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FIELD STUDIES OF THE SOURCES OF MOLD IN BUTTER

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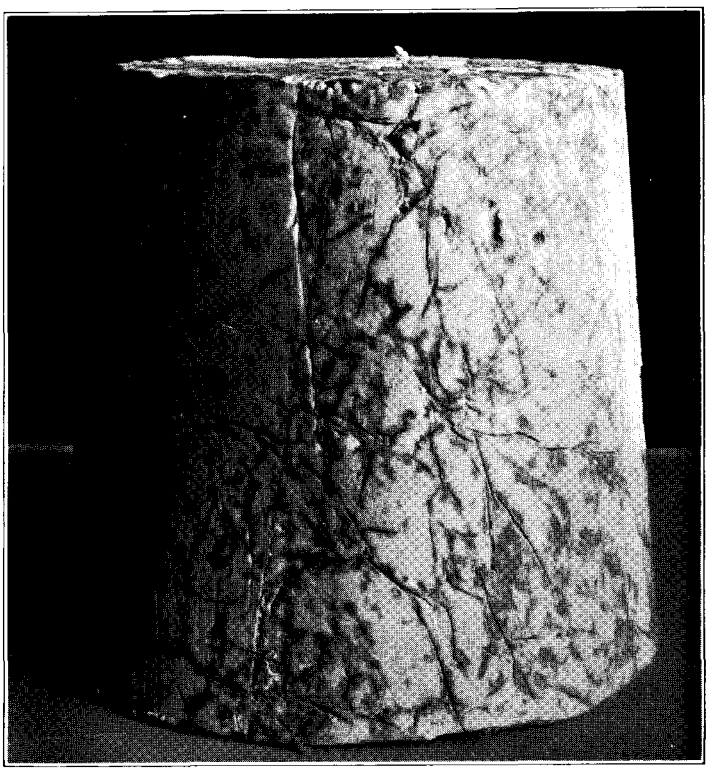

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FIELD STUDIES OF THE SOURCES OF MOLD IN BUTTER

H. MACY AND W. B. COMBS

The development of mold in butter has been responsible, year after year, for a great deal of annoyance and financial loss to creameries and dealers in butter. The butter industry has constantly faced the possibility that mold might appear on butter, wrappers, or packages before the butter reached the consumer.

The molding of butter is by no means a new problem, nor is there any reason to believe that it is more common today than it was fifty years ago. Renewed interest has been aroused, however, largely because of increased efforts on the part of the manufacturers of butter to improve in every way the quality of their product. The prevention of moldiness is an important phase of this general campaign.

Considering the importance of the mold problem, comparatively little has been done to solve it. Investigators in various parts of the world have attacked the problem from one standpoint or another and have made important contributions to our knowledge. In recent years, Lund, Bouska, Hood, and others have presented some very valuable data, particularly as to the sources of molds in butter, their prevalence, and methods of eliminating the dangers.

One of the first steps in a study of the mold problem is to determine the source of contamination. Some worth-while suggestions as to these sources have been made in the past. The available information, however, has not been generally disseminated. Too often the creamery operator has been misinformed as to the essential points. The information has been misinterpreted in a way to place emphasis upon unimportant details. The relative importance of each source and the difference between cause and effect must be appreciated. As an example, the refrigerator has been accused, rather generally, of playing the principal rôle in the contamination of butter with mold. In fact, it is really a very minor source of contamination, altho it may contribute conditions, particularly as regards moisture and air, that are favorable for the growth of mold on a product already contaminated from other sources. When the sources are known, remedies may be sought. Neither the experience of the past nor experimental study has done much more than suggest possibilities. This leaves the entire problem of moldiness of butter open for extensive and intensive studies.

Early in the spring of 1925, attention was called to excessively heavy losses by certain creameries of the state, due to mold on the butter.

The losses of some creameries amounted to hundreds of dollars in a single month. This condition was serious for any creamery, especially for the small co-operative organizations. It was obvious that something should be done to eliminate such losses. As information regarding the mold problem was meager, particularly on fundamental principles, the Division of Dairy Husbandry undertook extensive studies concerning the development of mold in butter. It was thought advisable first to determine the important sources of mold in various creameries. A survey was made and the results are presented in this bulletin. In the course of these studies, some very significant features of the mold problem were observed. They suggested further studies concerning the elimination of the sources and the fundamental relationships involved in mold development. The results of these investigations will be made public from time to time.

SOURCES OF MATERIAL

Members of the staff of the Dairy Division visited a number of creameries that were confronted with moldy butter, during the spring and summer of 1925. Through the co-operation of various creamery organizations, other representative creameries were studied in the summer of 1926.

Records of the mold and yeast counts of the butter from some of these creameries were available. From these records creameries were chosen that had maintained excellent, satisfactory, or unsatisfactory records for the previous year. Surveys at these creameries promised data that would explain their respective mold and yeast records. Several other creameries were selected, also, because they were using different methods of manufacture.

METHOD OF PROCEDURE

The necessary equipment and materials for mold analysis were transported to the creameries in metal cases similar to those used by cow testers. Each sample was plated at the creamery immediately after it was taken. Samples were taken with all necessary precautions at desired points in the plant or during the process of manufacture. The number of analyses was limited by expediency or by the difficulty and cost of transporting large quantities of laboratory supplies. All samples of cream, butter, water, etc., were plated in 1-cc. amounts. Parchment paper, cloth circles, etc., were cut into convenient fragments by means of sterilized scissors and handled by sterile forceps. Salt and miscellaneous solid substances were added to the plates in small, representative quantities.

Samples designated as "rinsings from churn," "rinsings from hose, pump, and pipe," etc., were taken as follows: A ten-gallon can of water was brought to a temperature of from 200 to 210 degrees F. by means of steam. The cover was placed on the can, and the water was allowed to stand at this temperature for one hour. At the end of this time, the temperature had in no case dropped below 185 degrees F. The water was then cooled to 90 to 100 degrees F. by placing the can in a tank of cold water. A sufficient quantity of this boiled water was then placed in the churn; the doors and outlets of the churn were closed, and the churn was revolved at low speed for 10 revolutions, after which a sample of the rinse water was taken for plating. The water that remained in the can was then pumped through the pipe lines by dipping the steamed end of the pipe or hose into the water and pumping the water through the line of pipes and pump. The sample was caught at the discharge end of the pipe. In every case, a check sample of the boiled water was taken, and was always found to be free from mold, consequently the plating of the rinse water demonstrated the presence or absence of contamination from the churn and pipes. All plates were poured with whey agar. Just before plating, 1 cc. of a 1 per cent sterile tartaric acid solution was added to each plate. The plates were incubated at room temperature for 3 days before counting. The results were recorded in terms of a cubic centimeter where such measurement was made, otherwise they represent the mold content of the material added. Because of the difficulty of reporting accurate counts for heavily seeded plates (since dilution was not practical under field conditions), the results were recorded as —, +, ++, +++. The — indicates that no molds were present; + that less than 10 molds developed on the plates; ++ that more than 10 but less than 100 colonies grew; +++ that the plate was so heavily seeded and covered that no count was possible. An × indicates that no sample was taken or that the sample was lost. The presentation of the results in this manner will give an idea of the relative importance of various sources at the different creameries.

