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INTRODUCTION

Most of our modern plants employ some mechanical process for removing the foreign material from milk as it is received from the producer. The two types of equipment in general use are the filter and the clarifier, both of which have been considered successful in removing this material. The most important points for study seem to be the effect of clarification and filtration on quality of milk and the composition of the materials removed by each process.

The principle of the centrifuge embodied in the clarifier would lead one to conclude that all matter of a specific gravity greater than milk would be removed by the clarifier. The filter on the other hand depends upon enmeshing solid particles in the fleecy surface of the filter cloth. Obviously the clarifier may remove semi-soluble material of smaller dimensions than the interstices in the filter, while the filter can only remove material which is too large to pass through the cloth. Whether the removal of this semi-soluble material is of importance or not should be indicated by the tests on keeping quality of the milk and also in the analysis of the material itself.

A comparison of the two processes must not only consider the efficiency of sediment removal but also the composition of the material removed and the effect of the process upon the quality of milk. The study herein reported considers these points under conditions of actual plant practice.

Previous Investigations

It will be noted from the literature cited that most of the early studies were made on clarification of milk and that filtration has been treated to a very limited extent. A brief survey of the most significant work in both fields will be presented in the following paragraphs.

Early investigators reported that the removal of large numbers of bacteria in the clarifier slime resulted in a decreased number of organisms in the clarified milk. This conclusion, although justifiable at the time, was not true, as has been proved by later work. More recent work has shown an increased plate count in the clarified milk over the unclarified and this increase is attributed to the breaking up of clumps of bacteria due to the agitation in the clarification process.

The principle of removing foreign material by centrifugalization was first studied in the centrifugal separator. Eckles and Barnes (1) found that the centrifugal separator removed all solid impurities and that from 37 to 56 per cent of the total number of germs were thrown out with the slime. They concluded that keeping quality of the milk was improved little if any by this method.

Doane (2) corroborated the work of Eckles and Barnes and stated that although considerable sediment and slime were removed, the keeping quality of the milk was reduced by the centrifugal separator.

A general increase in the plate count of clarified milk over unclarified milk was noted by a number of investigators including Dean (3), Hammer (4), McInerney (5), Sherman (6), Judkins (7), Dahlberg (8), and Lucas (9). In most cases they stated that the increased plate count showed an apparent increase in numbers which was due to the breaking up of clumps of bacteria present in the original milk. No such increase was found with the use of the filter as shown by the work of Dean (3), Dahlberg (8), and Lucas (9).

Marshall (10) studied the recovery of pure cultures of bacteria which were added to milk before clarifying. He found that these cultures were recovered to a high degree in the clarfier slime.

Dahlberg (8) concluded that the cell content of milk was reduced by clarification as much as 67.3 per cent, while filtration did not effect a uniform reduction. Hammer (4) found a decrease in cell count on clarification from 7 to 73 per cent, averaging 39 per cent.

The composition of milk (i.e.—fat and total solids) is not altered to any appreciable extent by clarification or filtration, as shown by McInerney (5), Fisk (11) working with clarifier and by Dahlberg (8) working with the filter and clarifier.

The creaming ability of clarified milk is somewhat less than that of the unclarified as indicated by the work of McInerney (5) who found an average reduction of 3.0 per cent in cream volume. Judkins (7) found a reduction of cream volume of .36 per cent in clarified milk.

Dahlberg (8) compared the effect of filtration and clarification and concluded that filtration at any temperature or clarification at a low temperature does not influence the creaming ability of milk. He found that creaming ability was impaired by clarification at a high temperature and although this decrease was easily measured on a 100 cc. cylinder it could not be detected on a quart milk bottle. The impaired creaming ability could not be restored by pasteurization.

The nature of the material removed by the clarifier is given by Richmond (12) as follows: water, 66.24 per cent; fat, .5 per cent; casein, 22 per cent (approx.); milk sugar, .5 per cent; other organic matter, 7.75 per cent; ash, 3.01 per cent.

