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BULLETIN NO. 91.

PREVENTING CONTAMINATION OF MILK.

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Conclusions.—The results of the work described in this Bulletin are of vital importance to the practical dairyman, as they show that extreme cleanliness is absolutely essential to the most successful dairying. Page 245.

PREVENTING CONTAMINATION OF MILK.

By Wilber J. Fraser, Chief in Dairy Husbandry.

Introduction.

It has long been known that extreme cleanliness is absolutely essential to the most successful dairying, but the real reason for this was not known until within the last few decades. Investigations of recent years have shown that all of the troublesome changes that take place in milk and make it such a difficult product to handle properly are caused by bacteria. In fact, successful dairying depends largely upon the ability to limit the number of bacteria obtaining access to milk, and to control those that cannot be kept out.

Milk becomes contaminated in so many ways in the process of milking that it is extremely difficult to secure it free from germs, but this has been done in an experimental way a sufficient number of times to prove that milk as formed in the milk glands of a healthy cow is germ free. Since bacteria invade the udder to some extent, and develop there, milk as drawn from the udder is not entirely free from germs; this is especially true of the first milk drawn.

When milk is secured free from germs, the common phenomenon of souring does not take place, but it remains sweet and practically unchanged indefinitely. It is, therefore, of the utmost importance not only to the milk producer and the consumer, but to the butter and cheese maker as well, that this ideal condition be as nearly reached as possible. By observing a few precautions dairymen can prevent the contamination of milk to a large extent, and thus produce, at but slight trouble or expense, a much better and more valuable as well as a longer keeping product.

Bacteria.

Comparatively little was known of bacteria until within the last two decades, but during this time much attention has been given to the study of these microscopic plants, and the knowledge of them has made wonderful progress. The study had not advanced far when it was discovered that certain species of bacteria had the power to produce disease, and the reputation which they thus gained clings to all bacteria in the popular mind to-day. With many people the words "bacteria" and "disease" are nearly synonymous terms, although the power to produce disease belongs to a small percentage only of the numerous species of these organisms. Bacteria are the chief agents in decay, and without decay all organic matter would remain unchanged after death.

SIZE.

These organisms, which are of such great importance, are so extremely minute that it is difficult to gain an adequate conception of their size. If they could be placed closely side by side, it would take several hundred to equal the thickness of ordinary writing paper. Of course, they can be seen only with the most powerful microscope. If bacteria could be magnified to the size of base-balls, a man enlarged in the same proportion would be over fifty miles high.

FORM.

In the more complex species of plants and animals, each has a form peculiar to itself. In bacteria, which are single-celled plants, there can be little difference in the form of the different species because of their simple structure and minute size. Although there are hundreds of species of bacteria, they all come under three different forms, which may be represented by balls, rods, and corkscrews.

SOURCES OF BACTERIA IN MILK.

Since milk, as formed in the milk glands of a healthy cow, is germ free, we would not expect to find bacteria always present in it, at least in such large numbers as usually exist. Freshly drawn milk may contain from 200 to 100,000 bacteria per c. c., or from 800 to 400,000 per teaspoonful, according to the care with which it is handled. By the time milking is completed, under ordinary conditions, the milk is badly contaminated indeed. It is then of the greatest importance to the dairy interests to learn the sources of bacteria which gain access to milk. The number found in freshly drawn milk is a good indication of the sanitary conditions under which it was produced.

Let us pause for a moment and see where these bacteria are in nature, and how they so readily gain access to milk. Investigation has shown that their presence is well-nigh universal. They are found floating on the dust in the air, and in the soil and water. It is difficult to find a cubic yard of air that does not contain thousands of them, and soil and water contain them in vastly larger numbers. In the air of enclosed spaces, as in dwellings and barns, they are much more numerous than out of doors. In the air of barns they are generally abundant, especially if a dust has been raised. They are also found in immense numbers in dung and dirt of every description, on the cows' udders, the hands of the milkers, and not only in the seams and cracks of unsterilized dairy utensils, but also clinging to the entire surface. Wherever there is a lodging place for dust, there bacteria will be found in vast numbers. The least stir in the bedding or of the dust on the floor will send myriads of them floating into the air. Everywhere in nature, then, these organ-

isms exist with the power to multiply with astonishing rapidity unless held in check by the conditions surrounding them. In most places they are dormant or growing very slowly. The bacteria clinging to the hair and dirt on a cow and those riding on the dust in the air, multiply slowly, if at all, but they have the power of growth, and as soon as they find moisture and nourishment, they develop rapidly if the temperature is favorable.

Freshly drawn milk is especially adapted to the growth of nearly all species of bacteria, as it contains all the elements necessary for their development, and besides affords a favorable temperature. Those that gain access to it, therefore not only contaminate it themselves, but multiply at an astonishing rate if the milk is not immediately cooled to near the freezing-point. The increase of bacteria usually occurs by the simple division of one individual into two. The exceptional power of rapid multiplication is one of their most important properties, especially in relation to dairying. In some species one germ may become two, under favorable conditions, in half an hour. Such multiplication in a geometrical ratio results in an increase of numbers with almost inconceivable rapidity. At this rate, starting with 1 organism, in half an hour there would be 2; in one hour each of these would have again divided, making 4; in one and a half hours 8, in two hours 16, in three hours 64, in four hours 256, etc., and if this rate of multiplication could be maintained for twenty-four hours there would be some 17,000,000, all the offspring of a single bacterium within a single day. Fortunately for humanity this maximum multiplication rarely occurs, as various factors soon interpose to check the development of these germs.

Temperature, moisture, and food supply are the conditions controlling the multiplication of bacteria. Milk at all temperatures furnishes ideal conditions as to moisture and food, and when freshly drawn its temperature is ideal for most species. This being the case, all germs that gain access to milk may multiply rapidly unless checked by an artificially low temperature or by the addition of some substance that prevents growth.

The temperature at which bacteria multiply most rapidly varies with the species. Some grow best at 75° F., and others at 90°, while a few reach their maximum rate of development at still higher temperatures.

THE EFFECT OF BACTERIA ON MILK.

The cow is a much more economical producer of human food than is the steer or the pig, and if bacteria could be prevented from getting into milk, dairying would be a far more remunerative occupation than it now is.

In milk, for whatever purpose it is to be used, nearly all species of bacteria are detrimental. They not only cause it to sour in a short time,

but make it less wholesome for infants and invalids, as well as often impart a bad flavor. Certain species, however, are essential in the manufacture of good butter and cheese.

The changes which bacteria produce in milk are several; the most common, and also the most important one, being the conversion of milk sugar into lactic acid, which is known as souring. Owing to the rapid changes which bacteria cause in milk, it is not, as ordinarily handled, in suitable condition for human food for longer than twelve to forty-eight hours after it is drawn, the time depending upon the temperature at which it is held. It is, then, essential that every family receive daily a fresh supply of milk. This necessitates the expenditure of a large amount of time and labor in delivering the milk. Generally speaking, it costs as much to deliver milk to the consumer after it is produced as it does to produce it. From this it is seen that were it not for the action of bacteria, a large supply of milk could be delivered at one time, and thus reduce the delivery to once a week, or even less frequently, which would increase the producer's profit several fold or greatly reduce the price to the consumer.

When we consider that milk is used daily by all classes of people, it will be seen that the action of bacteria on milk is of the utmost importance from a financial standpoint alone. In connection with this, the health of the community should be considered. for disease germs frequently find their way into milk where slovenly methods are practiced, and thus endanger not only the health but even the lives of the consumers.

OBJECT OF THE INVESTIGATION.

The purpose of the investigation reported in this bulletin was to determine the effect of the different common operations performed each day in dairies and dairy barns upon the bacterial content of milk, and to find the most practical methods by which this contamination could be reduced to the least possible amount.

METHOD USED.

