THE KEEPING QUALITY OF PASTEURIZED GRADE A MILK Offered for Sale in the Chicago Market

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The Keeping Quality of Pasteurized Grade A Milk Offered for Sale in the Chicago Market

By L. D. WITTER, P. H. TRACY, and H. K. WILSON[1]

DURING THE SPRING OF 1898 an investigation was made by Jane Addams of Hull House and H. S. Grindley of the University of Illinois (1)[2] on the quality of the Chicago milk supply. Their study showed that a resident of Chicago could buy, for 3 to 7 cents, a quart of unpasteurized whole milk that in all likelihood was liberally watered and had at least a portion of the cream removed. Today a resident of Chicago no longer can purchase a quart of milk for 3 cents, but he can obtain his fair share of butterfat and he does not pay for added water. More important, he no longer faces the hazard of contracting a disease through milk, for pasteurized milk properly handled contains no pathogenic bacteria. Pasteurized milk, however, is not free of spoilage organisms, which limit the keeping quality of milk.

This bulletin reports the results of a study undertaken in 1957 to obtain an unbiased measurement of the keeping quality of Chicago milk under variable-temperature storage conditions. More specifically, an attempt was made to evaluate the opinion that the Grade A milk being sold in and near Chicago was low enough in bacterial content to withstand storage at a reasonable temperature (40° to 50° F.) for at least five days without sufficient change in its bacterial flora or flavor to make the product undesirable to use as a beverage.

The keeping quality of milk is a major consideration in determining whether legislation limiting the date of milk sales is necessary. At present, the city of Chicago is one of 18 cities with populations of more than 100,000 that require that bottled milk be sold within a limited time after pasteurization and that the milk container be dated accordingly. Essentially, bottled milk distributed in the Chicago market must be in the possession of the consumer within 48 hours after pasteurization or be returned to the dairy and dumped. The practice of milk dating was studied and discussed by Dahlberg (14, 15), who concluded that it led to: (a) a decreased sale of milk owing to food stores' underordering in an effort to reduce leftover milk, (b) an increased number of special deliveries, (c) a false emphasis being placed on the

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[2] Numbers in parentheses refer to literature citations on pages 18 to 20.

age of the milk as a measure of quality, and (d) an increase in the dealer's operating costs. In Chicago and its environs this last item results in an additional selling price to milk consumers of approximately $1,000,000 a year. The sanitary hazards of a milk dating program were frankly presented by Bloom (6), who argued that the practice of dating milk was not only unnecessary but also undesirable. Other arguments for the elimination of dating ordinances are based on (a) the contention that at the present time a much improved quality of milk is available as the result of advances in dairy technology, (b) the existence of better refrigeration facilities in food stores and in homes, and (c) the existence of more significant sanitary standards for operating procedures at both the farm and plant level.

EXPERIMENTAL PROCEDURE

At the beginning of this study, the estimated average daily sale of milk in Chicago was 1,633,000 quarts, supplied by 45 approved milk plants. The quantity of milk sold in Chicago is so large that any sampling would necessarily constitute only a small fraction of the total output. Recognizing this limitation, the authors decided that the most satisfactory method for obtaining an overall view of the keeping quality of Chicago milk would be to collect and analyze milk samples from a representative number of dairy plants.

The dairy plants supplying Grade A fluid milk to the city of Chicago were divided into five approximately equal groups based on their capacities: Group A manufacturing less than 1,000 gallons a day; Group B manufacturing 1,000 to 3,000 gallons a day; Group C manufacturing 3,000 to 8,000 gallons a day; Group D manufacturing 8,000 to 25,000 gallons a day; and Group E manufacturing over 25,000 gallons a day.

The milk supplies of thirty plants, six in each group, were sampled during a twelve-week period, from April to July. Every other week during this period, samples of homogenized milk from five of the plants were collected from the stock of retail stores and from delivery trucks on approximately the first day after pasteurization (i.e., milk processed Tuesday and dated Thursday was collected on Wednesday). Each set of samples consisted of 7 quarts. The entire study was repeated during the colder months of November through February, using samples consisting of 5 quarts. Thus a total of sixty sets of samples, of 5 to 7 quarts each, was collected.

