PIPELINE-MILKER AND BULK-TANK MILK FILTRATION

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The filtration efficiency of various materials used in pipeline filters showed that the best filtration was secured using bonded non-woven cotton discs, followed in order by flannel fabric, muslin fabric, and flannel fabric after use in four milkings. However, bag filters of flannel and muslin gave inadequate filtration. The tests were made using a milk flow splitting apparatus, dividing milk equally between two kinds of filter materials, and by measuring the number and size of sediment particles found in one square centimeter areas of Lentine sediment testing discs after drawing samples from bulk tanks. Best uniformity in numbers of particles was secured when testing one gallon portions.

Pipeline milking installations as an accessory to bulk milk tanks are increasing. Filtration of the milk is a part of the system. The effectiveness of such filtration is not generally known. The study reported herein was made to determine the practicality of various filters for pipeline milkers and to ascertain the milk filtering ability of three different kinds of filter material used. No previous study concerning these filtering problems has been reported.

Filtering milk produced by pipeline milking systems must be confined to some kind of in-line filter. Three kinds of milk filter systems, using several kinds of filtering material are available. These include: (a) cylinder, with woven fabric bag; (b) dome, with non-woven fabric disc; and (c) a unit filter either with a disc or with a non-woven square fabric wrap.

Most research shows that filtering of milk does not improve its keeping properties. However, Marquardt (3) reported deterioration in flavor quality with retention of dirt in milk. Other important reasons exist for removing sediment. Sommer (4) directs attention to a "natural and decent impulse to remove dirt promptly, if any finds its way into milk" and to the use of sediment testing as a criterion of milk quality.

The 1953 edition of the U. S. Public Health Service "Milk Ordinance and Code" (5) states: "When milk is strained, strainer pads shall be used and shall not be reused." The code further states: "... in order to maintain products of high quality, it is recommended that each plant or receiving station make tests of each producer's milk, including odor, temperature... sediment" and that "tests should be made monthly or often, and plants should reject milk of abnormal odor... or milk found unsatisfactory by... sediment tests. Follow up inspections should be made... to discover and correct the cause."

Filtering media serve useful purposes in revealing care in milking practices and abnormal appearing milk. Some types of filter media or filtering units make it possible to observe the amount and nature of materials removed from milk better than others. A clean and effective filter unit should indicate that no extraneous material or abnormal milk entered the milk supply.

Filtering efficiency is measured by the completeness of extraneous matter removal, which, in turn, is indirectly related to the speed of straining. As a rule, speed of milk filtration increases directly with the size of the openings of the filtering material. However, completeness of filtration increases as the size of the openings become smaller. Dahlberg and Marquardt (1) found that the largest particle of sand which could pass through a milk filter was 30 to 40 microns in diameter. Thus, they concluded the filter pore size should be somewhat smaller than those dimensions. Also, these investigators observed that filter pores size became plugged with fat when the openings were minute, for example, the size of fat globules (10 to 12 microns).

PROCEDURES

Milk from the university dairy barn pipeline milker was filtered using three kinds of filters; (a) the unit filter, (b) the bag cylinder, and (c) the dome filter with disk. Filter (a) was located in the milk tube near the claw of the milking machine and filters, (b) and (c) were in the pipe near the bulk tank. Filters in the unit filter consisted of a fibre-bonded non-woven fabric square, those in the cylinder of a 56 x 56 thread count muslin bag weighing 3.6 ounces per square yard, or a 46 x 42 thread count flannel bag weighing 4.1 ounces per square yard; whereas those in the dome filter were of fibre-bonded, double faced gauze non-woven fabric in disc form. The bag and unit filters, encased in cylinders, were so connected that the milk entered the filter bags through the outer wall. The single filter-disc used in the dome filter was supported by a multi-perforated stainless steel plate, with the milk flowing downward to the holding tank. Each of the filters was tested alone.

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1Michigan Agricultural Experiment Station General Article No. 8057.
2Presently employed by Quartermaster Food & Container Institute, 1819 Pershing Road, Chicago 9, Illinois.
TABLE 1 - THE EFFICIENCY OF VARIOUS FILTERS IN REMOVING SEDIMENT FROM PIPELINE, BULK-TANK MILK.

