A STUDY OF SOME OF THE FACTORS AFFECTING THE QUALITY AND KEEPING QUALITY OF PASTEURIZED-HOMOGENIZED MILK ON THE LUBBOCK, TEXAS RETAIL MARKET

A THESIS

IN DAIRY INDUSTRY

by

PRESTON DEATON RIGSBY

Approved

Texas Technological College

May, 1955

AEF-4241

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Submitted to the Graduate Faculty
of Texas Technological College
in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF SCIENCE

by

Preston Deaton Rigsby, B. S.

Lubbock, Texas

May, 1955

ACKNOWLEDGEMENTS

This writer wishes to express his sincere appreciation to Dr. J. J. Willingham, Head of the Department of Dairy Industry, for his interest, valuable suggestions, and aid in scoring of samples; to Dr. W. H. Cloninger for his interest in the problem and suggestions on presentation; to Dr. J. Wayland Bennett for his suggestions on composition and presentation of the data; to Mr. Milton L. Peeples and Mr. Robert L. Hicks for their aid in scoring samples; and to LaRuth Rigsby for her valuable suggestions on presentation.

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INTRODUCTION

The fact that quality is of prime importance in all types of dairy products is widely accepted. This quality not only must be present in the product initially, but also must be maintained for a reasonable length of time after the product is in the hands of the consumer.

Milk, "the most nearly perfect food," supplies an excellent medium for certain forms of microbiological life which tends to decompose the milk. With the trend of the dairy industry to fewer plants and larger volumes of processing, milk does not reach the consumer as soon after production as did the milk delivered by the local dairyman of the past. Milk must be transported further with longer waiting periods before pasteurization than milk that is processed in the small local plant.

These changes required improved methods of handling to reduce the rate of milk spoilage. Modern methods of handling milk, with vastly improved methods of pasteurization, refrigeration, and transportation have greatly enhanced the keeping quality of the product. These improved methods of handling milk have been to provide the consumer with a wholesome, palatable, and most important, tasty product. The consumer depends upon regulatory officials to insure the wholesomeness of the product, but the consumer is the final (and probably the most critical) judge of the tastiness of the product. Therefore, the problem of keeping quality, as well as initial quality becomes important to the dairy industry.

Conditions under which milk is produced vary greatly with geographic areas. Research conducted in other areas is not directly applicable to Lubbock and the South Plains area. A study of some of the factors affecting quality and keeping quality in the local area was thought to be of value. This project was set up as a practical research problem to study some of these factors under local conditions.

REVIEW OF LITERATURE

The quality of milk, as well as other dairy products, has probably received more investigation than any other phase of dairy industry research. The literature available pertaining to milk quality is voluminous. Literature pertaining directly to the phase of milk quality studied in this work is not nearly so abundant.

Dahlbert (7) reported that milk in the New York Metropolitan area which was stored at 35-40 degrees F., had an average flavor score of 37.9 after one week of storage. Milk was collected at the milk plant and showed no criticism, or a score of 40 when the milk was two days old. In the same work, Dahlberg reported that milk stored at 35-40 degrees F. had a tendency to hold a constant coliform count, with definitely no increase from one to four days. When the milk was stored at 45-50 degrees F., the increase in coliform count was slow, but significant. In a later report, Dahlberg (8) found that at 45-50 degrees F. the coliform counts increased more rapidly than did the total bacterial counts. He attributes the greater coliform growth to the possibility that coliform organisms present are active recontaminants and are more capable of accelerated growth than are the organisms that have survived the temperature shock of pasteurization. In the later report, Dahlberg (8) also reported a slight increase in coliform counts when stored at 35-40 degrees F.

Olson *et al.* (19) found that pasteurization is effective in the destruction of coliform and psychrophilic bacteria. Samples that were pasteurized at 162 degrees F. for 16 seconds showed no coliform organisms present, almost negative psychrophilic count, and a relatively constant total plate count. However, upon examination of the finished product, they found that the psychrophilic count increased from 26 at one day to 9,600,000 in seven days. However, the significant increase was not present until the milk was five days old. The total plate count did not greatly increase until five days of storage, and coliform growth was not significant. This would indicate that significant growth of bacteria up to five days of storage is a result of post-pasteurization contamination.

The initial quality of milk determined the rate of bacterial growth according to Chaffee (6). After 120 hours of storage, bacterial counts did not increase appreciably on high quality milk, but did increase significantly on poor quality milk. Burgwald and Josephson (5) supported this theory in reporting that good quality milk would retain good flavor and bacterial qualities at least six or seven days in the winter, and at least four days in the summer. They also reported that total bacteria counts had little effect on the keeping quality of milk, but psychrophilic bacteria played an important role in the deterioration of milk stored in the refrigerator.