PRESENTATION OF DATA

The results of the surveys at the various creameries are listed separately. For convenience, the creameries are listed alphabetically. Because of differences in the operation of the plants, an equal number of samples could not always be taken. At other times, exigencies of field work prevented more extensive studies. In some cases, breakage in transit was responsible for omissions.

Creameries A to E, inclusive, were visited twice in 1925, as they had had difficulty with mold. Creamery D was a repeater in 1926, with

continued losses because of mold. Other creameries were selected because of their records or some special method of operation.

Creamery A

A shipment of unsalted butter from creamery A reached a local warehouse in April, 1925. Several lots were decidedly moldy. A section of a typical tub from the carload is shown on the cover page. This butter was several weeks old. The odor and flavor were distinctly like Roquefort cheese. A laboratory analysis showed a very large number of green molds *(Penicillium sp.)*, both in the outer layers of the butter, where it was apparent, and in the interior, where it was not visible. An analysis of butter from a subsequent churning at the same creamery, shipped in the same car, revealed an equal number of the same type of mold, altho the butter showed no signs of moldiness. A visit was made to this creamery as soon as possible, but not before the operator had been informed of the condition and cautioned to improve his methods. The results of the survey on April 22 are given in Table I. The building was an old frame structure with poor ventilation and average equipment. It was observed that the operator was not particularly adept at pasteurizing, which furthered a suspicion that pasteurization in the past had not been regularly practiced. This suspicion was partly based upon the fact that the buttermilk, which was returned to the patrons in the cream cans, and the raw cream received at the creamery, were heavily seeded with the same type of mold found in the samples of butter previously analyzed. Pasteurization on the day of the visit was thoro. It was also noticed that the rinsings from the rubber hose, pump, and pipes indicated considerable contamination. The molds were the same as those responsible for the molding of the previously mentioned lots. The rubber hose, in poor condition, was used to draw the pasteurized cream from the vat, and also to draw buttermilk from the churn through the pump to the buttermilk tank in the attic. It remained attached to this buttermilk pump the remainder of the day. The pump was permanently mounted and a stationary iron pipe extended to the tank. Unquestionally, there was leakage back through this hose during the night. The pipe used for transferring the cream from the cream pump to the churn was about eleven feet long and made of ordinary iron water pipe. It was practically impossible to clean it. The churn appeared to be in good condition. Obviously, the difficulty could be traced to improperly sterilized pipes, hose, and pump; and possibly, in the past, to a lack of pasteurization. Up to the time this creamery got into difficulties, it had been making unsalted butter. This made mold infection particularly dangerous. A return to the manufacture of salted butter was necessary. Instructions were given to the operator, and sanitary piping was purchased. No further trouble was reported and the creamery had an excellent record from

that time forward. Here was a clear-cut case of preventable contamination through careless methods. It also illustrates how definitely a mold menace can be removed.

TABLE I

CREAMERY A

Sample	Observations made on 2/22/25*	9/1/25*
Raw cream	+++	+++
Pasteurized cream	−	−
Starter	−	−
Rinsings from hose, pump, and pipe	++	+
Rinsings from churn	−	−
Water from well	−	−
Salt	−	−
Butter (unsalted)	−	×
Butter (unsalted)	−	×
Butter (salted)	−	×
Butter (salted)	×	−
Butter (salted)	×	−
Butter (salted)	×	+
Butter (salted)	×	+
Butter (salted)	×	+
Buttermilk, fresh from churn	+	+
Brine solution	−	−
Liner from brine	−	−
Ice	+	+

(* A − indicates no mold, + that less than 10 molds developed on the plates ++ that between 10 and 100 colonies developed, and +++ that colonies were so numerous that a count was impossible. × indicates that no sample was taken or that sample was lost.

Creamery B

Creamery B had also been troubled with moldy butter. A survey of the situation yielded results reported in Table II. This building was of frame construction, poorly ventilated, and with mediocre equipment. At the time of our arrival, on July 20, the cream in vat I had already been "pasteurized." The poor results led to a question as to its thoroness. The cream in vat II, no worse in quality when raw than in vat I, was pasteurized in our presence. The results speak for themselves. Ordinary iron piping with permanent connections was used for transferring the cream. The analysis of the rinsings from these pipes, the rubber hose (used from the vat to the pump), and the pump revealed large numbers of molds. The churn was in bad condition and had an unpleasant odor. The rinsings were heavily seeded. The contamination of the thoroly pasteurized cream from vat II by the hose, pump, pipes, and churn was reflected in the unusually high mold content of the finished butter. The principal sources of mold in this creamery were undoubtedly in the equipment just mentioned. Failure to pasteurize the cream properly was obvious. The plant was in need of improved methods and a general housecleaning. The return visit a month later indicated that pasteurization methods had improved, the cleaning of

the pipe lines was slightly more adequate, but the churn still remained a fertile source of reinfection. As in many later trials at other creameries, the sterilization of the churn (old and in bad condition) required strenuous treatment, and was, in fact, almost impossible. The purchase of a new churn is advisable under such circumstances.

TABLE II

CREAMERY B

Sample	Observations made on 7/20/25	8/19/25
Raw cream (vat I)	+++	+++
Pasteurized cream (vat I)	++	−
Raw cream (vat II)	+++	+++
Pasteurized cream (vat II)	−	−
Starter	−	−
Rinsings from hose, pump, and pipe	+++	+
Rinsings from churn	+++	+++
Butter (unsalted) vat I	+++	++
Butter (salted) vat I	+++	++
Butter (unsalted) vat II	+++	++
Butter (salted) vat II	+++	++
Liner from formalin solution	−	−
Buttermilk from tank	+++	+++

Creamery C

The losses at Creamery C, while not particularly heavy, were serious enough to cause some worry on the part of the operator. Pasteurization of the cream was not effective, as Table III indicates. The rinsings from the equipment contained many molds. It was noted that the operator did not rinse out or steam the pipes, etc., before transferring cream to the churn. The starter was badly infected. All these conditions could scarcely lead to any other result that the high mold content shown by the finished butter. The return visit demonstrated that pasteurizing methods had been improved so that they were adequate. The churn had been properly sterilized, altho the pipes and pumps (both ordinary iron) were still contaminated. The starter was moldy and the finished butter contained a number of molds, but not so many as previously. The contaminated pipes and starter had spoiled a good pasteurized cream.

