NOTES ON SOME DAIRY TROUBLES.

INTRODUCTORY.—FLAVOR IN MILK AND ITS PRODUCTS.

I. Fishy Flavor in Milk.
II. Bitter Flavor in Neufchatel Cheese.
III. Sweet Flavor in Cheddar Cheese.
IV. Rusty Spot in Cheddar Cheese.

H. A. HARDING, L. A. ROGERS AND G. A. SMITH.
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NOTES ON SOME DAIRY TROUBLES.

II. A. HARDING, L. A. ROGERS AND G. A. SMITH.

SUMMARY.

The appearance of a highly-disagreeable, fishy flavor in the product of a dairy was traced to the milk of a single apparently healthy cow. On rejecting the product of this animal no farther trouble was experienced. No cause for the outbreak could be found.

An intensely bitter flavor in Neufchatel cheese was found to be connected with the activity of an acid forming bacillus. The bitter flavor was not reproduced in liquid cultures but appeared upon draining and aerating the cheese curd.

The causal relation of certain yeasts to the production of undesirable flavors common in Cheddar cheese appeared probable from their constant presence in cheese showing sweet flavor and their absence in all those having a clean flavor.

The uniform reproduction of off-flavors, when using pure starters of these yeasts in cheese making tends still further to establish this relation.

Rusty spot in Cheddar cheese is caused by a bacterial growth. The addition of cultures of this bacillus to the vat before adding the rennet failed to reproduce the discoloration; but adding cultures of the same organism after cutting the curd gave a very marked case of rusty spot.
12 hours, and if the temperature is kept reasonably low, will not do so for a much longer period.

From this it will be seen that in the milk as it is ordinarily delivered in the milk trade of the smaller cities or at the factories there should be no odor due to plant growth. Whenever a disagreeable odor is present it can be ascribed either to aromatic substances absorbed or to holding the milk at too high temperatures.

This statement of the matter may at first glance appear to conflict with practical observation; for sometimes a certain odor becomes noticeable soon after the milk is drawn and appears to increase in the cheese curd. In this case it would be more in accord with the known facts to assume that the same class of bacteria which brought about the decomposition of the excreta in the barn and produced from them the vile odor which was absorbed by the milk also found their way into the milk itself and there, later, produced similar foul smelling compounds.

Under ordinary circumstances we can begin to reckon the 12 hours above mentioned, from the time the milk is drawn; but the interesting observation of Moore and Ward have impressed the fact that in some animals the bacteria work their way high up into the glandular tissue of the udder and continuously attack the milk as it is formed.

Animal and absorbed odors are to be avoided as far as possible, since they are never desirable. After they have once entered the milk aeration will assist in their removal. The process of pasteurization accompanied by a subsequent cooling of the milk by flowing in a thin sheet over a cold surface is recommended by some producers of fine dairy products as a means to the same end.

**HIGH TEMPERATURES HASTEN THE FORMATION OF ODORS.**

While under proper conditions the plants found in milk should not, and in most cases do not, produce flavors in the milk during the first 12 hours after milking, the fact remains that occa-

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sionally milk is so strongly inoculated with germs from its surroundings or is held at such high temperatures that the production of odors is accomplished in a shorter time. Moreover when cream is placed at a favorable temperature for ripening or milk in the cheese vat is heated for "setting" at 85° F. (24° C.) or goes through the so-called "cooking" at 98° F. (36.5° C.) the conditions are here favorable for a very rapid multiplication of the already large number of germs present. To support this amount of plant life and growth there is a correspondingly rapid decomposition of the constituents of the milk with an accompanying formation of aromatic substances.

The flavors in butter, both good and bad, are believed to be due to bacterial activity, with the exception of the inherent flavor of the fat and of a few cases where the odors absorbed by the milk are so pronounced as to pass over with the butter-fat, or when butter is allowed to absorb odors from its surroundings.

**FLAVOR IN CHEESE.**

In cheese, particularly of the Cheddar type, where the ripening process extends over a long period, the problem of flavor becomes complicated. It has been shown by Babcock and Russell, and corroborated by other investigators, that cheese contains chemical ferments capable of slowly producing profound changes in the casein which forms a considerable fraction of the fresh curd. The compounds which are thus formed undoubtedly have flavors peculiar to themselves, and these flavors are the fundamental elements in what we designate as the flavor of the ripening cheese. In addition to these fundamental ones, there are special flavors in every cheese, on the basis of which it is classed as poor to extra, and these differences have not yet been accounted for solely on the basis of enzym action.


