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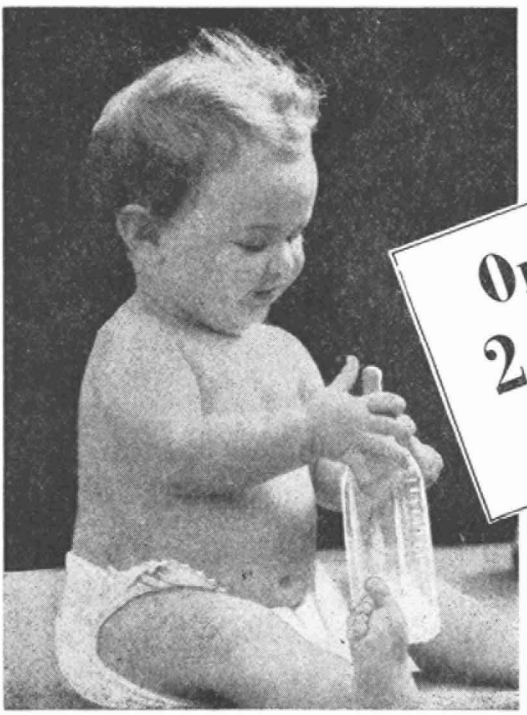

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A COMPARISON OF THE DIFFERENT METHODS OF CALCULATING YEARLY MILK AND BUTTERFAT RECORDS

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The Babcock tester and the milk scale constitute standard equipment for measuring the productive abilities of dairy cows. Differences exist, however, between methods of calculating records. Such differences develop largely because records are estimated on weights and tests taken at weekly, monthly, or bi-monthly intervals rather than for each day that a cow is in milk. The methods employed in calculating these "estimated" records have been devised by the breed associations, the U. S. Bureau of Dairy Industry, and the resident and extension dairy departments of the state Agricultural Colleges. Due to differences in origin, there have naturally developed slight differences in methods employed, with the result that some confusion has resulted—especially in the case of new testing supervisors who may be called on each month to supervise the regular dairy herd improvement associations, breed herd tests, and semiofficial tests for the various breed associations. Is it any wonder then that a new tester makes mistakes? Mistakes mean trouble and expense to the breed associations and to the state and often result in the herd owner losing confidence in the tester and in the testing program. Since the breed associations and the Bureau of Dairy Industry depend on the states to supervise all of these tests, it would seem logical that a uniform set of rules for calculating these records could be agreed upon. Such a move would be heartily endorsed by the state officials in charge of testing and would be enthusiastically received by the field testing supervisors.

Only a few investigators have reported on studies pertaining to the accuracy of computing yearly milk and butterfat records. McDowell (1) studied seventy yearly official records made at the University of Minnesota. He found, among the methods studied, that (a) the monthly method, where the yearly record was based on daily milk weights, ranked first from

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* The authors are indebted to C. C. Hayden and C. F. Monroe of the Ohio Agricultural Experiment Station for supplying the records for this problem, to C. H. Staples of Louisiana State University for his help during the course of the study, and to W. G. Cochran and J. L. Lush of Iowa State College for aid in statistical interpretations.

standpoint of accuracy; (b) the monthly method of computing dairy herd improvement association records was second; (c) the bi-monthly method based on daily milk weights was third; and (d) the bi-monthly method based on a test taken in the center of each two-month period was fourth in accuracy.

Kendrick (2, 3) made a study of sixty-nine lactation milk records secured from the Agricultural and Mechanical College of Texas. He compared the monthly and centering-the-testing-day methods with the actual official records. His method of comparing the two systems showed that the monthly method had a greater mean difference from the standard than did the centering method. He found a bias tending to make the monthly records too large when tests were made toward the first of the month and too small when tests were made toward the end of the month.

METHODS AND PROCEDURE

One hundred Holstein and Jersey yearly records made by sixty-seven Ohio Agricultural Experiment Station cows during the years 1935, 1936, and 1938 were used for this study. These records were made under the supervision of the experiment station staff and were records of cows milked twice daily. The yearly production (January 1 to December 31) ranged from 2,901 to 14,878 pounds of milk and 95.5 to 605.6 pounds of butterfat. The only records discarded in selecting the sample of one hundred were those of cows milking less than nine months of the testing year.

The actual total milk as taken from the daily milk sheets was used as the "standard" record for milk. The butterfat "standard" was based on daily milk weights and butterfat calculated from tests made at approximately weekly intervals, *i.e.*, on the 4th, 11th, 18th, and 25th of each month. The first and third weeks were each seven-day periods, while the second and fourth weeks consisted of from seven to nine days, depending on the month. The actual milk records and the butterfat records thus computed were used as standards in comparing other records.

Types of records studied and the methods of computation were as follows:

1. Monthly records for butterfat and milk were computed from a one-day test for the month and the number of days each cow milked during the month.

2. Centered records for butterfat and milk were determined by the Bureau of Dairy Industry plan (3).

3. Monthly records with daily milk weights for butterfat were based on daily milk weights and a one-day test each month.

4. Centered records with daily milk weights for butterfat were based on daily milk weights centered according to the Holstein plan (4) and a one-day test each month.

5. Bi-monthly records for butterfat were estimated from a one-day test every other month and the number of days each cow milked for the bi-monthly period.

6. Bi-monthly records with daily milk weights for butterfat were based on daily milk weights and a one-day test during that period.

Many contend, and most testing rules specify, that the testing day should be regular every month to secure the most accurate results. Groups of records were, therefore, calculated from tests taken at alternating periods zigzagging from the first toward the latter part of the months and from the latter toward the first part of the months in order to determine the validity of this contention.

Zigzag monthly records for butterfat were calculated from a one-day test for the month and the number of days each cow milked during the month.

Zigzag monthly records with daily milk weights for butterfat were based on daily milk weights and a one-day test each month.

Which month of the bi-monthly period seems the most likely one to obtain tests that will show the least errors? In an attempt to answer this question records were computed from tests conducted the same day of each month of the bi-monthly period.

Inasmuch as differences between methods of calculating records often involve the time that cows freshen or go dry, a summary was made relative to these two points for the one hundred cows included in the study (table 1).

TABLE 1

Period of month when cows freshened and were dried-off

Month	Freshened 1st half	Dried off 1st half	Freshened 2nd half	Dried off 2nd half
January	2	1	2	2
February	1	7	0	1
March	2	1	1	2
April	4	2	5	3
May	1	4	3	6
June	3	5	2	3
July	6	7	2	3
August	7	4	1	5
September	4	3	5	4
October	5	5	3	3
November	3	5	5	5
December	6	3	0	1
Total	44	47	29	38

This summary shows that forty-seven cows dried off the first half of one of the months during the time these one hundred records were made. Thirty-eight were dried off the second half while fifteen were dry when the testing year started or milked the full twelve months. The range in the number of cows going dry each month of the year for this period was between three and ten. The summary also shows that forty-four of these

cows freshened and their records started the first half of one of the months, while twenty-nine freshened and their records started the second half. This leaves twenty-seven that freshened before the testing year started.

RESULTS

Monthly versus Centered—Without Daily Milk Weights

Uniform rules for dairy herd improvement associations as published by the Bureau of Dairy Industry (3) specify that the testing day as established for the first month of a testing year shall be considered as the centering date of each succeeding monthly period. Under this plan a herd having a testing day on the fourth would calculate the production for June from the twentieth of May to the eighteenth of June, inclusive. If the testing day were the eleventh, the June production would cover the period May 27 to June 25, inclusive. Similar changes would take place in the monthly periods as the testing date changes. These periods differ from those of the monthly method first used in dairy herd improvement associations, particularly when the tests are made near either the first or the last of the month. Differences between the two methods arise largely when cows freshen or go dry. The monthly method conforms strictly to the calendar months and credits each cow for the number of days she is in milk during each of the twelve calendar periods.

Butterfat. A comparison of the centering and the monthly systems was made on the one hundred records with the fourth, eleventh, eighteenth, and twenty-fifth as the testing dates. Results of the comparisons (table 2)

TABLE 2

A comparison of the "Monthly" and "Centering the Testing Day" records with the "Standard" records for four different monthly testing days (Butterfat)

Type of record	Testing day	Mean difference from the standard (311.7 # fat)	Correlation with the standard records (r)	Regression equation constants		
				a	b	Standard error of estimate
Monthly	4	+5.1	.9911	1.3	.9799	±11.1
Centered	4	−3.1	.9854	5.5	.9921	14.2
Monthly	11	+1.4	.9914	2.1	.9889	10.9
Centered	11	−2.2	.9879	2.0	1.0007	12.9
Monthly	18	+0.6	.9929	5.7	.9797	10.0
Centered	18	+0.6	.9913	7.4	.9744	11.0
Monthly	25	−2.3	.9900	6.4	.9866	11.8
Centered	25	0.0	.9871	11.2	.9642	13.4

showed that the monthly butterfat records averaged 1.2 pounds above the standard and the centered records 1.2 pounds below the standard. The mean differences from the standard for the four testing days varied from −2.3 to +5.1 pounds for the monthly method and from −3.1 pounds to +0.6 pounds for the centering method. The centering method thus showed less variability for the mean differences, although the average difference remained the same.

The mean differences showed a slight trend for the monthly records to be too high when the testing day occurred during the first of the month and too low when the tests were made during the latter half of the month. Conversely, the centered records average too low for the first of the month, but differed hardly at all for the last two testing periods. When the eighteenth, or approximately the center of the month was the testing date, the mean differences were the same from the standard (+ 0.6) for each of the two systems.

Using correlation coefficients as measures of the relationship of the estimated records to the standard records showed (table 2) that the monthly records had higher correlations for each testing date than did the centered records. For the monthly method the average r was .9914 and for the centering method .9879. Both types of records are admittedly highly correlated with the standard.

Further evidence of the greater variability of the centered records from the standard was shown in connection with the standard error of estimate (shown under "Regression Equation Constants" in table 2). For example, if one were to correct for the bias evidenced when the testing day is on the fourth, one would utilize for the monthly butterfat records the equation, S(standard record) = 1.3 + .9799 (monthly record) $\pm$ 11.1. Thus when the monthly butterfat record equaled 300 pounds, the estimated standard record would be 295.3 $\pm$ 11.1 pounds. In similar manner a centered record of 300 pounds would be in terms of the standard (S) equal to 5.5 + .9921 (300) $\pm$ 14.2 or 303.1 $\pm$ 14.2 pounds. This example further illustrates what is shown in table 2, *i.e.*, that the standard errors of estimate for the centered records are more than enough larger than those for the monthly method to offset any advantage that the centering method had over the monthly method in mean differences from the standard. While monthly records show a tendency toward being high when tests are made toward the first of the month and low when tests are made toward the end of the month, corrections for this trend result in records averaging closer to the standard than do the corrected records computed by the centering method.

Milk. Differences between the standard records and the monthly records (table 3) average – 6 pounds of milk per cow per year, while the centered records average – 71 pounds of milk per cow from the standard records. For each of the four testing days the centering method of computing records resulted in milk production records which averaged less than the standard, ranging from – 46 to – 85 pounds per cow. Monthly records, on the other hand, varied from a + 160 pounds for the first of the month to a – 166 pounds when records were computed from tests made on the twenty-fifth of the month. Again, as with butterfat and in line with Kendrick's findings (3), there was a trend for the monthly method to give milk records that were too high when tests were made toward the first of the month and records that were too low when tests were made during the latter part of the month.

The centered records, on the other hand, were uniformly biased by being too low for each of the test periods.

TABLE 3

A comparison of the "Monthly" and "Centering the Testing Day" records with the "Standard" records for four different monthly testing days (Milk)

Type of record	Testing day	Mean difference from the standard (7501 # milk)	Correlation with the standard records (r)	Regression equation constants		
				a	b	Standard error of estimate
Monthly	4	+160	.9948	− 15	.9802	±219
Centered	4	− 80	.9918	+ 44	1.0049	±275
Monthly	11	+ 52	.9968	+ 00	.9932	±171
Centered	11	− 46	.9950	+ 41	1.0008	±215
Monthly	18	− 69	.9987	+ 19	1.0067	±111
Centered	18	− 71	.9971	+ 67	1.0005	±163
Monthly	25	−166	.9947	+ 75	1.0124	±222
Centered	25	− 85	.9927	+181	.9869	±261

Correlations between the monthly records and the standard records averaged .9962 for the four test periods, and ranged from .9947 to .9987. The corresponding correlations for the centering method averaged .9942 and ranged from .9918 to .9972. For each of the four test periods the monthly method correlations were slightly higher than for the centering method. The use of the regression equation constants (table 3) in an effort to correct for any bias, as in the case of butterfat, results with estimated values which vary more from the standard in the case of centered records than for monthly records. The actual differences, as shown by the standard errors of estimate, averaged forty-eight more pounds of milk than do those for monthly records.

Monthly versus Centered—with Daily Milk Weights

Butterfat. The use of daily milk weights and a butterfat test once a month (table 4) tended to remove some of the bias evidenced where daily

TABLE 4

A comparison of the "Monthly" and "Holstein Centering the Testing Day" methods for calculating yearly butterfat records based on daily milk weights

Type of record	Testing day	Average pounds butterfat	Mean difference from the standard (311.7 # B.F.)	Correlation with the standard records (r)	Regression equation constants		
					a	b	Standard error of estimate
Monthly D*	4	310.2	−1.5	.9958	+1.2	1.0019	±7.6
Centered D*	4	316.8	+5.1	.9956	+2.0	.9904	±7.8
Monthly D*	18	314.6	+2.9	.9963	+1.8	.9853	±7.2
Centered D*	18	314.6	+2.9	.9963	+1.8	.9853	±7.2
Monthly D*	25	316.3	+4.6	.9947	+1.8	.9795	±8.6
Centered D*	25	314.3	+2.6	.9950	+4.5	.9774	±8.3

* Indicates daily milk weights.

milk weights were not used (as shown in table 2), particularly as it applied to monthly type records. The mean differences for three testing periods average + 2.0 pounds of butterfat for the monthly type records and included only small differences of – 1.5, + 2.9, and + 4.6 pounds. The centered records used by the Holstein Friesian Association of America (4) had mean differences of + 5.1, + 2.9, and + 2.6 pounds and averaged + 3.5 pounds from the standard. Differences where daily milk weights were used thus slightly favored the monthly method.

Correlation coefficients and standard errors of estimate for these types of records (table 4) are practically identical, with r values for the monthly and the centering methods both averaging .9956 and the standard errors of estimate each averaging 7.8 pounds.

The Regularity of the Testing Date

Is it necessary that a herd be tested at approximately the same date each month in order to secure accurate results? In an effort to arrive at a partial answer to this question records based on irregular testing dates were compared to the standard records. These irregular records were based on variations in date of testing of a systematic nature, with the testing date zigzagging from the fourth to the eleventh, to the eighteenth, to the twenty-fifth of the month and back from the twenty-fifth to the eighteenth, the eleventh, the fourth, etc.

Resulting records computed by this zigzag method (table 5) compared favorably with the standard. Four comparisons, two with milk weights and two without, averaged just 1.1 pounds of butterfat above the standard with the widest deviation being + 3.0 pounds. The use of milk weights added to the accuracy of such records, reducing slightly the mean differences, raising the correlation coefficients, and lowering by about fifty per cent the standard errors of estimates.

TABLE 5

A comparison of "Monthly Zigzag" methods for calculating yearly butterfat records with and without daily milk weights

Type of record	First testing day	Average pounds butterfat	Mean difference from the standard (311.7 # B.F.)	Correlation with the standard records (r)	Regression equation constants		
					a	b	Standard error of estimate
Zigzag Monthly	4	314.7	+ 3.0	.9895	+ 13.5	.9477	± 12.1
Zigzag Monthly D*	4	314.6	+ 2.9	.9951	+ 7.3	.9977	± 8.3
Zigzag Monthly	25	309.8	– 1.9	.9927	– 2.0	1.0126	± 10.0
Zigzag Monthly D*	25	312.3	+ 0.6	.9949	+ 1.6	.9932	± 8.4

* Indicates daily milk weights.

As a group, the zigzag records had a smaller mean difference from the standard than did the corresponding monthly records based on regular tests,

i.e., – 1.1 pounds as compared to + 1.5 pounds (tables 2 and 4). Also, it is apparent that the zigzag method overcame the bias which tended to make the monthly records high or low, depending upon whether tests were made toward the first or the latter part of the month. The correlation values for the zigzag records averaged almost the same as the monthly records with .9930 as compared to .9929 for monthly records. This evidence would tend to show that a systematic irregularity in testing dates does not tend toward making records more inaccurate but that it may be conducive to greater accuracy.

The Accuracy of Bi-Monthly Records

Bi-monthly records with and without daily milk weights were computed by two methods, *i.e.*, where the test was made the first month of a bi-monthly period and where the test was made the second month of a bi-monthly period. Resulting records, when compared to the standard, show (table 6), with two exceptions, very close agreement with the standard. Both cases showing wide variations were those without daily milk weights. These two averaged

TABLE 6

A comparison of bi-monthly yearly butterfat records by the "Monthly" method with and without daily milk weights and a comparison of tests taken on the first month of the period with those of the second month

Type of record	Testing day	Average pounds B.F.	Mean difference from the standard (311.7 # B.F.)	Correlation with the standard records (r)	Regression equation constants		
					a	b	Standard error of estimate
1**Bi-monthly	18	302.5	– 9.2	.9737	+18.1	.9737	±19.0
2**Bi-monthly	18	322.8	+11.1	.9837	+17.6	.9112	±15.0
1**Bi-monthly D*	18	315.6	+ 3.9	.9890	+ 4.8	.9724	±12.4
2**Bi-monthly D*	18	314.4	+ 2.7	.9850	+ 2.3	.9843	±14.4
1**Bi-monthly D*	4	308.3	– 3.4	.9896	+ 5.6	.9932	±12.0
2**Bi-monthly D*	4	313.0	+ 1.3	.9927	+ 0.3	.9950	±10.1

* Indicates daily milk weight.
** Indicates month the test was taken for the period.

– 9.2 and + 11.1 pounds from the standard while the two corresponding bi-monthly groups with milk-weights averaged + 3.9 and + 2.7 pounds from the standard. Correlations were also higher for those with daily milk weights with an average r of .9891 as compared to .9787 for those without milk weights.

All bi-monthly records based on daily milk weights (table 6) averaged – 1.1 pounds from the standard with a range of – 3.4 to + 3.9. The corresponding monthly and centering records averaged + 0.8 from the standard with a range of – 3.1 to – 5.1. Correlations with the standard averaged .9891 for these bi-monthly records while the corresponding monthly and centered

records averaged .9911. Only small differences were found between the accuracy of bi-monthly records resulting from tests made during the first and the second months of a bi-monthly period. Mean differences from the standard averaged for the first-month records −3.2 pounds and for the second-month records +5.0. Correlations averaged .9841 for the first-month records and .9871 for the second-month records.

These comparisons indicated that bi-monthly records, when based on daily milk weights, were practically as accurate as were records based on monthly tests without daily milk weights and that it made little, if any, difference whether tests were made the first month or the second month of a bi-monthly period. The results, however, showed greater discrepancies for bi-monthly records without daily milk weights yet, on an average, such records serve as splendid indicators of a cow's actual production.

DISCUSSION

The results of this study should be a source of satisfaction to everyone concerned with the accuracy of existing short-cut methods of testing the milk and butterfat producing ability of dairy cattle. In general it can be said that any of the methods studied were highly reliable and sufficiently accurate to act as splendid guides in selecting high producing dairy cattle. In light of the findings, it is apparent that the differences between the accuracy of the various systems of computing records were too small to justify the variations in the testing rules now existing between those used by breed associations, the Bureau of Dairy Industry, and the state Agricultural Colleges.

This study secured results which are comparable to those from McDowell (1). In each the results showed that daily milk weights combined with monthly tests produced records which were more accurate than did similar tests without daily milk weights. Likewise, each study showed that bi-monthly tests with daily milk weights gave records which were only slightly less accurate than were records from monthly tests without daily milk weights. In each case bi-monthly records without daily milk weights were the least accurate of any of the types of records studied.

The findings leave room for doubt as to the necessity of confusing testing supervisors about centering the testing date. The monthly method showed a slight tendency toward records that were too high when tests were made during the first of the month and too low when tests were made late in the month. Some of this bias could have been due to the greater number of cows that freshened during the fore part of the month than freshened during the latter part of the month, *i.e.*, forty-four for first half and twenty-nine during the last half (table 1). When an entire association is considered, this bias, if real, would tend to balance itself. Within a herd, likewise, the bias would cause no great trouble for the entire herd would be affected

and cows could have their records compared one with another with little, if any, source of error arising from the method used in computing records. Some consistent error would arise when a herd tested during the first of the month was compared to a herd tested towards the latter part of the month. The indicated discrepancy arising in this most extreme case would represent 332 pounds of milk and 7.4 pounds of butterfat per cow for the year, with the real difference from the actual record, the standard, being approximately one-half these amounts (tables 2 and 3).

In accuracy the centering method also shows some errors. On an average, its records were too low, with butterfat averaging 1.2 pounds below the standard and – 3.1 pounds as the widest difference. The average mean differences from the standard (+ and –) favored the centering method by just 0.9 pound of butterfat per cow per year.

Milk differences for the centering method were all negative (table 3) ranging from – 46 to – 85, with an average of – 70 pounds. This, when compared to the average deviation of the monthly means from the standard (112 pounds) gave centering a 52 pound per year advantage in average accuracy. This small difference would represent 4.3 pounds of milk per month or 0.14 pound of milk per day.

The correlations found between the standard records and other types of records ranged from .9737 to .9914. The size of these correlation coefficients is sufficiently large to give confidence to the accuracy of any of the methods of computing records studied. This is particularly true when the correlations are compared to the average intra-herd correlations between consecutive records of dairy herd improvement association cows which range from .27 to .40 (5, 6), and even then represent considerably more than the hereditary portion of the variance between records of cows within the same herd.

When the centering method is compared directly with the monthly method (instead of with the standard), as in table 7, the greatest difference in butterfat yield is when the testing day is on the fourth of the month. This difference is 8 pounds per cow, and reduces to 3.6 pounds on the 11th, 2.3 pounds on the 25th, and no difference when the 18th is the testing day.

TABLE 7

A comparison of "Centering the Testing Day Method" with the "Monthly Method," for calculating Dairy Herd Improvement yearly butterfat records

Testing day	Ave. pounds B. F. for each method		Variations of centering from monthly in pounds of B. F.	r	t*	P
	Monthly	Centering				
4	316.8	308.6	– 8.2	.9976	6.65	$< .01$
11	313.1	309.5	– 3.6	.9978	4.01	$< .01$
18	312.3	312.3	0.0	.9993	3.66	$< .01$
25	309.4	311.7	+ 2.3	.9904	1.60	$> .05$

* See footnote following page.

It is of particular interest to note the high correlation coefficients when the two methods are directly compared. With all coefficients exceeding 0.99 there can be little difference between the two methods.

By the use of a special formula worked out by Cochran,* the significance of the differences between the correlations of the monthly and the centered records with the standard records were tested. (See table 2 for r values with standard and table 7 for r values between the two methods being tested.) The t values found show that for three of the testing periods, the monthly records were significantly more highly correlated with the standard than were the centered records. For the remaining testing period the test of significance resulted in a t – value (1.60) with a probability much closer to the five per cent level than to the fifty per cent level.

Correlations between the centered and the monthly records with the standard records favored the monthly method for each set of records regardless of the testing date. The consistency of this higher relationship and results of the test of significance between their differences would tend to support the conclusion that, in spite of a slight bias in the monthly records caused by differences in testing date, the monthly records do vary from cow to cow more nearly in step with standard records than do the centered records. Stated in another way, if one wished to correct for the tendency of the records to be too large or too small by the use of an appropriate regression equation (see tables 2 and 3), the resulting estimated monthly records would vary enough less from the standard (shown as standard error of estimate in tables 2 and 3) to more than offset any advantage that centered records have shown in mean differences over monthly records. Calculation of correlation coefficients from Kendrick's original data (2) showed close agreement to the standard for both the monthly and the centering methods, with the monthly correlation the higher when the testing date was on the twenty-eighth and the centering correlation higher when the third was the testing date.

Systematic variations in the testing date in a regular manner from the fourth to the eleventh, to the eighteenth, to the twenty-fifth, and then in a reverse order, failed to cause any discrepancies in resulting record. In fact monthly records so computed did not show the bias toward large or small records caused by differences in testing date as was found where the testing date was regular (compare data in tables 2 and 5). Perhaps some systematic variation in testing dates would be preferable in practice, not only in overcoming any consistent bias but also to make tests more nearly of a surprise nature than that which now exists in dairy herd improvement association work.

* Formula derived by W. G. Cochran of Statistical Laboratory at Iowa State College via personal communication:

$$t = \frac{(r_{y1} - r_{y2})\sqrt{n-3}\qquad\sqrt{1-r_{12}}}{\sqrt{2}\quad\sqrt{1-r_{12}^2-r_{y1}^2-r_{y2}^2+2r_{y1}\,r_{y2}\,r_{12}}}$$

Bi-monthly tests that require daily milk weights appear from the results of this study to be about as accurate as are tests based on monthly tests without daily milk weights. This system of testing is cheaper for herd owners than is monthly testing. It is, however, more conducive to error if herd owners are careless in their record keeping and necessitates an adding machine as standard equipment for testing supervisors as well as reducing the number of cows they can take care of in one day due to the time involved in adding up the daily milk sheets for the previous bi-monthly period.

SUMMARY

1. One hundred yearly Holstein and Jersey records were computed by various present-day methods of estimating their actual amounts. The standard records used for comparisons were based on actual daily milk weights and forty-eight butterfat tests during the year.

2. Centering-the-testing-day method showed only slight advantages over the monthly method (testing date not centered) in mean differences from the standard and its records failed in all comparisons to be as highly correlated with the standard as were the monthly records.

3. A systematic irregularity in testing dates tended to overcome some of the bias shown with regular testing dates and did not lower the correlation with standard records.

4. The use of daily milk weights tended to reduce the variability of the records when compared to the standard.

5. Bi-monthly tests and the use of daily milk weights resulted in records which were practically as accurate as were records from monthly and centering methods not utilizing daily milk weights.

6. Results of the study show only small differences between the accuracy of various methods now used by breed associations, agricultural colleges, and the Bureau of Dairy Industry, and indicate that uniform testing rules could be profitably adopted by all parties concerned.

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BLOOD SUGAR AND CARBON DIOXIDE COMBINING POWER OF THE PLASMA IN RELATION TO KETOSIS IN DAIRY CATTLE*

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Low blood sugars and decreased carbon-dioxide combining power of the plasma of cattle with ketosis have been reported from several sources (1, 8, 9, 10). There seems to be considerable unanimity of opinion that low blood sugars accompany the type of ketosis in which marked clinical symptoms are evident although acidosis is not an invariable accompaniment (2, 4).

During a preliminary survey for the incidence of ketosis in the cattle of the college dairy herd it was noted that a large number of these cattle gave a positive urine test for ketones in spite of the fact that no other clinical signs were evident. This ketosis seemed more prevalent during the winter months and tended to disappear when the cattle were turned to pasture in the spring. The blood sugars which were determined on these cattle and the carbon-dioxide combining power of the plasma indicated no abnormalities, a contradiction to the generally accepted concept of the relationship of blood sugar to ketosis in cattle.

METHODS

The data for this paper were obtained mainly from a similar survey of the herds of the various State institutions. In all, the urine of over 1500 cattle was tested by means of the sodium nitroprusside test for the presence of ketosis. In addition, data obtained from routine work carried out with the college herd are included. With a few exceptions clinical signs of ketosis were absent in this group of cattle. A large number (456) of these cattle, however, gave a strong ++++ urine test.

Blood samples were obtained only from those animals showing a ++++ urine test. Many other animals of course gave a positive ketone test of less intensity. Blood samples were not obtained from these however since previous work (Duncan & Huffman, unpublished data) indicated that the level of ketones in the blood is generally very low with +, ++, and +++ urine tests. Even ++++ tests do not always indicate marked ketosis. The blood samples were obtained from the jugular or abdominal mammary veins. Potassium oxalate was used as the anticoagulant.

On these samples the total ketones were determined by the method of Van Slyke and Fitz (13), the blood sugars by the Shaffer-Hartmann method as modified by Somogyi (11), and the carbon-dioxide combining power of the plasma by the method of Van Slyke and Cullen (12).

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The individual animals were placed in one of four groups according to the ketone concentration which was found to be present in the blood. Group I included all animals with less than 2.0 mg. ketones per 100 ml. Group II consisted of animals with from 2.0 to 6.0 mg. per 100 ml. In group III the individuals showed ketones at a level of 6.0 to 10.0 mg. per 100 ml. and group IV consisted of all animals showing a ketosis of 10.0 mg. per 100 ml. or more. The limits set for the various groups were chosen with a view to bringing out any differences which might exist with varying degrees of ketosis. Groups I and II, for practical purposes may be considered normal. Data compiled by Duncan, Huffman, and Tobin (4) indicate that the range for blood ketones in apparently normal cattle is from 0.69 to 5.54 mg. per 100 ml. The blood sugar values and those obtained for the carbon-dioxide combining power of the plasma of these animals were placed in the corresponding groups and averaged. In this way it was possible to correlate blood sugar and CO_2 values with the different degrees of ketosis which were present.

RESULTS AND DISCUSSION

The results obtained by treating the data obtained in the above manner are shown in table 1.

TABLE 1

Average blood sugar values and the carbon dioxide combining power of the plasma in cattle with ketosis

Group	Blood sugar		CO_2 combining power	
	Determinations	mgm. per 100 ml.	Determinations	cc. per 100 ml. plasma
I	235	54.1 ± .47	222	63.5 ± .35
II	161	53.5 ± .58	161	65.6 ± .41
III	24	49.2 ± 1.8	24	60.5 ± 1.37
IV	36	43.8 ± 1.6	36	66.8 ± .65

Group I—0–2 mg. ketones per 100 ml. blood
Group II—2–6 mg. ketones per 100 ml. blood
Group III—6–10 mg. ketones per 100 ml. blood
Group IV—10 or more mg. ketones per 100 ml. blood

The blood sugar values for groups I and II are within normal limits for dairy cattle (7) and no significant difference exists between the two groups. However, when the level of blood ketones exceeds 6.0 mg. per 100 ml. and particularly when the level exceeds 10.0 mgms. the blood sugar values were distinctly lower than in the preceding two groups. The data clearly indicated that low blood sugars accompany ketosis even when clinical signs are absent and would suggest that either faulty carbohydrate metabolism or insufficient available carbohydrate is a predisposing factor in the incidence of ketosis in dairy cattle.

That faulty carbohydrate metabolism is not always the primary cause is indicated by the fact that rather prompt, although only temporary relief usually follows the injection of glucose in clinical cases (5, 6, 8, 10). Cameron and Goss (3) have likewise shown that injections of glucose cause a prompt decrease in blood ketones in sheep and, in two cases which we have had an opportunity to study, a similar decrease was noted in cows. These observations would suggest that ketosis is not the result of failure of the organism to metabolize carbohydrate but rather that it is due to insufficient carbohydrate for complete fat oxidation.

On the other hand, it seems rather fanciful to suggest that a deficiency of available carbohydrate should ever exist in dairy cattle and that it should be sufficiently great to result in incomplete fat oxidation. However, it has been shown (4) that the addition of corn sugar or molasses to the ration of cows with marked ketosis results in prompt improvement in the condition. Similarly, the greater incidence of ketosis during the winter months points to insufficient carbohydrate as being an important factor. During the winter period the forage which is fed is distinctly lower in sugar than is pasture grass or other pasture crops. Up to the present, however, we have not been able to detect any significant variations in blood sugar under winter feeding conditions as compared to spring and summer conditions when the cattle are on pasture. Boddie (1) has reported similar observations. There is likewise a tendency for ketosis to be more prevalent among high producing cows than in less productive individuals. Apparently, in these individuals the demands on carbohydrate for milk production is such that insufficient amounts are available for other metabolic processes.

