JOURNAL of MILK and FOOD TECHNOLOGY

(*including* MILK AND FOOD SANITATION)

Title registered U. S. Patent Office

Volume 12 November–December Number 6

Editorials

The opinions and ideas expressed in papers and editorials are those of the respective authors. The expressions of the Association are completely recorded in the transactions.

A NEGLECTED INSPECTION TOOL

In our inspectional and supervisory activities, we mostly rely on our sense of sight. Sometimes the sense of smell can help. Tainted meat, unclean cans, "barney" milk, and other conditions are determined almost exclusively by the sense of smell. An advance was made in this field by the New York City Health Department when its milk inspectors showed that they could detect milk with excessive bacterial content. Many a food-handling operation could be sanitized if operators and supervisors realized that an off flavor is not the "natural can smell." A can itself has no odor—any smell therefrom is due to the adherent spoiled food.

The use of the olfactory sense could well be cultivated. The possibilities for fundamental research in this field are shown in the new book on "Odors" by McCord and Witheridge (reviewed on page 363). For example, "It would be convenient indeed to have established an odor spectrum in terms of chemical energy similar to the light spectrum generated by fluorescent and phosphorescent crystals and in turn excited by electron or ultraviolet rays. As Kahn states, 'Light and sound are related to the energy spectrum. Why not odor as well?'" They quote Pauling (the eminent physicochemist) that biological activity lies largely in the range of 10 to 100A° (10^{-7} and 10^{-6} cm.), and that the odor receptors probably are stimulated electrochemically from the odorous substance.

To clarify the terminology (which currently attributes odor to perception as well as to the chemical that induces the sensation) they use "osmyl" to designate the thousands of materials that lead to the sensation of odor. "Osmics" embraces the field of science concerned with smell. This certainly improves definiteness of description and corrects the confusion that now exists when we use the same word to designate the sensation as well as the agent.

Maybe if we knew more about the sources and phenomena of odors (osmyls and osmics) we could improve on our flavors of foods. Milk needs it. Again, more fundamental research is needed—with a long-time perspective and no publication expected within five years!

J. H. S.

MEAT INSPECTION

In a recent review of meat inspection over the country, Dr. H. E. Kingman, Chairman of the Special Committee on Food and Milk Hygiene, American Veterinary Medical Association,[1] asserts that only 69 percent of the total meat produced in this country is prepared under federal inspection. He expresses his interest in the 31 percent or 6,000,000,000 pounds for which no records are available.

A survey revealed that California is doing an outstanding job in a statewide meat program of veterinary ante- and post-mortem inspection. "A number of states reported adequate inspection being provided at the county or municipal level. Most states, however, provide only a sanitary inspection of slaughtering plants conducted by lay personnel."

It is noteworthy that the federal Meat Inspection Service was inaugurated to meet German meat import requirements. Hence originally it was an economic measure. By reason of the great wave of interest in "pure food" which swept the country at the turn of the century, the service was extended to American consumers. This figure of approximately two-thirds of the meat adequately inspected was found by this editorial writer to apply to the meat industry of a large eastern seaboard city. There, about 50 to 60 full-time veterinary and trained lay inspectors supervised the slaughter of two-thirds of the meat supply handled in about a dozen plants, whereas the remaining one-third was slaughtered in two score or more plants, large and small, scattered all over the city, under the inspection of but one man, a practical butcher. The condemnations recorded in the federal inspected houses, in contrast to those occasionally reported by the city inspector, revealed the extent of the protection afforded under the two systems. The inadequacy of the city inspection was confirmed by our finding morbid tissue unskillfully trimmed off and left adhering to dressed meat.

What becomes of such un-inspected meat? The public eats it. They wouldn't if they knew it—not any more than they would confectionery to which talc had been added, or milk to which polluted water had been added, or harmful colors in other foods. The food control officials have cleaned up the general food industry from adulterations and misbrandings but only here and there has state and municipal government concerned themselves about the marketing of meat from animals that were diseased—certainly a more repulsive sort of thing than (mere?) adulteration.

The argument of many health officers is that diseased meat does not constitute an appreciable health hazard. Limited funds and personnel restricts supervision to services directly concerned with the morbidity and mortality rates. This certainly is a cogent argument. However, in these days of increasing public consciousness concerning the desirability of good sanitation, especially in our food services, we ask who is the agency that would be expected to clean up and supervise the non-federal meat inspection services? If some one of several municipal departments undertook it, then heaven help the local regular food control officers and the inspected-to-death public! Overlapping fields and no-man's-land areas would cause confusion and neglect. Confusion, contradictions, irritations, duplications, etc. no end. The health department—or whichever organization does the general milk and food control work—must be the one to supervise the meat supply. It has the professional "know how," the public confidence, the field of environmental hygiene.

Poor housekeeping in a food plant does not *per se* cause an outbreak of deaths but nevertheless the health department enforces cleanliness or it closes down the plant. The sale of meat from diseased animals is worse than allowing a dirty plant to operate. The public may not recognize all this now—but they will sooner or later.

J. H. S.

1. *J. Amer. Veter. Med. Assoc.* **114**, 385 (1949).

SOME STUDIES ON THE SURVIVAL OF *ESCHERICHIA COLI* IN MILK AND OTHER DAIRY PRODUCTS

Mildred R. Wilson * and Harry H. Weiser

Department of Bacteriology
The Ohio State University, Columbus, Ohio

Introduction

Many investigations have been conducted on coliform organisms in dairy products. The presence of *Escherichia coli* in various foods has led to significant information concerning the sanitary processing conditions of these products. The growth characteristics and longevity of these organisms are important in the interpretation of *E. coli* counts of dairy products. If the organisms die very rapidly its value as an index of contamination is less useful. On the other hand, if the organism multiplies very quickly at storage temperatures the actual degree of contamination may be obscured.

Review of the Literature

Very few workers, however, have studied the growth of this organism in various types of milk at different temperatures. Only the maximum and minimum growth temperature requirements of this organism have been studied in any great detail.

Ayers and Clemmer (1) reported in 1918 that *Escherichia coli* did not grow at temperatures below 10° C. (50° F.). Hunter (5) in 1919 reported that temperatures greatly influenced the number of *E. coli* in milk. He obtained fresh milk from a dairy containing approximately 52 *Escherichia-Aerogenes* organisms per milliliter. After storage for 24 hours at 60° F. (15.6° C.) the numbers increased to 964 bacteria per ml. whereas at the storage temperature of 70° F. (21.1° C.) the count was 60,000,000 per ml.

Sherman and Wing (8) in 1933 stated that *E. coli* was not a reliable index of initial conditions of any milk which had been stored at a temperature that allowed bacterial growth. They obtained milk similar in respect to coliform counts and stored the samples under identical conditions. A few of the similar samples varied greatly in the number of organisms present after storage at various temperatures. Also in raw milk Sherman found that "our studies at various temperatures have shown that the colon count in milk generally increases more rapidly than the total count during the pre-souring stage." The temperatures used were 50° F., 59° F., 70° F., and 86° F.

Wilson (9) in 1935 reviewed some of his findings on the growth rate of *E. coli* in sterile raw milk at 37° C. and 22° C. He reported that the *E. coli* counts reached 25,000,000 in 24 hours at 22° C. and approximately 40,000,000 per ml. in 15 hours at 37° C. He stated that when the organisms passed the 100,000 per ml. level, there was a strong tendency for them to clump, thus lowering the plate counts as seen by the use of Breed smears. This introduces error into the accuracy of the plate counts after this level has been reached.

Barthram (2) discovered in 1937 that there was no growth of coliforms in milk held below 10° C. Also he stated that "an increase of coliform organisms reduced the keeping quality of

* Presently employed on the Dayton Board of Health, Dayton, Ohio.

milk to the same extent as a seven fold increase in plate count."

In 1945 Robinton and Genung (7) studied the effect of temperature on coliform organisms in milk and cream. They inoculated sterile 30 percent cream and milk with an 18-hour broth culture of *E. coli*. The samples were stored at 8° C. and 20° C. At the end of 3 and 6 hours' incubation, plate counts were made. It was noted that there was a greater increase in the number of coliforms in cream than in milk held at 8° C. It was also noted that the increase of the coliforms between the third and sixth hour of incubation at 20° C. was extremely large. This emphasized what may occur in milk or cream that is permitted to remain uniced or at room temperature for even short periods of time. The value of a quantitative test for the presence of coliform organisms in market cream was doubted since these organisms developed so rapidly even at refrigerator temperatures. They assumed that the growth of coliforms is in direct proportion to the butterfat content of the product.

In 1945 Morris (6) found that coliform cultures grew more rapidly in pasteurized than in raw milk due to the bactericidal substance naturally occurring in raw milk.

In 1946 Dahlberg (4) studied the relationship of the growth of all bacteria and coliform bacteria in pasteurized milk held at refrigeration temperatures. He concluded that "coliform bacteria in pasteurized market milk held at refrigeration temperatures increased more rapidly in numbers than the total count." In freshly pasteurized milk less than 0.02 percent of the total bacteria were coliform types. At 35°–40° F. the percent of the total bacteria which were coliforms did not increase in October, but in July and August increased to 1.12 percent in 4 days. After storage for 4 days at 45°–50° F. and at 55°–60° F. the coliform bacteria constituted about 5 percent of the total bacteria in October. During July and August the coliform count became 88 percent of the total count after 4 days' storage at 45°–50° F. and 50 percent at 55°–60° F. It appeared evident that the coliform bacteria grew more rapidly in warm weather than in cool weather.

Burgwald (3) in 1947 also reported that there was little change in the coliform count in winter milk stored at refrigeration temperatures, but that summer milk had more initial coliform counts and increased slightly over winter milk. He attributed this discrepancy to a slightly higher refrigerator temperature in summer months or to "temperature shock" given the samples during the warm summer months before storage and on days when the analytical samples were removed. Another possible explanation of this difference stated was the difference in the type of microflora present in summer and winter milks.

EXPERIMENTAL

During the months of January, February, and March, homogenized market milk, 20 percent cream, and skim milk were sterilized and inoculated with *Escherichia coli* so that the initial count of these organisms was 1,280,000 per ml. of milk. The samples were stored at 10° C., 20° C., 25° C., and 37° C. At various intervals plate counts were made of the milk samples to determine the number of surviving organisms. The record of these counts is tabulated in Table 1.

This experiment showed that the organisms survived much longer at incubation temperatures of 20° C. and 25° C. than at 37° C. or refrigerator temperatures (10° C.). The type of milk did not seem to affect the survival of the organisms at refrigerator temperatures. By the 38th day of storage at this temperature, there were between 10 and 60 organisms per milliliter in the samples. All the test organisms disappeared before the 157th day of incubation. It is interesting to note that the organisms did not multiply during these winter months in any of the milk samples stored at 10° C. The number of *E. coli* after 11 days' storage at refrigerator temperatures decreased from the initial count of 1,280,000 per ml. of sample to 240,000 per ml. of skim milk, to 91,000 per ml. in the homogenized milk sample, and to 8,500 bacteria per ml. in the cream sample.

When samples were incubated at 20° C. and 25° C. comparatively high counts of *E. coli* were observed in all samples even after 38 days of incubation. The highest counts were obtained in the homogenized milk samples at 20° C. and 25° C. incubation.

By the 18th day the organisms that were incubated at 37° C. had obtained their maximum growth and were dying out comparatively faster than the organisms incubated at lower temperatures. There were no *E. coli* present in the homogenized milk or the skim milk samples after 25 days of incubation. In cream the organisms survived somewhat longer. There were 320 organisms per ml. when this sample had been incubated at 37° C. for 25 days. However, the organisms disappeared in cream at the end of 30 days.

TABLE 1

THE SURVIVAL OF *Escherichia coli* IN STERILIZED SKIM MILK, HOMOGENIZED MILK, AND CREAM WHEN 1,280,000 ORGANISMS WERE ADDED PER ML. OF SAMPLE AND INCUBATED AT 10° C., 20° C., 25° C., AND 37° C. DURING JANUARY, FEBRUARY, AND MARCH

Storage Temperature	Sample	Survival of *E. coli* After Various Intervals of Incubation. Time Expressed in Days					
		11	18	25	30	38	157
10	Skim	240,000	1,000	720	201	15	0
	Milk	91,000	3,000	2,000	281	60	0
	Cream	8,500	1,700	1,400	125	10	0
20	Skim	532,000,000	750,000,000	364,000,000	320,000,000	400,000,000	0
	Milk	380,000,000	880,000,000	328,000,000	340,000,000	650,000,000	0
	Cream	338,000,000	220,000,000	156,000,000	32,800,000	19,000,000	0
25	Skim	584,000,000	650,000,000	72,000,000	180,000,000	10,600,000	0
	Milk	506,000,000	720,000,000	132,000,000	172,000,000	126,000,000	0
	Cream	156,000,000	460,000,000	15,400,000	2,900,000	4,320,000	0
37	Skim	980,000,000	—1,000,000	0	0	0	0
	Milk	1,700,000	—1,000,000	0	0	0	0
	Cream	140,000	—10,000	320	0	0	0

During the spring months of April, May, and June homogenized milk, skim milk, cream, chocolate milk, and buttermilk were sterilized and inoculated with *C. coli* so that the initial count was 83,400 organisms per ml. of sample. The results of the plate counts of these samples at approximately weekly intervals are recorded in Table 2.

Escherichia coli survived much longer in samples collected in spring as compared to the samples collected in the winter seasons when held at 10° C. Also the number of organisms increased from the initial inoculum of 83,400 per ml. to between 300,000 to 910,000 per ml. in 9 days except in the cream sample. The organisms in cream increased to 110,000 per ml. in 14 days of storage. More organisms were present in the chocolate milk sample and the skim milk sample than in the other types of milk stored at 10° C. for 62 days. Likewise, the organisms survived longer in these two samples. *Escherichia coli* did not disappear from skim milk or chocolate milk until after the 105th day of storage. Before 68 days the organisms had disappeared from the other types of milk that were stored at the same temperature.

TABLE 2

THE SURVIVAL OF *Escherichia coli* IN STERILIZED SKIM MILK, CREAM, CHOCOLATE MILK, HOMOGENIZED MILK, AND MARKET BUTTERMILK WHEN APPROXIMATELY 83,400 ORGANISMS WERE ADDED PER ML. OF SAMPLE AND INCUBATED AT 10° C., 20° C., 25° C., 37° C., AND 55° C. DURING APRIL, MAY AND JUNE

Storage Temperature	Sample	Survival of *E. coli* After Weekly Intervals of Incubation. Time Expressed in Days																							
		9	14	18	26	62	68	95	105	165															
10	Skim	910,000	130,000	8,000	220	6	2	1	3	0															
	Milk	440,000	10,000	700	46	4	0	0	0	0															
	Cream	80,000	110,000	95,000	360	1	0	0	0	0															
	Chocolate	300,000	40,000	57,000	6,000	+100	19	12	12	0															
	Buttermilk	710,000	26,200	−100,000	0	0	0	0	0	0															
20	Skim	530,000,000	146,000,000	940,000,000	1,248,000,000	...	...	0	0	0															
	Milk	1,190,000,000	29,000,000	748,000,000	140,000,000	140,000	1,200	0	0	0															
	Cream	400,000,000	240,000,000	610,000,000	114,000,000	...	...	0	0	0															
	Chocolate	1,020,000,000	580,000,000	760,000,000	792,000,000	...	...	0	0	0															
	Buttermilk	.....	16,700	32,300	0	0	0																		
25	Skim	1,030,000,000	690,000,000	760,000,000	67,000,000	1,600	0	0	0	0															
	Milk	1,390,000,000	190,000,000	830,000,000	248,000,000	0	0	0	0	0															
	Cream	400,000,000	162,000,000	334,000,000	5,000,000	0	0	0	0	0															
	Chocolate	800,000,000	292,000,000	970,000,000	792,000,000	1,000	0	0	0	0															
	Buttermilk	448,000	−1,000	0	0	0	0	0	0	0															
37	Skim	1,700,000,000	330,000	1,000	0	0	0	0	0	0															
	Milk	1,500,000,000	8,000,000	10,000	0	0	0	0	0	0															
	Cream	261,000,000	9,640,000	100,000	2	0	0	0	0	0															
	Chocolate	1,040,000,000	328,000,000	560,000,000	4,640,000	12,000,000	...	−1,000	0	0															
	Buttermilk	100	−10,000	0	0	0	0	0	0	0															
55	Skim	0																							
	Milk	0																							
	Cream	0																							
	Chocolate	0																							
	Buttermilk	0																							

At 20° C. the organisms showed an appreciable increase in all samples. After 95 days there were no *E. coli* per ml. in any of the samples.

At room temperatures (approximately 25° C.) the organisms also increased to high counts, but disappeared before the 68th storage day. Skim milk and chocolate milk supported a larger growth of *E. coli* than the other types of milk. The organisms disappeared in skim milk and chocolate milk in 68 days, in cream and homogenized milk in 62 days, and in buttermilk in 18 days.

A high count was obtained when the samples were incubated at 37° C. for 9 days. However, the organisms disappeared more quickly at this temperature than when the samples had been stored at lower temperatures. The bacteria had disappeared by the 62nd day in incubation in cream, by the 26th day in skim milk, and by the 18th day in buttermilk. However, in chocolate milk a high count was retained until the 62nd day even though the counts of the other samples were at this time zero. The organisms disappeared from the chocolate milk before the 105th day of 37° C. incubation.

When the samples were stored at 55° C. the organisms disappeared from all samples before the 9th day of incubation.

This procedure was repeated in the summer using the same types of milk samples. The initial count of *E. coli* was 1,320,000 organisms per ml. of sample. The same storage temperatures were used except the room temperature which varied from 30° C. to 34° C. in the summer. The results are tabulated in Table 3.

Escherichia coli increased more rapidly at 10° C. in samples obtained during the summer months of June, July, and August than they did in samples obtained in the spring or winter that were stored at 10° C. The organisms also survived much longer at this temperature in samples stored in the summer than samples stored in the winter or spring months. In 8 days the counts of *E. coli* increased in all milk samples except buttermilk. In one sample of milk the counts rose from 1,302,000 organisms per ml. to a high count of 24,400,000 organisms per ml. The count of *E. coli* remained high in the millions per milliliter until the 42nd day of storage. Even after 120 days of storage at 10° C., the counts ranged from 29 to 940 organisms per ml. There were more organisms in skim milk after 120 days' incubation than in any other sample. Here again the coliforms could not survive long at 10° C. in buttermilk. The organisms had disappeared in 32 days from this sample. At refrigerator temperatures (10° C.) cream supported the largest number of *E. coli*.

At 20° C. the organisms survived a much shorter time than at 10° C. In contrast, a shorter survival at 10° C. than at 20° C. occurred in the winter. At 20° C. incubation by the end of 55 days of storage there were 240,000 organisms remaining per ml. of cream as compared to 10 to 100 per ml. in all other samples except buttermilk. In buttermilk there was a decrease in organisms until the 14th day of incubation, which was followed by a marked increase in number, from 300,000 per ml. to 227,500,000 per ml. This increase occurred during the time between the 14th day of incubation and the 55th day. After the 55th day of incubation there was a gradual decline in the number of organisms until there were 5,300 organisms still present at the end of 120 days incubation. In skim milk there were only 10 *E. coli* per milliliter of sample after 55 days of storage. All the organisms disappeared from this sample before the 100th day of storage. There were 100 *E. coli* per milliliter in the homogenized milk sample after 55 days of storage. Here again the organisms disappeared before the 100th day of storage. After 55 days of storage, there were still 240,000 viable *E. coli* per

TABLE 3

THE SURVIVAL OF *Escherichia coli* IN STERILIZED SKIM MILK, CREAM, CHOCOLATE MILK, HOMOGENIZED MILK, AND MARKET BUTTERMILK WHEN APPROXIMATELY 1,302,000 ORGANISMS WERE ADDED PER ML. OF SAMPLE AND INCUBATED AT 10° C., 20° C., 34° C., 37° C., AND 55° C. DURING JUNE, JULY AND AUGUST

Storage temperature	Sample	Survival of *E. coli* after weekly intervals of incubation. Time expressed in days.																	
		1	2	8	14	32	42	49	55	58	95	100	106	113	120	127	134		
10	Skim	.....	.....	6,700,000	17,200,000	1,700,000	270,000	440,000	—	170,000	200	—	612	720	940	570	400		
	Milk	.....	.....	24,400,000	48,000,000	5,600,000	835,000	900,000	—	320,000	1,600	—	835	395	110	219	50		
	Cream	.....	.....	4,300,000	25,400,000	2,800,000	550,000	340,000	—	225,000	2,500	—	980	924	268	192	800		
	Chocolate	.....	.....	1,200,000	2,800,000	210,000	90,000	29,000	—	2,000	210	—	256	160	29	21	2		
	Buttermilk	.....	.....	—1,000	200	0	0	0	0	0	0	0	0	0	0	0	0		
20	Skim	.....	.....	2,750,000,000	58,000,000	1,400,000	194,000	13,000	10	—	—	0	0	0	0	0	0		
	Milk	.....	.....	3,800,000,000	700,000,000	1,900,000	196,000	83,000	100	—	—	0	0	0	0	0	0		
	Cream	.....	.....	1,400,000,000	990,000,000	3,200,000	1,470,000	440,000	240,000	—	—	0	0	0	0	0	0		
	Chocolate	.....	.....	430,000,000	230,000,000	—	—	—1,000	0	0	0	0	0	0	0	0	0		
	Buttermilk	.....	.....	1,150	300,000	2,016,000	—	5,000,000	227,500,000	—	—	28,800	7,000	21,000	5,300	130,000	12,000		
34	Skim	.....	.....	1,030,000,000	4,600,000	—	40,000	0	0	0	0	0							
	Milk	.....	.....	750,000,000	4,400,000	30,000,000	100,000	100	0	0	0	0							
	Cream	.....	.....	1,130,000,000	700,000	1,100,000	600,000	288,000	252,000	—	—	0							
	Chocolate	.....	.....	360,000,000	1,500,000	308,000	40,000	0	0	0	0	0							
	Buttermilk	.....	.....	8,600,000	—1,000	—	100	6,400,000	100,000	—	—	0							
37	Skim	1,410,000,000	.....	.....	8,000	0	0	0	0										
	Milk	830,000,000	.....	.....	1,000	0	0	0	0										
	Cream	320,000,000	.....	.....	54,000,000	29,000	100	0	0										
	Chocolate	244,000,000	.....	.....	1,230,000	20,000	800	2,000	0										
	Buttermilk	0	.....	.....	0	0	0	0	0										
55	Skim	0																	
	Milk	0																	
	Cream	0																	
	Chocolate	0																	
	Buttermilk	0																	

milliliter of cream. These organisms also disappeared before the 100th day of storage.

