A NEW METHOD OF DETERMINING MILK QUALITY.

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FROM BULLETINS BY
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Popular Edition *

of

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A NEW METHOD OF DETERMINING MILK QUALITY.

F. H. HALL.

Microscopic bodies in milk. To the unaided eye, normal fresh cows' milk is a faintly yellowish, white liquid, apparently uniform throughout and simple in composition. Probably most of its consumers realize, however, that milk is more complex in make-up than it appears at first view, since they see fat rise to the surface as cream or find the casein coagulating after longer keeping. Yet few milk drinkers appreciate the great complexity in composition of this common article of diet, or know how many and how delicate means and methods must be used by scientists to identify the varied components of milk and to trace their intimate relationships as these affect the handling of milk and the making of other dairy products.

Fundamental study of milk is very essential, for apparently slight variations in the relationships of its constituents may greatly affect its value or even change it from a most wholesome food to a menace to health or to an actual poison.

Many of these studies may be left to the chemist, for he must determine the ultimate composition of all the milk constituents; and some of them he, only, can find, since they are in solution and therefore beyond the range of vision, even if aided by the most powerful microscope.

But milk contains, ordinarily, three classes of bodies, or under some conditions four, which can be brought into view by the microscope; and two of these classes of microscopic objects — the fat globules and the bacteria — have most intimate relations to the value and wholesomeness of milk; and the third class — cells and cell fragments — may be indicative of sanitary quality. Casein belongs in the "possible" fourth class referred to, for the minute particles of this colloid, or jelly-like substance, are only just beyond the power of the compound microscope. They are revealed by "ultra-microscopic" methods.

*This is a brief review of Bulletin No. 373 of this Station on A Comparison of the Microscopical Method and the Plate Method of Counting Bacteria in Milk, by James D. Brew, and of Bulletin No. 380 on Cells In Milk Derived from the Udder, by Robert S. Breed. Those specially interested in the details of the investigations will be furnished, on application, with copies of the complete bulletins.
Fat globules in milk studies.

First of the bodies that may be seen when milk is properly exposed under the compound microscope are the fat globules. These are normal secretions of the udder and form an essential, though varying, proportion of all milk. Milk fat is very highly prized in human dietaries; so that the quantity of fat globules present in milk has come to serve as an index to its quality. Their amount can, however, be easily and accurately determined by a chemical method, the Babcock test; and microscopic study of them is not now considered so essential as at one time. Such study was very useful in early work on milk, in establishing the nature of these globules, and is still helpful in working out certain problems, like those of churning. In the most valuable microscopic work with milk, though, the fat globules are a detriment; since they are comparatively large and cover or obscure the other microscopic objects it is desired to study. Accordingly, in such work the fat must be dissolved. This is one step in a new method of microscopic examination of milk now in use at the Station, whereby the other two classes of minute objects are made to stand out clearly in the field of vision.

Of these two classes, the cells should properly be placed first since they are, like the fat globules, normal constituents of all milk and are derived from the udder. These cells are discharged at all times in varying numbers. The fluctuations may or may not indicate diseased or abnormal conditions in the udder, therefore the changes in number may become an index to the sanitary quality of the milk.

Though placed third among the microscopic bacteria bodies found in milk, because they are not normal constituents of it — are not produced by the udder but find their way into the milk after it is secreted — bacteria should really be considered first, for they are, without doubt, most important of all, at least from a sanitary standpoint. Though not essential components of milk, bacteria are almost universally found in it, even in the udder, and they exert a more immediate and greater influence toward change than any of the normal milk constituents. They are living organisms and make milk both their food and the scene of most diverse vital activities; so that each type of bacterium may change the milk materially, either for good or for ill.

Because of the importance of microscopic bodies Prescott–Breed in milk and because these have, until recently, microscopic method of milk study. been most studied by indirect methods, there seems much promise in a new plan of attack, originated by Prof. Prescott, of the Massachusetts Institute of Technology, and Dr. Breed, now of this Station. This method has already been used in two extensive series of studies made at the Station.
In using this method a small, measured drop (.01 cubic centimeter) is taken directly from a well mixed sample of milk, spread over a definite area of a clean glass microscope slide, and dried by gentle heat. Duplicate “smears” are usually placed on each slide. When dry, the slides are placed in xylol (a colorless, liquid chemical derived from benzine), which dissolves the fat. They are next immersed in alcohol to harden, or “fix,” the dried milk to the slide, then in methylene blue to stain the bacteria and cells. A final immersion in alcohol reduces the blue color somewhat, and brings the microscopic objects out distinctly on a light blue field.

