperature do you use?_____

What homogenization pressure?_____Temperature_____

What type freezer do you use?_____

The ice cream samples were packed with dry ice in corrogated paper boxes, sealed with gummed paper and sent via parcel post with special delivery and handling

instructions. This procedure insured the delivery of the ice cream in less than twenty-four hours.

Upon arrival the ice cream samples were placed in the college ice cream hardening room, where a temperature ranging from 0 to 5 degrees F. is maintained.

In order to have the analysis made under uniform conditions the samples were left in the hardening room until they were approximately 14 days old.

The number of bacteria in the ice cream was determined by two methods: The Standard Agar Plate method and the Direct Microscopic method each slightly modified.

The viable organisms in ice cream, in which we are most interested were determined by the plate method which was carried out according to "Standard Methods of Milk Analysis", 5th edition, with the following deviations:

1st. Sterilized cheese triers were used to take ice cream from the sample. The ice cream at the top of the plug was discarded by cutting it over the edge of the lower half of a sterile petri dish, so that it fell outside the dish. The ice cream was then melted rapidly over a hot water bath, but without heating it above 40 degrees C. The melted portion was gently agitated to distribute the bacteria evenly. In order to exclude air bubbles in pipetting, the tip of the pipette

was placed at the bottom of the sample of melted ice cream.

2nd. The plating medium used was that recommended in "Standard Methods of Milk Analysis", slightly modified by the addition of one percent sucrose. The modified medium contained the following ingredients:

Agar - - - - - - - 1.5%
Beef Extract - -0.3%
Peptone - - - 0.5%
Sucrose - - -- 1.0%
Distilled water

According to Hammer[32] the discrepancies that often occur in bacteria counts between different dilutions of the same sample of ice cream are greatly reduced by the addition of one percent of sucrose to the standard agar. The addition of sucrose to the medium facilitates counting by increasing the size of the colonies.

3rd. The dilutions used were 1-100, 1-1,000, 1-10,000, and 1-100,000.

4th. The Buck Colony Counter, manufactured by J. A. Fries and Son, Baltimore, was used in counting the bacteria. This counter has a Jeffer plate which is constantly and uniformly lighted by an electric bulb and

two rotating reflectors providing adjustment for proper illumination. The magnification required by the American Public Health Association is obtained in this counter by a special lens which also keeps the whole surface of the counting area within vision. This counter is recommended for counting pin point, transparent and opalescent colonies without confusing them with agar precipitates or bubbles.

Hammer[31] says, "A microscopic count in addition to a plate count on a sample of pasteurized milk may supply valuable information with reference to the number of bacteria present before heating and also help to explain the cause of unsatisfactory pasteurization by showing the general morphologic types of organisms present." The microscopic count was made in conjunction with the plate count to determine if this information could be secured about ice cream.

Instead of spreading .01 c.c. of melted ice cream over 1 square centimeter .03 c.c. of sterile distilled water was mixed with .01 c.c. of the melted ice cream and spread over 6 square centimeters of surface. The melted ice cream with a composition of 12 to 25 percent fat and 30 to 40 percent total solids, was thus reduced to proportions making it possible to obtain a satisfactory smear.

Newman's[45] methylene blue stain was used in preference to Loeffler's in preparing the smears because the removal of fat and the fixing and staining of the film are accomplished with one reagent, but with Loeffler's stain 3 solutions are needed, thus a saving in time and equipment is obtained by using Newman's stain. Newman's stain was also preferred to the Breed method because the smears thus produced are more free from participated material. According to Newman[45] six months trial under practical field conditions has demonstrated that this solution may successfully be substituted for Breed's[5] method in the examination of milk. The Newman stain has the following ingredients:

Tetrachloroethane(Tech.) - -	40 ml.
Ethyl Alcohol - - - - - - -	54 "
Methylene Blue Powder - - -	1 gm.
Acitic Acid - - - - - - - - -	6 ml.

The difficulty encountered in distinguishing organisms of the coccus form from debri or precipitated material in the stain was lessened by reducing the diameter of the microscopic field from .205 m.m. to .146 m.m.

