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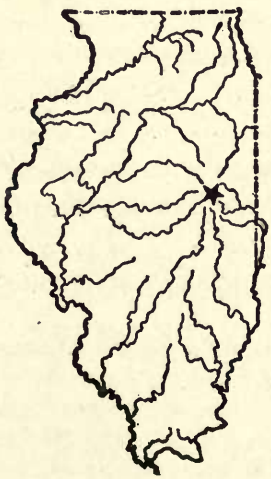
GERM CONTENT OF MILK

III. AS INFLUENCED BY VISIBLE DIRT

By H. A. HARDING and M. J. PRUCHA



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Contents of Bulletin No. 236

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III. AS INFLUENCED BY VISIBLE DIRT

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INTRODUCTION

For a number of years attention has been directed to the problem of the most economical production of milk of high quality. A high quality milk has been defined as one which is rich, safe, clean, and sweet.[1] In order that such milk be most economically produced, it is necessary that the influence of each step in the preparation of the milk upon each of these qualities be clearly understood.

Because keeping quality, or the ability to remain sweet and in satisfactory condition, was the element in milk quality in which deficiencies were most evident, recent studies have been largely concerned with the germ content of milk, since this is the factor controlling keeping quality.

It is a fundamental requirement that human food in general and milk in particular be clean. As this statement expresses a fundamental fact, it should not be taken in a narrow or technical sense. Even the finest certified milk contains a slight amount of material which under any classification would be called dirt. However, the amount of this material is so slight that such milk is unhesitatingly classed as clean.

Because of the common feeling that dirt spreads disease, the fundamental requirement of cleanliness is often confused with the equally fundamental requirement of safety. Since the diseases spread thru milk are principally caused by bacteria, the bacterial count is sometimes considered as an index of the cleanliness and of the safety of the milk.

That a high germ count in milk is no indication of the probable presence of germs of tuberculosis, typhoid fever, diphtheria, or any of the other disease germs known to be carried at times by milk, would probably be agreed to by all students of the question.

On the other hand, there is difference of opinion as to the extent to which a high germ count in milk indicates the presence of dirt. This difference of opinion arises in part because of the differences in what is considered as dirt in milk. Hair, dandruff, particles of soil, and all visible foreign matter in milk is unhesitatingly classed as dirt by all students, and any portion of similar matter in solution in the

milk is also classed as dirt. There is, however, a difference of opinion as to whether the bacteria entering the milk, mainly from dairy utensils, shall be classed as dirt.

All would agree that bacteria are undesirable in a sweet milk supply, and that care should be exercised to keep their numbers as low as practicable. However, as the presence of pathogenic germs is considered in connection with the safety of the milk, and the other relations of germ life to milk are covered by keeping quality, the consideration of bacteria as dirt serves no good purpose and makes for confusion rather than clearness. *Accordingly, in the present publication the word dirt will be used to designate the foreign matter in milk which is ordinarily visible, tho small amounts of this material may go into solution.* All gravimetric determinations of the dirt found in milk under various dairy conditions are necessarily restricted to the insoluble dirt, while the bacteriological measurements of the germ life accompanying such dirt includes the germ life accompanying the soluble dirt as well. However, in the present study the amount of soluble dirt was too small to be detected, and tests seemed to show further that there is no appreciable error in attributing the germ life found to the visible, insoluble dirt.

The data upon which this publication is based were secured during the years 1914 to 1917. Three former members of this department took an active part in the conduct of these experiments. The success of the bacteriological work depended to a large extent upon Messrs. H. M. Weeter and W. H. Chambers. The problem of removing and accurately determining the dirt present in over 3,000 pounds of milk was successfully handled by Dr. E. F. Kohmann. The efficient participation of these men in this work is gratefully acknowledged.

HISTORICAL

Foreign matter stands out so distinctly against the white background of the milk itself that the cleanliness of milk has long been a matter of general interest. The use of milk strainers or filters to remove foreign particles is an old and practically universal practice. The observation that dirt was thrown out against the walls of the separator bowl led to the development of the modern mechanical milk clarifier, which fairly completely removes insoluble foreign matter.

Modern milk production is characterized on one hand by an increasing care in keeping dirt out of milk, and on the other hand by improved mechanical means for removing the small amount of foreign matter which unavoidably enters during the milking process.

METHODS OF DETERMINING AMOUNT OF DIRT

Considering the universal interest in this question of dirt in milk, methods for the measurement of the dirt are comparatively recent.

in 1891 von Renk[2] pointed out that if one liter (about one quart) of milk was allowed to stand in a tall vessel, the dirt would settle, all but a small amount of the milk could be carefully poured off, the remainder diluted, and the process repeated until the liquid would pass thru a filter paper. The dirt caught on the paper could be dried and weighed. This remains one of the present methods of determining the dirt in milk, tho various modifications have been suggested, such as changing the shape of the sedimenting chamber, adding preservatives to prevent souring, and adding alkalies to dissolve the casein and facilitate sedimentation.

Von Renk suggested that the filter papers carrying the dirt could be displayed as an argument for the more careful handling of the milk. This suggestion was a forerunner of the modern sediment test, and the modern use of the sediment-test results.

The growing interest in clean milk led to the use of various materials as milk filters, and in 1904 Fliegel[3] devised a filter consisting of two perforated metal disks supporting a disk of cotton. This was intended for collecting and weighing the dirt in a measured amount of milk, and in principle is practically identical with present sediment testers.

Bernstein,[4] in 1906, devised a similar apparatus primarily for commercial use and with the idea of using the resulting cotton disks in grading the milk and in stimulating more care in milk production.

In this country apparently the earliest suggestion of considering the dirt content in modifying the price of milk was made by Weld[5] in 1907. He used individual strainer cloths in collecting the dirt. The sediment tester which is most commonly employed in America was described by Babcock and Farrington in 1910.[6] It collects the dirt from a pint of milk upon a pad of cotton.

The dirt caught on the cotton pad of a sediment tester presents a striking picture and early suggested the use of such pads as the basis for grading milk. Standards can be readily prepared by the use of milk containing known amounts of impurities, and in this way the dirt content of the milk may be quickly and accurately estimated. Such standards have been used by the Chicago Department of Health since 1910.[7] Similar standards for dividing milk into five degrees of cleanliness are given in the "Standard Methods for the Sanitary Analysis of Milk".[8]

The von Renk method, while fairly accurate, requires considerable time for the dirt to settle. In 1898 Eichloff[9] suggested that time could be saved and more accurate results could be obtained by substituting centrifugal force for the force of gravity in removing dirt from the sample of milk. He whirled 300-cc. samples in specially devised containers and obtained good results. Stocking,[10] in carrying out one of the first, if not the first, study of the dirt content of milk under American conditions, modified this method by passing

known amounts of milk thru a centrifugal separator and collecting and weighing the dirt deposited in the separator bowl.

It is seen that three groups of methods for determining the dirt content of milk have been devised, differing in that they depend upon sedimentation, filtration, or centrifugal force as a means of separating the dirt from the milk. Each of these methods has advantages; the centrifugal method is probably somewhat more accurate; the sedimentation method calls for less machinery; while the cotton filter method is the simplest and quickest, and when small amounts of dirt are involved, possesses a high degree of accuracy.

It will be noted that all of these methods of measuring dirt in milk assume that this dirt is both visible and insoluble. Neither of these assumptions is entirely true. Practically all of the dirt falling into the milk is dry and quite insoluble. Accordingly, while it should not be claimed that the sediment test or similar tests show all of the dirt in milk, the error of measurement involved in such sediment tests, when properly made, is undoubtedly less than the error involved in the ordinary determinations of germ content of milk.