The cells, cell fragments and bacteria may now be easily studied and counted under the microscope, the “fields” appearing somewhat as shown on the plates. No printed reproduction, however, can bring out the stained objects as they are revealed in the light-suffused smear on the glass slide.

By adjusting the tube of the microscope to a definite length and using the proper eye-piece, each field examined will have a definite area and will represent a fixed fraction of the whole smear and, therefore, of the sample and, finally, of the milk itself. Several fields are examined on each smear, and on one or more duplicates, and the average count of cells or bacteria is taken as representative of the milk from which the sample was drawn.

**STUDY OF BACTERIA IN MILK BY THE MICROSCOPICAL METHOD.**

It is believed by the investigators at this Station, that for many purposes, the use of the compound microscope for counting bacteria in milk is a much better method than the one now in common use. The present method of study is an indirect one, and depends on the fact that bacteria are living organisms. It counts them, not as they are in the milk, but only after they have so increased in numbers that around each one, or around each invisible cluster of them, a “colony” has developed large enough to be seen by using a hand lens or even the unaided eye.

The “technique,” or detailed scheme of operations, in this method requires the use of a sample of milk, drawn carefully so it shall fairly represent the larger quantity from which it comes, and dilution of this sample to separate the bacteria and make it possible for colonies to grow without overlapping and obscuring one another or being so numerous that it is difficult to count them.

A definite portion of this diluted sample is then mixed with a “nutrient medium” or food supply, which is a gelatinous, translucent, or almost transparent material, firm at ordinary temperatures but fluid when warmed. This must be made sterile by heat so that no bacteria or other living organisms shall be present except those coming from the milk sample. By thoroughly and repeatedly...
shaking together the warmed liquid medium and the milk sample, the bacteria are distributed somewhat evenly. The mixture is then poured into a flat, circular, glass dish known as a "petri plate," and spread evenly over the entire area. Usually one or more duplicate plates are made from each sample, and the plates are placed in an incubator to favor the growth of the colonies about each bacterial center. The temperature of incubation must be quite carefully regulated, for some bacteria are very sensitive and will not grow unless all the conditions are right. After four or five days, usually, colonies will have developed, presumably about each germ or group of them, until they are large enough to be visible under a hand lens of small magnifying power. Many of the colonies can then be seen by the naked eye, but others will be of pin-point size or smaller. All the colonies are counted on the whole plate or a definite portion of it, and the number obtained multiplied by the proper factor to account for the separation of the sample and amount of dilution. The final figure is commonly spoken of as the number of bacteria in the milk. This is never literally true, as some of the colonies always develop, not from single bacteria, but from "clumps" or unseparated collections of them. Moreover, a count made from plates held at one temperature only does not show all the colonies that might develop; for certain bacteria, like those accustomed to life in the udder and the warmth of the animal body, will not grow at low temperatures. By exposing the plates to such temperatures for two days longer, additional colonies may be developed. The opposite condition may also occur, and bacteria be present in the milk that thrive only at temperatures lower than the one commonly used for incubation.

It will be seen from this condensed popular description, that the "plate" method of counting bacteria is complex and time-consuming; and it is dependable only in the hands of trained bacteriologists, equipped with elaborate and costly appliances.

**Comparative advantages of the two methods.** This question will be discussed at some length later, for the number of bacteria present is an important index to the sanitary quality of market milk; but the two methods differ so materially on many other points that it is necessary to summarize briefly the advantages and disadvantages of each.

The microscopic method is simple, comparatively inexpensive, can be learned easily by any bright young man, and can be applied successfully by men who are not necessarily trained bacteriologists; it makes possible a report on the bacterial content of a sample of milk within a very few minutes; and it shows not only the numbers of bacteria, but also their forms. Through this feature of the method, certain types of bacteria thought to be especially important
in relation to health can be identified at once. The method also shows the number and kind of cells in the milk, some of which may indicate the sanitary quality of the milk. On the other hand, the samples used for direct microscopic work are very small, are somewhat difficult to measure accurately, and may not represent the milk quite so well as larger samples would do. It is believed, however, that the rapidity of the method makes it possible to duplicate samples so extensively that the small size need not interfere with the accuracy of the work. An important objection is, however, that all bacteria are counted, whether living and active at time of sampling, or already dead and harmless.