When samples were incubated at room temperature in the summer months, the organisms disappeared in all samples of milk except cream and buttermilk in 55 days. There still remained a count of 252,000 *E. coli* per milliliter of cream after 55 days of incubation. After 55 days of incubation of buttermilk there were still remaining 100,000 *E. coli* per milliliter. After 100 days of incubation *E. coli* had disappeared from both the cream and buttermilk sample.

At 37° C. *E. coli* died quickly in all samples except chocolate milk and cream. At the end of 42 days there still remained 100 organisms in cream per milliliter and 800 organisms per milliliter in the chocolate milk sample.

When the samples were stored at 55° C. the organisms disappeared from all samples before the first day of incubation.

DISCUSSION

Escherichia coli multiplied faster when the organisms were inoculated into milk in the summer than when they were inoculated in the winter or spring and the samples stored at 10° C. In fact the organisms that were inoculated into the milk samples during the winter did not multiply, whereas at this same temperature in the summer high counts were obtained from the milk samples. This seasonal change in growth of *E. coli* at 10° C. has been noted by Burgwald and Dalberg. Burgwald proposed the theory that this increase of *E. coli* at 10° C. during the summer may be due to a different microflora present in milk due to a change from winter and summer feed. He also assumed that the difference might be attributed to the amount of temperature shock given the samples during plating. In this study the room temperatures varied from approximately 24° C. in the winter to 35° C. in the summer.

Escherichia coli seemed to disappear quicker in buttermilk than in other types of milk when the samples were incubated at 37° C. and 10° C. At 10° C. the combination of the two inhibitory effects, the below optimum temperature of incubation and the presence of acid, was great enough to restrict the growth of the organisms. At 37° C. the organisms, the *E. coli,* and the other lactose-fermenting organisms present in cultured buttermilk, grew so rapidly that the already high acidity was probably increased beyond the level that *E. coli* could survive. Two samples of buttermilk, however, that were inoculated with 651,000 and 1,260,000 organisms per milliliter of sample during the summer supported good growth. This growth of *E. coli* was not obtained when the experiments were repeated once in the fall and twice in the spring using different samples of buttermilk. Perhaps this discrepancy is due to the difference in the bacterial content of the cultured buttermilk obtained from Ohio State Dairy on those occasions.

Throughout all the experiments, a higher count of *E. coli* was obtained in chocolate milk and quite often in cream than in other types of milk. Robinton and Genung also noted an increased growth of *E. coli* in cream. The amount of fat present in the milk was considered to be the cause for the increased count. In these experiments fat either in the form of butterfat or chocolate seemed to protect the organisms from some deleterious effect of growth, so that the organisms could survive much longer. The fat may be a protection for the organisms from the acid that is produced, for the high counts in chocolate milk and cream were most evident after there had been quite extensive growth. In other samples after high counts were reached, the number of organisms drop off quickly, yet in cream and chocolate milk the organisms were able to survive in large numbers for a comparatively long time.

With only a few exceptions the

growth of *E. coli* is determined by the temperature of holding. The size of inoculum did not influence the growth of *E. coli* except in a few samples of milk at 10° C. The temperature range of this organism is so wide that it can grow not only at 37° C. and above but also at refrigerator temperatures. Thus it again is obvious that coliform counts are of no value unless the previous history (length and temperature of holding) of the sample of milk is known.

In these tests *E. coli* survived for an extremely long time in milk. Even after the milk had passed the condition of being used for consumption, the organisms were still present in large numbers at all temperatures. Curdling and gas production were evident in all samples even at 10° C. Some samples became stringy and in all the foul odor was present. As a test organism, *E. coli* has the advantage of being able to survive a long time in milk, thus making the chances of the organisms disappearing, before most pathogens, very small. However, the rapid growth of this organism at temperatures ranging from ice box temperature to 37° C. does not permit this organism to be used as a good quantitative test of sanitary condition of milk.

Summary

1. *Escherichia coli* will grow at 10° C. more in the warm summer months than in the winter months.

2. A higher count and a longer survival of *E. coli* was obtained in chocolate milk and cream than in the other types of milk tested.

3. The survival of *E. coli* depends on the storage temperature. (The higher the temperature the more the growth and the shorter the survival time).

4. *Escherichia coli* still existed in large numbers for many days in milk that had passed the point of being used for food.

References

1. Ayers, S. H., and Clemmer, P. W. Significance of Colon Count in Raw Milk. *U.S.D.A. Bull.* 739, 1918.

2. Bartram, M. T., and Black, L. A. The Detection and Significance of Escherichia-Aerobacter in Milk, III Correlation of Total Bacterial Count and Presence of the Coli-Aerogenes Group. *J. Dairy Sci.* **20**, 105–112 (1937).

3. Burgwald, L. H., and Josephson, D. V. The Effect of Refrigerator Storage on the Keeping Qualities of Pasteurized Milk. *Ibid.* **30**, 371–383 (1947).

4. Dahlberg, A. C. The Relationship of the Growth of All Bacteria and Coliform Bacteria in Pasteurized Milk Held at Refrigeration Temperatures. *Ibid.* **29**, 651–655 (1946).

5. Hunter, O. W. The Colon-Aerogenes Group in Milk. *Ibid.* **2**, 108–130 (1919).

6. Morris, C. S. The Presence in Raw Milk of a Bactericidal Substance Specific for Certain Strains of Coliform Organisms and the Comparative Rate of Growth of Bacteria in Raw and Pasteurized Milk. *Dairy Industry.* **10**, 180–181 (1945).

7. Robinson, Elizabeth D., and Genung, Elizabeth F. The Effect of Temperature on Coliform Organisms in Milk and Cream. *J. Milk Technol.* **8**, 97–100 (1945).

8. Sherman, James M., and Wing, Helen Upton. The Significance of Colon Bacteria in Milk with Special Reference to Standards. *J. Dairy Sci.* **26**, 165–173 (1933).

9. Wilson, G. S. *The Bacteriological Grading of Milk.* London: His Majesty's Stationery Office, Medical Research Council: 153–207, 1935.

THE COMPOSITION AND SANITARY QUALITY OF A PRODUCT USED AS WHIPPED CREAM ON ICE CREAM IN UPSTATE NEW YORK*

A. C. Dahlberg and F. V. Kosikowsky

Department of Dairy Industry, Cornell University, Ithaca, N. Y.

It should be obvious to one familiar with commercial whipped cream that this product and its preparation has changed radically in the past ten years. The mechanical cream whipper no longer is used in most retail stores dispensing whipped cream. In its place is the small container of cream mix under gas pressure from which the cream is instantly whipped as the pressure is released to force the cream on the ice cream sundae or other food to which it is added.

The problem naturally arose concerning the nature of the product being sold for or in place of whipped cream. What is its composition, its sanitary quality, its body, and its flavor? Is the consumer receiving the same approximate food now in place of the mechanically whipped cream of former years? A survey was undertaken to ascertain the characteristics of this whipped product in four cities of upstate New York. The product will be referred to as whipped cream in this presentation without any assumption that the product would be classified as such by consumers or law-enforcing agencies.

Methods

Samples were taken in the cities of Auburn, Utica, Syracuse, and Rochester because of their proximal location. Retail stores serving ice cream, such as exclusive ice cream and dairy stores, confectionaries, drug stores, and restaurants, were selected at random while driving through the city. The samples were collected in September, 1948.

The state inspector asked a person behind the counter if they served whipped cream on their ice cream sundaes. If the answer was no, but we do serve some other product for whipped cream, the identity of the product was established and a sample was requested after the inspector introduced himself. If the answer was yes, then the inspector stated his identity and asked for a sample. If the person selling the whipped cream now stated it was not whipped cream, the product was recorded as not being whipped cream. In all other cases the product was being sold as whipped cream.

Data were collected verbally from the owner or manager. The one pint cup from the ice cream overrun tester of the Toledo Scales Company was filled with whipped cream and the surface was immediately leveled off with a spatula. This sample was promptly taken to the automobile and weighed. A portion from the center of the whipped cream was transferred to a sterile test tube and placed immediately in an insulated box with enough water to extend halfway up the tubes and enough ice to extend above them. This sample was delivered by automobile the same day to the bacteriological laboratory. The sample whipped cream was then tasted for quality. The remainder of the pint sample was transferred to a pint fruit jar, closed tightly, sealed and shipped by train the afternoon of collection to the chemical laboratory.

* The authors are indebted to Charles J. Robinson, inspector for the Department of Agriculture and Markets, who, with the senior author, collected and tasted all of the samples.

The standard plate count for total bacteria and the coliform bacterial count on desoxycholate agar and formate ricinoleate broth were made according to standard methods.[1] The air in the whipped cream was expelled by warming to 100° F. and then transferring 1 ml. by a pipette. Similarly, the total solids, fat, refractive index of the fat, protein, and the presence of vanilla flavor and stabilizer were determined by standard methods.[2] The nonfat milk solids were calculated by multiplying the percentage of protein by 2.66 and the percentage of sugar added was calculated by difference.

RESULTS

Identification of Product. There were four methods used for whipping the cream:

In method 1 the cream mix was prepared and placed in the final container under nitrous oxide pressure in a central wholesale dairy plant. The small containers of cream mix were delivered to the retailer, and empty containers were collected for washing and refilling.

In method 2 the container was filled with a cream mix prepared by the retailer and a small cartridge of nitrous oxide was then attached in the handle of the gas whipper. In this case the retailer used his own judgment in preparing the cream mix and he also cleaned the apparatus.

Method 3 was essentially the same as method 2 except that the whipper was filled by the retailer with nitrous oxide to a given pressure from a small cylinder of the gas.

Method 4 consisted of mechanical whippers which were actually of three types, even though classified together.

In one instance the cream was whipped by hand with a wire beater. In two cases the cream was whipped by mechanical beaters and in four cases the cream was whipped by a special apparatus to blow finely divided air bubbles through it without any other mechanical agitation. The retailers using mechanical whippers prepared their own cream mixes and cared for the sanitizing of their equipment.

There were 39 samples of whipped cream collected and 18 were made by method 1. The number of samples prepared by method 1 would have been much greater, except that such samples were intentionally limited to about one-half of the total.

The manufacturers of the method 1 process use a trade name for their whipped cream. Nevertheless, only 6 of the 18 dispensers identified their product as not being whipped cream, and several concerns made a special point of advertising "pure whipped cream". Users of the other two types of nitrous oxide whippers always sold their product as whipped cream.

Chemical Composition. The milk fat content of the whipped cream varied greatly. Of the 39 samples collected 9 were below the state law for light cream and only 2 complied with the state law for heavy cream, but 2 others were obviously made from heavy cream with sugar and vanilla. The products whipped by the release of nitrous oxide gas pressure all contained about the same fat content irrespective of whether the cream mix was prepared by a central wholesale dairy plant or by individual retailers. The average fat contents were as follows: method 1, 19.73 percent; method 2, 21.55 percent; and method 3, 19.24 percent. In rather marked contrast was the average fat content of 29.49 percent for mechanically whipped cream (method 4).

The detailed data on the reflective indexes of the fat at 40° C. were not presented, but these results varied from 1.4551 to 1.4563. The fat in the cream was all milk fat, as indicated by these data.

The percentage of non-fat milk solids was greatest in whipped cream prepared by method 1, average 8.68 percent, as this cream mix was slightly fortified with extra non-fat milk solids in its preparation. Some retailers who

TABLE 1

THE IDENTITY AND COMPOSITION OF A PRODUCT USED AS WHIPPED CREAM ON DISHES OF ICE CREAM IN UPSTATE NEW YORK

Sample No.	lbs. per pint	% total solids	% fat	% nonfat milk solids[2]	% protein	% sugar added[3]	Vanilla flavor added	Stabilizer added
Method 1—nitrous oxide and wholesaler prepared mix								
1[1]	0.18	31.43	16.32	8.67	3.26	9.14	—	—
2[1]	0.22	34.55	15.45	8.06	3.03	11.04	—	—
3[1]	0.18	33.55	13.41	8.67	3.26	11.47	—	—
4	0.37	33.59	17.73	9.52	3.58	6.34	—	—
11[1]	0.24	33.99	19.50	8.87	3.37	5.62	+	—
16	0.22	35.75	22.43	9.02	3.39	4.30	+	—
17	0.23	34.95	20.88	9.16	3.44	4.91	—	—
19[1]	0.24	34.30	21.30	9.33	3.51	3.67	+	—
20	0.20	36.20	22.24	8.43	3.17	5.35	+	—
21	0.19	35.54	20.77	8.55	3.21	6.22	+	—
26	0.19	35.19	20.57	8.47	3.19	6.15	+	—
27	0.19	34.77	20.03	8.60	3.23	6.14	+	—
28	0.23	33.31	20.44	8.43	3.17	4.44	+	—
31	0.19	35.28	21.46	8.45	3.18	5.37	+	—
32	0.20	33.59	19.89	8.56	3.22	5.14	—	—
33[1]	0.22	34.56	20.62	8.32	3.13	5.62	+	—
34	0.23	35.23	20.64	8.54	3.21	6.05	+	—
35	0.18	34.98	21.50	8.64	3.25	4.84	+	—
Average	0.22	34.49	19.73	8.68	3.27	6.21		—
Method 2—nitrous oxide cartridge and retailer prepared mix								
5	0.20	37.30	23.55	7.75	2.91	6.00	+	—
6	0.22	35.29	21.55	6.84	2.57	6.90	—	—
7	0.22	38.70	22.63	6.09	2.29	9.98	+	—
8	0.13	27.10	8.59	6.44	2.42	12.07	+	—
9	0.20	43.10	27.70	6.06	2.28	9.34	+	—
12	0.22	33.35	21.55	5.72	2.15	6.08	+	—
14	0.18	28.61	15.65	5.30	1.99	7.66	+	—
29	0.19	37.10	26.56	7.26	2.73	3.28	+	—
37	0.19	38.00	23.90	6.14	2.31	7.96		—
Average	0.19	35.39	21.30	6.40	2.41	7.70		
Method 3—nitrous oxide and retailer prepared mix								
13	0.22	25.55	17.25	7.53	2.83	0.77	—	—
15	0.44	34.34	22.20	6.35	2.39	5.79	+	—
18	0.26	43.45	25.77	7.19	2.70	10.49	+	gelatin
24	0.26	41.42	15.98	5.19	1.95	20.25	+	—
36	0.22	23.31	14.99	8.32	3.13	0	—	—
Average	0.28	33.61	19.24	6.92	2.60	7.46		
Method 4—mechanical with beaters or air blown								
10	0.54	44.00	33.75	5.96	2.24	4.29	—	—
22[4]	0.24	51.99	36.04	5.71	2.14	10.24	+	—
23	0.57	47.12	35.99	6.03	2.26	5.10	—	—
25[4]	0.28	34.86	18.91	6.89	2.59	9.06	+	—
30	0.57	51.72	34.33	5.05	1.89	12.34	+	starch
38[4]	0.35	34.47	25.60	7.65	2.88	1.22	+	gelatin
39[4]	0.28	36.20	21.78	6.75	2.54	7.67	+	—
Average	0.40	42.91	29.49	6.29	2.36	7.13		

[1] Not sold as whipped cream.
[2] % nonfat milk solids calculated from protein content.
[3] % sugar added obtained by difference.
[4] This product was whipped by air blowing through it.

TABLE 2

THE BACTERIAL COUNTS AND COMMENTS ON THE FLAVOR AND BODY OF A PRODUCT USED AS WHIPPED CREAM ON DISHES OF ICE CREAM IN UPSTATE NEW YORK

Sample No.	Bacterial count per gram	Coliform count per gram	Comments: Flavor	Comments: Body
	Method 1—nitrous oxide and wholesaler prepared mix			
1	2,840,000	123	stale, tallowy	fluffy
2	135,000	110	stale, tallowy	fluffy
3	185,000	1,830	stale, tallowy	fluffy
4	15,200,000	6,700	stale, tallowy	fluffy
11	126,000	245	stale	fluffy
16	17,700	13	stale	fair
17	2,055,000	1,950	stale, tallowy	fluffy
19	293,500	12	stale, tallowy	fluffy
20	6,850,000	42,000	stale, tallowy	fluffy
21	16,900,000	2,200	stale	fluffy
26	119,000	10	stale, tallowy	fluffy
27	26,100	8	stale, tallowy	fluffy
28	980,000	353	stale	fluffy
31	980,000	207,000	stale, tallowy	fluffy
32	52,500	21	stale, tallowy	fluffy
33	101,000	33	stale, tallowy	fluffy
34	16,200	30	stale, tallowy	fluffy
35	8,500	0	stale, tallowy	fluffy
log. ave.	299,000	193		
	Method 2—nitrous oxide cartridge and retailer prepared mix			
5	2,410,000	6,400	good	good
6	5,330,000	125,000	good	good
7	4,200,000	133	good	good
8	3,650,000	12,200	good	fluffy
9	1,650,000	47,000	good	good
12	30,200,000	147,000	good	good
14	3,430,000	7,200	excellent	fluffy
29	19,200,000	325,000	excellent	fluffy
37	3,825,000	8,300	excellent	excellent
log ave.	5,130,000	17,700		
	Method 3—nitrous oxide and retailer prepared mix			
13	4,400,000	32,000	good	good
15	15,600,000	360	good	good
18	28,000,000	1,040,000	excellent	excellent
24	6,570,000	3,600	excellent	fluffy
36	4,500,000	176,000	excellent	fluffy
log. ave.	8,930,000	23,700		
	Method 4—mechanical with beaters or air blown			
10	12,000,000	5,500	excellent	excellent
22	32,600,000	990,000	excellent	good
23	22,400,000	7,200,000	excellent	excellent
25	11,100,000	34,000	excellent	fluffy
30	5,900	285	excellent	excellent
38	2,100,000	182,000	excellent	excellent
39	174,000	25,500	excellent	excellent
log ave.	2,140,000	56,800		

prepared their own cream mix added ice cream to the cream and thus slightly increased the non-fat milk solids. Whipped cream prepared by method 2 contained 6.40 percent non-fat milk solids and by method 3, 6.92 percent. The lowest percentage of non-fat milk solids, 6.29 percent, was in mechanically whipped cream, because the fat content was highest and no product high in non-fat milk solids was used.

The percentage of sugar varied enormously, as was evident by flavor as well as calculated data. The individual whipped creams varied from 0 to 20.25 percent, the averages varying from 6.21 percent for method 1 to 7.70 percent for cream mix whipped by method 2. In one instance a retailer said he used no sugar and another used one teaspoonful per pint of cream mix.

Most of the whipped cream contained vanilla flavor, but a few retailers avoided its use. Two samples showed gelatin as a stabilizer and one contained starch. It is interesting that one retailer stated he used gelatin, three used powdered sugar for the starch it contained as well as for its sweetness, and two others added whipping aids.

Weight per pint. The weight of whipped cream per pint was remarkably consistent for the cream whipped by nitrous oxide. This is due to the control of overrun by gas pressure. The cream whipped by method 1 weighed 0.22 pound per pint; by method 2, 0.19 pound; and by method 3, 0.28 pound. This means that one pint of cream mix made about two quarts of whipped cream or a yield of about 400 percent.

The cream mechanically whipped by method 4 was much heavier as it weighed 0.4 pound per pint. The mechanically agitated cream weighed 0.56 pound per pint, and the air-blown agitated cream weighed only 0.29 pound per pint.