TABLE III

CREAMERY C

Sample	Observations made on 7/23/25	8/11/25
Raw cream	+++	+++
Pasteurized cream (vat I)	+++	−
Pasteurized cream (vat II)	+++	−
Rinsings from pipes and pump	++	+++
Rinsings from churn	++	−
Water from well	+	−
Starter	+++	+++
Pasteurized cream and starter (held over night)	+++	+++
Butter (salted) vat I	+++	++
Butter (salted) vat II	++	++
Buttermilk from churn (vat I)	+++	+++
Buttermilk from churn (vat II)	++	+++
Buttermilk from tank	+++	+++
Parchment (dry)	++	−
Parchment (from brine solution)	−	−

Creamery D

Creamery D was housed in an old building, poorly ventilated, and much of the equipment was worn out. The unsalted butter being made had a record for frequent molding and for off-flavor. At the time of the first visit, pasteurization was efficient. Iron piping was used for transferring the cream. It was permanently mounted and had inaccessible elbows. As might be expected, it was heavily seeded with mold, as indicated in Table IV. The same was true of the churn. The water used for washing the butter was stored in a tank suspended close to the ceiling in the boiler-room. The water was infected. Starter used was also contaminated. Combining all these sources of contamination, it was not surprising that the butter contained many molds and was subject to molding, especially as it was without salt to help protect it. As in many other creameries, the cloth circles were heavily seeded with mold. This added one more chance for infection. At the time of the second visit, the starter had been discontinued, the churn cleaned and sterilized, and the water drawn direct from the well. However, the pipes and pump were still in bad condition. This contamination was apparently sufficient to account for the high mold content of the butter.

In the spring of 1926 (see Table V), this creamery again had trouble with moldy butter. The survey brought out the fact that pasteurization in the worn-out vats was not adequate. The tinned, under-surface of the cover of vat I was badly cracked. Drippings from this cavity were heavily seeded with miscellaneous molds. The stuffing boxes on vat II were not tight, so re-infection may have occured at any time in that vat as in vat I. The ventilation in the plant was very poor. Fans over the vat were in motion constantly. Pipes located over the vats were continually sweating and the droplets fell into the open vats. Analysis showed

that the drippings contained many molds. The churn was in need of repair and sterilization. Scrapings from fissures in the churn rollers contained some mold. The iron pipes of the previous year had been replaced by sanitary piping, but it had not been properly sterilized. Water was again being used from the tank in the boiler room and brought over some mold. The conditions in the creamery were conducive to potential contamination of cream or butter, and the unsalted butter might mold at any time.

TABLE IV

CREAMERY D

Sample	Observations made on 7/24/25	8/10/25
Raw cream (vat I)	+++	+++
Pasteurized cream (vat I)	−	−
Raw cream (vat II)	+++	+++
Pasteurized cream (vat II)	−	−
Starter	++	×
Rinsings from pipes and pump	+++	+++
Rinsings from churn	+++	−
Water	++	−
Butter (vat I)	++	++
Buttermilk from churn (vat I)	+++	+++
Parchment from formalin solution	−	−
Cloth circle (dry)	+++	×

TABLE V

CREAMERY D

Sample	Observations made on 7/14/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	++
Scrapings from under-surface (vat I)	+++
Raw cream (vat II)	+++
Pasteurized cream (vat II)	+
Drippings from pipes over vats	+++
Rinsings from pipes and pump	+
Rinsings from churn	+
Scrapings from churn roller	+
Cream in churn (vat I)	+
Well water	+
Butter (unsalted) vat I	+
Buttermilk from churn (vat I)	++
Cream in churn (vat II)	+
Butter (unsalted) vat II	−
Buttermilk from churn (vat II)	+
Parchment from formalin solution	−
Formalin solution	−

Creamery E

The losses sustained by Creamery E during a single month amounted to more than $1500. A glance at Table VI will perhaps suggest the possible reason. Everything in the creamery was moldy. The building was a reconditioned frame structure in a good state of repair but sadly

lacking in ventilation. The equipment was fairly good but it was easy to see that conditions were not what they should be. The analysis of samples justified this conclusion. Upon the basis of the results, suggestions were made to the operator as to remedies for the situation. The survey on September 16 indicated that conditions had improved. Pasteurization had been made effective, the pipes were sterilized, a new starter had been developed, but the churn was still a menace, as was the well water, the parchment, and the salt. The walls of the creamery were covered with mold spots, so it was reasonable to expect contamination of the salt in an open barrel, parchment on open shelves, and water in an open tank. The churn was old and apparently difficult to sterilize. Colder weather, higher salt content of butter, and general improvement in conditions were probably responsible for the disappearance of the major difficulty.

TABLE VI

CREAMERY E

Sample	Observations made on 7/25/25	9/16/25
Raw cream	+++	+++
Pasteurized cream	++	−
Rinsings from pipes and pumps	+++	−
Rinsings from churn	+++	+++
Water from well	++	+
Salt	++	++
Starter	+++	−
Butter (unsalted)	+++	++
Butter (salted) vat II	+++	×
Buttermilk from churn	+++	++
Brine solution	+	−
Parchment in brine	+	++
Parchment (dry)	+++	++
Cloth circle (dry)	+++	+++

Creamery F

Evidence of mold contamination everywhere in Creamery F is presented in Table VII. With all the sources supplying an abundance of molds, the appearance of mold in the butter was not difficult to explain. A survey made ten days after the first visit revealed the fact that pasteurization had been made efficient but general sanitation was not much improved. The mold content of the butter was much lower than on August 3. At this plant the cooler was particularly poor. An ice bunker located overhead was leaking slowly so that there was an intermittent dripping of melted ice. Butter exposed in tubs which were left uncovered might have become contaminated on the surface from drops of ice water which were very heavily seeded with molds.[1]

[1] The six creameries discussed had met some losses from moldy butter during the spring of 1925. Only one had a repetition of the trouble in 1926. Coincidentally, this creamery was the only one making unsalted butter. This fact may be significant.

The creameries discussed in the following pages were selected because a laboratory history of each was available.

TABLE VII
CREAMERY F

Sample	Observations made on 8/3/25	8/13/25
Raw cream	+++	+++
Pasteurized cream (vat I)	+	−
Pasteurized cream (vat II)	+++	−
Pasteurized cream (vat III)	++	−
Rinsings from pipes and pump	+++	++
Rinsings from churn	+++	+++
Water from well	+	−
Butter (unsalted) vat I	+++	+
Butter (salted) vat I	++	+
Butter (unsalted) vat II	+++	×
Butter (salted) vat II	+++	×
Butter (unsalted) vat III	+++	×
Butter (salted) vat III	+++	×
Buttermilk from churn (vat I)	+++	++
Buttermilk from churn (vat II)	+++	×
Buttermilk from churn (vat III)	+++	×
Buttermilk from tank	+++	×
Parchment (dry)	++	×
Ice	+++	+++

Creamery G

Before July 1, 1926, Creamery G was using the flash system of pasteurization, but after that date it changed to the vat system. Consequently, four observations are reported.