In this investigation nearly all of the results were obtained by exposing petri dishes, which are circular glass dishes with vertical sides having covers similar in shape only large enough to fit easily over the sides, as shown in cut No. 1. The dishes used for this work were one-half inch deep and three and a half inches in diameter, the bottom containing sixty-three square centimeters of surface. These dishes were washed, and sterilized by baking in an oven at a temperature of 140° C. or 284° F. for twenty minutes. Enough sterilized beef broth containing three-fourths of one percent agar was then poured into them to cover the bottoms of the dishes about one-eighth inch deep. The beef broth furnished the nutrient material for the growth of the bacteria, and the

agar caused it to solidify when cool, so that it would not run when the dishes were tilted. These sterilized dishes were filled with the sterile nutrient medium in a laboratory where the air was comparatively free from bacteria, so that the least possible contamination would take place during filling. The dishes were then held at a warm temperature for two days, so that if any were contaminated they could be easily detected, for in that time the bacteria would have developed into colonies large enough to be visible, and, of course, all dishes not sterile were rejected.

CUT 1.—PETRI DISHES FILLED WITH NUTRIENT MEDIUM, READY TO BE EXPOSED.

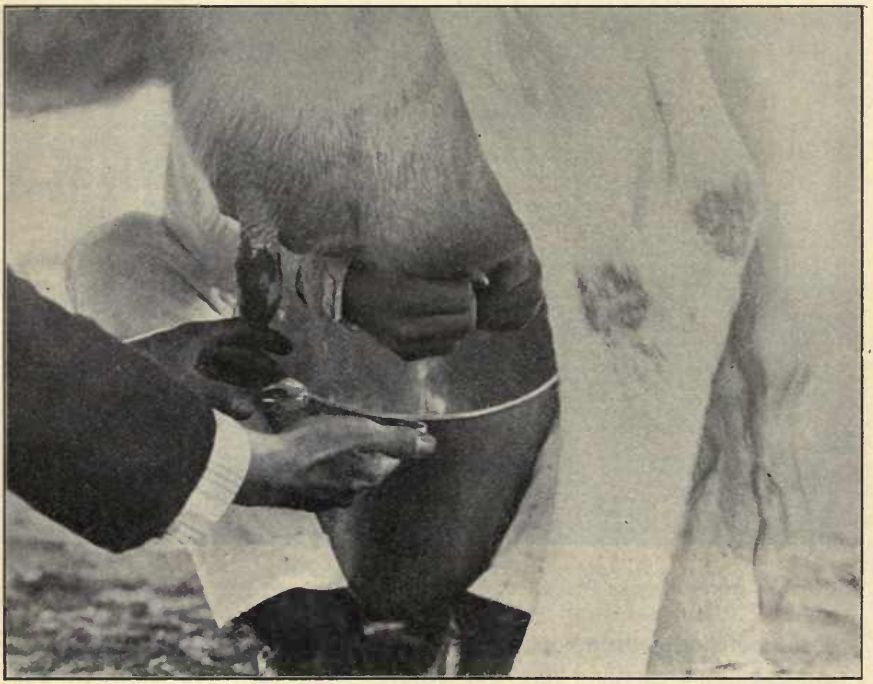
These sterile dishes were kept closed and carried to the place of exposure in a carrying case made for the purpose. An exposure was made, as shown in cuts 2 and 3, by placing a petri dish in a horizontal position, removing the cover for a definite length of time, then quickly replacing it. After being exposed, the dishes were returned to the laboratory, where they were held at a warm temperature for three days. Wherever a colony developed it showed that the dish had become contaminated by one or more bacteria falling on the nutrient medium in the dish at the time of exposure, and by counting these colonies the number of places that bacteria had fallen on the medium was determined.

That an accurate record of all exposures might be kept, the dishes were numbered consecutively as exposed, and the date, place, condition of exposure, and length of time exposed were recorded.

In this work the basis taken was the number of colonies developed on sixty-three square centimeters of surface for a half-minute exposure. In some places the exposures were necessarily for a shorter time, or the colonies

would have been entirely too numerous to count. For example, under udders the exposures were usually for only five seconds, and the actual number counted in each case was multiplied by six to bring it to the basis of an exposure of thirty seconds.

In this investigation 1,185 petri dishes were exposed. As the tables giving a complete record of these exposures are too extensive for publication, and of little general interest, they were condensed by dividing the exposures into groups as far as possible and the average for each



CUT 2.—EXPOSING PETRI DISH IN HANDS UNDER UDDER DURING MILKING.

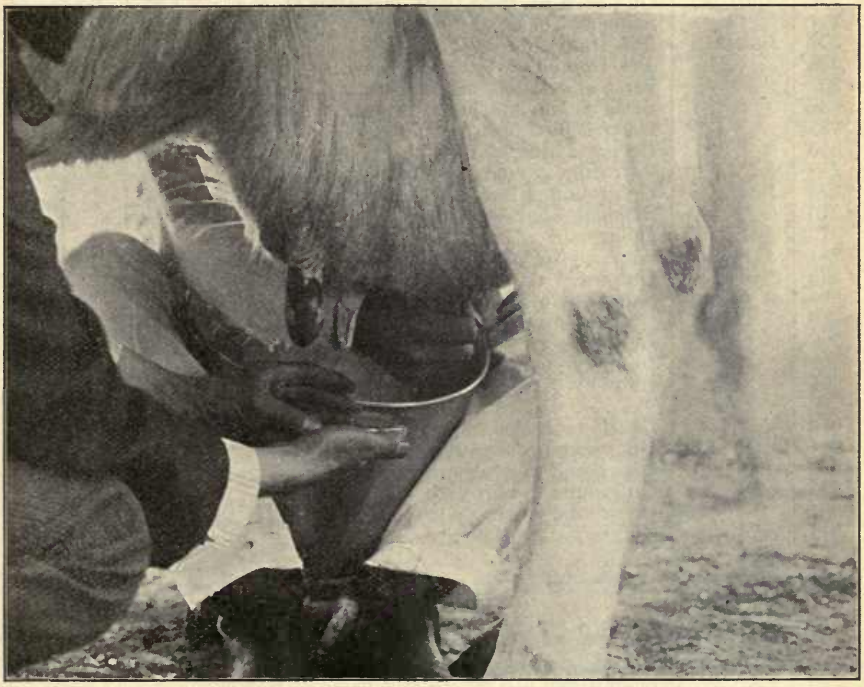
group is given. Averages were computed only when several exposures were made at the same time and under similar conditions.

The first column of each table contains the laboratory number of the dish, or the first number of a group of dishes exposed at the same time and place, and the second column gives the date of exposure. The first column at the right gives the number of exposures averaged, and the remaining column or columns the actual or average number of colonies developed.

CHECKS ON THE WORK.

As a further check against error and to learn whether petri dishes might become contaminated before or after direct exposure, certain tests were made.

January 21, four dishes were carried in the barn for five minutes at a brisk walk without removing the cover. Only one developed a colony, and that but a single one. On the same day one dish stood for



CUT 3.—PETRI DISH CLOSED JUST AFTER BEING EXPOSED UNDER UDDER.

twenty-five minutes in the barn and another was moved rapidly for five minutes through the dust arising from a pile of fodder freely agitated with a fork. Both covers were left closed, and neither developed a colony.

Again, twenty-eight dishes stood covered for five days in the dairy building, and twenty-three or eighty-two percent remained sterile.

March 10, five dishes still in the carrying case stood for one hour in the barn. These same dishes had been standing for five days in the dairy building. Only one dish developed a single colony. From all of which it is concluded that petri dishes are not subject to contamination even when in motion in a dusty barn except while the cover is removed.

TABLE 1.—BACTERIAL CONDITION OF OUTDOOR AIR.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.	
				Open field.	Barnyard.
	1897				
139	March 10	30 rd. from any building	4	$\frac{3}{4}$	...
176	April 24	On post 6 rd. from barn, just after shower	2	0	...
177	"	Same as No. 176, only at foot of post	2	0	...
227	June 3	3 ft. from ground	1	...	4
236	"	3 ft. from damp ground, no breeze	1	...	0
237	"	Same as No. 236, only on ground, slight breeze	1	...	80
238	"	Same as No. 237, only air quiet	2	...	3
255	"	On post 6 ft. from barn, wind from barn	1	...	18
256	"	On post, wind blowing across pasture	1	2	...
257	"	3 ft. from ground, 1 rod east of barn	1	...	4
274	July 2	On ground, 1 rod east of barn	2	...	$2\frac{1}{2}$
276	"	Same as No. 274, only on post	3	...	$1\frac{2}{3}$
279	"	On ground	2	...	5
281	"	Same as No. 279, only on post	1	...	1
325	Sept. 14	On post, 1 rod east of barn	1	...	1
326	"	Same as No. 325, only on ground	1	...	1
359	"	On post in dusty yard, wind from cows	2	...	12
398	Oct. 28	In dusty yard, wind from grassy field..	4	...	17
402	"	In dusty yard among cows, no breeze	4	...	86
406	"	In dusty yard after cows were let out	1	...	46
	1899				
613	May 11	Gentle breeze, shower night previous	14	$\frac{5}{14}$	...
634	May 14	On ground in barnyard	10	...	$2\frac{1}{2}$
639	"	On ground in grassy pasture	12	$\frac{1}{6}$	...
895	June 3	On ground in barnyard	10	...	$1\frac{9}{10}$
905	"	On ground in grassy pasture	8	$3\frac{3}{8}$	...
917	Sept. 16	On ground in barnyard	3	...	$6\frac{1}{3}$
		Average		**0.9**	**13**

Table 1 shows the average number of colonies that developed in petri dishes from exposures made at different times in the open field and in the barnyard.