Bacterial Counts. The bacterial counts varied greatly and were not very closely related to the method of whipping. The standard plate counts on individual samples varied from 5,900 to 32,600,000 per gram and the coliform counts from 0 to 7,200,000. The lowest logarithmic average bacterial count, 299,000 per gram, was obtained on the group of creams whipped by method 1. The highest average total count was 8,930,000 for cream whipped by method 3. The lowest coliform logarithmic average count of 193 was obtained by method 1, and the highest average count of 56,800 was obtained by method 4.

Flavor and Body Comments. The flavor of the whipped cream was judged solely on the basis of the cream quality as no consideration was given to the vanilla or sugar. The flavor of every sample of whipped cream prepared by method 1 was stale and tallowy. Although the data were not given in the table, the age of the cream mix from the time of delivery to whipping varied from a few hours to four days. It was evident that the cream mix was stale as delivered to the retail store. Furthermore, every sample of cream whipped by method 1 possessed a fluffy body.

Those retailers who used methods 2 or 3 prepared their own cream mix. The basis of the mix was fresh cream and milk, usually with added sugar and vanilla. Sometimes powdered sugar which contains starch was used and occasionally the sugar was added as a syrup. Ice cream was often added to the mix. The fresh good quality of the milk, cream and ice cream produced whipped cream that was always judged to be good or excellent in flavor. The body of this whipped cream was fluffy, good or excellent as this characteristic varied with both the fat and air content.

Those retailers who mechanically whipped the cream mix by air or beaters used fresh cream, sugar, and usually vanilla to prepare their own cream mix. One retailer added gelatin and another added a whipping aid. Some

used heavy cream only, some light cream only, and some mixed both creams. All of the whipped creams were judged excellent in flavor but in one instance a note was made that the flavor was not rich. Five of the samples were judged excellent in body, one was good, and one was fluffy.

Discussion

It was apparent from the data on the 39 samples of whipped cream collected in upstate New York that the numbers were sufficient to indicate the situation regarding this product.

A large majority of all the cream mix was whipped instantaneously by the nitrous oxide method, and mechanically whipped cream was almost obsolete. There appeared to be two reasons for the nitrous oxide whipping. The first consideration was the ease and convenience of whipping the cream mix just as needed for there was no effort in the whipping process. A second consideration was the reduced expense of whipped cream due to the low percentage of milk fat and the large volume of air in the finished product. In addition to these observed conditions, there was a special economic value for method 1 in that the fat in this product was charged for manufacturing rather than for fresh fluid cream under the classified price plan. Obviously, when ice cream retailers made their own cream mix from bottled cream, the fat was paid for in the higher priced class of fresh cream for bottling.

All samples of whipped cream made from cream mixes prepared by the retail ice cream dispenser possessed a good or excellent flavor as they were made from fresh bottled milk and cream. All samples of whipped cream (method 1) made from a cream mix prepared by a central dairy plant and distributed to the retailers were stale and tallowy. Information was not obtained to establish the causes of the stale flavor, but it was obvious that old dairy products must have been used in the cream mix, or the processing procedure, or the metal container was very faulty. This stale flavor must not regularly be in this product, as a stale product could not survive commercially.

The high bacterial counts were not studied to determine their origin, but they were prevalent in whipped creams produced by all methods. It is very probable that the temperature of storage was of much importance. It was noted that the containers of cream mix were seldom ice cold and bacteria may multiply rapidly in numbers at cool temperatures. The only circumstantial evidence for this thought is that whipped cream samples number 30 and 35 were observed to be really ice old in the ice cream store and they gave the lowest bacterial counts of all samples.

Most of the whipped cream prepared by the release of the cream mix from nitrous oxide pressure were light and fluffy in body to the extent that they were not considered satisfactory. The low fat contents which averaged from 19.24 to 21.30 percent and the low weight of the whipped cream which averaged from 0.19 to 0.28 pound per pint raised the problem of what should constitute a fair weight and fat content. It shall be acknowledged that the 9 samples below the New York State standard for light coffee cream contained too little fat. In this survey there were 24 samples judged as fluffy, and 22 of them contained less than 22.5 percent of fat and weighed less than 0.27 pound per pint. There were 7 samples judged excellent; 5 of them contained over 25 percent of fat and 4 of them weighed over 0.3 pound per pint. It should be pointed out that it was difficult to judge whipped cream accurately for body one sample at a time on a city street, especially when some of the samples tasted so stale that they were nauseating.

Experiments on the instantaneous whipping of cream have been published only by the originators of the process. In a preliminary abstract of their work Getz, Smith, and Tracy (3) stated: "For the commercial application of the process, it has been found that un-aged cream testing 35 percent fat (before adding sugar and flavor) saturated with nitrous oxide at 80–90 pounds partial pressure is satisfactory". The following year Getz, Smith, Tracy, and Prucha (4) showed that improved consistency of the whip and the absence of drainage from the whipped cream were directly related to increased nitrous oxide pressure and to increased fat content. Their data showed the best body of the whipped cream made from cream testing 22 percent was whipped with 85 pounds or more of nitrous oxide pressure which gave about 375 percent or more of overrun, from 28 percent cream was whipped with 80 pounds or more of pressure which gave 350 percent or more of overrun, from 32 percent cream was whipped with 70 pounds or more of pressure which gave 300 percent or more of overrun, from 36 percent cream with 60 pounds or more of pressure which gave 250 percent or more of overrun, from 40 percent cream with 55 pounds or more of pressure which gave 225 percent or more of overrun. The pressure and the overrun had to be increased as the percentage of fat decreased. The method they proposed is as follows: "A mix is prepared by adding 6 percent of sugar to fresh pasteurized cream of 35 percent fat content and flavoring it with vanilla. The pressure of nitrous oxide (N_2O) at which the mix is saturated is 80 pounds per square inch. At this pressure 7 to 8 ounces of mix produce approximately 1 quart of whip". By these standards it should be obvious that the instantly whipped cream observed in this survey ought not be satisfactory in body.

One can only speculate on minimum standards that might be reasonable to both the industry and consumers. Certainly, fresh cream or storage cream of excellent quality ought to be required. Getz, Smith, Tracy, and Prucha (4) proposed 80 pounds nitrous oxide pressure on 35 percent cream sweetened and flavored. This would give whipped cream with about 350 percent overrun weighing about 0.31 pound per pint. It is believed that 75 pounds pressure on a mix made from 30 percent cream, half heavy plus half medium cream, would yield a satisfactory body for such whipped cream would show about 325 percent overrun and weigh 0.34 pound per pint. This cream mix with a 10 percent dilution with sugar and vanilla would test 27 percent fat, and the minimum weight would need to be reduced to about 0.30 pound per pint to be below the average. Such a standard for excellence would compare well with the mechanically whipped cream found in this survey, as it contained 29.49 percent fat and weighed 0.40 pound per pint. The need is obvious for a state standard for the source and percentage of milk fat and the weight per pint of whipped cream.

Conclusions

The product used as whipped cream in upstate New York retail stores was collected and studied. It was generally sold as whipped cream, irrespective of its milk fat content.

Most of the cream mix was whipped instantaneously by the release of the product from pressure of nitrous oxide gas. A very limited amount of cream mix was whipped by agitation using mechanical beaters or bubbling air.

Of the 39 samples collected, 9 contained amounts of milk fat which were below state standards for light cream and only 2 were sufficiently rich to be heavy cream. The average percentages of fat of whipped cream prepared by 3 different devises using nitrous oxide gas were 19.7, 21.5, and 19.2. Cream mix whipped by agitation contained 29.5 percent fat. The fat was pure milk fat. Non-fat milk solids were added to a majority of the cream mixes and nearly all of them contained added

(Continued on page 349)

EFFECT OF THE CONDITION OF THE MILK CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK

NICHOLAS A. MILONE AND WALTER D. TIEDEMAN

New York State Department of Health
Albany, New York

MICROBIAL contamination in the research laboratory is considered an actuality when a pure culture is tainted by other species which are undesirable from the standpoint of pure culture study. The contamination concept as understood by the research worker delving in pure cultures is not the same as that held by the sanitarian engaged in quality control activities. Contamination, to the sanitarian, means that microbial species exist as mixed cultures nearly everywhere. Pure cultures are rarely found in nature and are the exception rather than the rule. It means that without being crowded out each species goes on existing either in competition with other species or in other possible relationships. This also means that experimental results, obtained in the pure culture study of micro-organisms, do not necessarily hold true when these organisms exist mixed with other species. Studies in contamination should consider the natural flora that is prevalent in the material under study, except in special instances when the object of the research indicates the study of pure cultures.

This study represents an attempt to add to our existing basic and fundamental knowledge on the role of the milk can in relation to its quantitative contamination potential to the prepasteurized milk placed therein as indicated by the plate count method.

Literature on the subject of the contamination of milk from external sources insofar as the milk can is concerned is not very extensive. Early studies indicate that utensils are important as a source of organisms. Prucha *et al.* (1918)[1] found that 170 freshly washed and steamed cans contained bacteria sufficient to have added from 197 to 2,557,000 organisms per ml., with an average of 128,592 if the can had been filled with milk. North (1917)[2] reported that milk from 60 farms at a shipping station had a count of 5,000,000 per ml.; after pasteurization the count was 6,700; the pasteurized milk 3 minutes after adding to un-sterile 10-gallon cans had a count of 560,000; while this milk tested in New York City next day showed a count of 12,000,000.

236 cans examined under all conditions of washing and steaming by Smith (1919)[3] would have added from 0 to 7,920,000 per ml. to the milk had it been placed in these cans. Subsequent work by the same author indicated variations dependent on treatment and dryness of the utensil. Shutt (1945)[4] found that samples of milk collected on a farm immediately after drawing into farm-sterilized pails had an average count of 700 per ml. but that when the same milk was poured into a can received from a dairy plant and held about 12 hours in a dairy cooler the count was 5,480,000.

Ayers *et al.* (1918)[5] found that at 40° F. growth is compartively slow, at 50° F. it is considerably more rapid, and that the difference between 50 and 60° F. is very striking. Breuckner (1938)[6] found that milk from well sterilized utensils had an average bacterial count of 4,300 when fresh, while milk from poorly sterilized equipment had an average count of 136,000. Also that within certain limits, cooling is not as important with good milk as it is with milk that contains a comparatively large number of bacteria before cooling is started. Shipman (1947)[7] made a study, by means of thermocouples, of what happened to the temperatures at various levels of the cans in different type coolers operated in various ways. He found differences between top and bottom can temperatures depending on whether the cooling medium was agitated or not and in the time required to bring the milk down to a desired temperature. The amount of stored refrigeration, water-bath temperature, the final can temperature, the number of cans in the cooler, the height of the water bath on the can or the type of agitation can all change the rate of cooling. The top levels were usually warmer than the lower levels. This means that bacterial growth may be relatively rapid at the higher temperature levels. Hamner (1948)[8] states that the excessive counts on many lots of milk reaching dairy plants are largely due to growth of organisms, since they are much greater than the counts obtained on freshly drawn milk, even when it is produced under very insanitary conditions.

Mathematically, based on the number of organisms rinsed out of high count cans, the case for stressing the importance of improperly sanitized utensils, in relation to subsequent contamination of milk poured into them, is hard to sustain. The paucity of data obtained under properly controlled conditions makes it somewhat difficult to evaluate accurately the role of utensils in the contamination of milk. From the logical viewpoint, the reasons given for considering improperly sanitized utensils as an important source of organisms are sound. The highest can rinse result obtained by Milone (1948)[9] in his study of the can rinse test from a presumably washed and disinfected can was 2 billion. This count represented the sum total of five successive rinsings and could be considered an extremely high count since previous rinsings of hundreds of cans never resulted in counts anywhere approaching this high figure. Further successive rinsings of this can would no doubt have yielded many more organisms but not enough to alter these calculations materially. Theoretically, a count of 2 billion should add about 50,000 organisms to each ml. of milk poured therein. Thus the initial effect on a low count milk should be small; a 5,000 count milk would have the count increased to 55,000 and a 150,000 count milk to 200,000 which in New York State would represent milk conforming to the allowable maximum of 200,000 for prepasteurized milk.

It is said that normal souring of milk results in time in a count of about one billion per milliliter. If a 40-quart can filled with sour milk and containing, therefore, about 40 trillion organisms had all but 20 ml. of the sour milk removed, the can would theoretically have about 20 billion organisms available to any milk placed therein. This would mean that about 500,000 organisms would be added to each milliliter of fresh milk placed in the can. If the fresh milk had a count of 10,000 per ml., the initial result should be to raise the count to 510,000, which considering the present day prepasteurized milk quality in many markets would not be considered very poor quality milk. The preponderance of lactic acid type bacteria in such milk should result in a fairly large reduction in number on pasteurization. The contamination potential of milk cans, then, figured on a theoretical basis, does not appear to be as high as one might believe, when other factors possibly affecting these calculations are ignored.

METHOD OF STUDY

Since the procedure varied in certain particulars in the performance of each experiment a general description is given, and any departure from the method is outlined in the experiment under discussion. In general, several

selected 40-quart cans were transported to a dairy farm chosen for the experiment in time for the night milking and placed in the milkhouse. As each milking-machine pail was brought into the milkhouse, it was carefully agitated by rotation, the top removed, and equivalent portions of the milk were poured into each of the test cans, after a representative sample had been collected from the milk pail. This procedure was repeated until the test cans were filled up to the beginning of the neck. The pail samples were composited. The samples were collected by means of hot air-sterilized aluminum thiefs. After the cans were filled they were allowed to stand 15 minutes, the milk in each can stirred by means of autoclave-sterilized metal stirrers, by moving the stirrer up and down forty times, each up and down motion being considered one excursion. This was done in order to simulate the rinse test procedure used in determining the practical sterility of milk cans. Care was exercised to assure that the stirrer did not scrape the walls of the cans. No strainer was used since it was felt that its use would complicate the experiments and serve no purpose. Thus the microbial content of the milk used for the experiment could be determined before and after the milk came in contact with the experimental cans.

Samples were collected in triplicate from the composite pail samples and from each experimental can and iced immediately. One set was used to determine the total count; the second set laboratory pasteurized at 160° F. for 15 seconds; and the third set at 143° F. for 30 minutes in a thermostatically controlled water bath with the water in continuous circulation, the samples being agitated carefully throughout the holding period. Immediately after pasteurization each sample was cooled to 40° F. within 3 minutes and kept at that temperature until plated. All of the samples were plated in duplicate, and in most instances the dilutions ranged from 1–100 through 1–10,000,000 by tenths in order to assure the greatest possible accuracy. All plates were poured with Difco Tryptone Glucose Extract Agar with one percent skim milk added except with the 1–10 dilutions used on the samples which had been laboratory pasteurized in which instances the skim milk was omitted. Incubation was at 35° C. for 48 hours. All samples were plated the same day collected, the plating being done within three hours after the last samples of the experiment were collected. This was done in order to eliminate the possible effect of overnight storage of samples on the bacterial content of the initial samples. Films for microscopic counts were made on all the samples.

After the filled cans were sampled they were placed in the cooling vat, care being taken to insure that the water bath was up to the level of the milk in the cans but not high enough to cause leakage of the cooling medium into the cans. An extra can filled with milk at the same temperature as the milk being experimented with was placed in the cooling vat and used to take temperatures of the unstirred milk, at various intervals, in order to determine the rapidity of the cooling. The experimental cans, properly identified, were met at the receiving platform of the plant purchasing the milk the following morning, and stirring and sampling procedure repeated. At this time temperatures were taken after sampling. The cans were subjected to the odor test prior to stirring the milk. The samples were again taken in triplicate so that total and thermoduric counts could be made. Samples from the cans were also composited and the samples plated so that the effect of mixing on the plate count could be determined. Thus the experiments were performed under controlled conditions, using naturally occurring flora, and variables were introduced as desired.

1. EFFECT OF THE UNCONDITIONED CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK

In this experiment three 40-quart cans and lids were selected after processing in a straightaway can washer. Can 1 had open seams, was very rusty, in fact very little tin was visible, and any sanitarian would have felt justified in condemning its use. Can 2 was in good condition but contained visible milkstone. Can 3 was in fair condition, had no open seams, and no visible deposits. Can 4 was a new can and lid sterilized in an autoclave at 20 pounds pressure for one hour and used as the control. "Unconditioned" refers to the fact that the cans used for this experiment received no treatment other than processing through the can-washing machine.

The dairy selected used milking machines and was equipped with an 8-can insulated cooling vat which was not provided with any means of agitating the cooling medium. No ice bank was observed at the time of loading the cooler and the temperature of the cooling medium did not vary much from a set temperature of 35° F. The cooler was loaded to capacity at the end of the milking operation.

The data assembled in this experiment, representative of similar results obtained in other trials under similar conditions, is graphically presented in Figure 1.

Temperature checks made on the unstirred milk in the temperature check can indicated that the temperature of the milk in the top level did not reach 50° F. until more than 5 hours had elapsed after the milk had been placed in the cooling vat. The elapsed interval between initial sampling and sampling the same milk next morning was 13 hours. It is apparent that there are no significant differences in counts on any of the samples. The control can counts are in close agreement with the composite pail sample count and individual can counts. The odor test indicated the milk to be acceptable.

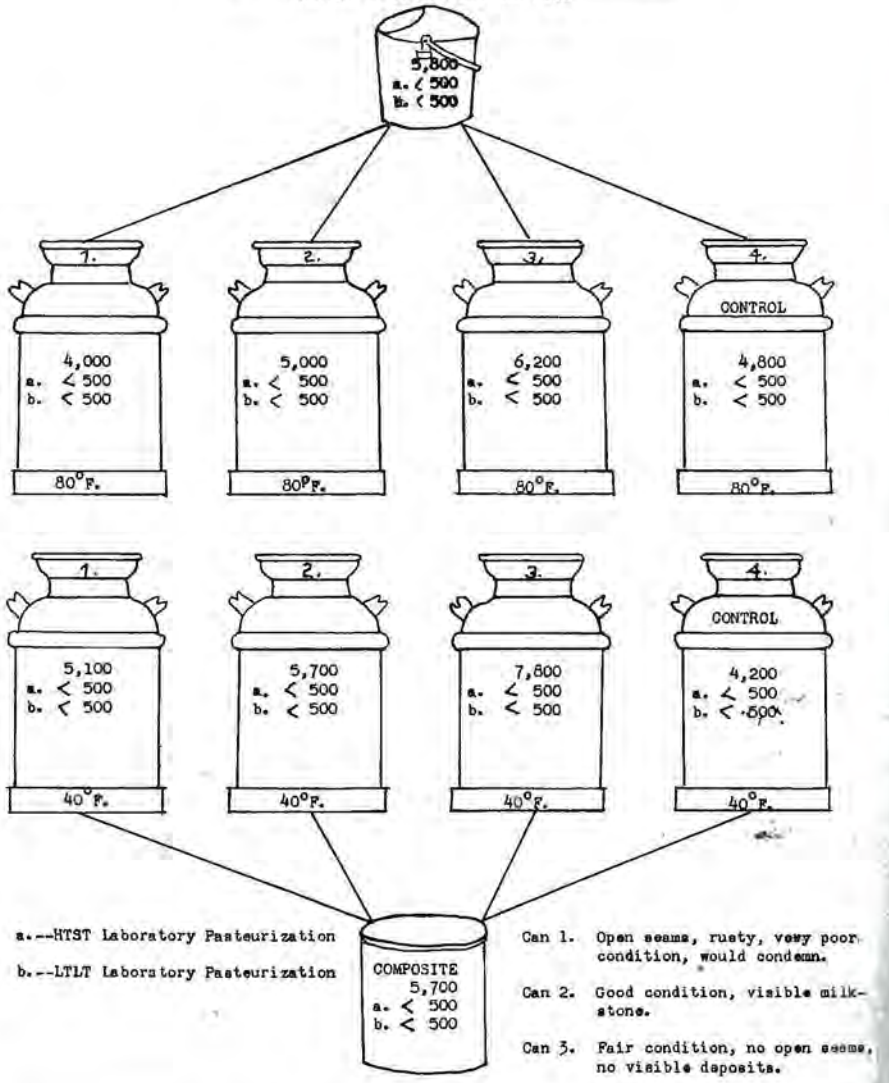
It is perhaps pertinent to add that the can washer through which Cans 1, 2, and 3 were sanitized was in excellent condition and that rinse and swab tests made on many cans processed in this machine gave very low counts. Still more important, the cans after treatment were always in a thoroughly dried condition. The interval between the sanitizing operation and use of the test cans was about 8 hours.

The letter "a" as used in all of the Figures refers to high-temperature short-time laboratory pasteurization and the letter "b" to low-temperature long-time laboratory pasteurization. Bacterial reduction by both methods of the milk in all the cans used in this experiment was satisfactory, the pasteurized counts being less than 500 and are reported as less than 500 because the lowest dilution used was 1–100. In the rest of the experiments the 1–10 dilution was always made on pasteurized milk samples. Direct microscopic counts on these samples were all less than 100,000.