<table>
<thead>
<tr>
<th>No. of trials</th>
<th>Kind and method of using filter material</th>
<th>Amounts of sediment taken from filtered bulk milk when various quantities were tested.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Non-woven disc</td>
<td>0.5 qt., 1.0 qt., 2.0 qt., 3.0 qt., 4.0 qt.</td>
</tr>
<tr>
<td>0</td>
<td>Flannel bag only</td>
<td>5 8 9 12 17</td>
</tr>
<tr>
<td>3</td>
<td>Used flannel bag only</td>
<td>35 71 98 242 275</td>
</tr>
<tr>
<td>11</td>
<td>Muslin bag only</td>
<td>26 42 77 88</td>
</tr>
<tr>
<td>7</td>
<td>Non-woven disc in dome and non-woven square in unit-filter</td>
<td>8 9 12 15 29 35</td>
</tr>
<tr>
<td>3</td>
<td>Flannel bag and non-woven square in unit-filter</td>
<td>16 15 26 29</td>
</tr>
</tbody>
</table>

*Number of particles per sq. cm. on standard 1.25 inch Lintine sediment discs.

Table 1 shows the efficiency of various filters in removing sediment from pipeline, bulk-tank milk. The table lists various trials and filter materials along with the amounts of sediment taken from filtered milk. The amounts are measured in quarts (qt.) and represent the efficiency of the filters.

The cows were prepared for milking by washing, massaging and drying the teats and udders just prior to milking. The cows were bedded with shavings and were milked with long-tube pipeline milker units. On occasions, teat cups dropped off during milking causing wood shavings to be drawn into the milk line.

Split-flow-testing

A special milk-flow divider was used to compare filtration efficiencies of different filtering materials. As the milk was discharged from the pipeline, a milk-flow splitting apparatus (Figure 1) divided the milk so that equal quantities passed through each of two kinds of filter materials described above. The apparatus was equipped with a 2.25 inch diameter Lintine sediment tester disc at each filter outlet to collect any sediment remaining in the milk filtered through the test filter media. Pressure gauges were used to measure the pressure build-up on each Lintine disc. Some filter efficiency tests were made, limiting the pressure build-up to 5 p.s.i.

Other comparisons were made using the time required to filter definite quantities of milk. By calculation, 23.4 pounds of milk filtered through a 2.25 inch Lintine disc was equivalent to filtering 8.6 pounds through a standard 1.25 inch Lintine disc.

Bulk tank testing

Sediment tests of milk from the bulk tank were made by pumping portions of milk through a standard 1.25 inch Lintine disc by means of a motor-driven tubing pump fitted with a standard sediment tester disc holder. The milk was stirred continuously for at least three minutes before and during sampling. No attempt was made to control the position of the tube inlet, which thus provided a random sample from the stirred milk. To facilitate pumping the cold milk through the Lintine sediment testing disc, a portion of the coiled suction tube was submerged in a pail of hot water.

The amount of sediment collected on the Lintine discs was determined by actual count: (a) of the particles present on a 1 sq. cm. center area, under a binocular with 6x magnification; and/or (b) under a 13.2x magnification of a slightly smaller area. All data were resolved to a 1 sq. cm. area basis.

RESULTS

Comparative efficiency of muslin bag and cotton disc filters with split-flow filtering.

An attempt was made to evaluate the efficiency of filter materials according to the number of sediment particles found on Lintine sediment discs obtained from split-flow filtered milk. However, counting the particles on the sediment discs was not feasible because of their great number and minute size. Also, many of the smaller particles were actually imbedded within the Lintine discs.