According to a report by the National Institute of Dairying,(13) bacteria counts and coliform counts were found unreliable as a definite means of assessing the keeping quality of milk. This same report also pointed out the unreliability of the resazurin and methylene blue tests for predicting the keeping quality of milk.

Andrews and Kaufmann(2) found that psychrophilic bacteria did not survive pasteurization by the High Temperature Short Time (HTST) method. They concluded that psychrophiles present in milk, which had been pasteurized by the HTST method, were post-pasteurization contaminants. According to Lawton and Nelson, (14) psychrophilic organisms make a significant contribution to the Standard Plate Count (SPC) when the plates were incubated at 32 degrees C. or below. They also found that some of the organisms present would multiply at a temperature of five degrees C. If the raw milk supply was contaminated with 1,000 of these organisms per ml this number could increase to as much as 10 million per ml after three to four days of holding.

Atherton *et al*. (3) observed that organisms surviving test-tube pasteurization of milk, and held at temperatures of 45 degrees F. or below for periods up to 15 days, exhibit little or no tendency to increase. If the temperature is 50 degrees F. or above, the growth will show a marked increase. In the same report it was found that freshly bottled samples of commercial milk, which had been exposed to recontaminants, showed a progressive increase in bacterial population, even when the samples were held at 40 degrees F. This was especially true when the plates were incubated at 32 degrees C. or under. Although the bacteria counts increased rapidly, the flavor score decreased slowly. The first perceptible indication of milk deterioration seemed to be a decrease in the stability of the casein.

Boyd *et al*. (4) found the average keeping quality of commercially pasteurized and homogenized milk stored at 40 degrees F. to be 13 to 18 days. This was based on a 37 plus flavor score. The keeping quality was 8 to 11 days, based on a 40,000 per ml bacterial standard. When the storage temperature was lowered to 33 degrees F., the average keeping quality of the milk was extended another 11 to 14 days. It was further observed that standard plate, coliform, and/or psychrophilic counts on freshly pasteurized milk were found to be of little value in predicting keeping quality. This was found to be true at either 40 or 33 degrees F. They attributed this to the possibility that the organisms causing spoilage are present in freshly pasteurized milk in such small numbers that these tests do not detect them accurately.

A positive coliform test is generally considered to mean that the milk was contaminated after pasteurization, according to a report by Weber (20). This contamination might be from improperly washed or improperly sterilized equipment, or milk equipment that was contaminated from the air, water, insects, rodents, or humans. On rare occasions, a positive test might be due to improper pasteurization, particularly if the raw milk by-passes the pasteurization operation. He concluded that the important fact is that if the coliform organisms gained entrance to the pasteurized milk, the portals were open for the entrance of more dangerous organisms. Hammer (12) found that the Escherichia-Aerobacter organisms always are undesirable in dairy products. In milk and cream, in addition to forming gas and acid, they produce a variety of objectional flavors.

Delay (9) suggested that milk processing plants should set an ultimate goal of not more than one per cent of bottled samples being positive to the coliform test. He observed that well equipped plants, without exceeding the limits of practicability, could submit bottled samples of which less than one per cent would be positive to the coliform test.

Wilson and Weiss (24) found that the ability of different strains of coliform organisms to grow at such a wide range of temperatures makes the coliform test inaccurate as a quality test for milk. They found that coliforms would grow at a range of 50 degrees F. to 98 degrees F. Except for milk that was under refrigeration at temperatures below 50 degrees F., coliform populations would increase rapidly, which would indicate a low quality product. Although coliform are not pathogenic, they are very closely related to species of bacteria which are pathogenic. According to a report by Weckel (21) these related species include the typhoid and dysentery organisms. Weckel further pointed out that the presence of coliforms denotes post-pasteurization contamination, since all organisms of the coliform group are killed by proper pasteurization.

Nelson and Baker (15) reported that coliforms would increase at 58 degrees F., and often at lower temperatures. Incubation at 32 degrees F. will result in detection of all high count samples, but will often result in lower counts on milk with initial low counts.

The preceding reports would tend to discredit the value of both total counts and coliform counts as a basis for predicting the keeping quality of milk. This information would support the well known fact that a high total count does not necessarily mean a poor sample of milk, nor does a low total count indicate a good quality sample of milk.

Weese and Henderson (22) conducted a survey of home-refrigerated milk in which 207 samples of milk were delivered to the homes in the normal manner. At intervals of three and seven days old, samples for testing were collected by taking portions of the milk from containers as the milk was found in the home. At three days old the average flavor score was 38.0; 83.3 per cent showed no increase in acidity; and no samples showed a great increase in acidity. At seven days old, the average flavor score of the milk was 34.1; only 8.3 per cent showed no increase in acidity, and 33.3 per cent showed a great increase in acidity. Bacterial growth was not significant for three days, but after seven days, all samples showed a great increase in bacteria counts.