It may be concluded, under the conditions outlined for this experiment, that slow cooling had no effect on the low bacterial count of the milk, and that the condition of the can, both from the viewpoint of physical defects and the presence of deposits, had no significant effect on the plate count of the milk placed therein, after the cans had been sanitized in an efficiently operated and well functioning machine resulting in thoroughly dry cans. It should be borne in mind, however, that the deposits present may have contained viable organisms that had not been killed by the heat treatment given by the machine because of the insulation afforded by the deposits and were not subsequently incorporated into the milk because of the insolubility of the deposits. The probability is small, though, that even if available for incorporation into the milk the deposits contained enough organisms to increase materially the plate count. The original thermoduric level of the milk was not

FIGURE 1

EFFECT OF THE UNCONDITIONED CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK



high enough to be of any significance even though the condition of the utensils left a great deal to be desired. The dry condition of the cans during the before-use interval, no doubt, did not afford enough moisture for thermodurics to multiply to any appreciable extent.

The composite count obtained on the milk from the four cans agrees exactly with the arithmetic average of their respective individual counts.

The tendency of some milk sanitarians to blame high counts solely on milk cans should be modified to include all other utensils since there is a very great possibility that high counts are the result of cumulative contamination from more than one source, which if high enough would be augmented by slow or delayed cooling methods. Certainly, this experiment indicates that physical inspection alone would have resulted, assuming that high counts were obtained on the milk, in fixing the responsibility on the cans when it would have been far from the truth. This is not to be construed as encouraging the use of cans in poor physical condition and containing milkstone deposits as these should be replaced or properly cleaned from the esthetic viewpoint alone, as well as the possibility that the cans may not have been efficiently disinfected and contain moisture thereby supporting growth and be a factor resulting in high count milk.

II. Effect of the Intentionally Seeded Can on the Microbial Content of Prepasteurized Milk

The same general procedure outlined for the previous experiment was followed in this trial, modified only in that two of the test cans were intentionally seeded with bacteria. Can 1 was in good physical condition, not seeded intentionally and obtained from a plant that used no detergent but "washed" the can in water followed by steaming. This can had a pronounced putrefactive odor, indicating the presence of proteolytic organisms in appreciable numbers. Can 2 was very rusty, had open seams, and would have been condemned on inspection. Can 3 was seamless, in good condition but contained visible milkstone. Can 4 was the autoclave-sterilized control. Cans 2 and 3 were taken directly off the can washer after treatment and were seeded 28 hours prior to use by pouring 500 ml. of fresh prepasteurized milk into each can, replacing the lid, and shaking in the can rinse machine described by Milone (1948).[9] The seeding material was left in these cans, with the lids in place, for 28 hours prior to use for the experiment in the open air at late spring temperatures. After the 28 hours had elapsed, the cans were once again shaken in the can rinse machine and samples of the seeding material taken in order to determine the number of organisms present in the milk used for contaminating the cans. The acidity of the milk, after the 28 hours, had not reached the point causing precipitation of the casein although the odor was sour. The film formed inside the cans was fairly uniform. The seeding material was drained from the cans for 15 minutes so that the amount of residual milk remaining in the bottom of the can was negligible. The milk selected for use as the seeding material was from a producer noted for his consistently high thermoduric counts.

The same dairy farm used for the previous experiment was selected for this trial. The results are shown graphically on Figure 2.

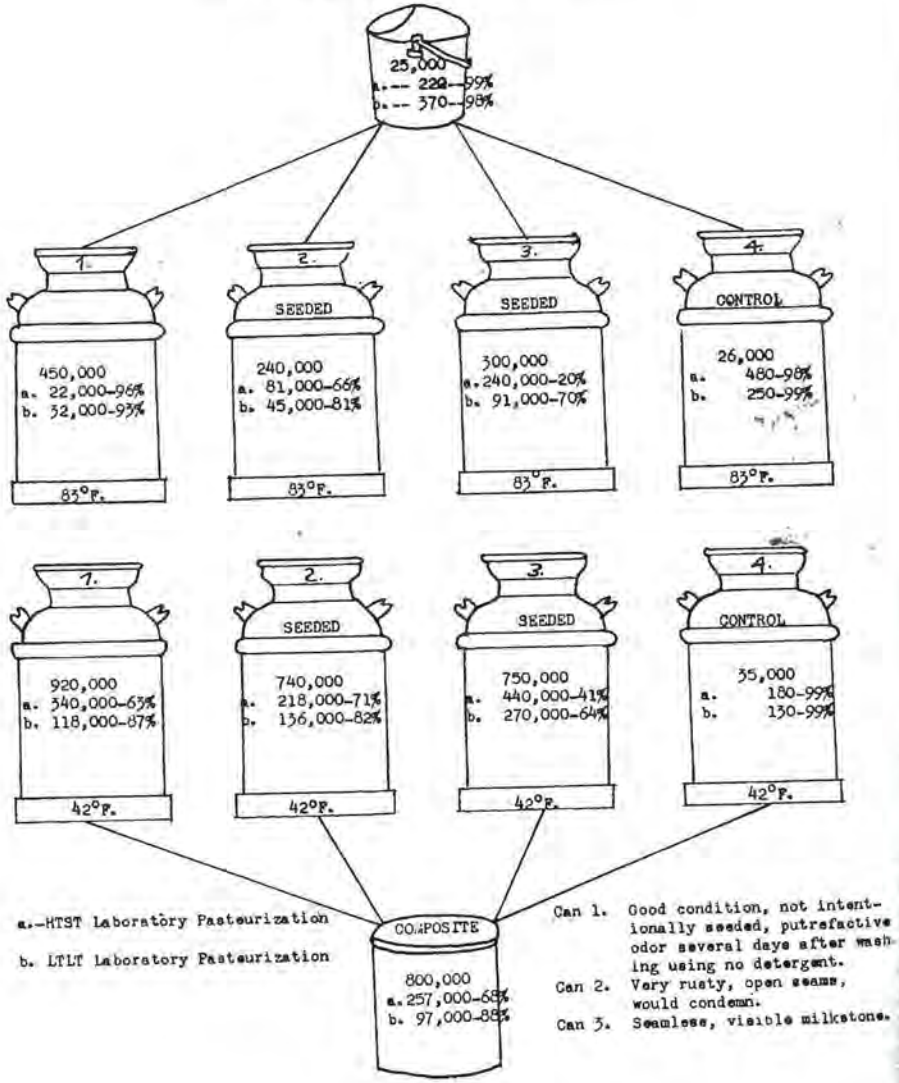
The effect on the total and thermoduric count of pouring low count milk into the cans is readily apparent. The composite pail sample shows satisfactory bacterial reduction by both methods of pasteurization, a result also substantiated by the control can samples both on initial sampling and on the following morning. The Can 2 seeding milk count was 270,000,000 per ml. Can 3 gave a seeding count of 135,000,000 per ml. An attempt was made to measure the amount of milk used for seeding Cans 2 and 3 so that the number of organisms in each can could be estimated. It was found, however, that because of leakage during shaking, measurements could not be made with any degree of accuracy. It is believed that about 20 ml. of seeding material remained in the seeded cans and the seeding material counts do give a fair idea of the extent of contamination of each can. The shaking procedure was refined in Trial C and will be discussed later.

Can 1 shows somewhat less efficient reduction indicating that the thermo-

duric level may be high enough eventually to cause trouble, an assumption borne out by the lower bacterial reduction shown on sampling the same can following overnight storage. The thermoduric level shows a definite rise immediately after pouring the fresh milk into seeded Cans 2 and 3. The bacterial efficiencies on pasteurization of the milk samples from Cans 1 and 2, taken initially and the following morning, within practical limits, are about the same, the difference being somewhat pronounced only in Can 3 and then only by the HTST method. The increase in the thermoduric count,

FIGURE 2

I. EFFECT OF THE CONDITIONED CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK



overnight, is more or less proportional to the increase in total count, both levels rising appreciably. Certainly the counts, after pasteurization, leave a great deal to be desired.

These results also indicate that the pasteurization efficiency of the two methods, under laboratory conditions, is by no means identical, when thermoduric organisms are present in significant numbers. In general, the LTLT method appears to result in comparatively better reduction than the HTST method, the results being in agreement with the findings of many other investigators. It is interesting to note that in no instance was a pasteurized count of 30,000 or less obtained on samples taken from Cans 2 and 3.

The total counts indicate an increase over the original level, on holding the milk overnight, of about one generation in Cans 1 and 3 and two generations in Can 2. The effect of the contamination on the total count when the cans were filled is by no means as great as one might expect. The effect is significantly enhanced by the slow cooling method involved and offers an interesting contrast to the results obtained in the previous experiment.

It is rather startling to remember that in actual practise the contamination conditions set up for this experiment are not generally realized and that according to these plate count results, one cannot escape the conclusion that the role of the milk can in the initial contamination of the milk placed therein is not as great as one would like to believe insofar as the total count is concerned. The effect on the thermoduric level, however, is significant. Considering the contamination involved, the total counts on Cans 2 and 3 are not much higher than the maximum established by the New York State Sanitary Code of 200,000 for prepasteurized milk. These results indicate that this standard is very lenient and could be lowered without working a hardship on a fairly careful producer. In fact one is surprised that so much of the prepasteurized milk on the market today shows counts higher than 200,000 and the most probable explanation may be the cumulative effect of slow or improper cooling on the initial contamination caused by all of the utensils on the farm and from other sources. It is reasonable to believe that if a producer is careless with milk cans he is also remiss with other utensils and the milking operation itself. The clump microscopic counts on all of the samples were not very much higher than the plate counts and in some instances lower.

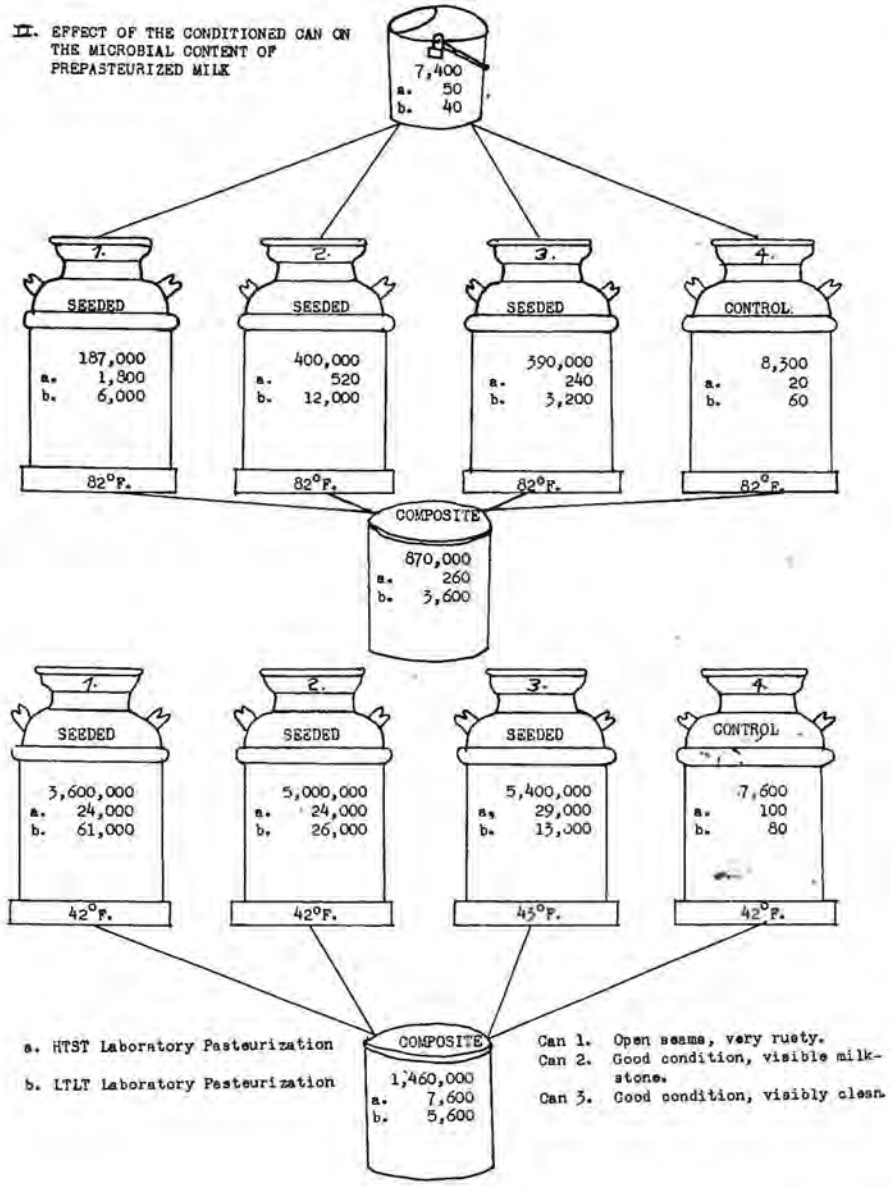
Another rather interesting fact shown by this experiment is that regardless of the contamination with proteolytic, lactic acid-producing, and thermoduric organisms and the subsequent growth overnight, the milk from Cans 1, 2, and 3 would have been accepted based on the odor test. Three experienced deckmen who were told nothing of the history of the milk stated that the milk was satisfactory.

The total count on the composite sample from all four cans as received the following morning was 800,000 contrasting with an arithmetic average count of the individual can samples of 611,000. The arithmetic averages of the thermoduric counts on the individual can samples agree fairly well with the pasteurization count of the composite sample by both methods of pasteurization. The percent reduction averages of the individual can samples also agree closely with the percent reduction averages of the composite sample by both methods of pasteurization. The percent reduction averages of the individual can samples by the HTST and LTLT methods of pasteurization, both on intial filling and the following morning, are 70 and 68 percent and 86 and 83 percent respectively.

Trial B.

The results of this experiment are presented on Figure 3. The cans were seeded in the same manner as the cans used in Trial A. This experiment dif-

FIGURE 3



fered only in that the milk used to seed the cans was left in the cans for 24 hours instead of 28 hours and all three cans were similarly contaminated. The same farm used for the previous tests was used for this experiment.

In contrast to the results obtained in Trial A, these results indicate that the milk used to seed the cans did not contain thermoduric organisms in sufficient numbers to be significant. In all instances at least 97 percent and in most instances 99 percent reduction was obtained by both methods of pasteurization.

The seeding milk counts per milliliter were 67,000,000 and 106,000,000 and 83,000,000 respectively for Cans 1, 2, and 3. As in Trial A the initial counts are again much lower than would be expected considering the extent of the contamination. Again the pronounced effect of slow cooling on the milk is apparent. In this instance, however, the initial number of organisms in all 3 cans is increased by about 4 generations. In contrast, it is noted that no increase is shown by the control can overnight, once again demonstrating that low count milk is not appreciably affected by the slow cooling method practised. The thermoduric level is sufficiently low to remain insignificant overnight possibly due to suppression by the abundant multiplication of the lactic acid type of bacteria.

This time Can 1 would have been rejected by the odor test. This can was very rusty and had open seams. This indicates that cold milk rejected because of odor due to high counts must be very bad indeed since a can in very poor condition, both bacteriologically and physically, was necessary to cause rejection of the milk.

It is also significant that the milk in each can showed satisfactory reduction in count by both methods of pasteurization. In only one instance, and that on the Can 1 milk, was the pasteurized count greater than 30,000 and that by the LTLT method. Comparable reduction efficiencies on pasteurization is seen by both methods of pasteurization. The satisfactory reduction of the bacterial count on pasteurization is shown on both the initially contaminated milk and the same milk held overnight under slow cooling conditions. It is also evident on the composite samples.

In this experiment, the composite sample from the initially contaminated cans gave a count of 870,000. The composite sample count from the same cans next morning was 1,460,000. The arithmetic averages of the individual can sample counts were 246,325 initially and 3,411,900 the next morning. While the composite counts do not agree with the individual can count averages as well as in the two previous experiments, they do indicate that the milk was unsatisfactory.

The microscopic examination of the films revealed small and large masses of staphylococci, bacilli, streptococci, and diplococci. The clump counts agreed fairly well with the plate counts.

Trial C.

In order to obtain an indication of the contamination potential of the seeded cans, the effect, if any, of freshly drawn milk on the flora of the seeded utensil, and the effect of rapid cooling on the milk, the general procedure was modified in the following respects in this experiment.

All of the 5 cans and lids used were new, the lids being carefully selected so as to fit the cans snugly. The vents in the rims of the lids were sealed by smooth soldering. All of the 5 cans and lids were autoclave sterilized prior to use.

Cans 1, 3, and 5 were seeded according to the procedure already outlined. They were then placed in a room where the temperature was kept at about 80–90° F. for 24 hours. At the end of that time the cans were shaken again in the can-rinse machine and samples of the seeding milk taken. The remaining milk was then carefully drained from each can into a graduate and the amount recovered measured. The figure of the amount sampled was added to the figure of the amount recovered, so that the amount of milk left adhering to the inside of the can could be established. The cans were allowed to drain for 15 minutes to remove as much of the seeding material as possible. It was determined that approximately 20 ml. remained in each can. Again, it was found that the milk used

for the seeding, although having a sour odor, showed no precipitation of the casein so that the measurements were easily made. Measurements were made at the same temperature used when the cans were originally seeded. Seeded Cans 1 and 3 were used as test cans, sterile cans 2 and 4 as controls, and seeded can 5 was subjected to a rinse test in an attempt to determine the extent of the contamination since Cans 1, 3, and 5 were identically treated.

The farm selected for this experiment was equipped with a 10-can cooling vat provided with an agitator so that the cooling medium was in continuous circulation. The temperature check can indicated that the milk in the cooling vat had a temperature of 40° F. about an hour after the milk had been stored in it. Three hours later the temperature was 36° F. and the milk as received next morning was at 36° F.

The producer was notified to withhold two 40-quart cans of the morning milk and keep it stored in the cooling vat. This milk was used for the experiment which started at 4:00 P.M., the same day. The milk from these cans was poured into a pail, where it was sampled, and equal portions were poured into Cans 1 and 2 and the process repeated until they were filled. The pail samples were composited as usual.

A similar procedure was followed with the freshly drawn milk using Cans 3 and 4. Thus the effect of the seeding on the milk produced at the previous milking and the freshly drawn milk could be compared. The results are shown on Figure 4.

It is interesting to note that the freshly drawn milk sampled from the pail is definitely higher in count than the older milk. Control Cans 2 and 4 counts, both initially and the next morning agree closely with the pail sample counts for both milks. The effect of rapid cooling and storage at very low temperatures is apparent on both milks. The Can 1 initial count which is close to the count obtained on Can 1, Trial B (Fig. 3) shows no increase on overnight storage which contrasts with the pronounced increase in count of the milk in the latter can. Apparently, even with relatively high count milk, rapid cooling and low-temperature storage can keep the count from materially increasing.

Bacterial reduction counts on pasteurization are satisfactory for all samples and exhibit very low thermoduric levels according to both methods of pasteurization. Composite counts agree fairly well with the arithmetic averages of the individual can counts.