The temperature of the milk and the refrigeration unit containing it were taken at the time the samples were gathered. All samples were immediately placed in iced, insulated chests and were transported to the University of Illinois at Urbana on the same day that they were collected. The temperature of the milk on arrival at Urbana never exceeded 40° F. and was usually in the low thirties. On arrival the samples were placed in 40° F. storage until the next day, that is, two days after pasteurization. This was the day that had been stamped on the cartons. Milk tested two days after pasteurization was referred to as two-day milk. It had been kept at the variable temperatures of the retail stores for one day and at 40° F. at the University for the second day. Four-day milk was milk that had been stored in the same manner as two-day milk and then stored an additional 48 hours at a given constant temperature before being examined. Six-day milk was stored the same as two-day milk and then stored an additional 96 hours at a given constant temperature before being examined.

On the second day after pasteurization six quarts from each lot of samples were placed in storage, two at 40° F., two at 50° F., and two at 55° F. From each lot of samples, one quart stored at each of the three temperatures was to be tested four days, and the other quart six days, after pasteurization. One quart of two-day milk from each lot was immediately examined for the following: coliform count, standard plate count, psychrophilic count, flavor, pH, and percentage of fat and total solids. These tests, except for the one determining the percentage of fat and total solids, were subsequently performed on quarts of four-day and six-day milk, which had been stored at each of the three storage temperatures.

The procedures outlined in *Standard Methods for the Examination of Dairy Products* (10th ed., 1953) were followed in making the coliform and standard plate counts. Violet red bile agar medium was used to determine the coliform colonies per milliliter, in conformance with the Grade A Milk Law of the State of Illinois; milk protein hydrolysate glucose agar medium was chosen for making the standard plate and psychrophilic counts. Plates for the psychrophilic counts were incubated at 50° F. for one week in order to determine the number of organisms capable of reasonable growth at the maximum allowable temperature for milk distribution. Duplicate plates were made of all bacterial counts.

The flavor judging was done by a panel of three experienced taste judges. Samples to be tested were warmed to approximately 65° F. and were identified only by number to eliminate the possibility of bias. Usually samples were tasted in the late morning to avoid having the panel members judge the milk soon after eating. The collegiate score card system of scoring was used. On milk receiving a score below 40 a criticism was made. The arithmetic average score of the three judges for a given quart of milk was considered to be the flavor score for that quart.

The pH of the milk samples was determined electrometrically with a Beckman Model H2 pH meter. The fat and total-solids content of all samples was determined by using a Mojonnier tester according to the procedures outlined in the Milk Industry Foundation's *Laboratory Manual, Methods of Analysis of Milk and Its Products,* 1949. For some samples the fat content was determined by the Babcock procedure modified by Lucas and Trout (21) for testing homogenized milk. The total solids were determined for some samples by applying the formula method (25) to the specific gravities obtained by a Quevenne lactometer.

From the experience and information gained during the warm-weather portion of the study, the following changes were made in the testing of the samples collected during the colder weather: The pH was not determined and storage at 55° F. was eliminated.

RESULTS AND DISCUSSION

Milk Temperatures

For milk to have good keeping quality, post-pasteurization contamination must be held to a minimum and bottled milk must be held at low temperatures. Hence, it is the responsibility of the dairy to produce a milk of high bacteriological quality and of the retail store to hold the milk at sufficiently low temperatures to prevent bacterial growth. In collecting samples for this study, an effort was made at each store to choose milk that was least likely to be under good refrigeration; e.g., samples on the floor were chosen over those under refrigeration, and samples from self-service cabinets were taken from the top layer in front when possible rather than from the lower part of the box.

The temperatures of all samples of milk used in this study were determined in the store at the time of collection. They were as follows:

	Number of samples	
Temperature	*Summer*	*Winter*
Below 40° F.	7	14
40° - 45° F.	15	14
46° - 50° F.	7	2
Above 50° F.	1	0

Only one sample of the sixty collected had a temperature above 50° F., the legal limit for milk distribution. This milk, which had a temperature of 50.8° F., was stored on the floor in the back of the store. This was not the only occasion that a poor practice was noticed. Samples of milk were found at times outside of the refrigeration facilities, and in some of the delivery trucks that were examined the milk was neither mechanically refrigerated nor iced. Although some milk deliveries were obviously being mishandled, the temperatures were nevertheless below 50° F. in all but one sample. The reason for the generally good temperatures may be that all samples were collected in the morning, possibly shortly after delivery, and had not been exposed to room temperature long enough for the milk to become warm.

