The problem of sediment in milk and its effect on the resulting end product has been discussed and written about for many years. There has been, however, differences of opinion within the dairy industry as to the part this plays in the quality of dairy products.

Marquardt (2) in 1944 found in New York that when more than 25 percent of the milk received contained excessive amounts of sediment, an unclean flavor was developed in a mixed tank of milk. This according to numerous observations took place in less than six hours even when the milk was cooled and held at 40°F, or below. Marquardt also studied the relationship of sediment to flavor and discovered that there was a correlation. He found that over 55 percent of samples were unclean at three plants before the clean-up program, and this was reduced to less than 19 percent after the program was started. Marquardt stated, “The average flavor score before the program was 19.9, and after the program 21.2. A score of 20.5 was the average of all of the cleanest milk before the program; this value was increased to 21.6 after the clean-up.” His work also showed that ageing milk at 70°F for four to six hours decreased the flavor score of dirty milk more than it did in the case of the clean milk. His data revealed that clean milk kept better than dirty milk, and pasteurization did not materially change the flavor scores.

Jensen and Jokay (1) stated, “Even under the finest conditions of pipeline milk production, some sediment will find its way into milk. Filtration is desirable to remove the sediment particles as rapidly and completely as possible.” They also stated, “Filtering media served useful purposes in revealing care in milking practices and abnormal appearing milk.”

The objective of the study reported herein was to determine the relationship between extraneous matter in milk supplies and the quality of aged cheddar cheese made therefrom. The milk supply selected was one where there were large producers so that it would take relatively few producers to produce a ten thousand pound vat of milk each day.

**Procedures**

The milk used in this project was produced in a northeastern state and was approved for use as fluid milk in one of the large metropolitan areas. The entire milk supply delivered in cans to the receiving plant (except the milk from individual patrons delivering their own milk) was used in this study.

**Preliminary Survey**

Each patron of the receiving plant was contacted and data was collected as to: filter media, type and condition of strainers, type of cleaners, type of bactericides and milk stone removers, number and type of milking machines, hot water heaters, wash tanks, other equipment, and use of antibiotics. Also, general observations were made as to over-all sanitation and housekeeping in effect on the farms.

**Division of Patrons**

The patrons were divided into two groups:

1. Experimental—Each patron in this group was instructed in the production of clean milk, taught proper filtration methods and how to use the disk as a check on the cleanliness of the milk, and the milking practices.

2. Control—These patrons continued to produce milk without benefit of an educational program.

The milk from the Experimental and Control groups was kept separate at the receiving plant and the milk from each group was made into cheddar cheese for ageing.

**Sediment Tests**

Off-the-bottom sediment tests at the start of the project were made every day on approximately one-half of each patron’s cans in the Experimental group and once a week on a like number of cans from the Control group. The sediment on each disk was scored according to the American Public Health Association Official Milk Standards of 1953 (5). The cans of milk that had 2.0 and over milligrams of sediment were rejected for use in the experimental cheese. For discussion and simplicity, 0.0 to 0.5 milligrams of sediment will be designated as Class 1, 1.0 milligrams as Class 2 and 2.0 milligrams and over as Class 3 or reject milk.

The used filter media from the Experimental herds were picked up at various intervals for the purpose of measuring progress on clean milk production.
Experimental and Control Milk

Three routes consisting of 36 patrons were used as the Experimental group and the other five routes, consisting of 63 patrons, as the Control group. The milk from the Experimental group was pumped directly from the weigh can to an upright tank in the cheese plant, mixed, and made into cheddar cheese for aging using general commercial practice. The control milk was treated in a like manner.

Forty pound blocks of cheese were saved from each of the Experimental and Control vats of cheese and aged with the remainder of the cheese from those vats. The aging of the cheese was supervised by experienced personnel at a commercial cheese warehouse.

Results

Sediment Tests

The preliminary survey of the 102 farms selling milk to the receiving plant showed that 63.5 percent were using 7 and 8 inch flannel squares, 29.8 percent were using double faced disks, 6.7 percent were using single faced and plain disks. Ten different makes of milking machines were used. Only 29 patrons had hot water in the milk house, but all of the patrons had mechanical milk coolers. There were 109 strainers, and of these, 39 were good, 49 fair and 21 in poor condition. Eighteen different cleaners were used, which included scouring powder and a cake-type cleaner. Five different bactericides were used and only ten patrons used milk stone remover. Antibiotics were freely used and generally were administered by the patron.