The Mojonnier[43] test was used in determining the butter fat and total solids content of the ice cream.

SCORING.

All samples examined by the judges were scored according to the following points: Perfect flavor 50 points, perfect body and texture 25 points, and the score for viable bacteria was given as follows:

Bacteria per c.c.	Score.
Under 50,000	20
50,000 to 100,000	19
100,000 to 150,000	18
150,000 to 200,000	17
200,000 to 250,000	16
250,000 to 300,000	15
300,000 to 350,000	14
350,000 to 400,000	13
400,000 to 450,000	12
450,000 to 500,000	11
500,000 to 550,000	10
550,000 to 600,000	9
600,000 to 650,000	8
650,000 to 700,000	7
700,000 to 750,000	6
750,000 to 800,000	5
800,000 to 850,000	4
850,000 to 900,000	3

Bacteria per c.c.	Score.
900,000 to 950,000	2
950,000 to 1,000,000	1
Over 1,000,000	0

Therefore, a perfect score would be:

Flavor - - - - - - - - -	50
Body and Texture - - -	25
Bacteria - - - - - - - -	20
Total	95

Discussion.

The data presented in this paper were secured from two sources:

1st. Correspondence with dairy officials in various states.

2nd. From analysis of 146 samples of ice cream secured from 12 cities in Massachusetts.

A bacterial standard of 150,000 bacteria per gram when sold by the manufacturers was adopted by California in 1927. A survey at that time revealed that only 55 percent of the ice cream analyzed was under the standard of 150,000. Surveys made since that time are as follows:

Survey	Percent Samples Legal.
1st, 1927-28	55.0
2nd, 1928	64.0
3rd, 1929	70.0
4th, 1930	73.4
5th, First 6 months of 1931.	79.0

The above data are compiled on the basis of all samples from all factories in the state, including those making 1,000,000 gallons annually, and those making only a few hundred gallons.

Mr. McDonald[42], Chief of the Bureau of the Dairy Control of California states: "On a volume

basis I feel safe in stating that 98 percent of the ice cream manufactured in California is coming well within the limit of 150,000 bacteria per gram. It is interesting to note that this improvement has been accomplished without the necessity of any legal action. Results of bacteria counts have in the past been used as a guide for detailed inspections rather than as a basis for prosecution. However, we feel that the manufacturers have had ample time to familiarize themselves with the necessary equipment and precautions essential to the manufacture of a quality product and we are using somewhat more drastic means of bringing about improvement."

Since 1930 the State of Connecticut has had a bacterial standard of 100,000 bacteria per c. c. Table No. 1, shows analysis of 433 samples of ice cream made in Connecticut from May 9, 1930 to January 1, 1932. At the present time there are no figures available that will show the condition of the ice cream at the time the standard was adopted, therefore, to discover the improvement made in reducing the number of bacteria in ice cream since the adoption of the standard in Connecticut is impossible. However, the statement of the milk

inspector is as follows: "We are rather proud of the showing that our manufacturers have made during the first year's work on the bacteria question."

Table No. 1.

Bacterial Analysis of 433 samples of ice cream made in Connecticut from May 9, 1930 to January 1, 1932.

Bacteria per c. c.	Percent of Samples.
Under 1,000	0.69
1,000 to 10,000	16.00
10,000 to 50,000	29.79
50,000 to 100,000	14.30
100,000 to 250,000	14.30
250,000 to 500,000	9.94
500,000 to 1,000,000	6.69
Over 1,000,000	7.85
Under 100,000	61.20
Over 100,000	38.80

Michigan has a bacterial standard of 150,000 per c. c. Although there are no figures to show the improvement, the Director of the Bureau of Dairying makes this statement: "The standard has been a means of greater improvement than we had

anticipated, and it has been surprising to note that it is possible to detect unsanitary conditions in the plant by means of the count. This seems to be more the case with ice cream than it has been with milk and the counts of the ice cream plants do not seem to fluctuate so much as in the case of milk. Invariably with ice cream when showing a high count, we are able to locate the cause for the same and generally it is due to either unsanitary piping or other equipment or to the use of poor grade of material."