By the plate method no dead organisms are counted, since living germs alone can grow to visible colonies. The colonies on the plates present differences in habit of growth that are quite characteristic for certain types of bacteria and this makes identification of some of them possible. By using different culture media, also, the plate method may be used to prove the presence or absence of liquefying bacteria, which cause some undesirable forms of milk decomposition, or of acid-formers that sour the milk. If particular types or species of bacteria are desired for special study, the plate method must be used to allow selection, isolation and the making of "pure cultures." Against the plate method we must place the length of time required before the count can be made—two, five, or even seven days in some cases before we can be sure that colonies have developed about all possible centers. The expense for apparatus—sterilizers, incubators, etc.—and the outlay involved in securing proper conditions to prevent outside contamination is large with the plate method; and the manipulations are so delicate that only trained bacteriologists can do the work successfully. The hand lens used is not powerful enough to show the individual bacteria; and these can not be readily studied on petri plates under the compound microscope; hence the information secured from colony-growth is all that is immediately available.

The numbers of organisms present, without special regard to the kinds, is the information usually sought in bacterial examination of market milk; and if the new method fails to give this information accurately, its other advantages must count for little.

Comparing the methods.

To determine the fundamental reliability of the microscopic method as compared with the now standard plate method, counts were made by Mr. Brew, by both methods, in 450 samples of milk from several different sources. In the main these samples were from milk from four farms contributing to the supply of the city of Geneva.

The studies on the milk of these farms began with the taking of samples of the milk each morning for ten weeks, as it was brought from the farms to a central delivery station in the city. Samples
of the fresh, morning milk were taken each day from the milk of one farm, and of the night milk, delivered at the same time, for 60 days. Not quite so many samples were taken from the other farms; but the series made possible a detailed study of the daily variation and development of the bacterial condition of the milk in 225 samples.

The milk from 33 other farms contributing to the city supply was studied in less detail, not more than a week being given to any farm, and only five fields in any sample were counted under the microscope. The object in these more superficial studies was to make a general survey of the situation and to determine the efficiency of the microscopical method when used rapidly as it would be under commercial conditions.

The results of the counts showed little relationship between the figures secured by the two methods when only single samples were considered; but when series of samples are examined a relationship is shown. The count made under the microscope is almost invariably much higher than that shown on the plates and certainly represents the total number of individual bacteria more accurately than the plate count, the results in the latter case being invariably low because of clumps. Among the 450 samples examined only three showed more bacteria by the plate method than by the direct microscope count.

The relative differences between the two counts are greater when the bacteria are few in number. In samples of milk showing plate counts of 10,000 per cubic centimeter, the microscope showed approximately 44 times as many individual bacteria. A somewhat fairer basis for comparison, however, is to consider each “clump” of bacteria shown under the microscope as a unit only, since such a collection of germs would, on the plate of nutrient medium, develop only one colony, perhaps indistinguishable in any way from the colony surrounding a single isolated bacterium.

On this basis, the germ-poor milk referred to above showed only 17 times as many organisms in the sample under the microscope as on the petri plate. When the milk contained more bacteria — about 1,000,000 per cubic centimeter — the count under the microscope was only about 5 times as great as on the plates; or, if the clumps were considered as units only, the microscope count was slightly lower than the plate count.

We cannot say definitely as yet, why there are such great differences in the counts by the two methods; but the fact that there are differences is not at all surprising under the conditions that have already been explained; and does not discredit either the old or the new method. It is hoped by further work to secure a logical and satisfactory explanation.
Plate I.—Drawings of Milk Smears as Seen Under the Microscope

All prepared in such a way that each bacterium or tissue cell seen is equivalent to 400,000 per cubic centimeter.

**Good Quality Milk.**

Fig. 1.—No bacteria seen. Two tissue cells. Cell count = 800,000 per c. c.

**Milk Souring Normally.**

Fig. 3.—Milk which is nearly sour. The majority of the bacteria are lactic acid bacteria. One tissue cell. Bacterial count = 80,000,000 per c. c. Cell count = 400,000 per c. c.
PLATE I.—DRAWINGS OF MILK SMEARS AS SEEN UNDER THE MICROSCOPE
All prepared in such a way that each bacterium or tissue cell seen is equivalent to 400,000 per cubic centimeter.

MILK OF FAIR QUALITY.

Fig. 2.—Two pairs of lactic acid bacteria and one single bacterium. One tissue cell. Bacterial count = 2,000,000 per c. c. Cell count = 400,000 per c. c.

POOR QUALITY MILK.