More extensive work is necessary before definite conclusions may be drawn concerning the factors which are responsible for the decrease in blood sugar which accompanies ketosis in cattle. The evidence which is available at the present, however, would suggest that the rations ordinarily fed to dairy cattle contain only sufficient readily available carbohydrate to meet ordinary requirements. When extra metabolic demands are made or when for any reason the carbohydrate content of the ration is decreased, then a lowered blood sugar results and ketone bodies begin to accumulate. Even a slight fall in blood sugar may permit ketones to appear in greater quantities than is ordinarily the case (table 1), a fact which further suggests that the metabolic requirements of cattle for carbohydrate are barely being met under ordinary conditions.

It will be noted that the blood sugar values of this group of cattle did not reach the low levels reported by others even when the ketosis exceeded 10 mg. per 100 ml. This difference was in all probability due to the fact that the ketosis reported by these workers was more pronounced than that encountered in this group of cattle. Within this group, however, were four animals which showed a more marked ketosis than the others as evidenced

by a decrease in milk production and lack of appetite. The blood sugars were also low and are in closer agreement with the values reported by other workers. The data on these four animals are shown in table 2.

TABLE 2

Blood sugar values and the carbon dioxide combining power of the plasma of four cows with marked ketosis

Animal	Total ketones mg. per 100 ml.		Blood sugar mg. per 100 ml.	Carbon dioxide combining power cc. per 100 ml.
	Blood	Urine		
1	29.1	338.0	25.0	68.0
2	29.9	373.0	23.0	60.0
3	89.3	1568.0	25.0	69.0
4	2.4	499.0	25.0	81.0

The values for the carbon-dioxide combining power of the plasma showed no consistent variations which could be correlated with the degree of ketosis (table 1). Even in those animals in which the ketosis was more pronounced, the values were within normal limits (table 2). These results indicate that acidosis is not an invariable accompaniment of ketosis. While acidosis may result from ketosis, as has been reported by others, it would seem that a very marked ketosis would be necessary to produce detectable alterations in the acid base balance of cattle in view of the preponderance of basic elements in the ration.

SUMMARY

Decreased blood sugar values accompany ketosis in cattle even when the ketosis is not sufficiently severe to be detected by clinical symptoms. The significance of the low blood sugars and causative factors in relation to ketosis is discussed.

Acidosis is not an invariable accompaniment of ketosis in dairy cattle.

The technical assistance of Mr. R. F. Jackson is gratefully acknowledged.

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THE EFFECT OF RATIONS DEFICIENT IN PHOSPHORUS AND PROTEIN ON OVULATION, ESTROUS, AND REPRODUCTION OF DAIRY HEIFERS*

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In a previous publication (1) from this station experiments were reported on uncomplicated phosphorus deficiency in mature dairy cows of as great severity as occurs naturally on phosphorus deficient range or on farms in phosphorus deficient areas. Disturbances in the estrous cycle did not occur in these animals even when the deficiency was maintained continuously for two or three years, although the breeding efficiency of the animals seemed to be reduced. We concluded that the disturbances in estrum and the low calf crops reported to occur under natural conditions in phosphorus deficient areas are probably due to the nutritive deficiencies which accompany the lack of phosphorus or to the combination of deficiencies that prevail and not exclusively to phosphorus deficiency.

Aside from the phosphorus deficiency, the most striking characteristic of rations given to cattle and other ruminants in the phosphorus deficient regions of Minnesota, and no doubt elsewhere, is their low protein content. In December, 1933, we began an experimental study of the effects of combined phosphorus and protein deficiency in dairy calves and heifers. This study continued until August, 1939. Eleven grade Holstein animals were studied during experimental periods of 24 to 59 months duration for the different animals. We were especially concerned with obtaining evidences of irregular ovulation and estrous cycles and suppressed sexual activity. Later we studied the reproduction of some of the animals. Guilbert and Goss (2) found that estrous in rats either ceased or occurred in long, irregular cycles when their ration contained only $3\frac{1}{2}$ to 5 per cent protein and Pearson, Hart and Bohstedt (3) found cessation of both estrous and ovulation in the same species restricted to a diet containing 5 per cent casein.

The rations given to our animals consisted largely of prairie hay, although a small amount of grain mixture and either plain or molasses beet pulp, was also fed. All the prairie hay came from the same farm in the phosphorus deficient region of Minnesota. The different lots of hay ranged in phosphorus content from 0.047 to 0.081 per cent, with an average of 0.066 per cent, and in total crude protein content from 4.23 to 6.49 per cent, with an average of 5.31 per cent. The grain mixture contained two or more of

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the following ingredients: corn, oats and low phosphorus corn-gluten meal. Feeding schedules were calculated for each animal at 30-day intervals, feed intakes recorded and the nutrient intakes calculated for each 30-day period from chemical analyses of the feeds.

Except for brief periods, or during lactation in the later phases of the study, the animals consumed 5 to 8 grams phosphorus and 0.4 to 0.75 pound digestible crude protein daily, depending on their age and their appetite for the hay. The digestible crude protein comprised between 5 and 10 per cent of the total digestible nutrients.

Table 1 shows the age of each animal at the start of the experiment, the length of time on experiment and the calculated mean daily intakes of phosphorus and digestible crude protein for each animal throughout the study.

TABLE 1

Animal no.	Age when placed on experiment	Length of time on experiment	Mean daily intake		Remarks
			P	Dig. crude protein	
	months	*months*	*grams*	*lbs.*	
E-192	23	27	7.4	0.72	.....
E-193	22	27	7.4	0.75	.....
E-207	6	37	7.0	0.64	.....
E-208	6	59	6.7	0.61	.....
E-211	8	58	7.3	0.65	Includes 9 mo. lactation.
E-217	8	52	7.8	0.69	Includes 9 mo. lactation.
E-242	8	36	5.8	0.51	.....
E-246	7	33	5.4	0.46	.....
E-265	7	31	5.3	0.45	.....
E-266	7	25	4.9	0.42	.....
E-269	7	24	5.2	0.45	.....

Each animal was weighed at 30-day intervals and a monthly composite sample of blood plasma, representing three consecutive days bleeding, analyzed for calcium and inorganic phosphate. During the course of the experiment five of the animals were subjected to one or more balance trials, each of 10 days duration. Frequent observations were made for evidences of pica, physical condition and general behavior. At the close of the experiment six of the animals were slaughtered and the right femur, humerus and scapula, and 6th and 11th ribs taken for analysis.

Table 2 shows that the animals gradually developed a state of chronic phosphorus deficiency as indicated by the subnormal phosphate content of the blood plasma. This state was reached more rapidly in the animals which entered the study in 1936 than with those which started in 1933 and 1934.

Of considerable interest is the observation that all the animals that were placed on experiment in 1933 and 1934 developed pica and osteophagia *before* the blood plasma inorganic phosphate became subnormal. However, when the protein intake was increased temporarily, the plasma phosphate

dropped sharply. Later the protein could be decreased without a rise in plasma phosphate. These relations were not observed in the remaining animals.

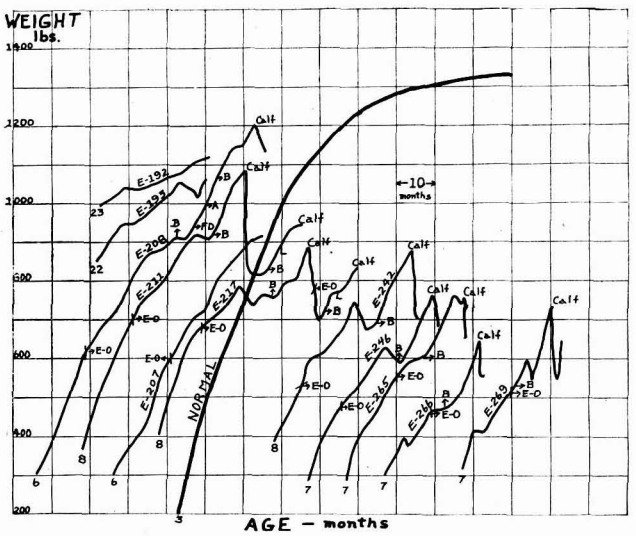

CHART 1. The letters employed on the curves have the following meaning: E–O = either first estrum and ovulation or the estrum-ovulation recurring after parturition; B = either first attempted breeding or the breeding attempted after parturition; FD = fetus died (E–208); A = abortion (E–208); L = lactation period. The figure at the base of each curve is the age of the animal, in months, when placed on experiment. The normal curve shown is based on the data given by Eckles (1920) extended to an assumed mature weight of 1350 pounds at 96–100 months of age.

Chart 1 shows the growth curves of the animals in comparison with Eckles' (4) normal curve[1] for the Holstein breed. The weights of the two older heifers were somewhat better than normal for their age at the start, but their development was very slow after they were placed on the deficient ration. They took on an emaciated, unkempt appearance and their condition became very poor as the experiment progressed. The weight increase of the first three of the young calves (E–207, E–208 and E–211) was fairly normal at first, but they were only 75–85 per cent normal when dropped from the experiment at a mature age. E–208 was the most nearly normal of the group at the close, but she was 5½ years old at the time. The others not only grew at a subnormal rate, but they developed the coarse, unthrifty

[1] Actually the data reported by Eckles have been extended to an assumed mature weight of about 1350 pounds at eight years of age, which is essentially the mature weight shown in the more extensive data reported later by Ragsdale (Missouri Agr. Exp. Sta. Bull. 336, 1934). Ragsdale's curve has a somewhat steeper slope than Eckles'. Either curve would be suitable for the present comparison.

TABLE 2

Progressive changes in Ca and inorganic P in blood plasma showing the concentration in mgm. % at beginning and end of experiment and the mean values for intervening six months periods

E–192											
Age (Mo.)	.....	.....	.....	23	29	35	41	47	51	.....	.....
Ca	.....	.....	.....	10.4	10.6	10.5	10.7	11.3	10.8	.....	.....
Inorg. P	.....	.....	.....	5.90	4.48	3.32	3.17	3.10	3.90	.....	.....
E–193											
Age (Mo.)	.....	.....	.....	22	28	34	40	46	50	.....	.....
Ca	.....	.....	.....	9.9	10.7	10.6	10.2	11.2	10.7	.....	.....
Inorg. P	.....	.....	.....	7.60	4.39	3.63	3.97	3.23	3.64	.....	.....
E–207											
Age (Mo.)	6	12	18	24	30	36	42	44	.....	.....	.....
Ca	10.0	10.0	10.5	10.6	10.9	11.0	11.2	10.9	.....	.....	.....
Inorg. P	8.16	5.68	5.49	4.04	3.16	2.86	4.00	3.16	.....	.....	.....
E–208											
Age (Mo.)	6	12	18	24	30	36	42	48	54	60	65
Ca	10.8	9.7	9.9	9.7	10.8	10.3	11.2	10.6	11.3	10.0	11.3*
Inorg. P	8.28	6.65	6.02	4.98	4.35	3.14	3.12	2.99	3.56	3.16	2.21*
E–211											
Age (Mo.)	8	14	20	26	32	38	44	50*	56†	60†	63*
Ca	9.9	10.3	10.3	10.6	10.5	11.0	10.8	12.5*	11.3†	11.2†	11.6*
Inorg. P	8.47	6.74	5.74	3.49	3.84	3.17	3.16	3.02*	2.69†	1.68†	2.31*

* Parturition.
† Lactation.

TABLE 2—(*Continued*)

E–217											
Age (Mo.)	8	14	20	26	32	38	44*	50†	56†	60*	.....
Ca	10.4	10.2	10.5	11.3	10.9	11.5	11.4*	12.0†	11.3†	12.5*	.....
Inorg. P	9.48	7.18	4.12	3.83	3.45	3.15	3.46*	1.73†	2.26†	1.61*	.....
E–242											
Age (Mo.)	8	14	20	26	32	38	44*	.....	.....	.....	.....
Ca	.....	10.3	11.3	12.1	12.0	12.3	10.8*	.....	.....	.....	.....
Inorg. P	.....	6.71	4.72	3.13	2.95	3.62	2.84*	.....	.....	.....	.....
E–246											
Age (Mo.)	7	13	19	25	31	37	41*	.....	.....	.....	.....
Ca	.....	10.8	10.7	12.7	12.7	11.0	11.0*	.....	.....	.....	.....
Inorg. P	.....	4.86	3.72	2.84	2.51	3.07	3.03*	.....	.....	.....	.....
E–265											
Age (Mo.)	7	13	19	25	31	37*	.....	.....	.....	.....	.....
Ca	.....	11.7	12.1	11.8	12.1	12.2*	.....	.....	.....	.....	.....
Inorg. P	.....	4.36	3.03	2.51	3.33	2.12*	.....	.....	.....	.....	.....
E–266											
Age (Mo.)	7	13	19	25	31	33*	.....	.....	.....	.....	.....
Ca	.....	12.0	12.3	12.6	12.9	9.6*	.....	.....	.....	.....	.....
Inorg. P	.....	4.29	3.29	2.49	2.97	2.50*	.....	.....	.....	.....	.....
E–269											
Age (Mo.)	7	13	19	25	31*	33	.....	.....	.....	.....	.....
Ca	.....	11.3	10.9	3.07	11.7*	10.2	.....	.....	.....	.....	.....
Inorg. P	.....	4.09	3.07	2.42	2.37*	2.48	.....	.....	.....	.....	.....

* Parturition.
† Lactation.

appearance, disproportionately large heads, coarse coat, and emaciated condition characteristic of the heifers and cows fed largely on prairie hay in the phosphorus deficient regions of Minnesota. E–217 and E–242 were only about 65 per cent normal weight when calving at 4 years of age and the others hardly more than 50 per cent normal weight when they calved. Figures 1, 2 and 3 show the appearance of three of the animals very soon after parturition.

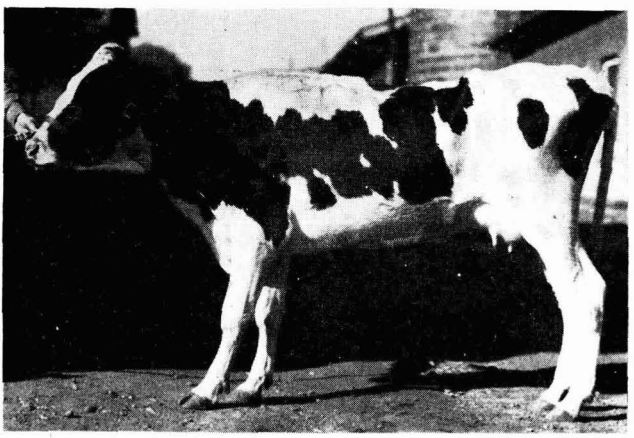

FIG. 1. E–217 at 49 months of age, one week after the birth of her first calf. She weighed only 750 pounds at that time. She should have weighed approximately 1150 pounds.

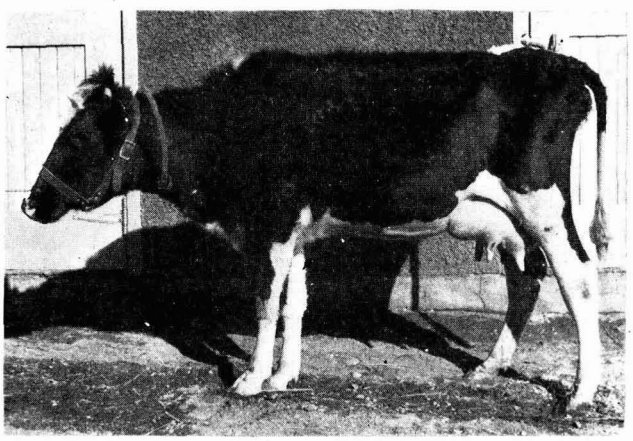

FIG. 2. E–246 at 39 months of age, the day following the birth of her calf. She weighed only 725 pounds at that time. She should have weighed at least 1100 pounds.

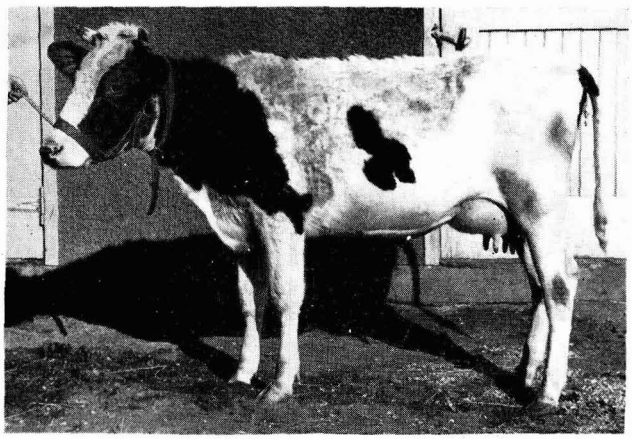

FIG. 3. E–269 at 30 months of age, four days after the birth of her calf. She weighed only 580 pounds at that time. She should have weighed 1000 pounds.

Table 3 shows the results of the N and P balance trials.

TABLE 3

Balance trials

Animal	Length time on experiment	Daily N intake	Daily N balance	N retained	Daily P intake	Daily P balance	P retained
	(*days*)	(*gm.*)	(*gm.*)	%	(*gm.*)	(*gm.*)	%
E–207	350	78.2	23.3	42.6	7.45	1.93	25.7
E–208	350	66.9	17.9	31.6	7.35	2.24	30.5
E–208	1140	71.8	2.5	3.5	6.98	1.07	15.3
E–208	1170	75.8	10.0	12.9	7.15	0.96	13.4
E–208	1230	74.6	0.7	1.0*	6.53	−0.34	.....
E–211	1080	77.0	4.2	5.5	7.31	1.18	16.2
E–211	1110	77.9	9.4	12.1	7.29	0.88	12.1
E–211	1170	77.0	8.7	11.3†	6.70	−0.80	.....
E–242	315	63.8	5.8	9.2	6.33	0.64	10.1
E–242	345	64.0	7.7	12.0	5.98	1.05	17.8
E–242	360	58.9	0.6	1.0	5.25	0.26	5.0
E–242	390	63.5	3.4	5.3	5.74	0.22	3.9
E–246	345	60.8	15.6	52.0	5.75	2.17	37.7
E–246	360	52.3	6.5	12.5	4.48	1.08	24.1
E–246	390	50.8	5.6	11.0	4.51	0.63	13.9

* N digestibility = 47.4%. † N digestibility = 49.7%.

For the most part the balance trials which are summarized in table 3 show a relatively low percentage retention of N and P in keeping with the slow growth and development of the animals. When the animals had reached maturity, at least in age, as was the case at the time of the last balance trials of E–208 and E–211, the phosphorus intake was insufficient to maintain phosphorus equilibrium.

Evidence that these animals must have been either in negative phosphorus balance or depositing little $Ca_3(PO_4)_2$ for considerable periods of time during the course of the experiment is seen in the chemical composition of their bones. This is shown in table 4 where their bone composition is compared with that of normal dairy animals. In every case the bone analyses show the abnormally low ratio of $Ca_3(PO_4)_2$ to $CaCO_3$ and the decreased ash content characteristic of phosphorus deficiency (1, 5). The different bones of these various animals, ranging in age from nearly three years to more than five years, were definitely inferior to the corresponding bones of normal, mature animals. The emaciated condition of some of the animals is reflected in the close correspondence between the ash content on the dry and the dry, lipide free basis. The bones of the calf (from E–265) which died at 24 days of age from digestive disturbances and general lack of vigor, did not show any evidences of mineral deficiency.

TABLE 4

Bone composition

Animal	Age	Bones	Ash content			Ratio $Ca_3(PO_4)_2$ to $CaCO_3$
			Fresh basis	Dry basis	Dry extracted basis	
	Months					
Mean of 4 normals	27–52	ribs	44.2	60.3	62.9	6.90
Mean of 4 normals	27–52	scapula	48.0	57.5	64.0	6.43
Mean of 4 normals	27–52	femur-humerus	42.8	50.0	67.7	6.78
E–208	63	ribs	35.0	47.9	59.7	5.87
"	63	scapula	41.5	48.9	64.2	5.59
"	63	femur-humerus	37.6	46.0	66.5	5.94
E–211	66	ribs	26.2	54.2	56.4	5.42
"	66	scapula	34.4	59.3	60.4	5.36
"	66	femur-humerus	30.3	61.3	64.1	5.62
E–242	44	ribs	30.6	49.4	56.5	5.26
"	44	scapula	36.6	49.6	60.3	4.99
"	44	femur-humerus	29.5	38.4	63.0	5.56
E–246	41	ribs	32.4	58.4	59.5	5.19
"	41	scapula	32.8	59.1	61.3	5.29
"	41	femur-humerus	27.9	60.0	64.0	5.36
E–266	33	ribs	31.4	48.3	56.3	5.10
"	33	scapula	30.0	46.4	59.1	5.07
"	33	femur-humerus	27.6	40.2	62.7	5.23
E–265	37	ribs	28.4	42.0	56.2	4.94
"	37	scapula	32.9	46.0	59.3	4.75
"	37	femur-humerus	28.8	41.5	62.4	5.15
Calf of	*days*					
E–265	24	ribs	33.2	60.3	61.5	8.00
"	24	scapula	32.8	59.0	60.3	8.00
"	24	femur-humerus	25.5	57.4	59.5	8.58

Drs. W. L. Boyd and C. P. Fitch conducted the physiological studies on sexual activity and behavior and supervised the breeding of the animals.

The studies on sexual activity included frequent, regular examinations for physical signs of menstruation in the young animals and for physical and psychological signs of estrum. Rectal examination of the uterus and ovaries for evidences of ovulation were also made at frequent intervals. During the last 45 months of the experiment all of these observations were made twice weekly.

It was found possible to determine the time of ovulation with considerable accuracy by the secretory activity of the ovaries and uterus. The changes occurring in the ovaries consisted of progressive and retrogressive changes of the follicles and corpora lutea. The uterus, in addition to secreting large amounts of mucous at the time of estrus, exhibits marked muscular contraction, especially when palpated. Whenever estrum was noted the inclination to "bull" other heifers or cows was also tested. However, bulls were not employed at any time to determine the physiological activity of the sex organs.

The effects of the deficiencies on the age at which sexual maturity was reached, as well as the regularity of sexual activity, was determined in only nine of the animals, the other two being employed only for observations on the regularity of estrum and ovulation, since they were already 22–23 months of age when put on the experimental ration.

Chart 1 shows the age at which sexual maturity was reached in each of the animals that started on experiment as calves, as judged by first ovulation and estrum. This ranged from 15½ to 21 months, the mean being 19½ months, showing that sexual maturity was much delayed in all cases. This was clearly not the effect of the subnormal growth rate *per se*, for E–207, E–208 and E–211 that grew most nearly at a normal rate were as slow in ovulating for the first time as E–266 and E–269 that grew at the slowest rate.

After ovulation and estrum began to occur, ovulation, but not estrum, continued to occur at normal intervals. No instance of retained corpus luteum was observed. This was interesting as we have in the past believed that absence of estrum, as a result of retention of the corpus luteum, is a fairly common occurrence. However, as regards estrum, the symptoms were at times so slight or mild that they almost escaped detection. Physiological evidences of estrum were not always accompanied by apparent psychological symptoms, *i.e.*, "bulling." In the young heifers menstruation occurred much less frequently than estrum, as would normally be expected.

Eight of the nine animals that started the experiment as calves were tested for breeding efficiency after being on the phosphorus-protein deficient ration for periods ranging from 14 to 37 months. Table 5 shows the reproduction record.

Four of the animals, E–208, E–211, E–217 and E–242, were 34 to 42½ months old when breeding was first attempted. These animals, as well as three of the younger ones, conceived at first service. About five weeks prior

TABLE 5

Reproduction record

Animal No.	Age at conception	Length of time on experiment	Number services required	Method of breeding	Condition of calf	Weight of calf	Character of parturition
	months	*months*				*lbs.*	
E–208	42.5	37.5	1	bull	dead	5 mo. fetus	.....
E–208	54	49	4	bull	vigorous	65	normal
E–211	42	34	1	bull	vigorous	100	normal
E–211	56.5	48.5	4	bull	vigorous	normal	normal
E–217	37.5	30.5	1	bull	normal	70	normal
E–217	50	43	1	bull	vigorous	65*	normal
E–242	35	27	2	1. artificial insemination 2. bull	normal	normal	very difficult
E–246	30.5	23.5	1	artificial insemination	normal	67	partial prolapse of vagina
E–265†	28	21	3	1. bull 2. artificial insemination 3. bull	weak‡	72	retained placenta
E–266	22.5	16.5	1	artificial insemination	dead	normal	Part. very difficult. Calf died of suff.
E–269	21	14	1	artificial insemination	dead	59	Part. very difficult. Calf died of suff. during forced removal.

* 263 day gestation.

† Cow very exhausted after parturition.

‡ This calf died at 24 days of age, due to constipation and general lack of vigor.

to the termination of her gestation period E–208 expelled a dead, partly resorbed fetus, the death of which had been noted at about the fifth month of pregnancy. She soon conceived again, although with more difficulty, and gave birth to a normal calf. Normal calves were also born to all but one of the other animals. The calf of E–265 was normal in size but not vigorous and died several weeks after birth. This cow, as well as E–266 and E–269, had difficulty in parturition, partly because of poor skeletal development. E–266 and E–269 weighed only 600 pounds at parturition (exclusive of fetus, etc.). Their calves suffocated during their expulsion. They were normal calves, and it was judged they would have lived.

Conception was effected for three of the cows by artificial insemination. This method failed on one trial with two other animals.

Figure 4 shows E–211 and her second calf.

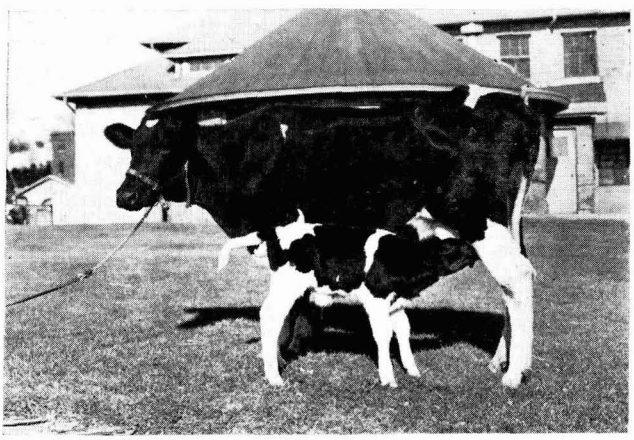

FIG. 4. E–211 and her second calf, when the cow was 65½ months of age. She weighed 840 pounds at that time. She should have weighed nearly 1300 pounds.

CONCLUSIONS

We conclude from this study that a combined deficiency of phosphorus and protein in the bovine, analogous to similar deficiencies in animals reared largely on prairie hay in the phosphorus deficient regions, delays sexual maturity, represses normal evidences of estrum so that periods of estrum appear to be missed, but does not interfere with normal regularity of ovulation or the ease of conception. The reduction in breeding efficiency noted in a previous experiment when phosphorus alone was deficient, was not observed in this study. The ease with which these undersized, miserable appearing specimens of the bovine species conceived when bred long after the normal age of first breeding and the normal vigor of the calves produced were definitely contrary to all expectations. However, the marked dystocia

(mainly maternal) which occurred in four of the eight animals employed for the breeding study must be regarded as probably due in large measure to the dietary deficiencies imposed.

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FACTORS INVOLVED IN THE EJECTION OF MILK*

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Cows which habitually "let down" or "hold up" their milk are common in all herds. Several theories have been advanced in an effort to explain the physiological processes involved, but each has been found at fault in some regard. In reviewing the literature dealing with the factors involved in the ejection of milk we find that the majority of investigators have failed to differentiate between the processes involved in the synthesis or the secretion of milk within the gland, and the act of ejecting the milk from the alveoli and the small ductules. This has caused some confusion in the interpretation of experimental results.

LITERATURE REVIEW

Routh (21) and Ribbert (20) offered evidence at an early date that the nervous system does not exercise a direct control over the combined acts of secretion and ejection. McKenzie (16) and McCandlish (15) injected numerous drugs, several of which might be classed as nerve stimulants, and failed to produce a marked effect on the rate of secretion or ejection of milk. Both, however, noted that pituitrin produced a marked galactagogic effect.

McKenzie (16), working with cats, noted some galactagogic effect from injecting extracts of corpus luteum and pineal body, and report some inhibitory effects of placental extracts on milk secretion. In these reports, however, no differentiation was noted between "secretion" and "ejection." Cannon and Bright (1) concluded that the autonomic nervous system was essential to lactation, from their work with a sympathectomized dog. They describe the effect as a belated one which caused the mother to be indifferent to her young and the gathering of a viscous, creamy material in the glands.

Hammond (7) and Macy *et al.* (13) accept Gaines (3) view that milk secretion in the sense of formation of the milk constituents is one thing and the ejection of the milk from the gland after it is formed is quite another.

Ingelbrecht (11), working with ten lactating rats, sectioned their spinal cords between the last thoracic and first lumbar vertebrae, thus incapacitating the six posterior glands and permitting the anterior six to remain intact. Nursing young died when permitted access only to the posterior six glands,

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but when two of the anterior glands were offered, all glands functioned normally, due probably to a stimulus which was transmitted in some manner to the denervated glands. Selye *et al.* (24) also found that nursing caused continued gland function in adjacent glands which were not nursed.

Gaines and Sanmann (4) Petersen, Palmer and Eckles (19), and Swett *et al.* (28) have recovered as much as 100 per cent of the milk from excised glands which they would have expected to obtain from a normal milking of the same glands. Their investigations have also demonstrated the existence of residual milk, or milk which cannot be removed from the glands under normal milking conditions.

Zietzschmann (32) takes the view that the involuntary excitation of the muscles of the teat provokes the retaining of milk in the gland, while most investigators are of the opinion that there is ample argument for the opposite view in nursing Cetacea where the act of suckling is incompatible with the under-water life of these animals. The ducts of their mammary glands are enlarged into reservoirs from which the milk is ejected into the mouths of the young. Circumstantial evidence has gradually accumulated which indicates the presence of a somewhat similar musculature within the bovine mammary gland, these muscles surrounding the small ducts and alveoli, and that the act of milk ejection consists in the contraction of these muscles. Gaines (3) found that the ejection of milk in a goat was coincident with a high intra-gland pressure and that low-pressure latent periods occurred between high-pressure periods. This pressure as related to the rate of milk ejection was further demonstrated by Tgetgel (29) who explains the sudden swelling of the glands from an internal pressure, as the milk is ejected before being withdrawn. Hammond (7), after reviewing the literature, offers an entirely different explanation for the occurrence of this pressure. He believes, "It is due to erection in the udder and nipples, which is caused reflexly by stimulation of the nipple by the act of sucking or milking."

Gieling and Robbins (5) point out that the preparations of the anterior lobe of the pituitary body exert their characteristic effects slowly, require repeated administration and affect more particularly the structural elements of the body; for example, the growth of the mammary gland, the persistence of secretion and other time-consuming functions. The posterior lobe, however, is much more abundantly supplied with nerves and its extracts "Elicit an immediate pharmacodynamic response" on isolated tissue preparations (*e.g.* the uterus) or in the intact animal.

Oliver and Schafer (17) noted the sudden increase in blood pressure following intravenous injection of extracts of the posterior lobe. Ott and Scott (18), Gaines (3), McKenzie (16), Schafer (22), Hammond (6), Hill and Simpson (9 and 10), Simpson and Hill (25 and 26), Turner and Slaughter (31), Maxwell and Rothera (14) injected pituitrin intravenously using various species including the human. They agree to a stimulating

effect although all except Gaines fail to differentiate between secretion and ejection. Two of these (3) and (25) report a lessening in effect when the administrations were continued for a period of time. Several (6 and 25) are of the opinion, however, that the response to pituitrin injection is caused by a direct action of the principle on the secreting tissues of the gland, and that it is not due to the contraction of smooth musculature around the secreting cells, a precedent for which has been mentioned with suckling Cetacea. Turner and Slaughter (31) are "Inclined to the theory that pituitrin is not a galactagogue but rather acts on the mechanism normally effective during the milking process. We are inclined to believe that contractile elements in the walls of the alveoli and ducts furnish the *vis a tergo* observed."