The literature just reviewed indicates that under conditions similar to those in the research conducted, bacteria counts would not increase sharply until after five days, but would tend to increase rapidly by the seventh day. It also indicates that coliform growth is not too significant, especially when the milk was under refrigeration below 40 degrees F. However, if the milk was refrigerated at a temperature above 50 degrees F., and often between 45-50 degrees F., the coliform growth was significant, even to the extent that on occasions the coliforms dominated the flora.

According to Nicholas and Anderson (18) care or treatment of the samples will enter into the keeping quality of milk. Pasteurized or pasteurized-homogenized milk with initial bacterial counts of 1,000 to 94,000 per ml kept an average of 17.2 days when stored at 40 degrees F., but when the samples were removed and shaken daily, the samples kept for only 10 to 14 days. The difference in the keeping time of the milk could be attributed to the agitation resulting in redistribution of the bacteria throughout the milk; thereby the clumps of bacteria which had become sluggish because of over population would take on new vigor and be very active in reproduction. This increase in bacteria counts would eventually offer more possibility for deterioration.

Doetsch and Scott (10) reported that there is no appreciable difference in quality of milk in a bottle and milk in a paper carton.

According to a report by Nelson (16) feed flavor is the most common flavor defect found in milk. This flavor can be eliminated by feeding the cows a sufficient length of time before milking. Enright (11) reported that objectional odors and off-flavors may cause consumers to turn away from dairy products for a long time; and that they must be controlled to get maximum milk consumption.

EXPERIMENTAL PROCEDURE

PART I

Samples were obtained by purchasing milk at a local self-service super market, except for one brand of milk that was not thus available. Samples were purchased from an open-top, refrigerated case, except for the brand that was not available in the super market, but was available in a closed, refrigerated case. Quart paper cartons of pasteurized-homogenized milk were selected. On occasions when quart paper cartons of a brand were not available at the place of purchase, half-gallon paper containers were substituted. Samples were selected at random, with no consideration to the age of the milk at the time of purchase.

Immediately after the samples were purchased, they were taken to the laboratory, Dairy Industry Department, Texas Technological College, for preparation. The milk from each plant was labeled A, B, C, D, and E. Five portions were taken from each sample and placed in 100 ml dilution bottles, which had been previously sterilized in a stream autoclave at 15 pounds of steam pressure for 20 minutes. The portions were placed in a domestic type refrigerator at 42 degrees F. for storage. The remaining milk, after the test samples had been prepared for storage, was used as the fresh sample for testing.

The first samples were purchased on Tuesday, September 2[illegible], 1954, and each Tuesday thereafter for four weeks. Sampling was started again on Tuesday, November 30, 1954, and each Tuesday thereafter for four weeks. The last four weeks of testing was started on Tuesday, February 1, 1955, and each Tuesday thereafter for four weeks, with the last samples collected on February 28, 1955.

Tuesday was chosen as the day of the week for collecting samples. A local custom of giving a bonus of savings stamps on Tuesday has created a much larger volume of grocery buying on this particular day. According to an interview with an executive of a local firm with several outlets in this area, in excess of 40 per cent of the groceries sold in their stores are sold on Tuesday. This would not indicate that 40 per cent of the milk sold in this area, or at least in that firm's stores, was sold on Tuesday. However, the percentage of total sales on Tuesday would indicate that the potential customers are present, and in all probability the volume of milk sales on this day would be in excess of those of any other day in the week.

EXPERIMENTAL PROCEDURE

PART II

After each sample was divided into five testing samples, the following tests were conducted: flavor and odor, total bacteria count, coliform count, and acidity. The remainder of each sample was then discarded. At intervals of one, two, three, seven and 14 days, one testing sample was opened and the same four tests were conducted. After testing was completed, the remainder in each instance was discarded; thus, the possibility of outside contamination was held to a minimum since the bottles were originally sterile and were opened immediately before testing.

The flavor and odor scores, along with the criticisms were determined by the staff in the Dairy Industry Department. These scores are based on the score assigned to flavor and odor on the Milk Educational Score Card which was compiled and published by the American Dairy Science Association. The assigned values on the score card are as follows: flavor 45 points, with no criticism assigned to a score of 40 or above; sediment 10 points; container and closure five points; bacteria 35 points; and temperature five points.

Total bacteria counts were made by plate counts on Tryptone-Glucose-Extract agar, with dilutions of 1/100, and 1/1,000, according to Standard Methods (1). Coliform determinations were made by plating one ml of milk direct on desoxycholate agar, and incubating the plates for 24 hours.