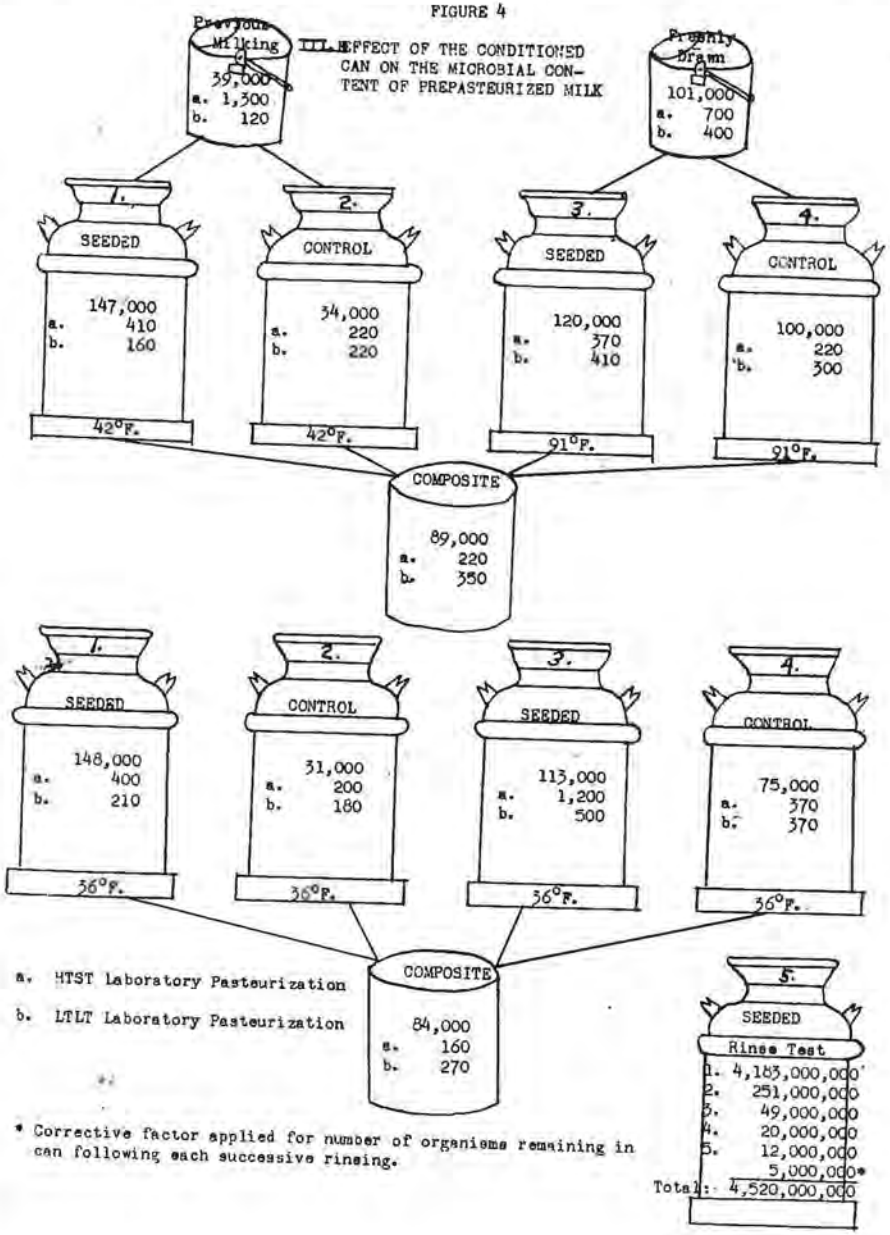
Again it is surprising to note that even the initially contaminated cans exhibit total counts well below the acceptable maximum of 200,000 set by the New York State Sanitary Code. In fact, all of the total counts including the composite counts would indicate good quality milk. The pasteurized counts would be considered as very good finished product counts. The microscopic counts of the Cans 1 and 3 milk were 400,000 and 420,000 initially and 320,000 and 360,000 on the samples taken the next morning.

The small increase in count in the milk initially poured into seeded Can 3 is worthy of note. The microscopic count of this milk was found to be 420,000 which agrees closely with the microscopic count of 400,000 obtained on the Can 1 milk. Whether this result was due to the so-called germicidal action of freshly drawn milk, involving phagocytosis, or agglutination or other reactions or because the organisms in the pail milk were resistant to the action of the fresh milk while the organisms in the seeded can were susceptible is difficult to determine. Certainly a bacteriostatic or bactericidal effect is evident. This effect cannot be demonstrated in the previous experiments since only freshly drawn milk was used. However, it is doubtful whether all freshly drawn milk exhibits this property to the same degree since variation in the resistance of different species and even strains, among other factors, would influence the results. Certainly, the initial temperature of the milk in Can 3 was favorable for the organisms whereas the temperature of the older milk in Can 1 did not favor growth.

The amount of the milk used for seeding Cans 1, 3, and 5 remaining in the cans after draining was found to be 20 ml. for each can. Table 1 gives the results obtained by plating samples of the seeding milk from Cans 1, 3, and 5 and rinse tests on Can 5.

FIGURE 4

III. EFFECT OF THE CONDITIONED CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK



* Corrective factor applied for number of organisms remaining in can following each successive rinsing.

TABLE 1

POTENTIAL VS. ACTUAL CONTAMINATION

(From Trial C)

Can	*Seeding count per ml. X20*	*Rinse test*	*Milk count (pail count subtracted)*	*By seeding count should be*	*By rinse test count should be*
1	8,760,000,000	——	108,000	219,000	113,000
3	7,200,000,000	——	19,000	180,000	113,000
5	9,400,000,000	4,520,000,000	——	——	——
1, 3, 5	8,520,000,000	——	——	——	——

Note: Successive rinsings of Can 5 demonstrate the fact that, in general, on very high count cans, the largest number of bacteria is removed on the first rinsing.

According to the above table about one half of the organisms in the seeded milk Can 1 were incorporated in the milk placed therein. The rather close agreement between the rinse test result and the contaminated milk count in Can 1 is interesting. The milk placed in this can represents milk that had been held over from early morning to late afternoon. The inhibiting effect shown by the freshly drawn milk in this experiment (Can 3) precludes the drawing of any definite conclusions insofar as that milk is concerned. The method of seeding the cans, as described, leaves a film on the inside surface of the can when it is shaken initially. When it is re-shaken 24 hours later, the initial film is dry and another film forms which is partially dry by the time the cans are used. One might logically conclude that the majority of the organisms are contributed by the fresher film although the effect of the fresher film may be to soften the older film and thereby result in the release of some organisms from the older film. The possible effect of the temperature of the milks on the film should be kept in mind. The higher temperature of the milk in Can 3 should allow easier incorporation of the organisms than the lower temperature of the milk in Can 1. Needless to say, under the conditions outlined, that the indications are that not all of the organisms, potentially available, are released or incorporated into the milk placed into the seeded cans. Thus variations may be expected in the number of organisms taken up by milk from utensils dependent on the surface chemistry of the film if one has formed. The authors are starting an investigation of this interesting problem. Although the constituents of milk appear to have good solvent properties, all of the seeding material was apparently not incorporated into the milk in this experiment.

The odor test again showed all cans to be acceptable.

Trial D.

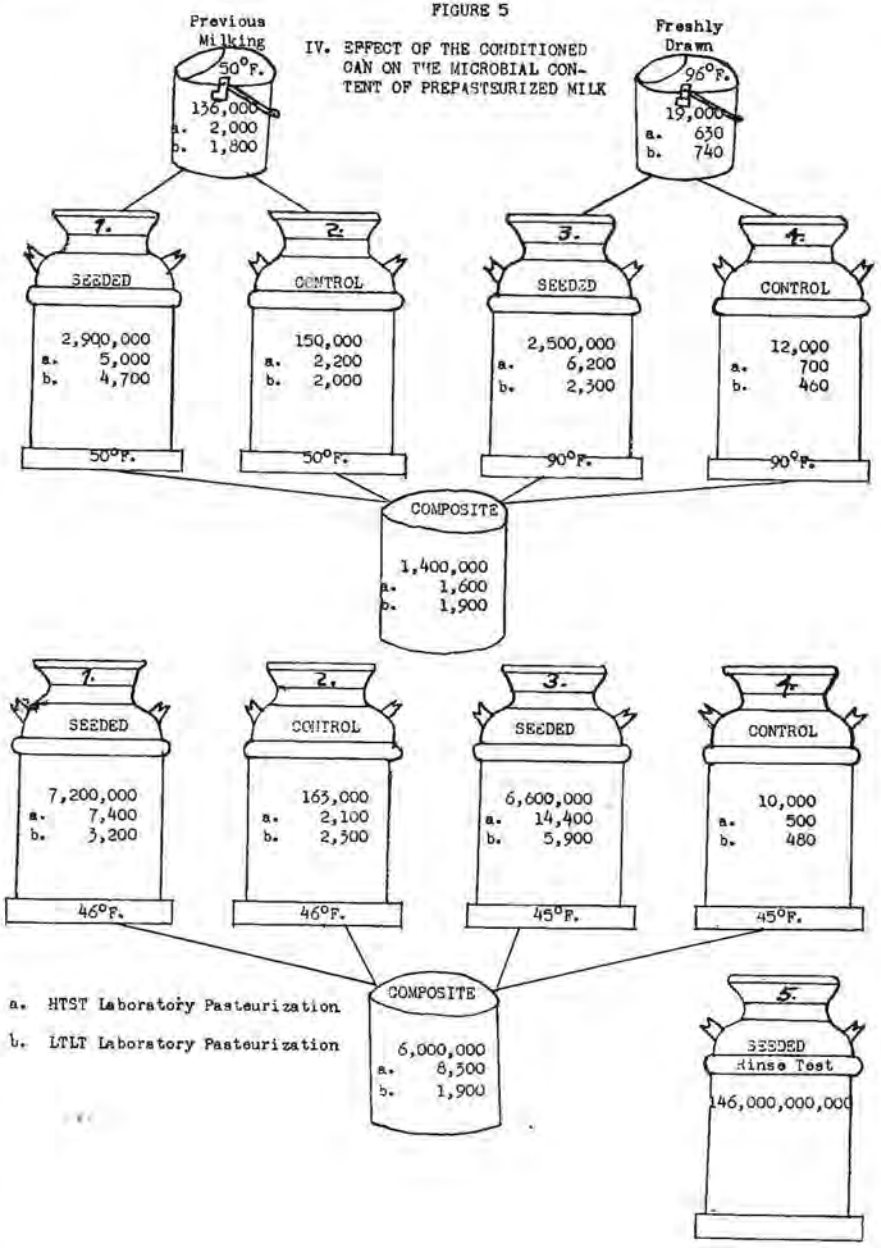
The experiment described in Trial C was repeated at another farm which was also equipped with a 10-can cooling vat provided with an agitator for the cooling medium. Two of the features were different. One was that the thermostat of the cooling vat functioned improperly so that the temperature of the freshly drawn milk did not get to 50° F. until 3 hours had elapsed after the milk can had been placed in the cooling vat. It did not reach a temperature of 40° F. until after midnight.

The other difference was that the seeded cans were kept overnight in a room where the temperature reached 106° F. This resulted in precipitation of the casein. The titratable acidity of the seeding milk, after incubation, was found to be 0.58 percent. It was, therefore, impossible to measure the amount of milk remaining in the cans after draining. The two differences, however, did set up the highest possible contamination potential for Cans 1 and 3 of any of the trials made in this study. The gross contamination of these cans surpassed the assumptions made in the theoretical discussion involving sour milk contamination given at the beginning of this article.

The results are presented on Figure 5. In this case the previous milking pail count is definitely higher than the freshly drawn milk pail count. Percent reduction of the count on pasteurization by both methods is satisfactory on

FIGURE 5

IV. EFFECT OF THE CONDITIONED CAN ON THE MICROBIAL CONTENT OF PREPASTEURIZED MILK



all samples. The control can counts agree closely with the pail counts. The composite can count agrees closely with the initial individual can count arithmetic average but is much higher than the individual can average next morning. The pronounced effect of the contamination on initial filling is evident on the milk in Cans 1 and 3. That effect is greatly augmented following overnight storage under slow cooling conditions. The milk in the Can 2 control shows a slight increase overnight even though the temperature dropped only 4° F. overnight from an initial temperature of 50° F. The slow cooling had no effect on the control Can 4 count. The storage period was 17 hours.

The inhibiting effect evidenced in Trial C of the freshly drawn milk is not apparent in this experiment. This indicates the extreme variations in the effect shown by milks from different herds and even from different cows. It signifies that contamination from utensils may be inhibited in varying degrees or may not be inhibited at all by the fresh milk placed into them.

Under the gross seeding conditions outlined for this experiment the initial contamination is again less than one would expect. Such a condition could only be realized on a farm if a producer were to allow milk residue in a can or pail to sour to the point of casein precipitation, drain the utensil, and immediately pour fresh milk into it. It is significant that notwithstanding the extremely high counts on Cans 1 and 3 next morning, the bacterial reduction by both methods of pasteurization is very satisfactory.

Finally, the rinse test performed in Can 5 resulted in a total count of 146,000,000,000. Divided by 40,000 this means that 3,650,000 organisms would be added to each milliliter of fresh milk placed in this can. Unfortunately, the inability to estimate the amount of seeding material left in the cans after draining precludes calculations such as were made for Trial C. In this experiment the rinse test indicates that a larger number of organisms were contributed to the milk placed in the cans than in Trial C. This may mean that the physical condition of the seeding milk made the organisms more readily available to the milk placed in the cans than the films on the inside surfaces of the cans used in Trials A, B, and C.

Cans 1 and 3 with the milk at a temperature of 45° F. as delivered the next morning would have been accepted by the odor test. The decision to accept the milk was made honestly by two experienced deckhands. The individual microscopic counts were definitely higher than the plate counts on all the samples.

Swab Tests:

Swab tests of the seeded cans used in Trails A and B were made prior to use by swabbing each can across two diameters at right angles to each other on the cylinder bottom representing an approximate area of 12 square inches. The lids were swabbed around the inside circumference of the unattached part of the rim with an approximate area of 11 square inches. Based on the ratio of area swabbed to milk contact area of can and lid, calculations indicated that subsequent initial contamination of the milk poured into these cans was much higher than was indicated by the swab counts. The most probable explanation may lie in the fact that the swab, because of the small amount of cotton used and its limited adsorption potential (non-absorbent cotton was used) picked up only a comparatively small number of organisms. However, the swab results did indicate a gross contamination of each utensil swabbed and based on the results the can would have been considered very unsatisfactory.

The Plate Count Method and Microscopic Method.

Contamination from shipping cans, milking machines, and other utensils bring large masses of micro-organisms into the milk. This is especially true when gross contamination takes place. The microscopic method also had drawbacks in that the total count, individual or clump, does not show the proportion of viable to dead organisms. Neither method gives a true picture of the state of activity of the organisms, and this fact, together with the fact that bacteria are not homogeneously distributed in milk, that there are more than one species present, and that many experimental errors are possible, make these methods, at best, only an estimation of the number of organisms present.

The 9th Edition of *Standard Methods for the Examination of Dairy Products* states that practically all methods have shortcomings. Such limitations are not serious provided they are not ignored when interpreting the results of tests. This statement has been kept in mind in analyzing the results of this study. Plate counts are still being used to determine compliance with standards. It is believed that the results reported do represent a trend, which properly evaluated can and does at least partly give the answers to some of the questions regarding the important subject of contamination.

It is believed that the need for more extensive research on the subject of contamination of milk, especially in reference to thermoduric organisms in relation to their isolation, physiological and morphological characteristics, and significance, is indicated by the results obtained in these experiments. The use of this approach to the problem, using both pure cultures and natural flora, promises to fill at least partially the void now existing in our knowledge of this most important subject.

CONCLUSIONS

Subject to the conditions under which this study was performed the results indicate that:

The condition of the can, both from the standpoint of mechanical defects and the presence of deposits, has no measurable effect on the bacterial content of the prepasteurized milk poured therein provided that the utensil has been sanitized in a well functioning, properly maintained can washing machine and is sufficiently dry on completion of the process.

With rapid cooling and low temperature storage (below 40° F.) the initial count of even fairly high count milk did not increase. Slow cooling on low count milk did not significantly increase the count on overnight storage.

Freshly drawn milk counts were not necessarily consistently lower than counts of milk from the previous milking. Freshly drawn milk produced under very insanitary conditions may have very high counts.

The contamination of milk, under practical conditions, appears to be a cumulative process and if the initial count at the time of cooling was sufficiently high, the effect may be considerably augmented by slow cooling methods.

The odor test as applied to cold milk on the receiving platform may result in the acceptance of very low quality milk.

The thermoduric level of milk poured into cans containing these organisms may rise high enough to give unsatisfactory bacterial reduction efficiencies on pasteurization by both the HTST and LTLT method. The presence of thermodurics in excessive numbers were not detected by the odor test performed on cold milk.

The role of the milk can in the initial total contamination of the milk poured therein, except in extreme instances, was not as important as is generally believed.

A producer must be very careless, insofar as cans are concerned, in order to contaminate highly the milk poured therein. The commonly accepted standard of 200,000 for prepasteurized milk, in the face of the results, is very

(Continued on page 369)

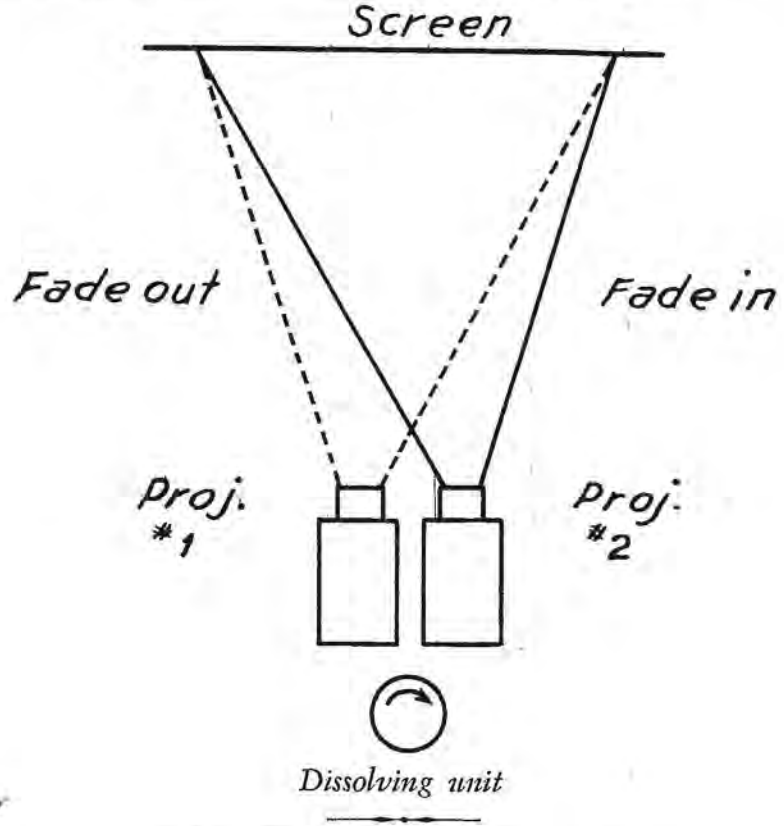
NEW APPROACH TO FOOD HANDLERS TRAINING

(Supplement)

J. L. ROWLAND, M.S.P.H., F.A.P.H.A.
AND
JACK FRITZ, B.S.
Department of Public Health and Welfare, Jefferson City, Mo.

IT'S magic. Yes, it is like magic and the new approach to food handlers training uses magic. Have you ever had to explain what bacteria really are to a lay person? A person who has never seen a microscope or much less ever looked through one? You educators! Have you ever been asked the question, "How do you know there are germs all about us?" To solve this problem, in our new approach to food handlers training we originally worked and experimented with fluorescent material and black light; that is, pictures were painted that were only visible under the ultra-violet rays. In our "patter" we would say bacteria are invisible and cannot be seen with the naked eye; yet they are about us every day; then we would show them this apparently blank poster and comment, "There is nothing on it. You cannot see anything on it, can you? It appears perfectly blank." Then on came the black light and the germs would pop up before them. This technique proved quite successful, but it had its limitations. It was limited to only small groups. It lost some of its effectiveness when the group attained a size of 20 or more. Our posters could not be made large enough to be seen from the back of the room; for when we did make the posters larger they became unwieldly and practically impossible to move from place to place. They became easily damaged, etc. These limitations started experiments in dissolved projection. We now can reproduce the same illusion of the invisible becoming visible by projection on a screen any desired size and in full color. We start by characterizing the germ. "Mike-Robe" he is called. He appears through a cloud and conducts a tour for the food handlers. He appears on an apparently clean glass right before their eyes; between a sandwich; on a butter patty; etc. At the close of the program he bids good-bye and steps back into the cloud. It is all done with 2" x 2" colored slides and dissolved projection. We feel confident that this teaching technique has unlimited possibilities not only in the training of food handlers but also in other fields. Would you like to know how it is done? Well, O.K. Here's how.

First, two slides must be prepared for any desired effect or illusion. One slide—the No. 1 slide has a subject and background but without germs. The second, or No. 2 slide, has identically the same subject and identically the same background, but it does have the germs. For example, with the glass illusion, the first or No. 1 slide has a glass, an apparently clean glass. The No. 2 slide has identically the same glass except that it now has the germs painted on the glass. We also must have two slide projectors with a dissolving unit between them. The No. 1 slide is projected, accompanied with the appropriate "patter." Then at the right moment by the controls of the dissolving unit the No. 2 slide is projected and at the same instance the No. 1 slide is dimmed out; thus, the illusion of the germs appearing right before your eyes. The attached drawing will perhaps make this explanation a little clearer. We have used this new teaching technique with amazing success as a teaching aid. It stimulates interest; and by its use we obtain a greater retention of knowledge. Thus, the illusions of magic are used as a teaching aid.



Product Used as Whipped Cream

(Continued from page 331)

sugar and vanilla. The whipped cream prepared by release from nitrous oxide pressure by 3 methods weighed an average of 0.22, 0.19, and 0.28 pound per pint. This means that 1 pint of cream mix made about 2 quarts of whipped cream.

The total bacterial counts and the coliform counts on the whipped creams were high, the majority of average total counts being in the millions per gram. The flavor of some instantly whipped cream was very stale, but when made from fresh bottle cream and milk the flavor was good or excellent. The body of most of the instantly whipped cream was fluffy and of the mechanically whipped cream was good or excellent.

Based upon this survey and published research, it was thought that whipped cream of satisfactory characteristics would contain not less than 27 percent fat and would weigh at least 0.30 pound per pint.