The State of Mississippi has a law which limits the number of bacteria in ice cream to 250,000 per c. c. The creamery inspector of that State said concerning this matter: "During the past year or two there has been an increased tendency on the part of many States to again go back to the bacteria standpoint, but as most all of our ice cream plants are well equipped and manufacturing a reasonably good product under present conditions we are not putting forth as much effort as we should, perhaps, in regard to the bacteria count."

The data presented in this paper on Massachusetts ice cream represents the analysis of 146 samples of ice cream from 12 cities. The plants

from which the ice cream was secured ranged in size from those making 500 gallons a year to those making over 1,000,000 gallons annually. The ice cream samples were collected during October and November of 1931. The sanitary conditions of these plants varied from those located in a dirty cellar to the ultra modern, scrupulously clean plant. There was likewise a great variation in the personal hygiene of the workmen.

Table No. 2 shows the number of bacteria appearing on the sucrose agar plates ranged from 3500 to 19,000,000, the average was 743,000. Fourteen and seven tenths percent of the ice cream samples analyzed had bacterial counts over 1,000,000 bacteria per c. c. These samples were secured from companies that manufactured less than 10,000 gallons of ice cream a year. Therefore, the number of gallons of ice cream with such high bacterial counts was small compared to the total number of gallons of ice cream manufactured in Massachusetts.

The average bacterial count of the ice cream when weighted according to number of gallons manufactured was 72,000 bacteria per c. c.

According to Table No. 3 the percent of samples of ice cream having a bacterial count of less than 50,000 was 35.7 percent in Massachusetts and 46.48 percent in Connecticut.

Table No. 2. Bacterial Analysis of 146 Samples of Massachusetts Ice Cream.

Bacteria per c. c. (Plate Method.)				Plant Production in Gallons.
Under	Maximum	Minimum	Average.	Average.
50,000	50,000	3,500	22,347	190,388
100,000	99,000	3,500	36,271	142,408
150,000	150,000	3,500	59,226	103,108
200,000	196,000	3,500	70,892	58,504
500,000	500,000	3,500	192,946	56,252
1,000,000	1,000,000	3,500	435,173	29,489
Over 1,000,000	19,000,000	3,500	5,336,000	5,500

Table No. 3

Bacterial Analysis of 146 Samples of Massachusetts Ice Cream.

Bacteria per c. c.

Sucrose Agar Plates.	Percent of Samples.
Under 50,000	35.7
" 100,000	50.0
" 150,000	63.5
" 200,000	73.0
" 250,000	75.4
" 500,000	83.34
" 1,000,000	85.7

If the bacterial counts of ice cream indicate the efficiency of the department of Dairy Inspection, then, according to Table No. 4, there is no correlation between the size of the city and the efficiency of its department of Dairy Inspection.

Table No. 5 brings out some interesting information pertaining to the cause of high bacteria counts in Massachusetts ice cream. One should note that as the size of the plant increases the number of bacteria in the ice cream decreases.

The ice cream used in this study was divided into 3 groups according to the ingredients used as the

source of butter fat in the ice cream. These groups are as follows:

1st. Cream.

2nd. Milk and Cream.

3rd. Milk, cream and butter.

From Table No. 6 it can be seen that of these three groups the ice cream made from cream contained the greatest number of bacteria per c. c. This ice cream was made by the small manufacturer. Thus, as stated before, the bacteria count is a good indication of the indifference or lack of knowledge on the part of the producer concerning sanitary methods in ice cream making.

Table No. 5.

Bacterial Content of Ice Cream from Different Size Plants.

Yrly. gallonage of plant.	Percent Total	Bacteria per c.c.
Below 10,000 gal.	65	1,157,000
10,000 - 200,000	18.2	176,104
Above 200,000 gal.	4.7	15,363
Av. of all plants	100.0	743,000
Weighted Average		72,000

Table No. 7 shows the same in respect to the source of added serum solids.