The sediment discs indicated that a decided difference existed between the ability of muslin bags and gauze-faced non-woven fabrics discs to remove sediment from pipeline milk. Photographs of these sediment discs obtained after 23.4 pounds of milk had been filtered through each material, and after continuous filtration had built up a pressure of 5 p.s.i. on either of the discs, are presented in Figures 2 and 3, respectively. Here, the sediment test discs show the relative amounts of sediment in milk which had been filtered through muslin bags (series A, several trials) and through non-woven discs (series B, several trials). The amount of milk passing through each sediment test disc was identical in every case, in A discs as in B discs with the same number. The heavier discoloration of the A discs indicate efficient filtration with cylindrical muslin bags than with non-woven discs in pipeline milk filtration. Results shown in Figure 3 substantiate this observation. In this case, the sediment tests were made of the milk after an internal pressure of 5 p.s.i. had been built up on one of the filter lines. This pressure was, in all trials, reached only in the chamber in which the milk had passed through the muslin-filter. The pictures actually show pressure spots on the sediment discs taken from this milk (series A).

Obviously, the reason for pressure build-up in one unit and not in the other was the more efficient filtration obtained through the non-woven disc than...
Figure 1. A milk flow splitting apparatus with pumps 1 and 2 used to divide the milk equally between two types of filters: (a) bag-in-cylinder; and (b) disc-in-dome, indicated by 3 and 4. Lintine discs were placed downstream in unions 5 and 6. Pressure taps 7 and 8 indicated pressure build-up from sediment deposition on lintines. (Provided through courtesy of Johnson & Johnson.)
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Figure 2. Differences in sediment density between discs in series A, after filtering through muslin fabric, and in series B after filtering through bonded gauze discs, after several 24.7 lb. runs per strainer.

...quantities of filtered milk are presented in Table 1. A single filter of each of the types studied was used in the first four test series, whereas double filtration with two filters were used simultaneously in the last series as shown.

Non-woven discs filtered the milk more effectively than did other materials tested, regardless of the quantity of milk examined. Flannel and muslin bags were second and third best, respectively. However, reused cotton flannel was ineffective as a filter, judged by the comparatively high numbers of sediment particles retained in the milk.

The data show a consistent relationship between the size of sample tested and the sediment particle count, the highest count being observed in tests from the 4-quart samples and the lowest from those taken from the 1-pint sample. Better consistency in the number of particles per square cm. of area was obtained when 3 and 4 quart samples were used than with lesser quantities.

The most complete filtration was obtained using the bonded non-woven disc either with or without the unit filter. Only 15 and 17 sediment particles, respectively were noted per sq. cm. on sediment discs...
taken from four quarts of milk so filtered. Flannel bag plus non-woven square in unit-filters yielded a sediment particle count of 29 from the same quantity of milk, thus rating under the cotton discs in effectiveness. The flannel and muslin bags, yielding 86 and 121 sediment particles per sq. cm, in four quarts of milk, respectively, were even less effective as filters than the flannel.

Reuse of the cotton flannel bag gave poor filtration. A sediment test of four quarts of milk filtered through a cotton flannel bag used four times showed an average count of 275 sediment particles per sq. cm.

Size of sediment particles found in milk filtered through different filter materials

Sediment particles on Lintine test discs, taken from 4-quart samples of milk filtered through various materials, were selected at random and measured. The particles found in milk filtered through the non-woven disc filter were smaller on the average, 45 x 60 microns, than those from milk going through the flannel and muslin bag filters. The largest particle noted in tests from the non-woven disc filter measured 116 x 125 microns, whereas those examined from milk filtered through a new and a 4-time used cotton-flannel bag measured 125 x 249 and 71 x 1273 microns, respectively. The largest particle found in the milk filtered with the muslin bag were of the dimensions of 400 x 1600 microns. These data seem to be consistent with those showing the relative efficiencies of filter material (Figs. 2 and 3, Table 1). There were more particles of a larger size in the milk in the tank when flannel or muslin were used in the in-line filters than when the non-woven disc filter was used.

Discussion

During this investigation, day-to-day sediment contamination of the pipeline milk varied considerably. Apparently, some contamination could never be entirely avoided. Despite more-than-usual care taken to have the stables clean and the udders and teats washed free of soil immediately before milking, some foreign particles did get into the milk.

As pointed out under "Procedure" test cups dropped off cows occasionally during milking permitting the entrance of wood shavings. This condition should be avoided by supporting the teat cup assembly when cups drop off the teats.

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.