REFERENCES

1. American Public Health Association. *Standard Methods for the Examination of Dairy Products.* 8th ed. 1941.
2. Association of Official Agricultural *Chemists. Official and Tentative Methods of Analysis.* 6th Ed. 1945.
3. Getz, C. A., Smith, G. F., and Tracy, P. H. Instant Whipping of Cream by Aeration. *J. Dairy Sci.*, 19, 490–491 (1936).
4. Getz, C. A., Smith, G. F., Tracy, P. H., and Prucha, M. J. Instant Whipping of Cream by Aeration. *Food Res.*, 2, 409–428 (1937).

THE USE OF HYPOCHLORITE AND QUATERNARY AMMONIUM COMPOUNDS IN THE ROUTINE WASHING OF COWS' UDDERS PRIOR TO MACHINE MILKING * †

E. M. KESLER, C. B. KNODT, G. H. WATROUS, JR., AND P. S. WILLIAMS

Department of Dairy Husbandry, The Pennsylvania State College, State College, Pennsylvania

IN a previous publication (2), data were presented which demonstrated the effectiveness of several udder washes containing hypochlorite and quaternary ammonium compounds in controlling the plate count of milk obtained by machine milking. No significant differences were found in the plate counts of milk obtained by using various udder washes under rigidly controlled conditions. The question arose as to the relative efficiency of hypochlorite and quaternary ammonium solutions as compared to water when used to wash a number of cows consecutively with the same solution in routine milking practise. Accordingly, the experiments presented in this paper were designed to answer this question.

EXPERIMENTAL PROCEDURE

Five groups of five cows each were selected from one of the college Holstein research herds. These groups were comparable in daily milk production and stage of lactation at the beginning of the trials. The average daily milk production for the cows used in this trial was 44 pounds and the average stage of lactation was 165 days. The experiment was conducted in October and November of 1947. The cows were housed in stanchion type stalls, and all were fed and managed similarly. The cows in a particular group were located side by side in the stanchions so that they formed a five-cow milking line; thus there were five such lines, one for each group of cows. Their udders were washed with clean water preparations as follows: water alone, 200 p.p.m. chlorine, 400 p.p.m. chlorine, 200 p.p.m. quaternary ammonium compound, and 400 p.p.m. quaternary ammonium compound. A generally-used commercial sodium hypochlorite powder was used for preparing the chlorine solution. Similarly, a widely-used commercial preparation containing 10 percent alkyl-dimethyl-benzyl-ammonium chloride of high molecular weight was used as a source of the quaternary ammonium compounds. Two gallons of each of these solutions were prepared just prior to milking, using amounts of the bactericides in accordance with the manufacturers' directions. They were prepared at a temperature of 125° F. and were held in wooden pails to prevent decreases in temperature as much as possible. A clean turkish towel was used for each solution. One pail of solution and one towel were used for washing the udders of the five cows in a particular group. Washing was done throughout by the same person. The udder and flanks of each cow were scrubbed thoroughly with the towel which had been removed from the solution and folded wet. The cloth then was rinsed in the solution, wrung dry, and used to wipe the udder. Two streams of milk were removed from each teat into a strip cup, and the milking machines were attached 1 minute after washing was begun.

Previous to each milking time, the milking machines were taken apart and scrubbed thoroughly with a detergent. They then were rinsed in clear warm water, reassembled, and placed on a rack to dry. At milking time they again were rinsed in clean water by using a milking machine washer. Care was taken to use only new rubber parts and to see that no cracks developed in them.

Milking was done by the same persons and at the same time each morning. Five machines were employed, one being assigned to each group of cows, as indicated in Table 1. This unit was used to milk the five cows in succession, a spare pail being provided for each unit to facilitate changing from one cow to the next. No attempt was made to rinse or clean teat cups or pails between cows. Each cow was milked dry and machine stripped only.

When the machine was removed from the cow, a proportionate sample of milk was obtained immediately with a sterile glass sampling tube and placed in a sterile sample bottle. The milk from each of the five cows in the group was obtained in this manner and placed in the same sample bottle. Thus, there were five samples of milk each day, one from each group of cows. The samples were iced, transported to the laboratory, and plated on tryptone-glucose-extract-milk agar within 0.5 hour after the last cow was milked. Plating and counting were done according to *Standard Methods for the Examination of Dairy Products* (1). This procedure was repeated five days with treatments randomized in a

TABLE 1

THE EXPERIMENTAL DESIGN AND THE STANDARD PLATE COUNTS OF MILK OBTAINED IN TRIAL I [a]

Cow Group	*Day 1*	*Day 2*	*Day 3*	*Day 4*	*Day 5*
I	Quat. ammonium 200 p.p.m. 22,000 A [b]	Chlorine 400 p.p.m. 15,000 C	Water 7,200 E	Chlorine 200 p.p.m. 9,300 B	Quat. ammonium 400 p.p.m. 9,400 D
II	Chlorine 200 p.p.m. 7,800 E	Quat. ammonium 400 p.p.m. 3,200 B	Quat. ammonium 200 p.p.m. 1,000 D	Chlorine 400 p.p.m. 6,900 A	Water 1,800 C
III	Water 2,600 B	Chlorine 200 p.p.m. 12,000 D	Quat. ammonium 400 p.p.m. 686 A	Quat. ammonium 200 p.p.m. 2,800 C	Chlorine 400 p.p.m. 2,500 E
IV	Chlorine 400 p.p.m. 2,100 D	Water 3,200 A	Chlorine 200 p.p.m. 2,100 C	Quat. ammonium 400 p.p.m. 5,100 E	Quat. ammonium 200 p.p.m. 3,600 B
V	Quat. ammonium 400 p.p.m. 1,000 C	Quat. ammonium 200 p.p.m. 2,100 E	Chlorine 400 p.p.m. 1,300 B	Water 1,400 D	Chlorine 200 p.p.m. 4,800 A

[a] Expressed as standard plate count per ml.
[b] Milking machines designated by letters A–E.

* The experimental data in this paper are taken from a thesis presented by E. M. Kesler in partial fulfillment of the requirements for the degree of Master of Science in Dairy Husbandry, Pennsylvania State College.

† Authorized for publication March 2, 1948, as paper no. 1434 in the Journal Series of The Pennsylvania Agricultural Experiment Station.

Latin square design so that no group of cows received the same treatment more than once during this period. Use of the five machines was randomized so that the same machine was used only once on each cow and only once with each treatment during the individual trial. The trial was repeated four times, using a separate Latin square design for each trial.

The same groups of cows were used throughout the experiment, except that one cow in group II suffered an acute attack of mastitis during the 2-day interval between trials I and II and was replaced prior to trial II. Similarly, during trial III a cow in group I also developed an acute case of mastitis and was replaced at the conclusion of trial III. Each of these cows was replaced

TABLE 2

THE PLATE COUNTS OF MILK OBTAINED DURING THE FIVE TRIALS[a]

Trial	*Day*	*Quaternary ammonium 200 p.p.m.*	*Quaternary ammonium 400 p.p.m.*	*Chlorine 200 p.p.m.*	*Chlorine 400 p.p.m.*	*Water*
I	1	22,000	1,000	7,800	2,100	2,600
	2	2,100	3,200	12,000	15,000	3,200
	3	1,000	680	2,100	1,300	7,200
	4	2,800	5,100	9,300	6,900	1,400
	5	3,600	9,400	4,800	2,500	1,800
	$\bar{X}$	6,300	3,876	7,200	5,560	3,240
II	1	3,000	2,700	1,400	11,000	9,100
	2	3,100	2,800	4,200	1,500	17,000
	3	2,100	4,300	13,000	4,300	2,900
	4	8,400	2,800	1,800	3,000	1,300
	5	1,800	8,200	1,400	1,800	1,700
	$\bar{X}$	3,680	4,160	4,360	4,320	6,400
III	1	1,600	15,000	2,000	5,500	1,200
	2	13,000	1,700	1,700	1,300	2,700
	3	1,800	26,000	2,000	26,000	6,600
	4	2,200	3,300	3,000	5,100	170,000[b]
	5	3,400	1,800	210,000[b]	2,700	6,600
	$\bar{X}$	4,400	9,560	43,740	8,120	37,420
IV	1	4,500	6,600	1,700	640	2,700
	2	2,100	7,400	1,400	6,300	1,100
	3	860	4,200	2,500	1,600	6,200
	4	2,200	2,600	6,900	1,700	3,000
	5	9,500	750	2,500	1,600	2,700
	$\bar{X}$	3,832	4,310	3,000	2,368	3,140
V	1	3,100	11,000	75,000[c]	1,200	3,400
	2	5,000	1,000	15,000	37,000[c]	670
	3	41,000[c]	610	3,500	1,900	1,400
	4	5,300	100,000[c]	2,700	2,800	3,500
	5	3,700	9,200	7,400	16,000	100,000[c]
	$\bar{X}$	11,620	24,362	20,720	11,780	21,795
Mean of 5 trials		5,966	9,254	15,804	6,430	14,399
	$\bar{X}$[d]	4,507	5,473	4,787	5,156	3,912

[a] Expressed as standard plate count per ml.
[b] Mastitis.
[c] Apparently defective milking machine.
[d] Corrected means deleting counts denoted by b and c.

by an animal producing a similar amount of milk daily and in the same stage of lactation.

RESULTS

The experimental design and results from the first trial are presented in Table 1. The other four trials were designed similarly. The bacterial plate counts of all combined milk from each group of five cows at each milking for the five trials are presented in Table 2. As a result of the case of mastitis during trial III, the plate count of the milk from group I increased 10-fold during the last 3 days. This cow was replaced at the start of trial IV. During trial V there was an exceptionally high count on the milk from a different cow group each day. This high count also was on a different treatment each day. Inspection at the end of the trial revealed that this increased count corresponded to the use of machine no. 4 throughout this trial. It was evident that there was some difficulty with this machine which careful cleaning before each milking did not overcome during trial V. The means of the bacterial plate counts for the 25 milkings on each treatment are presented in Table 2.

While the means for three of the five treatments are higher than the other two, examination of the data shows that these high means were due either to mastitis or to an apparently defective milking machine in trial V. When these high plate counts were removed and the means recalculated, examination of the data indicated that there essentially were no differences in the mean plate counts. An analysis of variance (3) was conducted on these data and no statistically significant differences were found between the treatments. Variations due to cow groups were significant. On the basis of these data and under the conditions of these trials, it does not appear that either hypochlorite or quaternary ammonium used in udder washes at levels of 200 and 400 p.p.m. were of any greater value than clean water when washing five cows with any one washing preparation.

SUMMARY

The effect of several commonly used udder washes upon the plate count of milk obtained in machine milking was studied using clean water preparations as follows: water alone, 200 p.p.m. chlorine, 400 p.p.m. chlorine, 200 p.p.m. quaternary ammonium compound, and 400 p.p.m. quaternary ammonium compound. No significant differences were found among the mean bacterial plate counts of the milk produced under the various treatments. Differences among cow groups were found to be significant. The five trials were conducted on five groups of five cows each under recommended herd milking practices.

REFERENCES

1. American Public Health Association. *Standard Methods for the Examination of Dairy Products.* 8th Ed. New York, N. Y. 1941.

2. Kesler, E. M., Watrous, G. H., Jr., Knodt, C. B., and Williams, P. S. The Value of Hypochlorite and Quaternary Ammonium Compounds, when Used in Udder Washes, in Reducing the Plate Count of Milk. *J. Dairy Sci.*, 31, 179–182 (1948).

3. Snedecor, G. W. *Statistical Methods Applied to Experiments in Agriculture and Biology.* The Iowa State College Press, Inc., Ames, Iowa, 1946.

A CRITICAL APPRAISAL OF MILK SANITARIANS *

C. A. Abele

The Diversey Corporation, Chicago

An experience of a quarter of a century in milk sanitation entitles me to the privilege of reviewing that experience and of appraising the methods followed by me and my contemporaries during that period, and currently. This review — limited to shortcomings — is presented thus publicly (a public confession, as it were) in the belief that the observations made apply with equal force to some methods and practices currently followed by some milk sanitarians, and that the enumeration and brief discussion of some of these shortcomings may have a beneficial effect.

It is not my purpose to detract from the credit due milk sanitarians for the progress which has been made in the betterment of milk quality, and the increase in and maintenance of the safety of milk and milk products through the past several decades. Milk is the only food product which has shown a decrease in number of epidemics traceable to it. But, as I look back over my period of milk sanitation activity, I become aware of a considerable degree of inefficiency in the routine, day-to-day conduct of my work, and of some rather serious omissions, not only in my own work, but also in that of many of my contemporaries. Had these inefficiencies and omissions been recognized and rectified, it is probable that we would all be further on the road to our common objective than is currently the case. If they can now be rectified wherever they currently prevail, our future advancement toward our objective will be more rapid, I am sure.

Furthermore, I cannot escape the realization that I have been, at times, rather obstinate in my resistance to change in policy or procedure, and frequently arbitrary in interpretations of the application of policy or regulations, when a less conservative attitude would, in the light of subsequent developments, have been more intelligent.

Although these generalizations might serve to ease my personal conscience and provide me with a mental hair-shirt, they are, without elucidation, unlikely to impress this audience, because a majority of you may feel that you are too advanced to be making the mistakes made by the last generation. I shall, therefore, present my criticisms in more detail.

General Inspection Practises

I stated that I had been rather inefficient in certain of my activities. Those activities included thousands of farm and milk plant inspections—alone in the early days, and with associates more latterly. An essential purpose of those inspections—as is true of most inspections—was to determine the degree of cleanliness of the equipment used. How did I make those determinations? By sight, touch, and smell; precisely the same tools as were used in the 1890's! It is readily granted that no more refined tools than these are required to note gross shortcomings with respect to the cleaning of equipment; but there are a number of borderline zones or shades between "not clean enough" and "clean," wherein the decision rested entirely upon my organoleptic and visual perception. Were my hands always clean? Was my vision sharp and clear enough? Was I unjust to the producer or plant operator in terming the equipment "unclean," or was I remiss in my duty to consumers in considering it "clean?" In instances in which I was not able fully to convince the producer or operator of the ineffectiveness of the cleaning operation, but maintained my position in spite of that, or in which I mistakenly assumed the equipment to be clean, could I have employed means which would have made the condition more obvious or more certain? I think that question must be answered affirmatively. But, I never carried a lens or a box of cleaning tissue with me, and I never had the initiative to use a fresh strainer disc, and in my whole experience I have seen very few milk sanitarians do so.

I understand quite clearly that providing themselves with a lens or cleaning tissue, or both, would further burden milk sanitarians with equipment, and that some of them would have to provide them from personal funds. But that does not obscure the fact that inspection based solely upon the unaided human senses is also rather likely to suffer from a certain degree of inefficiency, from at least two points of view: (a) some uncleanliness is likely to be overlooked, and (b) a producer or plant operator who is charged with ineffective cleaning is more likely to correct the deficiency if he can be shown evidence to substantiate the charge. And I wonder whether the handling and feeling of equipment with hands which last held the steering wheel or picked up a milking stool can really be justified. If we give the matter mature consideration, the wiping of equipment with the open hand, or the scratching of a surface with a fingernail, is—to say the least—a somewhat unscientific and a crude means of determining its condition.

Cleaning on Dairy Farms

Most milk sanitarians recognized the importance of cleaning as a phase of milk sanitation. I, too, knew this, even when I was considerably younger. I failed to make the distinction, however, between knowing that cleanliness is essential and knowing how to effect complete cleaning. The effecting of complete cleanliness is more technical than is generally appreciated. It is dependent upon: (a) the use of an appropriate combination of chemicals, (b) the correct concentration of the use-solution, (c) effective application of the solution, and (d) complete rinsing of adhering solution and suspended matter. When I saw a container of a commercial dairy washing compound in a milk house, I took it for granted that the producer AND his milk house employee, or ALL of the members of his family who help in the milk house, knew how to prepare washing-compound use-solutions, and how to apply them. And when I discovered equipment to be ineffectively cleaned, it was assumed that the cause necessarily was inadequate use of brushes or slovenly workmanship.

I assumed that producers knew how to prepare in proper strength solutions of the washing compound they purchased, because directions usually appear on the container label. In the light of subsequent experience, I am now certain that in many instances I made assumptions—assumptions which were easy to make, due to the fact that they coincided with my hopes, and which made it possible for me to proceed to the next observation or to the next farm without further loss of time. I also realize that I was not singular—in either sense of the word—in making that kind of assumption. Those assumptions are being made all over the Nation, every day (except Sundays and holidays).

I trust I shall not be censured for devoting so much attention to the relation of sanitarians to the cleaning operation. It is a subject, however, which can hardly be over-emphasized. I know, for instance, that in a recent survey of a relatively large number of dairy farms supplying a chain of milk processing plants, it was found that the average annual consumption of

* Presented at the Thirty-fifth Annual Meeting of the International Association of Milk and Food Sanitarians, Inc., Philadelphia, October 21, 1948.

dairy washing compound was 14 pounds per farm. A rough calculation indicates that the minimum quantity of alkaline cleaning compound needed in the course of a year, in the milk house of a farm producing 30 gallons (three cans) of milk daily, is fifty pounds. If the AVERAGE consumption on these farms was 14 pounds (between 25 and 30 percent of the minimum needed), some of the producers necessarily used considerably less. Whether those producers used too little of the compound purchased in preparing use-solutions, or whether they used the solutions too irregularly, the probable cause of any uncleanliness of utensils discovered is rather obvious. I know, too, that in my own experience, and that of others who are willing to be candid about the facts, uncleanliness of dairy farm utensils and equipment is the deficiency most frequently found by efficient milk sanitarians—even though their tools are only sight and touch. I am not quite willing to conclude that so large a proportion of milk producers are intentionally indifferent—if indifference may be said ever to be intentional—to the condition in which milk-handling equipment is maintained, or that they are so occupied with other farming activities that the time necessary for effective cleaning cannot be devoted to it. I am far more inclined to suspect (a) that they have not been fully instructed on the farm in the technique of preparing use-solutions and of cleaning, or (b) that conditions or facilities in the milk house—particularly in winter—are not conducive to effective cleaning. The point I wish to emphasize is the need for a recognition of the basic cause for the condition which most milk sanitarians agree to be a problem, and the desirability of the adoption of remedial measures. It is not my purpose to suggest or to discuss remedial measures; they are obvious. I do not hesitate to state, however, that this widespread problem, which all milk sanitarians face, will not be resolved by noting that there is a container of a proprietary washing compound on the milk house shelf or floor, and ASSUMING that the milk house personnel knows how to use it, and does use it twice daily.

Cleaning in Plants

Even though pasteurizing plants are generally inspected more frequently by milk sanitarians than are dairy farms, the location and condition in which detergent compounds are kept, the concentrations in which use-solutions are prepared, and the manner in which these solutions are applied, are rarely carefully checked by sanitarians. Lest I be misunderstood, I may say that I have frequently watched some portion of the clean-up operation in receiving stations and milk plants, and I have no doubt that most sanitarians carry inspections at least to that extent. But how many make it a practice to examine the detergent in the storage container, to note whether it has become caked and deteriorated, to check the relationship between the amounts customarily used and the volumes of water in which they are dissolved against the recommendations of the manufacturer? Concentration and temperature determine the effectiveness of cleaning solutions. If these are not adjusted to the work to be done, a normal degree of scrubbing will not be effective in removing all of the residue.

Common Oversights

Not only do milk sanitarians make many assumptions, some of which appear to be unwarranted; they also overlook and appear to be oblivious to situations which recur continually. There are also others, but I wish to make reference only to two.

The first is the maintenance of the necessary concentration of the washing solutions in can- and bottle-washers, particularly the former. We know, if we devote any thought to the matter, that the washing of each can, or row of bottles, reduces the cleaning power of the washing solution to an extent predetermined by the chemical nature of the compound used and by the degree of soilage of the cans or bottles. In other words, there is a limit to the number of cans or bottles which can effectively be cleaned by a solution of a given concentration. Continued use of such a solution, after this limit has been reached, would necessarily result in ineffective cleaning, UNLESS THE STRENGTH OF THE SOLUTION IS BOOSTED BY THE ADDITION OF MORE COMPOUND. Detergent manufacturers and dairy plant managements (but not as many milk sanitarians) have learned this from experience; and can-washer operators undertake to counteract this phenomenon in the following manner: The can-washer solution tank is freshly charged every morning. If the desired concentration of the solution necessitates a charge of a certain volume or weight, an excess over that quantity is added. The excess over the prescribed concentration assures adequate cleaning power of the washing solution for a certain number of cans, determined by experience, or possibly by rule-of-thumb. The operative's intent is to add more washing compound to the solution in the tank when the number of cans washed approaches the predetermined number. However, this manual maintenance of washing solution concentration is subject to the usual vagaries of human behavior, distractions, etc., so that in many instances more than the predetermined number of cans have passed through the washer before up-keep is added—in an amount which may or may not be adequate. This cycle of depletion and boosting of washing solution strength continues throughout the can-washing run, in consequence of which a graph of progressive solution strength would have a distinctly "saw-tooth" profile, a portion of which would lie below the desirable concentration level.