The temperatures of samples collected during the cool weather were substantially lower than those collected during the warm weather. This difference was only partly due to the difference in outside temperature; after the collection of summer samples and before the winter samples were collected, the Chicago Board of Health had increased the frequency of its temperature inspections, causing milk distributors to become more conscious of the importance of proper milk refrigeration.

In a study made in 1948 (29) of the temperatures of milk in the possession of intermediate handlers, 61 percent of the stores had temperatures exceeding the city's prevailing maximum standard of 50° F. In 1953 a limited survey was made of milk temperatures in the stores of two small Pennsylvania communities (4). Although no prevailing milk-temperature standard was given, the survey showed that 8 out of 23 milk samples taken from the front of refrigerated cabinets and 3 out of 21 milk samples taken from the rear had temperatures above 50° F. It could not be concluded from these two studies and the present one that the temperature of milk in stores was improving with the passage of years, but it was clear that the samples checked in the present study were better refrigerated than those previously reported.

Bacterial Counts

Bacterial growth as measured by the standard plate count generally must reach a population of at least 5 million per milliliter to produce definite changes in flavor (18). When tested two days after bottling, the logarithmic average of the standard plate count of the sixty samples studied was only 10,000 per milliliter (Table 1 and Figure 1). The samples stored at 40° F., which is the recommended temperature for the household refrigerator, showed no substantial increase in the standard plate count four days after pasteurization; at

Table 1. — Logarithmic Average Bacterial Counts of Sixty Samples of Pasteurized, Grade A, Homogenized Milk Collected in Summer and Winter of 1957

Type of count	Days after pasteurization	Average bacterial counts		
		Milk stored at 40° F.	Milk stored at 50° F.	Milk stored at 55° F.[a]
			per milliliter	
Coliform	2	1.6	1.6	2.0
	4	1.5	49	160
	6	3.1	570	140,000
Standard plate	2	10,000	10,000	14,000
	4	11,000	21,000	180,000
	6	35,000	1,200,000	37,000,000
Psychrophile	2	16	16	56
	4	97	1,600	110,000
	6	4,000	1,500,000	54,000,000

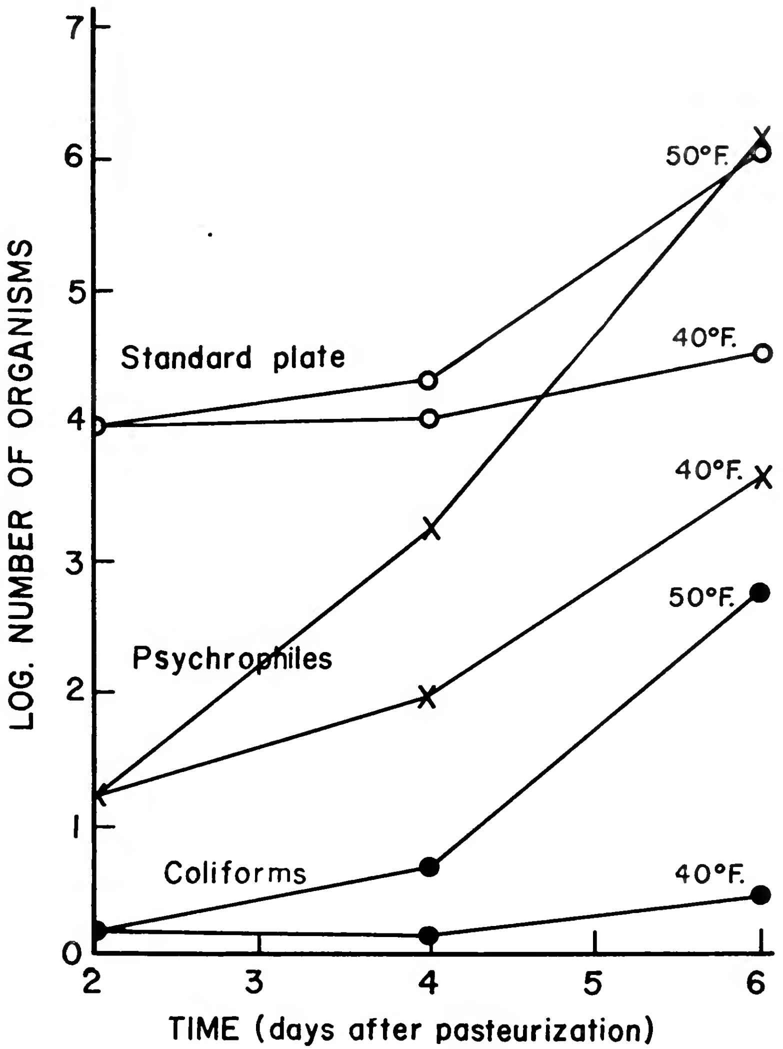
[a] Based only on thirty summer samples.