The choice of filtering material should be made on the basis of the completeness of sediment removal rather than on the speed of filtration. High-speed filtration is usually associated with high porosity and inadequate removal of sediment particles. This study proved bonded non-woven fabric disc filters superior to muslin or flannel bags for pipeline filtration of milk. Flannel, used once in in-line bags or in unit filters gave much better sediment removal than muslin bags. Cotton flannel bags, used, then washed and reused as many as four times, were ineffective in sediment removal. Obviously, the filtering efficiency decreased as the downy cotton flannel nap became compacted or removed with wear.

Sediment testing of bulk-tank milk must be done under conditions which are quite different than those which are encountered in sediment testing of milk received in cans. The bulk-tank milk represents a larger volume of milk at a lower temperature, usually, around 40° F. This temperature is not conducive to quick tests by the present methods of sediment testing. If the present sediment standards, based on bottom-of-can samples, are to apply to bulk tank milk, then it is necessary to test a much larger mixed-milk sample than now used. For that reason, quantities of mixed milk ranging from one to four quarts were tested for sediment. The data from Table 1 show that the sediment particle count was very consistent when three and four-quart portions of the stirred milk were tested. Such consistency was absent when the pint, quart and 2-quart portions were tested. It is therefore suggested that testing equipment should be employed that will rapidly sample 1-gallon portions of milk.

While unit filters, inserted in the milk line between the individual milker and the main pipeline, have the advantage of immediate filtration of cow-warm milk and of excluding sediment particles that enter milk at the point of milking, they do not exclude particles that may enter from within the line. This latter may be quite objectionable. In one instance during this study, pipeline contamination consisted of rubber particles from the diaphragm pump. In other instances, churned butter granules, resulting from excessive agitation caused by air intake and pipeline risers, were noted. Thus, a filter at the inlet to the bulk tank would appear to be advisable, in addition to unit filters.

Counting sediment particles on Lintine discs obtained in split-flow milk filtration was not satisfactory. Too many particles were present and too many were imbedded deeply in the fabric to make this measurement of filtration efficiency feasible. Rather, viewing the overall discs and noting the dark discoloration which reflected density of sediment was preferred.
One of the striking observations made during this study was the rapid build-up of pressure against the Lintine sediment test filter after the milk was filtered through muslin, without a similar rise in pressure against the Lintine when non-woven filters were used. One apparent reason for the higher pressure build-up was inadequate filtration of the partially churned butter granules by the muslin strainer. When conditions responsible for churning in the pipeline were removed, the pressure build-up on the muslin-filter side of the split flow was not so rapid, but still occurred, even though no butterfat granules were present. Thus, it was obvious that the greater number of particles of sediment deposited on the Lintine, downstream from the muslin, accounted for the more rapid rise in pressure on the Lintine than on the Lintine downstream form the non-woven fabric.

Bag filters were inadequate for the removal of the sediment particles normally found to enter milk during milking, shown by filtration tests involving the use of milk flow-splitting apparatus, as well as by counting sediment particles from tank-drawn samples. Reuse of bags for filtration appeared to add greatly to this inefficiency while also adding to the hazard of bacterial contamination.

SUMMARY AND CONCLUSION

The quality of four milk filtering materials was measured by filtering milk through these materials, then refiltering through standard Lintine sediment testing discs. The materials tested were: (a) bonded non-woven discs, (b) flannel fabric (c) muslin fabric, and (d) flannel fabric reused four times, each use followed by washing. Differences in quality of filtration were secured by observing the density of sedimentation on Lintine discs when using two of the filtering materials in a flow-splitting apparatus, and by measuring the size of sediment particles and the number of particles that were found in one square centimeter areas when various sized samples were drawn from a bulk tank. Best performance was secured with the bonded non-woven discs, followed in order by flannel fabric, muslin fabric, and flannel fabric after four times used. Bag filters of flannel and muslin fabric gave inadequate filtration.

Sediment testing of bulk tank milk required the filtering of one-gallon portions in order to secure the best uniformity of particle counts from stirred milk.

The dome filter disc made possible the means for an immediate observation of the cleanliness of the milking operation.

ACKNOWLEDGEMENTS

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REFERENCES