Acidity was determined by titrating nine ml of milk with 0.1N NaOH, using Phenolphthalein as indicator.

EXPERIMENTAL RESULTS

The results of the flavor and odor scores, hereinafter referred to as flavor score, as assigned by the staff of the Department of Dairy Industry, are presented in Table I. Of the 12 samples tested under Sample A, the average flavor score when fresh was 38.0. Sample A showed a slow, but constant decrease in score throughout the first and second day of storage. By the third day the average flavor score had dropped from 36.9 to 32.4. After seven days of storage the flavor score dropped to 27.3, and at the end of two weeks the average flavor score was only 9.0. Table II (Sample A) shows the number of times that Sample A scored 35 or above on flavor on a percentage basis. In 91.67 per cent of the tests Sample A scored 35 or above. This percentage was maintained throughout the first day of storage. By the second day of storage, Sample A scored 35 or above only 83.33 per cent of the time, 66.65 per cent on the third day, 58.33 per cent after seven days, and only 16.67 per cent after 14 days.

Sample B (Table I) had an average score of 38.9 when fresh. The decrease in score was very slight throughout seven days of storage. This decrease is represented by a drop of only one point, from 38.9 to 37.9. The decrease in flavor score was greatly accelerated during the second seven days of storage. The decrease was 24.0 points, or a drop represented by a flavor score of 37.9 at seven days of storage to a score of 13.9 after 14 days of storage. All the test samples of Sample B scored 35 or above during the first seven days of storage (Table II).

Table I. **Average Flavor and Odor Scores of all Samples When Fresh And After One, Two, Three, Seven, and 14 Days of Storage.**

Sample:	Fresh	One day	Two days	Three days	Seven days	14 days
A	38.0	37.3	36.9	32.4	27.3	9.0
B	38.9	38.3	38.5	38.4	37.9	13.9
C	38.2	38.0	37.4	37.2	34.1	23.7
D	38.7	38.1	37.9	37.5	36.2	14.9
E	38.6	38.5	37.9	37.6	36.7	7.6

Table II. **Per Cent of Samples Scoring 35 or More on Flavor and Odor on Fresh Samples and After One, Two, Three, Seven, and 14 Days of Storage.**

Sample	Fresh	One day	Two days	Three days	Seven days	14 days
	Per Cent					
A	91.67	91.67	83.33	66.67	58.33	16.67
B	100.	100.	100.	100.	100.	24.67
C	91.67	91.67	91.67	91.67	83.33	58.33
D	100.	100.	100.	100.	91.67	33.33
E	100.	100.	100.	100.	100.	20.0

The decrease in flavor score during the second seven days of storage resulted with only 24.67 per cent of the test samples of Sample B scoring 35 or above.

Sample C had an average initial flavor score of 38.2, which decreased consistently to 37.2 after three days of storage (Table I). Between the third day of storage and the seventh day of storage, the flavor score dropped from 37.2 to 34.1. The decrease in flavor score during the second seven days of storage was 10.4 points, or an average of 23.7. Table II shows that during the first three days of storage, 91.67 per cent of the test samples of Sample C scored 35 or above. After seven days of storage 83.33 per cent of the test samples of Sample C scored 35 or above, and the percentage dropped to 58.33 per cent after 14 days of storage.

Sample D dropped consistently from an initial average flavor score of 38.7 to 36.2 after seven days of storage (Table I). The average flavor score then dropped to 14.9 after 14 days, or a drop of 21.3 points during the second seven days. Table II shows that all test samples of Sample D scored 35 or above during the first three days of storage, with a drop to 91.67 per cent after seven days. After 14 days of storage, the percentage dropped to 33.33 per cent scoring above 35.

Table I shows a drop in flavor score of not more than 0.9 of a point during any one interval of testing of Sample E during the first seven days of storage. The average flavor score dropped from an initial 38.6 to 36.7 after the first seven days. This consistency in score is shown in Table II, which shows that all test samples of Sample E scored 35 or above during the first seven days of storage. However, after 14 days of storage, the average flavor score (Table I) had dropped to 7.6, and the percentage scoring 35 or above (Table II) had decreased to only 20 per cent.

Table III shows the average acidity in per cent by samples. The per cent acid increased steadily in the case of Sample A after a slight decrease after the first day of storage. Sample B also showed a consistent increase after a slight decrease at the one day interval; although the increase was not as much as the increase in the case of Sample A. Sample C had a relatively high initial acidity as compared to the other samples, but showed no increase throughout the first three days of storage, and showed a total increase in average acidity of only 0.015 per cent. Sample D had an average initial acidity of 0.171 per cent, which was the lowest of all samples. This low average was maintained throughout the first three days of storage, but a substantial increase in acidity was evident by the seventh day. The average acidity continued to increase during the second seven days of storage. The average acidity of Sample E increased substantially between the second and third day interval of testing, and maintained an increase throughout testing.