the end of six days the average number was only 35,000 per milliliter. Six days after pasteurization the increase in coliform bacteria was insignificant, and the average psychrophile count was 4,000 per milliliter.

When the samples were stored at 50° F., which is the maximum temperature allowable for milk distribution, there was an increase in standard plate count to 21,000 per milliliter four days after pasteurization and to 1.2 million per milliliter at the end of six days. Six days after pasteurization the coliform count was 570 per milliliter and the psychrophile count was 1.5 million per milliliter.

Only summer (April to July) samples were stored at 55° F., a temperature admittedly higher than that acceptable for milk storage or distribution. The average standard plate count of these samples four days after pasteurization was 180,000 per milliliter. Six days after pasteurization the standard plate count was 37 million per milliliter, the coliform count was 140,000 per milliliter, and the psychrophile count was 54 million per milliliter.

Effect of storage temperature on rate of bacterial growth. Within the range of storage temperatures tested the rate of growth of bacteria increased with increasing temperature, as would be expected. The importance of low temperatures in reducing the growth of coliform organisms is easily seen in Figure 2, which shows the number of times the coliform count doubled in number (number of generations) with time of storage at the three temperature levels. At 55° F. storage the



Logarithmic mean counts of all sixty samples. Since a storage temperature of 55° F. was used only for summer samples, this temperature was not included in the above graph. (Fig. 1)

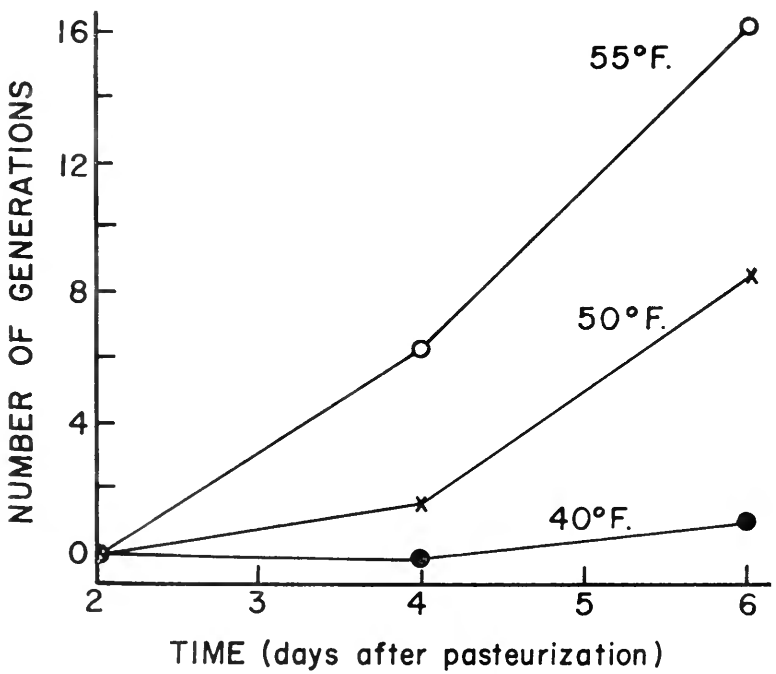
coliform count in six-day milk was over 75,000 times the two-day count, at 50° F. storage it was 294 times the two-day count, and at 40° F. it was less than two times the two-day count.

Comparable plots of the variation of standard plate counts and psychrophilic counts with time and temperature were qualitatively the same as that shown for the coliform counts. In all such plots and at all temperatures the rate of increase was greater between four- and six-day than between two- and four-day storage.