North (13) concluded that slime was invariably found in all milk including certified milk, that the amount of slime from individual cows ranged from 1.06 to 1.14 per cent and that traces of slime were found in the milk even after the third or fourth clarification.

Wardlow (14) studied the composition of clarifier slimes and found that the ash content was fairly constant. He gives the average values for calcium and phosphorus as CaO, 43.1 per cent, and P_2O_5, 43.9 per cent.

Hammer (4), studying the clarification of milk, found that the ratio between pounds of milk clarified and the amount of slime removed was highly variable. The slime was found to contain from 31 million to 1,445 million cells per gram.

The average composition of dried slime reported by Bohlman (15) was protein, 67.9 per cent and fat, 31.4 per cent.

EXPERIMENTAL

Source of Milk

The milk used in this work was obtained from the college dairy herd and from farmers delivering to the college dairy. Most of this milk was of fair to good in quality both from the standpoint of bacterial count and sediment. It had an average fat test of about 4.0 per cent.

Methods of Processing

The clarifier used was the DeLaval No. 105 with a rated capacity of 2000 pounds per hour. The filter used was a Von Gunten No. 319 which operated at a capacity of 5000 pounds per hour. The pump used to transfer milk from the supply tank to the clarifier and filter was a Viking sanitary pump of a capacity of five gallons per minute at 1200 R.P.M.

The milk was received at the plant at a temperature varying from 52°F. in winter to 65°F. in summer. The temperature of the milk was adjusted before processing by heating the mixed batch in a double jacketed dump vat.

This study includes 38 trials of from 800 to 1656 pounds of milk each. Studies were made of split batches by passing half of a batch of milk through the filter and half through the calarifier, or vice versa. This was done to compare the two machines under identical conditions. Relayed trials were made by passing a batch of milk first through the clarifier and then the filter to study the value of the two machines used in relay.

Tests Employed

The effect of processing on the number of bacteria in the milk was studied by making plate counts and direct microscopic counts of the milk before and after processing. The number of organisms was considered most important as city milk inspection systems determine the grade of milk largely by bacterial count. The direct microscopic count was used to indicate the numbers before and after processing and the methylene blue reductase test to measure the activity of the organisms present as a measure of keeping quality. Counts were made according to 'Standard Methods of Milk Analysis' 5th ed. (1928) using standard dehydrated media. Reduction tests were made by adding 10 cc. of milk to 1 cc. of standard solution of methylene blue and observing the time required for the blue color to disappear.

The efficiency in the removal of visible sediment was studied on the original and the processed milk by passing one pint of milk through a standard cotton disc in a vacuum sediment tester. Scores were made on the discs according to the chart by Kelly and Posson (16) to make possible comparison of a large number of samples.

The effect of processing on the cream line was studied by holding samples of the raw unprocessed milk and the same milk after processing, in 100 cc. graduated cylinders in the refrigerator at 33°–40°F. for 24 hours. The cream line was read in cc's. to give a comparative study of cream volume as it would appear on a bottle when delivered to the consumer.

The time required in operation of clarifier and filter was estimated from the average time required for setting up, operating, taking down and cleaning under actual plant conditions.

All the equipment used in handling the milk was washed and steamed carefully after each trial and steamed again when assembled for a new trial, to eliminate as much as possible contamination from the machines.

The Clarifier Slime

The clarifier was flushed with water upon the completion of each run. Three gallons of water adjusted to the temperature of the trial were used. This was done to remove the milk solids which are normally present in the clarifier bowl which should not be included as slime. Only the slime or sediment in the bowl was saved for analysis. The rinse water remaining in the bowl was decanted before removing the slime. The slime was then removed into an evaporating dish and dried by heating on a steam bath to remove the major portion of the moisture. The remaining moisture was removed by heating in a drying oven at 100°C. for 12 to 20 hours. When dry the sample was ground and mixed well for fat, protein and ash analysis. The amount of clarifier slime is recorded as the grams of oven dry material. Nitrogen in the oven-dry slime was determined by the Kjeldahl method and the result multiplied by 6.38 to express as per cent protein.