Table No. 4.

Bacterial Analysis of Ice Cream
from 12 Cities in Massachusetts.

City Population (Approximate)	Bacteria per c.c. Plate Method. Max.	Min.	Average.
6,000	80,000	29,000	54,500
13,000	188,000	13,000	55,762
15,000	1,500,000	3,800	409,550
35,000	196,000	23,700	103,233
44,000	19,000,000	37,000	7,929,400
64,000	330,000	3,500	77,142
50,000	3,000,000	31,000	973,855
100,000	6,000,000	11,000	767,275
104,000	590,000	4,000	224,000
114,000	10,000,000	7,000	79,246
115,000	4,200,000	31,000	1,082,333
190,000	11,000,000	10,500	705,316

Results of bacterial analysis of some of the ice cream samples by both the Standard Plate method and the Direct Microscopic method are given in Table No. 8. Due to difficulties encountered in preparing satisfactory smears no statement on the value of the microscopic method is justified from this work.

Table No. 6 Bacterial Analysis of Ice Cream Using Different Ingredients as Source of Fat.

Source of Fat	No. Plants	Bacteria per c. c. Plate Method. Max.	Min.	Av.	Plant Output.(Gals.)
Cream	34	11,300	14,000	3,298,560	6,350
Milk & Cream	30	19,000,000	4,000	1,767,983	97,016
Milk, Cream & Butter	9	250,000	3,800	55,155	564,444

Table No. 7 Bacterial Analysis of Ice Cream Made With Different Ingredients as Source of Extra Serum Solids.

Source of S.S.	No.Plants.	Plant Output.	Bacteria per c.c. Max.	Min.	Ave
Powdered Skim Milk.	7	108,571	590,000	4,000	173,842
Powder & Skim Milk.	2	500,000	99,000	63,000	81,000
Evap. or Condensed.	10	2,160	19,000,000	60,000	2,262,300
Sweet Condensed.	3	643,333	196,000	11,000	97,333

Table No. 8.

Bacteria as Determined by the Direct Microscopic & Standard Plate Methods.

Plate Method	Microscopic Method.
386,000	5,400,000
1,000,000	4,200,000
29,000	1,600,000
15,000	6,000,000
152,000	1,600,000
220,000	2,400,000
7,000	70,000
11,500	210,000
137,000	1,200,000
124,000	1,200,000
120,000	7,200,000
11,000	1,000,000
118,000	2,400,000
1,890,000	5,000,000
6,000,000	14,400,000
330,000	4,800,000
19,000	1,200,000
3,500	495,000
27,500	1,400,000
196,000	4,000,000
23,000	1,200,000
3,000,000	10,000,000
63,000	7,200,000
2,420,000	9,600,000
31,000	1,000,000
500,000	3,000,000

The butter fat content of the ice cream studied was found to vary between 7.7 percent and 22.79 percent with an average of 14.13 percent. The Massachusetts standard for butter fat in ice cream is 10 percent. From Table No. 9, we find 6.9 percent of the samples analyzed were illegal.

Table No. 9.

Fat Content of 118 Samples of Massachusetts Ice Cream.

Percent Fat.	Av. Percent Fat.	Percent of Samples.
Under 10	8.89	6.9
10-12	11.09	17.24
12-14	13.02	29.3
14-16	15.08	23.27
16-18	16.65	11.2
18-20	18.65	6.0
20-22	20.82	4.39
Over 22	22.69	1.71

The proper amount of fat to have in ice cream varies according to individual preference and, therefore, no comments are made on Table No. 10, except to note that the average percent of fat in Massachusetts ice cream is slightly lower than in

ice cream from the other States mentioned.

Table No. 10

Butter Fat Content of Ice Cream from 4 States.