The implication of this profile should be obvious. Milk sanitarians expect ALL—not only a variable portion—of the cans discharged from a can washer to be clean, and milk producers look for clean cans to be returned to them EVERY day. Those desiderata can not be assured, regardless of the mechanical design and operating condition of the can washer (about which there has recently been considerable comment and activity), if a varying percentage of each daily run of cans is subjected to washing with solution which is too weak to remove all of the residue left in the cans by the prerinse. Is it not evident that milk sanitarians, in a proportion which reflects seriously upon the extent of our acquaintance with normal can-washer operation, have been—and are currently—quite oblivious of this inevitable chemical reaction in can-washing solutions? I am aware of no organized or concerted action directed toward mandatory maintenance of adequate can-washing solution strength, which might be advanced in refutation of that circumstantial evidence. Is it possible that we have been focusing on some of the smaller trees so long that we cannot see the forest?

The second item of oversight to which I wish to refer is the condition of the interior of transportation tanks, although I propose to be very brief. I merely wish to call attention to the observation that a thorough inspection of the interior of a tank—storage or transportation, but especially the latter—cannot be made by leaning over or into the man-hole and directing a flashlight beam at the ends and periphery. A tank must be entered to be cleaned; it must also be entered to be inspected. Entry necessitates the wearing of coveralls, rubbers, and a cap, and the use of a strong flashlight or of an electric light with a good reflector, on an extension cord. Should this discussion inspire any of this audience to inaugurate the closer inspection of milk transportation tanks, they are warned not to make the potentially

fatal—and I mean FATAL—mistake of using an extension cord without a transformer (voltage reducer) somewhere in the line. The word "electrocuted" in a news item is so final! Any less prepared effort at milk tank inspection constitutes little more than a pretense. I ought to know, because I thought I had been inspecting tanks quite conscientiously, until I learned how to do it effectively.

MISDIRECTED ZEAL

Thus far I have discussed inspection inefficiencies of milk sanitarians. The other end of the behavior scale—misdirected zeal—also warrants consideration. It is possible that I have inappropriately used the term "misdirected zeal." In any event, there are two types of behavior which, in my opinion, are subject to a certain degree of criticism. These are: (a) the effort to restrict milk producers and plant managements to the use of equipment or supplies of specific manufacture, and (b) the tendency (generally limited to administrators) to oppose the use of equipment or products, or the adoption of methods, which depart from the conventional, but which may be the forerunners of real progress in our profession.

Taking up the first of these types in detail, I have read many milk ordinances and statutes, but I do not recall ever having noted a provision that a specific trade-marked product must be used. Nevertheless, it is a matter of common knowledge that milk sanitarians, here and there, from time to time (possibly in an effort to be of assistance), advise producers and plant managements what make of equipment or what brand of product to use or stock. However sincere such advice from an officially-connected milk sanitarian may be, it is usually regarded as specific instruction by the recipient, who draws his own conclusion.

Every milk sanitarian knows how easy it is to make reference, in conversation, to a product by its trade name, when discussing the remedy for a condition with a producer or plant superintendent. (Some classes of product have actually come to be known throughout the industry by the trade names of their prototypes.) In general, those slips of the tongue may be considered accidental and unintentional. When, however, officially-connected sanitarians specify that products or equipment bearing specific trade names are to be used, and prohibit—by innuendo or by instructions to local dealers—the use of similar products or equipment of other brands, they exercise a prerogative and authority not vested in them, and subject themselves, and their superiors, to the suspicion that their motives are not limited to the improvement or maintenance of milk quality. It has been my unenviable experience to have been, at different times, on both sides of such situations, and I can, from that experience, give positive assurance that these situations have explosive potentialities for serious embarrassment to those, even remotely, involved. I wish to make it clear, however, that this criticism applies only to officially-connected sanitarians, not to those engaged primarily in instructional activity, whose function it is to advise producers.

I recently visited the Pacific Coast states, and learned about and saw a number of developments in milk-handling which deeply impressed me. Most of you know, I suppose, that California production of milk for fluid consumption is conducted on a scale of a magnitude different from that in the Mississippi Valley and the East. A 75-cow dairy is considered small, the average ranges between 300 and 450 cows, and there are some at which over 1,000 cows are milked. The cows are confined and fed in a corral, the milk is cooled and stored in cold-hold tanks, and is transported to the pasteurizing plant in tanks. This is a relatively localized development, resulting from such local economic factors as land value, climate, cost of labor, and arability of the land, and is of interest rather than of significance to those of us who reside and carry on our work elsewhere. But I did also note several practises in milk-handling which appear to have significance for all of us.

Raw milk pipe-lines are, in a number of instances, rarely dismantled for cleaning. Instead, cleaning and bactericidal solutions are pumped through them. This procedure is followed at numbers of the farms at which milking machine combine systems are in use. These lines are from time to time broken for inspection by Health Department or Dairy Service Bureau personnel, and I was assured that the condition of the pipe lines is excellent and that bacterial content of the milk from dairies following that cleaning and bactericidal treatment practice is consistently under 25,000 per ml.

Rubber hose is used to transfer milk from farm storage tanks to transportation tanks, and to empty the latter. In this instance, also, the apparent liberality of milk control administrators appears to be justified by the record of laboratory findings.

I cite these two instances of rather sharp departure from conventional practises in most other sections of the Nation, because they constitute an index of the startling contrast in the viewpoint of administrators there and elsewhere, the contemplation of which generates the suspicion that some of us may have become ultra-conservative in our views and in our tendency to maintain the status quo. This latter theme might be elaborated upon; but my time is growing short, and I have, I think, already sufficiently clearly indicated the general nature of my views.

In this critical appraisal of milk sanitarians the obvious—the commendation for hard-won achievements—has deliberately been omitted. That omission should not be taken to connote that I am a misanthrope who sees only the dark side of the picture; I recognize our achievements, but I feel that commendation comes with better grace and has more savor when received from outside our ranks.

I realize that I have been sharp in some of the criticisms presented. If they appear to have been directed specifically at any individual—present or absent—be assured that that has not been my intent. Bear in mind that I have admitted my personal remissness in most of the matters discussed, and that I get around considerably. If, after these remarks, anyone still feels offended, I recommend that he suffer in silence, and avoid betrayal by acknowledgment of his shortcomings.

This paper has really been directed at the younger members of this Association who are engaged in official milk, or milk and food, control activities—maybe I should use the old term, "inspectors." Like Napoleon's troops, all of whom potentially carried in their knapsacks a marshal's baton, every younger member of this audience is potentially a milk or food sanitation administrator. I have discussed practises which, I trust you will agree, should be avoided, and policies which might well be carefully weighed, and possibly modified. Unless the tendencies described are curbed, the rising curve of public approbation of our profession is likely to break into a sharp decline—a development of far greater import to you who will eventually succeed us than it has been to us, who bequeath it to you.

MILK and FOOD SANITATION

MINIMUM REQUIREMENTS FOR EFFECTIVE MACHINE DISHWASHING *

National Research Council, Washington 25, D. C.

PROCURERS of mechanical dishwashers, including military and other Federal agencies, are concerned about securing the optimum in operating efficiency in new installations of dishwashing machines. Studies of the efficiency of such machines from the viewpoints of sanitation and public health have been reported by Committees of the American Public Health Association [1] and by the National Sanitation Foundation.[2]

To make it possible for Federal agencies to take advantage of the latest knowledge on this subject in making new installations of dishwashing machines this Committee, through its Subcommittee on Food Supply, developed and presents herewith recommended minimum requirements for machine dishwashing. The general adoption of these minimum standards by institutions, hotels and restaurants would simplify for all users the problem of procuring the types of dishwashing machines and auxiliary equipment required for dishwashing and installations that can be operated with consistently good results.

It is not anticipated that these standards will be applied to existing installations of dishwashing machines. The remodeling of an old machine to meet a single item of the minimum requirements may accomplish nothing. Among the few items that may be singled out to improve efficiency is that of prerinsing the dishes. Otherwise full compliance with all details of these requirements is essential to make old installations operate efficiently. In general it is likely to be cheaper to install new equipment meeting the requirements than to overhaul old installations.

* At its meeting on 9 June 1949, the Committee on Sanitary Engineering and Environment, National Research Council, approved the enclosed set of minimum requirements for machine dishwashing as a recommendation to the Armed Forces and other interested agencies of the Government.

Because the numerous inquiries received indicated a widespread interest outside of the Government, the Committee voted at its meeting on 7 October to release this material for public use.

RECOMMENDED MINIMUM REQUIREMENTS FOR MACHINE DISHWASHING

Status

This is a tentative functional specification designed to incorporate the results of recent studies of the efficiency of mechanical dishwashers.

Objective

To treat soiled eating and drinking utensils so as to remove all visible soil, wash water, and detergent, leave them clean and reasonably dry, and effectively reduce the public health hazard.

Scraping

Food remains shall be removed from the dishes by hand or suitable mechanical device.

Preflushing

The preflushing of dishes with warm water, with or without detergent, is highly desirable. This may be done in a preflush section of the dishwashing machine of demonstrated effectiveness or as a separate operation. The warm water containing detergent overflowing from the wash water tank or overflow rinse water may well be utilized for preflushing.

Racks and Racking

The dish racks shall be of such design as to minimize masking of the sprays. Construction with non-marking corrosion-resistant welded wire is recommended. The number of each type of utensil per rack shall be limited as overcrowding prevents effective washing. A sufficient number of racks shall be provided to permit continuous operation under maximum load. Means shall be provided for returning empty racks without damage or contamination from the outlet to the inlet end of the machine.

Washing

The temperature of the wash water shall be not less than 140° F. With good preflushing, higher temperatures, i.e., 160° F. or more are desirable. Means shall be provided to maintain the temperature of the wash water at not less than 140° F.

The minimum time of washing shall be 20 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of wash water per 100 square inches of tray area under not less than three pounds flow pressure at the top manifold.

In single tank machines the time of washing shall be controlled automatically at not less than 40 seconds, and in multiple tank machines such time shall be controlled at not less than 20 seconds by timed conveyors with effective method to prevent racks from being pushed through.

Means should be provided to maintain the concentration of detergent in the wash water automatically and continuously at not less than 0.1 percent by weight in excess of that necessary to satisfy the hardness of the water.

In multiple-tank dishwashing machines excessive spilling or carry-over of water shall be prevented by providing at least 15 inches of space between the beginning of the wash tank and the center of the first spray arm opening, at least 20 inches between the centers of the last wash spray arm opening and the first rinse spray arm opening, at least 5 inches between the center of the last rinse spray arm opening and the curtain rinse opening, and not less than 10 inches between the center of the last curtain rinse spray opening and the end of the rinse tank. When necessary, because of extended spray patterns or otherwise, baffles shall be installed between the wash and rinse tanks to prevent further intermingling of wash and rinse waters.

Rinse

A power or recirculated rinse (two-tank machine) is desirable wherever the quantity of utensils to be washed justifies the cost and the space available for installation permits.

The temperature of such rinse water shall be not less than 180° F. at the inlet to the spray arm. The minimum time of rinsing shall be 10 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of rinse water per 100 square inches of area under not less than 3 pounds flow pressure at the nozzles. Where this rinse is used as the sanitizing rinse provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of the rinse water drops below 180° F. A key-operated device shall be provided to permit starting and operating the machine in emergencies at less than the recommended temperature.

When a recirculated rinse is not provided, as in single-tank machines, the fresh water rinse from the pressure line shall be maintained at a temperature of not less than 180° F. at the inlet to the spray arm and provided with automatic stop and warning light as above. The minimum time of rinsing shall be 10 seconds during which time each rack of dishes shall be sprayed with not less than 3/8 gallons of fresh water per 100 square inches of area under not less than 15 pounds flow pressure at the nozzles. Provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of this rinse water drops below 180° F. A key-operated device shall also be provided for emergency operation.

Curtain Rinse

A curtain rinse may be provided on each multiple tank machine but is insufficient for use on single tank machines. Such rinse shall use not more than 2 gallons of water per minute maintained at 180° F. or more at the inlet to the spray arm.

Removal of Vapors

Where excessive moisture accumulates and causes condensation, the installation should include suitable means for ventilation and removal of the excess vapor.

Valves

The water and steam valves shall be of dependable construction, easily accessible, marked with standard designating colors in accordance with A.S.A.: A 13-1928 "Scheme for the Identification of Piping System," labeled as to purpose, and shall not so protrude as to be easily broken off. Valves shall be suitable for the purpose and built to withstand 125 pounds operating pressure. The water valves shall be of globe type with removable seats.

Thermometers

A dial type thermometer with 180° F. visibly marked, showing final rinse water temperature, shall be installed at eye level near the discharge end of the machine where it is protected against breakage. The bulb shall be located so as to show the temperature of rinse water entering the spray arm. Similarly, a thermometer shall be installed to show the wash water temperature.

Pressure Gages.

Gages shall be provided to show the flow pressure as near as practical to the spray arm openings of both the wash and rinse water systems.

Scrap Trays

Scrap trays shall have openings smaller than those in the spray arm and shall be readily accessible and removable for clean-

(Ed. note.—"A.S.A." means American Standards Association.)

ing. A strainer, accessible for cleaning, shall also be provided on the pump suction.

Spray Arms

Spray arms shall be made of material that is relatively non-corrodible in warm detergent solution and shall be easily removable and accessible for cleaning. The slots or jet openings shall be large enough not to clog easily and shall be so placed as to completely spray every part of every utensil in racks of the standard size delivered with the machine.

Either the spray arms shall move or the dish racks shall be moved during washing and rinsing to increase the coverage of the sprays.

Construction

The tanks and hood shall be constructed of monel metal, stainless steel or equally corrosion-resistant material in such a manner as to be easily cleaned.

Sharp angles, unnecessary ledges, and open seams shall be eliminated. To facilitate cleaning of the interior, consideration should be given to locating as much of the piping as possible on the exterior of the dishwashing machine.

Each tank *including the pump*, shall be easy to drain. The pump suction shall be at least 2 inches above the bottom of the tank.

Each tank shall be provided with a water level indicator.

The supporting frame, motors, and pumps shall be of smooth construction with all parts accessible for cleaning. Adequate guards shall be placed over moving parts.

The bottom platform of the machine shall be not less than 6 inches off the floor.

Side clean-out doors or removable panels not less than 16 inches in width shall be provided for convenience in cleaning the tanks.

Conveyors shall be so timed that the fixed speed will provide at least the minimum holding times herein specified for the various operations.

Water Supply

Water meters that are too small and water mains that are too small or too badly encrusted to deliver sufficient water for the sanitizing rinse under the existing conditions of installation are a frequent cause of failure of dishwashing operations.

When the hardness of the water exceeds 5 grains a hard water detergent should be used; when it exceeds 100 grains, softening to 5 grains or less is recommended.

In order to secure uniform water pressure the installation of a pressure-reducing valve on the hot water line to the fresh water rinse of the dishwashing machine is recommended, so set as to give 15 pounds flow pressure at the upper rinse arm openings while in operation.

The water connections to the dishwashing machines shall be so made as to prevent back-siphonage of dish water, sewage or wastes, and in accordance with A.S.A. A 40.6–1943, "Back-flow Preventers."

The hot water storage tank shall be of ample capacity and the heater shall have sufficient recovery capacity to supply the amount of water, at not less than 140° F., needed for maximum length dishwashing periods and other operations for which it is designed to provide water, if carried on simultaneously.

A booster heater shall be provided close to the point of application at the dishwashing machine for each fresh water rinse, and shall be of sufficient capacity to provide water at the rate of not less than 4 gallons per 100 square inches of tray area per minute at 180° F. or higher at the inlet to the spray arm for a single tank machine and 2 gallons or less per minute of 180° F. water for each curtain rinse on a multiple tank machine.

Placing

The machine shall be so installed that all parts are easily accessible for repair, servicing, or replacement.

Operating Instructions

Complete operating instructions shall be provided. Such instructions shall stress draining the tanks empty after the dishes from each meal are finished, cleaning the tanks and spray arms, and leaving them dry until the next use.

Committee on Sanitary Engineering and Environment

WOLMAN, DR. ABEL, *Chairman*
BAITY, DR. HERMAN G.
FAIR, DR. GORDON M.
HATCH, DR. THEODORE F.
MAXCY, DR. KENNETH F.
MORRIS, MR. SAMUEL B.
PARKS, DR. W. GEORGE
RUSSELL, DR. PAUL F.
TIEDEMAN, MR. WALTER D.
WHITTAKER, MR. HAROLD A.
YAGLOU, DR. C. P.

Subcommittee on Food Supply

TIEDEMAN, MR. WALTER D., *Chairman*
ADAMS, MR. HAROLD S.
EHLERS, MR. V. M.
WARRICK, MR. L. F.

REFERENCES

1. Tiedeman *et al.*, Report of the Committee on Washing and Disinfection of Dishes (Eng. Sect.), *Year Book, American Public Health Association*, 1941.

2. Mallmann *et al.*, A Study of Mechanical Dishwashing, *Research Bull. No. 1, National Sanitation Foundation*, October 1, 1947.

BOOK REVIEWS

Advances in Food Research, edited by E. M. Mrak and George F. Stewart. Vol. I. Published by Academic Press, Inc., New York 10, N. Y. 459 pages. 1948. $7.50.

This is the first volume of a series which the publisher announces will cover the development of food research as a whole. The editors break down the subject into the following headings: human nutrition, food acceptance, agriculture, microbiology and public health, biochemistry and histology, food technology and engineering, entomology and zoology, and commodity areas (comprising special food products). In the present volume the subjects discussed are:

The physiology and chemistry of rigor mortis with special reference to the aging of beef
Factors influencing the vitamin content of canned foods
The physiological basis of voluntary food intake (appetite?)
Biochemical factors influencing the shelf life of dried whole eggs and means for their control
Factors affecting the palatability of poultry with emphasis on histological post-mortem changes
Deterioration of processed potatoes
The influence of climate and fertilizer practices upon the vitamin and mineral content of vegetables
Nonenzymatic browning of fruit products
Microbial inhibition of food preservatives
High-polymer pectins and their deesterification

Each review deals extensively with current research, present thought in explanation of observed phenomena, many tables, and extensive references to the literature. The critical discussion of the newly published work is particularly useful in that it reveals the limitations of our knowledge and indicates fields where research is needed.

Odors—Physiology and Control, by C. P. McCord and W. N. Witheridge. Published by the McGraw-Hill Book Co., Inc., New York. 405 pages. 1949. $6.50.

In their preface the authors state that they have attempted "a summary of the latest knowledge of the perception, measurement, classification, control, and elimination of odors, and an appraisal of the significance of odors in relation to health, emotional life, economics, and related legal problems . . . particularly those odors which are classified as offensive."

Full and scholarly discussion is offered on olfcatory physiology and anatomy, the hedonics (pleasure) of odors, the relationship between health and odors, the control and abatement of odor nuisances, and pertinent legal statutes. An extensive bibliography of over three thousand references and many illustrations enrich and support the text.

After dealing with the anatomy and physiology of the olfactory system, odors ("osmyls"—see editorial, page 315) are discussed in relation to their chemical classification, constitution, detection, and measurement, various types of odors in relation to health, comfort, and disease, household and industrial odors, control and destruction, the making of an odor survey, and finally the legal aspects of odor nuisances.

JOURNAL of MILK and FOOD TECHNOLOGY

(*including* MILK AND FOOD SANITATION)

Official Publication of the

International Association of Milk and Food Sanitarians

(Association Organized 1911)

The JOURNAL OF MILK AND FOOD TECHNOLOGY (including MILK AND FOOD SANITATION) is issued bimonthly beginning with the January number. Each volume comprises six numbers. Published by the International Association of Milk and Food Sanitarians at 374 Broadway, Albany 7, N. Y. Executive Office, 23 East Elm Avenue, Wollaston 70, Mass.

Subscriptions: The subscription rate is $2.00 per volume. Single copy, 50 cents.

Correspondence regarding business matters, advertising, subscriptions, reprints, etc., should be addressed to Wm. B. Palmer, 29 North Day Street, Orange, New Jersey.

Manuscripts: Correspondence regarding manuscripts and other reading material should be addressed to the Editor, J. H. Shrader, 23 East Elm Avenue, Wollaston 70, Mass.

Membership and Dues: Active membership in the Association is $3.00 per year, and Associate membership is $2.00 per year, including respectively all issues of the JOURNAL OF MILK AND FOOD TECHNOLOGY (including MILK AND FOOD SANITATION). All correspondence concerning membership in the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, including applications for membership, remittances for dues, failure to receive copies of the JOURNAL OF MILK AND FOOD TECHNOLOGY, and other such matters should be addressed to the Secretary of the Association, George A. West, 44 Marshall St., Rochester 2, N. Y.