SOURCES OF DIRT FOUND IN MILK

Since milk is regularly placed in covered cans within a few minutes after it is drawn from the cow, the entrance of foreign matter at the farm is restricted to these first few minutes, except in the unusual cases where the covers of the cans are removed during the cooling process. Before the glass bottle came into general use, the milk was exposed to street dust at the time of delivery to the consumer. At present the delivery of dipped milk is prohibited by ordinance in many cities and is generally considered an undesirable practice.

The Air.—In the early production of certified milk extreme attention was given to the dirt content of the stable air, and in the directions for market milk production the dairyman has long been urged to avoid the feeding of hay, straw, or other dust-producing feeds during the milking process.[11] These recommendations and practices were based upon the fact that the resulting dust in the air could be easily seen, and upon the belief that this dust carried large amounts of germ life. In the cases where the amount of dirt in milk has been determined and found to be relatively large, frequently one-half or more of the total dirt consisted of particles of hay, straw, or chaff. While such material is clearly objectionable, and rarely finds its way into milk under proper stable management, it should be remembered that from the esthetic standpoint this material is fairly clean and is among the least offensive foreign materials found in milk.

The Utensils.—In Bulletin 204 of this Station,[12] attention was called to the fact that from a few thousand to a million germs per cubic centimeter are added to milk from the utensils, particularly

from the milk cans. These figures will lead many to conclude that the milk utensils studied were dirty. Such was not the case. A careful examination of these utensils would have shown them unusually free from any visible dirt, with the exception of a part of the cans, and these cans were up to the ordinary standards of cleanliness. Utensils classed as "dirty" usually contain evident remnants of milk. Since utensils which would ordinarily be called clean but which have not been thoroly dried, exert such a pronounced effect upon the keeping quality of milk, the effect of utensils in which evident traces of milk have remained and decomposed is so disastrous that the practice is self-limiting. Accordingly, while dairy utensils frequently leave much to be desired from the standpoint of germ life, at the time they receive the milk they are usually satisfactorily free from evident foreign matter. Because of the mechanical difficulties involved in washing them, the milk cans are probably the most frequent exceptions to this general statement.

It should be noted in this connection that the form of milk pail exerts a marked influence upon the amount of dirt falling into the milk during the act of milking. Stocking[13] has shown that milk drawn into a small-topped pail contained 40 percent less dirt than when an ordinary pail was used. Measurements of the effect of milking machines upon the dirt content of milk are still lacking, tho it seems evident that when properly handled they will largely prevent the entrance of dirt.

The Milker.—That the milker who is a disease-germ carrier is an element of danger is well known. However, it is certainly very rare that any measurable amount of dirt from the milker enters the milk. On the other hand the care, or lack of care, exercised by the milker during the milking process undoubtedly exerts an influence upon the amount of dirt finding its way into the milk from other sources. Exact measurements of the influence of this factor upon the dirt content are unfortunately lacking.

The Coat of the Cow.—The most important source of dirt in milk is the coat of the cow. The amount of dirt coming from this source differs markedly with the season. The coat is ordinarily most dirty in the winter, when the cows are continuously stabled, particularly if their stalls are not dry, or if they are not furnished with sufficient bedding. The coat is often muddy in the spring and ordinarily it is cleanest in summer when the cows spend practically all of their time in the open air.

KINDS OF DIRT FOUND IN MILK

While the consuming public objects to any dirt in milk, some kinds of dirt are much more offensive than others.

Dust.—A beam of light entering thru a small hole practically always shows considerable dust in the barn air. A study of barn

dust[14] shows that it may be divided into two classes: that which is so light as to float in the air, and the remainder which settles promptly. The floating particles are quite dry and, therefore, are in poor condition for supporting germ life. The researches of Winslow[15] indicate that all but about one such particle in one thousand are sterile. The shape of the cow is such that during the milking process she functions like an umbrella in protecting the milk from falling particles, except those which fall from her own body. Accordingly, little of the dust from the barn air finds its way into the milk except in those cases where milk stands exposed in the barn, or in the rare cases where it is later exposed to dusty air.

Feed.—Objection is commonly raised to the feeding of straw, hay, corn fodder, or dry ground feeds during milking. For the reasons already given, little of this material finds its way into the milk unless the open pails or cans are allowed to stand in the barn, or the milk pail is used in carrying ground feed. Both of these practices are objectionable and fortunately are rather infrequent.

Milk Remnants.—Improperly cared for utensils sometimes contain remnants of milk. While there may be some difference of opinion as to whether these remnants should be classed as dirt, the germ life accompanying them is objectionable because of its effect on the keeping quality of the milk. This effect on keeping quality is well understood, and the ordinary milk utensils are carefully freed from all traces of old milk before they are used. Unfortunately the same can not always be said of the tubes of the milking machine.

Very little material from these milk remnants finds its way into the milk, except where milking machines are used. Even here such material is rarely present in sufficient amount to be detected by any of the available tests for dirt, even where the effect of the germ life upon the keeping quality is clearly evident. The fact that this material is overlooked in measurements of the dirt content is largely compensated for by the fact that where it is present, even in minute quantities, the effect of its germ content is noted in the measurements of keeping quality.

Hair.—While the milking machine is open to the objection already mentioned, it largely prevents the introduction of the considerable number of foreign particles which almost invariably enter during hand milking. Of these particles, hair is fairly common. The amount of hair falling into the milk is quite variable, being especially abundant in the spring when the cows are shedding their winter coats (see page 376), but some hair finds its way into the milk at practically all seasons of the year.

Dandruff.—Likewise, dandruff is constantly being loosened from the skin of the udder and the adjacent parts by the act of milking,

and it falls into the milk pail. While constantly present, the total amount of this material is usually small.

Soil.—Whenever conditions are such that the flanks and udder of the cow become muddy, there is the possibility of the dried mud or soil finding its way into the milk. Such cows are ordinarily cleaned before they are milked. However, in the case of cows not evidently dirty, there is frequently a small amount of dry dirt mechanically held among the hairs of the flank and udder. During the milking process some of this dirt may fall into the milk.

Manure.—Most objectionable of all the dirt which finds its way into the milk is cow feces. From the statements which are frequently made, it might be inferred that fresh cow feces are commonly found in milk. This idea is entirely erroneous and fresh feces find their way into milk so infrequently, if at all, that the probability of their presence can be safely disregarded. However, where the cows are stabled without adequate bedding, a mixture of bedding and feces may adhere to their flanks. In case this material is not thoroly removed, it will become dry and brittle, and during the milking process some portions of it may be dislodged and find their way into the milk. While the amount of this dry material thus entering the milk even in extreme cases is small where proper attention is given to the bedding and the coat of the cow, such entrance commonly is and should be prevented. It is the just indignation over the occasional finding of traces of such material in milk which has led to exaggerated statements regarding the uncleanliness of milk supplies. The public will not be satisfied until the probability of such material reaching the milk is practically eliminated.

AMOUNT OF DIRT FOUND IN MILK

Altho dirt from a dozen different sources occasionally finds its way into milk, the amount of each kind of dirt present is usually too small to be determined separately. Removing and weighing the visible, insoluble dirt in milk according to any modification of the von Renk method is a slow and laborious process. Simpler methods are now available, but thus far they have apparently not been widely applied to the study of this problem. The available data regarding the dirt content of the milk of various cities were assembled in 1907 by Grosse-Bohle[16] and these are shown in the following table.