Plant sediment records were studied on the milk delivered during January and February, 1956, before the project began. This was done to get a picture of the sediment content of the milk supply. This information is shown in Figure 1. These tests were taken by plant personnel with a hand sediment tester. The data show that 95.5 percent of the sediment disks had zero sediment and only 0.4 percent (2 cans) were rejected for sediment over the eight-week period.

To confirm these results as nearly as possible, trained technicians took sediment tests of the milk from the same patrons with an approved automatic tester. These technicians also graded the disks. Figure 3 shows the results of eight weekly tests from March to June. It will be noted when Figure 2 is compared with Figure 1 there is a different picture of the sediment content of the milk from the same patrons. There were very few zero sediments and appreciable more samples with 2.0 milligrams and over. It must be pointed out that the weather and season may have been factors to increase the sediment content in the milk shown on Figure 2. Experience has shown, however, that if sediments are taken and read correctly, there should be very few zero sediment test disks.

During March, April and May, sediment tests were taken weekly on all patron’s milk. All the sediment tests taken in this study except those used in preparing Figure 1 were taken and read by trained technicians. The results of these tests for March and

Figure 1. Sediment Tests Taken and Graded by Plant Personnel January and February, 1956.

Figure 2. Sediment Tests Taken by Trained Technicians (Eight Weekly Tests, March to June, 1956)

Figure 3. Comparison of Sediments of the Experimental and Control Groups Before Program Started. (March and April, 1956)
CLEAN MILK FOR AGED CHEDDAR CHEESE

April are shown in Figure 3. The similarity of the two groups in sediment content is very striking. This was before any work was done with the Experimental group. Similar results were obtained from the tests made in May.

All Experimental patrons were changed on June 6, 1956, to 6½" Single Faced Rapid-Flo Fibre-Bonded Filter Disks and were taught proper methods for filtering the milk; also, they were instructed in methods of clean milk production and in the use of the filter disk as a check-up for sediment. During the months of June and July, sediment tests were taken every day on the Experimental group and once a week on the Control group. Sediment tests were taken of as many cans from each patron as possible with one automatic sediment tester without slowing the dumping of the milk. This averaged about one-half of the cans received. If the sediment in the milk of any Experimental patron exceeded 2.0 milligrams, the milk was diverted and was not used in the Experimental cheese. Also, the producer was contacted to find out why the milk was high in sediment and necessary changes were made to produce clean milk.

Figure 4 shows the comparison of the sediments of the two groups during June and July, after the Experimental group had been changed from the filter media they were using. This graph shows the results of sediment tests immediately after the change of filter disks were made and after instructions were given in methods of clean milk production. The Experimental group had 95.8 percent of the milk in Class 1 (0.0-0.5 mg) as compared to 81.0 percent of the Control. There was only 1.4 percent of the Experimental as compared to 10.1 percent of the Control milk in Class 3 (2.0 mg and over).

In August, September and the first part of October, sediment tests were taken of every can of milk every day in the Experimental group and every can of milk in the Control group once a week.

Figures 5, 6 and 7 give the comparisons of the daily sediments of every can of milk in the Experimental group and the weekly sediments of every can of milk in the Control group, for a period of nine weeks from July 24 to October 10. The data for three graphs was taken from 16,303 sediment tests.

Figure 5 shows how consistent the low sediment tests were in the Experimental milk, and the irregularity of these in the Control milk. This Figure also reveals that sediment in milk can be controlled by proper instruction of patrons in methods of clean milk production, in correct filtration of the milk immediately after milking, and in checking the used filter disk for sources of possible extraneous matter and making necessary corrections.

Figures 6 and 7 show the 2 and 3 sediment classes, respectively, of the milk in both groups over the 9 week period. These show the low number of cans of sediments of
milk that had large amounts of sediment from the Experimental, while the Control group had many more cans of milk consistently in the higher sediment classes.

If all of the milk containing 2.0 mg and over of sediment had been rejected from June to October 13, there would have been 99,760 pounds of the Control milk as compared to only 6,192 pounds of the Experimental milk.