Growth rates in summer milk of the three classes of bacterial counts were calculated by determining the number of generations per day necessary to give the observed increase in counts between two-day and six-day milk. The calculated growth rates were as follows:

Type of count	*Milk stored at 40° F.*	*Milk stored at 50° F.*	*Milk stored at 55° F.*
		(generations per day)	
Coliform	0.2	2.0	4.1
Standard plate	0.6	1.5	2.9
Psychrophile	2.0	3.6	5.1

The growth rates of coliform organisms were the most sensitive to temperature change and those of psychrophiles the least sensitive.



Effect of temperature on the growth of coliforms in milk. Since the 55° F. storage temperature was not used in testing the winter samples of milk, the values of the above graph were determined from the data on summer samples only. (Fig. 2)

Regardless of the storage temperature, psychrophiles were the fastest growing organisms. However, the difference in growth rates between psychrophiles and the other two categories of organisms decreased with increasing temperature.

Rate of growth of coliform and standard plate count organisms. Dahlberg (12, 13) emphasized the relatively rapid rate of growth of coliform organisms at refrigeration temperatures. His results showed that coliforms increase more rapidly than the standard plate counts of milk stored at 35° to 40° F., 45° to 50° F., and 55° to 60° F., with the greatest difference in growth rates at storage temperatures of 45° to 50° F. Nelson and Baker (22), however, observed that the coliform counts of stored milk samples did not increase more rapidly than the standard plate counts. In the milk samples used in the present study the growth rate of the standard plate count organisms was three times the growth rate of the coliform organisms when the samples were stored at 40° F. However, when the samples were stored at 50° or 55° F. the coliform organisms increased more rapidly than the standard plate count organisms, the difference in growth rates being greater at the higher temperature. Presumably, at some temperature between 40° and 50° F. the coliform counts and the standard plate counts increase at the same rate, while below this temperature the standard plate count organisms increase more rapidly and above it the coliform organisms increase more rapidly.

Several investigators of keeping quality have reported a consistent decrease in the standard plate count when milk was stored at 40° F. or lower (11, 12). Although several individual samples in this study showed a slight decrease in count with time when stored at 40° F., the general trend was toward an increased count with longer storage. That this increase was only slight, however, is clearly shown in Figure 1. Only one sample stored for six days at 40° F. had a standard plate count sufficiently high to be reasonably suspected of affecting the acceptance quality of the milk; nevertheless, this particular sample received a satisfactory flavor score of 37.7.

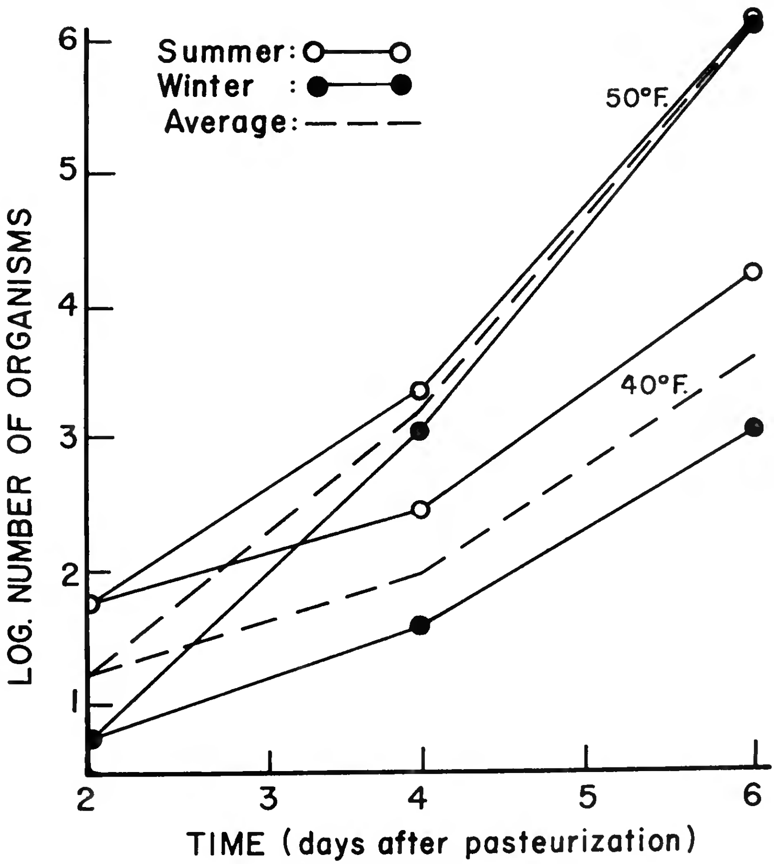
Growth of psychrophiles. As mentioned earlier and illustrated in Figure 1, psychrophiles were the fastest growing of the three kinds of organisms. Previous studies have shown that the organisms roughly classified as psychrophiles were of primary importance in limiting the keeping quality of milk (8, 10, 24, 26, 27). These organisms are thought to enter milk as post-pasteurization contaminants (23, 26, 27) and, although present in small numbers in freshly pasteurized milk, they often rapidly replace the mesophilic flora (2, 20). Despite the importance of psychrophilic organisms in the keeping quality of milk, their determination in freshly pasteurized milk cannot successfully be employed as a test for keeping quality (5, 7). The subject of psychrophilic micro-organisms in milk was recently reviewed by Thomas (28).