Kamn *et al.* (12) accomplished a fairly complete separation of the oxytocic and the pressor principle from pituitrin. The name "Pitocin" was chosen to designate a solution containing the oxytocic principle, alpha-hypophamine, which is "comparatively free" from pressor activity. This product is otherwise referred to as oxytocin or obstetrical pituitrin because its action is specific for smooth muscle and it is used by the medical profession to stimulate uterine contractions. Kamn's "Pitressin" designates a solution of the pressor principle, beta-hypophamine, which is "comparatively free" from the oxytocic principle and this "surgical pituitrin" is frequently used to reduce surgical shock. Stehle (27) has more recently devised other methods for effecting a separation of these two principles. It is quite possible that the existence of these two fractions in pituitrin may account for the differences in the observed effects on the mammary gland when injected intravenously.

EXPERIMENTAL

According to Turner (30) and Espe (2) each half of the bovine mammary gland derives its nerve supply from three sources: (1) the ilio-hypogastric nerve, (2) the ilio-inguinal nerve and, (3) the posterior inguinal nerve. The first carries only afferent fibers from the gland periphery while the second and third carry both afferent and efferent fibers between the interior of the gland and central nervous systems. It was believed, therefore, that if an operation could impair the functioning of (2) and (3) nerve supplies to half the udder, practically all motor or efferent impulses would be removed and the intact half of the udder could be used as a check.

Three Jersey cows were selected from the Kentucky Agricultural Experiment Station herd on which to experiment, to determine more exactly the relationship which exists between the nervous mechanism and the ejection of milk. The first two cows, E 124 and E 237, were chosen because they were due to freshen January 2nd and 4th, respectively, and it was possible to treat them together experimentally. On November 17th, 1936, while both

cows were dry, the left half of the udder of each was denervated to the extent of removing about two inches of the sympathetic trunk nerve, which is made up of the ilio-inguinal and the posterior inguinal nerves, at a point just below the left inguinal ring. Each cow received as a general anesthetic, one ounce of chloral hydrate and, after being placed on the operating table, 1 per cent procaine was used as a local anesthetic. The incision was made at a point above the secreting tissue about midway between the left front and rear teats. This nerve trunk is located between the external pudic artery and vein which descend together through the left inguinal ring. No infection occurred in either case and within eight or ten days the wounds were well healed. These cows freshened normally early in January, 1937, and were subjected to experimental milkings which were designed to measure the effect of the denervation on the rate of ejection of milk from the glands. A mechanical milker* was especially designed which directed the milk from each half of the udder into a separate container, and which hung on a Chatillon milk balance suspended on opposite sides of the cow. Thus both halves of the udder of each cow were subjected to a uniform vacuum at the same time and the yield of milk was observed and recorded at fifteen-second intervals.

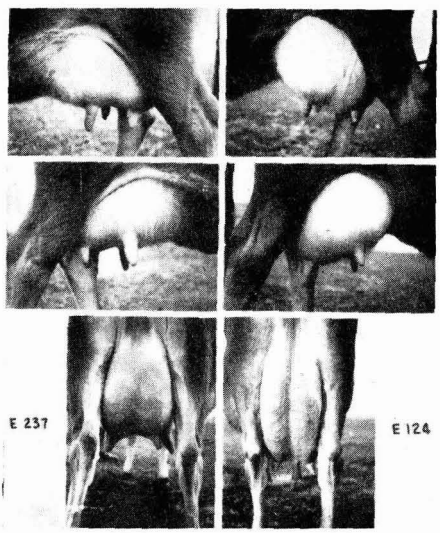
In September, 1938, another cow, E 307, was operated on in exactly the same manner. She calved normally on October 20th and for a period of three and one half months was experimentally milked using the same special equipment.

RESULTS

The photograph shows views of the udders of the first two cows, E 124 and E 237, taken soon after they freshened. The development of the left half of these udders seems not to be affected by the denervating operation. Figures 1 and 2 show the rate of ejection of milk (6 A. M. and 5 P. M.) each line representing an average of 13 milkings. In each figure the solid line represents the right or intact half of the udder while the broken line shows the response from the left or denervated half. It is quite apparent that the denervated half of the gland seemed as able to eject the milk as the intact half. Figure 3 shows the response measured in exactly the same manner for the third cow, E 307, and each line represents an average of twenty-eight normal milkings. No significance is given to the fact that in each individual milking the left half of 307's udder yielded more than the right or intact half. Such a difference was not noted in the other cows and is probably an individual characteristic of the normal udder of the experimental subject. These data indicate that the motor or efferent nerve supply to the bovine udder has little to do with determining the rate of ejection of milk under normal conditions. E 307 was then subjected to a series of experiments to determine the effect of the efferent nerve supply to the glands under various abnormal conditions such as fright and intravenous hormone injections.

* Courtesy of Mr. L. Dinesen, Perfection Milker Corp.

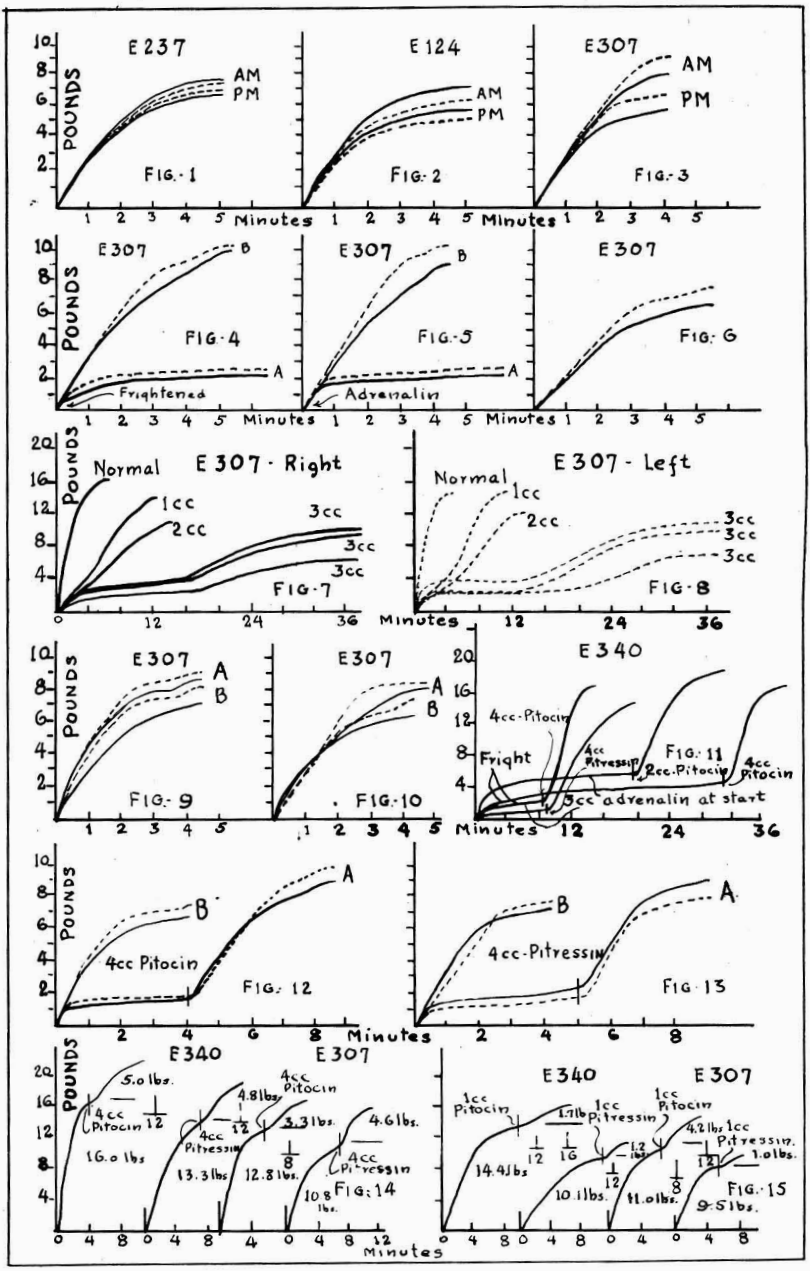
The effect of fright on the ejection of milk: Physiologists agree that animals can exist in an apparently normal state following gross sympathectomy but are unable to adapt themselves to a changing environment. It was thought that there might be a difference in the response of the two halves of the udder as measured by the rate of ejection of milk if the cow was severely frightened. Accordingly, E 307 was systematically frightened as the mechanical milker was attached. Frightening at first consisted in placing a cat on the cow's back and exploding paper bags every ten seconds for two minutes. Later the cat was dispensed with as unnecessary.



Photograph shows three views of the udders of E 237 and E 124 taken soon after freshening.

The result is shown in figure 4. Both halves of the udder responded alike in A. The milk was promptly drained from the cistern, followed by practically a complete cessation of ejection. In this instance 11.0 pounds of milk was removed from the entire udder by hand milking thirty minutes later, although the gland was still relatively hard, but considerably more relaxed than at the time of frightening. The subsequent milking yielded 19.8 pounds, or 3 to 5 pounds above normal. Figure 4 is typical of similar responses in repeated experiments. These experiments with fright indicate that the effect of denervation is not reflected by a different response as measured by the rate of ejection of milk.

The effect of intravenous adrenalin injections on the rate of ejection of milk: Physiologists agree that adrenalin is ejected into the blood from the medulla of the suprarenals in especially large quantities at a time of emo-


E 237
AM
PM
FIG. 1
E 124
AM
PM
FIG. 2
E307
AM
PM
FIG. 3
POUNDS
Minutes
E307
B
A
Frightened
FIG. 4
E307
B
A
Adrenalin
FIG. 5
E307
FIG. 6
E307 - Right
Normal
1cc
2cc
3cc
3cc
3cc
FIG. 7
E307 - Left
Normal
1cc
2cc
3cc
3cc
3cc
FIG. 8
Minutes
E307
A
B
FIG. 9
E307
A
B
FIG. 10
E340
4cc Pitocin
Fright
4cc Pitressin
2cc Pitocin
4cc Pitocin
5cc adrenalin at start
FIG. 11
Minutes
B
A
4cc Pitocin
FIG. 12
B
A
4cc Pitressin
FIG. 13
Minutes
E340
E307
5.0 lbs.
4cc Pitocin
16.0 lbs
4.8 lbs.
4cc Pitocin
4cc Pitressin
13.3 lbs
3.3 lbs.
12.8 lbs.
4.6 lbs.
4cc Pitressin
10.8 lbs.
FIG. 14
E340
E307
1cc Pitocin
14.4 lbs.
1.7 lb
1cc Pitressin
10.1 lbs.
1cc Pitocin
4.2 lbs
1cc Pitressin
11.0 lbs.
1.0 lbs.
9.5 lbs.
FIG. 15
Minutes

tional stress. It is also believed that musculature served by sympathetic nerves shows an especial response to the action of adrenalin. The sympathetics had been removed from the left half of the udder of E 307, and so it was decided to substitute for the fright an injection of 4 cc. of adrenalin solution (1 to 1000 Parke, Davis and Company) and note the result on the rate of milk ejection. This was repeated a number of times and a typical result is shown in figure 5 in A. The similarity to A in figure 4 is apparent. An hour after this particular milking 7.3 pounds of milk were removed by hand after considerable effort. The subsequent milking B was 19.1 pounds and above normal as was the case following fright.

In order to be assured that the response was due to the effect of the intravenous injection of adrenalin and not due to a degree of fright occasioned by the act of consummating an intrajugular injection, the experiment was repeated using 4 cc. of physiological saline instead of the adrenalin solution. Figure 6 shows that the saline failed to cause the response which was typical of adrenalin or fright. Undoubtedly some pain and excitement is caused by the act of making the injection, but sight and sound stimuli (exploding bags, etc.) seem to have a much more pronounced effect as measured by the rate of milk ejection.

Four cubic centimeters of the adrenalin solution seemed to be a serious shock to this cow, E 307. She always took her feed readily when it was placed before her prior to milking. Following adrenalin injections, she stood still, trembled slightly and refused to touch her feed and her udder became hard. Later experiments revealed that 4 cc. doses seemed to have a still more marked effect. In one instance E 307 threw herself three times in the stanchion, and due to such violent struggles, it was impossible to keep the milker attached. It was, therefore, considered advisable to limit the adrenalin injections to a maximum of 3 cc. to cows of her size (1000 lbs.).

The effect of intravenous injections of different quantities of adrenalin on the rate of ejection of milk: It was thought advisable to determine the effect of quantitative intrajugular injections of the adrenalin solution. E 307 was again used as the experimental subject because at the same time it would be possible to again measure the effect of denervation on the rate of response. Two to four days were allowed to lapse between experimental injections in order to permit the cow to resume her normal milking rate.

Figures 7 and 8 indicate that as the amount of adrenalin solution injected intravenously at the beginning of milking is increased, more time is required for its effect to diminish and permit the milk to be ejected. Figure 7 shows the response in the right or intact half of the udder, and figure 8 shows the same milkings for the left half of the udder which had been denervated. The similarity is quite apparent. Sixteen to twenty minutes elapsed before a relatively small amount of milk was ejected at a slow rate following the injection of 3 cc. of the adrenalin solution. The responses were less marked

when smaller amounts of adrenalin were injected. In each instance as the amount injected was reduced the response in terms of rate of ejection of milk more closely approached normal. Very similar results were noted when the series of injections was repeated on the Jersey cow E 194, a large-uddered fresh cow of known quiet disposition.

The effect of intravenous injections of posterior pituitary lobe fractions on the rate of ejection of milk: Due to the fact that pharmacodynamic responses, attributed to intravenous injections of posterior lobe fractions, were as pronounced in their effects as with similar adrenalin injections, it was decided to measure their effect on the rate of ejection of milk. Data were obtained in exactly the same manner as described for the adrenalin injections. E 307 was again used as an experimental subject. Repeated experiments with other cows also gave similar results.

Figure 9 shows the effect of an intravenous injection of 4 cc. of Pitocin (oxytocin 1 : 100) at the start of milking. The relationship between milking A, experimental, and B, the subsequent milking, is very typical of the many times this experiment was repeated. Again both halves of the udder responded in the same manner and the total yield following injection was from 2 to 5 pounds above normal, and the subsequent milking B was correspondingly less. Figure 10 shows the effect of an intrajugular injection of the same amount (4 cc.) of Pitressin (pressor fraction 1 : 100). The response in this case was the same as with Pitocin. The fact must be borne in mind, however, that Kamn *et al.* (12) do not claim that these two active fractions of pituitrin are completely separated in the Pitocin and Pitressin. There probably exists as much as twenty per cent Pitocin in the Pitressin and vice versa. When 4 cc. of either Pitocin or Pitressin was intravenously injected at the start of milking the result was a more complete drainage of the gland. This result seems directly opposed to the effect of fright or adrenalin solution when injected in a like manner.

It was decided, therefore, to determine the effect of delayed injections of posterior lobe fractions, following fright or adrenalin injections, at the start of the milking act. The results, using Jersey cows E 340 and E 307, are shown in figures 11, 12 and 13. These figures indicate that following fright, cessation of ejection is typical, but that within 30 seconds after the intrajugular injection of 4 cc. of either Pitocin or Pitressin, the ejection of milk is resumed in a very positive manner, and resulted in each instance in a total milk yield which was above normal, A. The subsequent milking B was always below normal in amount.

Jersey cow E 340 was used in a series of similar experiments, figure 11. These and experiments with other cows produced similar results when measured in terms of the rate of ejection of milk. There exists every indication that when 4 cc. of either of the posterior pituitary lobe fractions is intravenously injected, the result will be a prompt resumption of rapid milk

ejection. The length of time which is permitted to pass following the initial frightening or adrenalin injections seems not to affect the response to the delayed injections of the posterior lobe fractions.

When smaller quantities of Pitocin and Pitressin were used, following a standard intrajugular injection of 3 cc. adrenalin solution, the response was much more pronounced using Pitocin than Pitressin. Such data would seem to indicate that the response in the case of Pitressin, as measured by the rate of ejection of milk, might be due to the presence of Pitocin contained therein.

The effect of intravenous injections of Pitocin and Pitressin after a normal complete milking: Following a normal milking of two Jersey cows, E 340 and E 307, 4 cc. of Pitocin was injected intravenously and 4 days later the experiment was repeated, using Pitressin in place of Pitocin. The results are shown in figures 14 and 15.

A very marked response to 4 cc. of each of the posterior lobe fractions was noted. The yield of milk was slightly in excess of the expected normal yield. When the experiment was repeated using only 1 cc. of each fraction a greater response was noted in favor of the Pitocin. Apparently these "Super Strippings" consisted of milk which was literally squeezed from the alveoli and small ductules due to the presence in the blood of the oxytocic fraction of the product of the posterior lobe of the pituitary. The responses shown in figures 14 and 15 are typical of those obtained in other experiments using other cows.

The composition of the "Super Strippings" as compared with the normal complete milking is of interest. The following table shows only slight differences in specific gravity (lact. corrected to 60° F.), protein (N × 6.38) and lactose, when compared on a fat free basis. Great differences were apparent, however, in the per cent of fat.

	Cow E 332		Cow E 307	
	Normal	Pitocin Super Strippings	Normal	Pitocin Super Strippings
Milk lbs.	10.9	3.2	8.8	3.6
Specific Gravity	1.0338	1.0207	1.0347	1.0215
Lactose %	4.95	4.44	5.83	4.08
Protein %	4.52	3.87	4.17	3.75
Fat %	3.8	17.0	4.0	17.0

The percentage of fat in the "Pitocin super strippings" seemed to reflect the completeness of the normal milking. One cow, E 340, was subjected to this experiment on numerous occasions. Often she became excited and failed to let down her milk normally. Consequently her "normal" milking on one occasion amounted to only 7.6 pounds and tested as low as 1.9 per cent fat, while her super strippings which followed the injection of 2 cc. of Pitocin were equal in amount and contained 10 per cent fat.

On other occasions other Jersey cows were milked normally followed by two minutes of hand stripping preceding the intravenous injection of 2 cc. of Pitocin. Super strippings so obtained usually ranged from 14 to 24 per cent fat and the subsequent milking was always proportionately lower in fat.

A SUGGESTED THEORY BASED ON THESE FINDINGS

The delicate balance between the product of the suprarenal medulla, adrenalin, and the oxytocic principle of the posterior lobe of the pituitary body, in the blood of the cow at the time of the milking act, seems to be responsible for the rate of ejection of milk. The resection of the sympathetic nerves to the gland seem to play no important part as is shown in these experiments. The palpation of the teat, which so quickly increases intra-glandular pressure, can cause an impulse to reach the central nervous system through the afferent or sensory fibers of the ilio-hypogastric nerve which remained intact in these experiments. This teat palpation, however, is only one source of sensory impulses which reach the central nervous system, and this seems to be the initial step in a series of events which result in a high intra-glandular pressure.

There are many other sources of afferent stimuli which presumably might cause similar effects which occur regularly in a well-managed dairy. Rattling milk buckets, washing udders, the placing of feed before the cows, muzzling calves, etc., all occur regularly and are associated with the milking act or the relieving of the pressure within the gland. Any one or all of these, conceivably can cause afferent impulses to reach the central nervous system which, in turn, stimulates the posterior lobe to secrete the oxytocin into the blood, and it is this which is believed to be largely responsible for the increase in intra-glandular pressure, which literally squeezes the milk from the alveoli and smaller ductules. On the other hand, a variety of afferent impulses may reach the central nervous system of quite a different sort. Fright, caused by any unusual event, could in a similar manner, reflexly stimulate the natural production of adrenalin by the medulla of the suprarenals. Thus, under the influence of emotional stress, an extra quantity of adrenalin is ejected into the blood.

Evidence as to the very existence of the musculature surrounding the alveoli and small ductules is only circumstantial, but nevertheless quite convincing. The same may be said for the existence of a larger quantity of oxytocin in the blood at the moment the gland reaches its high point in pressure. These constitute special problem assignments which would throw still more light on this problem.

It would seem, therefore, that the positive act of "letting down" milk may be best explained as a conditioned reflex, and directly due to a high intra-glandular pressure caused by the presence of active oxytocin in the blood, which is responsible for the contraction of the alveoli and small

ductule musculature. On the other hand, the failure to "let down" milk is similarly due to the presence of adrenalin in the blood, which prevents the muscular contractions which are responsible for the high intra-glandular pressure.

SUMMARY AND CONCLUSIONS

Data are presented describing a series of experiments using Jersey cows, subjecting them to fright stimuli and intrajugular injections of adrenalin (In sol. 1:1000), Pitocin (oxytocic principle of the posterior pituitary lobe 1:100) and Pitressin (pressor principle of the posterior pituitary lobe 1:100). The left half of the udder of three of these cows had been denervated, and the response of this half of the gland was compared with the right or intact half measured in terms of the rate of ejection of milk. These data seem to justify the following conclusions.

1. Denervating the gland during the dry period resulted in no effect on the rate of ejection of milk during a subsequent lactation. There was also no change in the appearance of the two halves of the udders following the operation. This is additional evidence that the act of milk ejection is not under the direct control of the central nervous system.

2. Fright and intrajugular injections of adrenalin resulted in cessation of ejection of milk. The amount of adrenalin injected seems to determine the length of time that must elapse before natural ejection is possible. Presumably this length of time would also be proportional to the degree of fright, but this is difficult to measure.

3. Other symptoms of adrenalin shock were: a hard udder, refusal of feed, trembling and other signs of a severe nervous shock.

4. Intravenous injections of 4 cc. of either Pitocin or Pitressin caused the gland to be more completely drained than would be the case with a normal complete milking. This was also the case when the injection of these posterior pituitary lobe fractions followed fright or adrenalin injections, or at the end of a normal complete milking.

5. A smaller quantity of Pitocin showed greater potency in inducing prompt resumption of rapid ejection than was the case with Pitressin. These data support the belief that the effect of Pitressin may be due to incomplete separation of these two pituitrin fractions.

6. The extra or residual milk removed from the udder, following the injection of Pitocin, varied from normal composition of milk chiefly in per cent of fat. As one would expect, the more complete the normal milking the higher the per cent of fat in the "super strippings." The per cent of fat in these strippings ranged from 7.6 per cent to 24.0 per cent in a series of experiments.

7. A new theory is advanced which explains the "holding up" and "letting down" of milk, based on the results of these experiments.

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SOME FACTORS INVOLVED IN EFFICIENT MILKING*

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It has been generally recognized that the "letting down" of milk by a cow is more or less conditioned by the milker, the environment and the manner in which a cow is milked. Just how the manner of milking and environmental factors affect the "letting down" of milk has not been understood because of a lack of understanding of the mechanism involved in the "let down" or ejection of milk. While a number of theories have been advanced to explain the phenomenon, the problem remained unsolved until Ely and Petersen (4) showed that a hormone and a conditioned reflex are involved. According to their work the milking act is the normal stimulus which causes a secretion of the posterior pituitary gland hormone (oxytocin) into the blood, which in turn causes a contraction of the mammary gland musculature to force the milk out of the alveoli into the larger channels of the gland.

Ely and Petersen observed that in case of excitement, fright or the injection of epinephrine cows would not respond to the milking stimulus by the "let down" of the milk. Intravenous injection of oxytocin caused a prompt "let down" of the milk regardless of the emotional state of the cow. If too long a time intervened between the intravenous injection of oxytocin and the milking act the milk was not completely "let down," which fact was tentatively explained by postulating a dissipation of the hormone.

In view of this new concept relative to the physiology of the "let down" of milk it was deemed advisable to further test the effect upon milk and butterfat production of different milking procedures, although the literature contains some accounts of the influence of some milking procedures.

By slightly altering the milking routine, very marked decreases in production have been noted. One of the oldest of these reports was by Babcock (1) who reported a decrease in production as the quarters of the udder were milked one at a time in different order. He reported that the quarter milked second produced the most, just slightly more than the quarter milked first. The third and fourth quarters milked produced less in that order respectively. He found a decided decline in milk and an even greater decline in fat production by doubling the time involved in milking. Emery (5) and Beach (2) repeated Babcock's different-order-of-milking experiment with the same results. Bitting (3) also repeated Babcock's work but found that the first quarter milked produced the most and each successive

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quarter produced less. Skrodel (6) obtained one-half the milk and one-third the fat yield from the half of the udder that was milked three times as slowly as the other half. His findings indicate that part of the milk retained by slow milking is given in the following milkings, but there was a net decrease in both milk and fat production.

The study herein reported was divided into three parts: the effect of delayed stripping, after machine milking, on milk and fat production; the effect of manipulating the udder twenty minutes before milking on milk and fat production; and the effect of rapidity of milking upon the quantity of milk and fat. In this study two objectives were in mind. One was to ascertain the effect of any given milking practice upon milk and fat production, and the other was to attempt to explain the results in terms of the fundamentals now known as to the mechanism involved in the "letting down" of milk.

EXPERIMENTAL

Part I. The effect of delayed stripping, after machine milking, on milk and fat production.

A common practice among dairymen who use mechanical milkers is to milk all the cows before any stripping is done. This means that some cows are not stripped for some time after being milked. How this practice affects production may have practical significance.

Twenty-two cows, between 3 and 6 months in lactation, were divided into two groups by pairing so that the breed, number of days in milk, number of days pregnant, and production were equal in each group at the start of the experiment. One Jersey cow, 237, was dropped from the experiment when she developed mastitis. All of the cows had been stripped immediately after milking before the experiment began.

The experiment was divided into three periods of seven days each. The double reversal method of experimentation was employed. During Period I, both groups were maintained as check. During Period II, Group A was treated experimentally and Group B as check. Group B was treated experimentally during Period III while Group A was check.

During the check periods the cows were stripped immediately after removing the machine, and during the experimental periods stripping was done fifteen minutes later. Weights of machine-drawn milk and strippings were recorded for each milking. Samples for butterfat test were taken from each portion of the milking and tested daily. Total milk and average per cent of fat for the period were used in calculating fat production for the period.

Any change in production that might be attributed to the experimental procedure would be evident by a change in amount of strippings as well as total production. It is generally agreed that as the length of time taken in milking is increased production decreases. In light of this fact and our

present knowledge of "letting down" milk, a decrease in amount of strippings might be expected during the delayed stripping period. Just the opposite was found, as shown in table 1. Although total production dropped during the experimental periods, production as strippings increased slightly.

TABLE 1

Comparing milk and fat production of 21 cows during delayed stripping and immediate stripping periods expressed as average daily production

	Check		Experimental		Experimental in terms of check	
	Milk	Fat	Milk	Fat	Milk	Fat
	lbs.	*lbs.*	*lbs.*	*lbs.*	%	%
Machine Production	20.9	.87	20.26	.822	96.94	94.48
Stripping Production	1.514	.1182	1.606	.125	106.08	105.75
Total	22.414	.9882	21.866	.947	97.56	95.82

Of the twenty-one cows that finished the experiment, twelve showed an average increase in amount of strippings of .1945 lb. or 32.29 per cent daily compared to an average decrease of .145 lb. or 15.3 per cent daily for the other nine cows. Therefore, the net change was a gain of 6.08 per cent in favor of the experimental period. For fat production in strippings, ten cows increased .036 lb. or 31.69 per cent and the other eleven decreased .02 lb. or 16.35 per cent on the average per day, which gave a net increase of 5.75 per cent.

Although table 1 shows a slight decline in total milk and fat production during the experimental period, a closer inspection of the data shows that this decline is not great. There is a slight tendency for the amount of strippings to increase with each consecutive period, which gives the experimental period a slight advantage since the delayed stripping period for Group B was the third period of the experiment. The largest milk and fat production for both groups was during Period II, although this was the experimental period for one group. A summary of the data shows a slight decrease in production during the experimental period, but this decrease is not shown by enough cows to be significant. The trend by periods was downward, as would be expected, due to advance in lactation.

Milk as strippings is not forced down at the time of stripping as is the first drawn milk. This portion of the milking is not under pressure at this stage, hence it is not removed by the machine. The apparent increase in strippings might be due to drainage from the large ducts during the 15 minute interval.

Part II. The effect of manipulating the udder twenty minutes before milking on milk and fat production.

Many producers, especially those producing high quality milk, wash and

strip (in strip cup) each cow's udder before milking. In many cases the whole herd is treated in this way before milking begins. Therefore, it is desirous to know the effect of this practice on production.

With the exception of two Jersey cows that developed mastitis, the same cows were used in this experiment as were used in the delayed stripping experiment. The double reversal method of experimentation was used for this experiment also. Period I served as a preliminary when manipulation was done immediately before milking. Group A was treated experimentally during Period II and Group B was check. During Period III Group B was treated experimentally while Group A was check. Period IV was a control period and milk weights were recorded for each milking.

During the check periods the cows were manipulated immediately before milking. Manipulation of the udder during the experimental periods was done by washing the gland twenty minutes before, stripping (in strip cup) fifteen minutes before, and handling with bare hands ten minutes before the milking machine was put on. Each milking was weighed and a sample for butterfat test was taken. Total milk and average fat percentages were used in calculating production for the period.

TABLE 2

Production of milk and fat by 19 cows during manipulation experiment

	Period I	Period II	Period III	Period IV
Group A				
Lbs. Milk	1476.9	1408.5*	1391.7	1363.1
Ave. % Fat	4.194	4.24*	4.283	4.232
Lbs. Fat	61.94	59.73*	59.6	57.68
Group B				
Lbs. Milk	1323.6	1329.4	1120.1*	1135.0
Ave. % Fat	4.416	4.466	4.123*	4.368
Lbs. Fat	58.45	59.37	46.18*	49.58

* Manipulation periods.

TABLE 3

The effect upon milk and fat production of manipulating the udder twenty minutes before milking

Average daily production of 19 cows

	When milked immediately	When milked 20 min. later	% Change by manipulating 20 min. before milking
Lbs. Milk	20.1	19.0	−5.48
Ave. % Fat	4.327	4.195	−3.16
Lbs. Fat	.87	.797	−8.39

The data are summarized in tables 2 and 3. It is evident from these tables that manipulation twenty minutes before milking caused a marked decrease in production. Fourteen of the 19 cows decreased in milk produc-

tion and 12 decreased in fat production. The range in fat production was from a gain of 4.3 per cent during the manipulation periods to a decrease of 33.73 per cent. Eleven of the 12 that dropped in production during the manipulation period declined over 5 per cent, five declined over 10 per cent and four over 20 per cent. The picture for milk production is much the same, although the changes are not as great, being from a gain of 5.35 per cent to a loss of 22.7 per cent during the experimental period. Seven of the 14 lost more than 5 per cent, four more than 10 per cent, and two over 20 per cent.

When examining the data by periods, the above differences become more significant. As would be expected, the trend was downward but the greatest change was during the manipulation periods. The drop in fat production by Group A during the manipulation period is not great until it is compared to the upward trend by Group B during the same period. A partial recovery by Group B is noted in Period IV, the week after manipulating when total milk and fat rose while production by Group A was declining. Group A also showed some evidence of recovery during Period III, which was the week following manipulation.

One observation of considerable interest is the larger variation in daily milk yield and fat percentage during the manipulation periods. Individual cows were affected very much differently by the experimental procedure.

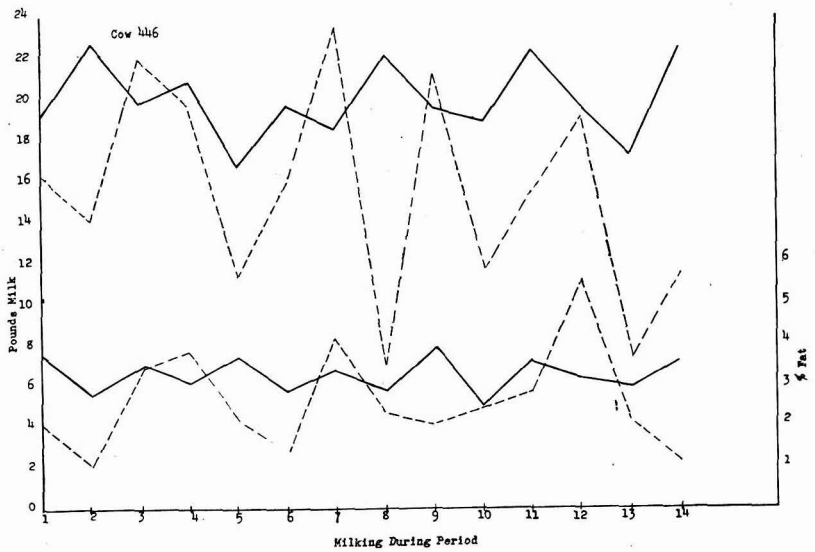

FIG. 1. Comparative variations of milk and butterfat per cent during normal milking and when the gland was manipulated before milking began. The results for check period are represented by solid lines. Those for the experimental period are represented by broken lines.