The growth of coliform organisms is shown in Tables IV, V, VI, VII, VIII and IX. All samples maintained a relatively constant coliform count the first day of storage (Tables IV and V). By the second day of storage, the percentage of samples with 10 or less coliforms began to decrease, and the percentage of samples with coliform counts of over 300 began to increase (Table VI). The trend toward a decrease in samples with 10 or less per ml, and an increase in counts of over 300 per ml is

Table III. Average Per Cent Acidity of All Samples When Fresh and After One, Two, Three, Seven, and 14 Days Storage.

Sample	Fresh	One day	Two days	Three days	Seven days	14 days
	Per Cent					
A	0.178	0.175	0.180	0.189	0.210	0.333
B	0.172	0.170	0.173	0.175	0.176	0.218
C	0.177	0.176	0.176	0.176	0.180	0.192
D	0.171	0.172	0.174	0.175	0.184	0.215
E	0.173	0.173	0.178	0.181	0.186	0.213

Table IV. Per Cent Distribution of Average Coliform Counts on Fresh Samples.

	Coliforms per Ml				
Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Per Cent				
A	75.0	0.0	0.0	0.0	25.0
B	50.0	25.0	16.67	8.33	0.0
C	91.67	8.33	0.0	00.0	0.0
D	91.67	0.0	0.0	0.0	8.33
E	90.0	10.0	0.0	0.0	0.0

Table V. Per Cent Distribution of Average Coliform Counts After One Day Storage.

Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Coliforms per Ml				
	Per Cent				
A	75.0	0.0	0.0	0.0	25.0
B	50.0	8.33	16.67	16.67	8.33
C	91.67	8.33	0.0	0.0	0.0
D	91.67	0.0	0.0	0.0	8.33
E	80.0	10.0	10.0	0.0	0.0

Table VI. Per Cent Distribution of Average Coliform Counts After Two Days Storage.

Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Coliforms per Ml				
	Per Cent				
A	66.67	8.33	0.0	0.0	25.0
B	25.0	8.33	16.67	8.33	41.67
C	83.33	8.33	0.0	0.0	8.33
D	91.67	0.0	0.0	0.0	8.33
E	80.0	10.0	10.0	0.0	0.0

Table VII. Per Cent Distribution of Average Coliform Count After Three Days Storage.*

	Coliforms per Ml				
Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Per Cent				
A	75.0	0.0	8.33	0.0	16.67
B	25.0	16.67	0.0	0.0	50.0
C	75.0	0.0	8.33	0.0	8.33
D	91.67	0.0	0.0	0.0	8.33
E	60.0	10.0	0.0	0.0	20.0

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table VIII. Per Cent Distribution of Average Coliform Counts After Seven Days Storage.*

	Coliforms per Ml				
Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Per Cent				
A	58.33	0.0	0.0	0.0	41.67
B	16.67	8.33	0.0	8.33	66.67
C	58.33	16.67	8.33	0.0	16.67
D	91.67	0.0	0.0	0.0	8.33
E	50.0	20.0	0.0	0.0	30.0

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table IX. Per Cent Distribution of Average Coliform Counts After 14 Days Storage.*

Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Per Cent				
A	50.0	0.0	0.0	0.0	41.67
B	16.67	0.0	0.0	0.0	83.33
C	41.67	16.67	0.0	0.0	41.67
D	75.0	8.33	0.0	8.33	8.33
E	30.0	10.0	0.0	0.0	50.0

Coliforms per Ml (column headings)

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table X. Per Cent Distribution of Average Coliform Counts on All Samples When Fresh and After One, Two, Three, Seven and 14 Days Storage.*

Sample	0 to 10	11 to 50	51 to 100	101 to 300	Over 300
	Per Cent				
Fresh	79.30	8.62	5.17	1.72	5.17
1 Day	77.68	5.17	5.17	3.45	8.62
2 Days	68.96	6.90	5.17	1.72	17.24
3 Days	65.61	5.17	3.45	0.0	20.69
7 Days	55.17	8.62	1.72	1.72	32.94
14 Days	43.10	6.90	0.0	1.72	44.82

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

shown in Tables VII and VIII; except for Sample A, Table VII, which shows an increase in the range of 10 or less per ml, over Sample A, Table VI. The coliform count ranges of the 14 day old samples are shown in Table IX.