**Other Tests**

During the course of the experiment, other tests were made on the milk and cheese. Isolation and counts of the enterococci was made on 54 vats of cheese (27 vats on each of the Experimental and Control). The reason for making these counts was to determine if the cheese from the two groups of milk would be significantly different in count. Certain investigations have indicated that the presence of large numbers of this group of organisms was associated with the development of inferior cheese when aged. The medium and the procedure used for plating and isolation of the enterococci was that of Reinbold *et al.* (3).

The counts of enterococci ranged from 14 million to 540 million per gram of cheese. There was no correlation between the numbers of organisms and the flavor score of the aged cheese.

A curd test was made on 186 vats of milk. The test used was a modification of the Wisconsin Curd Test (4) and was designed to give an indication of the quality of milk for cheese making. The procedure used was as follows:

1. The milk was taken from the cheese vat in a sterile wide mouth 16 oz. mason jar after the milk had ripened and the rennet had been added.
2. After the curd had set, the jar was rotated gently to break it from the sides of the jar.
3. The contents were heated to 100° - 101° F. until a
greenish color appeared in the whey.
4. The curd was then cut with a clean spatula into small pieces about ½” and cooked for one-half to one hour at 100° - 104° F.
5. After cooking, the whey was poured off every 20 to 30 minutes from 3 to 5 times. The curd was turned with a clean spatula at each pouring of the whey.
6. After the whey stopped draining freely, the curd was incubated at 98° - 100°F. overnight.
7. The next morning the odor of the curd was checked as the jar was opened and the curd was cut with a sharp knife and graded as follows:
   - No. 1—Firm body, close texture, good lactic aroma.
   - No. 2—Slight gas, slight defective texture.
   - No. 3—Gas, weak body, off odor.
   - No. 4—Very gassy, yeasty, spongy, soft body, off odor.

There were 63 vats of the Experimental milk and 123 vats of the Control milk tested by the curd test.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percent of Experimental Vats</th>
<th>Percent of Control Vats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85.7</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>14.3</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>21</td>
</tr>
</tbody>
</table>

The results of the modified curd test as shown in Table 1 definitely indicated that the Experimental milk was better from the standpoint of the presence of gas and off-odors that developed during overnight incubation at 98° to 100°F.

Odor tests on the milk from individual herds were taken throughout the experiment. The milk samples were taken from the weigh tank after all of the milk from a patron had been dumped. The samples were taken with a long handled 20-ml. dipper which had been rinsed in warm water and then dipped into a 200 ppm. chlorine solution. These samples of milk were put into sterile screw top test tubes and incubated at 45° to 48°F. for five days. The samples were then warmed to 80° to 85°F., shaken and smelled. The odor tests were made to give another indication as to the quality of the milk. Also, by using low temperature, selective development of psychophilic organisms, many of which cause off-flavor in milk such as fruity, putrid, stale and rancid, was obtained.

Table 2 indicates the various odors found in the milk from individual herds in the Experimental and Control groups. There were 2,019 samples of milk tested. The data on the Experimental group is divided into two periods. The first period (May 13-July 1)
covered milk that was produced before and just a short time after the change in filter disks was made and after instructions were given in the production of clean milk. The second period (July 4-October 18) covered the time the Experimental patrons were definitely on the program of producing clean milk. Milk samples from the Control group were taken on the same day as those from the Experimental. The data show that there was a 17.1 percent increase in the satisfactory samples (Experimental) during the second period; also, there was an increase of 3.8 percent in the sour samples which had no other off-odor. There was a decrease in the putrid and fruity odors of 5.1 percent. The barny and cowy odors decreased from 20.6 to 10.9 percent. Part of this reduction may have been due to the cows being on pasture. Furthermore, the comparison of the milk from the two groups revealed that the Control group had 17.9 percent less samples in the satisfactory class and had 7.4 percent more samples having putrid and fruity odors than the Experimental group during the same period. There were 8.7 percent more cowy and barny samples in the Control than in the Experimental milk.

**Quality of the Aged Cheddar Cheese Made from Experimental and Control Milk**

The final scoring of the cheese, by three experienced judges, was made after it was from ten to fifteen months old. The following criteria were used in the scoring: 36.5 or less was off; undesirable flavor; 37 to 38—slight off-flavor; 38.5 to 41—clean desirable cheese flavor.