Figure 1 is an example of extreme variation shown by cow 446. The standard deviation for the check periods was ± 1.45 lbs. and for the manipulation period ± 1.56 lbs. of milk per milking. For fat per cent the standard deviation was ± .65 per cent and ± .73 per cent fat per milking for the check and manipulation periods respectively. These differences become quite significant when the fact is considered that the check period covered two weeks and the experimental period only one, which would give the check period more chance for deviation since it covered twice as much time as the experimental periods.

One trial was run on 446 to see if the milk, not given by the cow when milked, was in the udder. On August 22 this cow was manipulated in the usual manner half an hour before the machine was put on. When milked and stripped very carefully, 11.7 lbs. of 1.9 per cent milk were all that could be drawn. One cc. of obstetrical pituitrin was then injected intrajugularly. Almost immediately more milk was "let down" and when milked an additional 6.5 lbs. of 9.0 per cent milk was obtained.

The findings of this experiment indicate that manipulating the udder twenty minutes before milking results in decreased production of both milk and fat. In every case the cow "let down" her milk when washed and stripped, as evidenced by distention of the teats and lower portion of the udder. During the manipulation periods at least 15 minutes elapsed between the "letting down" of milk and the beginning of milking. This caused increased pressure within the gland which was not released, by milking, for a quarter of an hour.

At the beginning of milking the pressure was somewhat reduced. Whether this pressure was reduced because of muscular fatigue within the gland or because of a dissipation of the oxytocic principle in the blood can only be conjectured at this point. The evidence seems to point, however, to a dissipation of the hormone as a more likely explanation. This point is further elaborated upon in the discussion of the following experiment.

The net result of a stimulation of the udder to "let down" milk some time before milking is lowered milk flow. That this is due to a failure of "letting down" all of the milk in the gland is proven by the substantial additional milk that may be secured by injection of obstetrical pituitrin.

Individual cows were affected differently by the experimental procedure. Although there is not a significant correlation between level of production and decrease by manipulation, cows late in lactation probably would not show any effect by experimentation since the cisterns and large ducts could hold all the milk "let down" the first time. Shape and structure of the udder may also be a factor.

Part III. The effect of rapidity of milking upon the quantity of milk and fat.

There are many parallels to this experiment in the literature and an

attempt will be made to explain these phenomena by using Ely and Petersen's theory of milk ejection.

Holstein cows 446 and 450, Jersey cows 215 and 225 and Guernsey cow 612 were selected to be milked one quarter at a time in different order. Cows 215 and 225 were dropped when sickness and mastitis, respectively, set in. The experimental work was done at the evening milkings of August 28, September 6, 12, 13, 16, 18 and 21. Not all cows were milked in this way on each of the above dates because it was desired to leave an interval between each trial so that the cows would return to normal before the next trial.

Milking was done one quarter at a time progressing in a clockwise manner around the udder. It was planned to run four trials on each cow starting with a different quarter each time, but only three trials were run on 612 because 215 and 225 furnished data for milkings starting with the right fore quarter. About 25 minutes were spent in milking each cow to get the maximum effect of time which was the only variable.

Thirteen trials were run in all. In five of these trials 1 cc. of obstetrical pituitrin was injected intrajugularly immediately after milking in an attempt to force out any milk that might have remained in the udder. The milk produced by each quarter was weighed and sampled for butterfat test.

TABLE 4

Summary of trials when cows were milked one quarter at a time in different order. Expressed as average per milking of 13 trials

	First quarter milked	Second quarter milked	Third quarter milked	Fourth quarter milked
Lbs. Milk	3.15	3.03	2.89	2.38
% Fat	4.759	4.515	4.343	3.643
Lbs. Fat	.1499	.1368	.1255	.0867
Production after injecting 1 cc. pituitrin—5 trials				
Lbs. Milk	.26	.46	.54	.86
% Fat	10.269	13.239	13.426	11.686
Lbs. Fat	.0267	.0609	.0725	.1005

Table 4 gives a summary of the results by quarters in the order milked before and after injecting pituitrin.

It will be noted that both milk and fat yields decreased for each successive quarter milked, which corroborates Bitting (3). The decrease forms essentially a straight line for the first three quarters with a significantly sharper decline for the fourth. While the time involved in milking was not controlled exactly, about 15 minutes elapsed before milking of the third and about 20 minutes before the milking of the fourth quarter was begun. More time was involved in milking the first quarter than any of the others, as time had to be allowed for the "letting down" of the milk.

That the decreased yield of both fat and milk for each successively-milked quarter was due to incomplete "letting down" of the milk is evidenced by the results following the injection of pituitrin. The increase in yields of both fat and milk secured after the pituitrin injection is of the magnitude that when added to the original milkings they will form essentially a straight line.

The reason that Babcock, Emery and Beach should have secured larger yields from the quarter milked second can only be conjectured. As none of these workers gave the time involved in the milking process, it is possible that milking of the second quarter was begun before the milk had been completely "let down." Then the optimum effect of the "letting down" mechanism was secured while milking the second quarter and a relatively larger yield was secured.

This experiment is closely related to the manipulation experiment because it involves the "letting down" of milk some time before milking begins, but is different because each quarter is a check against the others; whereas the previous experiment involved all four quarters and more time was necessary to do the experiment.

The results obtained in 13 trials confirm Bitting's (3) findings exactly and are similar to those of Babcock (1), Emery (5) and Beach (2). The five trials in which pitocin was injected after milking show that not all the milk secreted was removed the first time. The explanation for this decrease is the same as for manipulation. The ejection pressure subsides after a time and the milk is not all forced down when milking is actually done, probably because the cow has no more oxytocic principle available to act on the muscle around the alveoli. This seems a logical explanation as this hormone is completely dissipated before the normal milking and being dynamic in its action is probably quickly dissipated from the blood.

SUMMARY AND CONCLUSIONS

Data are presented to show the effect of some of the common milking practices on milk and butterfat production. The practical significance of the muscular contraction theory of milk ejection is shown in part, and some of the old problems of milk ejection are explained using this theory. The results of this series of investigations may be summarized as follows:

1. Delayed stripping after milking by machine has little or no effect on milk and butterfat production.

2. Manipulation of the udder by washing and stripping twenty minutes before milking begins causes an appreciable decrease in milk and especially fat productions.

3. When individual quarters are milked successively, there is a progressive decrease in both the amount of milk and of fat.

4. That the progressive decrease in amounts of milk and fat of suc-

cessively milked quarters is not due to lowered secretion of milk but is due to failure of completely "letting down" the milk is proven by the expulsion of the milk from the udder by the aid of obstetric pituitrin.

5. Proof is furnished that rapid milking is conducive to large milk flow.

6. The reason for lowered production from manipulation of the udder some time before milking and from a prolonged milking process is tentatively explained as being due to a dissipation of the oxytocic principle in the blood.

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THE INFLUENCE OF FAT ON THE QUALITY, COMPOSITION AND YIELD OF CREAM CHEESE

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Cream cheese as we know it today probably originated in the eastern part of the United States. It is a soft, unripened cheese resembling the Neufchatel type and is usually sold in foil lined boxes, foil or cellophane wrapped packages, glass containers or cardboard cartons.

References on cream cheese are not numerous and are concerned chiefly with the art of manufacture. Three methods of making it are recognized: the old Neufchatel system used by all manufacturers until about 1920; the cooked-curd method most commonly used now (1, 2, 3, 4) and the Dahlberg or Geneva method (7) which introduced a new idea of manufacture based on homogenization of a mixture of cream and dry skim milk together with a stabilizer. Of these three methods the cooked-curd system is undoubtedly the most widely used commercially because it produces cheese with an excellent flavor and body and permits a high yield of cheese per pound of fat especially when it is heated after draining, mixed with cream and possibly a stabilizer and then homogenized before packaging.

REVIEW OF LITERATURE

Fisk (1) in 1925 first described the cooked-curd method of making cream cheese. He stated that cream containing from 12 to 20 per cent fat should be used.

Marquardt (2) in 1927 after reporting results of making cream cheese from cream containing from 6.82 to 26.50 per cent fat stated that cream containing 15 to 18 per cent milk fat resulted in a smooth, pleasant-flavored cheese of good keeping quality. Cream containing more than 18 per cent fat caused excessive fat losses in the whey and sometimes delayed separation of whey from curd. Low-fat cream made granular cheese.

Van Slyke and Price (3) in 1927 described the manufacture of cooked-curd cheese from cream containing 14 to 20 per cent fat but gave no reasons for this range other than that it was commonly used commercially.

Reichart (4) in 1936 studied a number of factors affecting cream cheese quality. He suggested the use of cream containing 12 to 20 per cent fat and stated that the higher fat content produces smoother, richer and better keeping cream cheese.

EXPERIMENTAL METHODS

During this study approximately 200 lots of cheese were made. Data

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on composition and quality of approximately 175 lots of cheese have been classified to show the effect of each factor studied. This report, however, will be limited to presentation and discussion of the data pertaining to the influence of fat on the composition, quality and yield of cream cheese. A routine method for making the cheese was adopted.

Manufacturing process. The cheese was made from fresh cream, pasteurized at 145° F. for 30 minutes and passed through a single-stage homogenizer under 1500 pounds pressure at 120° F. Five per cent lactic starter and 3 ml. of rennet per thousand pounds of cream were used. The cream was set at 90° F. in 2½ gallon ice cream cans and held at that temperature in a water bath until the proper acidity of about 0.6 per cent or pH 4.7 had developed. This usually required 4 to 5 hours depending somewhat on the activity of the starter culture. The curd was then stirred thoroughly until it was perfectly smooth and free from lumps and the temperature was raised to approximately 125° F. in 45 to 60 minutes with continuous agitation during the heating process. The heated curd was held at the cooking temperature for about 10 minutes then poured on the draining cloth. These cloths, which were fastened on a suitable rack designed to collect the whey, were of unbleached muslin sheeting about 3 feet square. Each cloth held the contents of 1 can. The rate of draining was determined by collecting and measuring the whey from 10 pounds of curd during a period of 90 minutes. When most of the free whey had escaped, the cloths were tied into bags and pressed. The bags were opened once for salting and mixing. Salt was added at the rate of 0.9 to 1.0 per cent of the expected yield. After salting, pressure was applied until the curd attained the desired consistency after which it was chilled in a refrigerator to approximately 45° F.

Methods of analysis. Titratable acidity and pH measurements were made on the cream at intervals during the manufacturing process and pH measurements on the finished cheese during storage. The pH was determined potentiometrically with a quinhydrone electrode using a saturated calomel half cell. The titratable acidity, expressed as per cent of lactic acid, was calculated from titration with N/10 NaOH of a 9 ml. sample of cream diluted with an equal volume of water. Phenolphthalein was used as indicator. The relationship between pH measurements and titratable acidity measurements of the cream during the early stages of making was relatively close so that the use of either measurement in commercial practice would be justified. The difficulty of making accurate titratable acidity measurements of the finished cheese might, under some circumstances, make the electrical method of determining acidity more desirable.

Fat was determined by the Babcock method and moisture by drying to constant weight in an electric oven at 212° F. and under vacuum for the last hour of the operation.

Salt measurements were made by the non-ashing method described by McDowall and Whelan (5).

The cheese was graded on the second or third day after manufacture. Two or more persons did the grading of all lots. The system of grading used by the judges classified flavor, body,* texture,* and final grade into grades numbered from 1 to 5. Grade 1 in general was "very pleasing"; grade 2, "desirable"; grade 3, "satisfactory"; grade 4, "objectionable"; and grade 5, "disagreeable." Cheese to be classed as grade 1 or 2 could not be criticized in any characteristic; slight defects in flavor, texture or body were permitted in grade 3; pronounced defects were permitted in grade 4; and samples with very undesirable or disagreeable defects were placed in grade 5. The final grade of the cheese expressed the judges' opinions after taking all characteristics and defects into consideration. The final grade, therefore, is neither a sum nor an average of grades assigned to individual characteristics but rather an estimate of the quality of the cheese as a whole.

A mechanical method of measuring the body of cream cheese was developed by using a modification of the apparatus described by Sommer and Matsen (6). This apparatus and method have been described in an earlier publication (8).

EXPERIMENTAL RESULTS

Seven series of experimental lots of cheese were made to study the influence of the percentage of fat in the cream on the quality and composition of the finished cheese. For these trials, creams testing 8, 10, 12, 14, 16, 18, 20 and 22 per cent fat were used. From the seven series, thirty-three typical lots have been selected to illustrate the trends of the experimental results.

QUALITY

Flavor. Twenty-eight of the 33 lots were graded 2 or 3 in flavor; all percentages of fat were represented in these lots. Three lots containing 16, 18 and 20 per cent fat graded better than 2 while two lots made from 8 per cent cream graded lower than 3. High testing cream produced cheese which was sometimes criticized for having too much fat while that made from low testing cream lacked the rich, pleasing flavor of milk fat.

Body. Nineteen of a total of 33 lots were graded 2 or 3 in body and again cheese made from cream of every percentage of fat used was included in these 19 lots. The 9 lots grading better than 2 were made from cream testing from 12 to 22 per cent fat and the 5 lots below 3 were made from creams testing 8 and 10 per cent. The creams producing the most desirable bodied cheese had 16 to 20 per cent fat. When the fat in the cream was lower than about 14 per cent the cheese tended to be dry and crumbly, a condition which could be corrected in part by increasing the moisture con-

* "Texture" here refers to the smoothness of the cheese and "body" to its consistency.

tent of the cheese. Unfortunately, cheese with high moisture tended to deteriorate more rapidly and to leak moisture during storage. Cheese made from cream with 22 per cent fat tended to be soft and sticky.

Resistance to penetration was measured and the results are shown in figure 1. Data are shown only for 19 lots selected because they contained practically identical percentages of moisture. Despite the fact that the cheese was made at different times during the year, still, increasing the fat in the cream from which the cheese was made shows a definite softening influence on the body of the cheese. Resistance readings in general tend to be more variable in low-fat cheese because granules are usually present.

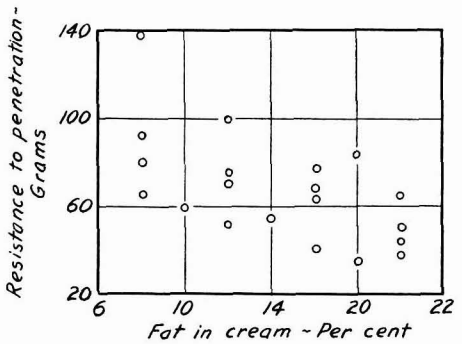

FIG. 1. The relation between the fat in the cream and the resistance of the cheese to the penetration of a metal cone 8 mm. in diameter at the base and 12 mm. in altitude.

Texture. The smoothness of the cheese increased with increasing fat content in the cream from which the cheese was made. Eighteen of the 33 lots of cheese were graded 2 or 3; included were lots made from cream containing the lowest and highest percentages of fat. Those lots grading better than 2 were made from cream testing 16 per cent fat or more while those lots grading below 3 were made from cream testing 12 per cent fat or less. Texture is more definitely affected than flavor by changing the fat content of the cream; grades on texture and body are about equally sensitive to these changes.

Final grade. The best cheese in all respects was that made from cream containing approximately 18 per cent milk fat. Changes in the composition of the cream caused gradual changes in quality except when the fat was decreased to less than 12 per cent. Excellent cheese was regularly made with as little as 14 per cent and as much as 22 per cent fat in the cream although the richness of flavor and character of the body of the latter type was questioned by the judges as being suitable for a commercial product.

COMPOSITION

Fat and moisture. Figures 2 and 3 show respectively the influence of cream composition on the fat and moisture content of the cheese. With in-

creasing fat in the cream from which the cheese is made there follows an increase in the fat and a decrease in the moisture in the cheese. This trend has been repeatedly observed in the approximately 200 lots of cheese on which such records have been kept.

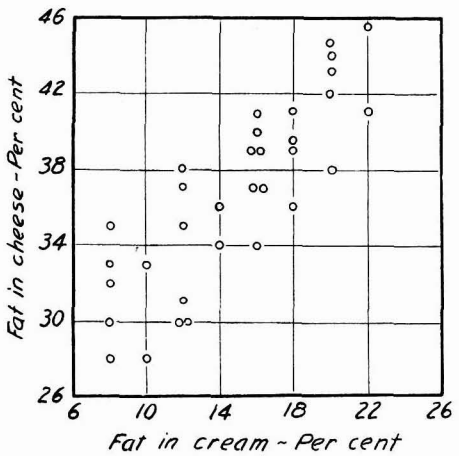

FIG. 2. The relation between the per cent of fat in the cream and the per cent of fat in the finished cheese.

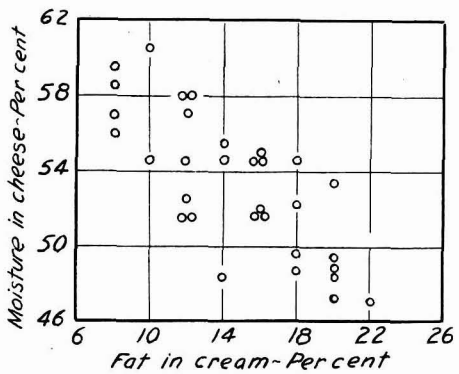

FIG. 3. The relation between the fat in the cream and the percentage of moisture in the finished cheese.

The percentages of fat and moisture required in the cheese to produce the best quality cannot be definitely stated. Fat and moisture tend to impart somewhat similar physical characteristics to cheese. To a limited extent moisture can be substituted for fat without changing these physical properties. In general, cheese containing 37 to 42 per cent fat and 50 to 54 per cent moisture had the most desirable spreading and slicing properties. During the summer months when the casein content of the milk is low and

the proportion of softer fats in the milk is relatively high the cheese tends to have a softer body than in the winter. Under the conditions of these experiments cheese containing approximately 80 per cent fat in the dry matter of the cheese was of excellent quality.

YIELD

Figure 4 shows the relation between the fat in the cream and the amount of cheese produced. As the fat content is increased the yield increases. Yields ranged from 15 to 55 pounds per hundred of cream. The average number of pounds of cheese obtained per pound of fat when creams testing 8, 12, 16 and 18 per cent fat were used were 2.96, 2.59, 2.42 and 2.18, respectively. Such differences in the efficiency of utilizing milk fat clearly show one reason why commercial manufacturers tend to favor the use of creams

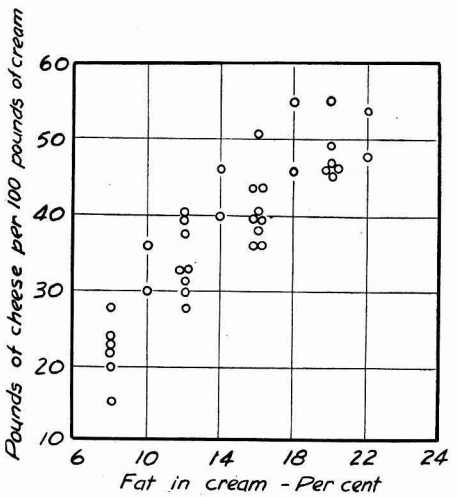

FIG. 4. The relation between the fat in the cream and the yield of cheese.

with low percentages of fat. Low-fat creams contain larger proportions of casein, the important water holding constituent of the cheese. High-fat cream, however, loses its whey during the curdmaking process more slowly than low-fat cream; this is probably caused by the physical interference of fat to the flow of whey through the curd interstices. The extent of the influence is shown in figure 5. Slow drainage may be an important factor in determining the general tendency of the industry to use cream with less than 16 per cent fat in the making of cream cheese.

ACIDITY

That the acidity of the cheese was not influenced to any great extent by the per cent of fat in the cream used in its manufacture is illustrated by

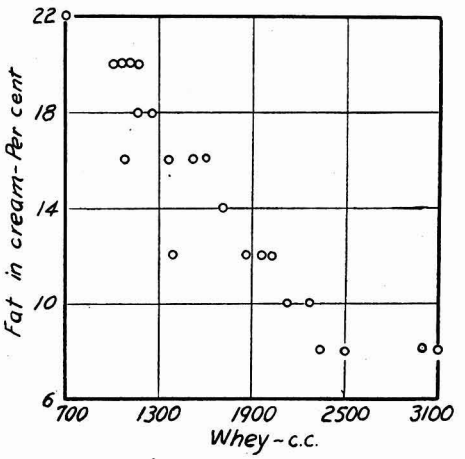

FIG. 5. The relation between the fat in the cream and the amount of whey separating from 10 pounds of cream cheese curd during the first 90 minutes of draining.

figure 6. These curves represent the data from an experiment in which the fat and solids-not-fat of the four lots of cream came from a common source. The results are similar to those of other trials of this same design and show that the fat is not the chief factor which determines the acidity during manufacturing and early storage. During the hours of manufacture varia-

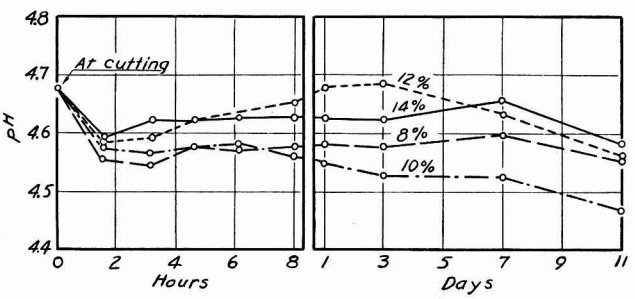

FIG. 6. The effect of fat in the cream on changes in pH during curd making and storage.

tions in acidity between the several lots of cream are small and they differ only slightly more during the next two weeks. Trends of acidity changes are relatively similar in all lots of cheese as shown in figure 6. The general slight increase in acidity toward the end of the holding period can be attributed to bacterial growth probably of the lactobacilli type of organisms.

DISCUSSION

Apparently, there is a minimum percentage of fat in cream which results in cream cheese of satisfactory quality when the making procedure used in

these experiments is followed. The defects of cheese made with cream of too low or too high a percentage of fat indicate that standardization of the cream to a desired ratio of casein to fat might be more desirable than using fat alone to regulate the qualities of the cheese. Assuming normal amounts of casein in milks with 3 and 4 per cents of fat, it is calculated that if creams from such milks are standardized to the same ratios of casein to fat the creams will vary in fat content approximately 2 per cent. For example, the casein to fat ratio in 12 and 14 per cent creams obtained from 3 per cent milk correspond closely with those in 14 and 16 per cent creams, respectively, obtained from 4 per cent milk. These facts undoubtedly explain some of the irregularities noted in quality and physical characteristics of some of the results considered in these experiments. It is recognized that, although the composition of the cream is an important factor influencing the quality of the cheese, the composition of the fat itself probably has a definite effect. Other factors are probably involved such as the hydration of the proteins, charge on the casein particles and possibly the size of the casein particles and each of these three factors might be influenced by the manufacturing processes. The effects of some of these factors will be discussed in a later paper.

Percentages of fat and moisture in the cheese required to impart the best quality vary with the composition of the cream and the conditions of manufacture. The same percentage of moisture may be too high or too low for maximum quality depending upon the variations in fat and milk-solids-not-fat. As a rule, when it is made from cream containing about 16 per cent fat, cheese with 50 to 54 per cent moisture and 37 to 42 per cent fat has the most desirable spreading and slicing properties. These characteristics are influenced somewhat by seasonal or feed differences which alter the chemical composition of the milk fat.

During and since the completion of these studies we have seen the influence of the original properties of the cream cheese curd upon the final product which results when this curd is reheated after draining, mixed with cream and sometimes stabilizers and then homogenized by the so-called "hot-pack" method. This procedure, which is essential if a cream cheese of especially low fat content is to be made, depends for its success on the quality of the curd which is so treated. The results of these experiments therefore can be applied directly in controlling the characteristics of the original curd used in this common commercial practice.

SUMMARY

Cream cheese of good quality can be made from cream testing from 16 to 20 per cent fat. The cheese made from such cream contains 37 to 42 per cent fat and 50 to 54 per cent moisture. Lowering the fat content of the cream tends increasingly to cause grainy texture and crumbly body while

increasing the fat content tends to cause excessive smoothness and stickiness. As the fat content of the cream used for the cheese increases, the yield of cheese per hundred pounds of cream increases and the yield per pound of fat in the cream decreases. The acidity of the final product in terms of pH is not influenced by the percentage of fat in the cream used to make the cheese.

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FROZEN CREAM; A REVIEW*

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The dairy industry, particularly the ice cream industry, is faced with the problem of surpluses and shortages at certain times of the year, and in certain localities. It is a problem of utmost importance to obtain cream from approved sources for ice cream manufacture in many eastern markets during some months of the year. On the other hand during certain periods an abundance of cream is available which results in a surplus. Due to the fact that the 40 per cent cream is usually purchased at prices considerably above the market price for butter a financial loss would result if the cream were converted into butter, therefore much is stored for future use in ice cream, for at the time when this is used the price of fluid cream will have usually advanced. Cream is therefore put into storage to utilize the cream advantageously, and to supply a later demand. Since liquid cream does not possess the proper keeping quality for storage, the product is stored in the frozen state and held at temperatures below zero Fahrenheit. In this state the cream has superior keeping qualities and may be stored for months.

The frozen cream industry is important, as may be seen in the figures supplied by the U.S.D.A. (11). The amount of cream in storage in the frozen state during the month of July 1936, 1937, 1938 and 1939 is listed below:

Year	No. of 40 qt. cans	Approximate weight, lbs.
1936	188,000	15,400,000
1937	226,000	18,500,000
1938	377,000	30,900,000
1939	257,000	21,000,000

Much of the frozen cream is used in the ice cream industry, while the cream cheese industry also makes use of frozen cream. Due to the fact that reconstitution by means of homogenization is necessary before frozen cream can be used, and that certain physical and chemical characteristics of the cream are altered this type of cream does not lend itself to ready use for market or whipping cream.

No records are available which give the origin of the storing of fluid cream for later use in ice cream or in other dairy products. The first record of its use in ice cream appeared in 1927 (12). This report emphasized the importance of the quality of the initial cream before storing, and the storage temperature as the important factors contributing to the quality of ice cream made from frozen cream. It was also noted that if the quality

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of the cream was uncertain better results would be obtained by churning the cream and storing the resulting butter. It was found that fresh sweet cream, frozen and stored at 5° F. for four months afforded as good a source of fat for ice cream as unsalted butter from the same source of cream stored under the same conditions. In 1928 (13) the same author compared high quality frozen cream, butter and butter oil from the same source, frozen and stored under the same conditions, and later used in ice cream. Equally satisfactory results were obtained in all cases.

Ellenberger and White (22) reported similar results in 1929. These writers called attention to the use of metal containers free from corrosion or bare spots of iron or copper, and concluded that cream stored in the proper containers would keep for 6 months with little or no deterioration in flavor. Heating temperature of 180° F. for 30 minutes before storage resulted in an unsatisfactory cooked flavor. They also found that high acidity (0.15 per cent) resulted in cream that was unfit for use after two months of storage. In the same year Newlander and Ellenberger (43) reported that the keeping quality of cream, butter and butter oil of the same quality stored at 0° F. for 4 to 6 months was nearly the same, although the butter kept slightly less successfully.

Considerable interest was manifested in the problem of cream storage in 1930. Numerous investigators studied the problem of keeping quality, the effect of freezing of the cream on such factors as freezing and whipping ability of ice cream containing frozen cream, viscosity and fat clumping. Interest was shown for the first time in the use of sugar as an added ingredient to facilitate thawing. About this time frozen cream became recognized as a staple ingredient for use in the ice cream mix, and investigators began to study the problems connected with its use. The fact that the freezing of the cream by the methods used alters the physical make up of the cream prompted several important investigations to determine the effect of freezing on certain properties.

The purpose of this paper is to review the literature on the subject of frozen cream and its use in the dairy industry. It is believed that this can be best accomplished by dividing the subject into several distinct parts and discuss those separately.

THE EFFECT OF FREEZING CREAM ON PHYSICAL PROPERTIES

When milk freezes without agitation the solid constituents become concentrated in the unfrozen portion while the frozen portion contains most of the water. This is generally accepted as being the case, although there may be an exception in the case of the milk fat. Authorities are not agreed as to the distribution of fat in milk during freezing. It was the general opinion that cream froze in a manner similar to milk. Baldwin and Combs (3), Trelogan and Combs (62), Baldwin and Doan (6) found that cream containing 25–30 per cent or more of milk fat will freeze homogeneously with regard

to the fat content. Trelogan and Combs (62) found that in fluid cream of low fat content the fat tended to rise as in milk and concentrated in the upper portion, but this tendency decreased as the fat content increased and the temperature lowered. This finding led to the later work (8) with frozen cream. When cream of low fat content freezes without agitation there is a similar rise of milk fat to the surface until the fat content of the cream reaches 25 per cent when such diffusion of milk fat is prevented and the cream freezes homogeneously. This diffusion is stopped or inhibited by increased viscosity due to increased fat content and because of the "more effective sealing of the interstices between the ice crystals by the increased amount of fat in the form of solidified globules" (6).

The fact that 40 per cent cream freezes homogeneously with respect to the milk fat, aids in the testing of the frozen cream. Obtaining a satisfactory sample of melted frozen cream for fat testing is nearly impossible. Trelogan and Combs (63) devised a simple method for testing frozen cream for fat. A sample is chipped from the surface of the frozen cream and weighed directly into funnels above the cream test bottle. The cream is permitted to melt and is washed into the bottle by means of 10 ml. of hot water. The acid is also added through the funnel, after which the sample is tested in the usual manner for cream.

Upon the thawing of frozen cream to fluid form, a noticeable change is observed in the physical condition and appearance of the product (2, 44, 52). It appears as if the product has been partially churned and coagulated. If heat is applied to the thawed cream the fat assumes the liquid form and comes to the surface as oil. Methods of thawing of partially frozen milk play an important role in the creaming ability and sampling of the product according to Baldwin and Combs (4, 5). The physical changes observed in thawing indicate a destruction or destabilization of the fat emulsion. Sommer (55) attributes the destruction of the fat emulsion to several factors, such as, changing of water into ice which crowds the fat globules closer together, destabilization of the protein adsorption film on the globules, making it less effective in stabilizing the emulsion, and the increase of salt concentration in the unfrozen portion which aids in breaking the emulsion.

It has been shown by Doan and Baldwin (20) that the pressure exerted on the cream during freezing is the important cause of the destabilization of the emulsion. The amount of pressure exerted depends on the degree of freezing. When the cream is frozen solid, the greatest pressure is exerted and the largest amount of "oiling off" of fat is observed upon subsequent thawing and melting. These authors conclude that changes in the stability of the protein play a minor role in the stability of fat in frozen cream.

Sugar has been added to the cream prior to freezing (67, 20, 36, 46, 48, 49) because of the beneficial effects obtained in thawing of the cream and

in the freezing of the ice cream mix in which the frozen cream is used. Doan and Baldwin (20) found that sugar limits the amount of pressure developed during freezing because of the small ice crystals, which form a less rigid frozen surface and also because of less water freezing at a given temperature. Approximately four times as much pressure is exerted in the unsugared cream as is exerted when 10 per cent sugar is added to 40 per cent cream. The amount of fat thrown out of emulsion is over four times greater also.

Josephson and Dahle (30) observed that sugar reduced the degree of oiling off during heating, from 5 ml. per 50 ml. of ice cream mix to 0.75 ml. Since freezing of cream causes destabilization of the fat it has been thought that homogenization of the cream prior to freezing might prevent the breaking of the emulsion. The above authors found that homogenization may even cause greater destabilization, both in the unsweetened and sweetened cream.

Mack (37) tried homogenization and the addition of gelatin to cream before freezing without success. Lindquist (34) found sodium citrate and disodium phosphate to afford no protection against "oiling off" during heating of thawed frozen cream. When low fat creams were homogenized by Webb and Hall (67) they found that the fat separation was reduced. The addition of milk solids not fat lessened greatly the fat separation. These investigators obtained a normal milk from milk concentrated 3–1 before freezing. No detrimental effects to the body or flavor were obtained.