	Lowest	Highest		Lowest	Highest
	mg. per L.	*mg. per L.*		*mg. per L.*	*mg. per L.*
Schwäbish-Gmünd . . .	27.6	116.0	Dresden (winter) . . .	6.2	24.6
Giessen	19.7	42.4	Dresden (summer) . .	2.6	6.5
Halle	14.9	72.5	Copenhagen	13.0	....
Christina	11.0	....	Leipsic	3.8	11.5
Hamburg	10.9	43.3	Würzburg	3.0	8.1
Berlin	10.3	50.0	Helingfors	1.8	....
Munich	9.0	27.9			

Some of the foregoing data represent unusual and extreme conditions and were originally published with the object of shocking the public into demanding greater cleanliness. In presenting the data, Grosse-Bohle points out that they indicate a much wider range of cleanliness in milk supplies than actually exists. One common and important source of variation in these reports arises from the different methods followed in reporting observed results. About 80 percent of fresh cow dung is water. Some observers, thinking that the dirt in milk came from fresh cow dung, and feeling that the small amount of dirt recovered by them did not fairly represent the dirt entering the milk, multiplied their actual findings by five and reported the resulting figure as the dirt in milk. Some multiplied their findings by ten and others used different factors. As has already been pointed out, moist cow dung practically never enters milk.

In the case of the figures given in the above table, it is impossible in most cases to learn the detailed methods of sampling. It has been the practice in some cases to prepare samples by taking the last of a large can of milk, knowing that such samples would include practically all of the sediment from the entire can. Results from such samples are often forty or more times higher than would be shown by a truly representative sample. These figures are subject to considerable variation depending upon whether the samples were taken immediately after the milking, when the amount of dirt is at its maximum, or at some other stage on the way to the consumer.

The above measurements all refer to European conditions and there is an almost entire lack of information regarding the dirt content of American milk supplies. At Chicago, filtration test records of the dirt content of milk have been kept since 1910. The amount of dirt in the milk is estimated by comparing the cotton disk, thru which one pint of milk has passed, with similar disks thru which suspensions of known amounts of dirt have been filtered. Of 111 samples collected on November 15, 1910, from the 40-quart cans of the farmers, 9 percent contained not more than one-half milligram of dirt per pint and were graded as "good;" 26 percent contained one to two milligrams and were graded as "fair;" and 65 percent contained three to nine milligrams and were graded as "bad."[17] While the number of samples is too small to be taken as a measure of Chicago conditions at that date, it was evidently presented as fairly typical of those conditions.

EXPERIMENTAL RESULTS

PLAN OF THE EXPERIMENTS

The absence of satisfactory information as to the amount of dirt finding its way into milk under American dairy conditions, and as to the effect of this dirt upon the germ count of milk, suggested that further information regarding these points was desirable.

The observations here reported are divided into three general groups:

First, there are observations upon the germ count of the milk from cows in three different barns. The cows in each barn differed in their cleanliness, but all of them were kept reasonably clean. These observations extended over about two years and include 1,665 samples of milk.

Second, there is given the results of a brief but intensive study of the bacterial count and the dirt content of the milk from the cows in one of the barns previously studied, after the cows had been allowed to become excessively dirty. This study includes the results from about 250 samples of milk.

Third, the large amount of germ life added to the milk by a relatively small amount of dirt from the excessively dirty cows seemed to call for an explanation. This was sought in a further study of the dirt from the coats of the cows.

Technic.—The technic employed in the first group of observations has already been given in detail in Bulletin 199 [18] of this Station, and that employed in the two other groups was essentially the same. The bacterial count was made from lactose agar plates, incubated successively for 5 days at 20°C., and 2 days at 37°C. Where special technic was made necessary by the nature of the experiment, it is described in connection with the experiment.

EFFECT OF DIRT FROM RELATIVELY CLEAN COWS

The detailed results of a study of the germ count in the milk of 138 cows, housed in three different barns, is given in Bulletin 199. In this study the small-topped milk pails were carefully steamed and protected from contamination up to the moment when the milking began. The samples for germ count were taken from the milk of individual cows when the milker brought it in pails from the barn into the adjacent milk room. The germ count found in these samples included the germs from two sources: first, the udder; and second, those brought in by the dirt falling into the milk.

The average germ count obtained from the milk from each of the three barns was very low, being 2,639 per cc. for Barn I; 920 per cc. for Barn II; and 5,777 per cc. for Barn III.

It has been shown [19] that ordinarily the germ count of the milk as it comes from the udder is about 500 per cc. Occasionally the count is much higher. In the case of Barn I the udder of a single cow contributed germs so freely that had her samples been omitted the average germ count of the milk in that barn (2,639 per cc.) would have been reduced to approximately 1,000 per cc. Additional study showed that, altho apparently healthy, this particular cow persistently gave milk with a high germ content, the source of which was her udder. Considering the remaining cows in Barn I, and allowing 500 per cc. for the germ life from the normal udder, there remains a germ count of approximately 500 per cc. due to the dirt entering the milk.

Barn I, which contained about 40 pure-bred cows, was being daily inspected by visitors, and the cows were frequently in the judging ring for class or exhibition purposes. The cows were carefully bedded and groomed, the interior of the barn was kept freshly painted, the floors were scrubbed and flushed with water, and the cows were kept unusually clean. While the attention to the cleanliness of the cows was not so extreme as in many barns where certified milk is produced, the general appearance of the barn and the cleanliness of the cows were roughly comparable with the conditions often surrounding the production of certified milk.

In Barn II, udder conditions appeared to be entirely normal. Making the same allowance of 500 per cc. for germs from the udder, there remains of the original germ count of 920 per cc. a germ count of approximately 500 per cc. to be accounted for on the basis of dirt.

Barn II contained about 40 grade cows which were used in various experiments. The brick side-walls were unfinished and the planks of the joists and the floor above were rough and unpainted. The length of the stanchion was adjusted to the need of the individual cow, and bedding was ample without being abundant. Traces of dirt and dried manure were usually to be found on the flanks of a number of the cows, but the amount of this material was always small. The conditions of cleanliness in Barn II were fairly comparable with those of the better class of dairies producing milk for city supply. This barn was farther away and visitors were not so common as at Barn I, but the lack of cleanliness in Barn II was sufficiently evident to occasionally excite unfavorable comment.

Conditions in Barn III differed from those in either of the other barns. As shown by a later study, the results of which are given on page 376, the germ count from the udder of a number of these cows was higher than the normal, and the average germ count coming from the udder was probably about 1,000 per cc. Figuring from the original germ count of 5,777 per cc., this leaves a germ count of about 4,500 per cc. to be accounted for on the basis of the dirt.

Barn III contained about 10 grade cows. It had a dirt floor, with no provision for drainage. In this barn the cows were allowed to run loose. Straw was added to absorb the liquid and cover the manure, and the resulting accumulation became two to four feet deep before it was removed twice a year. Clean straw was supplied abundantly, and in the main the coats of the cows remained fairly clean, tho the condition of the stable floor and, to some extent, the coats of the cows would undoubtedly have called forth a protest from a city dairy inspector. While the general conditions of cleanliness in Barn III were little better than those of average dairies of a generation ago, the liberal use of bedding resulted in a cleanliness of the coats of the cows which was roughly comparable with that in many market milk dairies.

Having in mind the increase in germ count resulting from the dirt entering the milk and the general conditions of cleanliness in the barns, attention may be directed toward the significance of the observed facts. The observations in connection with Barn I suggest that the dirt entering the milk under anything less than good certified-milk conditions results in an increase of about 500 per cc. in the germ count. The observations in connection with Barn II show that when the conditions of cleanliness are no better than those found in the better class of ordinary farm dairies, the dirt entering the milk produces approximately the same increase in germ count as noted in Barn I.

The explanation for these identical results under apparently widely differing conditions lies in the source of the dirt. Under the conditions obtaining in these two barns, the material falling into the milk was practically the same, consisting of hair and dandruff from the udder and, to a slight extent, from the flank. While the amount of falling hair varies with the time of year, the amount of dandruff remains practically constant.

