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A STUDY OF THE BACTERIAL CONTENT OF CREAM.

DEPARTMENT OF BACTERIOLOGY.

L. L. LEWIS W. R. WRIGHT

Oklahoma is located south of what is known as the best butter making section, and out of the true grass regions which really make the dairy industry a success in the north. Although we do not have the Kentucky bluegrass and clover, we do have the equal of these in Bermuda grass and alfalfa; and with these and the sorghums and cowpeas as our feed crops, it is more than possible by resorting to creamery butter making to compete with the dairy states of the north. It is not a difficult task in Canada and Northern United States, where an abundance of cold water can be had, to make a good dairy butter the entire year. Here the weather and water are both warmer, and successful private dairying is an unsolved problem. Although there is but little trouble experienced in making a good quality of butter on the farms in the great dairy districts of Wisconsin and other states of that latitude, farmers in those sections have found it to their interests to patronize the creamery. If it is an advantage to manufacture butter in the north by the creamery method the greater need of the same system of manufacture in Oklahoma is more than evident.

The general tendency in the dairy states has been to transfer the manufacture of butter from the farm to the creamery. Statistics from all of the dairy states show this to be the case. Several reasons may be assigned for this gradual change in the manner of manufacture. Probably the most important one is that the creamery is more completely equipped than is possible for the farmer to be, and for this reason the product manufactured is more uniformly high grade butter than is usually made on the farm.

The local conditions in Oklahoma are such as to encourage the dairy business. Located near practically an unlimited market in the south, with soil and climate favorable for the production of suitable feed crops, there is no reason why dairying should not become one of the important industries. The southern market is now supplied with butter shipped from the north, and if the dairyman of the north can make a profit from his product, after shipping such a great distance, the Oklahoma farmer being more favorably located should give a portion of his attention to this industry.

Many farmers living in the vicinity of the college made butter last year until the hot days of June and then gave up the work because they were unable to make a product of good quality. During the hot season the cream was delivered to the college creamery, where, with ice at hand, it wa

successfully manufactured into a good grade of butter. Most of the butter made on the farms and offered for sale in the local market during the summer months, was of such poor quality that it seemed imperative that the Experiment Station should make investigations along these lines to determine, if possible, the various causes operating to produce such a low grade product. As the improvement of the butter must be brought about by the improvement of the cream and the conditions under which it is kept, it was decided to determine the condition of the cream as delivered at our creameries. As no unusual restrictions were placed upon the patrons of the college creamery it was selected as furnishing the conditions commonly met with in the average creamery in Oklahoma.

A dairyman with good eyes and an unimpaired sense of smell may be able to tell good from poor cream, but if the cream be of poor quality he would in most cases be unable to locate the trouble. As ordinary examinations and observations are not searching enough to reveal the cause of any unusual change, bacteriological examinations have been made to determine the quality of the cream as it was delivered to the creamery.

It is quite generally known that the development of acid (souring of milk) is the result of the introduction and growth of micro-organisms, or small forms of plant life known as bacteria. By using a beef-tea preparation containing enough gelatin or agar to give it the firmness of jelly the cause of any change in milk or cream, such as natural souring, the development of vile odors, stringiness or unusual colors, can be determined. These changes are caused by the rapid multiplication of bacteria of various kinds. The normal souring of milk is due to the lactic bacteria, while the other changes mentioned are due to bacteria introduced into the milk which by their growth set up the undesirable changes.

To determine the quality of the cream delivered during the summer months, tests were made beginning with the last of June, 1906, and extending to the first of September of that year. This period included the hottest, and consequently the most unfavorable months for the handling of cream. As a check on these conditions a series of tests was made during the months of December, January and February following, the coldest season of the year. The reason for selecting the summer and winter seasons for this work was to show by comparison the great influence of a low temperature on the quality of cream. The results of these tests are in most cases arranged as bars accompanied by numbers, instead of being arranged in tabular form. On pages opposite these plates explanations of the results are given and conclusions drawn. These conclusions are given after each particular test of the experiment. They are brief but are complete enough to direct the reader's attention to the points of greatest interest.

SAMPLES AND METHODS OF TESTING.—For the tests that extended through the greater part of the summer, sixteen patrons were selected and all of the tests for that season recorded in the plates were made from cream delivered by these patrons. By referring to Plate 1 it will be seen that sixteen

samples are recorded in the results obtained June 30. These samples were the ones delivered first on that date and afterwards the examinations were confined to cream delivered by these particular patrons or as many of them as could be secured on the day samples were taken. These patrons had no special instructions and, in fact, did not know that their cream was being tested at all.

In making these bacteriological tests a medium was used which agreed in reaction (the per cent. of acid) with new milk, and the growth of bacteria took place in an incubator kept at a temperature most suitable for bacterial development. After growing for about three days in the media containing milk sugar, the number of germs, as indicated by the colonies developed, was determined. Tests for gas producing germs, which are usually introduced by the careless handling of cream, were made by using beef-tea agar containing the easily fermented sugar glucose. After growing for the above mentioned time, counts were made of all of the colonies appearing and also of the different kinds of colonies. A portion of each colony, representing the different kinds of bacteria in the plates, was introduced into a tube of sterile milk where its action indicated whether it had the power to produce acid, to form gas, or to digest the curd, the bacteria belonging to the last group being the ones that give rise to the unpleasant odors. The plates on the succeeding pages indicate the results of these tests and they are especially arranged so as to render easy of comparison the results obtained from the examination of summer and winter cream.