Fat in the oven dried slime was determined by extracting a 1.0 gram sample with ether in a Walker Bailey extraction apparatus. The ether was dried to constant weight in the drying oven at 98°C. Results are expressed as per cent on oven dry basis.

Ash was determined on 1.0 gram samples and expressed as per cent on oven dry basis.

The Filter Residue

Upon completion of a run the filter was rinsed with three gallons of water at the temperature of the trial, to push out the last of the milk. The filter cloth was then removed and the contents of the sediment receptacle under the filter was strained so as to retain all the sediment in the filter cloth. The cloth and sediment was then oven dried at 100°C. until no further loss in weight occurred. This usually required from 4 to 6 hours.

The weight of the material on the filter was determined by the difference between oven dry filter cloth and the filter cloth plus the residue. The fat in the residue was then determined by extracting the whole cloth with ether. The cloth was divided and placed in Florence flasks covered with ether and allowed to stand for 30 minutes before decanting off the ether extract. This was repeated four times and the total ether extract dried at 100°C. for 30 minutes and weighed to obtain per cent of fat on an oven dry basis.

Total nitrogen in the filter residue was determined by the Kjeldahl method on the whole filter cloth following the ether extraction. The cloth was divided into six portions to facilitate digestion. Results were expressed as per cent protein in the whole filter cloth using the factor 6.38 to convert nitrogen to protein.

Analysis of weighed portions of the filter cloth was attempted but a great variation in the amount of residue was found in different sections and this method was consequently abandoned. Checks were made on the original unused filter cloth and no measurable amount of fat or protein could be found.

Ash analysis of the filter residue was not made because of the impracticability of removing the residue from the cloth. Futhermore the amount of material on the filter was so small as to make it impossible to determine by analysis the difference between the original and used cloth.

Effect of Clarification and Filtration on Bacterial Counts

The average plate and direct counts of the original and processed milk are shown in Tables 1 and 2. It was considered advisable to vary the temperature to determine the effect of processing at these temperatures.

Table 1.—Plate count as effected by clarification and filtration at different temperatures.

		Average Plate Count				
Temp'ture of trials	Number of trials	Original count	Clarified count	Clarified % change	Filtered count	Filtered % change
60°F	13	113,400	266,000	+134.5	106,600	-6.37
90°F	15	122,000	166,000	+ 36.1	130,000	+6.56
110°F	10	65,000	78,000	+ 20.0	64,300	-1.08

The plate counts on the raw milk used in these trials ranged from 10,000 to 330,000 while the direct counts ranged from 160,000 to 1,420,000.

Higher counts are shown in the clarified milk than in the original by both the plate count and the direct count. This increase was greatest at the low temperatures as indicated by the plate count. As reported in previous investigations the greater number of organisms growing on the plates from the clarified milk was apparently due to breaking of clumps of bacteria. The direct microscopic count showed a larger number of individual bacteria and smaller clumps of bacteria in the clarified milk than in the original milk.

Table 2.—Breed count as effected by clarification and filtration at different temperatures.

		Average Plate Count				
Temp'ture of trials	Number of trials	Original count	Clarified count	Clarified % change	Filtered count	Filtered % change
60°F	13	536,000	675,000	+25.93	478,000	-10.82
90°F	15	415,000	486,000	+17.10	427,000	+2.90
110°F	10	866,700	1,113,600	+25.58	947,600	+6.87

A greater increase in plate count occurred upon clarification than with filtration. Clarification caused increases in plate count ranging from 20 to 134.5 per cent, the greatest increase occurring at the temperature of 60°F. Smaller increases in plate count at 110°F. were possibly due to the limiting effect of high temperature on the organisms present. The increased number of living organisms affect keeping quality as is shown in the study of methylene blue reduction in Table 3.