In Barn III a distinctly different situation was evident. Here the conditions of cleanliness were roughly comparable with those of ordinary dairies during the winter season, and the increase in germ count due to dirt was about 4,500 per cc. In this barn the hair and dandruff falling into the milk were supplemented by various other forms of dirt.

EFFECT OF DIRT FROM EXTREMELY DIRTY COWS

The barn conditions already described are representative of dairy conditions ranging from very good to rather questionable. In order to cover the subject it was desirable to study the milk produced by extremely dirty cows. It is the unwritten law of public institutions that dairy cows must be kept clean, and accordingly it was difficult to provide suitable material for such study. In the work already

described, the cows were allowed to become so dirty as to provoke unfavorable comment.

In the winter of 1916, taking advantage of a quarantine due to a neighboring outbreak of foot-and-mouth disease, the cows in Barn III were allowed to become extremely dirty. The accumulation of manure on the floor of the stable in which the cows were loose became about four feet deep. Practically no attempt was made to clean the cows for some months. Dried feces accumulated on the flanks and abdomens of the cows, and these animals were fairly representative of extremely dirty dairy conditions. The condition of the coat of one of these cows at the time of this study is shown on page 391.

Plan of the Study

When the cows and their surroundings had become representative of extremely dirty dairy conditions, the study of the milk was begun. This study included a determination of the germ count and of the dirt content of the milk of seven cows. These determinations were made in three series of ten milkings each, and in addition the germ count of the milk directly from the udder of each cow was determined at six separate milkings. Accordingly, germ counts were made upon 252 milk samples.

The three series differed from each other in that in the first series the milk pail was the small-topped one, with an oval opening 5 x 7 inches, used in the previously described studies in Barns I, II, and III; in the second series an ordinary open-topped milk pail, having a diameter of about twelve inches, was used; and in the third series conditions were the same as in the first, except that the coats of the cows had been thoroly cleaned. The milk pails in all cases were carefully steamed and protected until used.

The sample for determining the germ count was taken from the milk of each cow as the milk came in the pail from the stable to the milk room. The dirt determinations were made from the unstrained milk, collected in eight-gallon cans. The amount of this milk at each milking varied between 112 and 168 pounds.

Determining the Dirt in the Milk

A combination of sedimentation and centrifugal force was used in determining the amount of dirt. After the cans of milk had stood for eight hours, the bulk of the milk was siphoned (the first five samples were poured) thru a weighed 100-mesh sieve. The remaining milk was poured thru the same sieve but was collected in a glass cylinder. The cans were then rinsed and the rinsings poured thru the sieve into the cylinder. The sieve was washed with water and a little alcohol to free it from milk and fat, and these washings were added to the cylinder. The sieve was then dried and weighed. The

material retained by the sieve was largely hair, bits of straw, and what appeared to be scales from the skin of the cow.

Bichlorid of mercury was added to the material in the cylinder as a preservative, and after the cylinder stood eight hours the upper portion of the fluid was siphoned off. The remaining material was centrifuged for half an hour, the liquid poured off, the sediment again suspended in distilled water, and the centrifuging repeated. The liquid was then poured off and the sediment, washed into a weighed, folded filter, was dried and weighed.

Milligrams per liter is probably the best form for expressing the dirt content of milk, because the liter is the most widely recognized unit of volume. However, the volume of the U. S. quart is almost the same as that of the liter, and the quart is the accepted standard for retailing milk in this country. Since it is doubtful if the difference in the dirt content of a quart and of a liter can be detected by the available methods of measuring the dirt in milk, it will serve the present purposes better to express the dirt measurements in milligrams per quart. In round numbers one milligram of dirt per quart is one part of dirt to one million parts of milk.

Series I—When the Small-Topped Pail Was Used

In the previous studies in Barns I, II, and III, the small-topped milk pail was used. In order to obtain comparable data, it was again used in the first series of samples. The germ count obtained from the samples of milk drawn from each of seven extremely dirty cows into small-topped pails at ten successive milkings is given in Table 1.

TABLE 1.—GERM COUNT OF MILK DRAWN FROM DIRTY COWS INTO SMALL-TOPPED PAIL

No. of cow....	1019	1032	1033	1034	1036	1037	1038
	per cc.	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*
Feb. 24 a.m....	12 775	61 900	9 925	10 425	13 850	2 600	7 350
" 24 p.m....	17 375	21 725	5 125	15 525	3 800	3 650	4 000
" 25 a.m....	5 355	18 900	10 650	14 300	11 850	7 740	20 275
" 25 p.m....	44 325	4 200	10 650	10 700	8 125	8 725	4 425
" 26 a.m....	4 600	11 375	13 125	70 500	10 125	7 100	7 950
" 28 a.m....	2 850	7 325	9 925	5 725	3 000	3 625	5 450
" 28 p.m....	11 800	14 875	11 125	7 975	1 885	1 085	1 295
" 29 a.m....	9 267	31 375	3 125	13 675	5 300	3 275	1 800
" 29 p.m....	90 000	10 700	6 900	10 050	3 650	3 250	3 700
Mar. 1 a.m....	39 200	6 425	62 900	8 133	3 050	2 650	5 425
Average.....	23 755	18 880	14 345	16 701	6 463	4 370	6 167
General average.....12 954							

The germ count given in this table is the combined result of the germ life derived from the udder and the germ life carried into the milk by the dirt. To find the part of this due to dirt it is necessary to find the germ count of the milk coming from the udder. Samples of milk for this measurement were carefully drawn from the udder directly into sterile tubes when the cows were about half milked, and such samples were taken from each of the seven cows at six successive milkings. The results of the germ-count determinations of such samples are given in Table 2.

TABLE 2.—GERM COUNT OF MILK DIRECT FROM THE UDDER

No. of cow....	1019	1032	1033	1034	1036	1037	1038
	per cc.	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*
Mar. 20 p.m....	.....	345	2 130	855	750	1 995	150
" 21 a.m....	1 075	575	525	1 755	475	435	190
" 21 p.m....	1 390	735	2 280	430	540	370	50
" 22 a.m....	1 095	905	4 230	1 065	640	360	345
" 23 a.m....	.....	620	905	.....	555	1 150	820
" 23 p.m....	1 415	290	1 140	530	2 480	1 080	420
Average.....	1 244	578	1 868	927	907	898	329
General average.....964							

These determinations of the germ count of the milk as it came from the udder show that while there was considerable fluctuation in the successive samples from the same cow and distinct differences in the germ count of the milk from different cows, the average addition to the germ count due to udder conditions was approximately 1,000 per cc.

Since the results given in Table 1 show an average germ count in the milk of 12,954 per cc., and the samples from the udder show an average count of 964 per cc., there remain approximately 12,000 per cc. to be accounted for on the basis of the dirt falling into the milk when drawn from extremely dirty cows into small-topped pails.

The amount of dirt actually recovered from the milk as drawn from the dirty cows into small-topped pails is given in Table 3. (It is regrettable that the data in Table 3 include the milk from only seven of the ten milkings at which the germ count was determined. The practical difficulties connected with finding the dirt content did not permit of more determinations.)