Affiliates of INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS

ASSOCIATED ILLINOIS MILK SANITARIANS

President, C. V. Christiansen ..... Chicago
Vice-President, F. M. Keller ..... Chicago
Secretary-Treasurer, P. E. Riley, Illinois Department of Public Health, 1800 West Fillmore St., Chicago 12
Executive Board Members:
D. E. Harms ..... Dixon
J. E. Meany ..... Chicago
Sergeant-at-Arms, C. A. Abele ..... Chicago
Auditors:
Ben Cunningham ..... Peoria
V. B. Kurrus ..... East St. Louis

DUBUQUE DAIRY TECHNOLOGY SOCIETY

President, Martin J. Fangman ..... Dubuque
Vice-President, John Welp ..... Dubuque
Secretary-Treasurer, Clem Welsh, R. R. 4, Dubuque

FLORIDA ASSOCIATION OF MILK SANITARIANS

President, L. A. Scribner ..... Orlando
Vice-President, P. D. Shirley ..... Tampa
Secretary-Treasurer, L. R. Arrington, Dairy Products Laboratory, University of Florida, Gainesville
Members of Executive Committee: R. R. Hood, Pensacola; L. T. Smith, Jacksonville

IOWA ASSOCIATION OF MILK SANITARIANS

President, J. H. Burkett ..... Sioux City
Vice-President, C. J. Ruppert ..... Iowa City
Secretary-Treasurer, Milton E. Held, Iowa Department of Health, Des Moines, Iowa

KANSAS ASSOCIATION OF MILK SANITARIANS

President, Cecil Graves ..... Olathe
First Vice-President, Pascal Roniger ..... Manhattan
Second Vice-President, Roy Mitchell ..... Winfield
Secretary-Treasurer, H. M. Weindel, Kansas State Board of Health, Topeka, Kansas.
Auditors: E. F. Kubin, McPherson, Kan.
W. F. Green, Lawrence, Kan.

MICHIGAN ASSOCIATION OF SANITARIANS

President, Philip Shirley ..... Mason
Past President, Roy Cromley ..... Detroit
First Vice-President, John Wyman ..... Grand Haven
Second Vice-President, Vernon Waite ..... Pontiac
Secretary-Treasurer, Cranston Wilcox, Branch County Health Department, Coldwater, Michigan
Assistant Secretary-Treasurer, Morton Hilbert, Eloise
Directors:
Milo Wilson ..... Ludington
Gale Mosey ..... Montrose
Hugel Leonard ..... Lake City

MINNESOTA DAIRY FIELDMEN AND INSPECTORS' ASSOCIATION

President, C. M. Pesek ..... St. Paul
Vice-President, R. Koivisto ..... Browerville
Secretary-Treasurer, Dr. J. C. Olson, Jr., Associate Professor of Dairy Bacteriology, Dairy Division, University of Minnesota, St. Paul 1
Board of Directors: J. E. Hortch, Owen Owens, Dr. Geo. S. Failing, C. H. Mattson, Dr. A. L. Sjowall, and H. G. Oldfield

MISSOURI ASSOCIATION OF MILK AND FOOD SANITARIANS

President, Glenn Lotspeich ..... Warrensburg
Vice-President, George Reeves ..... St. Louis
Secretary-Treasurer, J. L. Rowland, Missouri State Division of Health, Jefferson City, Mo.

NEW YORK ASSOCIATION OF MILK SANITARIANS

President, F. B. Carkhuff ..... Binghamton
Vice-President, Sol Pincus ..... New York
Secretary-Treasurer, C. S. Leete, State Department of Health, Albany

OKLAHOMA ASSOCIATION OF MILK AND FOOD SANITARIANS

President, Glenn Earley ..... Oklahoma City
First Vice-President, Harper Orth ..... Shawnee
Second Vice-President, Clyde Harris ..... Oklahoma City
Third Vice-President, D. C. Cleveland ..... Durant
Secretary-Treasurer, Kay Matthews, Sanitarian, County Health Department, Wewoka, Oklahoma

VIRGINIA ASSOCIATION OF MILK SANITARIANS

President, G. S. Kennedy ..... Roanoke
Vice-President, H. C. Mitchell ..... Richmond
Secretary-Treasurer, A. W. Petty, Town Hall, Virginia Beach
Auditors, H. M. Hallett ..... Leesburg
G. E. Musgrave ..... Bristol

WISCONSIN MILK SANITARIANS' ASSOCIATION

President, C. K. Luchterhand ..... Madison
Vice-President, Dave Nusbaum ..... Green Bay
Secretary-Treasurer, L. W. Brown, State Department of Agriculture, Madison
Directors:
R. W. Carnes ..... Chetek
W. V. Price ..... Madison
Auditors:
Laura F. Bates ..... Sheboygan
E. H. Zobel ..... Ripon

Associations Which Have Designated the JOURNAL of MILK and FOOD TECHNOLOGY As Their Official Organ

CALIFORNIA ASSOCIATION OF DAIRY AND MILK SANITARIANS

President. A. E. Reynolds ..... Sacramento
First Vice-President, Jack Covert ..... Los Angeles
Second Vice-President, E. J. Helgren ..... Santa Rosa
Secretary-Treasurer, C. A. Whipple, San Joaquin Local Health District, P. O. Box 111, Stockton

CENTRAL ILLINOIS DAIRY TECHNOLOGY SOCIETY

President, Russell Pollitt ..... Danville
Vice-President, L. H. Winters ..... DeKalb
Secretary, P. H. Tracy, Department of Dairy Technology, University of Illinois, Urbana
Treasurer, Hazel Rhode, Normal Sanitary Dairy, 300 Broadway, Normal
Corresponding Secretary, Burton F. Whitmore, J. D. Roszell Company, Peoria
Sergeant-at-Arms, C. L. Einspahr ..... Bloomington

CHICAGO DAIRY TECHNOLOGY SOCIETY

President, Roy Robichaux ..... Chicago
Vice-President, H. C. Schroeder ..... Chicago
Secretary, P. H. Tracy, Department of Dairy Technology, University of Illinois, Urbana
Recording Secretary, H. P. Smith, Nordigard Corp., 342 N. Western Ave., Chicago 12.

Treasurer, Adolph Brunner, Geo. F. Schwartz Ice Cream Mfg. Supplies, 4547 Milwaukee Avenue, Chicago
Sergeant-at-Arms, Leslie L. Chandler.....Chicago

CONNECTICUT ASSOCIATION OF DAIRY AND FOOD SANITARIANS

President, H. Clifford Goslee.....Hartford
Vice-President, Harold D. Neumann...New Haven
Secretary-Treasurer, C. W. Chaffee.....Hartford

INDIANAPOLIS DAIRY TECHNOLOGY SOCIETY

President, J. Herrin.....Indianapolis
Vice-President, J. Meyerhoff.....Indianapolis
Secretary, Dr. F. J. Babel, Purdue University, West Lafayette
Assistant Secretary, W. K. Moseley...Indianapolis
Treasurer, T. Witham.....Sheridan

MASSACHUSETTS MILK INSPECTORS' ASSOCIATION

President, John J. Curtis.....Quincy
Vice-President, Percy A. Hill.....Worcester
Secretary-Treasurer, Robert C. Perriollo, Department Bacteriology and Public Health, Univ. of Mass., Amherst

METROPOLITAN DAIRY TECHNOLOGY SOCIETY

President, Fred E. Uetz.....New York
Vice-President, A. J. Powers.....Brooklyn
Sergeant-at-Arms, Paul Corash.....New York
Secretary, George L. Franke, L. I. Agri. & Tech. Institute, Farmingdale

PHILADELPHIA DAIRY TECHNOLOGY SOCIETY

President, R. K. Lawhorn.....Philadelphia
1st Vice-President, W. P. Fusselbaugh..Philadelphia
2nd Vice-President, Dr. John L. Barnhart, Philadelphia
Secretary-Treasurer, W. S. Holmes....Philadelphia Dairy Council, Inc. 234 South 22nd Street, Philadelphia 3
Ass't, Secretary-Treasurer, Donald Hayes, Philadelphia

ASSOCIATION NEWS

Minnesota Dairy Fieldmen and Inspectors' Association (Minnesota Milk Sanitarians Association)

The Minnesota Dairy Fieldmen and Inspectors' Association held their annual meeting September 23, 1949. During the afternoon the Association membership and others attended the Fieldmen's Conference sponsored by the Dairy Division, University of Minnesota. The program was as follows:

1:30 p.m.
Tracing Sources of Sediment
A. W. Rudnick, Jr.
New Insecticides and Their Use in the Dairy Industry.....H. L. Parten
Report on Comparative Studies of Methods Used to Evaluate Milk Quality .....J. C. Olson, Jr.
Evaluation of Detergent Sanitizers for Use in Farm Utensil Sanitation .....W. L. Mallmann

The annual meeting and banquet was held at the President Cafe, Minneapolis, Minn., at 6:30 p.m. Dr. W. W. Mallmann was the after dinner speaker and discussed the activities of the National Sanitation Foundation. During the business meeting, President Cy Pesek outlined the activities of the Association during the past year. Mr. Pesek pointed out that the passage by the legislature of a compulsory milk pasteurization law for the state of Minnesota was in a large measure due to the activities of the association membership. By action of the membership, the name of the Association was changed to the Minnesota Milk Sanitarians Association.

ANNUAL REPORT OF THE SECRETARY THIRTY-SIXTH ANNUAL CONVENTION COLUMBUS, OHIO, OCTOBER 21, 1949

The Secretary's report for 1948–49 embraces the handling of the various functions set up by the Secretary last year which have kept him pretty busy arranging for the Convention and program, servicing the membership, the affiliated Associations, standing Committees, and Executive Board, in carrying on the activities of the Association from October 1, 1948, to September 30, 1949, inclusive.

Budget and Expense: The detailed financial statement of the Association will be found under the Treasurer's report attached. Receipts during 1948–49 amounted to $7,300.52 compared to $8,419.15 for 1947–48, and disbursements of $5,040.10 in 1948–49 against $5,718.97 leaving a balance as of October 1, 1949 of $2,260.42 compared to $2,700.18 on October 1, 1948. Personal services, printing, mailing and postage were the major items of expense. New equipment and supplies to cope with the increasing demands on the Secretary were purchased to carry on the work more efficiently and expedite handling of the Secretary's job.

Committees: Inasmuch as most of the committee work is being handled by the committee chairmen, the Secretary has had little to do in this connection but service their requests for information.

Constitution and By-laws: By authority of the resolution passed in Philadelphia, the Executive Board addressed itself to the preparation of the proposed amendment circulated to the membership before this Thirty-sixth Annual Meeting. This amendment because of its important changes in the various classes of membership, the organization and acceptance of affiliates, the establishment of a Council, standing committees, and an article on publications required considerable deliberations of the Board and was later than usual in getting out to the Active membership. The other proposed amendment passed at the Philadelphia meeting providing for a president-elect was prepared and set out to the Active membership. It was passed by the required mail ballot by vote of 271-1, with one dissenting ballot, a summary of which is attached.

Convention: The 1948 Convention held in Philadelphia on October 19, 20, 21, 1948 at the Bellevue-Stratford Hotel brought out a registration of 271 against a 401 registration in Milwaukee in 1947. The Dairy Industries Exposition in Atlantic City attracted many of our members the following week who were unable to attend both conventions. This emphasizes the necessity of holding our alternate meetings with the Dairy Show at the time and place it is being held. The arrangement and preparations of the 1949 Convention program while the prerogative of the Secretary, the delay in collection of dues and routine association business, has made it difficult to carry on this function without assistance from the Executive Board. Without their complete cooperation the program at this meeting would have been long delayed. In 1946, the suggestion was made that the vice-presidents act as a program committee along with the Secretary-Treasurer. This suggestion has considerable merit and is to be recommended in the future as a desirable working policy of the Association. Last year your Secretary recommended the appointment of a local convention chairman to assist in handling on-the-spot details dealing with Convention facilities and services. This year such a convention chairman was appointed. He met with the local committee on September 8th and I can assure you that the success of this meeting can be attributed largely to their efforts.

Journal of Milk and Food Technology: The Journal, being the official organ of the Association, many requests are received from prospective members with the expressed desire to receive the Journal. The Association pays to the Journal editorial staff of managers one dollar for each subscription entered through membership. The Secretary has been lending his assistance wherever possible in establishing a master mailing list which will assure every member the regular receipt of his Journal. Failure of members to notify properly the Secretary-Treasurer or Journal of change of address is the most common reason for interruption in the receipt of the Journal.

Membership and Dues: During the year a new billing system was started using the window envelope. This has saved considerable stenographic time in readdressing envelopes for mailing membership cards and in addition provides a receipt for payment along with each membership card. During the year considerable difficulty was experienced in handling reports from Secretaries of affiliated associations due to no uniform method of reporting. The Secretary is now studying this phase of the work

with a suggested plan of establishing some uniform procedure with affiliate Associations now in process. Comparison of memberships and dues collected shows the following summary for 1947–48 and 1948–49:

Membership	*1947–48*	*1948–49*
Active:		
Direct to International..	255	296
Through Affiliates	165	195
Associate:		
Direct to International..	521	501
Through Affiliates	1,266	1,445
Total Paid Members.....	2,207	2,437
Total Unpaid Members ..	340	212
Total Membership	2,546	2,649

During 1948–49 there has been an increase of 230 paid members, and a decrease of 128 unpaid members over 1947–48. The net increase in membership is 103.

Affiliated Associations: During the year the Kansas Association of Milk Sanitarians petitioned the International for affiliation making the twelfth association of sanitarians to seek affiliation status. Details of affiliation have progressed to final acceptance following the Annual Meeting held in Topeka, Kansas, on October 3rd and 4th, 1949. Requirements for affiliation are now embodied in the proposed amendments to the Constitution to make affiliation procedure uniform and with legal definition of requirements.

Sanitary 3A Standards: While most of this work falls on the Committee on Sanitary Procedure in cooperation with the Dairy Industry Committee, the Secretary has supplied several schools and colleges with reprints for teaching purposes. Other requests have required the establishment of a definite working policy and procedure in ordering reprints at a price assuring cost of printing, mailing, etc. A closer working relationship between the Committee on Sanitary Procedure and the Secretary is to be encouraged if servicing of the many requests for Sanitary 3A Standards and information is to be strengthened.

Respectfully submitted,
(signed) GEORGE A. WEST,
Secretary-Treasurer

REPORT OF THE SECRETARY-TREASURER

From October 1, 1948 to Sept. 30, 1949

Financial Statement:

Receipts

Cash on hand October 1, 1948....	$2,700.18
Annual Dues	4,591.39
Sale of Sanitary 3A Standards....	8.95
Total	$7,300.52

Disbursements

Journal of Milk and Food Technology—One dollar per paid-up member October 1, 1948–July 31, 1949	$2,662.00
Personal services—secretarial, stenographic and clerical services....	963.80
Contractual services—legal fees....	25.00
Printing	620.75
Mailing and postage.....	363.34
Equipment and supplies.....	203.93
Fidelity bonds—G. A. West and Wm. B. Palmer.....	32.50
Travel of Secretary-Treasurer....	60.00
Refund on membership dues overpaid	39.50
Telephone and telegraph.....	12.94
Convention expense	53.69
Foreign exchange on non-par checks	2.65
Total	$5,040.10

****

RECEIPTS	$7,300.52
DISBURSEMENTS	5,040.10
BALANCE OCTOBER 1, 1949...	$2,260.42

INDUSTRIAL NOTES

New Waukesha Vented Pump

The new Waukesha vented pump, which ends the need for makeshift by-pass systems, is a positive displacement, sanitary pump with an easily adjusted shut-off diaphragm that automatically stops product flow into the pump the instant back pressure develops.

Once set, the pump automatically equalizes pressure on the suction and discharge sides, so that no damage can occur if a machine stops or someone automatically shuts off an active line. Even on the basis of a drop a minute, product movement will stop when enough back pressure develops to actuate the diaphragm.

The Waukesha vented pump, which meets 3-A standards, is produced in Waukesha Metal or Waukesha stainless steel. It is a product of the Waukesha Foundry Company, Waukesha, Wis. A request addressed to the manufacturer will bring complete details.

Condition of Milk Can

(Continued from page 347)

lenient and could be lowered without working a hardship on the fairly careful producer. The objection to slow cooling methods would not be generally valid if the milk, so cooled, has a low count prior to cooling.

In some instances very high count milk, resulting from gross initial contamination and increased by slow cooling practises resulted in very low counts on pasteurization by both methods. Medium count milk, resulting from initial contamination, and increased by slow cooling practises, resulted in efficient reduction on pasteurization (97–99 percent) but the pasteurized counts in some instances were close to the 30,000 standard for pasteurized milk.

Dependent on the physical characteristics of the film present on the milk contact surface of the cans, not all of the organisms present in the can are incorporated in the milk poured therein.

The germicidal or inhibiting effect shown by some freshly drawn milks on the bacterial flora of a seeded can was evidenced in one of the trials but not in another. This may have been due to the degree of germicidal action varying with the different herds used or that the effect on the organisms involved was more or less specific.

Acknowledgments. The writers wish to express their appreciation for the technical assistance of Miss Marie Rand of the City of Poughkeepsie Laboratory, the co-operation of Dr. W. H. Conger, Health Officer of the City of Poughkeepsie, and the help of Messrs. R. J. Hammer, H. G. Huto, and Dr. D. T. Baker of the Dairymen's League Poughkeepsie Plant.

REFERENCES

1. *Ill. Agr. Exp. Sta. Bul.*, 204 (1918).
2. *Amer. J. Pub. Health 7*, 25 (1917).
3. *J. Dairy Sci.*, 2, 487 (1919).
4. *Canad. Dairy Ice Cream J.*, 24, No. 7, 46 (1945).
5. *U. S. Dept. Agr. Bul.*, 642 (1918).
6. *N. Y. State Assoc. Milk Sanit.*, 12th Ann. Report (1938).
7. *Ibid.*, 21st Ann. Report (1947).
8. *Dairy Bacteriology*, 3rd Ed. John Wiley and Sons, 189 (1948).
9. *N. Y. State Assoc. Milk Sanit.* 22nd Ann. Report (1948)

NEW MEMBERS

ACTIVE

Babel, F. J., Purdue Univ., Smith Hall, W. Lafayette, Ind.
Barnett, Ben F., Box 133, Silver Lake, Ind.
Black, Andrew J., Room 706, City Bldg., Akron, Ohio
Faulkner, John D., 5008 Bradley Blvd. (Apt. No. 1), Chevy Chase 15, Md.
Gleason, Edmund H., County Health Dept., Lawton, Okla.
Gozdava, Eng. A., Casilla, 9279, Santiago, Rep. of Chili, South America
Green, William E., 117 Sterrett Ave., Covington, Ky.
Harper, Dr. Henry W. III, 2801 S. Dort Hwy., Flint, Mich.
Hart, Harold B., 3668 Davenport St., Omaha, Nebr.
Houser, Leroy S., 1101 Savannah St. S.E., Washington 20, D. C.
Locke, Joseph, Box 450, Whitehorse, Y. T.
Mundt, J. Orvin, University of Tenn., Knoxville, Tenn.

ASSOCIATE

Benzie, Wallace, Health Dept., Coldwater, Mich.
Boving, S., 3600 E. Forest Ave., Detroit 7, Mich.
Brown, Keith H., 206 W. Hickory St., Canastota, N. Y.
Bruce, J. F., R.F.D. 3, Charlottesville, Va.
Burleigh, John A., 2961 Farnam St., Omaha, Nebr.
Cina, Frank, 79 Cedar St., Hartford, Wis.
Cramer, V. E., Dairymen's League Coop., Elmira, N. Y.
Hamm, A. F., 28 Maurice Ave., Ossining, N. Y.
Haman, Dr. Robert, The Wander Co., Villa Park, Ill.
Hardin, E. D., M.D., Page-Warren-Shenandoah Health Dist., Luray, Va.
Harley, W. A., 225 East Ave. N., Hamilton, Ont., Canada
Hilleary, G. Homer, 404 So. Water St., Decatur 22, Ill.
Hodges, Furley E., 768 N. Main St., Viroqua, Wis.
Hoover, B. E., Health Dept., Box 307, Front Royal, Va.
Hough, William M., 400 So. Church St., East Troy, Wis.
Jordan, Thomas D., 203 South Valley Rd., Petersburg Va.
Kasten, Roy, 3600 E. Forest Ave., Detroit 7, Mich.
King, Elwin, 404 So. Water St., Decatur 22, Ill.
Morgan, Frank J., 24 Grant Ave., Cresshill, N. J.
Moynan, John Donald, 983 Highland Ave., Ottawa, Canada
Ostrom, Ralph J., 402 Clinton St., Hammonds, Ind.
Reece, M. F., Jr., Route 2, Stillwater, Okla.
Sanders, Gordon A., 2736-A No. Buffum St., Milwaukee, Wis.
Silverman, Gerald, 191 Malta St., Brooklyn, N. Y.
Stiritz, E. E., 396 Schuyler, Kankakee, Ill.
Talbot, A. J., City Health Dept., London and Green Sts., Portsmouth, Va.
Thompson, Walter L., 2000 West 14th St., Cleveland 13, Ohio
Ward, Henry D., Health Dept., Lawrenceville, Va.
Weiss, Alfred, 4055 Puritan, Detroit, Mich.

INDEX TO VOLUME 12

Authors

Subjects