The results of this study agreed with the findings of other investigators. Psychrophilic organisms were found to be present in two-day milk in relatively small numbers and the logarithmic average of all samples was 16 per milliliter. In six-day milk stored at 50° F. or 55° F. the average psychrophilic counts were greater than the standard plate counts. In six-day milk stored at 40° F. the psychrophilic count was rapidly approaching the standard plate count. Twenty of the summer samples were stored at 40° F. until 10 days after pasteurization and tested in the usual manner. In only two of these ten-day milks was the standard plate count higher than the psychrophilic count, but both milks were of exceptionally good bacteriological quality. Samples that showed a high initial psychrophilic count invariably were of poor keeping quality, but an initially low count was no criterion of good keeping quality.

Effect of season on bacterial counts. The relation of the psychrophilic counts of summer and winter samples to storage time and temperature is shown in Figure 3. Coliform counts or standard plate counts could have been used in place of psychrophilic counts in Figure 3 to illustrate the seasonal difference of the milk samples, since all the results were qualitatively the same. Hence, the following discussion, exemplified by Figure 3, is equally valid and applicable to all three types of count.

The count on two-day milk was higher for the summer samples. The contaminating organisms in milk stored at 40° F. grew at approximately the same rate in both winter and summer milk samples and differed only in the initial level of contamination. When samples were stored at 40° F. the count on six-day milk was a reflection of the count obtained on two-day milk. The contaminating organisms in milk stored at 50° F. grew more rapidly in the winter than in the summer milk samples. Hence, when samples were stored at 50° F. the count on six-day milk was not a reflection of the difference in initial count. Since no tests were run in an attempt to explain why the summer samples had a higher bacterial count for two-day milk than the winter samples or why organisms should, when stored at 50° F., grow more rapidly in winter milk than in summer milk, any explanation would merely be conjecture.

Although the initial bacterial counts and the rate of bacterial growth appeared to be related to season of the year, the effect of season on the keeping quality of milk was not as striking as that of temperature and length of storage period. However, other investigators have found that summer milk had a superior keeping quality (8, 10, 16). A difference in bacterial flora was offered as a possible explanation for these observations. Boyd, Smith, and Trout (8) have reported that the difference in keeping quality of summer and winter milk was accentuated by a reduction in storage temperature, which was the reverse of the results found in the present study.



Relation of psychrophilic counts to season. (Fig. 3)

Flavor Scores

The average flavor scores of all samples are summarized below. A score of less than 35.0 is considered unsatisfactory.

Days after pasteurization	*Milk stored at 40° F.*	*Milk stored at 50° F.*	*Milk stored at 55° F.*
2	37.4	37.4	37.4
4	37.4	37.1	36.8
6	37.0	36.1	32.8

Again the importance of storage temperature is apparent. When samples were stored at 40° F. no change in flavor score was found between the two-day and four-day tests and only a slight decrease in flavor score was noted on the six-day test. Samples stored at 50° or 55° F. received progressively poorer flavor scores with increased storage, and the samples stored at 55° F. had an unsatisfactory flavor after six days. Although the average flavor score for the two-day milk samples was 37.4, actually 65 percent of the samples had a flavor score superior to this average value.