It is evident that methods and materials which afford stability to protein of milk are apparently valueless in preventing the destabilization of the fat emulsion in frozen cream and that pressure is the cause of the de-emulsification.

That concentration of milk solids in milk before freezing aids in stabilizing fat emulsion has also been shown by Doan and Featherman (21). A concentration of three to one gives satisfactory results they noted. Homogenization of the concentrated milk prevents a "rise of cream in the thawed, reconstituted milk but decreased the churning, oiling off and cream plug tendencies and also appears to aid in preventing tallowy flavor." It is possible to store this type of milk for 12 weeks in the frozen state. These writers state that the protein of concentrated frozen milk is apparently denatured by holding for long periods in the frozen state but that a reversible action is possible. They encountered one sample in which the badly coagulated protein was redispersed to a normal condition by heating to 150–160° F.

Corley and Doan (9) later again substantiated the results obtained with homogenization so far as stabilization and oxidized flavor are concerned. This work also shows that a heating temperature of 180° F. before storage lessens the tendency for the formation of coagulated proteins. While concentrated milk has been shown by several to be quite stable after storage in

the frozen state, this is not the case with frozen cream as has been observed by many and the destabilization of the fat in frozen cream constitutes one of the major problems of frozen cream storage.

Slow freezing of the unagitated cream accentuates the degree of fat destabilization and precipitation of the caseinate system. This would be expected and Webb and Hall (67) show that the fat becomes destabilized at once while the proteins precipitate gradually. The latter has been confirmed in the freezing of condensed skimmilk. This product at first shows no change in appearance but gradually upon storage and subsequent melting shows a gel structure, which after continued storage of about 8 months exhibits considerable wheying off after melting (51). A curdy appearance in frozen condensed milk has been recorded after a much shorter storage period (10).

THE USE OF FROZEN CREAM IN ICE CREAM

It is in ice cream that the bulk of the frozen cream is used. When first used the quantity of frozen cream in the mix represented a substitution of approximately one-half of the total cream needed for the mix. It was often found that the quality of the cream after storage was such that a greater substitution resulted in stale flavors in the finished ice cream. On certain occasions all the cream for a mix is obtained from frozen cream with satisfactory results. The amount that may be used in a mix then depends on the quality of product when removed from storage. Dahle, Lawhorn and Barnhart (17) have shown that frozen cream may be used to provide all the cream needed in a mix providing the temperature of heating the cream before freezing exceeds 170° F. and the copper content is low. In all cases however the cream oiled off during pasteurization of the mix.

Gockley (23) recommends the use of about 60 per cent frozen cream and 40 per cent fresh cream since he finds that if frozen cream is used as the sole source of cream an unsatisfactory flavor results. The general opinion voiced by the majority of users is in agreement with Gockley.

Methods used in storing frozen cream: Dahle and Josephson (15) in summarizing a questionnaire sent out by the Ice Cream Field noted that there is no uniformity as to methods used in storing cream. Cream testing from 40 to 50 per cent fat is used and the acidity test is the criterion used to indicate the quality of the cream. Heating temperature ranged from 140° F. to 180° F. with about 62 per cent of the replies indicating that 160° F. or higher is used. About 68 per cent of the users add sugar to the cream in amounts ranging from 2 to 20 per cent with the majority adding from 10 to 20 per cent. Storage temperatures range from 0° F. to – 20° F., and the cream is held from 2 to 18 months with an average storage time between 3 and 9 months. Most of the users use from 15 to 30 per cent of the total cream in the mix in the form of frozen cream. Mack (35) shows that ice cream of

desirable flavor can be made when not more than one-third of the fat content is supplied from frozen cream.

Cream is usually stored in single service cans of 5 to 6 gallon capacity, although some large users use paper cans of a type used for dispensing ice cream. The tin containers (45) are about 9–13 inches in diameter and 15–22 inches deep, holding from 45 to 50 pounds of cream. Of the four users (15) who stored cream in paper cans three reported unsatisfactory results, stating as the main objections that the cans were harder to fill and handle, and greater loss of cream resulted than when tin cans were used, although Tracy (64) found that paraffined paper containers could be used with satisfaction. The advantage of the paper can lies in the convenience of removing the frozen cream at the time of using. The paper is merely stripped or cut from the solid cream and the frozen mass dumped into the mixer or pasteurizer. Some cut the tin cans with tin cutters in much the same manner, also. It has been pointed out by some (22, 64) that the cans must be well tinned and free from rust spots or exposed iron.

Because of the destabilizing effect of the freezing and thawing, cream has been put up by quick freezing methods. The idea back of this procedure is to produce a cream free from fat destabilization. This idea of quick freezing of cream dates back to the inception of the methods of quick freezing of food, but little work has been done on the subject until quite recently. In 1931, Grayson (26) described a method of fast freezing of milk which consisted of placing pasteurized and homogenized milk in a receiving reservoir of a de-aerating freezing unit under vacuum of 29.8 inches for 20 minutes. Later the milk is passed into a freezer where it is frozen to a slush in 4.5 minutes while still under vacuum. This slush is then run into gallon stone jugs of the thermos type and sealed under 15 inches of vacuum and placed in a freezing unit at $-45°$ F. The milk becomes hard in about two hours time. Little change in quality was noted when examined at 30-day intervals.

Price (47) suggested a method of freezing cream quickly with sugar in an ice cream freezer adjusted so as not to incorporate air. The system can be made continuous by entering cream as the frozen cream is discharged. Cream quickly frozen in vacuum sealed cans was shown by Roadhouse and Henderson (53) to thaw to a normal consistency without fat separation. The cream is frozen in $11\frac{1}{2}$ ounce vacuum sealed cans immersed in denatured alcohol maintained at a temperature of $-25°$ F. Upon defrosting and warming with vigorous agitation the cream presented a normal consistency and was satisfactory in coffee and cereal after 6 weeks of storage. Agitation during warming is necessary for a normal consistency. Since no separation of fat is obtained in the unhomogenized cream, the authors conclude that homogenization is not necessary. It must be remembered that the samples used were small and to put up frozen cream for ice cream by a quick freezing

method requires the handling of larger units. Spraying of milk and cream into a freezing chamber and later compressing the product into blocks has also been suggested (8) as a method for the quick freezing of cream, but no commercial installations have been made in this country. Quick freezing of milk seems to show no significant lowering of vitamins A and G when compared to those vitamins found in fresh milk from the same source (1).

Thawing of frozen cream: One of the problems of using frozen cream in the dairy industry is the thawing or defrosting of the product. In the past the usual practice was to let the cans of frozen cream stand out in the handling room having a temperature of around 70° F. until thawed out sufficiently to use. This might take 24 to 48 hours, and is not considered good practice. Some set the cans in water and heated the water with steam. This requires a large water bath which takes up considerable space. Time of melting is important from the standpoint of space available, and also in some cases from the standpoint of bacterial contamination. Gockley (23) mentions the use of an ice crusher as a means of breaking up the frozen cream quickly into small pieces which can quickly be melted in the ice cream mix or other product in which it is used. Advantages given for this machine are less loss of fat due to cans which may develop leaks when defrosted in water or air, convenience and speed. The crusher used must be constructed of sanitary material and in such a manner as to be readily cleaned and sterilized.

When using the crusher the single service cans of frozen cream, either tin or paper, are removed from the storage room and the sides ripped down to facilitate emptying. The frozen lump of cream is then dumped into the crusher to which a hopper is attached for collecting the pieces of frozen cream. When large quantities of frozen cream are used this system saves considerable time and space.

Slow defrosting has been shown by Mack (37) to result in an ice cream of better whipping qualities than when the cream is melted at the pasteurizing temperature. While this is an argument against rapid defrosting, the majority of large users haven't the time nor space to defrost slowly. The slower whipping of the ice cream mix can be overcome by means to be mentioned later. The usual procedure by large users is to strip the container free from the frozen cream, break the cream up or add it as it is to the vat of other liquids being used with the cream. If coil vats or vats containing agitators are used care must be taken that the large lumps of frozen cream do not interfere with or injure these moving parts.

Freezing cream with sugar: Mack (36) appears to be the first to mention the freezing of cream with sugar although the dairy industry had been using the procedure for some time. Mack added 10 per cent sugar by weight to the cream before freezing. The advantages claimed by the author were that the resulting cream melted more rapidly and gave a better flavor to the

ice cream than plain unsweetened cream. The ice cream made from the sweetened cream froze considerably faster than the unsweetened in the freezer and resembled ice cream made from fresh cream. The fresh cream produced the overrun (95 per cent) in two and one-fourth minutes less time than the mix containing plain frozen cream. The frozen cream mixes had a greater viscosity than sweet cream mixes and contained larger and more irregular size fat globules and fat clumps (36). Mack (39) reported that the viscosity was more than twice as great in the frozen cream mixes as in fresh cream mixes and that fresh cream mixes gave a maximum overrun of 130 per cent in 13 minutes as compared to 118 per cent overrun in 19 minutes when plain frozen cream was used.

It is accepted as a fact that frozen cream slows the whipping time of ice cream when frozen in batch freezers and that sugar added to the cream aids in restoring whipping time. The usual procedure is to add 10 to 15 per cent sugar to the cream during, before or after pasteurization but with intention of having it in solution. Sucrose is the sugar used generally, although Price (47) studied other sugars as well. His results coincide quite favorably with those of Mack so far as overrun, whipping time, etc., were concerned and it was noted that invert sugar proved to be as effective as sucrose in frozen cream.

Overrun and frozen cream: Price attempted to explain the inferior whipping of ice cream mixes containing frozen cream on the basis of lecithin precipitation in the cream during freezing, or some alteration of lecithin in the frozen cream. He noted that mixes containing butter or frozen cream behaved similarly. Whitaker (69) in explaining the reason for the poor whipping of mixes containing butter stated that the lecithin content of the butter mixes and fresh cream mixes differed, the cream mixes being higher in lecithin. Products containing lecithin in large quantities such as egg yolk were recommended for mixes of inferior whipping qualities. Frozen and dried egg yolk have been used for this purpose for years and Price (47) observed that a gummy mass separated from fluid egg yolk upon freezing which could not be reincorporated on melting and stirring. Urbain and Miller (65) called this material lecithin and prevented this separation by the addition of sugar before freezing the yolks. Price then showed conclusively that the sugaring of the eggs before freezing aided the whipping ability of the ice cream mixes and prevented separation. Urbain and Miller sugared the egg yolks with sucrose, dextrose, and levulose and found that monosaccharides were the most effective due, they stated, to the greater osmotic pressure and lower freezing point than was obtained with sucrose in the same concentrations.

Price (47) endeavored to show that the lecithin of the frozen cream is in some way responsible for the inferior whipping of mixes containing frozen cream, although no lecithin was separated from the frozen cream to offer proof that lecithin is changed by freezing of cream.

It was not until 1936 that lecithin was definitely proved to be involved in the difficult whipping of ice cream mixes when frozen cream was used in the mix. Josephson and Dahle (30) studied the "oiling off" of ice cream mixes and found that the degree of "oiling off" was in direct proportion to the whipping ability of the resulting mixes. Frozen creams containing sugar resulted in less "oiling off" than unsugared cream. Homogenization of the cream before freezing resulted in more oiling off, which was not expected. The writers showed then that the more fat separation obtained the greater would be the effect on the whipping ability of the resulting ice cream mixes. To prove this, fresh cream was placed in a churn and at intervals during the churning process the churn was stopped and enough of the contents removed to prepare ice cream mixes. Cream was removed before the breaking point, after visible breaking, and after complete breaking. A sample of finished worked unsalted butter was also taken. By making these samples into ice cream it was possible to show the effect of fat destabilization on overrun of ice cream.

The authors then proved that partial fat destabilization of cream before use in a mix is detrimental to overrun of ice cream. The fact that sugar added to cream before freezing and storing reduces the pressure during freezing of the cream and thus reduces the degree of fat separation, is the reason that sugared cream aids overrun.

Josephson and Dahle (30) also show that as the fat content of fresh cream increases the more danger there will be in having fat separating in the subsequent mixes and the slower will be the whipping of the mixes. It is thought that homogenization of the mix, which restores the fat emulsion, should take care of the oiling off problem. It does this, but this does not restore the whipping ability of the mixes.

The authors reasoned that in the freezing of cream the fat globule membrane is broken which permits the fat to run together as an oil upon thawing or subsequent pasteurization. This membrane which is a phospholipid-protein complex is not restored to the fat globule in a normal manner upon homogenization and this, these authors contend, is the reason for poor whipping of mixes containing frozen cream and butter. To prove this contention Josephson and Dahle (30) emulsified butter oil in various materials such as egg yolk, skimmilk, starch, gelatin, buttermilk, egg and milk phospholipids and the fat globule membrane. The cream obtained was made into mixes and these frozen in the usual manner. The fat globule membrane was the only material that restored whipping of the mixes to normal. Other materials restored whipping in proportion to their phospholipid content. When these phospholipid materials were added to mixes and homogenized with the mix in the usual manner only partial restoration of whipping was obtained. The conclusion reached was that freezing, churning, or anything that removed the fat globule membrane from the surface of the fat globule, is detri-

mental to the whipping of the resulting ice cream mixes, and that restoration of the membrane directly to the fat surface restores whipping to normal. In the ordinary processing of mixes this membrane is not readsorbed in a normal way. Other materials are also adsorbed and the whipping ability affected. Thus lecithin may be said to have a part in the whipping ability of mixes, and that freezing of cream may affect this constituent. Lecithin is affected only since it is the main constituent of the fat globule membrane and this membrane is ruptured by the ordinary freezing of cream. Quick freezing of cream which results in very small ice crystals has less effect on the membrane and thus there is less fat separation with the result that when this cream thaws out it has an appearance resembling fresh cream.

Improving the overrun in ice cream containing frozen cream: While it has been shown (30) that restoration of the fat globule membrane directly to the fat globule restored whipping to normal this method is not practical. Price (19), Mack (37) and others have shown that sugar aids the overrun when added to the cream before freezing but does not completely restore it to normal. Egg yolk added to the mix aids greatly in restoring the whipping ability and is used in regular practice by ice cream manufacturers. Walts and Dahle (66) restored the whipping ability of mixes containing butter to normal by additions of 0.5 per cent dried egg yolk. Dried egg yolk was greatly superior to frozen egg yolk when the eggs were frozen without sugar. Pettee (50) also found dried yolk to be superior to frozen yolk containing one per cent sugar.

More recently Dahle and Rivers (19), Dahle, Lawhorn and Barnhart (17) demonstrated that the reduction of the acidity of mixes containing frozen cream restores whipping to normal or near normal. The acidity in these experiments was reduced with various alkalies to an acidity of 0.07 to 0.10 per cent. These mixes obtained all of their butter fat from frozen cream with the exception of the control mix. In one set of trials the acidity reduction from about 0.23 to 0.10 per cent restored whipping to a point where it was superior to the fresh cream control. This may be seen in table 1. No

TABLE 1

The effect of reduction of acidity with magnesium oxide on the whipping ability of frozen cream mixes

	Initial acidity	Final acidity	Final pH	Time to reach 90% overrun
1	0.23	0.18	6.44	9′–30″
		0.10	7.25	7′–17″
2	0.24	0.18	6.42	9′–10″
		0.10	7.23	7′–35″
3	0.22	0.18	6.42	9′–25″
		0.10	7.24	7′–10″
Control fresh cream	0.22	0.18	7.45	7′–30″

attempt has been made to explain these results. It will be noted that a reduction of acidity from about 0.23 to 0.10 per cent was greatly superior to a reduction from the same acidity to 0.18 per cent. The main difference observed was in the improvement of the protein stability due to the reduction of the acidity. The danger in this procedure lies in the possibility of an alkaline flavor with certain materials. Magnesium oxide was quite satisfactory as a neutralizing agent in that it seemed not to produce much of a neutralizer flavor.

FACTORS AFFECTING THE KEEPING QUALITY OF FROZEN CREAM

In as much as frozen cream presents certain physical defects as mentioned, these can be overcome quite largely by use of the homogenizer or viscolizer after the thawing and pasteurization. The homogenizer renders the product useable for cream cheese, market cream in certain instances and ice cream. To offset the inferior whipping ability of ice cream mix due to the frozen cream used, egg yolk is usually added to the mix.

The main defect that may result from frozen cream is oxidized flavor. This may be present in the cream after storage, and appear immediately in the ice cream or it may develop later in the ice cream. Much attention has been paid to the keeping quality of frozen cream from the beginning of the use of the product in ice cream. Dahle (12), Ellenberger and White (22), Newlander and Ellenberger (43) were the first to call attention to the influences on flavor. Mack (37) later called attention to the use of sugar as improving the quality of the cream from the standpoint of flavor and recommended the use of one third of the total fat content (35) when frozen cream is used in ice cream. He also noted (38) that frozen cream stored at – 5° F. for 6 months was equal in flavor to cream stored at 10° F. for 4 months, and he suggested storage periods of less than 6 months. Price (48) also found that sugar improved the keeping quality of frozen cream. Lawhorn (33) on the other hand was unable to show that sugar improved the keeping quality when added to the extent of 10 and 15 per cent.

Temperatures and keeping quality: In some of the early work reported on keeping quality of frozen cream little attention was paid to the temperature of pasteurization except that Ellenberger and White (22) who used temperatures of 145° F. and 180° F. for 30 minutes reported that the highest temperature was not satisfactory due to the cooked flavor imparted to the cream. In view of our present knowledge (25, 31) of the relation of cooked flavor to oxidized flavor this cooked flavor would no doubt have enhanced the keeping quality from the standpoint of oxidized flavor.

Tracy (64) found that cream of high fat content kept better than cream of low fat content and that pasteurization at 145° F. for 30 minutes improved the keeping quality. Frozen cream stored at 0° F. for three and one-half months kept well providing it contained 39.5 per cent butterfat. Lower

testing creams did not keep well. Creams stored at 20 to 28° F. became tallowy in flavor after 29 days.

Temperatures higher than the ordinary temperature used in pasteurization of milk and fluid cream have been used for some time as a standard procedure by some companies in putting cream into storage. Sixty-two per cent of the manufacturers replying to a questionnaire (16) stated that they used temperatures above 160° F. with 180° F. being the upper limit reported. It is now definitely established that temperatures of 170° F. and above result in superior keeping quality so far as oxidized flavor is concerned. This, as Gould and Sommer (25), Josephson and Doan (31) have shown is due to the production of reducing substances due to the high temperature. Sulfhydryls are the reducing substances found and these products also are responsible for the cooked flavor obtained. So long as a cooked flavor persists no oxidized flavor occurs.

McFarland and Burgwald (40) used temperatures of 145° F. for 30 minutes, 172° F. for one minute and for 5 minutes and found that the latter temperature provided frozen cream with excellent keeping qualities even in the presence of considerable copper. The samples heated to 145° F. for 30 minutes were decidedly inferior, while those heated to 172° F. for one minute kept well. The extra holding time produced better results. Although the highly heated samples developed an objectionable cooked flavor at first it diminished sufficiently after one month in storage to become unobjectionable. These results coincide with those obtained by Lawhorn (33) who used temperatures as high as 190° F. Cooked flavors were obtained with the high temperatures but when the cream was used in the mix there was no cooked flavor in the finished flavored ice cream. Cream that was heated from 140° F. to 190° F. by direct steam injection had less cooked flavor than when heated in a jacket. Heating under vacuum to 170° F. also produced less cooked flavor and good keeping quality.

Dahle, Lawhorn and Barnhart (17) show that the higher temperature produced an increase in the amount of sulfhydryls formed in the samples. The Eh of the samples immediately after heating to high temperatures decreased showing the presence of reducing substances which were considered to be sulfhydryls. These samples of heated cream had superior keeping quality in all cases although the cooked flavor and keeping quality diminished greatly in the presence of copper.

Copper and keeping quality: As early as 1905 Golding and Feilman (24) observed that milk developed a metallic flavor when it passed over a cooler showing exposed copper. This metallic flavor is now generally considered to be the same flavor as oxidized flavor. Hunziker and Hosman (29) likewise showed that copper was responsible for tallowy flavor in butter. Since then the literature contains numerous references to the flavor defect in dairy products that may be catalyzed by copper. Ellenberger and White (22)

point out that containers in which frozen cream is stored should be free from corroded or bare spots of iron and copper, and that this applied to all metal containers in which cream is stored. The same was recommended by Tracy (64). Sommer (56) found that frozen cream stored at 0 to – 10° F. for 5 months kept best if the copper and acidity were kept low. The keeping quality was found to be poorest in samples having the highest oxidizing intensity. Sampey (54) listed copper as one of the causes of oxidized flavor in frozen cream and mentioned a rapid qualitative test for determining the presence of copper in amounts higher than one twentieth part per million, which test should be applied when selecting cream for storage.

While the tendency in plants is to eliminate copper equipment as much as possible today there still is a great deal of it used and it provides a source of contamination to milk products coming in contact with it. Dahle and Folkers (14) showed that as little as 1.3 p.p.m. of copper will cause oxidized flavor to appear in strawberry ice cream after hardening. Dahle, Lawhorn and Barnhart (17) more recently demonstrated that as little as 1.12 p.p.m. caused oxidized flavor to appear in frozen cream after 6 months storage at – 10° F. while 1.25 p.p.m. caused it to appear after one month storage. The cream in question had been heated to 170° F. flash. There is a difference in the susceptibility of cream toward oxidation, however, and it is possible sometimes to have a greater contamination of copper without oxidized flavor occurring. McFarland and Burgwald (40) were able to prevent oxidation in frozen cream containing 2.5 p.p.m. copper for 26 weeks by pasteurizing the cream to 172° F. while cream containing 0.5 p.p.m. of added copper and pasteurized at 145° F. for 3 minutes developed the defect in 6 weeks.

That acidity accelerates the onset of oxidized flavor in the presence of copper has been demonstrated (41, 54, 56). Reducing the acidity was found by Morris and Sommer (41) and Tracy (64) to delay the flavor defect. Barnhart (7) studying the relationship of acid and copper in frozen cream increased the acidity of 40 per cent cream from 0.11 per cent to 0.15 and 0.20 per cents respectively. Copper was added in amounts ranging from 0.25 to 1.0 p.p.m. The cream was heated to 170° F. for 10 minutes. The results indicated that there was no difference due to the acid up to 6 months in storage. The samples containing 1.0 p.p.m. of copper developed oxidized flavor after 6 months. The high temperatures of pasteurization for 10 minutes apparently aided the keeping quality. No mention of temperature above 145° F. was made by others (41, 56, 64). When cream acidity was neutralized back to the original acidity by Barnhart no difference was obtained. The disagreement with others' work was again no doubt due to the difference in pasteurizing temperature used.

Homogenization and flavor: Homogenizing the cream before freezing has been practiced from the standpoint of preventing oiling off of the cream during thawing and subsequent use in ice cream, but without success. Many

have shown it to be effective in preventing or delaying oxidized flavor in milk. It has been shown (14) that oxidized flavor in ice cream develops much more quickly in unhomogenized ice cream mix than in homogenized ice cream mix. Thurston, Brown and Dustman (61) showed that homogenization, freezing and thawing and agitation at low temperature had marked effects in reducing the susceptibility of milk to oxidized flavor after adding sufficient copper to cause the defect in non-treated milk. Their reasoning suggested that the freezing or low temperature agitation caused lecithin to move from the adsorbed layers on the fat globules to the milk plasma. It is on the basis of this theory that Sommer (61) suggested homogenization as a means of eliminating oxidized flavor in frozen cream.

Sommer froze samples of 40 per cent cream for 24 hours; then thawed them out at 70° F. The control samples without added copper did not develop oxidized flavor; all the unfrozen samples with added copper developed oxidized flavor, while the frozen samples with added copper did not develop the defect, or if it did the degree of oxidized flavor was not as great. This offers proof that the freezing of the cream is not responsible for any oxidized flavor that may ensue.

McFarland and Burgwald (40) present considerable data to show that homogenization prevents oxidized flavor in frozen cream in the presence of considerable copper. In one of their trials they showed that frozen cream kept without oxidation for 21 weeks in the presence of 1.5 p.p.m. added copper, while the unhomogenized control showed the defect in 2 weeks. In another trial the cream kept for 17 weeks with 3.0 p.p.m. added copper while the unhomogenized control developed the off-flavor in 4 weeks. All samples were heated to 172° F.

Tracy, Ramsey and Ruehe (64a) who were among the early workers to show that homogenization prevented or delayed oxidized flavor in milk state: "That the close relationship between the Eh value of homogenized and unhomogenized milk indicates that the lessened intensity of the tallowy* flavor developing in homogenized milk needs to be explained in some other way than on an oxidation-reduction basis." These writers found that the Eh of the milk that passed through the homogenizer without pressure had essentially the same increase in Eh regardless of whether or not it had received pressure. The ones receiving pressure did not become oxidized while the samples without pressure became oxidized. The difference in Eh between the homogenized and unhomogenized samples was slight. Lawhorn (33) on the other hand was able to show an increase in Eh due to homogenization in three separate experiments; the increase he obtained was considerable. Stainless steel homogenizers were used so there was no catalyzing effect due to copper.

Antioxidants in frozen cream: It has been shown that pasteurizing the

* Oxidized.

cream at temperatures above 170° F. (25, 31) greatly enhances the keeping quality, due no doubt in a large measure to the production of reducing substances such as sulfhydryls. Since oxidized flavor is the most serious flavor defect, in fact the most serious of all defects, attempts have been made to prevent it or delay its onset so cream may be stored for longer times than has been the practice. Thus McFarland and Burgwald (40) were able to extend the keeping quality of frozen cream several months by homogenization of the cream in addition to the high pasteurizing temperature used.

Lawhorn (33) was able to freeze and store cream in good condition for 8 months. This cream was used as the sole source of fat in ice cream with no flavor defect appearing in the ice cream. The cream was of good quality at the start and it was pasteurized at high temperatures. On the other hand cream has been stored with antioxidants added to improve the keeping quality. Dahle and Josephson (15) added oat flour to 40 per cent cream at the rate of 2 per cent of the weight of the cream. Two parts per million of copper were added to the cream. The results obtained when the cream was used as the sole source of fat in strawberry ice cream showed a decided improvement in the keeping quality of the ice cream. Lawhorn (33) later added oat flour at the rate of 2 per cent of the fat weight of the cream. A concentrate of oat flour was added at the rate of 0.2 per cent of the fat weight. To the cream was added 1 p.p.m of copper. Here the results showed also that oat flour and an oat flour concentrate delayed the onset of oxidized flavor in frozen cream. Lawhorn also tried to improve the keeping quality of 40 per cent cream by replacing the oxygen with nitrogen. In samples heated to 170° F. no difference was obtained and only slight improvement was obtained in samples heated to 150° F. A great reduction was observed in the Eh of the cream to which nitrogen had been added and a large increase in pH was obtained on the samples shortly after the addition of nitrogen.

Barnhart (7) confirmed Lawhorn's results with oat flour and a corn flour concentrate and also added living and dead bacteria, both of which proved to aid the keeping quality of frozen cream.

Antioxidants would seem to be unnecessary in view of the findings of McFarland and Burgwald (40).

Eh and flavor: Sampey (54) was among the first to attempt to use some test for determining the keeping quality of frozen cream. He suggested the use of the oxidation-reduction potential as a means of studying the susceptibility of the cream to oxidation. If he obtained a rise in Eh of 0.1–0.2 volt he considered the cream unsuited for storage and should be used up soon. Oxidation-reduction potential determinations expressed in terms of Eh is a means of measurement of oxidation. If oxidation takes place there is an increase in the voltage of the sample, likewise if reduction takes place there is a drop in the voltage.

Thurston (60) noted that the oxidation-reduction potential appeared to have no "practical value in predicting the possible behavior of milk as regards its tendency to develop oxidized flavor." In his studies he used milk only. Webb and Hileman (68) concluded that "the absolute value of oxidation-reduction potential of mixed milk pasteurized in glass has no relation to the degree of oxidized flavor which develops." These writers, however, do show as do others that the oxidation-reduction potential is a means of measuring or following the progress of oxidation. They point out that an increase of 0.1 Eh on the addition of 0.25 p.p.m. copper to 50 per cent cream shows "the extreme sensitivity of the oxidation-reduction potential system to amounts of copper comparable with those dissolved from plant equipment." Greenbank (28) on the other hand, while working with milk contaminated with copper, states that "if the increase in Eh of the sample containing copper is 0.01 volt or more, the sample probably will become oxidized after 24 to 48 hours' storage at 5° C. Conversely, those samples which do not show 0.01 volt rise, probably will not become oxidized for a similar time of storage at 5° C." These statements he added apply only on samples freshly drawn, as samples that have been shaken or allowed to stand for any appreciable length of time at room temperature may give varying results. The poising action of the milk will also give variations he pointed out. However, the author states that there is a direct relationship between the potential of the system and the tendency of a milk to develop off-flavor.

Dahle, Lawhorn and Barnhart (17) made an exhaustive study of Eh and oxidized flavor of frozen cream. They noted that the Eh of cream varied with the time of the year, and found it highest from November to February. Heating cream above 170° F. caused a great reduction in the Eh, the higher the temperature the greater was the reduction. The striking thing about the work of Dahle, *et al.* was that in practically every case the Eh of the frozen cream increased for the first month and then decreased as a rule up to eight months, while at the same time the flavor might have become oxidized.

TABLE 2

The effect of copper content and temperature on Eh

Heating temperature	Eh in volts
150° F.—30 min.	.2978
" " " +0.5 p.p.m. cu.	.3396
" " " +1 p.p.m. cu.	.4198
170° F.—Flash	.1487
" " +0.5 p.p.m. cu.	.2915
" " +1 p.p.m. cu.	.3497
190° F.—Flash*	.1568
" " +0.5 p.p.m. cu.	.1966
" " +1 p.p.m. cu.	.2988

* Not the same cream as used with 150° F. and 170° F. temperatures.

Copper added to the cream caused an increase in the Eh depending on the amount added. Since high temperature caused reduction in Eh and copper an increase it was of interest to note that copper influenced the Eh considerably in all heated samples.

These authors (17) show that samples of pasteurized cream having an Eh value approaching .29–.30 volt were likely to develop oxidized flavor, although there may be exceptions.

SUBSTANCES RESPONSIBLE FOR OXIDIZED FLAVOR IN FROZEN CREAM

When milk, cream or ice cream develops an oxidized flavor it has been assumed that this was due to oxidation of the butterfat. Thurston, Brown and Dustman (59) showed that the lecithin of the fat globule membrane was responsible for the defect rather than the fat. Dahle and Palmer (18) concurred with this finding but also along with Kende (32) were able to show by iodine number determination that the butterfat also was affected in spontaneously exidized milk. In later work (17, 42) it was shown that copper-catalyzed oxidized flavor in frozen cream had no effect on peroxide and iodine number of the pure fat. Pure fat was obtained from frozen cream having a strong oxidized flavor. This pure rendered fat possessed a strong oxidized flavor but the peroxide number of the fat was zero and the iodine number was unchanged although the fat had a strong oxidized flavor. This indicated that the phospholipids of the fat globule membrane contributed the oxidized flavor to the cream and that this flavor or odor was absorbed by the fat. When the pure fat was incubated at 60° C. for some days the peroxide number increased considerably but the iodine number showed little change until the fat had been incubated for a considerably longer time. Swanson and Sommer (58) demonstrated that the phospholipid fraction of milk was the factor responsible for oxidized flavor of milk. The phospholipid fraction (lecithin and cephalin) showed a marked decrease in iodine number while the pure butterfat did not show a significant decrease. They concluded that oxidized flavor in milk catalyzed by copper is due to oxidation of the phospholipid fraction.

SUMMARY

Frozen cream of 40 per cent or more fat is an important product of commerce in the dairy industry of the United States. Its use is largely confined to the populated centers although it may originate elsewhere.

Upon pasteurization in the ice cream mix the butterfat oils off considerably and must be emulsified by means of homogenizers or viscolizers. Due to this oiled off condition the whipping ability of the ice cream is adversely affected and some egg yolk product is usually used to restore the overrun. The removal of the fat globule membrane by the pressure of freezing and the failure to restore this membrane to the original fat are the causes of the poorer whipping of the ice cream mixes containing frozen cream.