Fig. 4.—Milk which is both nearly sour and suspicious in sanitary quality. Seven tissue cells. Bacterial count = 100,000,000 per c. c. Cell count = 2,800,000 per c. c.
In the rapid examination of the samples from the 33 farms, which were not studied in detail, only a few fields were examined on each smear and if very few or no bacteria appeared on these fields the milk was "passed" as of good sanitary quality. Is this a safe procedure? Of the 225 samples thus examined 60 were passed; and the plate counts of these 60 samples showed that 42 of them contained less than 50,000 bacteria per cubic centimeter, eight were between 50,000 and 100,000, eight more less than 200,000 and two above this figure. (One of these high counts was probably due to a contaminated plate.)

Among the 120 samples examined more closely, 101 would have been "passed" by the more rapid, commercial examination, of which only two showed more than 100,000 bacteria per unit. The average plate count of 161 samples where no bacteria would have appeared on examination of a few fields was 29,000 per cubic centimeter; that is, practically all of the milk was of good or excellent sanitary character.

In other words, it seems safe to assume that practically all samples passed by the microscope as having no bacteria present when several fields are examined would yield a plate count of less than 100,000 per cubic centimeter.

On the other hand, out of 450 samples examined there were 246 that gave plate counts below 100,000 per unit; and 67 of these gave microscope smears in which bacteria could be readily found. Thus the plate method passed 67 of the 246 samples as having less than 100,000 bacteria per cubic centimeter when the microscopic examination showed they had many more than this.

Considering both comparisons and assuming all of the bacteria to be active, we find the plate method passing 67 out of 246 samples as below a certain limit when the microscope count showed them to be above that limit — an apparent error of 23 per ct.; whereas the microscopical method passed erroneously only 9 or 10 of 60 samples cursorily examined, a 15 per ct. or 17 per ct. error, or two samples of 101 carefully examined — a two per ct. error. Thus when the microscope is used in this way it tests milk more severely and probably more accurately.

The comparison of the two methods has been made only on fresh, un Pasteurized milk, and the conclusions reached must be understood as applying only to the use of the microscopical method in milk of that character. Whether this method can be made applicable in studies of milk from unknown sources, which may include some that has been pasteurized, future studies must determine. In such milk most of the bacteria are dead and presumably harmless; but these dead germs appear under the microscope for a time, at least.
This new method of determining the bacterial content of milk, by the use of the compound microscope to count the organisms in stained milk smears on glass slides, from its rapidity, inexpensiveness, simplicity, absence of delicate manipulations calling for high technical skill, and wide scope in identification, seems a very promising assistant in the examination of milk.

It is hoped that this method, or some modification of it, can be made of practical use to the milk dealer, butter-maker and cheesemaker as a means of grading milk according to its bacterial condition. This should make it easier for the farmer to secure a better price for a high-grade milk than for a poorer grade.

**CELLS IN MILK.**

It has been known for three-quarters of a century that the first milk of each lactation period, the colostrum, contains cells derived from the udder or, through it, from the blood. The belief was, however, that these cells soon cease to be discharged, and that few are present in normal milk.

Recent studies, though, especially those made during the past fifteen years, have proved that cells in large numbers are found in all normal milk; and that in some cases, which have accordingly been considered abnormal or the result of udder infection or disease, the multitude of such bodies seen under the compound microscope has been so great as to be almost beyond count.

Much attention has been given to the development of methods for making such studies; but many of those employed have been indirect and complex. Most of these methods have required the rapid swirling of the milk in a centrifuge to throw out the sediment; and the samples for microscopic examination were taken from this sediment—not from the milk itself. The new method of Prescott and Breed, however, proves that not all of the cells in the milk are collected in this centrifuge sediment; for the counts of cells made by this method are much larger than those made by any examination of samples from sediment. The new method is a direct one, as small samples of the milk itself are taken and the counts made from "smears" viewed under the microscope. Though devised for the study of cell content of milk, this dried-smear method appears to be of even greater value in bacteriological work, as already pointed out.

Cells in milk have been held by many students to be abnormal constituents and therefore undesirable. The makers of milk clarifiers have counted as one of the valuable features of clarification the fact that this process removes many cells from the milk.
Some of the cells found in milk are leucocytes — the white blood corpuscles that are the active agents in destroying certain disease germs in the body; and after the first week or so of lactation, the presence of these leucocytes in the udder has been considered evidence that they were attracted there because disease germs were in the milk. It has been held, in particular, that there is a close relationship between the presence of large numbers of cells and of the germs that cause mastitis, or inflammation of the udder, a disease that results in "gargety" milk.