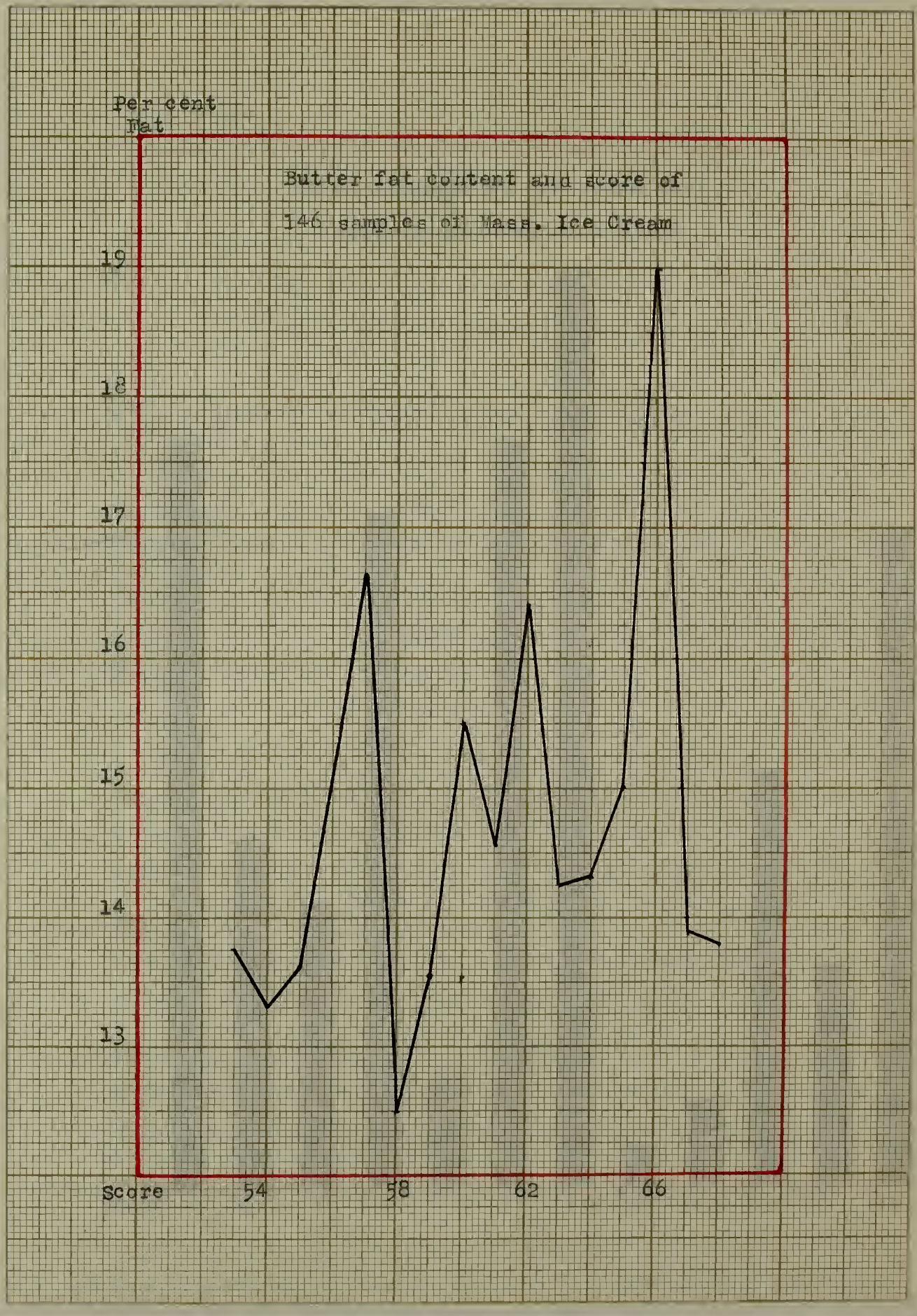
State.	Butter Fat Standard	Av. Percent Fat	Percent Illegal.
Massachusetts	10	14.13	6.9
Maine	14	16.13	12.5
Connecticut	8	14.15	
Rhode Island	8	16 (Estimate.)	

Figure No. 1 shows that the amount of butter fat in ice cream does not control the quality.

The total solids content of the ice cream studied was found to vary considerably. What influence this factor had on the ice cream studied is difficult to state, although it is interesting to note that according to Table No. 11 the best quality of ice cream having slightly higher total solids content was produced by larger companies.