The reduction of acid in ice cream mixes containing frozen cream to approximately 0.10 per cent also restores overrun.

The inferior keeping quality of much of the frozen cream often precludes its use as the sole source of fat in ice cream. Pasteurization of the cream to temperatures above 170° F., low copper content, low storage temperature (0 to −15° F.) in proper containers and homogenization at the heating temperature all aid in enhancing the keeping quality. Thus it may be possible to use a larger quantity in ice cream.

Eh determination of pasteurized cream may prove an aid in predicting the keeping quality of the product when frozen.

Oxidized flavor in copper-catalyzed cream, which is the chief flavor defect, is caused by oxidation of the phospholipid fraction of the fat globule membrane.

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ABSTRACTS OF LITERATURE

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CONTENTS

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PUBLICATIONS AND ABSTRACTORS

EDITORS

Dahle, C. D., Dahlberg, A. C., Elliker, P. R., Petersen, W. E., Tracy, P. H. and Weckel, K. G.

ABSTRACTORS

Anderson, E. O.
Archibald, J. G.

Babcock, C. J.
Berggren, Ruth E.
Brueckner, H. J.
Burgwald, L. H.
Bushnell, L. D.

Cole, W. C.
Cone, J. F.
Corbett, W. J.
Coulter, S. T.

Doan, F. J.

Dorsey, L. M.
Downs, P. A.

Erb, J. H.
Ely, Fordyce
Espe, D. L.

Frazier, W. C.

Garrett, O. F.
Glick, D. P.
Goss, E. F.

Hansen, Arne
Huffman, C. F.

Irvine, O. R.

Josephson, D. V.

Knight, D.

Lucas, P. S.
Lush, J. L.

Mack, M. J.
Macy, H.
Marquardt, J. C.
Martin, W. H.
Mueller, W. S.

Parfitt, E. H.
Price, W. V.

Reece, Ralph P
Riddell, W. H.
Ritter, W.

Stark, C. N.
Stebnitz, V. C.

Thomsen, L. C.
Trout, G. M.
Tuckey, S. L.

Webb, B. H.
Weckel, K. G.
White, G. C.

Yale, M. W.

JOURNALS

American Butter Review
American Milk Review
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Journal of Pathology and Bacteriology
Journal of Physical Chemistry
Journal of Physiology

Kaeseindustrie
Kolloid-Zeitschrift

Lancet
Le Lait

Milchwirtschaftliche Forschungen
Milchwirtschaftliche Zeitung
Milk Dealer
Milk Industry
Milk Plant Monthly
Molkerei Zeitung
National Butter and Cheese Journal

Oil and Soap

Pacific Dairy Review
Proceedings of Society of Animal Production
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Refrigerating Engineering

Scientific Agriculture

Tierernährung
Tierzüchter

Zeitschrift für Infektionskrankheiten Parasitäre Krankheiten und Hygiene der Haustiere
Zeitschrift für Physikalische Chemie, Abt. A and B
Zeitschrift für Untersuchtung der Lebensmittel
Zeitschrift für Züchtung. Reihe B. Tierzuchtung und Zuchtungbiologie
Zentralblatt für Bacteriologie
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The Royal Technical College, Copehagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

ADVANCE ABSTRACTS OF REPORTS ACCEPTED FOR PUBLICATION IN THE JOURNAL OF DAIRY SCIENCE

90. The Effect of Pasteurization on Esch. coli in Milk and Ice Cream Mix. CHARLES PALEY AND M. L. ISAACS, Columbia University, New York.

A study was made of the comparative resistance of a strain of *Esch. coli* to the temperature of 143° F. in ice cream mix and in milk. The organism appeared to be about twice as resistant in the mix as in milk (that is, about twice as long was required to produce an equal degree of killing in the ice cream mix as in milk). When the ingredients of a mix were added singly to milk it was found that only sodium alginate and locust bean gum increased the resistance of *Esch. coli.* It is particularly noteworthy that sucrose and gelatin did not increase the resistance of the organism.

91. Some Factors Affecting the Body of Market Cream. F. M. SKELTON AND E. O. HERREID, Vermont Agricultural Experiment Station.

The problem of cream body was approached synthetically through a study of normal, of washed and of reconstituted creams.

The raw creams showed higher viscosities during the late fall and winter months and were lowest during the summer, while the same creams after pasteurization exhibited lower viscosities that did not vary greatly from one season to another.

The viscosity of the washed cream was neither reduced greatly by pasteurization nor increased greatly with age and responded to temperature treatment during the winter. The viscosity of the skimmilk reconstituted cream decreased with pasteurization and age and did not respond greatly to temperature treatment, while the viscosity of the cream reconstituted with materials obtained from the surfaces of the fat globules was not greatly altered by pasteurization, but was considerably increased by the temperature treatment. The materials associated with the fat globule membrane appear to be associated with increases in viscosity by temperature treatment, but not with decreases in viscosity by pasteurization. The temperature treatment used is described by J. C. Hening and A. C. Dahlberg in N. Y. (Geneva) Agr. Exp. Sta. Tech. Bull. 197. 1932.

92. Care of Milking Machines. C. K. JOHNS, Dominion Department of Agriculture, Ottawa, Ont.

In a recent paper by Mallman, Bryan and Begeman (J. DAIRY SC. **23:** 621. 1940) the practice of flushing machines with cold water only, then

filling the tubes with either alkali or chlorine solution, is condemned as very poor operating practice. It is inferred that satisfactory results may be looked for only where the cold water rinse is followed by a rinse with hot detergent solution.

That milker tubes may be maintained in good sanitary condition without the use of hot detergent solution has been reported by several workers. Lye solution acting during the long period between milkings is as effective a detergent as is a brief rinse with hot cleanser solution. Chlorine solutions lack this detergent action and fail to keep the tubes clean. Additional data are presented illustrating the effectiveness of lye solution even under extreme conditions.

93. The Effect of Cocoa upon the Digestibility of Milk Proteins. L. D. LIPMAN AND W. S. MUELLER, Massachusetts State College, Amherst.

Whole milk powder plus a commercial brand of Dutch-process cocoa and whole milk powder plus a commercial brand of American-process cocoa, with and without additional cocoa fat, were fed in comparison with whole milk powder in feeding trials with albino rats. The amount of cocoa added to the diets was approximately 16 per cent by weight, which is equivalent to approximately 3.6 per cent by weight on an ordinary chocolate milk basis. The digestibility of the milk and cocoa proteins was studied.

The rats were able to digest approximately 85, 69, 71, and 71 per cent of the food proteins, when rations containing 62.9 per cent milk powder, 52.6 per cent milk powder and 15.8 per cent Dutch-process cocoa, 52.6 per cent milk powder and 15.8 per cent American-process cocoa, 48.7 per cent milk powder and 14.6 per cent American-process cocoa and 7.1 per cent cocoa fat were fed, respectively. Subjecting these results to mathematical analysis revealed that the digestibility of milk proteins (85.3 per cent) was reduced 7.8 and 6.0 per cent when the ration contained 15.8 per cent Dutch, and 15.8 per cent American-process cocoa, respectively. The inclusion of 7.1 per cent of cocoa fat to the American-process cocoa-milk rations reduced the digestibility of the milk proteins by 5.8 per cent.

The proteins of the American-process cocoa were more completely digested (44.5 per cent) than those of Dutch-process (38.1 per cent), when the ration contained 16.5 per cent of cocoa and cocoa was the only source of protein in the diet. The digestibility of the proteins in the American-process cocoa was found to be only 41.1 per cent when 7.4 per cent by weight of cocoa fat was included in the ration.

On the basis that the addition of cocoa to whole milk powder (in quantity equivalent to 3.6 per cent by weight on a chocolate milk basis) does not greatly reduce the digestibility of the milk proteins, we may assume that the amount of cocoa in average commercial chocolate milk (approximately 1 per cent by weight) has no significant adverse effect upon the digestibility of the milk proteins.

94. Effect of Free Fat Acids of Milk Fat on Curd Tension of Milk. Relation to Milk Esterase, Temperature, Use of $CaCl_2$, Kind of Fat Acid, Milk Lipase and Churning. L. S. PALMER AND C. L. HANKINSON, University of Minnesota, St. Paul.

Raw skim milk and whey are shown to possess an enzyme or enzymes which catalyze the hydrolysis of diglycol laurate, diglycol oleate and other fat acid esters at 10° C. or lower. When lauric or oleic acids are thus liberated in skim milk or when they are added directly to it and aged in the cold the subsequent clotting of the milk by rennet at 35° C. is found to be greatly impaired or inhibited. Capric acid is shown to be the only other common fat acid of milk fat which has this effect. The adverse effects of capric and lauric acids on curd tension are shown to be reversed completely by proper heat treatment prior to the clotting test but the effect of oleic acid, which occurs to some extent without aging the milk in the cold, was found not to be completely overcome by like heat treatment. The adverse effect of lauric acid on curd tension is not evident if sufficient $CaCl_2$ is employed in the clotting test and preliminary studies are reported on the cause of this counteracting effect. In a study of some of the practical applications of the above findings to natural milk lipolysis it was found that whole milk which has undergone fat hydrolysis shows some reduction in curd tension but similar lipolytic effects were not found to be induced in raw cream by churning in the experiments undertaken, although the curd tension of the buttermilk showed a normal reduction in comparison with skim milk from the same cream.

95. Tables and Nomograph for Sharp and Hart's Equation for the Calculation of Total Solids in Milk. LINCOLN M. LAMPERT, Dairy Service Laboratory, State Department of Agriculture, Sacramento, California.

With some pertinent references to the literature, two tables and a nomograph are presented to facilitate the use of Sharp and Hart's equation (J. DAIRY SC. **19**: 683, 695. 1936). The tables give factors for each 0.1 per cent fat up to 6 per cent and for each 0.5 degree of lactometer reading between 22 and 37. The per cent total solids in a sample is found by adding the factor corresponding to the fat content to that for the lactometer reading. The nomograph, shown in detail, permits a direct estimation of the total solids for any fat content up to 6 per cent and for any lactometer reading between 25 and 34 degrees.

BOOK REVIEWS

96. The Virus, Life's Enemy. KENNETH M. SMITH. The Macmillan Co., New York. 1940. 176 pages, illustrated. $2.00.

This book presents the subject of the nature and behavior of the virus in

two parts. Included in Part I are chapters dealing with the discovery of viruses, methods employed in studying the virus, present concepts concerning the identity of the virus. Part II includes discussions of the means by which viruses get about, the relationship between viruses and the insects which spread them, the relationship between the virus and the living cell and brief treatments of the important virus diseases and their prevention and control. There is also a brief discussion on the nature and identity of bacteriophage.

The author has outlined in a simple, yet concise, manner the most significant accomplishments in the field of virus study. The present status of virus research is clearly outlined together with many of the important specific problems still confronting investigators in this field. The effectiveness of many of the discussions is enhanced by brief descriptions of the techniques employed in virus experiments.

The contents are presented in such a manner that they should be easily read and understood by the layman. Teachers and research workers in bacteriology and related fields also should find this brief treatment of the subject interesting and highly informative. P.R.E.

97. Elementary Bacteriology. J. F. GREAVES AND E. O. GREAVES. W. B. Saunders Co., Philadelphia, Pa. 1940. Fourth Ed. 587 pages, 164 illustrations. $3.50.

The present edition of this book is divided into 48 chapters. In this edition numerous changes have been introduced and many chapters completely revised. The chapter on viruses has been rewritten and a section on the classification of common molds has been added. A schematic diagram of the seven orders of bacteria with their subdivisions is included, although a detailed description is given of only four of the orders.

As would be indicated by the title of the book, it is an elementary text and no attempt has been made to present the subject matter in great detail. The text is well arranged and satisfactorily illustrated. Each chapter is followed by a list of review questions. Some of these require outside reading as suggested by the instructors.

Perhaps the chief criticism of the book is the fact that the writers have attempted to cover too much material, with a result that some important points are not discussed in sufficient detail. This might be improved by limiting some of the introductory material in the first five chapters and adding more on the chemical activities of bacteria. However, the subject matter is well presented and should find a place in any laboratory offering the subject to beginning students. L.D.Bushnell

98. Man's Greatest Victory over Tuberculosis. J. ARTHUR MYERS, Univ. of Minn. July, 1940. 419 pages, 30 figures. Charles C. Thomas, Springfield, Ill. Price $5.00.

The "foreword" written by Dr. John R. Mohler, chief of the U. S.

Bureau of Animal Industry, presents the story the book is to tell, that of the progress made in the eradication of tuberculosis from the cattle of this country in the period 1920–1940. "Thus, these achievements truly constitute man's greatest victory over tuberculosis."

The first 82 pages present subjects having no direct relation to the title of the book, such as the veterinarian, his recognition, his sacrifices and his accomplishments; the U. S. Bureau of Animal Industry, its quarantine and its meat inspection services. The following 301 pages present a statement that will be of interest to the future student of tuberculosis. He will not obtain a very clear picture of the progress made in the period 1894–1917, during which time the ground was being prepared for the intensive effort of the later period, in which the Federal agencies played a more important rôle than in the earlier period. In the chapter on Education and Legislation some of the most important legislation is not mentioned, such as the Wisconsin law of 1911 which prohibited the sale of untested dairy and breeding cattle. The cost of the project to government units is estimated to be $260,000,000. Nothing is said concerning the work of the future other than that the testing of cattle must continue as long as reactors to tuberculin are found. If this point of view is accepted the time may never come when the continued testing of all cattle can be stopped and the expenditure of $5,000,000 or more annually cease, since in certain states there has been almost no change in the percentage of cattle reacting to tuberculin in the last decade in spite of the testing and slaughter plan. It would seem as though some thought and some research should be given to modification of the program to be followed in the future in some areas.

The final chapter is the most interesting one; namely, "Lessons for Physicians in Human Medicine." In the preface the author states that he has in recent years presented the subject of tuberculosis literally before hundreds of medical audiences in this and other nations. In this statement the author presents himself in his most frequent and important rôle—that of a "crusader." Many statements made in the final chapter could be made only by one who believes the ultimate truth has to him been revealed and at the same time deftly concealed from those who have sought for it by patient research. The author intimates that the results obtained by Lumsden, p. 392, in a study of the incidence of tuberculin-positive individuals in two southern areas were due to the use of faulty tuberculin. One of the great unknown areas of the entire field of tuberculosis is that of tuberculin, and its use in human medicine. When 25 per cent of a large group of people react to one product and 80 per cent of the same group to another, and when the two on the basis of our present knowledge should be judged identical in nature, additional study is at least indicated. One of the needs of the moment in the human field is the development of a tuberculin which shall detect all significant cases of tuberculosis and the minimum number of non-significant cases of sensitization to tuberculin.

It seems very doubtful whether the results obtained in the bovine field have the significance in the human field that the author presents. E.G.H.

BACTERIOLOGY

99. The Coliform Index. DAVID LEVOWITZ. J. Milk Tech., *2:* 300–303. 1939.

The use of the "coliform index" is discussed. Plants which are working under a coliform control system will frequently show perfect results; but not always. Their laboratory has found that no plant has been able to maintain a coliform index of 0/10 (equivalent to no coliform organisms in 5 tubes inoculated with 10 ml. portions) in all batches for all products indefinitely. They consider a plant doing a good job if its index never gets below 3/1 (equivalent to 3 tubes out of 5 inoculated with 1 ml. portions showing the presence of coliform organisms).

Recommendations for milk plant and ice cream plant sanitation for coliform control are given. L.H.B.

100. Symposium on Tryptone—Glucose—Extract—Milk Agar. HOWARD E. LIND. J. Milk Tech., *3:* 208–210. 1940.

Various state and city milk control laboratories were contacted in all parts of the country and were asked to comment favorably or unfavorably on the use of T.G.E.M. agar in their daily routine. "The response was surprisingly great."

The replies were summarized as follows:

1. Size of colonies are increased.
2. Easier detection of thermophilic and thermoduric organisms.
3. Those who commented on dilution and split sampling, concluded that there was a close agreement in both instances.
4. Reports varied with regard to actual counts on pasteurized and raw samples. A few reported a greater count on the new medium in the low count range, but more reported the greatest difference in the high count range. Still others reported very little change from old to new medium in any range.
5. pH of medium was reported as a factor by one laboratory, while another reported that the pH range given in standard methods 6.2 to 7.0 had no effect.
6. The most consistent unfavorable comment concerning the use of the new medium was the formation of precipitates and flocculates. Holding the melted agar at 50° C. will eliminate this trouble.
7. The use of good quality fresh skimmilk was advocated in most instances. However, the use of Difco dehydrated skimmilk was also reported to be satisfactory.

8. All agreed that the use of the new medium would not upset any operation under the Sanitary Code.

In a discussion by Dorothy Dixon, Health Dept., Kansas City, Missouri, a review of some of the findings by other investigators is given together with the results obtained at the Kansas City laboratory.

The increased count on the new medium is often an indication of "cutting corners" in the production, processing or handling of the milk. When control methods are good, there is no difference in the results of the two media. L.H.B.

101. A General Consideration of Thermoduric and Thermophilic Organisms as a Source of Contamination of the Milk Supply. D. M. RUDIG. J. Milk Tech., *3:* 165. 1940.

A thermophilic organism was recently isolated in the Chicago Laboratories which was able to survive a temperature of 170° F. for 20 minutes. It was killed when exposed to this temperature for 30 minutes, however.

It is recommended that all equipment after thorough cleaning be treated with hot water at temperatures above 180° F. or by steam. L.H.B.

102. An Agar Slice Method for the Detection of Mold and Yeast on Utensils. J. D. WILDMAN. J. Milk Tech., *3:* 162–163. 1940.

Although this method has not been critically compared with other methods for determining the presence of yeasts and molds, it is believed to have some advantages with regard to simplicity and speed.

Detailed instructions for making the test are given. "In general it was found that yeasts and molds were fairly common on dairy utensils." The molds most generally were air-borne molds; *O. lactis* being less frequently found. When utensils were carefully washed, yeasts and oidia were almost entirely eliminated. L.H.B.

103. Findings in Comparative Studies of Old and New Culture Media. C. A. ABELE. J. Milk Tech., *3:* 24–32. 1940.

The principal arguments for change in medium composition are: 1. Counting of plates is made easier and more accurate because the colonies are larger; 2. The presence of tryptone is said to favor growth of mastitis streptococci.

This study shows that there is an increase in the bacterial count of milk, cream and ice cream and mix, in most instances, when using the new media. However, the increase in most cases is less than 100 per cent, and the greatest percentage increases in count occurred in milks of low count on old standard media. There were also a goodly number of decreased counts on the new media compared to the old.

The increased count on the new media would have meant a change in grade for some of the products tested; however, the results obtained indicated the following conclusion of the author. "That the average plate count limits now fixed in milk (and frozen desserts) ordinances and regulations need not be revised to avoid chaos in the grades of milk and milk products supplies resulting from the higher counts obtained by the use of the new standard (T.G.E.M.) agar." L.H.B.

BREEDING

104. Preservation of Bovine Spermatozoa in Yolk-Phosphate Diluent and Field Results from Its Use. E. L. WILLET, H. K. FULLER, AND G. W. SALISBURY. Cornell Vet., *30:* 4, 507. Oct., 1940.

Samples of bull semen, undiluted and diluted with Phillips yolk-phosphate buffer were compared under carefully controlled conditions, which included the gradual cooling of the samples to storage temperature, 5° C. (41° F.), at the rate of 5° C. change in 5 minutes, and warmed to 37° C. (98.6° F.) at the same rate of change for purposes of examining for motility after two, four, six and eight days' storage. The yolk-phosphate buffer diluent maintained the viability of spermatozoa at a higher level than the undiluted samples of the same ejaculates. When care was exercised in obtaining, handling, and storing the semen it was found that four-day-old semen was as satisfactory as semen used the day it was collected. Data is obtained from 1,500 inseminations of the Seneca Cooperative Cattle Breeders Association, Inc. F.E.

105. The Buffering Capacity of Bull Semen. SEDGWICK E. SMITH AND S. A. ASDELL. Cornell Vet., *30:* 4, 499–506. Oct., 1940.

These authors found bull semen to be a well-buffered solution and capable of maintaining a favorable pH in spite of the addition of considerable amounts of organic acids.

A high buffering capacity region near pH 5 may explain why stored semen becomes more acidic until a pH of 5 is reached, following which the pH remains stationary. F.E.

106. Improved Herd Efficiency through Artificial Breeding of Dairy Cattle. J. W. BARTLETT. The Association Bull., Intern. Assn. Milk Dealers, 33rd yr., No. 6, 177–179. Dec., 1940.

The essentials necessary to the successful operation of a cooperative artificial breeding association are listed. The beneficial effects of exercise, ascorbic acid, a new type of diluent, green feed, etc., are pointed out. At a cost of 5 or 6 dollars per calf from sires with fat producing indexes of 500 to 700 pounds the annual expense to the dairymen for a 20-cow herd

is 100 dollars. Artificial breeding enables the dairymen to both increase the efficiency of the herd and reduce his costs. E.F.G.

107. Improving Dairy Herds to Lower the Cost of Milk Production. O. E. REED. The Association Bull., Intern. Assn. Milk Dealers, 33rd yr., No. 6, 159–164. Dec., 1940.

In 1939 the average herd improvement cow produced 8,000 lbs. of milk at a feed cost of 79 cents per 100 lbs. compared with the average cow of the U. S. which produced 4,500 lbs. of milk at a feed cost of $1.06 per 100 lbs. Raising three dairy heifers to producing age to get one good one is one of the farmer's biggest expenses. The author is confident that the wide application of the proved sire system of breeding will accomplish more permanent good in the way of reducing cost of milk production and developing efficient herds than any other program now in sight for the industry. During 21 years of this system with Jerseys at Beltsville the average production was raised from 11,626 pounds of milk and 622 lbs. of fat to 13,255 lbs. of milk and 717 lbs. of fat. Eight proved sires were used over the 21 years and no culling of females was practiced. In the Holstein herd during the same period milk per year was increased 339 lbs. and fat 95 lbs. The real objective of the proven sire program is to "purify" the germ plasm so that the cost of raising low-producing heifers will be avoided. About 80 per cent of the Beltsville-bred bulls loaned to farm herds for proving have increased production while considerably less than 50 per cent of herd improvement association bulls so used have effected improvement.

In the newest phase of the herd improvement work to date the bureau has tabulated the proven sire records for 7,356 association sires with 5 or more daughters. Sons of approved sires are fast becoming available.

E.F.G.

BUTTER

108. The Neutralization of Cream for Buttermaking. II. The Speed of Acid Reduction and the Influence of Pasteurization Temperature. R. C. TOWNLEY AND I. A. GOULD. Can. Dairy and Ice Cr. J., *19:* 6, 50. 1940.

The time necessary for a neutralizer to react with the acid in cream is influenced by the amount and kind of neutralizer used. Magnesium lime was found to be slower in action than sodium hydroxide, sodium carbonate or calcium hydrated lime. The reaction between any one of the neutralizers and cream is almost as complete after 5 minutes as it is after 20 minutes. Different pasteurization methods seemed to have no appreciable influence on acid reduction in cream treated with either sodium hydroxide or calcium lime. The acid reduction due to pasteurization generally became progres-

sively greater as the amount of either a carbonate or magnesium lime neutralizer added to cream was increased. O.F.G.

109. Water Supplies in Relation to Surface Taint Butter. J. B. LINNEBOE. Scientific Agr., *21:* 133–138. 1940.

Surface taint is a defect of bacterial origin which occasionally makes its appearance in butter and especially during summer. In studying 52 creamery water supplies where trouble was being experienced, organisms of the *Achromobacter putrefaciens* type were shown to be present in 9 waters collected at the well-head. An additional 5 creameries of the above group had the organism present in the water coming from the holding tank. Six out of 55 farm waters also contained this organism. Thus improperly pasteurized cream may be a source of the organism. Mould and yeast counts furnished a good index of the efficiency of pasteurization, however.

A simplified procedure of identifying organisms of this type is presented. The ordinary public health analysis does not necessarily indicate the suitability of a water for creamery purposes. O.R.I.

110. A Bacterial Discoloration of Print Butter. A. H. WHITE. Scientific Agr., *20:* 638–645. 1940.

A defect evident as black to reddish brown discolorations in irregular patches has been found in several cases where print butter is held at 40°–55° F. for 4 to 9 days. Low concentrations of salt appear to be essential for proper growth of the organism and salt added to the culture media aids in demonstrating its pigment producing characteristics. In butter the growth occurs almost entirely at the surface.

A full description is given of the organism's reactions and the name *Pseudomonas nigrifaciens* suggested for it. O.R.I.

111. Butter Profits and Butterfat Losses. M. MORTENSEN. Nat. Butter and Cheese J., *31:* 12, 66. Dec., 1940.

Losses in manufacturing operations can be decreased by careful use of all types of records, accurate testing, and thoughtful consideration of sources of butterfat losses. A problem is worked out showing how it is possible to figure the overrun from losses sustained during the process of manufacturing. W.V.P.

112. Trends and Results in Butter Technology. M. E. PARKER. J. Milk Tech., *3:* 264–268. 1940.

The skill of the buttermaker is still a vital factor, but the application of science is essential. The "why" is most important if we hope to learn "how."

Empirical practices cannot be ignored, but to assure the best results, applied science is also essential.

The cause of fishy flavor has been discovered, as well as the causative factor of so-called cheesy defects.

Some of the changes which have occurred in the butter industry to improve the flavor and keeping quality of butter are lower acidities of cream, higher pasteurizing temperatures of cream, lower salt content of butter. The necessity of pure wash waters and clean equipment is recognized.

L.H.B.

113. A Comparison of Butter Made from Cream Pasteurized by Three Different Methods. C. A. WILSON, S. L. TUCKEY, AND H. A. RUEHE. Nat. Butter and Cheese J., *31:* 12, 12. Dec., 1940.

A study was made of the keeping qualities of butter produced from cream pasteurized in the Reid flash pasteurizer, the Cooney direct steam-injection unit and in a glass-lined vat. Observations were made on the bacterial flora of the cream and butter, the total proteolytic and bacterial counts, the pH values and the copper of the butter. Cream with 0.27 to 0.43 per cent acid was neutralized at 70° F. to 0.16 to 0.20 per cent. It was then divided into three portions; the first was pasteurized in the Reid machine at 175° F. for 30 to 40 seconds; the second was heated with the Cooney unit to 190° F. for 20 to 30 seconds after a preliminary heating with the unit of the whole lot in about 20 minutes to 155° F.; the third portion was heated to 160° F. for 30 minutes. All lots of cream were cooled to 40° F., held overnight and then churned in a single roll churn. Averages of observations are shown in the following table:

Average of observations	Cream pasteurized in		
	Reid machine	Cooney unit	Glass-lined vat
Germ-killing efficiency	99.989%	99.997%	99.995%
Fat losses in buttermilk	0.891%	0.903%*	0.702%
Score of fresh butter	90.06	90.06	90.04
Decrease in score after:			
12 weeks at 40° F.	1.135	1.020	1.192
1 week at 65° F.	0.354	0.479	0.438
2 weeks at 65° F.	0.833	0.875	1.125
3 weeks at 65° F.	1.25	1.192	1.231
Total bacteria† in butter after 12 weeks at 40° F.	73,600	188,000	97,000
Proteolytic organisms after 12 weeks at 40° F.	260	245	262
Changes in pH:			
After 3 weeks at 65° F.	−0.176	−0.155	−.141
After 12 weeks at 40° F.	−0.138	−0.093	−.121

* Allowing for dilution of cream.
† Geometric average.

Tallowy flavor was found most frequently in butter made from the cream pasteurized in the vat at 160° F. for 30 minutes. In general, no cor-

relation was observed between the quality of the butter and the character of the bacterial flora, the decrease in pH during storage and the copper content of the butter. W.V.P.

CHEESE

114. Determining the Salt Content of Cheese. O. R. OVERMAN AND B. F. WHITMORE. Can. Dairy and Ice Cream J., *19:* 7, 60. 1940.

Three methods of digesting the cheese previous to the determination of salt were investigated: 1. with sodium hydroxide; 2. with nitric acid; 3. with 35 per cent sulfuric acid. The sulfuric acid distillation method is simple and requires less time than present methods. In the procedure approximately 3 grams of cheese are weighed and placed in a 300-ml. distilling flask along with 40 ml. of 35 per cent sulfuric acid. The distilling flask is connected to a condenser with dips into a receiving flask which contains 10 ml. of 0.1711 N silver nitrate solution and 100 ml. of 4 per cent nitric acid. After distilling over the chloride as hydrochloric acid, the excess silver nitrate is titrated with 0.1711 N ammonium or potassium thiocyanate. O.F.G.

115. Merchandising Cheese. L. C. ROY. Can. Dairy and Ice Cream J., *19:* 8, 19. 1940.

After discussing advertising and what primary producers of other types of food have done in the way of organization and advertising, the author suggests the following lines of action: 1. Production of a uniform high-quality graded product; 2. Use of brands according to grades; 3. Adoption of a long-term advertising and merchandising policy. O.F.G.

116. Quality and Uniformity in Cottage Cheese. D. W. GLOVER. Can. Dairy and Ice Cream J., *19:* 6, 40. 1940.

Some of the factors which influence the quality and uniformity of cottage cheese are: 1. Quality of the raw milk; 2. Pasteurizing temperature; 3. Quality and amount of starter; 4. Amount of rennet enzyme used; 5. Acidity of the whey at the time the curd is cut; 6. Use of water to aid in cooking; 7. Rapidity of heating the curd; 8. Time and temperature used in cooking; 9. Temperature of wash water and number of washings; 10. Proper chilling of curd before creaming.

Clean, sweet, skim milk is essential for a good cheese. The acidity of the whey at the time of cutting the curd is perhaps the most important factor. Creaming the curd before it has been chilled is an undesirable practice. Homogenized milk may be used if calcium salts are added to restore the coagulating properties. O.F.G.

CHEMISTRY

117. The Stability of Vegetable Oils. III. Investigation of the Effect of Radiations on the Methylene Blue-Oil System. W. G. BICKFORD, SCOTT ANDERSON, AND K. S. MARKLEY. Oil and Soap, *17:* 252. 1940.

Irradiation experiments with methylene blue–soybean oil systems showed that light in the region λ 3400 to 4400 catalyzes the reaction of carotenoids or unsaturated substances with dissolved oxygen of the oil but does not effect the reduction of methylene blue. Irradiation with light of λ 6300 or longer catalyzes the reaction of the reduction of methylene blue but only in the absence of oxygen. Light of this wave length apparently is not able to catalyze the reaction between oxygen and the carotenoids or other unsaturated constituents of the oil. It was shown that light, oxygen and unsaturation are co-reactants and must be present simultaneously during the determination of the stability of an oil by the methylene blue method.

V.C.S.

DISEASE

118. The Expulsion of Haemolytic Streptococci by Nasopharyngeal Carriers. RONALD HARE. Can. Pub. Health J., *31:* 539–555. 1940.

As a result of some of the work of early investigators it has been assumed that H. S. of scarlet fever, tonsillitis, and other upper respiratory-tract infections are spread when carriers speak, cough or sneeze. This mode of disease transmission may be due to moisture droplets or evaporated "droplet-nuclei" floating for some distance in the air.

To test this assumption, patients suffering from the above types of infection were placed with their mouths at the center of a circle 12 inches in radius and asked to cough or speak facing a group of blood agar plates arranged along one quarter of the circumference of the circle. Trials were run with the head facing both horizontally and vertically. In a second series of tests an air centrifuge was employed to test samples of air for the presence of infected "droplet-nuclei."

The number of colonies of H. S. developing from the sources of infection was very small. In many of the trials the plates failed to develop any haemolytic colonies at all even though all the patients studied were shown to have H. S. present in nasal, throat or saliva swabs. "Droplet-nuclei" were shown to be particularly inefficient as avenues for spreading this type of infection. The expulsion of these organisms is almost entirely inside heavy droplets which fall rapidly under the influence of gravity.

O.R.I.