Boards of health in some large cities, and one National organization, have adopted, as a standard for normal milk, a cell content not exceeding 500,000 per unit (a cubic centimeter, or 18 to 20 drops); and would reject milk showing more cells than this as abnormal and unfit for human food.

It is therefore important that the dairy farmer should know what justification there is for the belief that cells in milk are detrimental in themselves or as indicators of abnormal conditions or disease in the udder that might make milk unwholesome.

The studies on the cell content of the milk of the Station herd were made by Dr. Breed before he became a member of the staff; but his appointment as Bacteriologist renders doubly appropriate the publication, in a Station bulletin, of the valuable data secured.

The three main purposes in this work and the extent of the investigations were as follows:

1) To make a number of examinations of the milk of individual animals in order to determine the normal cell content of milk. For this part of the work from five to eight samples were examined from each of 21 cows in the Station herd, from 62 to 68 samples from each of four other cows in this herd, and one sample from each of 53 cows in a Guernsey herd belonging to Mr. Alfred G. Lewis of Geneva. In the summaries along this line data are also included relative to the cell content of the milk of two other herds previously studied by Dr. Breed and his associates, one at Meadville, Pa., of 41 cows, and one in Germany of 3 cows.

2) To make detailed examinations of the milk of individual cows in the hope that some reason could be discovered for the known variations. These included studies on the effect on cell content of period of lactation, age of cows, udder troubles, etc. For part of this work two cows fresh in milk were used for one week and for three weeks, respectively; four cows, more advanced in lactation, for five weeks; and eighteen cows, near the end of lactation, for one or two milkings.

3) To study the influence of the milking machine on the number of cells discharged in milk. In these tests six cows were used for about forty days in a detailed study of the effect of varying the vacuum; two cows were under observation for 8 or 9 days in testing
the effect of a change from hand milking to machine milking; and
the remainder of the herd furnished 56 samples of hand-drawn milk
and twice as many drawn by machine.

The investigation proves plainly that milk appar-

**Normal milk rich in cells.** all stages of lactation, milked by hand or by machine,
contains large numbers of cells. The average for
the Station herd was lower than that of any other herd examined
but was still 439,000 per cubic centimeter; the Guernsey herd came
next, with 895,000, the three German cows were third, with 932,000;
and the Pennsylvania herd averaged over a million cells per cubic
centimeter. These numbers are much greater than those reported
by other investigators, owing to the greater severity of the method
used. By the older methods many cells in centrifuged samples were
lost in the cream or remained in the milk and therefore could not
be counted in the sediment samples used. It will be noticed that
the average number for each of these herds, except that of the Station,
is above the limit fixed as an allowable maximum as a result of
examinations made by the older methods.

The milk of nine goats in the Station flock was also examined,
and gave astonishingly high cell counts, the average for these goats
and two others previously studied being nearly seven and a half
million cells per unit. As goat milk is used with great success in
the nutrition of infants and invalids, it would seem that high cell
counts can not be a reliable indication of poor sanitary quality.

The average obtained for the Station herd repre-

**Variations and fluctuations in cell counts.** separate quarters of the same udder at the same
time. The greatest average number of cells occurs
in colostral milk; but equally large numbers of cells are occasionally
found in milk drawn at any time during the lactation period. Several
very high cell counts have been obtained from the milk of cows near-
ing the end of lactation, and such high counts appear to be more
common at this time than near the middle of the time in milk.
The average counts for the latter half of the period, however, are
not markedly higher than those for the earlier half. As the quantity
of milk is less toward the end of lactation the whole number of cells
discharged is lower than during the earlier part of the period.

Marked variations occur in the numbers of cells found in the
milk from day to day; but the cause or causes of these fluctuations
have not yet been discovered. There is uniformly a larger number
of cells in the strippings than in milk previously drawn, but it was
not possible to assign a cause for the increase in cell counts in the
strippings. No constant relationship could be found between the
counts for the first streams from the udder and those from samples
taken later.
The four quarters of the udder act independently, so far as cell content is concerned, since the counts for the different quarters of one cow's udder may show as great variations as those from separate udders.

In the group of cows that gave high average cell counts were two cows that had recently aborted, two old cows and one that had suffered from udder troubles, which might appear to indicate that these cows sustain the common belief that the peculiarities mentioned are causes of profuse cell shedding. On the other hand, however, one cow in this high-count group possessed no characteristic that has ever been thought to have an influence in producing such counts; and the low-count group contained one cow that had recently had udder troubles and still had a hard lump between the front quarters, one cow that had aborted within five weeks of the time of testing, and one old cow.