A summary of coliform counts of all samples is shown in Table X. 79.30 per cent of the fresh samples had coliform counts of 10 or less per ml, 8.62 per cent had from 11 to 50, 5.17 per cent had from 51 to 100, 1.72 per cent had from 101 to 300, and 5.17 per cent had over 300 per ml. After 14 days of storage, 43.10 per cent had 10 or less per ml, 6.90 per cent had from 11 to 40, 1.72 per cent had from 101 to 300, and 44.58 per cent had over 300 per ml. It should be pointed out that 30.96 per cent of the samples were negative to the coliform test when fresh, and remained negative throughout testing.

The results of the Standard Plate Counts (SPC) were recorded in Tables XI, XII, XIII, XIV, XV, and XVI by samples, with each table representing a testing interval. As is indicated in each table, each testing interval produced higher SPC counts as the samples became progressively older. Sample C (Table XI) had initial SPC of 20,000 or less per ml in all test samples when fresh. After seven days of storage, only Samples B, C, and D had test samples with 20,000 bacteria. All test samples of Sample E had SPC of over 300,000 after seven days of storage. After 14 days of storage, no test samples had SPC in the range of 20,000 or less. Samples A, B, and E show all test samples over 300,000 SPC, with Samples C and D having 83.33 per cent over 300,000 SPC. A summary of all Standard Plate Counts is shown in Table XVII.

Table XI. Per Cent Distribution of Average Standard Plate Counts on Fresh Samples.

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Organisms per Ml				
	Per Cent				
A	58.33	0.0	0.0	8.33	33.33
B	75.0	16.67	8.33	0.0	0.0
C	100.0	0.0	0.0	0.0	0.0
D	75.0	8.33	0.0	0.0	16.67
E	70.0	20.0	0.0	0.0	10.0

Table XII. Per Cent Distribution of Average Standard Plate Counts After One Day Storage.*

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Organisms per Ml				
	Per Cent				
A	33.33	0.0	0.0	0.0	50.0
B	33.33	33.33	0.0	8.33	16.67
C	91.67	8.33	0.0	0.0	0.0
D	41.67	8.33	8.33	8.33	16.67
E	50.0	10.0	10.0	10.0	10.0

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table XIII. Per Cent Distribution of Average Standard Plate Counts After Two Days Storage.*

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Organisms Per Ml				
	Per Cent				
A	33.33	0.0	0.0	0.0	50.00
B	33.33	0.0	0.0	16.67	25.0
C	75.0	0.0	8.33	0.0	0.0
D	8.33	33.33	8.33	8.33	25.0
E	10.0	0.0	20.0	20.0	30.0

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table XIV. Per Cent Distribution of Average Standard Plate Counts After Three Days Storage.*

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Organisms Per Ml				
	Per Cent				
A	8.33	0.0	25.0	8.33	50.0
B	25.0	0.0	8.33	8.33	58.33
C	25.0	8.33	16.67	8.33	25.0
D	0.0	16.67	8.33	16.67	41.67
E	20.0	10.0	0.0	0.0	70.0

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table XV. Per Cent Distribution of Average Standard Plate Counts After Seven Days Storage.*

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Per Cent				
A	0.0	8.33	8.33	8.33	75.0
B	8.33	0.0	0.0	0.0	91.67
C	16.67	8.33	8.33	0.0	58.33
D	8.33	0.0	0.0	8.33	75.0
E	0.0	0.0	0.0	0.0	100

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

Table XVI. Per Cent Distribution of Average Standard Plate Counts After 14 Days Storage.

Sample	Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Per Cent				
A	0.0	0.0	0.0	0.0	100
B	0.0	0.0	0.0	0.0	100
C	0.0	8.33	8.33	0.0	83.33
D	0.0	8.33	8.33	0.0	83.33
E	0.0	0.0	0.0	0.0	100

Table XVII. Per Cent Distribution of Average Standard Plate Count on All Samples When Fresh and After One, Two, Three, Seven, and 14 Days Storage.*

Sample	Organisms Per Ml: Less Than 20,000	20,000 to 50,000	50,000 to 100,000	100,000 to 300,000	Over 300,000
	Per Cent				
Fresh	75.86	58.62	1.72	1.72	12.07
1 Day	50.00	12.07	3.45	5.17	18.96
2 Days	32.94	10.34	6.90	8.62	25.82
3 Days	15.52	12.07	6.90	8.62	48.27
7 Days	6.90	3.45	3.45	3.45	79.30
14 Days	0.0	3.45	3.45	0.0	93.1

*Difference between reported percentages and 100 per cent for each sample includes laboratory accidents and plates that could not be counted accurately.

DISCUSSION

The results show that the milk on the Lubbock, Texas retail market has an average flavor score of 38 to 39. The flavor scores decrease about 0.5 of a point a day for about the first three days when the milk is stored in a domestic type refrigerator. After three days of storage the flavor score decreases more rapidly, depending upon the initial quality of the milk.