On September 8, 1925 (Table VIII), the first heated cream sent over the cooler was not thoroly pasteurized but later in the run the results were satisfactory. The churns, pipes, and pump were not badly infected. The butter contained a few molds. The analyses made on the following day indicated that pasteurization was not so efficient as on the 8th. This condition might be expected in a small creamery where the cream comes in irregularly, so that the flash heater is not running at full capacity at all times. When the steam regulating valve is set for a certain temperature for a given capacity, or when it is controlled manually, it is impossible to prevent marked fluctuations in pasteurizing temperatures. Part of the time the temperature will be high enough and again it may be too low to destroy the mold spores. The pipes and pump were thoroly sterilized after the first day, as the record demonstrates. The churns were in better condition, in fact, the mold content of the pasteurized cream and the contamination from the equipment was so low that the butter manufactured on the 9th was apparently free from mold. Here is an illustration of the result of increased effort on the part of the operator when he is aware of defects.

TABLE VIII
CREAMERY G

Sample	Observations made on 9/8/25	9/19/25
Raw cream	+++	+++
Heated cream, first over cooler, after flashing	+	+++
Heated cream, second batch over cooler	−	+
Heated cream, half through run	−	+
Heated cream, near end of run	−	+
Rinsings from pipes and pump	+	−
Rinsings from churn A	+	−
Rinsings from churn B	++	+
Water from well	−	−
Salt	−	−
Butter (unsalted) churn A	+	−
Butter (unsalted) churn B	+	−
Buttermilk from tank	+++	+++
Brine solution	+	−
Parchment (dry)	+	+

When the vat pasteurizers were put into operation in this creamery, in 1926, two more trials were arranged. Table IX gives the results. It will be noted that pasteurization was satisfactory. The cream apparently acquired enough reinfection from the pipes and pump to yield a high-count butter, altho the churns were in good condition. A month later, pasteurization was very effective. However, there was some contamination from the pipes and pump. Churn B was very heavily seeded with mold. It had not been used for several weeks. The influence of this churn contamination on the butter is remarkable. A sample of the butter was found to be moldy when examined one month later. This creamery is operated under good conditions, as a rule, and an attempt is made to eliminate contamination, but apparently the precautions are not always sufficient.

TABLE IX
CREAMERY G

Sample	Observations made on 7/26/26	8/25/26
Raw cream (vat I)	+++	+++
Pasteurized cream (vat I)	−	−
Raw cream (vat II)	+++	+++
Pasteurized cream (vat II)	−	−
Water from well	−	−
Salt	−	−
Rinsings from pipes and pump	++	+
Rinsings from churn A	−	+
Rinsings from churn B	−	+++
Cream in churn A (vat I)	+	+
Butter (unsalted) churn A (vat I)	++	++
Buttermilk from churn A (vat I)	+++	++
Cream in churn B (vat II)	−	+++
Butter (unsalted) churn B (vat II)	+	+++
Buttermilk from churn B (vat II)	+++	+++
Liner solution	−	+
Parchment from solution	−	−

Creamery H

Unsalted butter of rather good quality was being produced by Creamery H. Table X leads one to wonder how the operator had escaped the mold menace. It is one of the puzzling examples of the inadequacy of our knowledge regarding the factors involved, in the development of mold in butter. Why does butter with a high mold content, such as that made at this creamery, fail to mold even when no salt is present to prevent it? The answer is still to be found.

TABLE X

CREAMERY H

Sample	Observations made on 7/16/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	+
Raw cream (vat II)	+++
Pasteurized cream (vat II)	−
Raw cream (vat III)	++
Pasteurized cream (vat III)	−
Rinsings from pipes and pumps	−
Rinsings from churn	+++
Water from well	+
Cream in churn (vat I)	++
Butter (unsalted) vat I	++
Buttermilk from churn (vat I)	+++
Cream in churn (vat II)	++
Butter (unsalted) vat II	++
Buttermilk from churn (vat II)	+++
Cream in churn (vat III)	+
Butter, (unsalted) vat III	++
Buttermilk from churn (vat III)	++
Formalin solution	−
Parchment from formalin solution	−

Creamery I

Creamery I was housed in a good building with ordinary equipment. Sour cream was delivered by the patrons, necessitating neutralization. No starter was used. In Table XI the facts are set forth regarding the contamination inside the plant. It was not particularly bad anywhere. The butter had a low mold count and was highly salted. Observations agree with the records available for this creamery. It had maintained a low count in its butter for a long time.

TABLE XI

CREAMERY I

Sample	Observations made on 7/28/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	−
Raw cream (vat II)	+++
Pasteurized cream (vat II)	+
Rinsings from pipes and pump	+
Rinsings from churn	+
Salt	−
Water from well	−
Cream in churn (vat I)	+
Butter (unsalted) vat I	+
Buttermilk from churn (vat I)	+
Cream in churn (vat II)	+
Butter (unsalted) vate II	+
Buttermilk from churn (vat II)	++
Liner solution	+
Parchment from solution	+
Parchment (dry)	+
Cloth circle (dry)	+

Creamery J

Data concerning Creamery J indicated that it had a splendid record for a low mold count in butter. Observations at the creamery corroborated this fact, as will be seen in Table XII. While the raw cream came into the plant with a high count, pasteurization was efficient in both vats. A patron came into the creamery late in the day with a can of cream. The operator dumped this into the pasteurized cream in vat II. Note how it raised the count. However, this operator did something most others fail to do. He repasteurized the whole vat of cream, with the results shown. Note the results of the analysis of the other

TABLE XII

CREAMERY J

Sample	Observations made on 7/29/26
Raw cream (vat I)	+++
Pasteuurized cream (vat I)	−
Raw cream (vat II)	+++
Pasteuurized cream (vat II)	−
Pasteurized cream + raw cream	++
Pasteurized cream + raw cream (repasteurized)	−
Rinsings from pipes and pump	−
Rinisngs from churn	−
Water from well	−
Salt	−
Cream in churn (I + II)	−
Butter (unsalted)	−
Buttermilk from churn	−
Liner solution	−
Parchment from solution	−
Cloth circle (dry)	−

samples. There was not a blemish on his record. The operator used plenty of boiling water to sterilize all his equipment. This shows what can be done, and it was done in an old frame creamery, by an operator who was greater than his handicaps.