Figures 8 and 9 show the percentage of vats of cheese having flavor scores of 38.5 and over and less than 37, respectively. There were 130 Experimental vats and 285 vats of Control aged cheese graded. During the month of May, 1956, samples of cheese were made from all the producers milk and were scored at 15 months of age to give an indication of the quality of cheese made before the program started. The percentage of cheese which scored less than 37 and which

<table>
<thead>
<tr>
<th>Odor</th>
<th>May 13 to July 1</th>
<th>July 4 to Oct. 18</th>
<th>July 4 to Oct. 18</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. samples</td>
<td>Per. cent</td>
<td>No. samples</td>
</tr>
<tr>
<td>O. K.</td>
<td>394</td>
<td>56.4</td>
<td>531</td>
</tr>
<tr>
<td>Putrid</td>
<td>84</td>
<td>12.0</td>
<td>67</td>
</tr>
<tr>
<td>Fruity</td>
<td>24</td>
<td>3.4</td>
<td>13</td>
</tr>
<tr>
<td>Feed</td>
<td>13</td>
<td>1.9</td>
<td>6</td>
</tr>
<tr>
<td>Cowy</td>
<td>72</td>
<td>10.3</td>
<td>30</td>
</tr>
<tr>
<td>Barny</td>
<td>72</td>
<td>10.3</td>
<td>46</td>
</tr>
<tr>
<td>Bancid</td>
<td>7</td>
<td>1.0</td>
<td>3</td>
</tr>
<tr>
<td>Sour</td>
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<td>4.2</td>
<td>62</td>
</tr>
<tr>
<td>Medicine</td>
<td>3</td>
<td>0.4</td>
<td>5</td>
</tr>
<tr>
<td>Malty</td>
<td>1</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>Musty</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>699</td>
<td></td>
<td>799</td>
</tr>
</tbody>
</table>
would be undesirable as far as flavor was concerned was 26.7; the percentage of cheese which scored 38.5 and above was 26.6 (Figure 8). For the month of June, the Experimental had 41.9 percent and the Control had 44.2 percent of the vats of cheese in the clean, desirable cheese flavor class (Figure 8). In July when the clean milk program had definitely been established with all of the Experimental producers, the picture changed from practically the same quality aged cheese in both groups to 73.3 percent of the Experimental cheese scoring 38.5 and over in flavor while the Control cheese showed nearly the same percentage having this score the previous month. In August, the Experimental had 87.1 percent of the cheese in the no criticizable off-flavor class while the Control aged cheese had 49.9 percent. The September and October cheese was ten and eleven months old when it was scored and had been aged at 35°F. Whether or not the cheese would have developed more off-flavor if it had been forced at the end of the aging period, as the rest of the cheese was, is not known. No satisfactory explanation can be given as to why the Control cheese increased from 49.9 to 90.2 percent during this period. It is known, however, that forcing the ripening of cheese at higher temperatures often brings out flavors in aged cheese that are not apparent in cheese not forced.

Figure 9 shows the percentage of cheese from the two groups that scored less than 37 in flavor score and was considered to be undesirable.

In June, before the clean milk program had started in its entirety, the Experimental had 25.8 percent of the cheese in the undesirable flavor class while the Control had only 14.7 percent. Then in July, the two groups had practically the same percentage in this class. For August, September and October, there was no Experimental cheese in the undesirable flavor class while the Control cheese had 17.6 percent.

SUMMARY AND CONCLUSIONS

A study of milk approved for fluid use was made in a northeastern state to determine if clean milk would improve the quality of aged cheddar cheese.

A preliminary survey of the 102 patrons selling milk to the receiving plant showed that 63.5 percent were using 7" and 8" flannel squares for straining the milk. Ten makes of milking machines were used. Hot water heaters were used by only 29 patrons. Eighteen different cleaners were used including common household scouring powder and cake-type cleaner. Antibiotics were used freely and generally were administered by the patron.

Preliminary plant data revealed that 95.5 percent of the cans of milk had 0.0 milligrams of sediment during January and February, 1956. Tests taken later by trained technicians showed only very few cans of milk from the same patrons had zero sediments and the milk had a much higher sediment content than previous tests had indicated.

The patrons were divided into two groups—Experimental and Control. The Experimental group was given an educational program on clean milk production, while the Control group continued to produce milk without benefit of such a program. A comparison of sediment tests on milks from the Experimental and Control groups before the program was started showed very little difference in the sediment content of the milk.