119. Streptococci Other than Streptococcus agalactiae Found in the Cow's Udder. R. B. LITTLE. Cornell Vet., *30:* 4, 482–494. Oct., 1940.

Four herds were studied and results are reported on the cultural characteristics and clinical manifestations in the udder of streptococci other than *Str. agalactiae* cultured from milk from three of the herds. It was shown that these other kinds of streptococci possess cultural characteristics quite different from those distinctive for *Str. agalactiae.* Possibly one kind of mastitis caused by *Str. dysgalactiae* is not commonly encountered except in an occasional herd, for in two herds no infections occurred during a period of four and nine years, respectively.

Str. uberis and the atypical streptococci which ferment mannite and split aesculin may cause either transient, mild or severe infections. Of the atypical strains, certain ones were definitely regarded as *Str. fecalis.*

It was suggested that further study may reveal that the natural habitat of streptococci which attack mannite and aesculin may be the cow or the environmental conditions under which she is maintained. H.B.M.

120. Hippelates Flies as Vectors of Bovine Mastitis (Preliminary Report). D. A. SANDERS. J. Am. Vet. Med. Assn., *97:* 763, 306–308. Oct., 1940.

In studying the transmission of mastitis from diseased to healthy udders, the role of *Hippelatus* spp. (fruit fly or eye gnat) was investigated. These flies were observed in the vicinity of mucous membranes of natural body openings of cattle confined in corrals and pastures. They were also seen in abundance in the vicinity of udders. Stained smears from these flies that hovered around infected udders showed the presence of organisms resembling those causing bovine mastitis. When the teat orifices of several healthy cows were exposed to Hippelates which had fed on infected secretion, mastitis developed in several of the quarters.

The author states that Hippelates and some other insects are vectors of mastitis, but recognizes that this disease is undoubtedly transmitted in other ways. H.B.M.

121. Improvement of the Hotis Test for the Detection of Mastitis Streptococci. J. FRANK CONE AND FRED M. GRANT. J. Milk Tech., *3:* 75–79. 1940.

Further tests with Hotis' method for detecting mastitis showed that the dye used in the test did not inhibit the growth of mastitis streptococci.

A new procedure to eliminate the doubt in interpreting the suspicious reactions is given. Using this procedure on 1434 samples from the individual quarters of 37 cows, it detected with accuracy 98.6 per cent of

the samples from infected quarters and 99.5 per cent of the samples from streptococcus-free quarters.

The procedure recommended is as follows:

1. Set up Hotis test in the usual manner.
2. Record the approximate pH of the milk dye mixture (normal, slightly alkaline, alkaline).
3. Incubate the tubes at 37° C. for 24 hrs.
4. Classify the reactions according to some convenient system of classification.
5. Prepare Breed smears from all the tubes showing doubtful reactions, stain and examine under microscope for presence of long chain streptococci.

The classification given was based on one described by Murphy and is as follows:

Negative (Murphy's Class A). Uniform blue color.

Class P. Peptonization of the milk.

Class M (Includes Murphy's Classes 8, 9, and 10). Slight sediment, white, pale yellow, or brownish in color.

Class 1. Small white or pale yellow colonies with chocolate-colored colonies with white or pale yellow centers.

Class 2. Thick yellow deposit on bottom of tube.

Class 4. Small white colonies in blue column.

Class 5. Uniform yellow column.

Class 6. Uniform yellow or green column, with gas formation.

Class 7. Yellow colonies in blue or yellow column.

With this classification, Class 7 samples are definitely positive, Class 2 and Class 5 reactions were found to be 98 per cent positive. All negative, Class P and Class 4 reactions may be considered definitely negative and no smears need be prepared.

Smears should be made from all tubes in the class M, Class 1, and Class 6 groups. L.H.B.

122. The Effect of the Bang's Disease Control Program on Milk Production in Florida Dairies. J. V. KNAPP. J. Milk Tech., *3:* 33–35. 1940.

A marked increase in the number of reactors has been noted since the inauguration of the program in 1934. During that fiscal year 38,109 cattle were tested and 8,732 reactors found or 22.9 per cent. This number has been greatly reduced as shown that for the three-month period of July to September 1939, 119,718 cattle were tested and only 1,188 reactors found or slightly less than 1.0 per cent.

Reducing the number of reactors has resulted in an increase in milk production according to the records; lesser number of cattle have invariably produced a greater amount of milk.

In the Jacksonville area to the time of the first test, there were 8,304 cattle; 2,319 reactors were found. At the time of the last test there were 7,403 cattle in the same area and only 38 reactors were found. Milk production records showed that these 7,403 cows produced 1,430 gallons more milk per day than did the 8,304 head previously.

Similar records are given for the Miami area. L.H.B.

123. Milkers' Nodules. FREDERIC T. BECKER. J. Am. Med. Assn., *115:* 2140. 1940.

The literature, etiology, and differential diagnosis are reviewed. All cases of milkers' nodules have occurred in people employed as milkers of cows on whose udders crusted or ulcerated lesions were found to be present. All cases have developed in the latter part of the summer. One attack apparently leaves immunity. Most veterinarians have diagnosed the lesions which have been present on the cows as being similar to those of cowpox.

Four cases of milkers' nodules were observed. One case is illustrated by photograph and photomicrographs. No relation between milkers' nodules and vaccinia could be demonstrated in these cases since the Paul test which was performed with material from two cases was negative and two of the infected persons showed no immunity to smallpox vaccination. The clinical course of milkers' nodules and the distinct variations in the pathologic picture are further evidence that this disease shows no relation to variola vaccine. The cause of milkers' nodules is apparently a virus which may be either an attenuated or biologic modification of vaccine virus. D.P.G.

HERD MANAGEMENT

124. Lowering Milk Production Costs through Efficient Farm Management. ELBERT S. BRIGHAM. The Association Bull., Intern. Assn. Milk Dealers, 33rd yr., No. 6, 171–176. Dec., 1940.

The feeding and management methods employed in building up a profitable high producing Jersey herd over a 36-year period are described. In 1939 the average production for nearly 100 producing cows was 10,284 lbs. of milk with an average of 1,890 lbs. of grain per cow. E.F.G.

125. Dealer-Producer Cooperation for Efficient Milk Production. H. B. ELLENBERGER. The Association Bull., Intern. Assn. Milk Dealers, 33rd yr., No. 6, 165–170. Dec., 1940.

Some ways by which dealers may encourage more efficient production are mentioned. These include the following: Dairy Herd Improvement Associations, Prizes and Medals, Better Bulls, Artificial Breeding Units, Boys Production Clubs, Research or Educational Fellowships, Night Feeding Schools and various Demonstrations. E.F.G.

ICE CREAM

126. A Discussion of Ice Cream Stabilizers. W. C. COLE. Can. Dairy and Ice Cream J., *19:* 7, 48. 1940.

Stabilizers, if properly used, usually improve the quality of the final product. Anything used as a stabilizer which may justify the old consumer criticism—"full of cornstarch"—should not be employed. The list of stabilizers frequently used includes gelatin, sodium alginate, various gums, pectin and agar. An extended discussion of the properties and proper use of gelatin and sodium alginate, the two most commonly used stabilizers, is given. O.F.G.

127. Washing the Ice Cream Equipment. W. B. COMBS. Can. Dairy and Ice Cream J., *19:* 6, 70. 1940.

Cleaning operations in the ice cream plant require the personal attention of the plant manager. Specific directions are given for washing and steaming the vats, cleaning the freezer and washing the pipes and fittings. The following "don'ts" are given: 1. Don't use excessive amounts of washing powder. 2. Don't use a cloth in cleaning equipment. 3. Don't waste water. 4. Don't place washing powder directly on metal. 5. Don't fail to rinse all parts thoroughly after washing. 6. Don't allow equipment to remain wet. O.F.G.

128. Sterilizing the Ice Cream Equipment. H. MACY. Can. Dairy and Ice Cream J., *19:* 6, 70. 1940.

The equipment should be sterilized after it has been thoroughly cleaned. Directions for sterilizing vats, pipes and fittings, homogenizer, coolers, and freezers are given. Vats should be steamed until the indicating thermometer shows at least 200° F. All metal surfaces should be made hot enough by steam so that they will dry immediately. Chlorine solutions containing from 50 to 100 parts per million of available chlorine are recommended for from 3 to 5 minutes exposure. Chlorine sterilization should be followed immediately by a fresh water rinse. All equipment should be kept dry following sterilization until used again. O.F.G.

129. Selecting Serum Solids for the Ice Cream Mix. H. E. OTTING. Can. Dairy and Ice Cream J., *19:* 6, 26. 1940.

With the elimination of bare copper in milk equipment and improved methods of manufacture the satisfactory storage for future manufacturing of serum solids in the form of condensed milks or various powders has become possible. The kind of milk solids used depends on: 1. Freedom from heated or cooked flavors; 2. Stability or keeping quality of the prod-

uct; 3. Laws of boards of health governing territory of distribution; 4. Water absorbing ability; 5. Composition of the mix; 6. Cost; 7. Availability. Plain skim condensed milk has limited keeping qualities and must be kept under cold storage conditions to avoid high acidity and bacterial growth. Plain condensed whole must be handled similarly to skim condensed and especial care must be taken to avoid copper contamination. The objectionable heavy body of superheated condensed milk can be eliminated by homogenizing without the loss of its influence on improved body, texture, water absorption and whipping properties which it imparts to the mix. Sweetened condensed skim milk has good keeping qualities and lends itself for shipping and storage conditions to better advantage than other semi-fluid serum solids milk. Evaporated milk is seldom used because of its high cooked flavor. Spray skim milk powder is widely used. Due to its high solubility, good keeping qualities and the fact that it does not require refrigeration for storage, it serves as an excellent base of serum solids in compounding an ice cream mix. Atmospheric roller dried skim milk is not as popular as the spray process milk. O.F.G.

130. Chocolate Ice Cream Manufacture. S. L. TUCKEY. Ice Cream Rev., *24:* 2, 21. 1940.

The production of cocoa and chocolate liquor is given as well as a brief outline of the problems encountered in the manufacture of chocolate ice cream. The author is of the opinion that the flavor imparted to ice cream by cocoa is not the same as the flavor imparted to it by chocolate liquor. This is thought to be due to the difference in the processing of cocoas and chocolate liquors.* J.H.E.

* *Abstract Editor's Note:* Contrary to findings of several investigators who used the same source of beans for cocoa and chocolate liquor.

131. Pointing for Profit. VICTOR H. STEMPF. Proc. 40th Ann. Conv. Int. Assn. Ice Cream Mfrs., *1:* 51. 1940.

The importance of cost accounting in profitable business management is the principal point stressed. The ice cream industry should offer a splendid opportunity for efficient budgetary control because of the considerable amount of statistical data relative to the industry which has been made available by the Statistical and Accounting Bureau of the I.A.I.C.M.

The job of pointing for and actually realizing profits which represent a reasonable return on the capital invested in a business is a task demanding the best possible information and interpretation of both internal and external happenings. Through budgetary control, standard costs, improved reports, specialized analyses and the extension of internal audit control methods, the industrial accountant will be found to be important in the guidance of corporate affairs. However, the cost of securing cost analyses

must be kept low, otherwise the purpose of securing this information will have been overlooked. M.J.M.

132. President's Address. W. J. BARRITT. Proc. 40th Ann. Conv. Int. Assn. Ice Cream Mfrs., *1:* 19. Oct., 1940.

The speaker states in this address that the International Association of Ice Cream Manufacturers has become indispensable to the industry. The association actively follows government regulations as they affect ice cream manufacturers and works with government agencies in a consideration of problems affecting the industry. The work of the Accounting Bureau is especially helpful to manufacturers faced with increased costs and responsibilities without commensurate opportunity for increased selling prices.

The program of national defense, and how it may affect the industry during the next few years, was an important part of this address. M.J.M.

133. Ice Cream Consumption and Consumer Purchasing Power. E. E. VIAL. Ice Cream Rev., *24:* 2, 18. 1940.

Statistics and charts are given on ice cream production and purchasing power from 1919 to 1938 inclusive. From the records the author concludes that consumption of ice cream fluctuates with the purchasing power of consumers but fluctuates much more violently. From 1921 to 1929 per capita purchasing power rose 28 per cent while per capita production of ice cream rose 45 per cent. From 1929 to 1933 consumer purchasing power declined 25 per cent while ice cream production declined 45 per cent. During 1933 to 1937, consumer purchasing power rose 32 per cent while ice cream production rose 80 per cent.

Temperature is also an important factor affecting ice cream consumption. From 1919 to 1938, inclusive, the per capita production of commercial ice cream in July averaged .279 gallons and in January .065 gallons, or only 23 per cent as much as in July. J.H.E.

134. Safety Devices as Protection for Your Refrigeration Plant. C. T. BAKER. Ice Cream Rev., *24:* 3, 39. 1940.

To protect motor-driven refrigerating plants against excessive condensing pressures resulting from failure of the condensing water supply, a high pressure cutout should be provided. This opens the motor circuit supplying the compressor motor. All liquid receivers, shell and tube condensers and shell and tube brine coolers should be protected against over-pressure with safety valves. The electric motor should be protected against overheating resulting from an overload or single phase operation and all electrical equipment should be properly grounded so as to protect workmen against injury. J.H.E.

135. Spray Powdered Egg Yolk for Ice Cream. V. CONQUEST AND C. D. WILBUR. Ice Cream Rev., *24:* 3, 60. 1940.

The advantages of spray powdered egg yolk in ice cream are cited. These are color, flavor, texture, stability, nutritional qualities, reduced whipping time, and reduced dipping losses. It is said the natural egg yolk lecithin is a "flavor stabilizer" since it has anti-oxidative qualities that prevent development of off-flavors due to rancidity. J.H.E.

136. Increasing Ice Cream Consumption through Consumer Education. GERTRUDE DRINKER. Proc. 40th Ann. Conv. Int. Assn. Ice Cream Mfrs., *1:* 70. Oct., 1940.

In this discussion, the work of a local dairy council is presented. There are 40 council offices in all, through which about 30 million people are reached. The work is carried out principally with three groups: professional groups including doctors, dentists, and nurses; educational groups, including schools and home economists; and consumer groups, such as womens' clubs, service clubs, and so on. Visual education methods are employed in much of this work, especially with school children.

The belief is expressed that the most effective and economical way to increase ice cream sales is through the Dairy Council. This has been shown to be true with sales of milk. Ice cream sales should be increased by teaching the consumers that ice cream is made carefully, that high quality products are used in it and that there are many different ways of serving good ice cream. M.J.M.

137. Promotion with Purpose. MILTON HULT. Proc. 40th Ann. Conv. Int. Assn. Ice Cream Mfrs., *1:* 69. Oct., 1940.

The ice cream industry was urged to cooperate more extensively with the National Dairy Council than it has in the past. The Council does not merely advertise dairy products, but carefully analyzes the purposes of each and every promotional activity undertaken.

After a brief explanation of the activities of the National Dairy Council, the speaker gave a visual presentation of the work of the Council, entitled "Promotion with Purpose," with sound effects and sliding charts.

M.J.M.

138. How to Make a Chocolate Ice Cream Soda. C. E. HENDERSON. Ice Cream Rev., *24:* 2, 23. 1940.

The procedure for making a quality chocolate ice cream soda is outlined. Chocolate mint ice cream sodas are a pleasing variation from the usual flavor. J.H.E.

139. Application of Low Temperature Insulation. C. T. BAKER. Ice Cream Rev., *24:* 4, 34. 1940.

One of the most important things in connection with the application of cold room insulation is that of water-proofing the surface against which the insulation is to be placed. An approved method of preparing the walls and floors and applying insulating material is discussed. Cross-sectional drawings accompanying the article show details of construction. J.H.E.

140. More Mileage for Electrical Equipment in Ice Cream Plants. R. E. TOOMEY. Ice Cream Rev., *24:* 2, 17. 1940.

Electrical motors, electrical controls, conduits and wiring in ice cream and milk plants are subjected to severe moisture conditions from condensation and splashing of water. For the fractional and the small integral horsepower motors it is preferable to use totally enclosed non-ventilated motors. Above $1\frac{1}{2}$ horsepower the totally enclosed motor is undesirable. In this case splashproof motor construction with special moisture resisting insulation is more practical. The article contains many worthwhile suggestions for protection of electrical equipment against failure due to moisture.

J.H.E.

141. The Year's Work. ROBERT C. HIBBEN. Proc. 40th Ann. Conv. Int. Assn. Ice Cream Mfrs., *1:* 24. Oct., 1940.

The International Association of Ice Cream Manufacturers keeps in touch with different Federal departments and through friendly relations serves the industry. During the past year, the association has worked closely with the Food and Drug Administration, Wage and Hour Division, Interstate Commerce Commission, Temporary National Economic Committee, and the Surplus Marketing Agency.

In the interests of better consumer relations, the association has distributed thousands of leaflets about the food value of ice cream. These pieces of literature were prepared with the cooperation of the National Dairy Council. Assistance was given the National Dairy Council in carrying forward the work of June Dairy Month.

The Statistical and Accounting Bureau has developed a new Accounting System, with these new features:

1. Very much improved methods of distributing steam refrigeration, and hot water costs.

2. A complete cost problem worked out to illustrate the instructions contained in the text.

3. Many improved methods of accounting.

Other activities of the statistical and accounting bureau are yearly expense comparisons of dealers' costs, statistical surveys, and ice cream sales indexes.

The Ice Cream Merchandising Institute has these major activities: The Merchandising Short Courses, Merchandising Services, Inter-Industry Relations, and the publication of sales material. Attendance at the 1940 short courses in Merchandising increased 22 per cent over that of 1939.

M.J.M.

142. The Paley Type Test Bottles. B. I. MASUROVSKY. Ice Cream Trade J., *36:* 11, 44. Nov., 1940.

The Paley test bottle was designed with an opening in its side to overcome some of the difficulties encountered in weighing thick, viscous or lumpy material into the narrow neck of the Babcock test bottle.

The following procedure for testing ice cream using the Paley type Babcock test bottle is given:

1. Weigh on a cream scale or balance 9 gms. of a representative sample of ice cream directly into the test bottle by means of a narrow spatula, or by means of a stirring rod if the ice cream is in a very viscous or plastic state.
2. Introduce 10 cc. of glacial acetic acid washing down any ice cream inside the mouth of the bottle.
3. Insert stopper securely into the opening.
4. Place the bottle and content in a hot water bath (about boiling point) for 10 minutes then cool to room temperature.
5. Very carefully add sulphuric acid (sp. gr. 1.82–1.83) one to two cc. at a time through the reading tube, mixing thoroughly after each addition until the material assumes a dark cherry red color and no longer lumps or particles of casein are inside. (About 8–11 cc. of sulphuric acid depending upon the material to be tested.)
6. Let the bottle stand for five minutes, shaking well every minute or two.
7. Place bottle in a centrifuge such as is used in milk analysis by the Babcock method and centrifuge for five minutes.
8. Add hot water until liquid level is at base of neck and centrifuge again for two minutes.
9. Add hot water again until entire fat column is in the reading tube, and centrifuge again for one minute.
10. Place in water bath at 140° F. for 5 minutes, add glymol and read direct, or if desired, the stopper may be manipulated until the bottom of the fat column is exactly at the zero mark. Then add glymol and read to junction of the glymol and the butterfat.

W.H.M.

143. High Solids in Ice Cream. PAUL VASTERLING. Ice Cream Trade J., *36:* 12, 18. Dec., 1940.

The author of this article states that ice cream with 11 to 20 per cent solids can be made without danger of sandiness provided the lactic acid

content of the mixes is controlled to a figure comparable to an 8 or 10 per cent serum solids normal-acid-content. He also states that "at a recent short course and conference at the University of Missouri a poll of some 86 ice cream production men representing all sections of the country, was taken. The 'ideal' ice cream was voted to contain

12.00% butterfat
13.20% solids-not-fat
14.50% sugar
0.20% egg
0.25% stabilizer
40.15% total solids

pasteurized at 165° F. for 30 minutes, homogenized at 2500 pounds pressure first stage, 500 pounds pressure second stage, frozen in a continuous freezer, and served at a temperature of 10° F.; the additional solids obtained from skim condensed, butterfat being obtained from fresh sweet cream and whole milk, and with the lactic acid controlled to 0.13 per cent, weight of the ice cream, 4.25 pounds per gallon or approximately 118 per cent overrun." W.H.M.

144. Homogenization. P. H. TRACY AND A. J. HAHN. Ice Cream Trade J., *36:* 12, 16. Dec., 1940.

A rotary homogenizer operated at 500 pounds pressure was compared with a two-stage homogenizer and an old type viscolizer for processing ice cream mixes of varying per cents of fat. The following summary and conclusions were presented by the author: "While the rotary machine used operating at its maximum pressure did not produce as desirable results as did the high pressure machine operating in the pressure range of 2,000–3,000 pounds, it did equal 1,000–1,500 pounds on the high pressure machine. The efficiency of the two types of machines was compared on the basis of fat globule size in the mix, mix viscosity and whipping, body of the ice cream and melt down characteristics of the ice cream. No attempt was made to compare the mechanical efficiency of the rotary and high pressure machines." W.H.M.

145. Ice Cream Gallonage by States, Months and Plants. ANONYMOUS. Ice Cream Trade J., *36:* 12, 12. Dec., 1940.

A new all time high of 303,209,000 gallons of ice cream was produced by wholesale and retail ice cream manufacturers in the United States in 1939 according to a report recently released by the United States Department of Agriculture. Of this total 25,839,000 gallons were produced by 8,481 retail manufacturers. The report shows monthly production by the two types of manufacturers as well as production by states. The ten leading

states in ice cream production for 1939 were Pennsylvania, New York, Ohio, California, Illinois, Michigan, Massachusetts, Missouri, and Indiana. The total amount of sherbet including ice milk, made in 1939, was 13,764,000 gallons. W.H.M.

146. Sales vs. Mileage. W. H. WATTS. Ice Cream Trade J., *36:* 12, 32. Dec., 1940.

The Foremost Dairies of Philadelphia, Pennsylvania, have found it desirable to know the amount of business per "stop" and the amount of business in dollars per mile per route. Such an analysis has made drivers more efficient and made it possible to drive fewer miles per day without any sacrifice in services to customers. W.H.M.

147. Moisture Control in Cabinet Operations. WILLIAM R. COPELAND. Ice Cream Trade J., *36:* 12, 10. Dec., 1940.

Freezing up of expansion and capillary tubes of ice cream cabinets in which Freon (F–12) was used as a refrigerant caused the Pioneer Ice Cream Division of the Borden Company to develop a reclaiming board and charging board for reclaiming gas which contained excessive moisture.

After trying the addition of Anhydrous Methyl Alcohol to the cabinet to eliminate freezing of expansion valves, this practice was given up as unsatisfactory and in its place a dryer was used as an antifreeze with good results.

A complete description, together with a diagram and photographs of the reclaiming and charging equipment, is presented in this article. With this equipment it is possible to reclaim Freon gas with a water number equivalent to that of new gas. W.H.M.

148. The Use of Various Sweetening Agents. B. I. MASUROVSKY. Ice Cream Trade J., *36:* 12, 40. Dec., 1940.

Definition of the various sugars used in the human diet and the composition of corn sugars is presented. The author summarizes his article as follows:

"To summarize, sweetening agents constitute an important part of the total solids to the extent of about 50 per cent in the case of ice cream and 85 per cent in water ices and sherbets. The sugars provide the sweetness and palatability in the finished product, and also aid in maintaining the body and texture of the product during the process of manufacture as well as in storage and later in the dealer's cabinet.

"The blended sugars in frozen desserts offer a proper supply of carbohydrates to satisfy the nutritional requirements in a balanced form.

"The role of the sugars in ice cream products is three-fold: physical,

chemical and nutritional. Physical, because of its contribution to the mechanical structure as to body and texture of the finished products. Chemical, because the lowering of the freezing point of the mix facilitates physico-chemical changes during the manufacture of frozen desserts. Finally, sugars are food materials utilized by the human body as the carbohydrate portion of the nutrients present in ice cream products." W.H.M.

149. The Troy-Fucoma Method for Testing Butterfat. B. I. MASUROVSKY. Ice Cream Trade J., *36:* 9, 34. Sept., 1940.

The author of the article states, "With butterfat representing a major cost essential and because of the rigid butterfat requirements in effect by state law throughout the nation, it is essential that the ice cream manufacturer handle his fat carefully and give this phase of the business the particular attention which it really deserves." He suggests a very practical test for fat in ice cream, a modification of the Gerber method[1] known as the Troy-Fucoma method. The acid used in this test is commercial sulphuric (sp. gr. 1.82) diluted with water (87 cc. acid to 13 cc. water for vanilla and 94 cc. acid and 6 cc. water for chocolate ice cream.)

The test is made as follows:

1. Transfer 10 cc. of sulphuric acid to Ice Cream Butyrometers (Ice Cream Test Bottles).
2. Melt the ice cream sample, mix, and weigh 5 grams of it into the butyrometers.
3. Add 5 cc. water and 1 cc. amyl alcohol.
4. Insert stoppers and shake well until every particle of the ice cream is dissolved.
5. Place in the centrifugal machine and whirl for 5 minutes at the proper speed adjusted for the load.
6. Remove Butyrometer from centrifuge and read immediately.

W.H.M.

150. Charting the Trends of the Retail Ice Cream Store. ROBERT J. COOLEY. Ice Cream Trade J. *36:* 10, 66. Oct., 1940.

The author traveled 6,000 miles in 15 states, visited 150 retail ice cream stores and obtained data by questionnaires from a total of 747 stores operated by 19 different organizations. Many interesting facts are presented by means of 37 charts. The amount of annual business done by 55 per cent of the stores ranged between $10,000 and $25,000. Of those interviewed, 67 per cent recommended $4,000 to $6,000 as a minimum investment per retail store. The average rental allowance given by 50 per cent of the operators was 3.5 to 5 per cent of gross sales. Average amount of sales was

[1] See circular 552, State of New York, Dept. of Agriculture and Markets, "Regulations Governing the Sampling and Fat Testing of Milk and Cream."

found to be higher on week-end days than it was during the first days of the week. Daily inventories were kept by 31.2 per cent of the stores, while others kept weekly or monthly inventories. Sixty per cent of the stores sold double dip cones for 5 cents. Reasons given for lost customers, in order of importance, were poor service, poor salesmanship, high price, slipshod methods, and poor quality. W.H.M.

151. Protein Stability. C. D. DAHLE AND P. W. RIVERS. Ice Cream Trade J., *36:* 10, 58. Oct., 1940.

The acidity of ice cream mixes was standardized with sodium hydroxide, calcium hydroxide and magnesium oxide and the effect on protein stability and other properties of the mix and ice cream noted. When sodium hydroxide was added the alcohol and acid numbers of the mix were increased, indicating greater stability of the proteins. Overrun was obtained in a shorter time. The protein stability of the batch and continuous freezer ice cream was about the same; however, the acid number on the melted ice cream indicated that freezing and hardening of the ice cream had a destabilizing effect. The results obtained when calcium hydroxide was added were quite similar to those secured with sodium hydroxide, except the acid and alcohol numbers were somewhat lower than for sodium hydroxide and freezing in either freezer did not seem to destabilize the proteins. Magnesium oxide gave similar results to calcium hydroxide, although there were some discrepancies obtained in connection with viscosity results. Less alkali flavor was noticed in the ice cream and the melted ice cream had greater stability than the plain mix when calcium hydroxide was used.

The three alkalies were also added to mixes in which all of the fat was obtained from frozen cream. As measured by the alcohol number the proteins of the mixes are fairly stable, but they are less stable when measured by the acid number; this was true for fresh mixes and also for the melted ice cream. As measured by the acid number the protein for the ice cream frozen in the continuous freezer was slightly less stable. In this trial all samples of melted ice cream showed signs of wheying off and a slight acid flavor persisted even after a reduction to a low point with the alkali. Magnesium oxide gave the best flavored product and sodium hydroxide the poorest. Overrun of the ice cream was greatly improved by the procedure in frozen cream mixes.

In another trial the effect of slow and fast cooling was observed in mixes to which the alkalies had been added. Slow cooling had little effect on viscosity and alcohol or acid numbers. The quickly cooled mixes whipped a little faster and the calcium hydroxide tended to speed up the whipping of slow cooled mixes.

The slow freezing without agitation of mixes containing alkalies had little influence on protein stability. By comparing all control mixes with

the melted mixes from the frozen samples it was concluded that freezing had little effect on the protein stability as measured by the acid and alcohol numbers. Another observation made was that "when alkalies were used to lower the acidity of mixes below the normal range, considerably more were needed to cause a calculated reduction in acid due to the buffering capacity of the system."

Sodium hydroxide was more effective in reducing the acidity than either calcium hydroxide or magnesium oxide and its influence in stabilizing the proteins was evident. This product affected the flavor more than either calcium hydroxide or magnesium oxide. W.H.M.

152. When Will Ice Cream Assume Its Full Share of Consumer Education. ESTELLE MARIE BARKER. Ice Cream Trade J., *36:* 10, 42. Oct., 1940.

It is the opinion of the author of this article that now is the time for ice cream manufacturers to do more than they have in the past to educate the consumer of ice cream regarding the product and industry. The consumer should be told the story of ice cream in simple terms, attractively styled, and continuously. Home economics teachers and other teachers who work with children need educational material on ice cream, such as films and other supplementary literature and follow-up information. W.H.M.

153. Profits from Fancy Forms. JOSEPH A. BANNON. Ice Cream Trade J., *36:* 10, 32. Oct., 1940.

Many ice cream plants have recognized the profit and advertising possibilities of ice cream fancy forms. A department for this purpose also helps overcome the problem of seasonal employment by furnishing work throughout the entire year. High class, trained individuals, ample light, a work room with a 50° F. temperature, heavy cream for whipping, stainless steel molds properly chilled before filling, and semi-hard ice cream for filling the forms are some of the essentials listed for success. Forms which are suitable for various occasions and holidays should be brought to the attention of the public through advertisements and displays. Stenciled slices of brick ice cream, ice cream cakes and pies are other popular forms which can be made by the fancy form department. W.H.M.

154. Sidewalk Advertising. JOHN J. WIEST. Ice Cream Trade J., *36:* 10, 44. Oct., 1940.

Signs are one of the oldest forms of advertising; they tell the purchaser where an article can be purchased and remind him that the purchase should be made. Curb signs should be simple in design and of an attractive harmonious color, backgrounds of white, reds and yellows are good eye catchers,

and darker blues, greens, and browns are best for lettering. Signs should be kept in good repair and repainted occasionally to keep them attractive.

W.H.M.

155. Outline of Activities. R. C. HIBBEN. Int. Assn. Ice Cream Mfrs., Washington, D. C. Spec. Bull. Oct., 1940.

This bulletin is a brief presentation of the activities of the International Association of Ice Cream Manufacturers and Ice Cream Merchandising Institute for the year ending September 30, 1940. The association has actively followed State and Federal legislation which affects the ice cream industry, has cooperated in work with the U. S. Department of Agriculture and U. S. Department of Commerce, and has worked for consumer relations and publicity of a helpful nature to the industry. The statistical and accounting bureau of the association has developed a new accounting system and has, in addition, published bulletins covering trends in ice cream costs, an analysis of truck refrigerating systems, and the ice cream sales index for the first four months of 1940.

The activities of the Ice Cream Merchandising Institute have largely been: I. Presentation of a series of merchandising short courses; 2. Offering merchandising servises to ice cream manufacturers; 3. The maintenance of satisfactory inter-industry relations; 4. The publication of booklets and other matter useful in merchandising programs. M.J.M.

156. A Method for the Accurate Sampling of Ice Cream. A. C. MAACK AND P. H. TRACY. J. Milk Tech., *3:* 123–125. 1940.

A means for preparing nut and fruit ice cream samples so as to obtain an accurate fat test on them is described. By taking a 4 or 5 ounce sample of the ice cream and thoroughly breaking up and mixing the nuts and fruits in it with a Stevens malted milk mixer, results were obtained which checked very accurately with the calculated test on specially prepared samples containing known amounts of fruits.

Tests made on samples containing known amounts of nuts always gave higher tests due to the ether soluble substances in the nut meats. The same was true for Toffee ice cream.