Creamery K

The results given in Table XIII are for another creamery making unsalted butter. The building and equipment were new but the operator had not quite mastered them. He was doing fairly well, as the report shows. Nevertheless, there were contaminating possibilities here and there that were danger signs. The pasteurization was inadequate, sanitation was neglected just a trifle, and the water supply was infected. These items must be remedied in any creamery.

TABLE XIII

CREAMERY K

Sample	Observations made on 8/6/26
Raw cream (vat I)	++
Pasteurized cream (vat I)	−
Raw cream (vat II)	++
Pasteurized cream (vat II)	+
Rinsings from pipes and pump	+
Rinsings from churn	+
Starter	−
Salt	+
Water from well	++
Cream in churn (vat I)	+
Butter (unsalted) vat I	−
Buttermilk from churn (vat I)	−
Cream in churn (vat II)	+
Butter (salted) vat II (churned first)	+
Buttermilk from churn (vat II)	++
Liner solution	−
Parchment from solution	−
Cloth circle (dry)	+

Creamery L

Creamery I, also making unsalted butter, was studied, with the results given in Table XIV. The quality of its product had greatly improved. While it had trouble with mold in the spring of 1925, it escaped in 1921. Pasteurization was not adequate. General sanitation was much better than in Creamery K. The high mold content of the butter could be traced largely to insufficient pasteurization and possibly in part to infected pipes and water.

TABLE XIV

CREAMERY L

Sample	Observations made on 8/10/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	++
Raw cream, 2nd grade (vat II)	+++
Pasteurized cream (vat II)	+
Starter	−
Water from well	+
Salt	−
Rinsings from pipes and pump	+
Rinsings from churn A	−
Rinsings from churn B	−
Cream in churn B (vat I)	+
Butter (unsalted) churn B (vat I)	−
Buttermilk from churn B (vat I)	++
Cream in churn A (vat II)	++
Butter (salted) churn A (vat II)	++
Buttermilk from churn A (vat II)	−
Formalin solution	−
Parchment from solution	−

Creamery M

Among the creameries producing salted butter, this one had maintained a fair record. Table XV shows that it reduced the mold count of the raw cream by pasteurization satisfactorily in vat I but not in vat II. Further, a constant reinfection of the cream may be observed from the vat to the churn and in the churn.

It is surprising that the mold content of the butter is as low as it is. Each source must have contributed a small amount of contamination.

TABLE XV

CREAMERY M

Sample	Observations made on 8/11/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	−
Raw cream (vat II)	+++
Pasteurized cream (vat II)	+
Rinsings from pipes and pump	+++
Rinsings from churn A	+
Rinsings from churn B	++
Water from well	−
Salt	++
Cream in churn A (vat I)	+
Butter (salted) churn A (vat I)	+
Buttermilk from churn A (vat I)	++
Cream in churn B (vat II)	+
Butter (salted) churn B (vat II)	++
Buttermilk from churn B (vat II)	++
Liner solution	−
Parchment from solution	−

Creamery N

On the day of inspection, the operator of Creamery N was away, leaving the helper in charge. The creamery had maintained a reputation for low mold counts in its butter, placing it in the ranks of the best. However, it will be noticed in Table XVI that carelessness crept in on this particular day to spoil the operator's record. All along the line, with the exception of the pipes and pump, which the operator had probably cleaned, sterilized, and dried the day before, contamination was introduced. The fact that the water and salt were infected with mold was not to be blamed on the helper. At any rate, the whole record is not particularly bad.

TABLE XVI

CREAMERY N

Sample	Observations made on 8/11/26
Raw cream (vat I)	+++
Pasteurized cream (vat I)	−
Raw cream (vat II)	+++
Pasteurized cream (vat II)	+
Raw cream (vat III)	+++
Pasteurized cream (vat III)	+
Rinsings from pipes and pump	−
Rinsings from churn	+
Water from well	+
Salt	+
Cream in churn (vat I)	++
Butter (salted) vat I	+
Buttermilk from churn (vat I)	++
Cream in churn (vats II & III)	+
Butter (salted) (vats II & III)	++
Buttermilk from churn (vats II & III)	++
Liner solution	−
Parchment from solution	+
Cloth circle (dry)	++

Creamery O

The flash heating of the cream and the regenerative system of forewarming and cooling were practiced in Creamery O. Table XVII indicates that the flashing of the cream at 180 degrees F. was sufficient to destroy the molds. Recontamination took place, however, in the cooling drum. It was not possible on this day to obtain a sample of rinsings from the pipes and pumps or from the churn. The cream in the churn, nevertheless, was infected with mold in both churnings, but the resulting butter showed a relatively low count, indicating that contamination could not have been excessive anywhere.

TABLE XVII

CREAMERY O

Sample	Observations made on 9/13/26
Raw cream, in forewarmer	+++
Cream, flashed to 180 degrees F.	−
Heated cream leaving regenerator	−
Heated cream leaving cooler	++
Cream in churn A (vat I)	++
Butter (salted) churn A (vat I)	+
Buttermilk from churn A (vat I)	++
Water	−
Salt	−
Starter	−
Cream in churn B (vat II)	+
Butter (salted) churn B (vat II)	+
Buttermilk from churn B (vat II)	++
Butter (salted) (1 day old)	+
Parchment (dry)	++
Cloth circle (dry)	+++

Creamery P

In Creamery P the flash and regenerative heating and cooling was practiced. From the time the cream passed through the first heater drum, it was entirely enclosed within tubular devices. Table XVIII presents the data for observations made on two successive days. Note that the heating of the cream to 120 degrees F. in forewarming did not reduce the mold content. On the other hand, the flashing at 150 degrees F. followed by an additional heating to 180 degrees F. destroyed all the mold. Lot I, on September 14 went through the process without a trace of reinfection. This is an excellent record and should satisfy any one who says, "It can't be done." In lot II, on the following day, 152 degrees F. was not sufficient to destroy all the molds, but beyond that point, everything was clear until the cream reached churn B, which was infected. Here the butter took up the contamination. This is an example of the individuality of churns. This churn had not been properly sterilized. Ordinarily the operator of this plant was particularly careful about the sterilization of all equipment. Large quanities of boiling water were sent through all the equipment, including churn A. Churn B had been boiled out on the day before and had not been used on the 14th. This one-day vacation had given mold a chance to develop. More will be said about this condition in another place.