After the Experimental patrons were instructed on clean milk production, were provided with 6/8" Single Faced Rapid-Flo Fibre-Bonded Filter Disks, and were taught to use the disks to detect and control sources of sediment, a marked decrease occurred in the sediment content of the Experimental milk. The sediment content in the Control milk fluctuated and was significantly higher during the experiment.

The data on every can sediment tests over a nine week period showed how consistent the low sediments were in the Experimental milk and the irregularity of these in the Control milk. The data also revealed that sediment in milk can be controlled by proper instruction to the patron on correct filtration of the milk immediately after milking, and in using the used filter disk for detecting and controlling sources of sediment.

Over 24,000 off-the-bottom sediment tests were taken by trained technicians during a period of nine months for this study.

Enterococci counts showed only four Experimental vats of cheese higher in count than the Control cheese. There was no correlation between the counts and the quality of the aged cheese.

A curd test on the vat milk from the two groups indicated that the milk used for the Experimental cheese was of higher quality than that used for the Control cheese.

There were 2,019 odor tests made on patrons' milk during the experiment. The Control milk samples had less satisfactory odors and substantially more putrid, fruity, cowy and barny odors than the Experimental samples.

The final grading of cheese made from these milks was scored at the age of ten to fifteen months by three experienced judges. The flavor scores showed that the cheese from the two groups was practically the same during June before the entire program was started with the Experimental group. The Experi-
mental cheese had 41.9 percent in the 38.5 and over class (no criticizable off-flavor) and the Control 44.2 percent. In July and August, the Experimental cheese had 73.3 and 87.1 percent, respectively, in this class while the Control remained practically the same (44.3 and 49.9 percent). The cheese criticized for undesirable flavor and scoring less than 37 showed that in June the Experimental cheese had 25.8 percent to only 14.7 percent for the Control cheese. In July the cheese from both groups had practically the same number of vats in this undesirable flavor class. For August, September and October, there was no Experimental cheese scored with an undesirable flavor while the Control had 17.6 percent.

Acknowledgements

The authors wish to acknowledge the assistance given by Mr. A. M. Cheney, Jr., Mr. R. L. Oliver and Mr. G. M. Jones of Johnson & Johnson for helping with the sediment testing and supervision of the Experimental patron, also the filter Products Division of Johnson & Johnson for supporting and making this project possible.

References


Changes in the pH and the Reduced Ascorbic Acid Content of Milk Held for Every-Other-Day Pick-Up in Farm Bulk Milk Tanks

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(Received for publication April 18, 1958)

Since the bulk system of handling milk was first introduced, a practice commonly referred to as every-other-day pick-up has been adopted in many producing areas. This is used primarily to reduce transportation costs by combining milk routes and increasing the pay load of tank trucks.

When this system of milk pick-up is used, the milk is held in the farm tank from 36 to 48 hours. During this time warm milk is mixed with cooled milk as the milk from each subsequent milking is added to the holding tank. Usually, the contents of the holding tank are agitated during the cooling period after each milking. These treatments may cause various physical and chemical changes in the milk.

Sommer (9) stated that sudden changes in holding temperatures of milk cause variations in the pH equilibrium. Rapp (7) reported that raw whole milk held at 5°C. for 48 hours showed a rise in pH from 6.54 to 6.76.

The changes in temperature and periods of agitation may have an effect on the ascorbic acid content of the milk. Holmes (4) found that raw whole milk stored in darkness in a closed container, at 10°C. for 96 hours showed a 64 percent loss of reduced ascorbic acid. Hand (3) showed that bottled whole milk stored in a refrigerator at 1°C. for a 6-day period lost 60 percent of the ascorbic acid originally present.

This study was undertaken to determine the changes in pH and reduced ascorbic acid content of milk held in farm milk tanks over a 36-hour period during which time the warm milk was added after each successive milking, stirred and cooled to the appropriate temperature.

Procedures

The studies were made with one 200-gallon and one 150-gallon direct expansion refrigerated farm bulk milk holding tank at the University of Wisconsin Dairy Farm. Both of these rectangular tanks were equipped with mechanical agitators mounted vertically in the center of the tank. The agitator motors were wired so that when the refrigeration compressor was operating during the cooling phase the agitator was in motion.

The agitator motors could be switched to manual control for independent operation. The agitator in the 200-gallon tank was designed with two 12-inch