The milking machine has been thought a cause of increased cell content of milk; as it was believed that the use of unusually high vacuums has a tendency to draw blood or its leucocytes into the udder: that is, to cause "leucocytosis." The comprehensive data secured in these tests indicate that there is no basis for such a belief.

In all the comparisons made, machine-drawn milk appeared to have a lower cell content than hand-drawn milk; and variations in the vacuum used, up to 19\(\frac{1}{2}\) inches, gave no corresponding changes in cell content. In the vacuum-increase tests, three cows of different ages and milking history, and each in a different part of the lactation period, were selected as experimental animals; and three in similar stages of milk giving and of comparable cell counts were used as checks.

Starting with a vacuum of 14\(\frac{1}{2}\) inches, five successive increases in the degree of vacuum secured, each of an additional inch of mercury supported, were made at weekly intervals. The high vacuum of 19\(\frac{1}{2}\) inches was maintained for only one milking and the machines were rapidly returned to the normal by a change at each milking.

The animals showed no physical effect from the vacuum increases; and the changes in cell content of the milk could be connected in no way with the changes in conditions. The milk of one of the experimental animals appeared to increase slightly in cell content as the vacuum increased, with one rather high count after the first rise of an inch and others while the vacuum was at 17\(\frac{1}{2}\) inches and at 18\(\frac{1}{2}\) inches, with a return to practically the original figure at 19\(\frac{1}{2}\) inches and a rise to a high count again when the machine supported only 14\(\frac{1}{2}\) inches of mercury. The check cow of this pair, without vacuum increases, showed very similar and almost as great changes in the cell content of her milk.
With the second pair of animals, the cell content of the milk of both remained nearly constant throughout the test, the one high count being in the milk of the check cow.

With the third pair, also, the fluctuations in cell count were greater with the cow milked without vacuum changes; and the number for the experimental animal was as low at the high-vacuum milking as at the start or at any time during the test.

These data manifestly show no evidence of "leucocytosis."

Two fresh cows were milked by hand for one week and two and one-half weeks respectively, and then by machine. The average cell content for the last four or five days of hand milking was 510,000 for one cow and 95,000 for the other; and the corresponding averages for the first four days of machine milking were 230,000 and 55,000.

Part of the animals in the Station herd are milked by hand regularly, part by machine, which made it possible to compare quite large numbers of normal samples of milk taken by each method of drawing. Of such samples, 56 from hand milking had an average cell content of 381,000, and 113 from machine milking 309,000.

The facts that half of the Station herd has been milked by machine for years and that the herd as a whole gives a lower average cell count than any other herd examined, appear to confirm the other evidence that machine milking, by the vacuum type of machines, does not increase the cell content of milk or tend to draw cells from the interior of the udder.

Do high cell counts mean unwholesome milk?

The investigations in the Station herd and others have not demonstrated that any relationship exists between the number of cells discharged and specific bacterial infections of the udder. None of the cows in these herds gave "gargety" milk at any time, thus making it impossible to study the influence of that particular udder trouble on cell counts. Some of the cows had aborted, however, and others had previously suffered from diseased udders; but in these cases no consistently high cell counts or abnormal fluctuations were noted that were not duplicated or exceeded in milk of cows apparently normal in every way.

Many udders or quarters of udders showed the presence of large numbers of bacteria of a type undistinguishable by any cultural methods from those producing inflammation of the udder; but the cell counts of the milk when these bacteria were present were sometimes large, sometimes small; so that the evidence so far obtained makes it impossible to decide whether or not the discharge of large numbers of cells in connection with particular types of bacteria has any sanitary significance.

The studies of the cell content of milk made by the

Conclusion. Prescott-Breed method appear to prove the accuracy and utility of the method; they have made it very evident that the presence of large numbers of cells in milk does not
necessarily indicate abnormality; they have shown that the vacuum type of milking machine does not draw blood from the udder or increase the cell content of the milk; and they have made it necessary to secure much additional data before we can say in what way cells in milk can be used as indicators of sanitary quality.
ANNUAL REPORTS AVAILABLE.

The Station has for distribution small numbers of the annual reports for the years 1908 to 1912, inclusive. These reports consist of the reprinted "complete" bulletins of the years named, with financial reports and meteorological data. So long as they are available these reports will be sent free to those who request them.