TABLE XVIII
CREAMERY P

Sample	Observations made on 9/14/26		9/15/25
	Lot I		Lot II
Raw cream in prewarmer	+++		+++
Cream, at 120 degrees F., from generator	+++		+++
Cream, at 152 degrees F., through first heater	—		+
Cream, at 180 degrees F., through second heater	—		—
Cream, coming out of regenerator	—		—
Cream, coming out of cooler	—		—
Cream in vat I	—	Vat II	—
Rinsings from pipes and pump	—		—
Rinsings from churn A	—	Churn B	+
Cream in churn A (vat I)	—	Ch. B (vat II)	+
Butter (salted) from churn A (vat I)	—	Ch. B (vat II)	+
Buttermilk from churn A (vat I)	—	Ch. B (vat II)	++
Starter	—		—
Water from well	—		—
Brine solution	—		—
Parchment from brine	+		+

PHOTOGRAPHIC RECORDS OF SURVEYS

In order to preserve a permanent record of the results of certain surveys which represented interesting conditions, photographs were taken of the petri plates made at the creameries.

Figure 1 shows, on the left, a plate made from raw cream, The large, cottony areas scattered over the plate are common mold colonies. The small, bright, shiny spots are yeast colonies. The plate on the right was prepared from cream which was thoroly pasteurized. The cloudiness is due to the presence of the cream. There are no colonies of either mold or yeast.

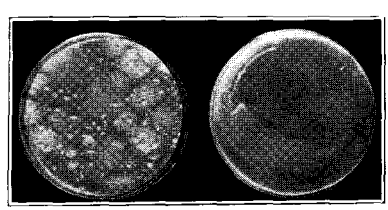


Fig. 1. Plates Made from Raw and Pasteurized Cream

Left, raw cream. The large cottony areas scattered over the plate are common mold colonies; the small shiny spots are yeast colonies.

Right, thoroly pasteurized cream. The cloudiness is due to the presence of the cream. There are no colonies of either mold or yeast.

Figure 2 illustrates, left to right, plates made from water, butter, and buttermilk, all of which are free from mold. The distinct spots in the center plate (from butter) are merely the hardened droplets of melted butterfat. On the agar they are dull and can be distinguished from yeast colonies, which are usually shiny. The buttermilk placed

in the plate at the right was curdled by the tartaric acid in the media.

In Figure 3, three plates are presented showing contaminated parchment paper and a cloth circle. The shiny spots on the plate at the left represent yeast colonies from contaminated, cold, saturated brine solution in which the parchment was kept. The plate in the center is covered with mold colonies from dust-laden parchment. The sample on the right is a badly contaminated cloth circle. The cloth can scarcely be seen, as it is almost completely covered by a variety of mold colonies.

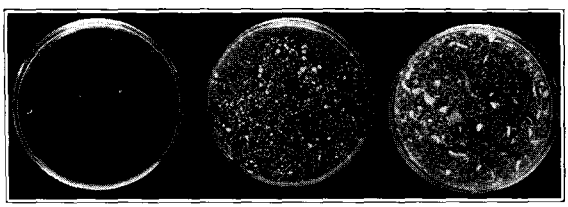


Fig. 2. Plates Made from Water, Butter, and Buttermilk, All Free from Mold

The distinct spots in the center plate are merely the hardened droplets of melted butterfat. On the agar they are dull, and can be distinguished from yeast colonies, which are usually shiny. The buttermilk in the plate at the right was curdled by the tartaric acid in the media.

It may be seen, readily, that it is possible to detect sources of mold by these plate methods and to have a permanent record of the results.

An example of a photographic record of a mold survey is given in Figure 4.

The discussion in regard to this creamery may be found in the preceding pages. Conditions were very bad. The plates show it definitely.

A creamery in which conditions were even worse yielded results illustrated in Figure 5. Every sample shows molds or yeasts.

At Creamery O (Fig. 6) it is obvious that the contamination was coming from the equipment.

For comparison with the results in these creameries, the results from Creamery J as shown in Figures 7 and 8 are interesting.

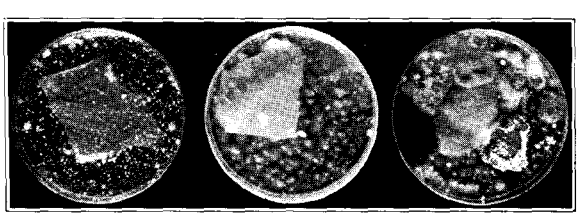


Fig. 3. Plates Showing Contaminated Parchment Papers and Cloth

The shiny spots on the plate at the left are yeast colonies from contaminated, cold, saturated brine solution in which the parchment was kept. The plate in the center is covered with mold colonies from dust-laden parchment. The sample at the right is a badly contaminated cloth circle. It is almost completely covered by a variety of mold colonies.