Since a standard plate count or psychrophilic count of 5 million per milliliter or greater might reasonably be expected to result in detectable changes in milk quality, the samples were evaluated on this basis. None of the samples stored at 40° or 50° F. had bacterial counts of 5 million per milliliter four days after pasteurization. Of the samples stored for six days at 40° F., only one had a count in excess of 5 million per milliliter and this particular sample had a flavor score superior to the average flavor score of the two-day milk samples. On the sixth day of storage at 50° F., 45.5 percent of the samples had bacterial counts in excess of 5 million per milliliter, but only 39 percent of these were considered to have an unacceptable flavor score. With storage at 55° F., on the sixth day 96 percent of the samples had bacterial counts in excess of 5 million per milliliter and 70.9 percent of these were considered to have an unacceptable flavor score.

Quite clearly, in some milk samples the high bacterial counts had not resulted in an unsatisfactory flavor score. Equally true was the fact that in a number of samples with unsatisfactory flavor scores the bacterial content was not responsible. One sample of six-day milk was judged unacceptable because of an unclean flavor, a criticism usually associated with bacterial growth, but this sample had a coliform count of 1 per milliliter, a standard plate count of 750 per milliliter, and a psychrophile count of 5 per milliliter. In a large number of tests the high or low flavor score assigned to the sample was difficult to resolve in terms of bacterial content.

The criticisms of "cooked" or "feed" were applied to 65 to 70 percent of the milk samples, regardless of the temperature or time of storage. Neither of these criticisms was considered to be due to bacterial growth. In two-day milk the next most frequent criticisms were "rancid" and "oxidized," and in six-day milk they were "unclean" and "high acid."

Boyd, Smith, and Trout (8) concluded that the deterioration of flavor was closely associated with the growth of psychrophilic bacteria in all samples. In the present study flavor deterioration was not necessarily associated with the growth of psychrophilic bacteria. In order to show a firm relation between psychrophilic counts and flavor score one should observe a low flavor score in each sample having a high psychrophilic count and, conversely, a high psychrophilic count for each sample having a poor flavor score. The ratios of the number of samples having both high psychrophilic counts (greater than 5 million per milliliter) and low flavor scores (less than 35) to the number having either a high psychrophilic count or a low flavor score were 0/11, 9/27, and 17/23 for six-day milk stored at 40°, 50°, and 55° F., respectively.

Other Observations

Change in pH. A reduction in pH greater than 0.1 unit was observed only in six-day milk stored at 55° F. The samples that showed a drop in pH all had very high bacterial counts and unsatisfactory flavor scores. However, some samples of six-day milk stored at 55° F. had bacterial counts in the hundred millions and received unsatisfactory flavor scores but showed no change in pH. Measurement of the pH of the samples supplied virtually no information on how the milk might have been changing during storage. Consequently this test was not used on the samples collected during the winter months.

Percentage of butterfat and solids-not-fat. Two-day milk was tested for butterfat and total solids with the Mojonnier tester, and the solids-not-fat was calculated as the difference between the two. Chicago requires that milk contain not less than 3.25 percent butterfat and not less than 8.5 percent solids-not-fat. The average butterfat content of the summer samples was 3.60 percent, but the calculated average solids-not-fat was only 8.33 percent. Duplicate samples had been collected by representatives of the Chicago Board of Health at the same time and same place as the samples used in this study and had been tested by them. They employed the Babcock method to determine the butterfat content and the lactometer method to determine the solids-not-fat content. The average solids-not-fat calculated from their data was higher than the required standard of 8.5 percent.

In an effort to evaluate the discrepancy in the results of the two solids-not-fat tests, single quarts of milk from twelve different dairies were purchased from stores in Chicago and the solids-not-fat content was determined by both the lactometer and the Mojonnier methods. The average solids-not-fat content of these twelve milks was 8.6 percent by the lactometer method and 8.47 by the Mojonnier test. Such variations in the solids-not-fat content determined by any two of the many dozens of available methods have been repeatedly reported (9, 19, 30, 31). Since the solids-not-fat content of the 12 quarts as determined by the Mojonnier test was consistently below that determined by the lactometer method, both methods were used on all samples collected during the winter. The fat and solids-not-fat contents of winter samples determined by the Mojonnier method were 3.45 and 8.49 percent, respectively. The fat content determined by the Babcock method and the solids-not-fat calculated by the lactometer method were 3.46 and 8.63 percent, respectively.