The initial acidity of the milk on the local market is slightly above 0.17 per cent. This acidity stays relatively constant throughout the first three days of storage. The decrease in acidity which is shown in Table III is probably due to the loss of acid reacting gases which were lost during the pouring of the samples into the test sample bottles for storage. This loss in acidity was present after only one day of storage. No decrease in acidity was found during subsequent acidity tests. Only in the case of one sample did the average acidity increase to a point that would indicate sour milk after seven days of storage.

The results show that there is a relationship between the increase in acidity and the flavor score. Sample A showed the greatest increase in acidity, beginning with the second day of storage. By comparison, the average flavor score had dropped to 36.9 after the second day of storage. This drop in flavor was continued, and after three days of storage the average flavor score was 32.4. This drop in flavor score was accompanied by an increase in acidity of 0.009 per cent.

After seven days of storage, Sample A had an average flavor score of 27.3, or another decrease of 5.1 points. This decrease was accompanied by an increase of 0.021 per cent in average acidity. The average acidity after 14 days of storage was 0.333 per cent, and was accompanied by an average flavor score of 9.0. The relationship between increase in acidity and decrease in flavor score, in the case of Sample A, was maintained by the percentage of samples scoring 35 or above. After two days of storage, 83.33 per cent of the test samples scored 35 or above. The decrease in flavor score resulted in only 66.67 per cent of the test samples scoring 35 or above after three days of storage, 58.33 per cent after seven days, and 16.65 per cent after 14 days.

Sample B showed no large increase in acidity after seven days of storage. By comparison, the average flavor score was 37.9 after seven days of storage, or a decrease in flavor score of one point with an increase in average acidity of 0.004 per cent. However, during the second seven days of storage, the average acidity increased 0.042 per cent, while the flavor score decreased 24 points. On a basis of per cent, 100 per cent of the test samples of Sample B scored 35 or above during the first seven days of storage, but this percentage dropped to only 24.67 per cent after 14 days of storage.

Sample C showed no increase in acidity during the first three days of storage. In the interval between three and seven days, the acidity increased 0.004 per cent. During the second seven days of storage, the increase in acidity was 0.012 per cent. The flavor score decreased one point during the first three days of storage, but decreased another 3.1 points by seven days, and decreased another 10.4 points during the second seven days of storage. The calculated per cent of samples scoring 35 or above was 91.67 per cent during the first three days of storage. This percentage dropped to 83.33 per cent after seven days, and to 58.33 per cent after 14 days. In comparison with the other samples tested, Sample C represents the highest average score, the highest percentage of samples scoring 35 or above on flavor, and the lowest increase in acidity during the 14 days of storage.

Sample D shows a relationship between the flavor scores, the increase in acidity, and the percentage of samples scoring 35 or more, which is almost identical to the relationship of the same factors in Samples A, B, and C. The increase in acidity was slight during the first three days of storage, but became more pronounced after seven days, and during the second seven days. All of the test samples of Sample D scored 35 or more during the first three days of storage, 91.67 per cent at seven days, and 33.33 per cent after 14 days.

The flavor scores of Sample E, along with the percentage of samples scoring 35 or more was again very similar to the other samples. However, the increase in average acidity started at the second day interval of testing, but did not increase as rapidly as did the acidity in the case of Sample A, which resulted in an average acidity after 14 days of storage, which was similar to Samples B, C, and D. The final flavor score was the lowest average. All of the test samples scored 35 or above on flavor during the first seven days of testing, with the significant drop in score being present during the second seven days.

A study of the coliform counts does not reveal a definite relationship to the deterioration of the milk in storage. Sample A provided the most test samples with an initial coliform count of more than 300 per ml, but after 14 days of storage 40 per cent of the test samples had 10 or less per ml. Sample B produced the highest percentage of coliform counts at the end of 14 days with 83.33 per cent, and maintained the highest averages throughout testing. However, Sample B showed a much better keeping quality. This was evidenced by an average flavor score of 37.9 at the end of seven days of storage in the case of Sample B, while Sample A had an average score of only 27.3 at the end of seven days. The high percentage of the test samples of Samples C, D, and E, which had 10 or less coliforms, might be a factor in their keeping quality. The fact that the keeping quality of Sample B compared very favorable with Samples C, D, and E, would indicate that the presence of coliforms is not a definite detriment to the keeping quality. Certainly, a low coliform count does indicate efficient pasteurization and reasonable protection against post-pasteurization contamination. The absence of coliforms does indicate a quality factor, but this work does not indicate a definite relationship between coliforms and flavor scores.