PLATES 1 and 2.—The numbers given in the upper plate, indicate the average total number of bacteria found in a cubic centimeter of cream (about twenty drops) as delivered by the same patrons, while the figures given in the lower plate indicate the results obtained by the examination of cream delivered by different patrons. The bars are drawn to a scale and a comparison of these gives a fair idea of the relative numbers of bacteria present on different days of the same season, as well as for different seasons. The plates on the same page are drawn to a scale so that the season's influence may be studied by a general comparison of the two. Even a hasty comparison of the two plates satisfies one that weather conditions have much to do with the number of bacteria developed in cream.

In the abridged weather-chart on another page, the weather conditions at the time of taking the sample and for three days previous in summer and six days previous in winter, are given. These periods cover the time which influenced the changes in the cream lots sampled.

There are at least three factors to be considered in making a study of these plates: temperature, age of the cream, and the manner in which the cream is handled. A comparison of Plate 1 with Plate 2 naturally leads one to conclude that a high temperature causes a rapid multiplication of bacteria in cream. The large per cent. of four day old samples taken July 21 and August 11 as shown in Table 1 accounts in large measure for the low bacterial counts on those dates.

TABLE 1.

Date of Delivery.	1 Day	2 Days	3 Days	4 Days	5-8 Days	Av. Age
1906.						
June 30	1	5	6	4		3
July 21		2	1	5		3½
July 28		3	1	2		3
August 4		1	3	4		3½
August 11	1	1	4	6		3¼
August 18			3	1		3¼
August 22		4	1	1		2½
September 1	1		1	1	2	3½
September 8		4	17	6		3
Total	3	20	37	30	2	3⅓

Date of Delivery.	1 Day	2 Days	3 Days	4 Days	5-8 Days	Av. Age
1906.						
December 22		1	2	3		3½
1907.						
January 12		1	1		4	5½
January 19				2	3	6
January 26			3	3	5	5
February 2			5	1	5	5
February 12			2	3	3	5
February 19			3	5	2	4⅓
Total		2	16	17	22	5

This table is arranged to show the ages of the cream samples, the average age of each lot, and the total number of samples of different ages that were taken.

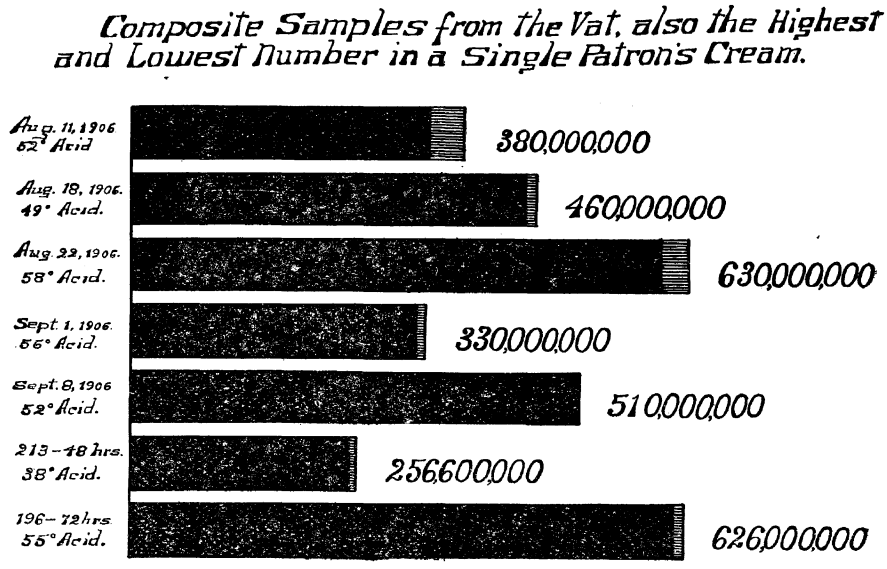


PLATE 9.

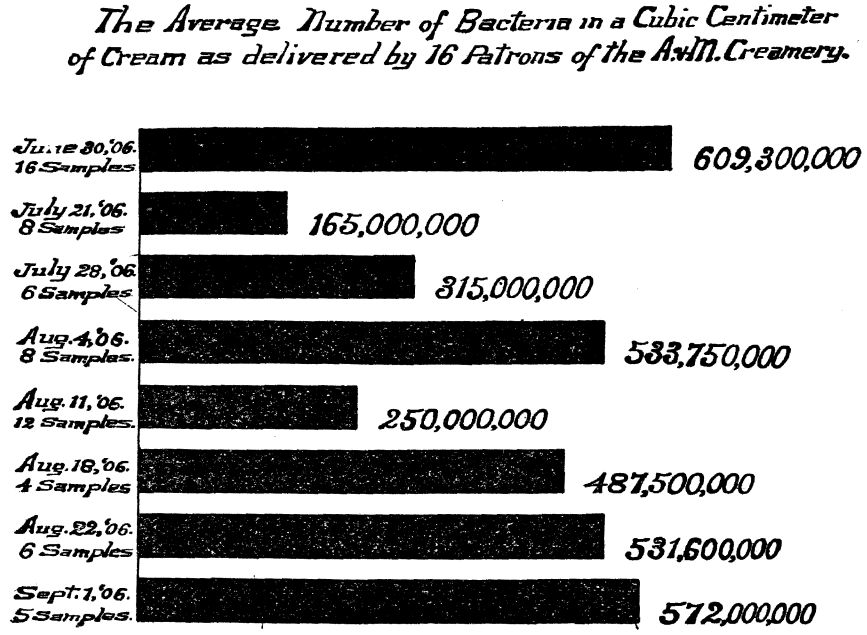


PLATE 1.