By referring to the column containing the results of exposures made in the open field, it is seen that the group averages range from 0 to $3\frac{3}{8}$ colonies, and that the average of the entire forty-three exposures was less than one colony. From the last column, which shows the results of exposures made in the barnyard, it is seen that the group averages range from 0 to 86 colonies, with an average for the fifty-one exposures of 13 colonies. Of the exposures made in the open field, fifty percent were sterile, while of those made in the barnyard only twelve percent were sterile, showing that the air in the open field was comparatively free from bacteria, while that in the barnyard, where the ground was bare and dusty, contained more.

BACTERIAL CONDITION OF AIR IN DAIRY BARNS.

The two following tables show the results from exposures made in dairy barns varying in their sanitary condition and care. They also show the effect upon the bacterial content of the air of the different common operations performed in dairy barns.

TABLE 2.—DAIRY BARN NO. 1.

Frame barn, 30 x 50 ft., containing two rows of cows; tight floor overhead; plank floor under cows; dirt floor back of cows; cobwebs numerous.

Laboratory number of dish.	Date of exposure.	Place and condition of exposure.	Number of colonies developed.
	1897		
232	June 15	Barn vacant, open, air still, floor dry	5
233	"	Barn vacant, open, air still, floor dry	33
234	"	Barn vacant, open, air still, floor dry	19
235	"	Barn vacant, open, air still, floor dry	50
		Average	**27**
240	"	After cows were let in	150
241	"	After cows were let in	54
242	"	After cows were let in	44
243	"	After cows were let in	24
		Average	**68**
245	"	After No. 240, in window, wind blowing out	44
246	"	Same as No. 245, only another window	208
		Average	**126**
247	"	In window, opposite side, wind blowing in	4
248	"	Same as No. 247, only another window	44
		Average	**24**
250	"	Back of cows, 3 ft. from floor, 30 min. after No. 240	34
252	"	Back of cows on floor, 30 min. after No. 240	36
253	"	4 ft. from floor between two rows of cows	150
254	"	On floor	718

DAIRY BARN NO. 2. H. B. GURLER.

Barn 50 x 60 ft., containing four rows of cows; cement floor, wooden stalls, sides and ceiling whitewashed. Milking in progress.

332	Oct. 20	Middle of west end, cows eating grain and silage	2
336	"	Northwest corner	51
337	"	Northeast corner, wind blowing in	16
340	"	Northwest corner	37
341	"	Southeast corner	29
342	"	Middle of barn	23
343	"	Middle of barn	86
344	"	Middle of barn	18
345	"	Middle of barn, just after letting out cows	30
346	"	Middle of barn, just after letting out cows	26
		Average	**32**

In Table 2 the result of each exposure is given, and the average of each group is shown in heavy type.

June 15, when the barn had been vacant, but open for six hours, and the air was comparatively still out of doors, four exposures averaged 27 colonies, for so much of the floor was dry and dusty that the air in the barn was far from sterile. After the cows were let in, four exposures averaged 68 colonies, indicating that letting in the cows had increased the bacterial content of the air two and one-half times. Immediately following these, two exposures in a window, wind blowing out, averaged 126 colonies, which is nearly twice as many as were obtained from an average of four exposures made at different places in the barn just before. Two exposures in a window, wind coming in, averaged 24 colonies, showing that the air was not badly infected when entering the barn, but that it became so while there.

Exposures Nos. 250 and 252, made back of the cows, showed 34 and 36 colonies, while at the same time two exposures made in feed alley between rows of cows showed 150 colonies three feet from the floor, and 718 on the floor, from which it appears that there were many more bacteria in the center than at the sides of the barn, and more at the floor than three feet above.

From the results obtained in this barn we learn that with a dry and dusty floor the bacterial content of the air is high when the cows are in the barn, even though they are not brushed and no hay or bedding is moved.

At the time the ten exposures were made in dairy barn No. 2, the barn was full of cows eating grain and silage and four men were milking. The number of colonies that developed in the different dishes ranged from 2 to 86, with an average of 32. This difference was doubtless due to local conditions, as a cow switching her tail near the exposed dish might send myriads of bacteria into the air at that place. The low average shows that the air was comparatively free from bacteria for a barn full of cows and when milking was in progress. This condition was, no doubt, due to the fact that the barn was built and cared for in a most sanitary manner. An excellent system of ventilation was provided, the cement floor was scrubbed clean every day, sides and ceiling were whitewashed and no cobwebs were allowed to collect.

TABLE 3.—BACTERIAL CONDITION OF AIR IN DAIRY BARN NO. 3.

Stone basement, 32 x 40 ft., containing two rows of cows; tight floor above, paved floor below; an inch of dusty chaff on floor; cobwebs numerous.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.
	1897			
351	Oct. 25	Just before cows were let in; barn vacant all day, except 8 calves in end	6	152
363	"	Immediately after cows were let in	5	202
371	"	1 hr. after No. 363	6	192
381	"	30 min. after No. 371, just after letting out the cows	4	150
387	Oct. 28	Conditions same as No. 351	6	126
394	"	Window sill, slight breeze blowing in from empty yard	2	30
396	"	After No. 394, in open door, wind blowing out	2	75
408	"	Same as No. 394, only 5 min. later, cows having been let in barn in meantime	2	39
410	"	Same as No. 408, only in door on opposite side, wind blowing out	2	66
412	"	30 min. after cows were let in; exposures made in different parts of barn	6	129
422	"	30 min. after No. 410, in door wind blowing out.	2	325
424	"	30 min. after No. 408, same window, brisk breeze blowing in from vacant yard	2	77
426	"	5 min. after No. 422, in door wind blowing out, cows let out in meantime	2	321
428	"	In yard below window where No. 424 was exposed	1	76
		DAIRY BARN NO. 4, UNIVERSITY OF ILLINOIS.		
73	Feb. 13	After sweeping and feeding, cows eating roughage		94
78	"	1½ hr. after No. 73, a little bedding put in 20 min. previous	4 5	72
83	"	20 min. after No. 78, 6 cows brushed in meantime	2	692
90	Feb. 23	After feeding chopped fodder and sweeping, dust visible	6	84
96	"	40 min. after No. 90; barn quiet in meantime, except cows eating	6	61
104	"	25 min. after No. 96; 13 cows brushed in meantime	10	159
121	March 10	After feeding and sweeping; doors open, strong wind from south	5	40
127	"	1 hr. after No. 121, barn open in meantime, strong breeze from south	6	84
133	"	20 min. after No. 127; 10 cows brushed in meantime, barn open, windy	6	44
152	April 24	Cows in, eating oat hay; barn closed and swept	6	57
158	"	1 hr. after No. 152; barn quiet except cows eating hay	4	119
164	"	20 min. after No. 158; 11 cows brushed in meantime	5	131
170	"	10 min. after No. 164; barn quiet in meantime	1	53