Plate counts of the filtered milk did not show a uniform increase or decrease in processing. A small decrease in plate count on milk filtered at 60°F. might be explained by the possible straining effect of the filter at this temperature. Much more fat was deposited on the filter at this temperature and this may have caused the straining out of some organisms. This did not occur uniformily throughout the trials as is shown by the increased count on milk filtered at 90°F. The differences in counts can possibly be explained as variations inherent to the plate count method, or as experimental error.

Clarification lowered keeping quality more than filtration, as shown in Table 3, by the more rapid methylene blue reduction at all temperatures. The difference between the clarified and filtered milk was not great at 110°F., indicating that some other factor influenced the rate of reduction.

Table 3.—Effect of clarification and filtration on methylene blue reduction time.

Temperature of trials	Number of trials	Methylene blue reduction time (Percent based on time for original sample) Original	Clarified	Filtered
60°F	13	100	78.44	93.75
90°F	15	100	82.92	89.68
110°F	10	100	87.57	91.30

The loss of keeping quality as indicated by methylene blue reduction was greater when the milk was clarified at the lower temperatures. Clarification at 110°F. was most efficient in preserving, keeping quality, probably due to the effect of the higher temperature in limiting the growth of organisms present. This was also shown in Table 1 by the smaller increase in count for the milk clarified at 110°F.

The filtered milk showed slightly lower keeping quality than the original although this decrease was not uniform. In a few cases the rate of methylene blue reduction was the same in the original and filtered milk. The temperature of filtration did not affect the resulting methylene blue reduction test as in the case of the clarifier.

The clarification and filtration were not solely responsible for the decreased keeping quality. The time and temperature of holding and the agitation in pumping undoubtedly had some effect on the bacterial flora of the milk. This effect, however, was the same for both machines and therefore a comparison could be made.

The decreased keeping quality in the processed milk was due to increased numbers of active organisms as shown in Table 1. The number of colonies on the standard plate count was decidedly greater in the clarified milk than in the original milk and also greater for clarified than filtered milk. This apparent increase in count was no doubt due to breaking up of clumps of bacteria as reported in the previous investigations. Nevertheless the increased activity of organisms was significant and indicated the relative keeping quality.

Efficiency of Sediment Removal

The comparative efficiency of the clarifier and filter in cleaning milk is shown in Table 4 by sediment scores on the original and the processed milk.

Table 4.—Efficiency of sediment removal by clarification and filtration at different temperatures.

Temperature of trials	Number of trials	Sediment Score Original	Clarified	Filtered
60°F	13	8.31	9.86	9.78
90°F	15	8.11	9.87	9.80
110°F	10	7.93	9.90	9.76

The clarifier and filter were both efficient in removing the sediment which can be detected by a sediment test. The differences in score were made by very minute traces of sediment on the sediment disc in the case of the clarifier and very fine sediment and slight discoloration in the case of the filter. The disc from filtered milk usually showed a slight tinge of brown indicating that small amounts of semi-soluble sediment remained after filtration.

No appreciable difference due to temperature could be noted in either clarified or filtered milk. Clarification at all temperatures gave higher sediment scores than did the same milk when filtered. These differences in score were due to slight differences in sediment and also to the tinge of color which was so common on the discs from filtered milk. These differennces are shown in Plate 1 in which gauge I is the original milk, gauge 2 is an unused filter disc, gauge 3 is taken from the same milk filtered and gauge 4 from the clarified milk.

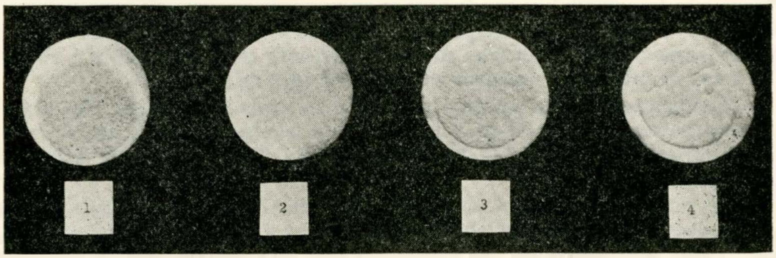

Plate I.—Sediment discs showing the effect of clarification and filtration.