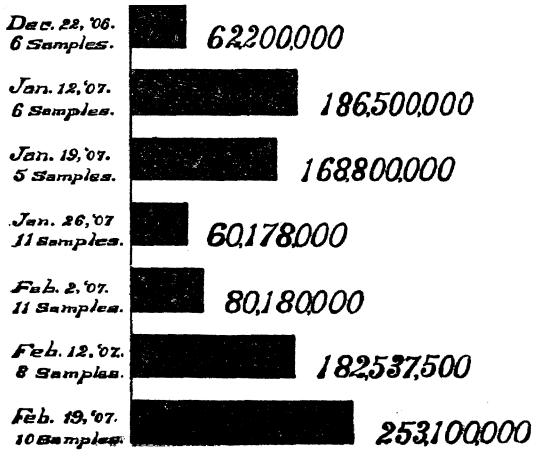


PLATE 2.

In Plate 1 the expressions, "Eight samples, Six samples," etc. indicate the number of the original sixteen patrons who brought cream to the dairy on that date. In Plate 2 the corresponding numbers do not indicate the same patrons, for it was more difficult to obtain samples regularly during the winter, so these samples were taken without attempting to secure them from the same patrons. An examination of the weather chart for the conditions existing at the time of taking the samples during the winter will show the fact that the number of bacteria varied nearly in proportion to the temperature.

SUMMARY.—Cream delivered in summer at an age of 3.3 days contained an average of 462,600,000 bacteria in a cubic centimeter.

Cream delivered in winter at an age of five days contained an average of 134,800,000 bacteria in a cubic centimeter, or less than one-third that of the three day old samples in summer.

Age has an influence on the number of bacteria in cream, but temperature exercises the greatest control.

To prevent excessive development of bacteria, cream must be kept cold, and it should be delivered frequently at the creamery.

PLATES 3 and 4.—These plates show the results obtained by bacteriological examinations of samples of cream of different ages. For example, only three samples were obtained during the entire period covered by the tests that were only one day old, and the average count for these three samples was 350,000,000 bacteria per cubic centimeter. The remainder of Plates 3 and 4 is arranged to show the number of samples, of the age indicated, that were examined.

The effect of age on the number of bacteria in cream can be determined, also the variation caused by the difference of temperature. Cream less than one day or more than four days old was very rarely delivered, so samples of these ages are limited in number. By studying Plate 3 it will be seen that there is an increase in the number of bacteria up to the third day, followed by a steady decrease. One must not conclude from this that an eight day old sample of cream is superior to a three day old sample, merely because it has fewer bacteria. It indicates rather that many of the bacteria have been killed because of over crowding, and as the death of bacteria in cream or milk does not remove the objectionable products formed during their development, the cream is in worse rather than better condition at the end of eight days.

Numbers are given in Plate 4 for a good sample of freshly separated cream as secured at the college dairy. No extra precautions were taken in milking, none not easily observed upon any good dairy farm. In winter cream there is a steady increase of bacteria for four days, after which there is a gradual decrease. A three day old sample in summer contained four times as many bacteria as a four day sample in winter. It is interesting to know that the maximum number in winter was only about one-third of the

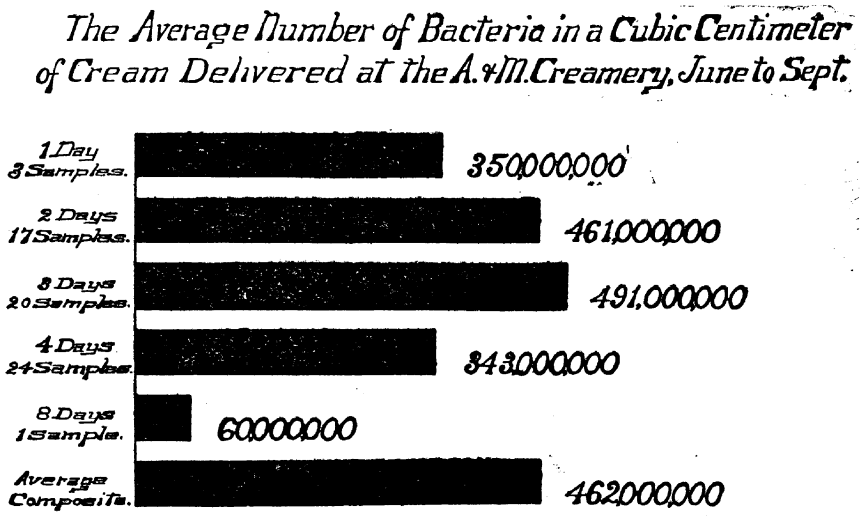


PLATE 3.