From a regulatory standpoint, the solids-not-fat content of milk is used primarily as a presumptive test for the adulteration of milk with water. Such an adulteration was not indicated in any of the samples collected for this study. Also, for milk in the Chicago market, a required solids-not-fat content of 8.5 percent might not be too realistic a standard since a large percentage of the herds supplying milk are Holstein cows, whose milk is known to be consistently low in solids-not-fat (3, 17).

SUMMARY AND CONCLUSIONS

Sixty samples of homogenized Grade A milk, consisting of a total of 360 quarts, and representing the output of thirty Chicago plants, were collected from stores and delivery trucks in Chicago in the summer and winter of 1957. Parts of each sample were stored at temperatures of 40°, 50°, or 55° F. until two, four, or six days after pasteurization, and were then examined for the following: coliform count, standard plate count, psychrophilic count, flavor, pH, and percentage of fat and total solids. The purpose was to determine if

Chicago milk could maintain a good keeping quality at a reasonable temperature (40° or 50° F.) for at least five days.

Of the sixty samples collected, only one had a temperature at the time of collection that exceeded the legal limit of 50° F.

Samples stored for two days (at variable temperatures in the retail stores for one day and at 40° F. at the University of Illinois for one day) had low logarithmic average bacterial counts: 1.6 coliforms per milliliter, 10,000 standard plate count organisms per milliliter, and 16 psychrophiles per milliliter.

Milk stored for four days had the following average standard plate counts per milliliter: 11,000 when the milk was stored at 40° F., 21,000 when stored at 50° F., and 180,000 when stored at 55° F.

After six days of storage, the milk samples had the following average bacterial counts per milliliter:

(a) When stored at 40° F.: 3.1 coliforms, 35,000 standard plate count organisms, and 4,000 psychrophiles.

(b) When stored at 50° F.: 570 coliforms, 1.2 million standard plate count organisms, and 1.5 million psychrophiles.

(c) When stored at 55° F.: 140,000 coliforms, 37 million standard plate count organisms, and 54 million psychrophiles.

Only six-day milk stored at 55° F. had bacterial counts high enough (above 5 million per milliliter) to be reasonably expected to result in detectable changes in the quality of the milk.

The rate of increase of psychrophilic and standard plate counts in milk stored at 40° F. was roughly one-half that of the rate of increase in milk stored at 50° F. The growth rate of coliform organisms was the most sensitive to temperature change and that of psychrophiles the least sensitive.

Standard plate counts increased more rapidly than coliform counts in milk stored at 40° F., but coliform counts increased more rapidly than standard plate counts at 50° F. and even more rapidly at 55° F.

Psychrophiles were the fastest growing organisms at each temperature level. Present in two-day milk in relatively small numbers, the psychrophilic count in six-day milk averaged more than the standard plate count when stored at 50° and 55° F. and was rapidly approaching the standard plate count when stored at 40° F.

Samples collected in the summer had a higher bacterial count for two-day milk than those collected in the winter. Summer milk and winter milk increased in bacterial counts at about the same rate when stored at 40° F. When stored at 50° F., the bacteria in winter milk increased more rapidly than those in summer milk. However, season apparently was not as important as temperature and length of storage period in affecting the keeping quality of milk.

Milk judged for flavor two days after pasteurization received an average score of 37.4. Increased storage periods and temperatures were accompanied by lower flavor scores, with six-day milk receiving the following average flavor scores: 37.0 for milk stored at 40° F., 36.1 for milk stored at 50° F., and 32.8 (considered unsaleable) for milk stored at 55° F. High bacterial counts did not always result in a low flavor score, and low scores were not all due to high bacterial counts. Most frequent criticisms of the samples were: feed, cooked, oxidized, rancid, high acid, and unclean.

Some of the samples of six-day milk stored at 55° F. showed a decrease of 0.1 pH unit or more. However, measurement of the pH of the samples supplied virtually no information on how the samples might have been changing during storage.

An examination of the butterfat and solids-not-fat content of the samples produced no indication that any of the milk had been adulterated with water.

The results of this study indicate that Chicago milk is of high bacteriological quality and that it can be stored for at least five days at 40° to 50° F. without serious bacterial deterioration taking place. Storage of milk at a temperature of 55° F. was found unsatisfactory for good keeping quality.

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