The material retained by the sieve consisted mainly of bits of hay and straw, hair, and dandruff. It chanced that this and, more particularly, the later tests were made at the time when the cows were shedding their hair freely. The greater part of the material retained by the sieve would ordinarily be removed by the straining at the

TABLE 3.—DIRT AND GERMS IN MILK DRAWN FROM DIRTY COWS INTO SMALL-TOPPED PAIL

Date	Milk	Dirt				Bacteria
		On sieve	On filter	Total	Per quart	
	lbs.	*mgs.*	*mgs.*	*mgs.*	*mgs.*	*per cc.*
Feb. 24 a.m.	162.1	236.6	250.7	487.3	6.467	12 734
" 24 p.m.	148.1	727.2	259.6	986.8	14.325	8 416
" 25 a.m.	167.7	518.4	66.2	584.6	7.495	12 400
" 25 p.m.	148.9	352.4	96.2	448.6	6.466	12 115
" 26 a.m.	161.1	512.7	83.8	596.5	7.961	17 896
" 29 p.m.	142.1	370.0	133.9	503.9	7.624	14 800
Mar. 1 a.m.	158.7	435.6	82.5	518.1	7.019	19 577
Average					8.1	14 000
Average omitting 2d sample					7.1	

farm, and if missed there, would be removed by the strainers at the milk plant. In all except the first test in the Table 3, the dirt retained by the sieve amounted to more than 50 percent of the total dirt recovered from the milk, and the average for the seven tests was 76 percent.

The dirt retained by the filter would probably have passed thru ordinary strainers and would hardly have been removed by anything employed in the milk business, except centrifugal force, such as that exerted by the milk clarifier. Accordingly, it represents the dirt which remains in the milk as delivered to the consumer, except in those cases where a clarifier is employed.

It will be noted that the proportion of dirt present in the milk on different days was fairly constant, being between 6.5 and 7.9 milligrams per quart, except for the second milking, when it was 14.3 milligrams per quart. It will be noted that at this milking the excessive amount of dirt was retained by the sieve. As a matter of fact, this excessive weight of dirt was largely due to a piece of hay which was floating in the milk. The dirt content of the entire 506.4 quarts of milk averaged 8.1 milligrams per quart, or if the second milking be omitted, the average was 7.1 milligrams per quart.

Not the least surprising of the data are those given in the column showing the bacteria per cubic centimeter. The germ count of the milk for each day was calculated as the total germ count of the milk of all the cows, divided by the total number of cubic centimeters of milk. It will be noted that the lowest germ count was found on the day when the proportion of dirt in the milk was highest, but it has already been explained that in this case the excess dirt consisted of a bit of hay which undoubtedly carried but little germ life.

Taken as a whole these results indicate a surprisingly small variation in germ content in this milk, coming as it did from extremely

dirty cows and carrying a relatively large amount of dirt. To many the low germ count of the milk obtained under these circumstances will be even more surprising. Had all this milk been produced at one time and the milk carefully mixed, a representative sample should have given a germ count of 14,000 per cc. In this connection it should be remembered that this germ count was made after an incubation of the plates for five days at 20°C. and two days at 37°C., instead of the single incubation for two days at 37.5° C. required by the official methods of routine milk examination.[20]

This longer incubation period has been used consistently in all of these research studies because of the fact that it gives distinctly higher germ counts. Had these samples of milk been given the official routine bacteriological examination, the majority of them would have been reported as being below 10,000 per cc., which is set as the upper limit for certified milk.

In justice to certified milk it should be made clear that the production of certified milk is surrounded by other safeguards in addition to a limit of 10,000 per cc. germ count, but the illustration is used at this point because in the estimation of the general public and too often in the thinking of health officials, a count of 10,000 per cc. is taken as complete evidence that the milk in question has been produced under the most exacting conditions of cleanliness. The data given in Table 3 make it clear that a germ count of 10,000 per cc. does not necessarily mean anything of the sort.

Series II—When the Ordinary Milk Pail Was Used

In commercial dairies, under the exceptional conditions where the cows would be permitted to become as dirty as those in this study, the ordinary type of open milk pail would often be used. Under these conditions the maximum amount of dirt would fall into the milk. In order to measure the dirt under the worst conditions, the seven cows were milked into open-topped pails for ten successive milkings. A sample of the milk from each cow was taken and its germ count determined. The results of these determinations are given in Table 4.

The data in Table 4 show that the germ count of the samples from the various cows averaged between 28,485 and 10,783 per cc. They also show that there were fairly characteristic differences in the germ counts from the different cows, the samples from Cow 1019 being quite consistently high in germ count, while those from Cows 1037 and 1038 are quite consistently low. Reference to Table 1 will show that practically the same relations obtained during the first series of samples. The explanation does not seem to lie in the degree of dirtiness of the cows, since Cow 1019 is at times recorded as "moderately dirty," while Cows 1037 and 1038 are at times among those marked "extremely dirty." The explanation of the high count from Cow

TABLE 4.—GERM COUNT OF MILK DRAWN FROM DIRTY COWS INTO OPEN-TOPPED PAIL

No. of cow....	1019	1032	1033	1034	1036	1037	1038
	per cc.	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*
Mar. 1 p.m....	19 125	45 100	64 250	7 425	6 875	4 650	9 425
" 2 a.m....	21 150	13 000	3 865	10 657	5 750	7 450	10 400
" 2 p.m....	68 925	25 975	11 300	17 833	6 100	9 000	7 350
" 3 a.m....	13 800	27 400	1 550	18 450	58 800	3 400	4 825
" 3 p.m....	45 550	10 600	2 750	9 075	18 500	4 633	44 750
" 6 a.m....	6 300	22 550	11 125	9 625	4 300	9 025	8 150
" 6 p.m....	10 050	4 100	5 375	20 350	4 075	5 500	9 000
" 7 p.m....	21 200	45 375	3 125	15 350	94 000	36 175	27 175
" 8 a.m....	20 100	15 100	7 150	6 150	9 750	5 700	19 800
" 8 p.m....	58 650	39 825	5 450	16 750	34 150	22 300	3 525
Average....	28 485	24 902	11 594	13 167	24 230	10 783	14 440

General average.....18 229

1019 probably lies in the fact that it was so difficult to milk her that twice the ordinary time was consumed in the milking process. The prolonged agitation of the udder above the pail allowed more dirt to fall into the milk.

When one remembers that these samples came from milk drawn from extremely dirty cows into open-topped pails, the most surprising feature of the data is the low bacterial count. Forty-six percent of the samples gave a germ count under 10,000 per cc. The general average of all of the samples was only 18,229 per cc., and there is but one sample among the seventy with a germ count above 60,000 per cc., which marks the upper limit for New York Grade A milk. It should further be remembered that the method of incubation used with these counts should lead to counts at least 20 percent higher than would be secured by the official methods used in routine milk control.

In considering the relation of these germ counts to dirt as a source of the germs, it should be remembered that allowance for the udder content should be made according to the results shown in Table 2.

The amount of dirt actually recovered from the milk as drawn from the dirty cows into open-topped pails is given in Table 5.

In considering the data given in Table 5, it is at once apparent that the dirt determinations from the last three samples are abnormal. The results are here given just as determined, tho the reason for the abnormality was understood at the time of determination. On these three days the milk promptly became ropy and it was not possible to separate all of the milk from the sediment. The difficulty is most evident in material retained by the sieve, tho the results from the filter were also affected. If these abnormal results were included,

TABLE 5.—DIRT AND GERMS IN MILK DRAWN FROM DIRTY COWS INTO OPEN-TOPPED PAIL

Date	Milk	DIRT				Bacteria
		On sieve	On filter	Total	Per quart	
	lbs.	*mgs.*	*mgs.*	*mgs.*	*mgs.*	*per cc.*
Mar. 1 p.m.	140.0	574.1	107.7	681.8	10.5	22 179
" 2 a.m.	162.1	871.7	108.1	979.8	13.0	9 164
" 2 p.m.	143.8	695.6	66.9	762.5	11.4	17 470
" 3 a.m.	158.0	562.7	98.4	661.1	9.0	15 959
" 3 p.m.	140.5	589.9	75.5	665.4	10.2	17 929
" 6 p.m.	149.2	1 103.5	119.5	1 223.0	17.6	8 250
" 7 p.m.	132.8	1 029.9	271.4	1 301.3	21.1	35 623
" 8 p.m.	150.7	1 309.2	157.7	1 466.9	16.6	22 303
Average					14.2	18 244
Average omitting last 3 samples					10.8	

14.2 milligrams of sediment per quart would be shown, or if the calculations were restricted to the five days when conditions were normal, the average dirt content would be 10.8 milligrams per quart. Of this amount 88 percent was retained by the sieve.