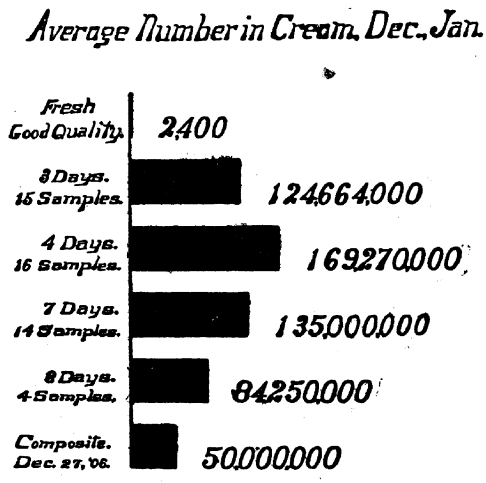


PLATE 4.

maximum number in summer as the cream was ordinarily delivered, but in the eight day old samples the numbers are about the same.

The composite samples were obtained from the cream vat after most of the cream for the day had been emptied into it. As these samples were taken four or five hours after the first cream had been delivered they give a count which does not accurately represent the condition of the cream as presented at the creamery.

SUMMARY.—Bacteria were found to increase in cream for a period of three days in summer and four days in winter, after which there was a steady decrease.

The maximum number in summer was about three times that in winter.

Old cream is not better than fresh cream because it has fewer bacteria, for samples of eight day cream had an old, unpleasant odor.

PLATES 5 and 6.—As a rule considerable weight is given to the gas test when determining the quality of milk or cream, and there is a good reason why so much dependence should be placed upon it. Bacteria which ferment sugar, producing carbonic acid gas and alcohol instead of lactic acid, come from filth allowed to drop into the milk, or from impure water used in washing the cans. The presence of gas producing bacteria in considerable numbers is then an indication that the milk or cream tested has not been obtained and cared for in a manner calculated to enable the dairyman to make from it a good quality of butter. But many claim that the separator removes all of the dirt and objectionable material which enters the milk so that great care in milking is not necessary. This assumption is based on the fact that after separating, the bowl of the separator is coated with a dirty slime which must have been removed from the milk. If it is borne in mind that it is not the visible dirt but the minute bacteria multiplying in this dirt which are the objectionable features, it will not be so difficult to understand the statement that separators have fewer cleansing properties than is claimed for them. Tests of milk before and after separating indicate but little reduction in numbers by separation. Plate 5 shows the per cent. of cream samples containing 100,000 or more gas producing bacteria in a cubic centimeter. For example, the results obtained from the test on June 30 showed that 18 per cent. of the samples tested had the above number of becteria or more. Excepting in the lot taken June 30th, a half, or more than a half, of the samples tested contained not less than 100,000 gas producing bacteria per cubic centimeter of cream. In addition to the tests indicated by the plates, 36 lots were tested for gas production by the introduction of a small amount of the cream into flasks of sterile milk. Of this number, nine gave an excessive production of gas (a floating curd) and sixteen gave some evidence of gas formation. Then, out of thirty-six samples twenty-five were gassy, an average of nearly 70 per cent. Our tests warrant the assertion that more than 50 per cent. of the cream delivered at our creamery during the hottest months of last summer contained an excessive number of gas producing bacteria.

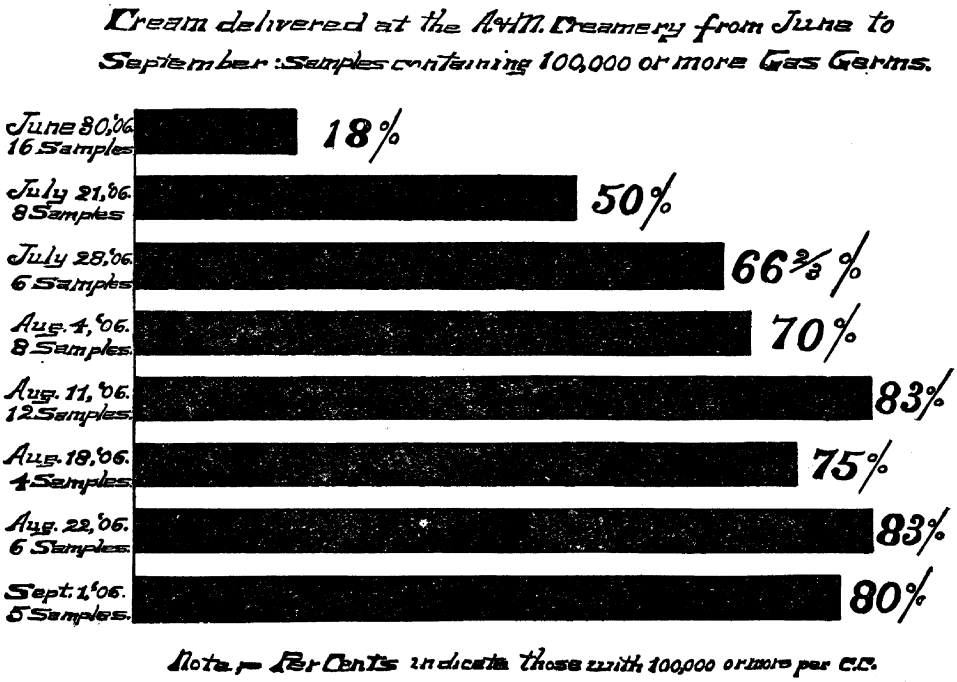
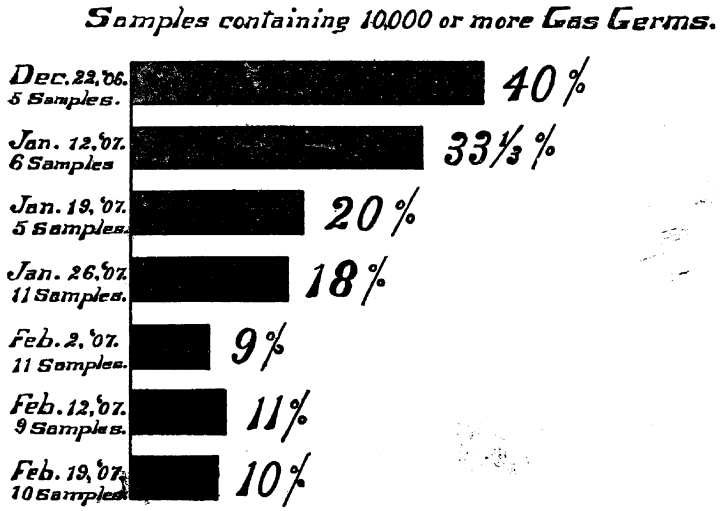