As is indicated in the coliform tables, the results did show that the coliforms present were able to grow at a storage temperature of 42 degrees F. Of the 79.30 per cent of the fresh samples which had 10 or less coliforms per ml, 55.17 per cent had 10 or less after seven days of storage. These percentages include 30.96 per cent of the samples that were negative to the coliform test throughout testing. It should also be noted, that when the coliform counts exceeded 10 per ml, they rapidly increased to above 300 per ml. This growth may be due to the fact that the coliforms present had not survived pasteurization, but were recontaminants, which were capable of immediate accelerated growth.

An irregularity occurred in a few instances during the coliform testing. The plates would have a heavy growth, but the colonies did not have the color which is characteristic of positive coliform colonies. This heavy growth was accompanied by a complete bleaching of the dye from the agar, leaving a semi-transparent appearance similar to the TGE agar used for the Standard Plate Counts. It might be presumed that the coliform growth was so heavy that all the dye was utilized by the growing bacteria, but the next days testing produced heavy growth, with the colonies containing the typical dye, which would identify them as positive colonies.

A comparison of the Standard Plate Counts to the flavor scores fails to show a definite relationship. Sample A had the greatest percentage of test samples with SPC over 300,000 per ml on fresh testing. Sample B had more test samples with SPC of over 300,000 by the third day of storage than did Sample A, and continued to have the greater percentage after seven days of storage. The keeping quality of Sample A did not compare favorable with the keeping quality of Samples C, D, and E. However, the data shows that Sample B did compare favorably with the keeping quality of Samples C, D, and E. It should be noted that Sample C maintained the lowest SPC averages throughout testing, and had the highest average flavor score after 14 days of storage, also the greatest percentage of samples scoring 35 or above after 14 days of storage. This would indicate that the total bacteria counts are a factor in the keeping quality, but cannot be used as a basis for predicting the keeping quality.

The results do show that the bacteria present in the samples tested will grow at the storage temperature of 42 degrees F. This growth might be attributed to several factors: (1) Post-pasteurization contaminants may have been present and had the ability to dominate the flora since they had not been subjected to the temperature shocks in pasteurization. (2) After leaving the refrigerated storage of the milk plant, a temperature low enough to prevent bacterial growth may not have been maintained, thus allowing the bacteria that had survived pasteurization a chance to regain initial vigor. (3) The temperature in the milk cases in the grocery stores may not have been kept constant. These factors might also affect the growth of coliforms.

SUMMARY

Between September 28, 1954 and February 28, 1955, 58 samples of milk were purchased through grocery stores in Lubbock. Flavor scores, acidity, coliform counts and total bacteria counts were determined on fresh samples, and after one, two, three, seven, and 14 days of storage at 42 degrees F.

The fresh samples of milk had an average flavor score of 38 to 39. The average flavor score decreased at each interval of testing. The average acidity increased at each interval of testing, with the exception of a slight decrease in some instances after the first day of storage. It was found that a definite relationship existed between the increase in average acidity, and the decrease in average flavor score. A slow, but general rise in acidity resulted in a slow decrease in flavor score. When the development of acidity accelerated, the decrease in flavor score also accelerated.

Most of the samples had coliform counts of 10 or less when tested fresh. Of all samples tested, 30.96 per cent were negative to the coliform test throughout testing. The coliforms present showed an ability to grow at the storage temperature of 42 degrees F. No definite relationship was found to exist between coliform counts and keeping quality.

Total bacteria counts were found to be generally below 20,000 per ml when the samples were fresh. In most instances the bacteria were capable of growth at the storage temperature, and by seven days of

storage almost all the SPC were over 300,000 per ml. No definite relationship was found to exist between the SPC and the keeping quality, but in one instance the sample with the highest average SPC of over 300,000 per ml at initial testing had the smallest percentage of samples scoring 35 or over after seven days of storage. Also, the sample with the smallest percentage of test samples with SPC of over 300,000 after 14 days of storage had the highest percentage of samples scoring 35 or over on flavor for the same interval.

Both the coliform counts and the SPC increase during storage, especially the SPC. The total growth in neither case appeared to be sufficient to affect the keeping quality.

CONCLUSIONS

The keeping quality of milk on the local market, ascertained by a flavor score of 35 or above, does not compare too favorably to the results of similar work in other areas. Coliform organisms are present in a large percentage of milk. Bacteria show an ability to grow, indicating either post-pasteurization contamination or irregular refrigeration temperatures. The acid produced by the bacteria is detrimental to the keeping quality of the milk.

The results indicate a need for the plants selling milk on the local market to check for possible scores of post-pasteurization contamination.

This writer believes that a record of refrigeration temperatures in the stores, and control samples obtained from the milk plants should be included in a further study of this problem.

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