The calculation of the bacterial count for each milking shows that at two milkings the entire product of the seven cows had a germ count of less than 10,000 per cc., and that at no milking did it go above 36,000 per cc. The average germ count for the entire 1,177 pounds of milk was 18,244 per cc.

Series III—When the Cows Had Been Cleaned

In Series I and II are given the germ counts found and the dirt recovered from the milk of seven extremely dirty cows when they were milked into small-topped and into ordinary pails. The cows were dirty as a result of lying upon an accumulation of straw and their own manure, which at the time of the study was about four feet deep.

In order to bring out more clearly the effect of the condition of the coat of the cow upon the cleanliness and germ count of the milk, the coats of the cows were cleaned, but all of the other factors in the situation remained unchanged. For ten successive milkings these cleaned cows were milked into small-topped pails, and the germ count and the dirt content were determined as in the preceding series. The results are recorded in Table 6.

It will be seen from this table that the cleanliness of the coat of the cows really lasted just one day. Before each successive milking, the milker made some effort to remove the dirt evident upon the cow, and the resulting cleanliness of the cows was in marked contrast to their former condition, but sufficient labor was not available to keep the coats of the cows clean when they were living on the top of a

TABLE 6.—GERM COUNT OF MILK DRAWN FROM CLEANED COWS INTO SMALL-TOPPED PAIL

No. of cow....	1019	1032	1033	1034	1036	1037	1038
	per cc.	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*	*per cc.*
Mar. 17 a.m....	3 000	5 900	4 150	6 550	3 250	1 975	1 150
" 18 a.m....	55 600	3 600	38 850	4 500	4 900	8 333	3 000
" 18 p.m....	14 400	4 700	8 575	7 650	1 550	850	2 650
" 20 a.m....	.....	4 600	4 900	5 500	2 250	2 750	2 800
" 20 p.m....	25 025	6 338	3 110	5 163	4 270	.....	1 385
" 21 a.m....	3 680	4 590	6 510	10 725	3 525	3 200	7 710
" 21 p.m....	5 576	6 720	7 355	16 700	3 510	5 100	2 205
" 22 a.m....	7 975	6 170	10 000	9 300	3 795	2 910	4 080
" 23 a.m....	22 775	14 305	9 785	8 050	10 880	3 100	4 105
" 23 p.m....	3 415	3 278	2 210	4 375	5 040	4 420	1 890
Average.....	15 716	6 020	9 544	7 851	4 297	3 626	3 097

General average.....7 165

manure heap. While the attempt at keeping the cows clean was not entirely successful, the effect of their increased cleanliness upon the milk was very evident. Only 15 percent of the samples gave a germ count of over 10,000 per cc., and the average of the 68 samples was 7,165 per cc.

The amount of dirt actually recovered from the milk as drawn from the cleaned cows into small-topped pails is given in Table 7.

TABLE 7.—DIRT AND GERMS IN MILK DRAWN FROM CLEANED COWS INTO SMALL-TOPPED PAIL

Date	Milk	Dirt				Bacteria
		On sieve	On filter	Total	Per quart	
	lbs.	*mgs.*	*mgs.*	*mgs.*	*mgs.*	*per cc.*
Mar. 17 a.m.....	145.6	160.6	7.6	168.2	2.48	3 490
" 18 a.m.....	143.3	208.7	26.0	234.7	3.52	17 219
" 18 p.m.....	128.1	210.8	54.5	265.3	4.45	5 379
" 20 a.m.....	126.4	142.6	60.1	202.7	3.44	3 672
" 20 p.m.....	112.4	249.8	56.8	306.6	5.86	6 473
" 21 a.m.....	148.7	222.3	48.9	271.2	3.92	5 650
" 21 p.m.....	134.4	415.1	79.1	494.2	7.91	6 382
" 22 a.m.....	155.0	103.3	75.6	178.9	2.54	6 086
" 23 a.m.....	146.7	392.9	26.1	419.0	6.15	9 108
Average					4.6	7 117

It is seen from this table that the dirt removed from the milk of the cleaned cows averaged 4.6 milligrams per quart. This amount is directly comparable with the 8.1 milligrams per quart removed from the milk of the dirty cows milked into small-topped pails. Accordingly, the cleaning of the cows reduced the recoverable dirt by 44 percent.

It also should be noted that the sieve recovered 83 percent of the dirt, while but 0.8 of a milligram per quart was recovered by the filter.

The reduction in germ count is also interesting. The milk when drawn from dirty cows into small-topped pails gave a germ count of 14,000 per cc., while the milk from the cleaned cows drawn into similar pails gave a germ count of 7,117 per cc. Allowing 1,000 per cc. as the germ life from the udder, it will be seen that the cleaning of the cows reduced the dirt in the milk 44 percent and the germ count due to dirt 46 percent.

So far as indicated by the germ count, the milk from the cleaned cows left little to be desired. It chanced that two of the highest counts of the series occurred in the samples on the morning of March 18, when the average germ count for the milking was 17,219 per cc. The combined average for the counts of the other eight milkings, as shown in Table 7, was but 5,780 per cc.

Discussion of the Results from the Three Series

The data from the three series of observations on the milk of the seven cows emphasise two points: first, that the amount of dirt recovered from the milk is small; second, that the increase in the germ count due to dirt is slight.

The small amount of dirt entering the milk was not due to any lack of dirt on the cows. The dirt entering the milk during the milking process comes mainly from the surface of the udder and to a less extent from the flank. Under filthy surroundings, while the flank often becomes dirty, the udder ordinarily remains fairly clean, even in the case of cows with large udders. During milking the pail is at one side, not directly under the udder, and a considerable portion of the dirt loosened by the milking process falls outside of the pail.

In the case of the extremely dirty cows milked into an ordinary pail having a diameter of about twelve inches, the dirt recovered from the milk amounted to 10.8 milligrams per quart. When the same cows were milked into a pail having an opening 5 x 7 inches, the recovered dirt amounted to 8.1 milligrams per quart; or if the milking where the total dirt was increased by hay falling into the milk while it was being carried from the stable be omitted, the average was 7.1 milligrams per quart. These figures show that on one basis of calculation the dirt kept out of the milk by the small-topped pail amounted to 25 percent, and on the other basis to 34 percent, of that entering the open pail. Stocking found in his studies that a similar small-topped pail reduced the amount of dirt entering the milk by 40 percent.

At the first milking in the third series (the series in which the cows were cleaned), the dirt recovered amounted to only 2.5 milligrams

per quart. While not a sufficient basis for generalization, this probably indicates what may be expected under very clean conditions. On this basis the range in results between clean and extremely dirty conditions is the range between 2.5 and 10.8 milligrams of dirt per quart. The cleanliness of the cows during the third series would compare favorably with the cleanliness of a majority of dairy cows during the later portion of the winter, and the average of the dirt recovered from this series of milkings amounted to 4.6 milligrams per quart. From this it would seem that milk could not be considered abnormally dirty until the recoverable dirt in the unstrained milk amounted to at least 5 milligrams per quart.