PLATE 5.



PLATE

An examination of Plate 6 shows that less than an average of 20 per cent of the winter cream contained even 10,000 bacteria in a cubic centimeter, a small per cent. when compared with the 70 per cent. in summer cream. These gas producing bacteria, growing best at body temperature, increase slowly at a low temperature. This probably accounts for the comparatively small number in winter, rather than that there was any great difference as to cleanliness in handling the cream.

SUMMARY.—The gas test is an index of the care exercised in securing and handling milk or cream—a strong test for gas indicating careless management.

Visible filth is removed, in some measure, by the separator, but the gas bacteria, which are the active elements in the filth, remain and multiply, producing changes which decrease the value of cream.

Gas producing bacteria are much more troublesome in summer than in winter because a high temperature favors their growth, hence the need of greater care in performing dairy operations at that season of the year.

PLATES 7, 8, and 9.—In Plates 7 and 8, the open bars indicate the proportion of gas producing bacteria, while the solid bars indicate the proportion of digesting bacteria. In Plate 9, the open part of the bar indicates both the digesting and gas germs, while the solid bar represents the lactic type of bacteria.

For convenience, a division of the different kinds of bacteria found in cream was made on the basis of their action upon sterile milk in tubes. The classes made are as follows: Normal curd producing (the lactic type); gas forming and curd digesting (resulting in offensive odors). The lactic type (the bacteria producing a pleasant flavor) constituted more than 90 per cent. of each composite test made, and in the sample taken September 8th, only lactic germs were found. A limited number of the other classes was, no doubt, present but in numbers less than one-fifth of 1 per cent. These statements refer to Plate 9.

By referring to Plates 1 and 7, it will be seen that of the 609,300,000 bacteria, the average total for June 30th, 7,700,000 produced gas and 5,000,000 digested curd, while the remaining 596,600,000 produced acid favorable for butter making. The small number of 6,000 digesting germs per cubic centimeter was the average for July 21st. A comparison of Plates 7 and 8 will make it clear that relatively small numbers of objectionable bacteria are present during the winter months. These were so few in number that bars of the proper length could not be drawn. Only on two dates, January 12th and February 12th, did the combined number of these objectionable classes of bacteria exceed 1 per cent. of the total number of bacteria.

SUMMARY.—The combined numbers of gas and digesting germs in cream range from a fraction of 1 per cent. to 2 per cent. in summer, and from a smaller fraction to a little more than 1 per cent. in winter.