TABLE 3.—BACTERIAL CONDITION OF AIR IN DAIRY BARN NO. 4—Continued.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.
	1897			
178	May 4	Cows in, eating hay; barn closed for 15 min.....	6	62
184	"	20 min. after No. 178; 8 cows brushed in meantime.....	6	92
190	"	15 min. after No. 184; barn quiet in meantime ..	3	59
206	June 3	Barn quiet, cows let in, all quiet 15 min.; small amount of bedding in stalls.....	9	46
218	"	20 min. after No. 206; 11 cows brushed in meantime.....	6	88
268	July 2	10 cows in, brushed, quiet 15 min., windows open on one side, no wind, damp outside.....	6	12
285	July 10	Cows in, bedded, and fed hay; no rain, and very hot for 10 days	2	55
316	Sept. 14	Milking in progress	3	276
	1898			
465	Nov. 30	Barn empty, swept, and closed for 3 hours; snow on ground 3 days	6	$\frac{1}{6}$
471	"	10 min. after No. 465	6	$\frac{1}{6}$
477	"	30 min. after No. 465; cows let in, fed chopped fodder; floor swept, dust slightly visible.....	1	236
478	"	30 min. after No. 465; cows let in, fed chopped fodder; floor swept, dust slightly visible.....	1	291
479	"	30 min. after No. 465; cows let in, fed chopped fodder; floor swept, dust plainly visible.....	1	412
480	"	30 min. after No. 465; cows let in, fed chopped fodder; floor swept, no dust visible.....	7	151
488	"	1 hr. after No. 480; cows eating in meantime....	9	84
498	"	10 min. after No. 488; 16 cows brushed in meantime.....	2	858
	1901			
931	June 5	Milking in progress; no hay moved for 1 hr.; barn open, slight breeze	12	$7\frac{1}{2}$
	1897			
282	July 2	On floor, south door of barn, slight breeze from south, 5 cows in barn.....	1	0
283	"	On floor, center of barn, no breeze	1	29
284	"	On floor, north door of barn, no breeze	1	33
	1897			
322	Sept. 14	3 ft. from cow being brushed	2	800
	1898			
497	Nov. 30	3 ft. from cow being brushed	1	600
487	"	Feed room after corn meal was let down from bin above, much dust visible	1	20
500	Dec. 8	Feed room after corn meal was let down from bin above, much dust visible	4	$4\frac{1}{2}$
512	"	10 min. after No. 500	2	6
516	"	Behind 8 cows just after being brushed 4 min.; less dust visible than at No. 500	4	764
522	"	5 min. after No. 516	2	123
524	"	10 min. after No. 516	2	150

TABLE 3.—BACTERIAL CONDITION OF AIR IN DAIRY BARN NO. 4—Continued.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.
	1899			
566	April 13	Behind cows, milking in progress	2	60
592	May 11	Behind cows, milking in progress	4	8½
628	May 14	Feed room after musty corn meal was let down from bin above	2	284
630	"	Barn loft 3 min. after hay was moved, small amount of dust visible	4	7½
700	May 16	On floor back of cows, milking in progress	8	8¼
713	May 19	Barn loft after pitching hay, dust plainly visible.	4	323
717	"	Same place as No. 713, 3 min. later	4	45
725	"	Immediately after No. 717, on beam 8 ft. above.	2	27
721	"	Same place as No. 717, 3 min. later	4	22
727	"	In feed room after corn meal was let down from bin above, dust plainly visible	4	57
731	"	Same place as No. 727, 3 min. later	4	15
735	"	Same place as No. 731, 3 min. later	4	12
739	"	In feed room after bran was let down from bin above, dust slightly visible	4	418
743	"	Same place as No. 739, 3 min. later	3	6
830	May 28	On floor back of cows, milking in progress	2	4
832	"	In front of cows, milking in progress	3	11
850	June 3	On floor back of cows, milking in progress	5	3⅜
885	"	After bran was let down from bin above, dust slightly visible	5	114
890	"	Same place as No. 885, 6 min. later	5	8⅜
927	Sept. 16	On floor back of cows, milking in progress	4	19

October 25 and 28, exposures were made in a barn that had been vacant all day excepting eight calves in one end. From the number of colonies which developed it is seen that when the barn floor is dry and dusty, and cobwebs are allowed to collect, the bacterial content of the air is high if there are animals moving about. In such cases the number of bacteria is increased but slightly by letting in the cows.

These results show that under normal conditions air which enters windows and doors is comparatively sterile, while that which passes out is badly contaminated.

Barn No. 4 in Table 3 was the University dairy barn before being remodeled.

The floor of the barn was swept each day and no cobwebs were allowed to collect. From the group averages, Nos. 268, 465, 471, and 931, it is seen that the bacterial content of the air in the barn was low, even though the cows were in if they were quiet and no hay or bedding had been moved for some time. Immediately after bedding or feeding roughage the number of bacteria in the air was much greater, while an hour later it was reduced about one-third. There were occasional exceptions to this, as in the three groups on March 10, when all door and windows were open. At the same time there was a strong breeze blowing, rapidly replacing the dusty air with air from out of doors, which was nearly sterile.

To show the effect of having the barn quiet, November 30 all stock was let out, windows and doors closed, and the barn locked for three hours, after which an average of six exposures gave only one-half a colony; ten minutes later, after having moved about in the barn, an average of six exposures gave but five-sixths of a colony. This shows that when the air in the barn remains perfectly quiet for some time, it becomes comparatively sterile.

Half an hour after letting in the cows and feeding and sweeping, one exposure, where dust was plainly visible, showed 412 colonies, and eleven exposures made at different places in the barn where there was no dust visible, averaged 151 colonies. These results show the number of bacteria that are in the air as a result of feeding and sweeping when the air was nearly sterile before. One hour later nine exposures averaged 84 colonies, showing that the dust and bacteria soon settled out of the air. Ten minutes later, sixteen cows brushed in meantime by two men, an average of two exposures gave 858 colonies, showing that brushing the cows had increased the bacterial content of the air over ten times.

Even though the number of bacteria caught when the cows were eating hay was large, the increase caused by brushing the cows varied from a small amount in one case to over ten times the number in another case, the only exception being when there was a strong breeze blowing through the barn, for in such cases the results are especially uncertain.

From the table it is seen that the number of bacteria in the air is greatly increased by brushing the cows, and it may also be noticed that the bacteria rapidly settled by allowing everything to remain quiet for from ten to twenty minutes.

From the latter half of Table 3, beginning with exposure No. 322, it is seen that dust arising from different sources in dairy barns may be similar in amount and yet differ greatly in bacterial content. The average of four exposures made where dust from each of the following sources was plainly visible, contained colonies as follows: corn meal, 57; hay, 323; bran, 418, and from brushing cows, 764. It is seen from this

that dust which comes from brushing cows contains about twice as many bacteria as that from either hay or bran, and thirteen times as many as dust from corn meal. This is doubtless due to the fact that bacteria find on the cow a good place to develop, as both warmth and nutriment are present. The dust from hay comes from the external and exposed parts of plants, and since bran is from the external portion of the wheat kernel it is natural that the dust from these be heavily laden with bacteria, as the exposed parts of all plants are more or less covered with these organisms Since the great bulk of corn meal comes from the inner portion of the kernel, which is sterile, it is not strange that dust from fresh corn meal contains but few bacteria compared with that from other feeds. The two exposures in dust from musty corn meal, in group No. 628, averaged 284 colonies, while an average of four exposures in fresh corn meal gave in one case 57 colonies, and in another 4½ colonies, showing that dust from musty corn meal contains bacteria in much larger numbers than dust from fresh corn meal, as bacteria multiply greatly during the process of fermentation.

Exposures made a few minutes after a dust had been raised showed in each case that much had settled from the air, and that where there was no movement to keep up a dust, the air soon became comparatively sterile.

TABLE 4.—BACTERIAL CONDITION OF EXPERIMENTAL MILKING ROOM, UNIVERSITY OF ILLINOIS.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.
	1897			
257	June 25	Floor damp, sides dry, window open, damp outdoors	4	0
261	July 2	Window closed, cloudy and damp	7	1⅞
289	July 10	Small window open all day, slight breeze	4	6¾
295	"	5 min. after No. 289, sides and ceiling sprinkled with hose in meantime	3	11
300	"	Cow being brushed 3 ft. distant	1	6174
301	"	After cow had been brushed 4 min. and removed; room quiet 4 min.	2	147
305	"	30 min. after No. 301, room quiet and closed in meantime	3	5½
429	Nov. 13	After room had been closed 6 hours	6	7⅚
435	"	10 min. after No. 429, just after sprinkling sides and ceiling with hose	6	19
441	"	50 min. after No. 435, room closed in meantime	6	4½
447	"	2 min. after No. 441, cow brought in and brushed 1 min.	2	262
449	"	After cow had been brushed 4 min. and removed from room	4	32
453	"	3 min. after cow had been removed	2	11
455	"	7 min. after No. 453	6	3
461	"	8 min. after No. 455	2	0

The results of exposures, shown in Table 4, were obtained in an experimental milking room where the conditions were more completely under control than in the barn; the purpose being to determine the condition of the air in a room that had been vacant for some time, also after sprinkling the sides and ceiling with a hose, immediately after brushing a cow, and at frequent intervals thereafter.