Relayed trials (Table 5) were made to study the effect of first filtering and then clarifying the same milk.

Table 5.—Sediment score as effected by filtration and clarification of the same milk using the filter first.

Temperature of trials	Number of trials	Original Sediment Score	Filtered Sediment Score	Clarified Sediment Score
60°F	4	7.82	9.72	9.87
90°F	5	8.42	9.76	9.76
110°F	4	8.20	9.72	9.88

The milk processed by first filtering and then clarifying did not give a higher score than the milk which was clarified only. The disc from the filtered milk shows some discoloration and a very slight sediment. Clarification removed the material which was responsible for the discoloration and also removed more of the larger particles of sediment. No advantage, however, was indicated to warrant the use of the filter ahead of the clarifier, as the clarifier alone seemed to clean the milk as efficiently as the use of the two machines combined.

Unfortunately these trials do not include milk of very low sediment score and therefore no information was obtained on such milk. The relay method of filtration followed by clarification might be of value in treating such milk due to the greater amount of sediment present.

Effect on Cream Line

A very common objection to clarification has been its detrimental effect on cream line. The effect of the clarifier and filter used at different temperatures is shown in Table 6.

Table 6.—Effect of clarification and Filtration at various temperatures on cream volume.

Temp'ture	Number	Cream Volume in cc.				
of trials	of trials	Original	Clarified	% Decrease	Filtered	% Decrease
60°F	13	14.56	13.71	5.84	14.54	.14
90°F	15	14.70	13.74	6.53	14.37	2.24
110°F	10	14.65	13.59	7.23	14.15	3.41

These results show somewhat greater reduction of cream volume than has been previously reported. McInerney (5) reported an average of 3.0 per cent while Judkins (7) reported .36 per cent reduction on clarification. As shown in Table 6 the cream line was reduced an average of 7.23 per cent at 110°F. by the clarifier and 3.41 per cent at 110°F. by the filter. These results, which are much higher than those previously reported, may be partly caused by the pumping and agitation in transferring the milk to the machines. This effect was the same for both machines and the smaller decrease in filtration indicates the limit of this effect.

Clarification caused greater reduction in cream line than filtration at all tmperatures. The reduction by filtration was small in all cases and almost imperceptible at 60°F. In no case would this decrease be noticeable on a quart bottle.

The reduction in cream volume on milk clarified at 110°F. was not the only effect. The cream which did rise did not form a distinct line of demarcation, and therefore the cream volume was not as readily apparent. This lack of a distinct cream line would probably be more noticeable than the decreased cream volume on the quart bottle.

Effect on Cell Count

The removal of cells from milk has been considered of importance in the quality improvement of milk by clarification. Body cells are often associated with abnormal conditions in the cow and therefore the removal of cells has been considered desirable.

The number of cells in milk before and after processing is shown in Table 7 together with the per cent reduction.

Table 7.—Effect of clarification and filtration on cell count.

		Cell Counts				
Temp'ture of trials	Number of trials	Original count	Clarified count	Clarified % reduction	Filtered count	Filtered % reduction
60°F	12	527,500	343,000	34.98	468,000	11.28
90°F	15	514,300	276,300	46.28	476,000	7.45
110°F	10	432,500	202,400	53.20	403,400	6.73

The cell count was made in connection with the breed direct microscopic count of bacteria. Due to relatively small numbers of cells per micoscopic field the degree of accuracy is not as great as it might be by more detailed methods.

These findings agree fairly well with Hammer's (4) fiindings in which the reduction of cell count by clarification averaged 39 per cent, and Dahlberg (8) who found an average reduction of cells of 67.3 per cent in the clarified milk.

Comparison of clarification and filtration of the same milk showed that a decidedly greater decrease in cell count results from clarification. This reduction was greatest when milk was clarified at 110°F. This can possibly be explained by the lower viscosity in milk at this temperature, which allowed centrifugal force to be more effective.

In the case of the filter more efficient removal of cells occurred at the lower temperatures. This can be explained by the increased straining effect provided by the greater amount of residue on the filter cloth at lower temperatures.

Effect on Chemical Composition of Milk

The effect of clarification and filtration on the chemical composition of milk has been studied by various investigators who have claimed some noticeable decrease in milk constituents. Several of the trials reported in this work were checked by the use of the Mojonnier milk tester to determine the effect of clarification and filtration. No appreciable difference could be noted between the original, the clarified and filtered milk. Variations of .01 per cent fat or total solids were found but increases were noted as often as decreases, signifying experimental error rather than the effect of processing. Futhermore the small amount of fat and total solids present in the residues obtained in the processing indicated that an appreciable loss of milk constituents was impossible under ordinary conditions.

The Material Removed by Clarification and Filtration

The data were obtained on the same trials as those used in the study of milk quality including 13 trials at 60°F., 15 trials at 90°F. and 10 trials at 110°F. These data show the general composition of the slime and residue removed in the cleaning process and something of the amount and nature of this material.

Table 8.—The material removed from 1000 pounds of milk by clarification and filtration.

	Grams of material from 1000 pounds milk						
Temp'ture	Total		Protein		Fat		Ash
of trials	Clarifier	Filter	Clarifier	Filter	Clarifier	Filter	Clarifier
60°F	39.08	32.29	20.36	2.27	5.23	19.43	3.79
90°F	28.02	19.41	16.98	1.52	2.38	8.73	3.00
110°F	24.14	14.29	16.04	1.47	.59	6.34	3.29

A greater amount of residue was obtained by clarification than by filtration, when half of a batch of milk was processed in each machine. Whether this material was of physiological significance was not determined. The effect of sediment on the bacterial content of milk cannot be corrected by the removal of the sediment and therefore the process is of questionable sanitary significance. The bacteria and foreign flavors carried on the sediment remain after clarification or filtration. The improvement in appearance of the milk is therefore the most important result of the processes.

The general decrease in the amount of material removed as temperature was increased shows something of the efficiency at different temperatures. These relations are shown more clearly in Tables 9 and 10, which consider the two processes separately.

The amount of material removed by the clarifier and filter was very small in all cases. It is interesting to note that the number of grams of material removed did not seem to depend upon the original sediment score of milk but upon substances which were not determined on a sediment disc. In no case was the material removed in great enough quantity to be considered an appreciable loss of milk constituents even if it were all considered as nutrient material.

The influence of temperature on the amount of material removed by clarification is shown in Table 9. The protein, fat and ash are calculated in per cent based on the total dried slime to show the relations between these constituents.

Table 9.—Material removed from 1000 pounds of milk by clarification at different temperatures.

		Grams material removed per 1000 pounds milk						
Temp. of trials	No. of trials	Total Grams	Protein Grams	Protein Per cent	Fat Grams	Fat Per cent	Ash Grams	Ash Per cent
60°F	8	39.08	20.36	52.10	5.23	13.64	3.79	9.70
90°F	10	28.02	16.98	60.60	2.38	8.49	3.00	10.71
110°F	6	24.14	16.04	66.44	.59	2.44	3.29	13.63

No correlation existed between the amount of clarifier slime removed and the improvement in sediment score on milk. In fact the lowest score on clarified milk resulted at 60°F., the temperature at which the greatest amount of sediment was found in the clarifier slime. This indicates that the amount of clarifier slime removed is independent of the amount of sediment in normal milk when different temperatures are used.

After the first few trials it was evident that the total residue removed by clarification could not be of commercial significance because of its relatively small proportion. There was slightly over .08 pounds of dried slime removed from 1000 pounds of milk by clarification at 90°F. Of this dried slime about 60 per cent was protein and about 8 per cent was fat. No doubt some of the protein was normal milk protein while all of the fat appeared to be normal milk fat.

The amount of protein and fat in clarifier slime was greatest at the lowest temperature. The physical condition of these constituents at this temperature no doubt was responsible for this trend.

The ash found in clarifier slime proved to be quite constant at the various temperatures. This inorganic material resulted largely from the insoluble sediment in the milk and its removal was quite complete due to its greater specific gravity.

In Table 10 the amount of material removed by filtration is presented in grams and per cent to show the effect of using various temperatures of processing.

Table 10.—Material removed from 1000 pounds of milk by filtration at different temperatures.

		Grams material removed from 1000 pounds milk				
Temp'ture of trials	Number of trials	Total Grams	Protein Grams	Protein Per cent	Fat Grams	Fat Per cent
60°F	9	32.29	2.27	7.02	19.43	60.17
90°F	10	19.41	1.52	7.82	8.73	44.98
110°F	6	14.29	1.47	10.27	6.34	44.37

The amount of material removed by filtration decreased with each increase in temperature. This removal of solid material, however, did not mean more complete sediment removal, as the sediment score of milk (Table 4) filtered at 60°F. was no higher than that filtered at higher temperatures. The material strained out by the filter was not dependent on the amount of sediment present in the milk but varied with the temperature involved in processing, which allowed for more or less straining out of milk constituents.

The material removed by filtration is largely fat, as shown by the comparatively high percentage of fat at all temperatures. A greater percentage of fat was removed at 60°F., due to the physical condition of fat at this temperature which caused more of it to strain out.

The amount of protein removed was fairly constant at the different temperatures, decreasing slightly with increased temperatures of filtration. In no case was the amount of filter residue of any commercial significance as the total residue would be only .04 pounds from 1000 pounds of milk processed at 90°F.

The time required for operation of the clarifier and filter on 1000 pounds of milk was checked and recorded on a number of trials. The clarifier required an average of 35 minutes on 1000 pounds while the filter required an average of 16 minutes on the same volume of milk. No variation in time with temperature of processing was noted, but this factor might be of importance if the capacity of the machines were approached. The deposit of sediment on the filter would slow down filtration and increase the time of processing. The relatively small volumes of milk handled in these trials, however, did not give information on the capacity of the machines. The time required for cleaning was greater in the case of the clarifier due to the larger number of parts. This time, however, was not great in either case. Sterilization could be accomplished in either case by regular methods.

The cost of operation including cost of the machines is not included as this would depend mainly on the type and size of machine used. The initial cost of the clarifier would be greater than the filter but the cost of filter cloths would probably offset this difference over a period of years. Other factors of comparison herein presented are considered of much more importance in choosing the method for cleaning milk and it is these factors which are stressed in this report.

Summary and Conclusions

1. Clarification at all temperatures studied increased the plate count in milk. This increase averaged 134.5 per cent at 60°F., 36.1 per cent at 90°F. and 20.0 per cent at 110°F. The direct microscopic count indicated that these increases were caused by the breaking of clumps of bacteria.

2. Filtration did not effect a uniform change in plate count.

3. Increased bacterial counts and more rapid methylene blue reduction in clarified milk indicated that the keeping quality was slightly impaired by the process.

4. The effect of filtration on keeping quality of milk was hardly noticeable as indicated by the bacterial counts and methylene blue reduction time.

5. The clarifier proved slightly more effective than the filter in the removal of sediment from milk. Both processes, however, resulted in complete removal of the visible sediment in milk.

6. Cream volume was reduced more by clarification than filtration at all temperatures studied. Filtration at 60°F. did not reduce the cream volume to any appreciable extent but at 90°F. a definite decrease resulted. Processing by either method at 110°F. resulted in a decreased cream volume and a less distinct cream line.

7. A greater percentage of the cells in milk was removed by the clarifier than by the filter. Clarification at 110°F. removed the greatest numbers of cells averaging 53.20 per cent.

8. More material was removed by the clarifier than by the filter when used on equal portions of milk. Material removed by clarification averaged about 60 per cent protein, 8 per cent fat and 10 per cent ash by analysis. The material removed by the filter averaged about 8 per cent protein and 50 per cent fat by analysis.

9. The total nutrient material removed by either process was not of commercial significance.

10. The filter required less time for operation and cleaning than the clarifier.

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