As investigations have shown that large numbers of curd digesting bac-

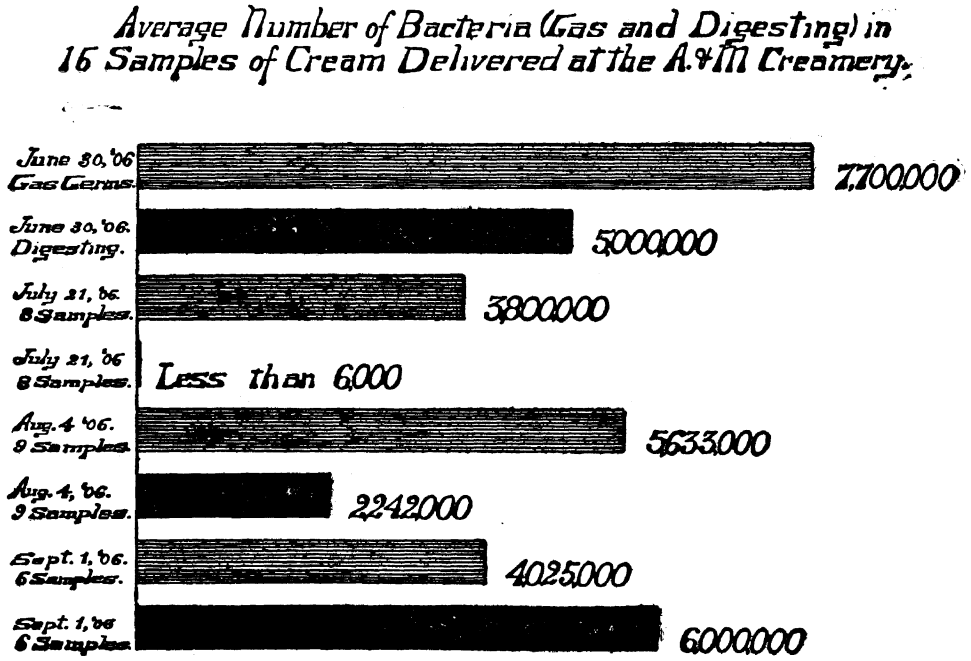


PLATE 7.

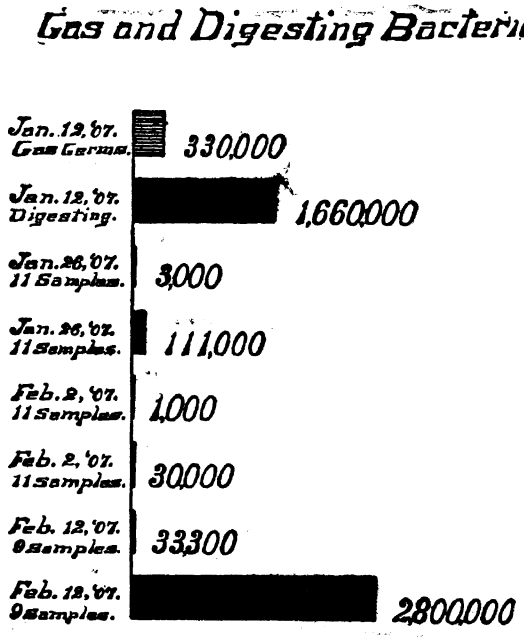


PLATE 8.

teria are found in hay and straw, these feeding materials should not be handled during the milking period.

PLATES 10 and 11.—These plates are intended to show the actual condition of the cream as delivered at the creamery so far as its acidity is concerned.

As expressed on a previous page, acid is developed in milk and cream by the growth of the lactic type of bacteria. When enough of the sugar of milk has been acted upon and converted into acid (lactic), the whey separates from the curd and the milk is said to be sour. As the souring of milk is known to be due to the presence of bacteria, a certain relation must exist between the number of bacteria present and the quantity of acid formed. A comparison of the plates opposite with Plates 3 and 4 leads one to conclude that to a certain extent a relation does exist.

The numbers 14 degrees, 33 degrees, etc., do not indicate the per cent. of lactic acid in the cream, but indicate the relative amount of acid present in the samples. A steady increase in the amount of acid, both summer and winter, to the eighth day is indicated. As it was difficult to secure many samples more than four days old in summer and more than seven days old in winter, it is more than probable that 114 degrees and 39 degrees respectively represent the average limits of acid production for the different seasons. In summer the three day old cream gave the maximum bacterial count and a medium amount of acid, but eight day old cream gave the smallest bacterial count and the largest amount of acid. This naturally leads to the conclusion that in summer the amount of acid in cream is a better indicator of its age than the number of bacteria present. In winter the increase in acidity was slight, but corresponded in general with the tests made during the summer.

On September 1, 1906, thirty-six lots of cream ranging in age from two to five days were tested for acidity. But little variation was found, the average being not less than 52 degrees, nor more than 60 degrees for cream of the different ages. This is approximately the right amount of acid for churning, but unsatisfactory results follow from the mixing of sweet and sour cream just before churning and as the temperature of the cream as delivered at the factory is usually too high, it is kept until the next day. As the cream is usually too sour the following day it must, if best results are to be obtained, be delivered in a less acid condition.

SUMMARY.—Ordinary souring of milk is due to the action of lactic bacteria on milk sugar, changing it to lactic acid.

Cream becomes more sour with age, though the number of bacteria is ess after the third or fourth day.

The average cream more than two days old in summer is too sour to be handled at a creamery with good results.

PLATES 12 AND 13.—Creamery patrons are often asked to bring richer cream, the reason commonly given being that a rich cream becomes less sour than a thin cream when kept under the same conditions. To test th