From this table it is seen that June 25, when the floor of the milking room and the outside air were damp, four exposures were sterile, and July 2 seven exposures averaged $1\frac{6}{7}$ colonies.

A series of exposures was made under varying conditions July 10 and November 13, and from these it is seen that somewhat fewer colonies developed upon entering a room than after thoroughly sprinkling the sides and ceiling with a hose, as the force of the water seemed to raise a slight dust. This, however, settled rapidly, for as soon as the dust touched any wet surface it adhered to it. July 10 a cow was brought into the nearly sterile air of the room, brushed four minutes, and removed, when exposure No. 300 was made and 6,174 colonies developed. An average of two exposures, group No. 447, made after a cow had been brushed one minute, gave 262 colonies, showing again that the dust which comes from cows is heavily laden with bacteria. It is noticed in both of these cases that the dust rapidly settled when the room remained closed so that there were no currents of air, and in the course of half an hour the air was practically free from bacteria.

TABLE 5.—BACTERIAL CONDITION OF AIR IN DAIRY ROOMS, UNIVERSITY OF ILLINOIS.

Laboratory number of group.	Date of exposure.	Place and condition of exposure.	Exposures averaged.	Colonies developed.	
				Front room.	Bottling room.
	1897				
10	Jan. 13	On table	2	15	....
11	"	On table	2	..	$\frac{1}{2}$
12	"	On table, milk cooling	2	..	0
175	April 24	On table, room closed for 30 min.	2	..	0
327	Sept. 14	On table, milk cooling	3	..	$\frac{1}{3}$
330	"	On table	1	14	..
	1899				
621	May 11	On table, room empty	24	..	$\frac{1}{12}$
625	"	On table, room empty	18	..	$\frac{1}{18}$
708	May 16	On table when bottling milk	5	..	$2\frac{1}{5}$
913	Sept. 16	On table when bottling milk	4	..	$\frac{1}{2}$

Table 5 shows the average number of colonies developed from exposures made in dairy rooms which have cement floors and painted sides and ceilings. From the three exposures made in the front room, which is used both as an office and separating room, the average number of colonies developed was 15. In the bottling room everything is kept

TABLE 6.—COLONIES DEVELOPED FROM EXPOSURES UNDER UDDERS IN VARIOUS CONDITIONS.

Laboratory number of group.	Date of exposure.	Number of exposures averaged.	Average number of colonies developed; different udders.		Average number of colonies developed; same udder before and after treatment.				Six feet behind cows.
			Unwashed.	Washed.	Before washing.	After washing.	Before wiping.	After wiping.	
	1897								
198	May 4	3	....	486	....	....	....	....	....
313	Sept. 14	3	....	219	....	....	....	....	....
319	"	3	1031	....	....	....	....	....	....
331	Oct. 20	3	....	200	....	....	....	....	....
526	Dec. 8	8	....	....	2973	....	....	....	....
534	"	4	....	....	....	90	....	....	....
	1899								
538	April 13	16	....	....	470	....	....	....	....
554	"	11	....	....	....	133	....	....	....
566	"	2	....	....	....	....	....	....	60
568	May 11	6	....	....	421	....	....	....	....
574	"	6	....	....	....	226	....	....	....
580	"	6	....	....	211	....	....	....	....
586	"	6	....	....	....	88	....	....	....
592	"	4	....	....	....	....	....	....	8½
651	May 16	5	....	....	230	....	....	....	....
656	"	4	....	....	....	25	....	....	....
671	"	4	....	....	157	....	....	....	....
676	"	10	....	....	....	72	....	....	....
686	"	3	....	....	372	....	....	....	....
690	"	8	....	....	....	152	....	....	....
700	"	8	....	....	....	....	....	....	8¼
746	May 23	5	....	....	25	....	....	....	....
751	"	10	....	....	....	48	....	....	....
761	"	5	....	....	90	....	....	....	....
766	"	10	....	....	....	11	....	....	....
776	"	4	....	....	127	....	....	....	....
781	"	9	....	....	....	58	....	....	....
791	"	2	....	....	....	....	....	....	6
793	May 28	4	....	....	144	....	....	....	....
799	"	10	....	....	....	286	....	....	....
811	"	5	....	....	116	....	....	....	....
817	"	9	....	....	....	269	....	....	....
830	"	2	....	....	....	....	....	....	4
835	June 3	15	33	....	....	....	....	....	....
850	"	5	....	....	....	....	....	....	3
855	"	15	....	20	....	....	....	....	....
870	"	15	....	27	....	....	....	....	....
920	Sept. 16	3	....	23	....	....	....	....	....
923	"	4	56	....	....	....	....	....	....
927	"	4	....	....	....	....	....	....	19
	1901								
943	June 5	4	....	....	....	....	2301	....	....
947	"	8	....	....	....	....	....	503	....
955	"	3	....	....	1756	....	....	....	....
958	"	6	....	....	....	512	....	....	....
964	June 14	2	....	....	....	....	1614	....	....
967	"	2	....	....	....	....	....	291	....
973	"	2	....	....	....	....	1026	....	....
976	"	4	....	....	....	....	....	369	....
996	June 22	5	....	....	....	....	1586	....	....

TABLE 6.—COLONIES DEVELOPED FROM EXPOSURES UNDER UDDERS IN VARIOUS CONDITIONS.—Continued.

Laboratory number of group.	Date of exposure.	Number of exposures averaged.	Average number of colonies developed; different udders.		Average number of colonies developed; same udder before and after treatment.				Six feet behind cows.
			Unwashed.	Washed.	Before washing.	After washing.	Before wiping.	After wiping.	
1001	June 22	10	....	....	....	....	....	346	....
1011	"	4	1401	....	....	....	....	....	....
1016	June 24	5	....	....	....	....	482	....	....
1021	"	10	....	....	....	....	....	118	....
1031	"	4	....	....	....	....	120	....	....
1036	"	10	....	....	....	....	....	123	....
1046	"	5	....	....	....	....	202	....	....
1051	"	10	....	....	....	....	....	133	....
1061	"	5	....	....	....	....	94	....	....
1066	"	8	....	....	....	....	....	229	....
1095	June 27	5	....	....	....	....	266	....	....
1100	"	9	....	....	....	....	....	421	....
1110	"	4	....	....	....	....	114	....	....
1115	"	9	....	....	....	....	....	262	....
1125	"	3	....	....	....	....	448	....	....
1130	"	8	....	....	....	....	....	193	....
1140	June 28	5	....	....	....	....	329	....	....
1145	"	10	....	....	....	....	....	191	....
1155	"	4	....	....	....	....	849	....	....
1160	"	9	....	....	....	....	....	313	....
1170	"	5	....	....	....	....	314	....	....
1175	"	10	....	....	....	....	....	407	....
Number of exposures averaged			26	42	74	103	58	117	27
Average			**362**	**83**	**615**	**148**	**630**	**270**	**12**

scrupulously clean, and the floor is usually damp, thus keeping the greater part of the dust out of the air. Sixty exposures were made in this room at different times of the year, and the average for the total number was one-third of a colony. More than half of all colonies developed from the bottling room were from five exposures made when bottling milk; forty-seven of the sixty exposures in this room were sterile. In other words, a dish would have to be exposed an average of one and a half minutes to catch one bacterium. In an atmosphere as nearly sterile as this, milk becomes contaminated very slowly, even where a large surface is exposed, as in passing over a cooler.

To learn something of the amount of contamination that takes place during milking, and how much this may be reduced by washing the udders, 420 petri dishes were exposed under washed and unwashed udders. The average number of colonies developed from exposures made under washed udders was 192 and under unwashed udders 578, or three times as many. The group averages from these exposures are shown in Table 6.