The present state of knowledge of the subject does not justify dogmatic statements as to the origin of those delicate and agreeable flavors which are so highly prized in cheese, but the trend of evidence favors bacterial activity.

YEAST AS A NEW FACTOR IN CHEESE FLAVOR.

A factor which in the past has been almost entirely ignored in work upon milk and cheese problems is the relation of yeast to the dairy industry. The occasional occurrence of yeasts in Cheddar cheese has been previously noted by a number of investigators, but the fact that they may at times play an important part in the matter of flavor has been very generally overlooked.

As the result of investigations detailed in the following article on sweet flavor it is ascertained that yeasts probably play a considerable rôle in the production of certain objectionable flavors which are annually the source of great financial losses in the State of New York.

The real need of exact knowledge on a subject of so much practical importance as that of flavor is evident. The goal to be attained, particularly in the case of cheese, is a clear understanding of the causes which produce the most desirable flavor, and of the best manner of assuring their constant operation. In attaining this end those well marked objectionable flavors which appear only at intervals, and offer least resistance to an analysis of the conditions under which they have been produced, become the natural avenue of attack upon the larger problem.

The cases of fishy flavor in milk and bitterness in Neufchatel cheese herein described, may be taken as types of many of the sporadic troubles which perplex the dairyman. The methods used in locating the source of trouble in each case were so simple that it is hoped many may profit by the suggestions and be inspired to help themselves.

With sweet flavor in Cheddar the situation is somewhat different. Here we have to deal with a trouble which is both widespread and of long standing in the State, where it produces annually a large economic loss. This trouble has found its way into some of the cleanest and best managed factories, and there it remains despite the exertions of some of the most careful
makers. In the past their efforts have been paralyzed by an entire lack of information as to the nature of the cause of this trouble.

While the discovery of the true cause is naturally the first step, especially in a biological problem, it should be followed by a study of the place of residence or manner of constant introduction into the factory before attempting the third and most practical step—the formulation of practical methods of combating the trouble.

It is our hope to follow out each of these steps in the order given in our attempt at aiding in the control of this widespread evil.

In attacking problems calling for training along such diverse lines, the Bacteriological Department and the Dairy Expert have joined forces for the general good; but each assumes the responsibility for the correctness of certain portions of the work. The Bacteriological Department is solely responsible for the isolation and preparation of the cultures and starters, and the judgment of the Dairy Expert has been relied upon in manufacturing the experimental cheese, and in deciding upon the similarity of the flavors there produced to those of the troubles under investigation.

CARD OF THANKS.

Owing to the unsatisfactory nature of conclusions based on the sense of smell we have improved every opportunity for obtaining the verdict of many of the cheese experts of the State and in the matter of samples we have been very materially aided by the representatives of the Department of Agriculture as well as by the cheese buyers throughout the State. For these many courtesies rendered we desire to return our sincere thanks.

I. FISHY FLAVOR IN MILK.

In June, 1900, a milk dealer brought to the Station a milk sample having a rank, disagreeable odor and taste, as though it had been in close proximity to herring or other fish. The taint was so strong that the milk was of no commercial value, although coming from a dairyman of more than ordinary carefulness in the handling of his herd.
Within an hour the dairyman called, bringing a sample direct from the farm. Although this was saturated with the same odor the producer protested in all good faith that he could smell nothing unusual.

METHOD OF LOCATING THE TROUBLE.

As the trouble was evidently located upon the farm the dairyman was provided with a supply of sterile, self-sealing pint bottles and directed to collect a sample from each cow by milking directly into the bottle from each quarter in turn. The following morning the bottles were returned properly filled and numbered.

An examination by the nose showed that the trouble was limited to a single cow and the dairyman was directed to reject the milk from this animal. The following day the milkman reported that the trouble had disappeared and that his supply was highly satisfactory.

A second set of samples at the end of three days gave the same result and showed that the trouble was stationary in the product of one cow. A visit to the farm threw no light upon the origin of the trouble. The pasture was a dry upland containing no objectionable weeds as far as known. The feed and general treatment of all the cows had been the same and they were all apparently in the best of health.

The odor of the milk was strong as it was drawn and did not appear to increase on standing. This would incline one to the belief that the trouble was due either to the food or to the general condition of the animal; but no food has ever been known to bring about the flavor described, and all the food had been shared by the whole herd. Neither was there any discernible ailment or lesion of the cow and the physical appearance of the milk was normal.

NO BIOLOGICAL CAUSE FOUND.

Considerable culture study was carried on in the laboratory with the milk from the different quarters of this cow's udder and several kinds of bacteria were isolated. When these organisms were grown separately or in mixture in milk they failed to reproduce the characteristic fishy odor. A form was found to be very plentiful in the strippings which was peculiar in that it
refused to grow in the ordinary lactose agar or gelatin unless five per ct. to ten per ct. of milk was added. This organism was further tested by introducing a culture of it into two quarters of the udder cavity of a healthy cow leaving the other two quarters as a control. The results of this test were also negative in that no odor was produced.

**OTHER OUTBREAKS.**

While a fishy flavor in milk is by no means a common trouble, Mr. W. E. Griffiths, one of the agents of the Department of Agriculture, informs us that he has observed two outbreaks of somewhat similar nature in the Fifth District. In one instance June butter with a fine flavor was placed in cold storage at 18° to 22°F. until winter and when sold in the local market was returned with the complaint that it had a disagreeable flavor. Upon inspection by butter experts this was pronounced a fishy flavor. No cause could be found. The second case occurred in 1899, when a cow kept for family use gave milk which was so pronouncedly fishy in the odor arising from it and in the taste, that the milk was discarded during the latter part of July and the month of August. The milk as soon as drawn had this peculiar flavor and did not seem to develop any more upon standing.

**II. BITTER FLAVOR IN NEUFCHATEL CHEESE.**

The bitterness in Neufchatel cheese which is here described should not be confused with the well known bitter flavor in milk and cream. This latter is often produced in summer by the activity of digesting bacteria which by enzym action break down the chemical compounds of the milk into simple ones having a bitter flavor; and in winter by a different class which seem to thrive at temperatures lower than those favorable to the ordinary acid forming germs and produce the bitter flavor as one of the by-products of their metabolism. In either of these cases the objectionable flavor appears in the liquid.

In the case to be described the milk gave no outward sign of being abnormal and it was only when the manufacture of the Neufchatel had progressed to the stage of draining and aerating the curd that the bitterness became apparent. Since but a single
outbreak has come to our notice a detailed description would hardly be called for except for the fact that the methods employed to get the maker out of his trouble were very simple, and can be easily applied to many of the other troubles which perplex the factoryman.

A sample of intensely bitter Neufchatel cheese was received in October, 1899. The maker stated that he had repeatedly scrubbed and scalded out everything that came in contact with the milk after it was received from the farm but the trouble had persisted and ruined his product. The factory was visited and everything found acceptably clean; but the conditions for controlling temperature were not good. However, the temperature at that time was not unfavorable, and the trouble could hardly be ascribed to this cause. The milk that had been used for the Neufchatel was that of a single patron who had been selected because of the high fat content of his product.

**METHOD OF DETECTION.**

The following day samples from each patron's milk were taken in scalded milk jars by the maker, cooled, numbered and delivered at the Station in the afternoon. The samples were then heated to 70°F., rennet added and the milk held at 70°F. until morning. At the end of 18 hours all the samples were curdled normally except two. These showed much whey on top, considerable gas in the curd and had a bad smell. On draining the curd one of these developed a markedly bitter flavor. On reporting these facts to the maker it was found that this was from the very patron whose milk had been selected for making the original bitter cheese. The maker was advised to scald once more all the cans and cloths that had been used, and proceed with milk from a different source. He later reported that on following this suggestion the trouble disappeared.

**DUE TO THE ACTIVITY OF BACTERIA.**

Since the bitter flavor did not exist in the fresh milk but only appeared a day or two later in the curd and for some time continued to increase in quantity it was evidently connected with some form of life.
Cultures made from the bitter cheese and from the samples of milk furnished a variety of forms of bacteria and molds, and these were tested by preparing a pure-culture starter of each, adding it to some fresh milk from our own dairy and making small Neufchatel cheeses. To make sure that any bad flavors found in these experimental cheeses were not due to anything contained in our own dairy several samples of the same milk were made into cheese without the addition of any starter.

These control cheeses and nearly all of the cheeses to which pure cultures of different kinds had been added, were free from any bitter flavor, but one form was found that quite uniformly gave bitter cheese under these conditions. This germ was a short bacillus, forming sufficient acid when grown in sterile milk to produce curdling in one to two days.

It did not form an enzym capable of producing a visible change in the consistency of the milk and when grown in pure culture no bitter flavor was produced even when kept for some weeks. The formation of bitter flavor by this organism seems to be intimately associated with the exposure of the curd to the air since, under any of the conditions that were tried, the bitter flavor appeared slightly or not at all when a soft, poorly-drained curd was prepared; while in a dry, friable curd the bitterness was very evident. Although it was grown almost continually in milk the organism lost the power of producing bitter flavor after about six months and further experiments were necessarily discontinued.

In this particular instance of the bitter cheese the trouble having been found to arise not from the factory but upon the farm it would have been of considerable interest to locate more closely the source from which these germs gained access to the milk. However on being informed of the results of our work the producer became highly incensed at the idea that there could be anything amiss with his milk and the investigation was not carried any further. As a result we could not aid him by suggesting practical means of ridding himself of the trouble nor have we the data upon which to advise others.
III. SWEET FLAVOR IN CHEDDAR CHEESE.

WHAT IS MEANT BY SWEET FLAVOR.

As was intimated in the introductory chapter on flavor there is a class of off-flavors which appears especially during the spring and fall in the output of many of the factories in this State and bears the general title of "sweet flavor."

A conservative estimate places the annual loss from this source at $10,000.

When cheese experts are questioned concerning the matter they usually agree in dividing this trouble into at least two classes—"fruity" and "sweet"—while in individual instances many other terms are used. When samples are selected and sent in by these experts the result is a collection of odors often having little in common and representing all gradations from a well marked odor of pineapple to the beginning of putrid decomposition.

Partly because of this evident confusion in the use of terms among practical men and partly because of the general nature of the information which we are now able to give concerning the matter, the flavors of this group will be here considered together.

NO CAUSE FOR THE TROUBLE PREVIOUSLY KNOWN.

At the beginning of the investigation we faced the problem of a serious trouble so obscure in its origin that not even a plausible explanation had been suggested, and the maker was handicapped in his attempts at combating the trouble by the lack of anything tangible against which to direct his efforts.

METHOD OF WORK.

From the fact that this trouble appears after the cheese has been some time in the curing-room the idea that it is in some way connected with life seemed to offer a starting point for work. Samples were secured from a number of cheeses considered to be typical examples of this trouble and a careful separation of the flora of each cheese was undertaken. It was assumed that if there was any specific organism or class of organisms causing the trouble they would be found in all the samples examined. A comparison of the results of a number of such examinations
showed nothing unusual in the flora, except that in every case there was a considerable number of yeasts present.

YEASTS NOT COMMON IN GOOD CHEESE.

The subject of yeasts in cheese has been studied incidentally by a number of investigators when going over the cheese flora, and while it is not improbable that they may function in the ripening of some of the soft cheeses no one seems to have seriously considered their relation to hard cheese other than to suggest that they may play a rôle in some of the gas formation. Among all the examinations into the flora of cheese none have been carried on in a more careful manner than the one by J. Weinzirl under the direction of Dr. H. L. Russell, and in a report upon the flora of six Cheddar cheeses, yeasts were mentioned only once, and in that case a bad odor had been noticed in the curd. Very recently Weinzirl has reported the results of an examination of 50 different Cheddar cheeses from factories scattered through seven states of the Union as well as from Canada, and in only four cheeses were yeasts found. In three of these four cases the yeasts did not exceed 1 per ct. of the total flora.

In connection with the present investigation we have examined a very limited number of samples selected for us by experts as being clean flavored cheese, and in every case we have failed to find more than an occasional yeast among the thousands of bacteria.

YEASTS ALWAYS FOUND IN SWEET FLAVOR CHEESE.

Since beginning work in 1899 we have examined samples selected for us by cheese experts as showing sweet or fruity flavor, coming from thirteen factories located in seven different counties in this State, besides several samples of unknown

7 Weinzirl, J. Bacteria in Cheddar Cheese Ripening. Thesis Univ. of Wis., 1896.
origin received from commission men. In every cheese, yeasts were present in considerable numbers, and while strictly quantitative data were not obtained it is believed that they were rarely as low as one per ct., and often approximated 50 per ct. of the total flora.

Owing to the present undeveloped condition of the classification of yeasts we have not yet been able to reduce the collection of yeasts obtained in this way to the basis of varieties represented, nor have we attempted to establish the relation between slight variations in the flavor of the cheese samples and variations in the yeast flora.

SWEET FLAVOR PRODUCED BY YEAST STARTERS.

In discussing the causal relation of any organism either to a disease or to a fermentation it was formerly the custom to ignore all other factors than the mere presence of the germ. The fallacy of this method of reasoning has come to be recognized in medical matters and our experience detailed below, as well as the results of our study of the activity of the organism producing rusty spot, shows that the accompanying conditions exert a profound influence upon the activity of fermentative organisms. The fact that sweet flavor in a factory undergoes seasonal and even daily variations in its activity would suggest the same idea. In beginning experimental work upon such an untried field as the relation of yeasts to cheese flavor, it is not surprising that the results have not been uniformly good. By referring to the article on rusty spot it will be seen that, while in a majority of attempts the use of a starter of the causal organism resulted in failure so far as a real reproduction of the typical trouble was concerned, yet when the right conditions were obtained this same organism reproduced the rusty spot in even more marked form than is met with in the factories.

The starter used with a majority of the cheeses made in this connection was prepared from a pure culture of a yeast which is designated in the laboratory as 2F. This yeast was isolated from a cheese showing a well marked case of sweet flavor. In each of these experimental cheeses there was reproduced in a slight degree the characteristic flavor of the original cheese. The deter-
mination of this fact rests not only upon the judgment of one of us but has been subscribed to by a number of experts to whom these cheeses have been submitted. However it must be said in all fairness that the sweet flavor reproduced in these experiments fell short of the intensity often met with in factories and would probably have been overlooked in a commercial transaction.

Before and during the time of these experiments the manufacture of cheese for other purposes was being carried on in the same room without any appearance of sweet flavor. A vat which had been used in making one of the yeast-infected cheeses and had been cleaned in the usual manner but without any special precautions, was again used after an interval of two days in making six Young America cheeses which were distributed among the various curing rooms. Upon examination at the end of two months they were decided by a number of competent judges to show well marked cases of sweet flavor. An examination at this time showed the presence of a goodly number of yeasts.

CONCLUSION.

"Sweet flavor," as the term is generally used, includes a group of undesirable cheese flavors. Clean-flavored cheese contains very few if any yeasts, while sweet-flavored cheese contains large numbers of yeasts, at least during the first stages of ripening.

The addition of starters of certain yeasts to the cheese vats has repeatedly resulted in the production of off-flavors some of which would be included under the general term of "sweet flavor."

IV. RUSTY SPOT IN CHEDDAR CHEESE.

A discussion of rusty spot in Cheddar cheese may seem out of place in a bulletin otherwise given up to the subject of flavors but since this is one of the annoying dairy troubles in the State, and has received considerable attention at the Experiment Station during the past two years, a short article upon this subject is given here.
WHAT IS RUSTY SPOT?

"Rusty spot" is the name given to small yellowish-red points or patches scattered quite evenly throughout the mass of the cheese and having the general appearance of iron rust. A closer examination shows that a majority of these colored points are located on the walls of the small openings left by the incomplete union of the particles of cut curd or by the later formation of gas bubbles.

These points rarely become visible in cheese under eight days old and gradually increase in size during the first two to three months. During the latter portion of this time the extension of these spots is probably not due to real growth but rather to a mechanical spreading of the coloring matter along the surface upon which it has been produced.

This trouble is most common in spring and fall, appearing in May and disappearing in October, while in the case of a badly infected factory it may continue through the summer season.

The coloring matter does not seem to be in any way harmful to the consumer and if a trade could be built up in variegated cheese this might command an increase in price on account of its color. However, the present attitude of the market is quite the reverse and the presence of these spots means a cut in the price and corresponding loss to the producer.

The only other trouble in hard cheese coming to our notice which might be confused with the one under discussion, is a pink discoloration of the rind occurring either in isolated spots or in confluent patches. This latter is attributed to mold and certainly has nothing in common with the genuine "rusty spot," which is confined to the interior and scattered throughout the mass of the cheese. A peculiarity which will illustrate the difference lies in the fact that when the rusty spots in cheese are brought to the air and light they fade from red through yellow, growing fainter until they finally disappear, while these pink discolorations are formed and continue on the exterior of the cheese in direct contact with the air and light.

THE TROUBLE IS CAUSED BY A BACTERIUM.

From the fact that the spots cannot be seen in the young cheese but appear later and continue to grow more evident for
some time, one would be led to suppose that the production of color is connected with the activity of some form of life in the cheese. The truth of this supposition was confirmed in 1897 by Connell, who isolated from a rusty spot cheese an organism which he called *Bacillus rudensis*. He showed the causal relation of this bacterial form by using a starter made from it in the manufacture of cheese in which these rusty spots later appeared.

In our own experiments we have repeated this with organisms derived from outbreaks in different factories. The evidence seems to be conclusive that the red spots are produced by the growth of a minute plant which finds its way into the curd before it is put to press.

HOW DOES THIS BACTERIUM GET INTO THE VAT.

In the factory studied by Dr. Connell, the drain leading from the factory was found coated with a reddish-yellow slime which contained the organism causing the discoloration in the cheese. Upon giving the factory a thorough cleansing, washing the floor and woodwork with disinfecting solution, whitewashing the inside walls and replacing the wooden drain with an iron one, the trouble disappeared. From the fact that this attempt at disinfection covered all the available points about the factory, no substantial conclusion can be drawn as to the particular road through which the bacteria gained entrance to the curd. The one fact that seems evident is that in this instance the source of the infection was located at the factory rather than upon the farms.

In a number of New York factories an honest attempt has been made to meet all the demands of cleanliness and still this discoloration continues in the cheese. While the source of infection and methods of distribution of this trouble remained in such an unsatisfactory condition there was little inspiration for the factory men to take more vigorous steps for its removal.

In view of this incomplete knowledge of the subject and of the fact that some factories have suffered a considerable cut in the price of their output during a number of successive seasons, work

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was begun upon this line in the spring of 1899 and has been continued whenever opportunity offered since that time.

**ISOLATION OF THE CAUSAL ORGANISM.**

The first step was the isolation of the causal organism from affected cheese preliminary to the study of its behavior when introduced as a starter into a vat of good milk. Quite contrary to what would be expected from the published work upon the subject the isolation of the causal organism presented many difficulties. The red spots in the cheese are essentially colonies of the bacillus and the removal of a portion of one of these spots with a flamed needle gives approximately a pure culture but in order to complete and make certain of the separation it is desirable to resort to plate methods.

Lactose agar does not prove suitable since, quite contrary to the ordinary rule, this organism refuses to produce color upon this medium; and no other basis of classification on agar is evident.

Gelatin plates seem to be but little more suited to the work because only at rare intervals is sufficient color produced in the colonies to characterize them. In some instances the germ even refuses to grow upon gelatin when transferred from a potato culture, portions of the material carried over from the potato lying dormant in the gelatin for more than a week, yet when returned to a fresh potato surface setting up a vigorous growth.

The culture media was for the most part made neutral to phenolphthalein with sodium hydroxide, but variations of acid and alkaline media have been tried with no better success.

Cooked potato offers a very suitable medium for growth and production of color. Cut into slices and sterilized in Petri dishes it gives a broad surface for inoculation. A flamed needle touched to one of the red spots in a cheese and then drawn repeatedly over a couple of such surfaces rarely fails to give isolated colonies of the desired organism. Transfers made in like manner from these isolated growths to other potato slices usually gives quite homogeneous cultures, the purity of which may be later tested upon gelatin plates and other substances. Following this old method, which on account of its inconvenience has been discarded by bacteriologists for a generation, pure cultures have
been obtained from outbreaks in a half dozen factories scattered from St. Lawrence County to Allegany County.

While the methods in use enable us to isolate the organism with comparative ease from the red spots in cheese where it is present in an almost pure culture they are very little use when the desired form is mixed with a variety of others; as is the case in samples taken from the factory and its surroundings. The attempt has been made in the laboratory to perfect methods for recognizing the causal organism when present in relatively small quantities as would be the case in the mixed milk from the vat or in the can of any patron provided it was derived from such a source. Thus far these efforts have not been crowned with a high degree of success.

Fine distinctions as to the manner of growth of cultures derived from such widely separated portions of the country will not be discussed at this time but will be reserved until work upon the whole subject has reached such a satisfactory stage as to justify a more extended treatment. Suffice it to say that all the cheese samples examined presented essentially the same general appearance and each could clearly be referred to a biological cause; so that we can feel fairly certain that we have to do with a definite biological trouble spread over a wide extent of territory.

PRODUCING RUSTY SPOT IN EXPERIMENTAL CHEESE.

While the attempt was being made in the laboratory to devise means of readily recognizing the cause of this trouble, cheeses were prepared in various ways using starters derived from infected cheese with the aim of finding the habits of the causal organism. In all, a dozen infected cheeses have been made beside the appropriate controls.

Of these, three were made at different times each with the addition of a half dozen plugs drawn from a cheese thoroughly spotted with the trouble. These plugs were first rubbed to a thin paste with water and then added to the vat before it was set with the rennet. In each of these experimental cheeses the spots which developed were so widely scattered that they would have passed any but a very careful inspector, and these three trials may be put down as failures as far as the production of spots in the cheese is concerned.
Seven cheeses were made with the addition of a culture of the causal organism to the milk before adding the rennet, and these likewise failed to produce more than a few red points scattered through the mass of the cheese, and as far as practical considerations are concerned these can also be classed as a failure to produce anything approximating what is commercially known as rusty spot.

Two cheeses manufactured at different times and using cultures derived from outbreaks in different factories were made by adding a culture to the vat just after the curd had been cut. In each case the interior of the uncolored cheese within ten days was so abundantly filled with small red points that at first glance these colored points seemed to blend and give the entire cheese a high red color.

While these observations are too few to be relied upon as proving anything regarding actual conditions in the factory they are in many ways very suggestive. In the first place these experiments show that a cheese may contain a large number of the proper kind of germ and still not show any discoloration. This may throw some light upon the failure of the spots to appear in the make of certain days in an infected factory.

Again, these results suggest that the stage of the process when the germs enter the vat may be very important. When the milk is curdled by the rennet all these minute plants within the mass are caught and held in the coagulum. It was to be expected that many of these would be liberated by the cutting and farther manipulation of the curd, but this does not seem to have occurred to any considerable extent in the above experimental cheeses.

It should be stated that to avoid contaminating our curd mill the cheese was all handled as stirred curd. It is generally agreed that this trouble is worse in home trade than in the more acid export cheese, and in all these tests the attempt was made to produce a low-acid cheese.

The differences in results with cultures can not be well attributed to differences in the cultures themselves, since in one case approximately equal quantities of the same organism were used in two cheeses made with an interval of about twenty days. In
the first instance the culture was added directly to the milk before setting with rennet, while in the other cheese the culture was added immediately after cutting the curd. The first cheese gave only very faint evidence of discoloration while the second was intensely colored by a multitude of closely-set yellowish-red points.

CONCLUSION.

While we are not yet in a position to give the clear cut information desired by the factorymen, still the following points may be of assistance:

The rusty spots in Cheddar are simply the growth of minute plants on the walls of the air spaces within the cheese. While the growth does not seem to be harmful to the consumer it is objectionable because it is unsightly.

Coloring the cheese will cover up these spots except in very bad cases.

High acid content, with the consequently small amount of moisture in the air spaces within the cheese, tends to keep down the production of color.

The trouble usually appears in May, often does little harm through the middle of the summer, and ordinarily disappears in October.

Specific directions for freeing a factory once infested can not be given from the amount of data at hand, but plenty of hot water followed by plenty of live steam on the vats, cans and working utensils seems to be called for by the above experiences. We will be pleased to correspond with, and as far as practicable, visit every factoryman in the State having this trouble in the hope both of learning something ourselves and of being of use to the maker.