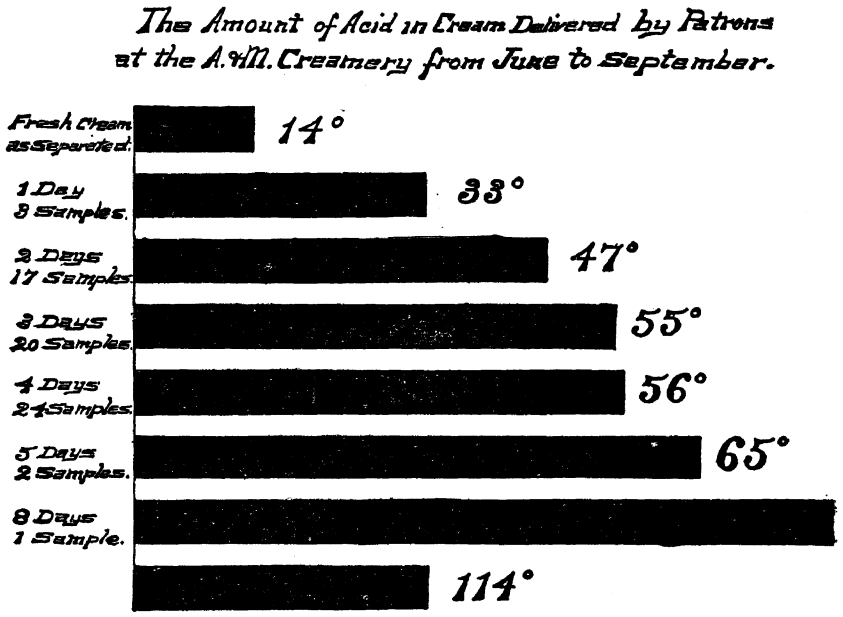


PLATE 10.

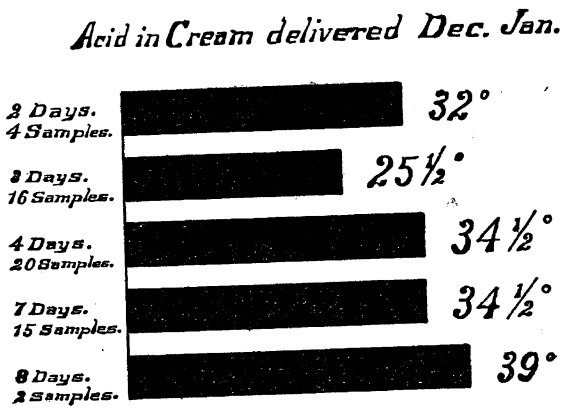


PLATE 11.

truth of this statement, the amount of acid in cream of different per cents of butter fat was determined by testing cream as delivered at the A. & M. creamery. To render comparison easy, all of the cream tested was divided into four divisions, each having a maximum and minimum per cent. of fat, and these were grouped as follows according to age: three and four days for summer, and three, four, and five to seven days for winter. The fat tests were not made for each sample, but are the creamery fat tests made at the middle and end of each month.

An examination of Plate 12 shows that the rich cream was less sour, but the difference was not great enough to warrant giving the subject undue consideration so far as the acidity is concerned. Plate 13 agrees quite closely in comparative results with Plate 12, excepting in the four day old lot, where a marked influence is evident. The data given in these plates offer a means of comparison of samples of summer and winter cream of different degrees of richness, and of the same age.

Two other reasons may be given for delivering rich cream: A creamery can manufacture more butter with the same vat and churning capacity and the patron has more separated milk for use on the farm.

The reason why rich cream is less sour than thin cream is this: If 50 per cent. of the cream is fat, then the remaining 50 per cent. must be of the composition of skim milk, which contains about 5 per cent. of milk sugar; in 25 per cent. cream, 75 per cent. will be skim milk and there will be a greater per cent. of milk sugar in thin cream than is present in the 50 per cent. cream. As stated on a previous page, acid is produced by the action of bacteria upon this sugar, so that it follows, other conditions being the same, that the greater the quantity of sugar the more acid can be produced by the action of bacteria upon it.

SUMMARY.—Rich cream contains a smaller amount of milk sugar than thin cream.

Milk sugar is changed into lactic acid by the action of the lactic bacteria.

From the above conditions, it is evident that the lactic bacteria will produce less acid in the rich than in the thin cream.

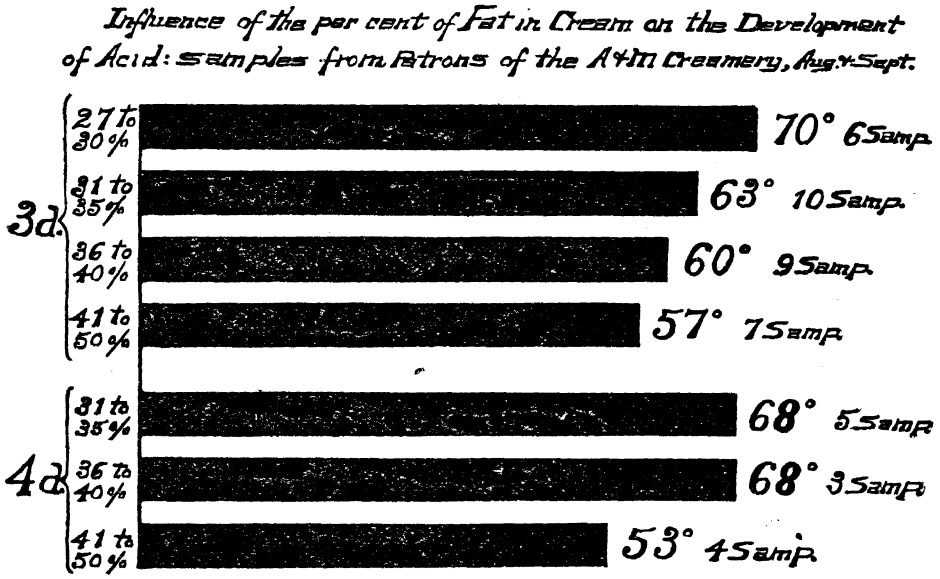


PLATE 12.