The quality of ice cream studied is shown in the total score. Out of a possible 95 the minimum was found to be 46 and the maximum 89. The average score was 73.3. Figure No. 2 shows no correlation between the size of the city from which the samples were obtained

Fig. 1


Per cent
Fat
Butter fat content and score of
146 samples of Mass. Ice Cream
19
18
17
16
15
14
13
Score
54
58
62
66

and the score of ice cream produced. The author makes no attempt to account for this condition.

Table No. 11.

Total Solids Content of 118 Samples of Massachusetts Ice Cream.

Percent Total Solids	Av. Percent Total Solids.	Percent of Samples.
30-32	31.37	5
32-34	33.13	12
34-36	35.18	21
36-38	37.41	23
38-40	38.95	17
40-42	40.85	15
42-44	42.45	7

Figure No. 3 shows the relationship between total solids content and the body and flavor score of the ice cream. In this figure attention is called to the variation of total solids in ice cream scoring less than 60. After the score exceeds 60 it increases as the total solids increase. A majority of the ice cream samples with total solids over 37 percent were made by the larger companies. In general the larger companies produced ice cream of higher quality. This is shown in Table No. 12.

Fig. 3

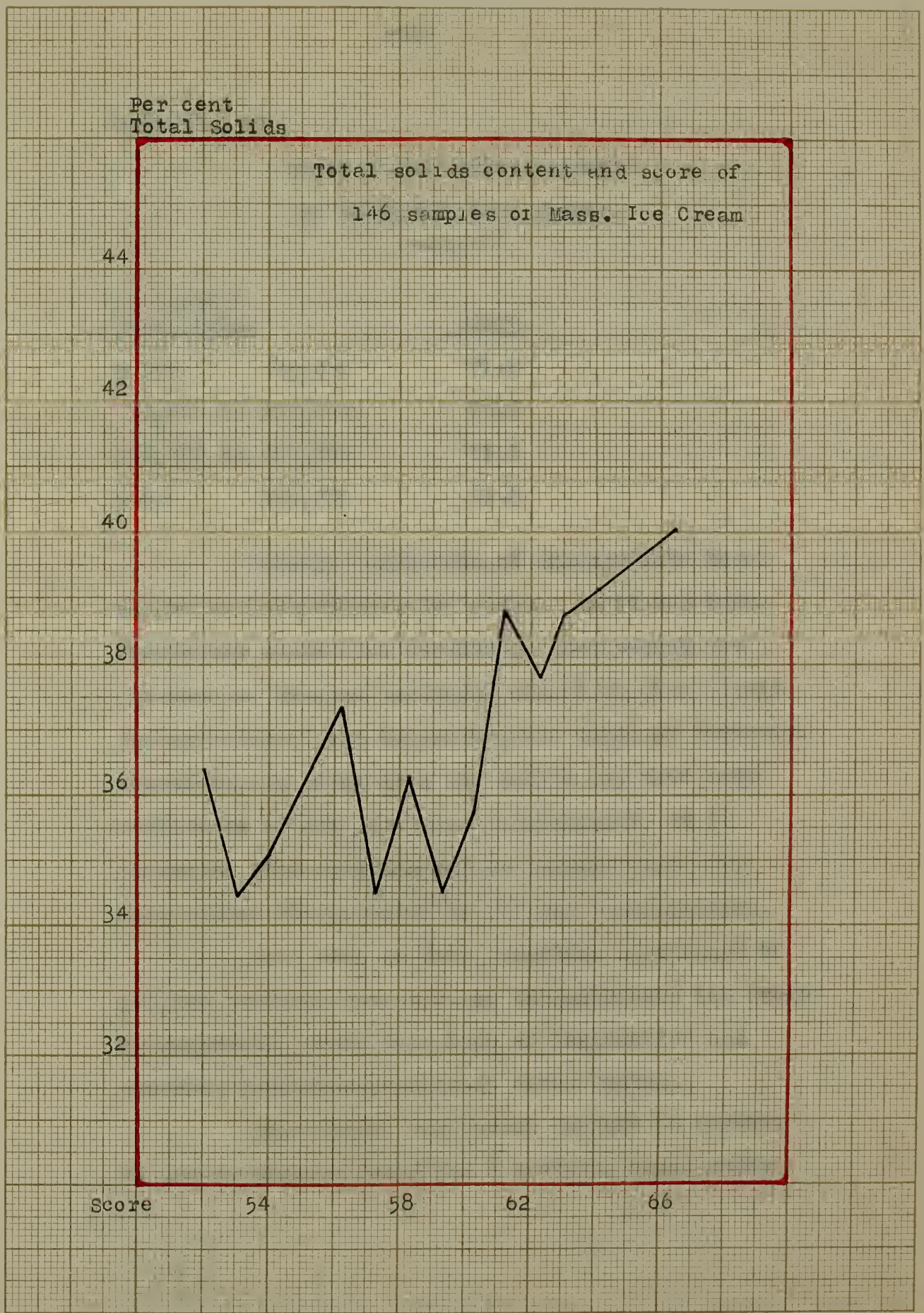

Per cent
Total Solids
Total solids content and score of
146 samples of Mass. Ice Cream
44
42
40
38
36
34
32
Score
54
58
62
66

Table No. 12

Score of Ice Cream Produced
by Different Size Plants.

Production in Gallons.	Score.
Under 10,000	71.2
10,000 to 100,000	78.7
100,000 to 500,000	81.1
Over 500,000	81.9

Numerous outbreaks of disease have been traced to contaminated ice cream. As it has been previously stated the conditions that permit the presence of disease producing organisms also permit the presence of the non-pathogenic types of bacteria. Therefore, in order that the public may have more confidence in the ice cream manufacturer, it is essential that some measure be adopted that will help reduce the possibility of such contamination.

As a step in this direction a standard of 100,000 bacteria per c. c. in Massachusetts ice cream is suggested, since this type of legislation has produced desirable results in other States.