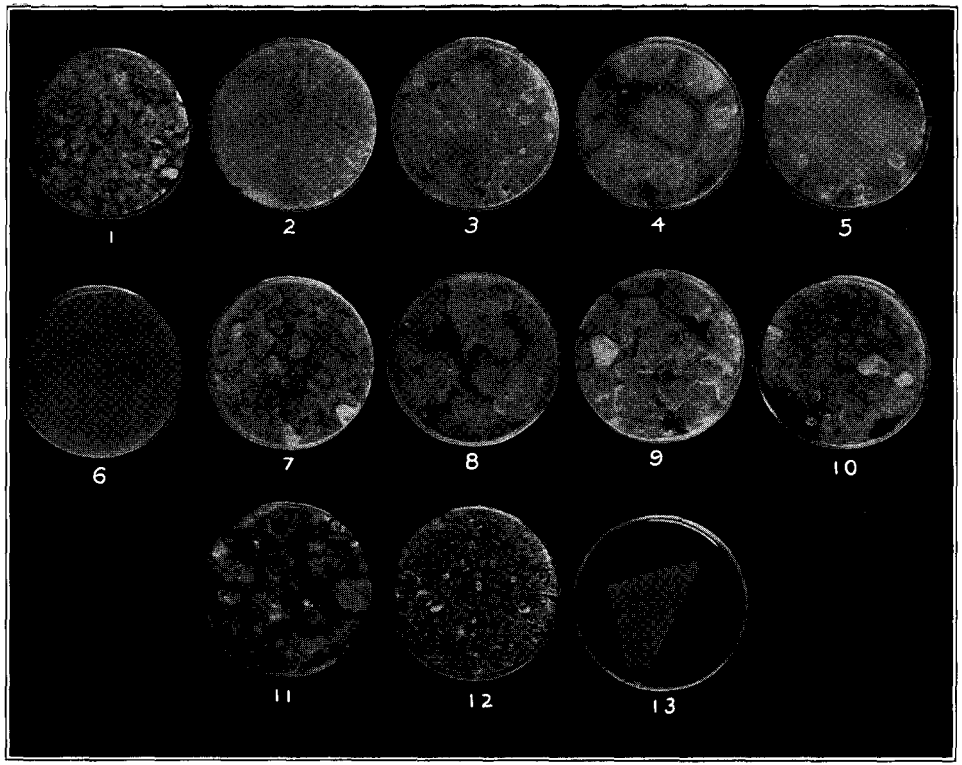
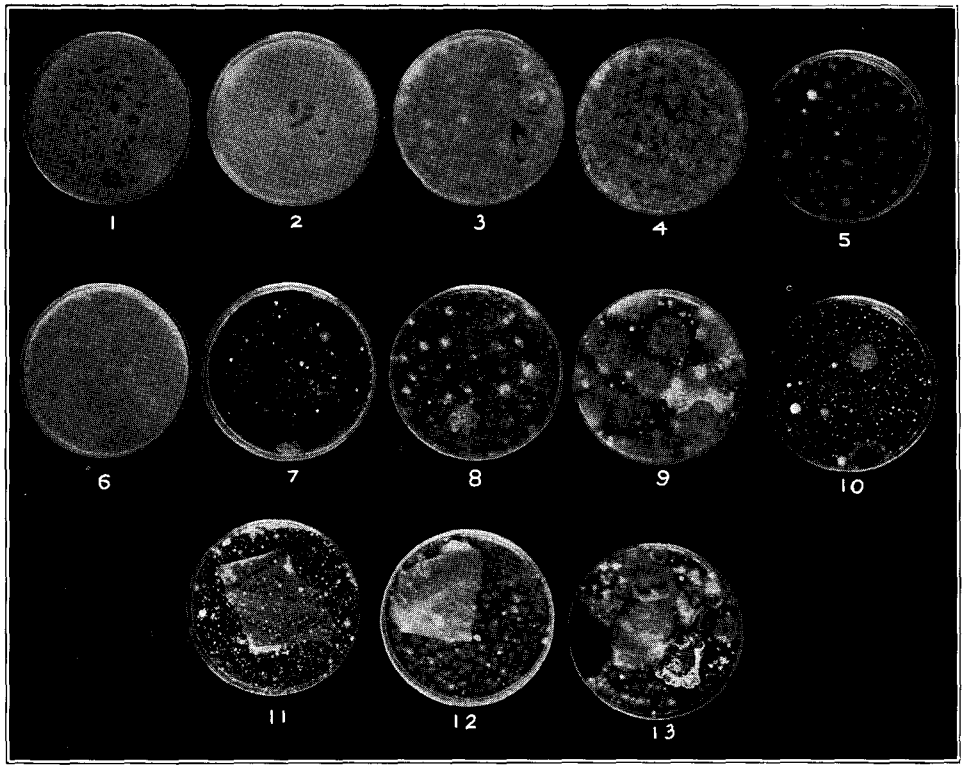


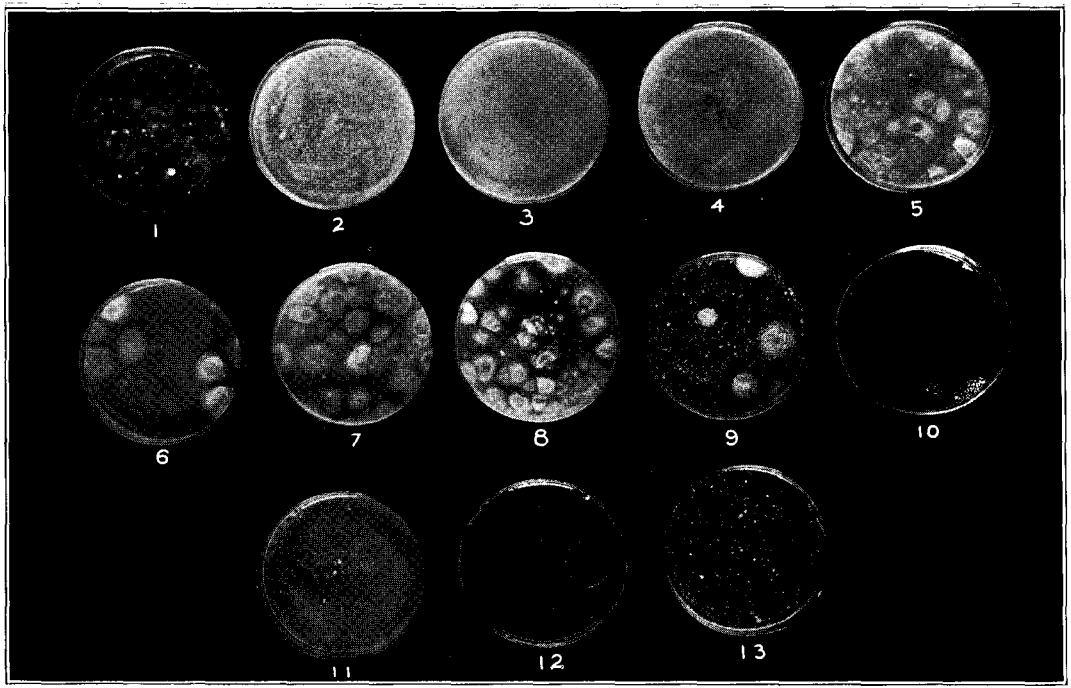
Fig. 4. Results of Investigations at Creamery B, Conditions Very Bad

1. Buttermilk from tank—moldy
2. Raw cream from patron—moldy
3. Raw cream, vat I—moldy
4. Pasteurized cream, vat I—moldy
5. Raw cream, vat II—moldy
6. Pasteurized cream, vat II—O. K.
7. Unsalted butter, vat I—moldy
8. Salted butter, vat I- moldy
9. Unsalted butter, vat II—moldy
10. Salted butter, vat II—moldy
11. Rinsings from pipes and pump—moldy
12. Rinsings from churn—moldy
13. Parchment from formalin—O. K.



1. Buttermilk from tank
2. Raw cream, vat I
3. Pasteurized cream, vat I
4. Starter
5. Well water
6. Unsalted butter
7. Salted butter, two days old
8. Rinsings from pipes and pump
9. Rinsings from churn
10. Brine solution
11. Liner from brine solution
12. Circle from brine solution
13. Cloth circle

Fig. 5. Results from Creamery E, Conditions Worse Than at Creamery B
Every sample shows molds or yeasts.



1. Water standing in pipes over night—moldy
2. Raw cream—moldy
3. Cream flashed to 180 degrees F.—O. K.
4. Cream leaving regenerator—O. K.
5. Cream leaving cooler—moldy
6. Cream going into churn—moldy
7. Cream in churn—moldy
8. Buttermilk—moldy
9. Butter—slightly moldy
10. Water—O. K.
11. Starter—O. K.
12. Salt—O. K.
13. Salted butter, one day old—O. K.