The possibility of judging of the conditions of production by the dirt recoverable from the milk is further complicated by the fact that thoro straining removes 75 percent or more of the recoverable dirt. This means that even in the dirtiest milk the recoverable dirt may be reduced by thoro straining to about 2 milligrams per quart. When, in addition to the straining process the milk is later exposed to the action of the milk clarifier, the amount of dirt in the milk as delivered to the consumer is reduced toward, if not to, the vanishing point.

In computing the increase in germ count due to dirt in the milk of these seven cows, the germ count due to the udder may be considered as 1,000 per cc. The results from the examination of the milk indicate that when the cleanliness of the cows is roughly comparable with that of winter conditions in ordinary dairies, and the recoverable dirt amounts to 4.6 milligrams per quart, the germ count due to dirt amounts to about 6,000 per cc. Where the cows are more dirty and the recoverable dirt amounts to 7.1 milligrams per quart, this dirt adds 13,000 per cc., while under extremely dirty conditions the recoverable dirt may amount to 10.8 milligrams per quart and the increase in germ count due to dirt be raised to about 17,000 per cc. This increase of 17,000 per cc., which may enter with the dirt under extreme conditions, taken by itself seems like a significant amount of contamination. However, it becomes a small and uncertain part of the 50,000 to 70,000 bacteria per cc. commonly found in market milk in which multiplication of bacteria has not yet occurred.

To those who rely upon the germ count of market milk to indicate the conditions of cleanliness under which milk is produced and handled, these results cannot be otherwise than discouraging. The results are not open to criticism of the manner of determining the germ count, because the methods employed are recognized as productive of germ counts distinctly higher than those resulting from routine official methods.

Germ Count of the Dirt from Extremely Dirty Cows

It will be noted that thruout the discussion of the results from these three series of studies of dirty cows, the calculations have been based upon the determined dirt. It is recognized that the method used in determining the dirt was imperfect and that undoubtedly some of the dirt was not recovered. Again, there is no question but that some of the dirt passed into solution and thereby escaped detection. It is important to know the extent to which the dirt thus overlooked should modify the conclusions drawn from data concerning the part of the dirt which was determined.

While the accuracy of the determinations of the dirt content of this milk may be questioned, the determinations of the relatively small increase in germ count which accompanied the additions of the dirt to the milk, can hardly be doubted. Since the germ-count determinations are the portions regarding which there can be little question, they may be used as a means of testing the accuracy of the dirt determinations.

The milk in each of the three series of tests amounted to about 1,000 pounds and included a known amount of dirt. The germ count of this milk was carefully determined. From these data it is possible to compute the germ count of the dirt recovered from the milk. All that is necessary for this determination is to find the total germ count of the milk, subtract the 1,000 per cc. due to udder flora, and divide the resulting number by the grams of dirt. The data for this calculation for each of the three series are given in Table 8.

TABLE 8.—GERM COUNT OF DIRT RECOVERED FROM MILK

Series	Volume of milk	Dirt found	Germs in milk	Germs from udder	Germs from dirt	Germs from 1 gram of dirt
	cc.	*gms.*	*millions*	*millions*	*millions*	*millions*
I.....	478 537	4.1258	6 700	479	6 221	1 508
II.....	372 162	3.7506	5 339	327	5 012	1 342
III.....	545 765	2.5408	3 884	546	3 339	1 314

The data in Table 8 place the germ count of the dirt recovered from the milk at approximately 1.5 billion germs per gram. Those who are familiar with the germ count of such substances as milk and soil will at once recognize that this is a high figure. In fact it is so high as to offer some basis for the suggestion that this large amount of germ life may have entered the milk in connection with a larger amount of dirt than was later recovered from the milk.

Manifestly the most direct means of determining the germ count of the dirt falling from the udder and the flank of the cow during the milking process is to secure some of this material and to determine the germ count of weighed quantities of this dry dirt.

The two cows used in making this test were in two different barns. Cow 152 was in Barn I. She had been brushed daily and her coat showed no visible dirt. She was representative of very clean cows. Cow 1039 was in Barn III, and her condition and surroundings were the same as the seven cows in Series I and II. Her flank and abdomen were partially covered with dried manure and she was an extremely dirty cow.

Neither cow was in milk, and the samples were collected using a sterilized, open-top, milk pail. Any loose bedding on the flanks or udder was brushed away by hand, as is customary before milking, but the cows were not otherwise prepared for the tests. The pail was held partially under the udder, as would be done during ordinary hand-milking, and the udder was manipulated as tho the cow were being milked. In the first two tests the manipulation was continued for seven minutes, and in the other three, for ten minutes. The pail was then taken to the laboratory and the visible dirt was brushed out and weighed. The dirt was then mixed with a definite amount of sterile skimmed milk and after being mixed for fifteen to twenty-five minutes plates were prepared for germ-count determinations. The results of five such determinations are given in Table 9.

TABLE 9.—GERM COUNT OF DIRT FROM COATS OF COWS

No. of cow	Condition of cow	Dirt from milk pail	Germ count of dirt	Germ count per 1 gram
		gms.		
152*	Clean	.043	766 000	17 814 000
1039*	Dirty	.240	94 285 000	392 800 000
"	"	.108	496 000 000	4 592 000 000
"	"	.083	15 300 000	184 300 000
"	"	.171	293 475 000	1 716 000 000

* In these two tests the manipulation of the udder was continued but seven minutes, while in the other three the manipulation lasted ten minutes. To facilitate comparison, the amount of dirt and its germ count was increased to a ten-minute basis. This did not affect the final computation of germ count per gram of dirt.

From Table 9 it will be seen that clean and dirty cows are in different classes, both in the amount of dirt falling into the pail during a given time and in the germ count resulting from a gram of dirt. In other words, the dirt from a dirty cow is not only more abundant than from a clean cow, but it is also a different kind of dirt with a much higher germ count per gram.

In removing the dirt from the pail during the experiments it was noted that the dirt falling from Cow 152 consisted of some hair and fine dandruff. The dirt from Cow 1039 was made up of considerable hair, dandruff, and many fine particles of dirt, presumably in part dried manure. Because of the distinctly different germ count of the

material from the two cows, interest is at present centered upon the results from Cow 1039, since she was a companion cow with the seven dirty cows in Barn III.

It will be noted that four tests of this cow on successive days gave widely differing results, not only in the amount of dirt collected, but also in the germ count per gram of this dirt. While variation is undoubtedly due in part to the varying germ count of the different kinds of dirt finding their way into the pail, it is also due in part to the difficulty of getting representative samples of the material in making the plates. In preparing the samples the dirt was placed in measured amounts of milk varying from 500 cc. to 5,000 cc., and after fifteen minutes of thoro shaking samples were taken for plating within the following ten minutes. The number of samples taken, from which dilutions and plates were made, varied from two to twenty on the different days, and six to nine plates were made from each sample. Not all of these plates could be counted, but the germ counts given for the four tests of Cow 1039 are based upon counts from 11, 20, 13, and 46 plates respectively.

Extreme variations occurred in connection with the second test of Cow 1039, and as this was the test giving the highest germ count per gram, and as the results well illustrate the difficulties in determining the germ count of such material, they will be given in some detail. In this experiment 0.108 of a gram of dirt was suspended in 500 cc. of milk. Four separate samples were drawn from this suspension, and nine plates were made from each sample. The results are given in Table 10.

TABLE 10.—GERM COUNT WITH 0.108 OF A GRAM OF DIRT SUSPENDED IN 500 CC. OF MILK

Sample	Plates counted	Average per cc.	Total germs in 500 cc.	Germ count per 1 gram of dirt
I	6	878 000	439 000 000	4 064 000 000
II	5	611 000	305 750 000	2 831 000 000
III	3	143 000	71 500 000	662 000 000
IV	6	2 336 000	1 168 000 000	10 810 000 000

Had any one of the four samples shown in Table 10 been taken alone, the germ count of this dirt might have been given as anything between 662 million and 10,810 million per gram.