This figure was chosen because 50 percent of the samples analyzed had a bacteria count under

100,000, 83.6 percent of the ice cream samples that contained over 100,000 bacteria per c. c. were made by companies manufacturing less than 10,000 gallons of ice cream a year. It is possible as indicated by Table No. 13 for these companies to manufacture ice cream with a bacterial count under the proposed standard. The State of Connecticut adopted such a standard about 2 years ago and it has encountered little difficulty in maintaining it; and at the same time improvement has been made in reducing the average number of bacteria in ice cream.

Fabian[19] and others conclude that it is entirely possible to manufacture ice cream with a count of less than 100,000 bacteria per c. c.

For the above reasons a standard of 100,000 bacteria per c. c. is suggested.

Table No. 13.

Bacteriological Analysis of Ice Cream made by 7 Small Plants.

Production in Gallons.	Bacteria per c.c.
2,000	14,300
1,000	37,000
1,750	20,000
1,000	27,500
1,000	25,000
1,000	11,000
1,000	10,500

SUMMARY.

1. The Bacterial count of 146 samples of Massachusetts ice cream was found to vary from 3,500 to 19,000,000. Fifty percent of the samples contained less than 50,000 bacteria per c. c. and 14.7 percent had over 1,000,000 bacteria per c. c.
2. There was a fair correlation between the quality of ice cream analyzed and the size of the company that manufactured the ice cream.
3. The butter fat content of the samples studied varied from 7.7 percent to 22.79 percent with an average of 14.13 percent. The larger plants made ice cream with a fat content generally under 15 percent.
4. The total solids content of the ice cream varied from 30 to 45 percent with an average of 36 percent. The ice cream made by the smaller companies averaged less than 35 percent total solids.
5. The States of California, Michigan and Connecticut report that considerable progress has been made in reducing the number of bacteria per c. c. since the adoption of a bacterial standard.
6. A standard of 100,000 bacteria per c. c. is suggested for Massachusetts.

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This thesis has been read and approved by: