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THE CLARIFIER AND THE FILTER IN PROCESSING MILK

By P. S. Lucas, L. H. Cooledge, O. T. Goodwin and R. J. Werdon

AGRICULTURAL EXPERIMENT STATION
MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

DAIRY AND BACTERIOLOGY SECTIONS

East Lansing, Michigan

FOREWORD

Under the present system and practice of producing and handling milk on the farm and in the milk plant, the removal of sediment from milk is an important problem. This bulletin gives the results of an exhaustive study of the filter and the clarifier. While data have been available for the past several years in regard to clarification, the information relative to the filter has been very limited. The data reported herewith were collected over a period of two years and, therefore, cover all seasons of the year.

It is hoped that the results reported will serve to aid the milk plant operator in cases where one or both of these systems of removing sediment are used.

O. E. REED,
Professor of Dairy Husbandry,
Michigan State College.

The Clarifier and the Filter in Processing Milk

By

P. S. LUCAS, L. H. COOLEDGE, O. T. GOODWIN AND R. J. WERDON

There is a great diversity of opinion among operators of milk plants relative to the particular merits of centrifugal clarifiers and mechanical filters for removing sediment from milk. Information has been available to the present time on the efficiency of the clarifier only. Within the past few years, milk filters have been placed on the market, but plant managers lack data on the effect that these may have on milk. To compare the two under identical conditions, the experimental work herein recorded was undertaken. The effects of each were noted on the following: bacterial (plate) count; different groups of bacteria; cream line; keeping quality; and sediment removal.

Experimental data, previously published, indicate that clarification removes some bacteria; but that the number of bacteria, in a majority of cases, as determined by the plate count, is greater than before. The percentage of increase is placed at varying figures by different investigators. Eckles and Barnes (1) state that 37 to 56 per cent of the bacteria are removed; Earnst (2) that large numbers are removed. Similar results were obtained by Hammer (3), and Sherman (4).

The plate count of milk after clarification has been shown to be higher in many cases by Harrison (5), Severin (6), Earnst (2), Hastings (7), Bahlman (8), Hammer (3), Sherman (4), Judkins (9), Marshall (10), and McInerney (11). The apparent increase is believed due to the breaking up of clumps of bacteria by centrifugal force. Harrison (5) states that clarification apparently increases the number of liquefying bacteria; Sherman (4), that streptococci count is not lowered; Marshall (10), that putrefactive ferments such as *oidium lactis, Saccharomycetes cereviseae,* and *bacillus tumescens* are apparently removed, and lactic acid streptococci activated; and McClintock (12) that many types of disease germs are greatly reduced, due probably to their large size and weight.

According to Hastings (7), clarified milk "creams" as well as unclarified milk; McInerney (11) reports that the cream line is slightly reduced. Eckles and Barnes (1) state that clarification improves the keeping quality of milk but little, if any; Sherman (4), that the keeping quality is slightly reduced, due to activation of the bacteria; Marshall (10), that "clarified milk undergoes lactic acid fermentation", whereas "in unclarified there is more often a putrefactive decomposition"; and McInerney (11), that acidity development is slightly more rapid in clarified milk. All investigators agree that clarification removes practically all insoluble dirt.

The Clarifier and Filter

Both the centrifugal clarifier and mechanical filter are designed for removal of sediment and dirt from milk. The former has been in commercial use some sixteen years, the latter about four years. The clarifier resembles closely the cream separator with the exception that milk and cream layers are not separated. Sediment collects in the bowl with the so called slime. Two makes of clarifiers are on the market, the DeLaval and Sharples, the principle of each being identical, although different in construction. The bowl operates at a speed of 6,000 revolutions, depending on the size, and such speed should be attained before milk is admitted. Milk is best clarified at from 85° F. to 100° F. temperature. Lower temperatures impair efficiency; higher temperatures injure the cream line.

The operation of filtering milk consists of forcing it through filter cloth. The milk is forced upward through the filter, which permits sediment to fall back on the floor of the filter plate. In this manner, milk does not pass continuously over the sediment, less sediment passes through the cloth, and the cloth does not become clogged so readily. Some four or five types of filters are on the market. Capacity depends on the size of the filter plate. Filter cloths are made from heavy fleeced cotton fabric. These are placed between perforated plates, fleece side down. Cloths are changed each two to four hours, depending upon temperature and cleanliness of the milk filtered. A temperature range of 85° F. to 110° F. is usually recommended. Operating costs of the filter and clarifier are practically the same.

Experimental Methods

All samples of milk used were representative, and plant conditions were duplicated as nearly as possible. A 5,000 pound clarifier was used, and 21 and 29 inch filters. Raw milk only was used. A period of thirteen months was taken to complete the work so that any variations due to season might appear in the results. The usual precautions were taken to insure uniform distribution of fat, sediment, and bacteria. All apparatus was properly washed and steamed before use. The milk was gathered from farmers in the surrounding country and was of average quality. The quantity of milk used in each batch varied from 2,000 to 5,000 pounds.

Bacterial counts by the plate method were made of the clarified milk run through the clarifier at 85° to 95°, and at 55° to 70° F. Samples were cooled in ice water until plated. Platings were made on milk powder agar media as described by Ayres and Mudge (13), incubated at 37° C., and read after forty-eight hours. The same procedure was followed for the filtered samples. Brome-cresol-purple was added to the media to aid in differentiating groups of organisms. Those colonies having a cloudy, yellow fringe were counted as strong acid groups. Those having a yellow, but not cloudy, halo were counted as weak acid groups. Peptonizers were identified by flowing a 5% acetic acid solution over the plate, and counting the colonies having clear rings about them. Those remaining after the sum of the above three groups had been deducted from the total were listed as the alkaline or inert group.

Keeping quality, as affected by clarification and filtration, was determined by the colorimetric hydrogen ion method of Cooledge (14). This test is a measure of the rapidity of acid development in milk. The pH reading in each case was transcribed as a score by means of a chart given in the reference cited above.

The effects of the two systems on the cream line were measured by the Harding method (15). This, in brief, consists of placing the samples in 100 cc. graduated cylinders and allowing them to stand twenty-four hours in a room at 34°-36° F. They were then read for cream line depth.

To determine the comparative efficiency of clarification and filtration for removing foreign material from milk, samples were run through the

"Vacuum" type sediment tester before and after processing. This sediment tester consists of a straight-side metal cup equipped with a tight fitting plunger operated by means of a handle. The center face of the plunger carries a screen frame for holding a cotton disc. To operate, the cylinder is filled with milk, the plunger drawn up slowly, and the milk, being forced through the center of the plunger, deposits its sediment on the cotton disc. The discs from unclarified or unfiltered milk were classified as 1, Fairly clean; 2, Dirty; and, 3, Very dirty. Clarified and filtered milk were classified as 1, Clean; 2, Few specks; and, 3, Slight deposit.

RESULTS

Effect of the Processes on Bacterial Counts

There is but one explanation of the apparent increase of bacteria after clarification. Clumps of bacteria that are counted as one colony on the plate may be broken up and each smaller group form a separate colony. Actually there is a decrease in numbers, for many are separated from the milk and help compose the separator slime. This, in cases, is so marked as to show a decrease in bacterial count as determined by the plate count. In a majority of cases, however, there is an apparent increase in numbers. It has been argued by many that a breaking up of bacterial clumps serves to activate the organism, thus causing hastened souring and spoilage. This may be determined only by holding processed and unprocessed milk under identical conditions and noting the changes, or by measuring the activity of the germs. These effects are shown later in the table comparing keeping qualities. Tables I and II show the effects of clarifying warm and cold milk in relation to resultant bacterial count as determined by the plate method.

Table I.—Effect on bacterial plate counts of clarifying warm milk.

Temperature of milk	Lbs. of milk clarified	Plate count per c.c. before clarification	Plate count per c.c. after clarification	Percentage change in number
90°F.	600	6,000	8,500	41
		9,000	8,000	−11
		10,000	8,000	−20
		7,000	8,000	14
		9,000	9,000	00
		6,000	12,000	100
		9,000	11,000	22
		6,000	7,500	25
		4,000	7,000	75
		8,000	6,500	−18
90°F.	800	52,000	43,000	−17
		45,000	63,000	40
		50,000	50,000	00
		28,000	43,000	53
		35,000	56,000	60
		31,000	55,000	77
		39,000	59,000	51
		38,000	63,000	65
		37,000	37,000	00
		33,000	42,000	27
90°F.	600	50,000	65,000	30
		50,000	70,000	40
		48,000	54,000	12
		57,000	64,000	12
		52,000	48,000	−7
		34,000	46,000	35
		45,000	57,000	26
		45,000	50,000	11
90°F.	600	18,000	21,000	16
		39,000	30,000	−23
		28,000	30,000	7
		22,000	28,000	27
		30,000	34,000	13
		26,000	26,000	00
		28,000	32,000	14
		39,000	38,000	−2
		32,000	35,000	9
85°F.	500	90,000	87,000	−3
		85,000	90,000	5
		79,000	85,000	7
		86,000	87,000	1
		82,000	93,000	13
		77,000	85,000	10
		80,000	80,000	00
		69,000	81,000	17
		88,000	83,000	−5
		70,000	79,000	13
		73,000	83,000	13
		81,000	84,000	3

Table II.—Effect of clarifying cold milk on bacterial count as determined by plate counts.

Temperature of milk	Lbs. of milk clarified	Plate count per c.c. before clarification	Plate count per c.c. after clarification	Percentage change in number
58°F.	1,000	590,000	670,000	13
		580,000	650,000	12
		560,000	560,000	00
		540,000	500,000	−7
		540,000	460,000	14
		500,000	440,000	−12
		520,000	570,000	9
		510,000	540,000	5
		600,000	510,000	−15
		570,000	610,000	7
		470,000	500,000	6
		470,000	490,000	4
		550,000	500,000	−9
58°F.	1,000	250,000	250,000	00
		270,000	260,000	−3
		270,000	300,000	11
		220,000	220,000	00
		280,000	280,000	00
		270,000	290,000	7
		250,000	270,000	8
55°F.	1,200	200,000	160,000	−20
		180,000	190,000	5
		170,000	190,000	11
		180,000	180,000	00
		170,000	150,000	−11
		160,000	160,000	00
		190,000	160,000	−15
		180,000	150,000	−16
		170,000	180,000	5
		170,000	200,000	17
60°F.	1,100	160,000	170,000	6
		160,000	150,000	−6
		160,000	160,000	00
		130,000	140,000	7
		130,000	150,000	15
		150,000	170,000	13
		160,000	180,000	12
		150,000	150,000	00
		150,000	170,000	13
		120,000	150,000	25
60°F.	1,100	130,000	160,000	23
		110,000	100,000	−9
		140,000	220,000	57
		160,000	190,000	18
		160,000	200,000	25
65°F.	700	40,000	47,000	17
		40,000	42,000	5
		43,000	50,000	16
		40,000	58,000	45
		41,000	56,000	36
		38,000	39,000	2
		40,000	45,000	12
		50,000	37,000	−26
		41,000	46,000	12
		43,000	39,000	−9
		48,000	46,000	−4
		41,000	52,000	26
		40,000	46,000	15
		42,000	49,000	16
65°F.	900	140,000	200,000	42
		150,000	210,000	40
		170,000	230,000	35
		160,000	170,000	6
		130,000	160,000	23
		150,000	130,000	−13
		140,000	210,000	50
		120,000	180,000	50
		120,000	160,000	33
		140,000	140,000	00
		130,000	220,000	69

Table II.—Continued

Temperature of milk	Lbs. of milk clarified	Plate count per c.c. before clarification	Plate count per c.c. after clarification	Percentage change in number
60°F.	800	40,000	120,000	200
		70,000	90,000	28
		70,000	60,000	−14
		90,000	120.000	33
		60,000	70,000	16
		65,000	70,000	7
		80,000	60,000	−25
		70,000	55,000	−21
		40,000	50,000	25
		35,000	50,000	42
		20,000	20,000	00
		25,000	80,000	220
		1,600,000	1,600,000	00
		1,600,000	1,400,000	−12
		1,800,000	1,800,000	00
		1,700,000	1,800,000	5
		1,600,000	1,900,000	18
		1,600,000	1,500,000	−6
		1,800,000	1,600,000	−11
		1,700,000	2,000,000	17
		1,600,000	1,500,000	−6
		1,600,000	1,700,000	6
		1,600,000	1,900,000	18
		1,700,000	1,500,000	−11
		1,500,000	1,500,000	00
		1,300,000	1,300,000	00
		1,300,000	1,600,000	23

It will be noted that forty-nine samples are recorded in Table I. These were clarified at temperatures ranging from 85° to 92° F. Thirty-five, (71%), showed a bacterial increase of 28.1%, the range being from 1% to 100%; five, (10%), showed no increase; and nine, (19%), showed an average decrease of 11.7%, the range being from 2% to 23%. Aside from possible hastening of separation of vegetative cells or contamination by unclean machines and apparatus, the increase is due to breaking up of clumps. The greater the number of bacterial clumps in milk, the greater will be the increased count, it is reasonable to expect. The increaase may also vary with the type organism present, the larger, heavier varieties being more easily removed by centrifugal force.

Ninety-seven samples were clarified at the lower temperatures of 55°-65° F. Of these, sixty, (62%), showed an average increase of 25.9%, variation being from 2% to 220%; fourteen, (14%), showed no change; and twenty-three, (24%), showed an average decrease of 12.2%, ranging from 3% to 26%. In either case the range of decrease is practically identical. The average increase is also nearly the same, but the range of increase is greater with cold than with warm clarified milk. The average increase, however, is smaller, due probably to the increased viscosity.

Table III.—Effect of filtering warm milk on bacterial content as shown by plate counts.

Temperature of milk	Plate count per c.c. before filtering	Plate count per c.c. after filtering	Percentage change in number
90°F.	8,400,000	6,000,000	−28
	6,400,000	4,700,000	−26
	5,000,000	6,000,000	20
	7,500,000	6,900,000	−8
	6,000,000	5,700,000	−5
	7,000,000	5,900,000	−15
	6,900,000	6,400,000	−7
	5,300,000	4,500,000	−15
	5,600,000	4,100,000	−26
	4,700,000	2,600,000	−44
	4,300,000	3,600,000	−16
	4,400,000	3,400,000	−22
90°F.	3,400,000	2,600,000	−23
	3,600,000	3,500,000	−3
	3,500,000	2,500,000	−28
	4,700,000	4,000,000	−15
	4,800,000	3,700,000	−22
	3,500,000	2,800,000	−20
	3,000,000	3,000,000	00
	3,200,000	3,300,000	3
	4,500,000	3,900,000	−13
	4,900,000	4,200,000	−14
85°F.	33,000,000	33,000,000	00
	38,000,000	32,000,000	−15
	30,000,000	40,000,000	33
	40,000,000	36,000,000	−10
	28,000,000	32,000,000	14
	25,000,000	20,000,000	−20
	34,000,000	30,000,000	−11
	34,000,000	33,000,000	−2
	28,000,000	34,000,000	21
	32,000,000	27,000,000	−15
85°F.	50,000,000	85,000,000	70
	45,000,000	58,000,000	28
	40,000,000	43,000,000	7
	56,000,000	49,000,000	−12
	44,000,000	22,000,000	−50
	33,000,000	17,000,000	−48
	23,000,000	22,000,000	−4
	20,000,000	27,000,000	35
	27,000,000	35,000,000	29
	30,000,000	14,000,000	−53
	18,000,000	20,000,000	11
85°F.	10,000,000	11,000,000	10
	11,000,000	11,000,000	00
	12,000,000	13,000,000	8
	12,000,000	15,000,000	25
	7,000,000	6,000,000	−14
	8,000,000	9,000,000	12
	11,000,000	20,000,000	81
	10,000,000	6,500,000	−35
	8,000,000	8,000,000	00
85°F.	3,600,000	3,600,000	00
	3,700,000	3,400,000	−8
	4,000,000	2,600,000	−35
	4,100,000	2,500,000	−39
	3,500,000	2,500,000	−28
	3,700,000	3,500,000	−5
	2,500,000	2,900,000	16
	3,500,000	3,000,000	−14
	2,400,000	2,800,000	16
	3,000,000	2,300,000	−23
85°F.	4,600,000	3,000,000	−35
	3,300,000	3,200,000	−3
	3,900,000	3,900,000	00
	3,600,000	3,400,000	−5
	3,600,000	3,300,000	−8
	4,300,000	3,900,000	−9

Table IV.—Effect of filtering cold milk on bacterial content as shown by plate counts.

Temperature of milk	Plate count per c.c. before filtering	Plate count per c.c. after filtering	Percentage change in number
68°F.	12,000,000	10,000,000	−16
	10,000,000	12,000,000	20
	15,000,000	12,000,000	−20
	14,000,000	13,000,000	−7
	14,000,000	12,000,000	−14
	10,000,000	11,000,000	10
	11,000,000	9,500,000	−13
	10,000,000	10,000,000	00
	13,000,000	13,000,000	00
	14,000,000	12,000,000	−14
65°F.	15,000,000	12,000,000	−20
	40,000,000	25,000,000	−37
	14,000,000	30,000,000	114
	28,000,000	13,000,000	−53
	27,000,000	12,000,000	−55
	32,000,000	20,000,000	−37
	22,000,000	28,000,000	27
	16,000,000	11,000,000	−31
	20,000,000	8,500,000	−57
	16,000,000	8,600,000	−46
65°F.	8,000,000	10,000,000	25
	7,700,000	11,000,000	43
	8,600,000	5,200,000	−40
	4,000,000	6,000,000	50
	4,000,000	4,600,000	15
	5,200,000	5,900,000	13
60°F.	3,800,000	3,800,000	00
	4,000,000	4,500,000	12
	3,500,000	3,300,000	−5
	3,000,000	3,000,000	00
	2,400,000	1,700,000	−29
	1,900,000	1,600,000	−16
	1,100,000	1,300,000	18
	1,700,000	1,400,000	−17
	700,000	700,000	00
	400,000	300,000	−25
70°F.	48,000,000	45,000,000	−6
	50,000,000	50,000,000	00
	60,000,000	46,000,000	−23
	55,000,000	64,000,000	16
	20,000,000	15,000,000	−25
	25,000,000	26,000,000	4
60°F.	4,000,000	3,700,000	−7
	4,700,000	3,300,000	−30
	4,000,000	4,900,000	22
	3,800,000	3,500,000	−7
	3,000,000	3,300,000	10
	2,000,000	2,300,000	15
	1,400,000	1,400,000	00
	2,300,000	1,200,000	−48
	2,300,000	2,000,000	−13
60°F.	10,000,000	12,000,000	20
	12,000,000	12,000,000	00
	11,000,000	13,000,000	18
	11,000,000	11,000,000	00
	6,000,000	6,000,000	00
	7,800,000	5,100,000	−34
58°F.	700,000	400,000	−43
	300,000	300,000	00
	400,000	200,000	−50
	100,000	100,000	00
	200,000	100,000	−50
	100,000	100,000	00
	800,000	600,000	−25
	900,000	1,100,000	22
	1,100,000	700,000	−36
59 F.	500,000	260,000	−48
	300,000	260,000	−13
	240,000	190,000	−20
	900,000	100,000	−88
	880,000	740,000	−16
	900,000	900,000	00
	1,100,000	700,000	−36
	1,000,000	1,200,000	20

Tables III and IV show the results of filtration on bacterial plate count under temperature conditions similar to those used for clarification. Of the sixty-eight batches filtered at 85°-90° F., eighteen, (26%), showed an average increase of 24.4%, varying from 3% to 81%; six, (9%), showed no increase; and forty-four, (65%), showed an average decrease of 19.3%, varying from 2% to 53%. Of the seventy-four batches filtered at temperatures of 55° to 70° F., twenty, (27%), showed an average increase of 24.7%, varying from 4% to 114%; fourteen, (19%), showed no change; and forty, (54%), showed an average decrease of 29.3%, varying from 5% to 88%.

It will be noted at once that the filter tends to lower rather than increase the bacterial plate count, but that the reducion is by no means consistent. There is undoubtedly less breaking up of bacterial clumps in the filter because the milk is not subjected to any great force. The decrease, as shown by plate count, is no doubt due largely to removal of bacterial clumps along with the dirt and slime.

Effects of Processing on Bacterial Group Counts

Group counts were made of clarified and filtered milk. These are interesting, because of the effect a preponderance of any one might have on the resulting milk. The results should be regarded as indicative rather than conclusive, however, because the culture media has not yet been proved infallible.

Table V.—Effect of clarification on bacterial content of milk as shown by plate count of specific groups of bacteria in milk.

Temperature of milk	Strong Acid Group			Weak Acid Group			Peptonizing Group			Inert and Alkaline Group		
	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change
	Unclarified	Clarified		Unclarified	Clarified		Unclarified	Clarified		Unclarified	Clarified	
90°F.	1,000	1,000	00.0	3,000	5,000	66	1,000	2,000	50	14,000	13,000	-7
	1,000	1,000	00.0	7,000	3,000	-57	4,000	2,000	-50	28,000	24,000	-14
	1,000	1,000	00.0	3,000	1,000	-66	1,000	1,000	00	23,000	29,000	26
	1,000	1,000	00.0	2,000	2,000	00	1,000	1,000	00	19,000	25,000	31
	1,000	1,000	00.0	3,000	4,000	33	2,000	1,000	-50	24,000	28,000	16
	1,000	1,000	00.0	3,000	5,000	66	1,000	1,000	00	21,000	19,000	-9
	1,000	1,000	00.0	5,000	4,000	-20	2,000	1,000	-50	20,000	26,000	30
	1,000	1,000	00.0	3,000	5,000	66	2,000	2,000	00	34,000	31,000	-8
	1,000	1,000	00.0	3,000	3,000	00	3,000	1,000	-66	26,000	31,000	19
	1,000	1,000	00.0	5,000	6,000	20	15,000	11,000	-26	32,000	25,000	-21
92°F.	1,000	1,000	00.0	5,000	7,000	40	11,000	6,000	-45	34,000	37,000	8
	1,000	1,000	00.0	3,000	2,000	-33	7,000	6,000	-14	18,000	35,000	94
	1,000	1,000	00.0	4,000	2,000	-50	11,000	12,000	9	20,000	42,000	110
	1,000	1,000	00.0	3,000	7,000	133	4,000	6,000	50	23,000	41,000	78
	1,000	1,000	00.0	4,000	4,000	00	13,000	8,000	-38	22,000	47,000	113
	1,000	1,000	00.0	2,000	1,000	-50	6,000	7,000	16	29,000	29,000	00
58°F.	10,000	10,000	00.0	20,000	20,000	00	340,000	290,000	-14	230,000	360,000	56
	10,000	10,000	00.0	20,000	30,000	50	320,000	280,000	-12	220,000	330,000	50
	10,000	10,000	00.0	30,000	20,000	-33	220,000	260,000	18	310,000	280,000	-9
	10,000	10,000	00.0	30,000	30,000	00	300,000	160,000	-47	210,000	260,000	24
	10,000	10,000	00.0	30,000	30,000	00	280,000	180,000	-36	200,000	230,000	15
	10,000	10,000	00.0	30,000	20,000	-33	220,000	220,000	00	270,000	320,000	18
	10,000	10,000	00.0	30,000	20,000	-33	210,000	230,000	9	260,000	310,000	19
	10,000	10,000	00.0	20,000	40,000	100	340,000	200,000	-41	230,000	260,000	13
	10,000	10,000	00.0	20,000	20,000	00	340,000	290,000	-14	220,000	300,000	36
	10,000	10,000	00.0	10,000	20,000	100	250,000	210,000	-16	210,000	270,000	28
	10,000	10,000	00.0	20,000	10,000	-50	250,000	230,000	-8	280,000	300,000	7
58°F.	10,000	10,000	00	20,000	20,000	00	260,000	230,000	-11	270,000	260,000	-3
63°F.	3,000	1,000	-66	10,000	8,000	-20	3,000	3,000	00	24,000	35,000	45
	1,000	2,000	100	12,000	12,000	00	4,000	4,000	00	26,000	32,000	23
	1,000	3,000	200	10,000	12,000	20	6,000	5,000	-16	23,000	38,000	65
	2,000	3,000	50	10,000	14,000	40	6,000	5,000	-16	24,000	34,000	41
	1,000	1,000	00	10,000	12,000	20	6,000	4,000	-33	21,000	22,000	4
	1,000	1,000	00	9,000	13,000	44	7,000	5,000	-28	24,000	30,000	25

Table VI.—Effect of filtering on specific groups of bacteria as shown by bacterial plate counts.

Temperature of milk	Strong Acid Group			Weak Acid Group			Peptonizing Group			Inert and Alkaline Group		
	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change
	Before Filtering	After Filtering		Before Filtering	After Filtering		Before Filtering	After Filtering		Before Filtering	After Filtering	
90°F.	1,400,000	1,000,000	−28	5,600,000	3,000,000	−46	300,000	100,000	−66	1,200,000	1,000,000	−16
	1,100,000	1,000,000	−9	2,000,000	1,100 000	−45	500,000	100,000	−80	2,800,000	2,600,000	−7
	700,000	400,000	−43	1,900,000	3,500,000	84	100,000	150,000	50	3,800,000	2,000,000	−47
	1,000,000	1,400,000	40	2,300,000	1,000,000	−56	200,000	100,000	−50	4,000,000	4,400,000	10
	800,000	1,100,000	37	1,300,000	1,100,000	−15	500,000	100,000	100	3,800,000	3,400,000	−10
	800,000	400,000	−50	1,400,000	2,000,000	42	130,000	150,000	15	4,600,000	3,300,000	−28
	900,000	900,000	00	800,000	300,000	−62	200,000	100,000	−50	5,000,000	4,100,000	−18
	400,000	800,000	100	1,000,000	700,000	−30	100,000	100,000	00	4,100,000	2,500,000	−39
	900,000	400,000	−55	1,200,000	800,000	−33	100,000	100,000	00	2,700,000	1,300,000	−52
	500,000	600,000	20	1,000,000	800,000	−20	150,000	50,000	−66	2,600,000	2,100,000	−19
	900,000	500,000	−44	1,400,000	900,000	−35	200,000	100,000	−50	1,900,000	1,900,000	00
	500,000	200,000	−60	1,000,000	2,100,000	110	80,000	100,000	25	1,900,000	200,000	5
	600,000	300,000	−50	1,000,000	2,200,000	120	100,000	100,000	00	1,900,000	900,000	−52
	600,000	100,000	−83	2,200,000	1,400,000	−36	100,000	100,000	00	600,000	900,000	50
	300,000	100,000	−66	1,300,000	1,700,000	30	100,000	100,000	00	3,000,000	2,100,000	−19
	100,000	400,000	300	1,800,000	2,000,000	11	100,000	100,000	00	2,800,000	1,200,000	−57
	500,000	300,000	−40	1,900,000	1,500,000	−21	100,000	100,000	00	1,000,000	900,000	−10
	100,000	100,000	00	900,000	800,000	−11	100,000	200,000	100	2,200,000	2,200,000	00
	200,000	700,000	250	1,700,000	800,000	−52	300,000	100,000	−66	2,300,000	2,300,000	00
	400,000	500,000	25	1,400,000	1,300,000	−7	200,000	100,000	−50	2,900,000	2,300,000	−21
85°F.	2,400,000	8,000,000	233	11,000,000	16,000,000	45	100,000	100,000	00	36,000,000	60,000,000	66
	1,600,000	4,000,000	150	8,800,000	11,000,000	25	100,000	100,000	00	34,000,000	42,000,000	23
	1,600,000	2,400,000	50	11,000,000	16,000,000	45	100,000	100,000	00	27,000,000	24,000,000	−11
	8,000,000	2,400,000	−70	10,000,000	8,000,000	−20	100,000	100,000	00	37,000,000	39,000,000	5
	1,600,000	800,000	−50	7,200,000	4,000,000	−44	100,000	100,000	00	35,000,000	27,000,000	−22
	3,200,000	800,000	−75	6,400,000	6,400,000	00	100,000	100,000	00	22,000,000	10,000,000	−54
	2,400,000	3,200,000	33	5,600,000	6,400,000	14	100,000	200,000	100	15,000,000	13,000,000	13
	3,200,000	1,600,000	−50	8,000,000	5,600,000	−30	100,000	100,000	00	19,000,000	19,000,000	00
	1,600,000	2,400,000	50	5,600,000	4,800,000	−14	100,000	100,000	00	19,000,000	27,000,000	42
85°F.	4,000,000	1,600,000	−60	6,400,000	4,800,000	−25	100,000	100,000	00	19,000,000	8,000,000	−57
	2,400,000	3,200,000	33	5,600,000	8,000,000	43	100,000	100,000	00	10,000,000	8,000,000	−20
	800,000	300,000	−62	800,000	1,500,000	87	100,000	100,000	00	8,400,000	9,200,000	9
	600,000	900,000	50	900,000	1,800,000	100	100,000	100,000	00	4,000,000	8,500,000	112
	1,200,000	700,000	−41	1,800,000	1,200,000	−33	100,000	100,000	00	4,000,000	4,600,000	15
	400,000	900,000	125	1,200,000	1,000,000	−16	100,000	100,000	00	1,900,000	1,700,000	−10
	1,300,000	800,000	−38	700,000	600,000	−14	100,000	100,000	00	1,600,000	1,900,000	18
	1,600,000	1,300,000	−18	400,000	200,000	−50	100,000	100,000	00	1,900,000	800,000	−57
	1,800,000	1,000,000	−44	600,000	400,000	−33	100,000	100,000	00	1,600,000	1,000,000	−37
	1,900,000	1,200,000	−36	200,000	200,000	00	100,000	100,000	00	1,300,000	1,000,000	−23
	1,200,000	1,000,000	−16	400,000	400,000	00	100,000	100,000	00	800,000	1,500,000	87

Table VI.—Continued

Temperature of milk	Strong Acid Group			Weak Acid Group			Peptonizing Group			Inert and Alkaline Group		
	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change	Plate count per c.c.		% Change
	Before Filtering	After Filtering		Before Filtering	After Filtering		Before Filtering	After Filtering		Before Filtering	After Filtering	
85°F.	1,100,000	1,000,000	−9	500,000	400,000	−20	100,000	100,000	00	1,500,000	900,000	−40
	900,000	1,000,000	11	600,000	300,000	−50	100,000	100,000	00	800,000	400,000	−50
	900,000	8,000,000	−11	1,000,000	400,000	−60	100,000	100,000	00	1,100,000	1,100,000	00
90°F.	400,000	600,000	50	2,500,000	1,400,000	−44	300,000	300,000	00	1,400,000	700,000	−50
	200,000	400,000	100	1,300,000	1,500,000	15	200,000	100,000	−50	1,600,000	1,200,000	−25
	800,000	800,000	00	1,700,000	1,400,000	−17	200,000	600,000	200	1,200,000	1,000,000	−16
	600,000	600,000	00	1,900,000	1,900,000	00	200,000	500,000	150	900,000	400,000	−55
	500,000	900,000	80	2,600,000	2,000,000	−23	200,000	500,000	150	1,000,000	500,000	−50
68°F.	300,000	600,000	100	2,000,000	1,800,000	−10	1,100,000	700,000	−36	7,400,000	6,400,000	−13
	1,400,000	700,000	−50	3,700,000	2,400,000	−35	900,000	1,300,000	44	7,000,000	8,600,000	23
	700,000	1,100,000	57	2,200,000	1,500,000	−31	1,100,000	900,000	−18	10,000,000	8,500,000	−15
70°F.	10,000,000	5,000,000	−50	2,400,000	1,900,000	−20	400,000	100,000	−75	600,000	500,000	−16
	6,000,000	2,000,000	−66	12,000,000	27,000,000	125	200,000	100,000	−50	700,000	800,000	14
	10,000,000	2,000,000	−80	17,000,000	12,000,000	−29	100,000	200,000	100	900,000	400,000	−55
	6,000,000	5,000,000	−16	20,000,000	11,000,000	−45	100,000	100,000	00	600,000	400,000	−33
	1,000,000	700,000	−30	30,000,000	18,000,000	−40	100,000	100,000	00	500,000	500,000	00
	1,400,000	1,800,000	28	19,000,000	25,000,000	31	100,000	200,000	100	900,000	500,000	−44
	400,000	100,000	−75	15,000,000	9,700,000	−36	100,000	100,000	00	200,000	700,000	250
	200,000	100,000	−50	20,000,000	7,600,000	−62	100,000	300,000	200	200,000	500,000	150
58°F.	4,400,000	3,800,000	−13	2,900,000	5,700,000	96	200,000	300,000	50	500,000	900,000	80
	3,100,000	4,800,000	54	4,000,000	5,900,000	47	200,000	400,000	100	400,000	700,000	75
	3,000,000	2,200,000	−26	4,700,000	2,600,000	−44	300,000	100,000	−66	600,000	400,000	−33
	1,400,000	1,900,000	35	2,400,000	4,400,000	83	100,000	300,000	200	200,000	400,000	100
	900,000	2,100,000	133	2,600,000	2,100,000	−19	100,000	100,000	00	500,000	300,000	−40
	600,000	1,700,000	183	1,600,000	1,600,000	00	100,000	100,000	00	1,600,000	500,000	−68
	1,600,000	1,200,000	−25	1,700,000	2,700,000	58	100,000	300,000	200	1,000,000	300,000	−70
	1,300,000	900,000	−30	1,600,000	1,900,000	18	100,000	100,000	00	500,000	400,000	−20
	700,000	1,000,000	42	1,700,000	1,400,000	−17	100,000	200,000	100	600,000	400,000	−33
	1,000,000	600,000	−40	900,000	800,000	−11	100,000	100,000	00	500,000	300,000	−40
	600,000	300,000	−50	300,000	400,000	33	100,000	100,000	00	200,000	600,000	200
	600,000	700,000	16	700,000	400,000	−42	100,000	100,000	00	400,000	300,000	−25
	1,000,000	1,100,000	10	2,700,000	2,100,000	−22	100,000	100,000	00	300,000	500,000	66
	1,400,000	700,000	−50	2,600,000	1,800,000	−30	100,000	100,000	00	500,000	800,000	60
	900,000	1,100,000	22	2,300,000	3,600,000	56	100,000	100,000	00	800,000	500,000	−37
	1,300,000	900,000	−30	1,600,000	2,200,000	37	100,000	100,000	00	100,000	100,000	00
	700,000	500,000	−28	500,000	700,000	40	100,000	200,000	100	200,000	100,000	−50
	500,000	400,000	−20	1,000,000	400,000	−60	100,000	100,000	00	800,000	300,000	−62
	700,000	600,000	−14	1,400,000	1,000,000	−28	100,000	100,000	00	100,000	400,000	300

Thirty-four samples were clarified, and from each, samples were plated for the four groups of bacteria. Three samples, (9%), plated for the strong acid group showed an average increase of 117%, ranging from 50% to 200%; thirty samples, (88%), showed no change, and one sample, (3%), showed a decrease of 66%. It would appear that the strong acid group is but little changed in apparent numbers by clarification. Of the thirty-four plated for the weak acid group, fourteen, (41%), showed an average increase of 57%, the variation being from 20% to 133%; nine, (26%), showed no change; and eleven, (33%), showed an average decrease of 40.4%, the range being from 20% to 66%. There is a slight tendency for this group to be increased by clarification. Of the thirty-four batches, six, (17%), showed an average increase in the peptonizing group of 25.3%, varying from 9% to 50%; seven, (21%), showed no change; and twenty-one, (62%), showed an average decrease of 30%, the variations being from 8% to 66%. There is a tendency toward reduction in count in this group, which may be accounted for by their greater weight facilitating their removal by centrifugal force. In this manner the clarifier may exercise a certain amount of selective action. There was a marked average increase in count of the alkaline and inert group. Twenty-six, (76%), showed an average increase of 38.2%, varying from 4% to 113%; one sample, (3%), showed no change and seven, (21%), showed an average decrease of 10.1%, the variations being from 3% to 21%. It would seem a reasonably safe conclusion that members of the alkaline and inert, and, to a less degree, the weak acid group, are greater cluster formers than the other two, and that, any activation that might take place through the breaking up of clumps, takes place among groups comparatively harmless in milk.

The results of seventy-eight filtered samples are shown in detail in Table VI. These were plated for the four groups of bacteria, as were the clarified samples. In the strong acid group, thirty, (39%), showed an average increase of 80.6%, the range being from 10% to 300%; four, (5%), showed no change; and forty-four, (56%), showed an average decrease of 42.1%, varying from 9% to 83%. Filtering showed no marked effect either in apparently increasing or decreasing strong acid group counts. In the weak acid group, twenty-five, (32%), showed an average increase of 55.8%, varying from 11% to 125%; five, (6%), showed no change; and forty-eight, (62%), showed an average decrease of 32.1%, the extreme variations being 7% and 62%. There was a tendency towards reduction of this group by filtration. Nineteen samples, (24%), showed for the peptonizing group an average increased count of 109.7%, varying from 15% to 200%; forty-five samples, (58%), showed no change; and fourteen, (18%), showed an average reduction of 55.2%, ranging from 18% to 80%. Filtration apparently has but little effect upon the numbers of peptonizers. Seventy-eight tests of the alkaline and inert group of bacteria show a slight average decrease in the plate counts; twenty-four tests, (31%), showing an average increase of 73.9%, ranging from 5% to 300%; seven, (9%), showed no change; forty-seven, (60%), showed an average decrease of 34.6%, ranging from 7% to 70%. The results seem to indicate that the filter has but very little selective action in removing bacteria but that the peptonizers pass more readily through the filter cloth than members of the other groups.

Effect of Processing on Keeping Quality

The effect of apparent increase in bacterial count would lead the manufacturer to infer that keeping quality of the product is reduced thereby. This would be especially probable if the members of the strong acid and peptonizing groups were increased and activated. The samples tabulated in Tables V and VI were clarified or filtered at warm temperatures. At lower temperatures filtration might be a trifle more efficient in removal of a few bacteria because of partial clogging of the filter cloth, thus cutting down the size of the openings through the cloth. It makes necessary, however, the inconvenience and expense of replacing the filter cloth more often than would otherwise be the case. The greater removal of bacteria is so slight as to merit no importance from the practical viewpoint.

Table VII.—Effect on the keeping quality of clarifying warm milk.

Temperature 90° — 92°F.
Pounds of Milk 500 — 800

pH Score		% Change	Keeping Quality After Clarifying	pH Score		% Change	Keeping Quality After Clarifying
Before Clarifying	After Clarifying			Before Clarifying	After Clarifying		
70	55	−21	Poorer	50	50	00	Same
65	60	−8	Poorer	65	70	8	Better
60	70	16	Better	65	55	−15	Poorer
60	60	00	Same	60	65	8	Better
65	65	00	Same	65	55	−15	Poorer
70	60	−14	Poorer	65	65	00	Same
60	65	8	Better	75	70	−7	Poorer
70	60	−14	Poorer	70	55	−21	Poorer
70	60	−14	Poorer	55	60	9	Better
65	60	−8	Poorer	55	65	18	Better
65	65	00	Same	70	60	−14	Poorer
55	55	00	Same	65	55	−15	Poorer
50	50	00	Same	60	55	−8	Poorer
60	50	−16	Poorer	65	60	−8	Poorer
65	55	−15	Poorer	50	55	10	Better
50	50	00	Same	60	50	−16	Poorer
50	50	00	Same	55	50	−9	Poorer
50	50	00	Same	50	50	00	Same
50	55	10	Better	50	55	10	Better
55	50	−9	Poorer	55	50	−9	Poorer
60	50	−16	Poorer	50	50	00	Same

Table VIII.—Effect on keeping quality of filtering warm milk.

Temperature		85°	—	90°F.		
Pounds of Milk		2,000	—	5,000		

pH Score		% Change	Keeping Quality After Filtering	pH Score		% Change	Keeping Quality After Filtering
Before Filtering	After Filtering			Before Filtering	After Filtering		
75	70	−7	Poorer	75	65	−13	Poorer
70	70	00	Same	80	70	−12	Poorer
75	70	−7	Poorer	80	75	−6	Poorer
70	70	00	Same	80	75	−6	Poorer
70	70	00	Same	75	75	00	Same
70	75	7	Better	75	75	00	Same
75	75	00	Same	75	80	7	Better
75	75	00	Same	80	90	12	Better
75	70	−7	Poorer	90	90	00	Same
70	70	00	Same	90	90	00	Same
70	75	7	Better	90	90	00	Same
75	75	00	Same	90	75	−17	Poorer
75	75	00	Same	55	55	00	Same
75	80	7	Better	55	55	00	Same
80	80	00	Same	55	60	9	Better
80	85	6	Better	55	55	00	Same
85	85	00	Same	55	55	00	Same
75	80	7	Better	55	60	9	Better
80	85	6	Better	75	60	−20	Poorer
80	80	00	Same	70	65	−7	Poorer
80	80	00	Same	70	70	00	Same
80	80	00	Same	70	70	00	Same
80	80	00	Same	65	65	00	Same
80	85	6	Better	65	65	00	Same
80	80	00	Same	65	60	−8	Poorer

There were forty-two batches of warm milk clarified and fifty filtered, both of which were tested by means of the Cooledge hydrogen ion determination for keeping quality. Of those clarified, nine, (21%), show an average of 10.8% better keeping quality, varying from 8% to 18%; of those filtered, eleven, (22%), show an average increase of 7.2%, varying from 6% to 12%. Twelve clarified samples, (29%), showed no change; twenty-eight filtered batches, (56%), showed no change in keeping quality. Twenty-one, (50%), of the clarified samples showed an average of reduced keeping quality amounting to 12.9%, and ranging from 7% to 21%; while eleven filtered batches, (22%), showed an average reduction in keeping quality of 10%, the variations being from 7% to 20%.

There was, therefore, caused by clarification a slight reduction in keeping quality. This is caused in all probability by a stimulation of the acid producing bacteria present, a condition which is registered by the hydrogen ion determination. There was very little change caused by the filtration of warm milk under proper conditions. The bulk of the samples showed no change in keeping quality.

Effect of Processing on the Cream Line

Table IX.—Effect on the cream line of clarifying warm milk.

Temperature	85°	—	90°F.		
Pounds of Milk	400	—	700		

c.c. of Cream		% Change	c.c. of Cream		% Change
Before Clarifying	After Clarifying		Before Clarifying	After Clarifying	
12.0	12.0	00	12.0	12.0	00
12.0	11.7	-2	12.0	12.0	00
12.2	11.9	-2	12.0	11.7	-2
12.1	12.0	-1	11.9	11.5	-3
12.0	11.6	-3	12.0	11.5	-4
12.0	12.0	00	11.8	11.7	-1
12.0	12.0	00	12.2	11.8	-3
12.3	12.0	-2	12.0	12.0	00
12.2	12.0	-1	12.0	12.2	1
12.2	12.0	-1	11.9	11.9	00
11.6	11.7	-1	11.8	11.4	-3
11.8	11.5	-2	12.0	11.7	-2
11.8	11.3	-4	11.2	11.0	-1
11.7	11.3	-3	11.3	11.2	-1
12.0	11.5	-4	11.2	10.8	-3
11.8	11.5	-2	11.4	11.0	-3
11.6	11.7	1	11.5	11.2	-2
11.5	11.5	00			

Table X.—Effect on the cream line of filtering warm milk.