An inspection of the records of the plates made from the four samples shows that the plates made from each sample agree fairly well among themselves. For example, in Sample III the three plates made from the 1-1000 dilution produced 127, 150 and 152 colonies respectively. Likewise, the three similar plates from Sample IV produced 1,800, 2,000, and 2,050 colonies. The difficulty in getting accordant results from the examination of such suspensions of dirt in

milk seems to lie principally in withdrawing representative samples. The fact that in these experiments the dirt was suspended in less than one-tenth of the volume of milk in which it would be suspended in ordinary milking undoubtedly added to the difficulty.

Reverting again to the data from the four determinations of the germ count of the dirt from Cow 1039, as given in Table 9, it is plain that little can be gained by considering a mathematical average of germ counts which vary from 184 million to 4,592 million per gram. At the same time it is clear that if a large number of such determinations were averaged, as was done with each of the three series of samples from Barn III, it is altogether likely that such an average would show a germ count for the dirt of at least 1.5 billion per gram. Accordingly, in so far as conclusions can be drawn from such a limited number of observations, these direct examinations of the dirt falling into the milk pail from a dirty cow suggest that the dirt recovered from the milk in the three series of examinations was sufficient in amount to account for the increase found in the germ count. In other words, these results tend to show that the methods employed in recovering the dirt from the milk recovered essentially all of the dirt.

In the case of three of the suspensions included in Table 9, where a known amount of dirt was suspended in 500 cc. of skim milk, advantage was taken of the opportunity to test the extent to which it was possible to recover this dirt by filtration thru cotton. In each case the weight of the cotton filter, after filtration and drying, was found to be increased by an amount slightly in excess of the weight of the dirt added to the milk. Evidently the milk adhering tenaciously to the cotton more than offset any tendency of the dirt to go into the solution, or to pass thru the cotton. As the technic employed in the case of these 500-cc. suspensions was different from that employed in removing the dirt from the large quantities of normal milk, they throw little light upon the accuracy of the other method, except to suggest that the element of solubility is not large in the case of the dirt which falls into the milk, from extremely dirty cows.

SUMMARY AND CONCLUSIONS

It is a matter of common knowledge that under ordinary dairy conditions practically all the dirt entering the milk at the farm enters during the act of milking.

The use of the small-topped pail materially reduces the amount of dirt entering the milk, the reduction varying from 25 to 40 percent.

The quantity of dirt entering the milk during the milking process is small. When the cows were unusually dirty, and were milked into an open-topped pail, the dirt in the unstrained milk amounted to 10.8 milligrams per quart. When the conditions were comparable to those of ordinary dairies, and the small-topped pail was used, the dirt in the milk was less than 5 milligrams per quart. Under conditions comparable with the better class of market milk dairies, and when the small-topped pail was used, the proportion of dirt was about 2.5 milligrams per quart.

The kinds of dirt falling into the milk vary with the condition of the coat of the cow. With hand-milking, the entrance of some hair and dandruff is practically unavoidable, tho the amount may be reduced by regularly brushing the coat of the cow. If the flank or udder is soiled with dried manure and other dirt, some of this may find its way into the milk.

Thoro straining removes the hair, dandruff, and larger particles which form 75 to 90 percent of the dirt.

While some of the dirt undoubtedly passes into solution in the milk, the amount in this study was so small that it escaped determination.

Germ life is abundant on the dirt from extremely dirty cows, the plate counts indicating approximately 1.5 billion per gram of dirt. However, owing to the small amount of this dirt which finds its way into milk, the effect of the dirt upon the germ count of the milk is relatively small. When the cows were extremely dirty, and the dirt in the milk amounted to 10.8 milligrams per quart, the increase in the germ count of the milk, due to dirt, was about 17,000 per cc. Under the same conditions, except that the use of the small-topped pail reduced the dirt entering the milk to 8.1 milligrams per quart, the germ count due to dirt fell to 13,000 per cc.

In ordinary milk production, germ counts as low as 17,000 per cc. resulting from any factor will be entirely overshadowed by the influence of utensils and other factors. Where the time interval permits growth, any attempt to judge of the conditions of cleanliness surrounding the production of a given sample of milk, on the basis of its germ count, becomes hopeless.

RELATION OF THESE RESULTS TO THE PROBLEM OF CLEAN MILK

When the results of this study are properly understood, it will be clear that they cannot be used legitimately as an excuse for the production of dirty milk.

The study shows that where the germ count is relied upon to protect the consumer against milk which has contained a relatively large amount of visible dirt, the consumer will not be protected. It is entirely possible for the dirtiest milk to pass the most stringent standards, based on bacterial counts, which have been established in connection with the supervision of municipal milk supplies.

While it is still an open question as to what may ultimately be accepted as the most satisfactory index for the keeping quality of milk, there is no question but that when the bacterial count is properly determined it is a serviceable index for this purpose. It is not, however, an index by which the presence of dirt can be determined, for the bacteria are commonly so numerous in milk, and come from so many sources other than dirt, that there is no constant relation between the dirt content and the number of germs present. Such being the case, the conclusive demonstration of the uselessness of bacterial counts as a means of detecting the presence of dirt is the necessary first step toward developing methods for accurately safeguarding the public against dirty milk.

As has been repeatedly pointed out in this publication, if the public is to be protected against dirty milk it must be, not thru attention to germ counts, useful as germ counts are as a measure of keeping quality, but thru attention to measurements of the dirt actually present.

The measurements herein reported are submitted as a pioneer attempt looking toward the formulation of better standards for clean milk.

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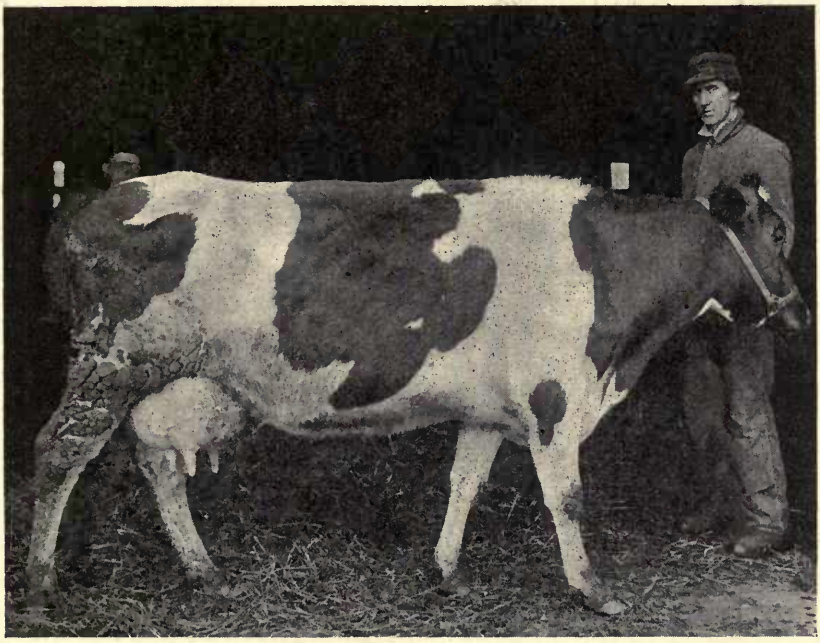

Cow 1033

The coat of Cow 1033 is shown as typical of the condition of the dirty cows during the experiments reported on pages 375-380. The germ count of the milk from these cows was increased 17,000 per cc. by the dirt which fell into it during the process of milking, when the cows were milked into open-topped pails. When small-topped pails were used, the germ count of the milk was increased 13,000 per cc. by the dirt falling into it.