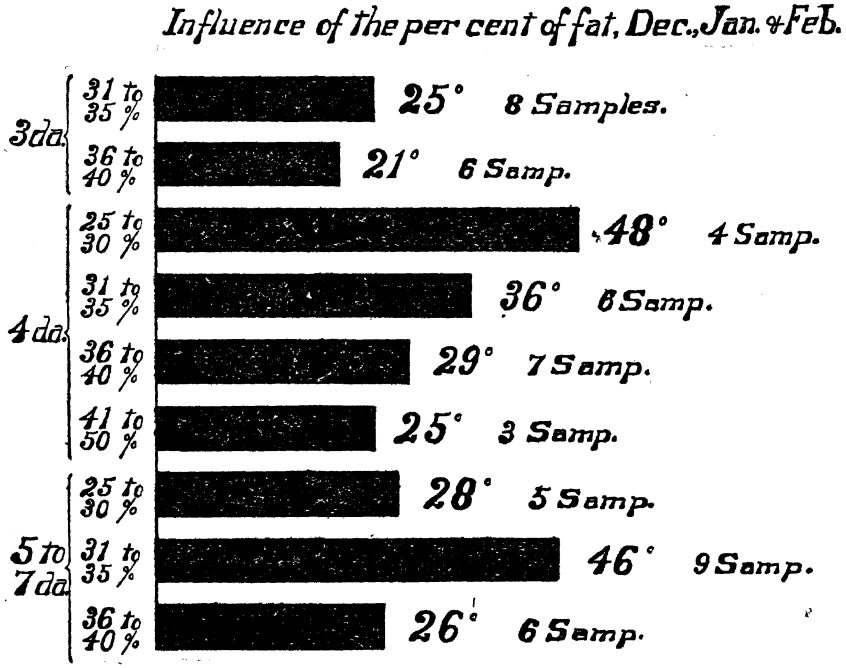


PLATE 13.

WEATHER CHART.

(Summer)

Date. 1906	Tempeaature. Min. F°	Max. F°	Precipitation. No. of Inches.	State of Weather Cloudy, Etc.	Remarks. Direction of Wind.
June 27-30	61	93	0	Mostly clear	S. E. wind and constant comparative temperature.
July 18-21..	65	92	1.2 on 21st	Mostly clear	S. E. wind and constant comparative temperature.
July 25-28..	66	87	.3 on 28th	Cloudy days	S. W. wind and constant comparative temperature.
Aug. 1 4.....	65	93	.06 on 4th	1 and 2 clear 3 and 4 cloudy	N.W. wind and constant comparative temperature, except the 4th.
Aug. 8-11..	66	91	.22 on 8th .41 on 11th	8 and 9 cloudy 10 and 11 clear	N.W. and S.W. winds
Aug. 15-18..	68	93	.59 on 17th	Partly cloudy except 15th	S. E. wind 15 and 17 S.W. and N.E. 16-18
Aug. 19-22	68	90	.04 on 22d	19 and 20 clear 21 and 22 cloudy	S. and S.W. wind
Aug. 29 to Sept. 1.....	55	91	.64 on 21st 2 84 on 1st	29 and 30 clear 31 and 1 cloudy	N. E. on 31 S. W. and S. E. 29-30
Sept. 6-8	67	90	0	Partly cloudy	N. W. 6; S. W. 7-8
Av. Tem.	64½	91			

(Winter)

Date. 1906-7	Temperature. Min. F°	Max. F°	Precipitation. No. of inches.	State of Weather Cloudy, Etc.	Remarks. Direction of Wind.
Dec. 16-22..	14	56	1.25 (snow)17th	Mostly clear	S. 19; N. W. or N. for 6 days
Jan. 6-8.....	32	75	0	Mostly cloudy	Variable wind but N. W. and S. W. prevailing
Jan. 9-12....	26	69	1.6 (snow) 10th	Partly cloudy	Variable wind but N. W. and S. W. prevailing
Jan. 13-15..	34	71	0	Cloudy (foggy)	N. W. constant
Jan. 16-19..	25	68	.7 on 19th	Cloudy (foggy)	S. W. on 18 and 19
Jan. 20 &23	24	57	0	Clear	N. W. 21 and 22
Jan. 24-26..	12	59	0		S. W. 20 and 23
Jan. 27-30..	15	51	0	Partly cloudy Clear	Hard wind on 25th North wind
J. 31-Feb 2	22	39	0	Partly cloudy	N. 31 and 2; S.W. on 1
Feb. 6-8.. ...	5	43	0	Cloudy	N. E. 6; S. 7 and 8
Feb. 9-12..	27	70	0	Clear	S.W. 9 and 10; N. 11
Feb. 13-16..	30	79	0	Clear	N.W. 13; S.W. 14-16
Feb. 17-19..	26	79	0	Clear	S.W. 17-18: N.W. 19
Av. Tem.	22.4	62.7			