Temperature	85	—	90°F.		
Pounds of Milk	2,000	—	5,000		

c.c. of Cream		% Change	c.c. of cream		% Change
Before Filtering	After Filtering		Before Filtering	After Filtering	
14.0	14.0	00	13.5	13.4	-1
14.0	14.0	00	11.8	11.8	00
14.0	14.0	00	12.5	12.2	-2
14.0	14.0	00	12.0	12.0	00
14.5	14.8	2	12.2	12.0	-2
14.5	14.5	00	12.5	12.7	1
14.3	14.5	1	12.5	12.5	00
14.5	14.5	00	12.8	12.5	-2
11.0	11.2	1	12.5	12.5	00
11.0	11.4	3	12.5	12.8	2
11.5	11.5	00	14.5	14.5	00
11.5	11.5	00	14.0	14.0	00
13.0	13.0	00	14.0	14.0	00
12.5	12.5	00	14.0	13.7	-2
12.5	12.5	00	13.5	13.5	00
12.5	13.0	4	13.5	13.5	00
14.5	14.5	00			

Warm Milk. Close inspection of Tables VII and VIII shows that of thirty-five samples clarified at temperatures ranging from 85° to 90° F. there was an average reduction in the cream line amounting to 1.5%; while, of thirty-three samples filtered at the same temperatures there was, on the average, scarcely any reduction. Two batches clarified, (6%), showed an average increase of 1%; seven batches filtered, (21%), showed an average increase of 2%, varying from 1% to 4%. Eight batches clarified, (23%), showed no change; twenty-one batches, (64%), filtered showed no change. Twenty-five, (71%), of the clarified batches showed an average decrease in cream line amounting to 2.4%, ranging from 1% to 4%; five, (15%), batches filtered showed an average reduction of 1.8%, varying from 1% to 2%.

The effect of clarification in reducing the cream line is but slight. Such reduction as does occur is probably due to the breaking up of fat globule clusters by the centrifugal force to which the milk is exposed. When broken from cluster formation the individual fat globules offer a greater surface exposure in proportion to their mass and therefore meet with more resistance as they rise to the surface of the milk. When warm milk is filtered there would seem to be no danger of injuring its creaming ability. The depth of the cream line on filtered warm milk checks with that on the unfiltered tests from the same batches.

Table XI.—Effect on the cream line of clarifying cold milk.

Temperature 55 — 70°F.
Pounds of Milk 400 — 700

c.c. of Cream		% Change	c.c. of Cream		% Change
Before Clarifying	After Clarifying		Before Clarifying	After Clarifying	
13.5	13.0	−4	12.0	12.0	00
13.5	13.0	−4	12.0	12.0	00
13.3	13.2	−1	12.4	12.0	−3
13.4	13.0	−3	12.2	11.8	−3
13.3	13.0	−2	12.0	11.7	−2
13.2	12.8	−3	11.9	11.7	−1
13.2	13.1	−1	12.0	11.6	−3
13.2	13.9	+5	11.8	11.5	−1
12.8	12.4	−3	11.8	11.5	−2
12.9	12.5	−3	11.7	11.5	−1
12.8	12.7	−1	12.8	12.4	−3
12.7	12.6	−1	12.6	12.4	−1
12.6	12.6	00	12.2	12.0	−1
12.8	12.3	−4			

Table XII.—Effect on the cream line of filtering cold milk.

Temperature	60	—	70°F.	
Pounds of Milk	1,500	—	2,000	

c.c. of Cream		% Change	c.c. of Cream		% Change
Before Filtering	After Filtering		Before Filtering	After Filtering	
14.5	14.5	00	14.5	14.5	00
14.2	14.5	3	14.5	14.3	−1
15.2	15.2	00	14.8	14.5	−2
16.0	16.0	00	14.3	14.0	−2
16.0	16.0	00	14.0	14.0	00
15.2	15.0	−1	14.2	14.0	−1
15.7	15.7	00	14.2	14.2	00
15.0	15.0	00	14.5	14.5	00
15.0	15.0	00	14.2	14.2	00
15.0	15.2	1	13.8	13.8	00
16.0	15.7	−2	14.0	13.7	−2
16.0	16.0	00	14.0	14.0	00
15.8	15.8	00	13.5	13.2	−2
15.3	15.3	00	12.0	12.0	00
15.2	15.5	2	12.5	12.9	3
15.0	14.5	−4	12.5	12.5	00
14.7	14.5	−1	12.5	12.2	−2
14.5	14.5	00	12.0	12.0	00
14.8	14.8	00	14.0	13.8	−1
15.0	15.0	00	14.0	14.0	00

Cold Milk. Of twenty-seven batches of milk clarified at temperatures ranging from 55° to 70° F. there was an average decrease in the cream line amounting to about 2%. Three batches, (11%), showed no change; twenty-three, (85%), showed an average decrease of 2.2%, varying from 1% to 4%; one, (4%), showed an increase of 5%. Of forty batches filtered at the same temperatures, there was a slight average decrease. Four, (10%), showed an average increase of 2.3%, varying from 1% to 3%; twenty-four, (60%), showed no change; and twelve, (30%), showed an average decrease of 1.8%, varying from 1% to 4%.

The clarification of cold milk affects the cream line to a slightly greater extent than clarification of warm milk. The effect is again probably due to the breaking up of clusters of fat globules. Cold milk is undoubtedly exposed longer than warm milk to the centrifugal force in the clarifier bowl, for it flows through more slowly due to its greater viscosity caused by the lower temperature. In either case the reduction is so small as to make its effect scarcely noticeable in a milk bottle. The cream line on filtered cold milk is slightly shorter than on filtered warm milk. Cold milk is more viscous and plugs the filter cloth much more readily. This may break up fat globule clusters and remove a few. The effect is smaller than that of the clarifier and is negligible from the standpoint of the milk plant operator.

Effect of Processing on Sediment Removal

Relative removal of visible dirt was determined by making sediment tests of the processed batches of milk. Of twenty-three clarified batches the average percentage removal of visible dirt amounted to 99.6. But five showed any trace of dirt remaining. These results are shown in Table XIII. Of nineteen batches filtered, the average removal of visible dirt amounted to 99%. Seven showed traces of fine dirt remaining. The clarification and filtration of cold milk had almost exactly the same relative proportions of visible dirt removed as did warm milk. The results were so nearly identical that it was thought superfluous to include the tabular information.

Under ordinary conditions both the clarifier and filter are remarkably efficient in the removal of visible dirt from milk. Coarse dirt is removed entirely, but the finer particles of muck and similar finely divided particles may pass through. Such particles rarely show in a bottle to any extent.

Table XIII.—Effect on removal of visible dirt by clarifying warm milk.

Temperature 85 — 90°F.
Pounds of Milk 400 — 700

Before Clarifying	After Clarifying	Percentage of Dirt Removed
Dirty	Clean	100
Dirty	Clean	100
Dirty	Few specks	98
Dirty	Clean	100
Dirty	Clean	100
Very dirty	Clean	100
Very dirty	Few specks	99
Very dirty	Very slight deposit	97
Fairly clean	Clean	100
Fairly clean	Clean	100
Fairly clean	Clean	100
Dirty	Clean	100
Dirty	Few specks	99
Dirty	Clean	100
Fairly clean	Clean	100
Fairly clean	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Few specks	98
Dirty	Clean	100
Dirty	Clean	100
Very dirty	Clean	100

Table XIV.—Effect on the removal of visible dirt by filtering warm milk.

Temperature 85 — 90°F.
Pounds of Milk 2,000 — 5,000

Before Filtering	After Filtering	Percentage of Dirt Removed
Dirty	Clean	100
Dirty	Few specks	99
Dirty	Clean	100
Dirty	Clean	100
Very dirty	Clean	100
Very dirty	Slight deposit	96
Very dirty	Few specks	98
Dirty	Clean	100
Very dirty	Few specks	99
Very dirty	Very slight deposit	97
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Clean	100
Dirty	Slight deposit	95
Very dirty	Few specks	97

MISCELLANEOUS OBSERVATIONS

Efficiency of Filter Cloths

Both the clarifier and filter must be cleaned at proper intervals or their efficiency will be reduced. This reduction begins when either become sufficiently charged with sediment that they are unable to take any further quantity of sediment from the milk passing through. Experimental results are shown in Table XV.