As a rule, washing udders makes a marked reduction in the number of colonies developed from exposures made under them. This difference is much greater in some cases than in others. The most noticeable

CUT 5.—IN MID-WINTER. PROPERLY CLEANED TO PREVENT ALL POSSIBLE CONTAMINATION

difference was obtained December 8, when an average of eight exposures, No. 526, showed 2,973 colonies before washing, while an average of four exposures made under the same udder after washing showed only 90 colonies. In other words, the contamination which took place in this instance was thirty-three times greater before washing than after.

In a few cases a less number of colonies developed from exposures made under unwashed udders than from those made under the same udders after washing. A possible explanation for this is that dirt from

the unwashed udders fell in larger particles, and thus the dishes were contaminated in fewer places, although a greater total contamination took place, for a colony developed on a petri dish may have originated

CUT 6.—AFTER A RUN OF THREE WEEKS ON PASTURE. IMAGINE THE SOURCE OF CONTAMINATION DURING WINTER.

from a single bacterium or from a particle of dirt large enough to be seen with the naked eye and containing thousands of bacteria.

It should be borne in mind that the udders used in this experiment were not only apparently clean, but they had been washed regularly each day before milking, and in all probability there was much less dirt adhering to them than to udders that had never been washed. With soiled or muddy udders, such as are frequently found in dairies, the benefits derived from washing are much greater than these results show.

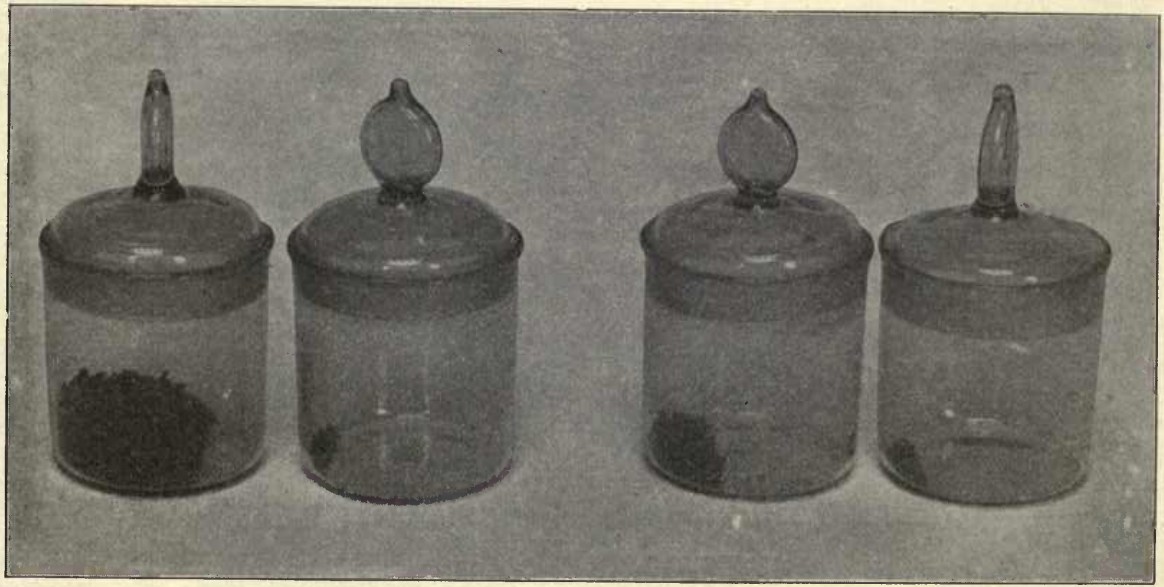
TABLE 7.—WEIGHT IN GRAMS OF DIRT WHICH FELL FROM UDDERS DURING TIME OF MILKING.

Udders apparently clean.				Udders slightly soiled.				Udders muddy.			
Date.	Before washing.	After washing.	Ratio of washed to unwashed.	Date.	Before washing.	After washing.	Ratio of washed to unwashed.	Date.	Before washing.	After washing.	Ratio of washed to unwashed.
May 20.....	.0395	.0081	4.88	May 20.....	.0682	.0062	11.00	July 18.....	.3025	.0105	28.81
" 20.....	.0230	.0075	3.06	July 3.....	.0303	.0041	7.39	" 24.....	.3997	.0038	105.18
" 20.....	.0297	.0061	4.87	" 18.....	.0429	.0104	4.12	" 25.....	.4273	.0075	56.97
July 2.....	.0056	.0061	-1.09	" 18.....	.0579	.0054	10.72	" 28.....	.7088	.0160	44.30
" 2.....	.0122	.0055	2.22	" 31.....	.1841	.0120	15.33	" 30.....	.7520	.0088	85.45
" 3.....	.0056	.0075	-1.34	" 31.....	.0761	.0057	13.35	" 31.....	.9921	.0068	145.89
" 7.....	.0072	.0027	2.67	" 31.....	.1210	.0121	10.00	" 31.....	.5586	.0162	34.48
" 7.....	.0025	.0019	1.31	Aug. 6.....	.0502	.0087	5.77	" 31.....	.2899	.0073	39.71
" 9.....	.0079	.0028	2.82	" 6.....	.0985	.0075	13.13	Aug. 25.....	.6651	.0044	151.15
" 9.....	.0030	.0037	-1.23	" 7.....	.0929	.0108	8.60	" 26.....	.5977	.0158	37.83
" 9.....	.0370	.0040	9.25	" 7.....	.0817	.0033	24.75	" 26.....	.2634	.0149	17.68
" 11.....	.0145	.0038	3.81	" 26.....	.1150	.0067	17.27	Oct. 6.....	1.3110	.0058	226.03
" 11.....	.0063	.0045	1.40	Sept. 23.....	.1428	.0100	14.28	" 6.....	2.2156	.0061	363.21
" 11.....	.0023	.0014	1.64	" 23.....	.1023	.0045	22.73	" 21.....	1.2213	.0059	207.00
" 12.....	.0023	.0016	1.44	Oct. 6.....	.1716	.0065	26.40	" 21.....	1.5150	.0078	194.23
" 12.....	.0184	.0034	5.41	" 21.....	.1171	.0039	30.25	" 24.....	1.4813	.0050	296.26
" 15.....	.0196	.0030	6.53	" 21.....	.0057	.0080	6.96	" 24.....	1.7553	.0085	206.51
" 17.....	.0107	.0026	4.11	" 24.....	.1648	.0139	11.86	April 18.....	.9512	.0103	92.35
" 21.....	.0237	.0089	2.66	" 24.....	.2387	.0058	41.15	" 18.....	.8096	.0112	72.28
" 21.....	.0347	.0135	2.57	Nov. 1.....	.2838	.0065	43.66	" 18.....	.9192	.0103	89.24
" 21.....	.0023	.0013	1.77	" 1.....	.1811	.0040	45.27	" 18.....	.5528	.0147	37.16
" 24.....	.0193	.0040	4.82	" 1.....	.1163	.0094	12.37	" 21.....	1.2507	.0091	51.47
" 26.....	.0370	.0029	12.72	" 1.....	.2946	.0080	36.82	" 21.....	.6293	.0142	44.31
Aug. 7.....	.0024	.0016	1.50	" 1.....	.3337	.0050	66.74	" 21.....	.5750	.0160	35.94
Sept. 23.....	.0127	.0025	5.08	April 18.....	.1697	.0098	17.31	" 21.....	.9342	.0090	17.23
Average ..	.0152	.0044	**3.5**	Average ..	.1316	.0079	**18**	Average ..	.8831	.0098	**90**

AMOUNTS OF DIRT CAUGHT UNDER WASHED AND UNWASHED UDDERS DURING MILKING. THE GLASS WEIGHING TUBES SHOWN BELOW ARE NATURAL SIZE.

UDDER MUDDY.
BEFORE WASHING. AFTER WASHING

UDDER SLIGHTLY SOILED.
BEFORE WASHING. AFTER WASHING.



CUT 8.—THE AVERAGE WEIGHT OF DIRT WHICH FALLS FROM MUDDY UDDERS DURING MILKING IS 90 TIMES AS GREAT AS THAT WHICH FALLS FROM THE SAME UDDERS AFTER WASHING, AND WHEN UDDERS ARE SLIGHTLY SOILED IT IS 18 TIMES AS GREAT. SEE PAGE 243.

WEIGHT OF DIRT WHICH FALLS INTO MILK DURING MILKING.

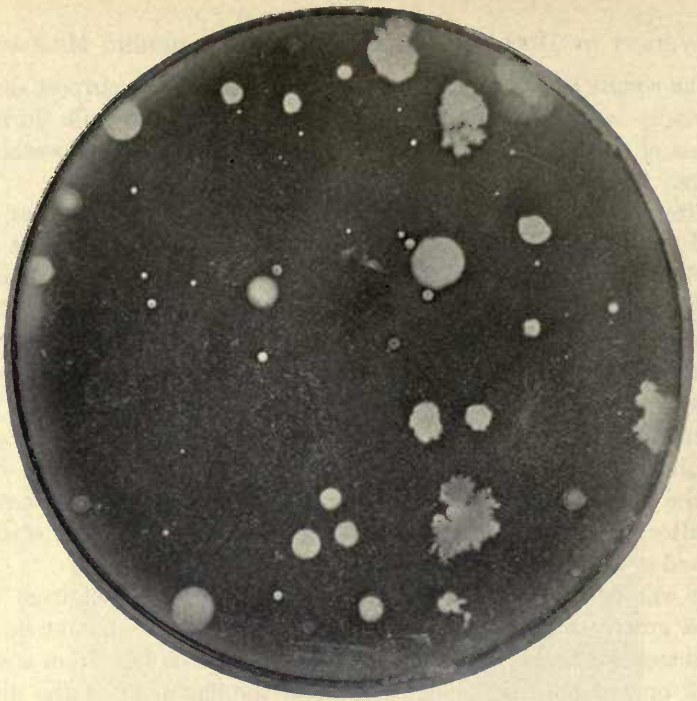
The results shown in Table 7 were obtained for the purpose of determining by weight the amount of filth which falls into milk during the process of milking, and how much this may be reduced by washing the udders.

After several trials with three different milkers on thirty cows, it was found that it required an average of 4½ minutes to milk a cow. A glazed dish, eleven inches in diameter, the size of an ordinary milk pail, was held under a cow's udder 4½ minutes, while the milker went through motions similar to those made in milking, but not drawing any milk. The amount of dirt which fell into the dish during the operation was, of course, approximately the same as would have fallen into the milk during the milking process. The dirt caught in the dish was then brushed into a small glass weighing tube, such as shown in cut 9, the udder washed, and the process repeated. Both tubes were then placed in a desiccator, and after drying twenty-four hours to remove moisture, were accurately weighed in a chemical balance.

It will be noticed that the weight of dirt which fell from udders varied greatly when there appeared to be the same amount on them. The reason for this is that the amount of dirt which falls from a clean, a soiled, or a muddy udder depends upon the character of the dirt, the amount of hair on the udder, its shape, the length of the teats, etc.

Seventy-five trials were made at different seasons of the year with three classes of udders, those apparently clean, soiled, and muddy. With udders that were apparently clean, it was found that an average of 3½ times as much dirt fell from the unwashed udders as from the same udders after they were washed. With soiled udders the average was 18, and with muddy udders 90 times as much dirt from the unwashed as from the washed.

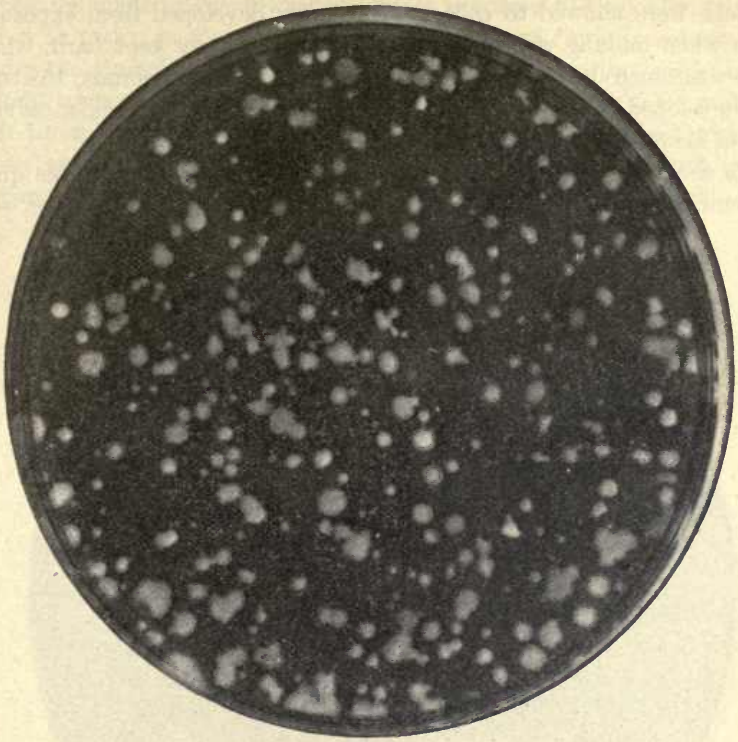
The average weight of dirt falling from muddy udders during the time of milking was found to be .8831 of a gram. Since in one ounce there are 28⅓ grams, an ounce of dirt would fall into the milk for every 32 milkings. From a year's records, kept by the department of dairy husbandry, of eight herds containing 144 cows, it was found that one gallon, or 8⅔ pounds, was the average yield at a milking. On this basis, in 32 milkings, 275 pounds of milk would be produced containing one ounce of filth. With the same udders after they were washed, 24,030 pounds of milk, or 90 times as much, could be obtained before the amount of filth it contained would reach one ounce. This shows the decided advantage, in the production of clean milk, of washing the udders before milking.



CUT 9.—PETRI DISH, SHOWING COLONIES DEVELOPED FROM EXPOSURE DURING MILKING IN WELL-KEPT DAIRY BARN.

TABLE 8.—AVERAGE NUMBER OF COLONIES DEVELOPED FROM EXPOSURES MADE IN DIFFERENT PLACES AND TIME MILK WOULD HAVE TO STAND AT THOSE PLACES TO RECEIVE AS MUCH CONTAMINATION FROM THE AIR AS IT WOULD UNDER AN UNWASHED UDDER DURING THE 4½ MINUTES OF MILKING.

Place of exposure.	Number of exposures averaged.	Average number colonies developed from ½ min. exposure.	Ave. number min. milk would have to stand at the different places to receive as much contamination from the air as it would under an unwashed udder during the 4½ min. of milking.	Time in days.
Open field	43	9/10	2890	2
Barnyard	51	13	200	..
Well kept barn during milking	10	32	81	..
University barn during milking	46	38	68	..
Poorly kept barn during milking	21	168	15	..
Barn empty, closed 3 hours	12	⅔	3901	2⅔
Before feeding	9	46	57	..
After feeding	34	109	24	..
After brushing cows	38	307	8	..
Under apparently clean unwashed udder	158	578	4½	..
Under washed udder	262	192	14	..
Bottling room	60	⅓	7803	5⅔
Dairy front room	3	15	173	..



CUT 10.—PETRI DISH, SHOWING COLONIES DEVELOPED FROM EXPOSURE DURING MILKING IN POORLY KEPT DAIRY BARN.

CONCLUSIONS.

The results of the work described in this bulletin are of vital importance to the practical dairyman, as they show that extreme cleanliness is absolutely essential to the most successful dairying.

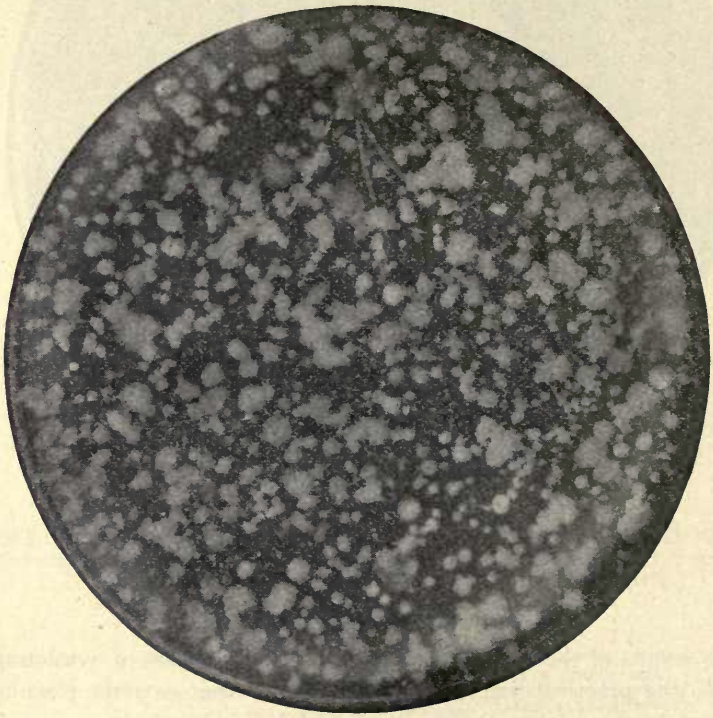
Table 8, which contains averages of all exposures made in different places, shows where and under what conditions milk becomes contaminated most rapidly, and that the bacterial content of milk may be greatly reduced by a few simple precautions easily carried out in any dairy. The nearer the ideal condition is reached, the fewer bacteria in the milk, and the more wholesome will be not only the milk itself, but the products made from it, and the better their keeping quality.

From exposures made out of doors it was found that air in the open field was nearly sterile, since an average of less than one colony developed for each half-minute exposure, while in the barnyard an average of 13 colonies developed in the same time. This increase over the number in the field was doubtless due to the fact that the ground in the barnyard was bare and dry, and the cows moving about created a dust.

In a well-kept dairy barn, where the floor was swept clean and no

cobwebs were allowed to collect, 32 colonies developed from exposures made when milking was in progress, and in a poorly kept barn, where there was much dust on the floor and cobwebs were numerous, 168 colonies developed, or five times as many. This shows the decided advantage of keeping the dairy barn as clean as possible.

To show the effect of having everything in the milking stable quiet for some time, the University dairy barn was swept, after the cows were



CUT 11.—PETRI DISH, SHOWING COLONIES DEVELOPED FROM EXPOSURE UNDER APPARENTLY CLEAN UNWASHED UDDER.

let out, and closed for three hours; exposures then made showed an average of less than one colony.

When the cows were in, but before feeding, 46 colonies developed for each half-minute exposure; immediately after feeding roughage 109 colonies developed, and after brushing the cows the number was increased to 307. These results indicate that feeding roughage and brushing cows greatly increase the bacterial content of the air. Such operations, therefore, should not take place immediately before milking, but some time should intervene to allow the dust to settle.

By far the greatest source of contamination in milk is the cow herself, and the greater part of this contamination comes from the udder, unless that is washed before milking. The one hundred fifty-eight

exposures made under unwashed udders averaged 578 colonies, or three times as many as the average number developed from exposures made under the same udders after washing. Table 7, giving the weight of dirt caught under udders in different conditions, shows that three and one-half times as much dirt fell from apparently clean unwashed udders as from the same udders after washing. Thus it is seen that in the case of apparently clean udders the ratio of the weight of dirt caught corre-

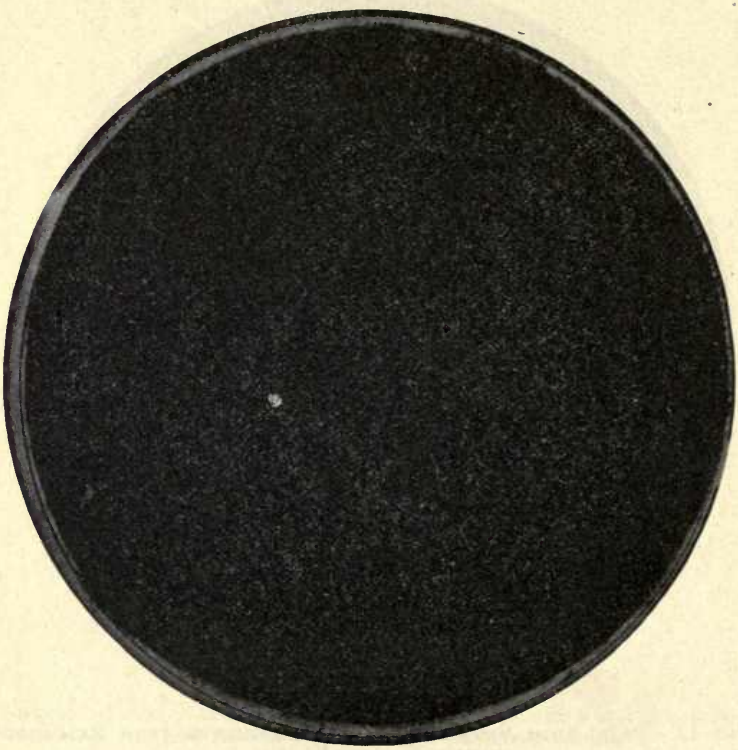
CUT 12.—PETRI DISH, SHOWING COLONIES DEVELOPED FROM EXPOSURE UNDER WASHED UDDER.

sponds very closely with the ratio of the number of colonies developed from exposures under washed and unwashed udders. The amount of contamination from soiled or muddy udders was not determined from a bacteriological standpoint; the benefit derived from washing such udders was determined only by the comparative weights of dirt caught under them. With soiled udders the weight of dirt was eighteen times greater from the unwashed udders than from the same udders after washing, and with muddy udders it was ninety times greater.

In the University of Illinois dairy rooms, which have cement floors and painted sides and ceilings, there are comparatively few bacteria in the air. This is especially true of the milk bottling room, where the floor

is frequently scrubbed, and is usually damp, as an average of sixty exposures showed only one-third of a colony.

From the averages in the preceding table it is seen that the amount of contamination that milk receives from the bacteria of the air falling into it, depends entirely upon the conditions under which it was exposed. The table also shows the length of time it would take milk exposed in the pail to receive the same amount of contamination at the designated places that it gets from an unwashed udder during milking,



CUT 13.—PETRI DISH, SHOWING COLONY DEVELOPED FROM EXPOSURE IN MILK BOTTLING ROOM.

which time was found to be 4½ minutes. Since an average of 578 colonies developed on sixty-three square centimeters of surface for every half-minute exposure under an unwashed udder, in 4½ minutes the number would have increased to 5,202. In the milk bottling room an average of one-third of a colony developed on a like area for every half-minute exposure, or two-thirds per minute. A pail of milk would, therefore, have to stand exposed to the air in this room 7,803 minutes, or more than five days, to receive as much contamination as it would under an apparently clean unwashed udder during milking. This emphasizes not only the great importance of washing the udders before

milking, but also of having the dairy rooms and all surroundings as clean and the air as free from dust as possible wherever dairy products are handled.

An effort was made to determine the different species of bacteria that gain access to milk, but in the present state of development of the science of bacteriology, this is difficult to do satisfactorily. For the practical dairyman it is sufficient to say that a majority of the forms found grow readily in milk. Many of the species produce visible changes in milk, such as curdling or peptonizing, while others affect the flavor.

It should be borne in mind that a great majority of the species of bacteria that gain access to milk do not possess the power to produce disease, and are not injurious to healthy adults, although many of them are likely to produce disorders of digestion in infants and invalids.

Paying special attention to cleanliness in every step of the production and care of milk will result not only in clean milk, but in a marked reduction in the number of bacteria it contains, which will greatly lengthen its keeping qualities. That the desired results may be obtained, care must be constantly exercised. It is of little consequence to practice extreme cleanliness in all of the steps of milk production but one, and be filthy about that one, as this spoils the whole. Even if the majority of species of bacteria which ordinarily gain access to milk are not dangerous to health, no one cares to consume milk in which a sediment is found at the bottom if it is allowed to stand for a short time. Frequently much filth is allowed to get into milk during milking, and many milkers practice the filthy habit of keeping the teats wet with milk during the milking process, yet after it is drawn the greatest care is exercised that no dust or dirt gain access to it. As far as the final result is concerned, all painstaking care in the subsequent operations is lost because of the careless work at the beginning during the process of milking, for if filth once gains access to milk, no amount of care afterwards can remedy the difficulty. It is, therefore, of the greatest importance to the advancement of better dairying that special emphasis be placed upon the operation where milk is liable to receive the most contamination. The work reported in the preceding pages shows that the greatest source of contamination in milk, as ordinarily produced, is the cow herself, and this is doubly important because it is the source which is given the least attention in actual practice.