The use of the mixer for candy ice creams had no advantage in the accuracy of the tests, providing the candy was dissolved before sampling, other than shortening the time required to dissolve the candy.

Duplicate tests performed on each sample gave very close checks.

L.H.B.

157. Suggested Program of Week-end Specials and How to Make Them. O. E. ROSS. Can. Dairy and Ice Cr. J., *19:* 8, 46. 1940.

The problem that confronts the ice cream manufacturer today is to

increase the volume of business done by the dealer. In planning week-end specials it is necessary to organize at least 6 months ahead. First, organize the week-ends and pick out the special holidays. Stick to good substantial flavors but give consideration to the time of year. Use fruits in season and nuts in the fall. Educate the public to look for certain week-end specials. Suggested specials for a few holidays are given and directions are indicated for making certain types of specials. O.F.G.

158. Keeping Down Bacteria Counts in Ice Cream Mixes. W. SCHWEN. Can. Dairy and Ice Cream J., *19:* 8, 30. 1940.

A regular check on the bacteria count gives a constant knowledge of the sanitary quality of the ice cream mix. The mix should be pasteurized at 155° to 160° F. Steam, if applied long enough to insure sufficient heating of surfaces, is an efficient and economical heating medium. Chlorine solutions containing 50 to 100 p.p.m. have their place in sterilizing the homogenizer and surface coolers. Store the mix at 40° F. or below. Check fruits, colors and flavors for high counts and coli. Check equipment for open seams and incrustations. Every step in processing must be watched.

O.F.G.

159. Report of Committee on Ice Cream Sanitation. T. W. FABIAN. J. Milk Tech., *3:* 72–74. 1940.

The committee believes that "it would seem to be reasonable to require manufacturers to give all ingredients added to ice cream mix after pasteurization a treatment equivalent to pasterization."

As suggested standards for ingredients the following are given.

Hook and Fabian: 5,000 bacteria per ml. for flavoring and fruit syrups.

Prucha:	Coloring solutions	10,000 per ml.
	Flavoring extracts	100 per ml.
	Fruits	1,000 per gr.
	Nuts	100 per gr.

There should be an absence of coliform organisms and hemolytic streptococci, and the yeast and mold count should not exceed 10 per ml. or gr.

Further items discussed by various members of the committee are: 1. Continuous freezer operations; 2. The use of plastic cream and butter in ice cream; 3. Preparation of fruits and nuts; 4. French and custard ice cream; 5. Sanitation in retail outlets; 6. The coliform index and phosphatase test.

The committee believes that the only way to handle the "counter freezer" situation is to require them to meet all of the regulations for producing ice cream regardless of size of the plant.

Uniformity of regulations is necessary. L.H.B.

MILK

160. A Discussion of Homogenized Milk. C. J. BABCOCK. Can. Dairy and Ice Cr. J., *19:* 8, 24. 1940.

In the preparation of homogenized milk certain precautions are essential if a good product is to be placed on the market. Raw milk should not be homogenized because of the development of rancidity. Sedimentation occurs in homogenized milk if the leucocyte count is much above 100,000 per ml. Clarification will remove a large percentage of the leucocytes and thus prevent sedimentation. The author recommends the following order of processing: 1. Clarification; 2. Homogenization; 3. Pasteurization. Some operators prefer to homogenize at the pasteurizing temperature. There seems to be no advantage in homogenizing at a pressure greater than 2,000 or 5,000 pounds. Homogenization does not improve the sanitary quality of the milk; consequently, the milk should be of high quality in the beginning. High bacterial content of homogenized milk, which was of low count in the beginning can be traced most likely to improper care of the homogenizer. Advantages claimed for homogenized milk are: 1. Even distribution of fat; 2. Improved palatability; 3. Greater digestibility. The latter claim has not, as yet, been fully substantiated. The author thinks that in the future the dairy industry is going to promote homogenized milk but feels that its future depends on a high quality product. O.F.G.

161. A Survey of the Compositional Quality of Milk. (An interim report of investigations made by the National Institute for Research in Dairying). Can. Dairy and Ice Cr. J., *19:* 6, 74. 1940.

Little is known about the factors which control the compositional quality of the non-fatty solids of milk. A survey was made by the Research Committee of the Milk Marketing Board through the National Institute for Research in Dairying. The survey covered 12,500 herds comprising 245,000 cows in 30 different districts in England and Wales. In the first year 13.11 per cent, and in the second year 9.15 per cent of the total number of herd samples were below the standard of 8.5 per cent m.-s.-n.-f. Herds which during the summer received supplementary feed produced milk with a significantly greater m.-s.-n.-f. content than did herds maintained on grass alone. The most important single factor found to influence the m.-s.-n.-f. content was the presence of udder infections. Of the cows which yielded milk containing less than 8.5 per cent m.-s.-n.-f., about 70 per cent were suffering from chronic infectious mastitis. Administration of thyroxin or the feeding of dried thyroid gland, not only made cows produce more milk, but also milk of better quality, both as regards fat and as regards non-fatty solids. Cows which normally produced low m.-s.-n.-f. milk remarkably im-

proved the solids content for the rest of the lactation period when ovarian hormone was administered. Injection of "stilboestrol" into the body acted in very many respects in the same way as the natural ovarian hormone. Hormonal treatment has not yet reached the practical stage. O.F.G.

162. Is Six-day Daylight Delivery Feasible? RICHARD NUGENT. Can. Dairy and Ice Cr. J. *19:* 6, 28. 1940.

After experimenting with 3 milk routes an advertising campaign was started which asked for consumer cooperation in establishing the 6-day daylight delivery of milk. Surprisingly little consumer resistance was encountered. One objection of several consumers was that they were using more milk on the new delivery plan and consequently their milk bill was higher. The double delivery on Saturday was taken care of by sending feeder trucks out to each route truck. Reorganization of plant schedules was necessary. O.F.G.

163. High Bacterial Counts in Pasteurized Milk. W. H. BURTON. Can. Dairy and Ice Cr. J., *19:* 6, 24. 1940.

A certain dairy which was following approved sanitary practices was troubled with high counts of "pin point" colonies in the pasteurized milk. Preliminary investigation revealed that none of the producers' samples was very high, but that there was very little reduction in the count as the result of pasteurization. The only significant plant contamination was in the homogenized milk where considerable numbers of *B. coli* were picked up from the homogenizer. *B. coli* were eliminated by running hot water (180° F.) through the homogenizer just prior to operation. A second more careful investigation of producers' samples revealed that considerable contamination was picked up by the milk as it passed through the milking machine. These bacteria were heat-resistant micrococci. O.F.G.

164. Reports of Committees for Association Year Ending September 30, 1940. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 1, 12–46. 1940.

Detailed information about progress made during the past year as well as recommendations for the future are contained in these reports which include the names of sixty-six committee members. The following committees reported: Accident Prevention; Accounting Advisory; Aptitude Tests for Selecting Salesmen; Industrial Relations; Laboratory Methods; Legislation; Milk Definitions and Standards; Plant Advisory; Production Advisory; Public Relations; Sanitary Procedure; Simplified Practice; Transportation. E.F.G.

165. Address of the President at the 33rd Annual Convention, Internat. Assn. of Milk Dealers. F. F. RENNIE, JR. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 1, 3–11. 1940.

A two-fold program for the industry is presented; first to decrease costs of distribution and second to broaden the program of consumer education with regard to the importance of milk in health maintenance. Sixteen specific major accomplishments of the twenty-one active committees are cited and explained briefly. Attention is called to the fact that the number of dairy cows on farms on January 1 is expected to be 1 to 2 per cent over the number at the beginning of 1940. Figures by the Milk Industry Foundation covering $\frac{1}{3}$ of the total pasteurized milk routes of the country in 140 cities in 39 states show increases in 82 per cent of the reports, decreases in 10 per cent with 8 per cent the same. Total fluid milk sales for the first eight months of 1940 were .77 per cent over 1939. Employment was 1.04 per cent under 1939, but payrolls were .30 per cent over the same period. Reports indicate that out of 156 markets 83 have had their sales affected by cash and carry stores. Out of 105 markets 46 indicate an increase in store distribution while 59 experienced a decrease. Attention is called to the fact that 4 minutes of work in the U. S. will buy a quart of milk while in many other countries 2 to 6 times as many minutes is required.

Notice is taken of "Dairy Month" as an outstanding cooperative movement between important producer and distributor groups. E.F.G.

166. New Developments in Glass Milk Containers. SCOTT FARON. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 3, 71–79. Nov., 1940.

Without special effort to promote sales the volume of milk sold in 2 quart and gallon bottles in St. Louis, Chicago and suburbs, and Los Angeles is between 30 per cent and 35 per cent of total class one sales. The glass industry is not interested in one type of glass container as compared with another. The 2 quart bottle was standardized last January because it seemed to be the more practical container and is apparently here to stay. Regarding trippage for 2 quart bottles, St. Louis reports 30 to 40, Chicago 40 to 50 and Los Angeles about 50. Savings in bottles, capping, space, sales and delivery amounting to 2 cents on the 2 quart container of milk compared with the price of 2 single quarts seem to be justified according to studies by the California Department of Agriculture. Apparently a one cent per quart saving to the consumer of milk in the 2 quart bottle and $1\frac{1}{2}$ to 2 cents per quart saving in gallon purchases seems to work well provided store prices are in reasonable relationship. A generally held opinion in the Los Angeles market is that multiple quart bottles have increased consumption and figures seem to bear this out in the St. Louis market.

A $17\frac{3}{4}$ oz. bottle with a 48 mm. finish and one inch shorter, at a saving of

½ cent in original cost, has met with approval by both plant and customer. Two of the largest New York distributors commenced its use on September first and others have made the change or are preparing to do so. E.F.G.

167. **Thirty Years of Safety.** P. D. Fox. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 2, 49–60. 1940.

The dairy industry had 21.34 disabling injuries per million man hours worked in 1939 compared with 16.70 for the food industry as a whole. Twenty-six industries had a lower rate and only 4 a higher rate than the dairy industry. Among heavy industries, cement had only 4.26 disabling injuries per million man hours worked and steel, 6.57. An unsafe practice, an incorrect habit or poor reasoning is the beginning of an accident. It is stated that the ratio of narrow escapes to accidents is about 300:1. A list of nine recommendations is given which will aid in removing both direct and indirect causes of accidents mainly through the adoption of practices and policies which are safe and correct. Accidents are mainly the result of inefficiency and can largely be prevented. E.F.G.

168. **The Nation-Wide Dairy Products Advertising Campaign.** D. T. Carlson. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 2, 64–68. Nov., 1940.

The American Dairy Association was launched on January 26, 1940, and its organization completed on May 21. Tentative pledges toward a fund for national advertising were made by the five states of Wisconsin, Iowa, Minnesota, Washington and Montana totaling $289,500 and an 8 months advertising budget of $250,000 was adopted. A Chicago advertising office has been opened. Twenty-two newspapers and 31 radio stations in 11 key markets will carry the advertising through 34 weeks. Merchandising emphasis will be placed on butter and cheese in the eastern markets while butter, cheese, ice cream and milk will be promoted in participating states. Industry advertising by Associated Coffee Industries of America resulted in a 17 per cent increase in per capita consumption of coffee in the 2 years following 1937. The Tea Bureau reported an increase of more than 20 per cent after two years of active promotion. The American Dairy Association hopes to increase the consumption of dairy products by industry advertising.

E.F.G.

169. **Facts Regarding the Cost of Milk.** Harry R. Leonard. Assn. Bull. Internat. Assn. Milk Dealers, 33rd yr., No. 4, 101–108. Dec., 1940.

In January, 1920, distributors were paying $3.47 per 100 lbs. for 3.5 per cent milk and the cost of manning a milk wagon was $110.00 per month. Now in Minneapolis it costs $223.00 per month to man the milk wagon and the producer gets $1.75 per 100 lbs. The producer receives 49 per cent less while the routeman gets almost double. If the farmers return had increased

in the same proportion as the route man's, the consumer would now be paying 7¾ cents more than the present prevailing price. The consumer knows that the farmer gets less, and feeling he should pay less for milk clamors for a different system of distribution. One of the largest distributing companies in Minneapolis showed an average net profit per unit for the last 3 years of one tenth of a cent. Where there is cooperation between a producer organization and the distributors of a city the producers cannot afford to enter the retail milk distribution field. Lack of cooperation between producers and distributors resulted in an increase of cooperative distributing organizations from 25 in 1928 to 140 at present. Milk distributors should frankly tell the public that the chief cause of high costs is the constantly increasing cost of labor. Milk stores, an attempt to reduce the cost of distribution, are a threat to the distributor, the producer and organized labor in particular. The Elwell plan or similar plans may help to solve the situation if route men cooperate. However, the producer still believes that the distribution of the consumer's dollar is not on an equitable basis. E.F.G.

170. Public Relations. B. F. CASTLE. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 4, 91–100. 1940.

The unquestioned value of milk and the high esteem in which it is held as a food give it a decided advantage in competitive advertising. The inexpensive and efficient service of the milk distributor should be publicized to both the consumer and producer. E.F.G.

171. Producer-Dealer Relations. CHARLES W. HOLMAN. Assn. Bull., Internat. Assn. Milk Dealers, 33rd yr., No. 4, 125–131. Dec., 1940.

About 1916 occurred reluctant recognition by many distributors of the farmers' right to collective bargaining on terms of equality and this gave impetus to the establishment in many milk sheds of the so-called base and surplus plan and the classified use plan of marketing milk. Through the 20's a growing cooperation developed between dealers and producers in efforts to educate the consuming public to the beneficial qualities of dairy products. In the depression federal control over milk markets developed in an effort to protect the producer from too low prices. Today under public regulation producers and dealers are farther apart than they were fifteen years ago. It is suggested that the milk industry needs a resumption of sound constructive relationships between producers and dealers in order to avoid being placed somehow under public domination. E.F.G.

172. The Whence and Whither of Milk Sanitation. ROBERT S. BREED. Can. Pub. Health J., *31:* 414–424. 1940.

Modern milk sanitation did not begin until bacteriological methods such as agar media and dilution methods of counting were developed. At the

end of the first decade of this century some of these methods had become well established. Boston was probably the first city to fix a definite bacterial count limit for raw milk supply. During this period the regulations introduced by city health authorities were sustained in the higher courts of the United States.

The evolution of present day standard methods of bacterial analysis have been difficult, especially in regard to securing agreement on a satisfactory incubation temperature for the plate count.

While methods may vary, the need is for tests which will enable the inspector to determine whether the milk was reasonably clean before pasteurization, whether it has been properly pasteurized and also whether it has been protected against recontamination. Experienced inspectors should be able to secure this information by microscopic examination, phosphatase test and coli determination. An odor test is also important in the inspection of raw milk prior to pasteurization. O.R.I.

173. High Temperature-Short-Time Pasteurization of Milk. F. C. BUTTON. J. Milk Tech., *3:* 198–203. 1940.

This paper presents the present status of the high temperature short-time process for pasteurizing milk.

A review of both recent and early studies is given; together with present day requirements. L.H.B.

174. Syllabus on Milk Sanitarians Associations. V. M. EHLERS. J. Milk Tech., *3:* 194–197. 1940.

The value, objectives and national aspects of milk sanitarian associations are discussed. L.H.B.

175. Comment on Licensing of Pasteurizer Operators from Oakland, California. R. L. GRIFFITH. J. Milk Tech. *3:* 189–193. 1940.

All pasteurizer operators in Oakland, California, are required to be licensed. The methods of instructing and examining operators are discussed in detail.

Although results of such a practice with regard to effect on safety of pasteurization cannot be measured, it is a protection against incompetence and ignorance as to the reason why certain requirements are necessary. It is recognized that trustworthiness or dependability in addition to training and intelligence is absolutely necessary in obtaining a thorough job of pasteurization. L.H.B.

176. Milk Investigations of the U. S. Public Health Service. F. J. MOSS. J. Milk Tech., *3:* 145–154. 1940.

This paper gives a very comprehensive review of the research work of

the U. S. Public Health Service, Office of Milk Investigations, on public health aspects of milk.

It also discusses the standard milk ordinance and code. This ordinance is now in effect in about 2200 communities in 34 states. L.H.B.

177. Sanitary Milk Control Situation in Havana. J. Milk Tech., *3:* 132–136. 1940.

A very interesting discussion is given of some of the problems encountered in quality milk control work in the Havana market and methods of supervision. Although only 20 per cent of the milk supply is pasteurized, there have been no milk-borne epidemics due to the fact that the Cuban people practice the custom of boiling all milk before using it. L.H.B.

178. Familiarizing Milk Plant Personnel with Sanitary Requirements. S. A. Layson. J. Milk Tech., *3:* 80–83. 1940.

Methods used in the State of Illinois to improve plant sanitation and operation are discussed. L.H.B.

179. The Voluntary Grading of Milk Supplies in Alabama. Fred H. Downs, Jr. J. Milk Tech., *3:* 97–100. 1940.

Interest in the voluntary grading plan is growing in the smaller communities in Alabama.

No milk may bear the label "Grade A" unless it meets the requirements of Grade A milk. L.H.B.

180. Low Bacterial Counts in Milk With Tryptone Agar at 32° C. Theodore Marcus. J. Milk Tech., *3:* 103–104. 1940.

It is possible to maintain low bacterial counts under commercial conditions when using the new tryptone agar at 32° C.

To do this for pasteurized milk it is usually necessary to pasteurize samples of each producer's milk in the laboratory and inspect those farms showing a high count. A high count due to poor cooling will give a low count after pasteurization, but if it is due to dirty utensils, or strainer cloth it will be high after pasteurization. L.H.B.

181. The Pan American Sanitary Bureau and its Cooperative Work in the Improvement of Milk Supplies. Hugh S. Cumming. J. Milk Tech., *3:* 105–108. 1940.

Practically all Latin American Countries have promulgated rules to improve the sanitary quality of their milk supplies.

Consumption of milk is far below the amounts recommended as conducive to good health. Argentina has the highest consumption of any of the

countries represented in the Pan American Sanitary Bureau, about 137 cc. per day per capita. In some of the individual cities consumption is higher, however.

Pasteurization is gradually, although slowly, gaining recognition.

Tuberculosis, Bang's Disease, and Mastitis are still very prevalent in the herds in these countries. L.H.B.

182. A Study of the Effect of the Growth of Some Organisms in Milk on the Phosphatase Test. CHARLES PALEY. J. Milk Tech., *2:* 251–253. 1940.

A study was made to determine the effect of the presence in rather large numbers of some of the common organisms found in milk upon the phosphatase test.

The test organisms used were: *B. lacticus, S. aureus, E. coli* (two strains), *L. acidophilus, L. bulgaricus, S. lactis, B. subtilis,* and *S. albus.*

Ten cc. of the control milk was inoculated with one cc. of the culture of the test organisms and incubated at 37° C. for 4 to 5 hours. The milk was then tested by both the Scharer and Gilcress and Davis phosphatase tests. The growth and presence in large numbers of these organisms did not have any effect upon the phosphatase test by either method.

The two methods compared favorably for the determination of the phosphatase content of milk. L.H.B.

183. How to Overcome Defective Babcock Cream Tests. T. J. GRENIER. J. Milk Tech., *3:* 230–231. 1940.

To obtain perfect tests on cream by the Babcock method 100 per cent of the time, the following procedure is recommended.

Weigh accurately 9 gr. of the well mixed cream into a 9 gr. 50 per cent Babcock cream bottle. Add 9 cc. sulphuric acid (sp. gr. 1.82–1.83) directly to the cream; *do not* add water to the cream. Acid and cream should be 60° F. at the time of mixing. (If 18 gr. sample of cream is used then double the amount of acid is needed.) Mix with a rotary motion until curd has disappeared; then shake for ½ minute longer. The mixture should be chocolate brown in color. If not dark enough add a little more acid and mix. Do this until the proper color is obtained.

As soon as samples attain the proper color, add 2 to 4 cc. of hot soft water (160°–200° F.) to each bottle. Let the water run down the sides of the bottle. (*This is the important step.*) Do not shake. The hot water if allowed to run down the side of the bottle will form a layer on the top of the acid mixture and will float the fat off of the acid, preventing the burning action of the acid on the fat. Having the cream acid mixture at the proper color and adding the hot water at the correct time to the mixture in the manner stated will prevent charred or cloudy fat columns. L.H.B.

184. Measuring the Sanitary Quality of Market Cream. F. E. NELSON, AND W. H. MARTIN. J. Milk Tech., *3:* 245–254. 1940.

The sanitary quality of the cream was measured by the use of the phosphatase test (Scharer's field test, using 30 min. incubation, and Gilcreas and Davis' test), the standard agar plate count, the Escherichia-Aerobacter count (using violet red bile agar), direct microscopic count, and acidity tests (titratable, using procedure recommended by Sommer; and pH measurements, using quinhydrone electrode).

It was found that under laboratory pasteurization, the enzyme phosphatase was more heat resistant than Escherichia-Aerobacter bacteria.

Laboratory pasteurization of 20 per cent and 35 per cent cream at 143.5° F. for 30 min. did not give negative phosphatase tests in every instance.

Positive phosphatase tests were frequently obtained on samples of cream separated from milk pasteurized at 143° F. for 30 min. Negative tests were always obtained on cream separated from milk pasteurized at 150° F. or higher for 30 min. The cream samples, as compared with the milk from which they were separated, showed an increase in the plate count, a marked increase in the number of Escherichia-Aerobacter bacteria, and an increase in the number of positive phosphatase tests.

The results indicate that several different tests are necessary to determine the true quality of market cream. L.H.B.

185. Facts for Consumers Regarding Cost of Milk. HAROLD W. COMFORT. Assn. Bull., Int. Assn. Milk Dealers, 33rd yr., No. 4, 109–124. Dec., 1940.

A frank and open presentation to the public of all facts surrounding the marketing of milk is essential. More information is needed by the consumer on the following: premium milk and its effect upon spread, price of milk to the farmer, meaning of Class I and II milk, the problem of surplus, services of the distributor factor of labor which is approximately 65 per cent of the total cost of distribution. The combination of 2 quart bottle and every other day delivery offers a most effective way of reducing delivery expense by increasing the quantity of milk per delivery. Six day delivery tends in the same direction. The Borden Company method of presenting costs is to determine weighted average selling price. The consumers' dollar is then broken down into major headings: Cost item breakdown of dollar sales to trade for the year 1939:

Farmer—raw products	$ .4396
Labor	.3669
Bad debts	.0036
Bottle, box and can loss	.0163
Property operating expenses (All costs of operating buildings, equipment and vehicles, not elsewhere specified.)	.0646

Depreciation	.0239
Taxes, licenses and unemployment compensation	.0274
Insurance	.0054
Freight	.0165
Salaries of officers or owners	.0102
All other expenses	.0343
Profit or loss	.0087 (def.)
	$1.0000

Gross spreads in 3 periods in Chicago furnish evidence of a sharp reduction in spread.

Dealer gross margin per quart of fluid milk—Chicago

	1930	1935	1940
Home delivery price	14.00	10.68	11.70
Dealer price to store	12.50	9.68	7.50
Proportion sold to home	.85	.75	.48
Proportion sold to store	.15	.25	.52
Average selling price	13.77	10.43	9.52
Dealer buying price	5.74	4.84	4.30
Gross spread	8.03	5.59	5.22

A breakdown of the standard retail price of milk per quart is quite essential in disclosing information to consumers and detailed figures are given by the author for 1940. When all units of special products are figured in, the loss on a quart of milk above may be turned into a profit on all units handled. E.F.G.

186. Time Required for Destruction of Bacteria at Different Temperatures of Pasteurization. M. H. PRUCHA AND W. J. CORBETT. J. Milk Tech., *3:* 269–273. 1940.

In this study raw milk, aseptically drawn from a cow selected for her low bacterial udder contamination, was inoculated with a 24 hour culture of a heat tolerant strain of *E. coli* so that it contained from one to four million colonies by the plate count. The milk was then pasteurized in about 3 ml. quantities in small, thin walled test tubes, at temperatures ranging from 143° F. to 162° F. for varying periods of time, ranging from 5 seconds to 35 minutes.

The samples were then tested for phosphatase activity using Scharer's phosphatase test (laboratory method) and a photoelectric cell; and for viable organisms by inoculating two fermentation tubes with 1 ml. portions of the milk. Agar plates were also used in some instances.

At 143° F. it required 25 minutes to kill all of the bacteria. In regular pasteurization the milk is held 30 minutes at 143° F., so in comparing the other time and temperature exposures with the results obtained at 143° F. for 30 minutes, the time interval necessary for killing all of the bacteria was

increased 20 per cent so as to establish the same pasteurization safety factor as in the case of the control (143° F. for 30 minutes).

Time and temperature combinations equivalent in killing efficiency to 143° F. for 30 minutes are shown on the left. The time necessary to inactivate phosphatase so as to give a reading under 0.8 p.p.m. phenol is on the right. (Heating the milk to 143° F. for 30 minutes gave a reading slightly under 0.8 p.p.m. phenol.)

146° F.—18 min.	10 min.
150° F.— 8 min., 30 sec.	5 min.
152° F.— 5 min., 56 sec.	2 min.
154° F.— 3 min., 36 sec.	1 min.
156° F.— 2 min., 24 sec.	25 sec.
158° F.— 1 min., 36 sec.	5 sec.
160° F.— 47 sec.	Instantaneous
161° F.— 30 sec.	"
162° F.— 21 sec.	"

Studies were also made on the effect of pasteurizing temperatures on the flavor and cream volume of the milk.

The results of the study showed that the killing effect on bacteria did not parallel with the cream rising, with the development of cooked flavor, nor with the inactivation of the enzyme phosphatase. Smaller cream volumes were obtained at the higher temperatures, while less cooked flavor was present. L.H.B.

187. Common Causes for Intermittent High Bacterial Counts and Positive Phosphatase Tests. MILTON R. FISHER. J. Milk Tech., *3:* 260–263. 1940.

In order to control the intermittent high bacterial count and the occasionally positive phosphatase test, it will be necessary to make tests on certain plant samples. The first four bottles from a vat of milk will sometimes tell a story not found in the other bottles. L.H.B.

188. Syllabus on an Educational Program for the Production of Safe Milk. V. M. EHLERS. J. Milk Tech., *3:* 255–259. 1940.

It is suggested that the production of safe milk would require a series of educational or training programs as follows: 1. Education of the consuming public; 2. Securing interest of appropriating bodies; 3. Training the milk control officials; 4. Training the milk plant operators or pasteurization equipment operators; 5. Training the milk producers and distributors. Plans for carrying on such programs are suggested. L.H.B.

189. Report of the Committee on Sanitary Procedure, Internat. Assn. of Milk Sanitarians, for 1939. W. B. TIEDEMAN. J. Milk Tech., *3:* 65, 71. 1940.

The committee has prepared a form to be used by any person for submitting proposed items to the committee for acceptance or standardization. The committee plans to meet quarterly.

Among the items accepted and standardized since the last report are the following. (Illustrations of same are also given.)

1. A removable nut for attaching thermometers to equipment.
2. A bend; both ground and seat type and gasket type.
3. An increasing or reducing fitting.
4. A device with metal umbrella for inserting, indicating and recording thermometers through the covers of pasteurizers without the use of threads.
5. A substitute for the 4 in 1 fitting for interchangeably installing thermometers in pipe lines.

A study on the use of plastics, both hard and flexible, for use in dairy equipment is underway. From studies to date, it appears that certain types of plastics may be used under some conditions. L.H.B.

190. Closures Employed for Dairy Product Containers. D. LEVOWITZ. J. Milk Tech., *3:* 41–43. 1940.

A method for determining the efficiency of bottle closures is discussed. A technique employing suspensions of organisms not commonly found in dairy products is used. L.H.B.

191. Necessity for and Some Difficulties of Public Health Milk Control. F. D. BROCK. J. Milk Tech., *3:* 36–40. 1940.

The necessity for milk control is shown by the report of 723 milk-borne epidemics in the United States from 1919 to 1937.

Some of the difficulties encountered in the large cities are political interference. In the smaller cities there is frequently too great a dependency upon the surrounding farms for their business patronage which results in a tendency to be too lenient in the enforcement of an ordinance because of its possible effect upon business. Then there is the small city or town which is not able to provide continuous inspection or enforcement. Grading and labeling in these places is meaningless.

The provisions of a state law regulating and defining grades of milk, securing competent inspection and grading in small cities, and making it possible for several small communities or even counties to form or organize "milk inspection units" is helping Texas to meet these difficulties.

L.H.B.

192. The Training of Personnel for the Field of Milk Sanitation. T. H. BUTTERWORTH. J. Milk Tech., *3:* 19–23. 1940.

To further improvement in milk sanitation, three things are necessary. Of first importance, is a trained personnel; second, sound laws to be administered; and third, adequate funds for their execution.

Some of the means used in various cities and states for training milk sanitarians are discussed.

The importance of licensing personnel, not only as inspectors, but as laboratory technicians and pasteurizing plant operators, is manifold.

L.H.B.

193. Farm Pasteurization. ARTHUR H. WILLIAMSON. J. Milk Tech., *3:* 5–8. 1940.

A vivid description is given of some of the problems encountered in obtaining *proper pasteurization* on the farm. L.H.B.

194. Method for Making a Milk Bottle Cream Volume Gage. T. H. BUTTERWORTH. J. Milk Tech., *2:* 304–305. 1939.

Detailed instructions for making and calibrating cream volume gages to fit any size and shape milk bottle are given. L.H.B.

195. The Relationship between State and Municipal Supervision of Milk Supplies. W. B. PALMER. J. Milk Tech., *2:* 290–294. 1939.

A means for obtaining an adequate and efficient supervision of milk supplies in all areas of a state is shown to be feasible. A close relationship between state and local boards of health is encouraged. L.H.B.

196. Application of the Resazurin Test to Pasteurized Cream. HERBERT JENKINS. Milk Dealer, *30:* 3, 58–60. Dec., 1940.

Using the resazurin test, it was found that cream which had a reduction time of less than one-half hour had a bacteria count of *uncountable;* none of it fell within the 40,000 per cc. legal limit, and this cream had a 100 per cent "complaints rating." Cream which had a reduction time ranging from ½ to 3 hours in no way met city and state requirements and received a high percentage of complaints from purchasers. In the 3 to 4 hour reduction time group, 39 per cent of the samples were above the 40,000 legal limit and 7.5 per cent of the cream sold in this group was complained about by customers. It was not until pasteurized cream had a reduction time of 6 to 7 hours that all samples met the legal bacteria count and occasioned no complaints from customers. C.J.B.

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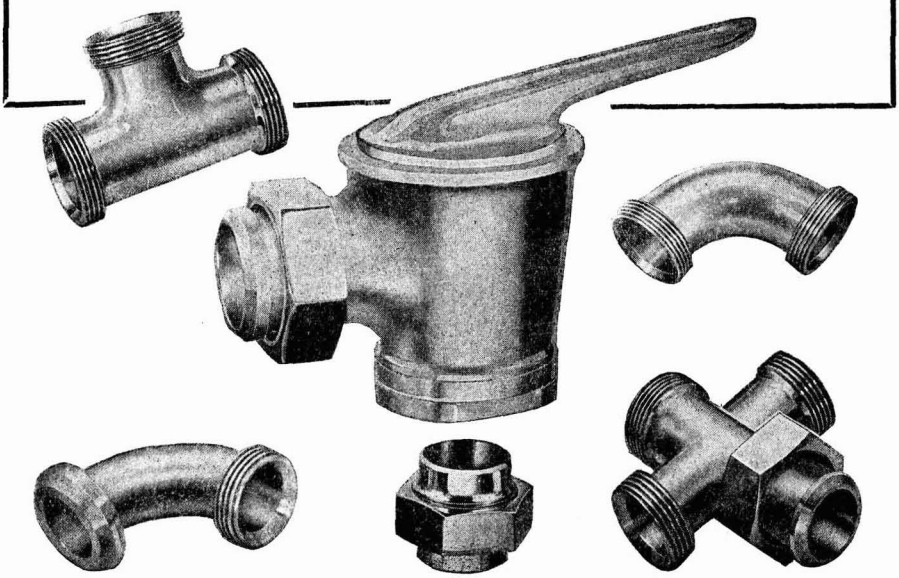

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