It will be noted from Table XV that when warm milk has been run through a filter cloth for two hours there is shown an increase in the bacterial plate count of the milk and a corresponding decrease in its keeping quality. The increasing numbers of bacteria undoubtedly are due to the accumulation of contaminating material on the filter cloth. This would seem to make it desirable that filter cloths be changed after one and one-half hours use. Probably if milk were filtered at higher or lower temperatures than those recorded there would not be so great an increase in bacterial count.

Table XV.—Effect of time factor on bacterial plate counts and keeping quality scores, when filtering warm pasteurized milk through the same filter cloth at 95°-110° F.

Trials	Time Interval	Before Filtering		After Filtering	
		Plate Count per c.c.	Keeping Quality Score	Plate Count per c.c.	Keeping Quality Score
1	Beginning 1st hour	33,000	65	24,000	65
	End 2nd hour	25,000	70	250,000	45
	End 4th hour	30,000	65	2,000,000	40
2	Beginning 1st hour	14,000	80	24,000	70
	End 1st hour	21,000	70	25,000	65
	End 2nd hour	13,000	65	80,000	55
	End 3rd hour	9,000	75	200,000	45
	End 4th hour	7,000	95	1,500,000	40

Capacity of Filter Cloths

The point at which a filter cloth had collected its capacity of foreign matter was noted by the observation of changes in the flow of milk from the outlet pipe of the filter and by running sediment tests. This point is approximate only. It indicated a time at which the filter cloth should be replaced. The observations cover temperature ranges of 60° to 90° F. and both dirty and fairly clean milk. The results are given in Table XVI.

Table XVI.—To determine the volume of milk efficiently filtered per unit of filter cloth.

Temperature Degrees F.	Condition of Milk	Size of Filter	Change after following number of Lbs. have passed through
90	Fairly Clean	29 in.	10,000
90	Dirty	29 in.	5,000–7,000
80	Fairly Clean	29 in.	7,000–9,000
80	Dirty	29 in.	5,000–6,000
70	Fairly Clean	29 in.	5,000–7,000
70	Dirty	29 in.	3,000–4,000
60	Fairly Clean	29 in.	3,000–4,000
60	Dirty	29 in.	2,000
70	Fairly Clean	21 in.	2,000–3,000
70	Dirty	21 in.	1,000–2,000
60	Fairly Clean	21 in.	700–1,500
60	Dirty	21 in.	500–1,000

In general, the higher the temperature the less often the filter must be changed, and, the cleaner the milk the greater the capacity of the filter cloth. The capacity of a single filter cloth is reduced to about 30% for each 10° F. reduction in temperature. Very dirty milk reduces the capacity from 20 to 50 per cent depending upon the kind of sediment in the milk. A clean milk means much for the economic and efficient operation of the filter. Preheating is also desirable.

Washed Filter Cloths

The cost of filter cloths is an item of expense in the operation of a milk filter. To determine the effect of washing and steaming on their efficiency, a few cloths were used several times, being thoroughly washed and steamed before use each time. The milk filtered through them was fairly dirty. Their efficiency after washing was checked by means of the sediment tester. The results are shown in Table XVII.

Table XVII.—Effect on sediment test of filtering milk through a used filter cloth properly washed.

Temperature	70	—	72°F.
Pounds of Milk	1,800		
Condition before filtering	Rather Dirty.		

Times Previously Used	Condition of Milk After Filtering	Times Previously Used	Condition of Milk After Filtering
Once	Clean	Twice	Slight deposit
	Few specks		Very slight deposit
	Few specks		Few specks
	Clean		Fairly clean
	Clean		Few specks
Once	Slight deposit		Clean
	Few specks	Twice	Very slight deposit
	Very slight deposit		Few specks
	Clean		Slight deposit
	Clean		Slight deposit
Once	Clean		Very slight deposit
	Few specks		
	Clean		
	Very slight deposit		
	Few specks		

A filter cloth used once and sterilized is still fairly efficient for removing sediment but not quite so much so as a new one. Its efficiency is reduced to approximately 80 per cent by a second washing. These statements apply to fairly dirty milk. Cloths may be used successfully a second or third time where the milk is fairly clean. In case of very dirty milk it is proper to use a new cloth each time.

SUMMARY

I. The bacterial count as shown by the plate method is increased after clarification. This increase is apparent, undoubtedly, and is due to the breaking up of bacterial clumps. Filtration in the majority of cases does not increase the bacterial count.

II. The clarifier asserts some selective action in removing clumps of bacteria. Apparently the count of peptonizers is reduced. The filter shows very little selective action.

III. Clarification slightly reduces the keeping quality of milk, probably due to a stimulation of the acid producing bacteria. Filtration has no effect on keeping quality.

IV. Neither clarification nor filtration affects to any great extent the depth of the cream line.

V. The clarifier removes over 99% of the visible sediment in milk. The filter is almost as efficient. Temperature affects very little the efficiency of the clarifier but lower temperatures increase the efficiency of the filter slightly.

VI. When milk is filtered at temperatures from 90° to 115° F. the filter cloth should be changed each two hours. Cleanliness and temperature affect the capacity of the filter cloth. Washing reduces the efficiency of the filter cloth.

Bibliography

1. Eckles and Barnes. Purification of Milk by Centrifugal Separation. Iowa Agr. Coll. Exp. Sta. Bul. 59: 55-59 (1901).
2. Earnst. Milk Hygiene, Pgs. 1-281 (1914).
3. Hammer, B. W. Studies on the Clarification of Milk. Iowa Sta. Res. Bul. 28 (1916), Pgs. 19-32.
4. Sherman, J. M. Some Bacteriological Tests of the Milk Clarifier. Journal Dairy Science, 1, (1917) No. 3, Pgs. 272-278.
5. Harrison, B. W. The Bacterial Contamination of Milk. Rev. gen'lait 2: 457-463, 481-489, 510-519, 538-546 (1903).
6. Severin, S. A. Vermindent de Zentrifugiering die Bukterienzahl in der Milch. Centbl. Bakt. 2: 14: 605-615 (1905).
7. Hastings, E. G. U. of Wisc. J. of Am. Med. Ass'n 68, 899-901 (1907).
8. Bahlman, E. Milk Clarifiers. Am. Journal of Pub. Health No. 8, Pgs. 854-857 (1916).
9. Judkins, H. F., and Downs, P. A. Studies in Processing Milk. Conn. Storrs Sta. Bul. 99, Pgs. 449-470 (1919).
10. Marshall, C. E. Studies in the Clarification of Milk. Mass. Exp. Sta. Bul. 187, Pgs. 155-242 (1920).

11. McInerney, T. J. Clarification of Milk. N. Y. Cornell Agr. Sta. Bul. 389.

12. McClintock. Further Investigations Upon the Clarification of Milk. Milk Trade Journal, Pg. 64, Sept., 1916.

13. Ayres, S. H., and Mudge, C. S. Milk Powder Agar for the Determination of Bacteria in Milk. Journal of Bacteriology, Vol. V, No. 6, Nov., 1920.

14. Cooledge, L. H. Colorimetric Hydrogen ion Determination as a Means of Studying Biological Changes in Dairy Products. Michigan Agr. Exp. Station, Tech. Bul. 52 (1921).

15. Harding, H. A. Method of Measuring the Volume of Cream on Milk. Journal of Dairy Science, Vol. V, Sept., 1922.