Fig. 6. Results from Creamery O, Conditions Good

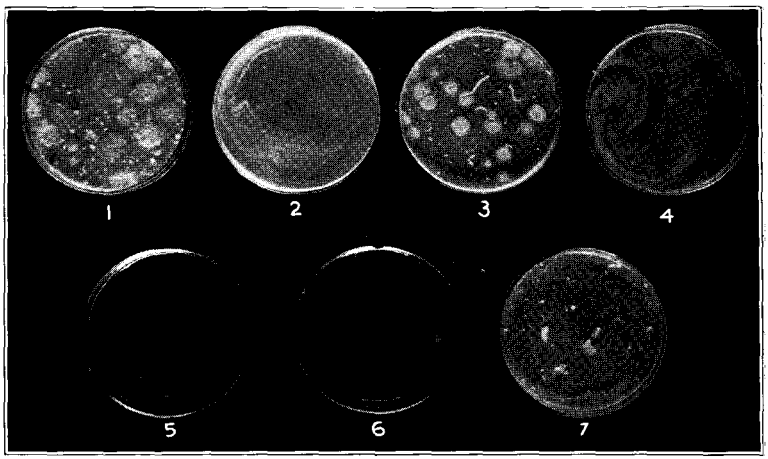


Fig. 7. Results at Creamery J

1. Raw cream—moldy
2. Pasteurized cream—O. K.
3. Pasteurized cream with raw cream added—moldy
4. Cream of 3 repasteurized—O. K.
5. Rinsings from pipes and pump—O. K.
6. Rinsings from churn—O. K.
7. Cream in churn—O. K.

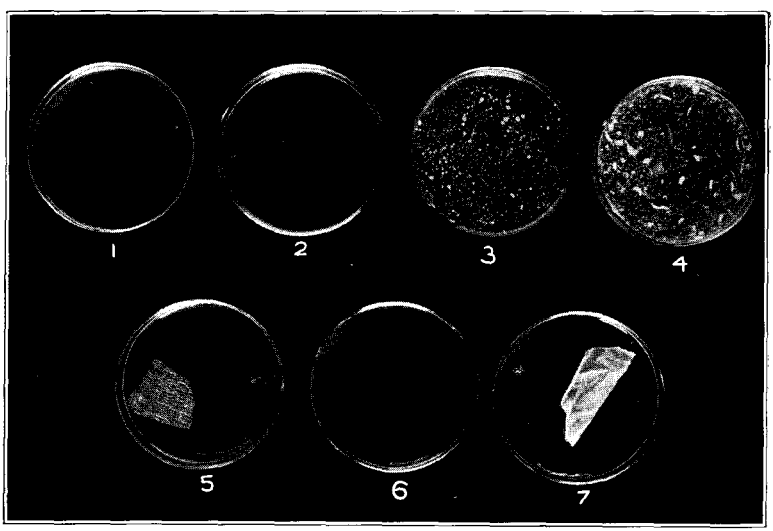


Fig. 8. Additional Results from Creamery J

1. Salt—O.K.
2. Water—O.K.
3. Butter—O.K.
4. Buttermilk—O.K.
5. Cloth circle—O.K.
6. Brine solution—O.K.
7. Parchment from brine solution—O.K.

It is obvious that equipment in this plant was in perfect condition. The results also indicate the danger from adding a small amount of raw cream to properly pasteurized cream. The operator at this creamery did not take a chance, but re-pasteurized this cream.

With such photographs, it is possible to approach a creamery operator with certified evidence of conditions in his plant. They have been very useful in eliminating sources of mold.

DISCUSSION OF DATA

This series of observations demonstrated the outstanding sources of mold in creamery butter. It was found that raw cream was in all cases heavily contaminated with mold, even tho most of it was sweet and fresh. In 40 per cent of the samples of cream supposedly pasteurized, the mold had not been destroyed. Practically 90 per cent of the dry parchment and cloth circles carried mold spores. The pipes and pumps were sources of mold in nearly 75 per cent of the creameries, and the churn in more than 65 per cent. Liners were shown to be improperly sterilized in more than 40 per cent of the observations. The following were sources of molds in the percentage of cases indicated: Water 44 per cent, starter 40 per cent, and salt 33 per cent. According to our experience, the raw cream, pipes, pumps, and churns stand out as the most serious potential sources of mold.

With a continued laboratory supervision of a creamery, it is possible to determine sources of contamination and to check the methods used to eliminate them. Some of the cases cited illustrate this point. Even more striking results may be accomplished by continued attention to details.

SOURCES OF MOLD IN BUTTER

It must be recognized from the beginning that molds are to be found wherever milk and its products are produced, transported, manufactured, or stored. The mold spores may be found at times in every substance which becomes a part of the finished product, and on materials making up the packages. They are especially prevalent on creamery equipment; in fact, molds are ready to establish a habitation wherever food materials and moisture are available. The spores, which are very resistant to drying, may be scattered about with the dust until they are deposited upon shelves, ledges, and containers, and on the products themselves. These facts make it necessary to take every precaution to protect the product and equipment from unnecessary exposure to contamination and to destroy the mold spores wherever they have gained access.

Milk and cream.—As soon as the milk leaves the cow, it is exposed to contamination by mold spores from the dust of the stable or yards, filth from the cow, unclean pails, strainer cloths, separators, and other equipment. Too often the cans from the creamery come to the patron poorly washed, seldom really sterilized. Cream cans may be used for carrying buttermilk to the farm. From a wide experience, it is certain that the buttermilk from the creamery tank cantains tremendously large numbers of molds. In the hundreds of samples of raw cream which have been examined in our laboratories, we have yet to find a single sample that was free from mold. Under conditions as they exist, however, the creamery operator must make the best of it. Thoro pasteurization of the cream overcomes this original contamination.

After the cream is pasteurized every precaution must be taken to prevent recontamination. Leaky vats, coils, stuffing boxes, covers, etc., often contribute molds to spoil a thoroly pasteurized cream. Drippings from ceilings, pipes, shaftings, etc., and dust from the air may add more molds. Occasionally, the hole in the cover of the vat used to accommodate a thermometer is full of decomposed cream badly infected with mold, and from it droplets may fall into the pasteurized cream. Raw cream must not be allowed to drip from pipe lines into a vat of pasteurized cream. A can of highly contaminated raw cream is often dumped into a vat of carefully pasteurized cream. No operator can expect good results when such practices are followed.

The operator may overcome contamination in raw cream by adequate pasteurization, but he must also prevent its recontamination by watchfulness and faithful attention to details.

Creamery equipment.—From the time the cream is pasteurized until it is made into butter and shipped out of the creamery, there is a constant possibility that it may be recontaminated from many sources, particularly from equipment. Sanitation is absolutely essential and must be maintained for the entire plant. This does not mean that sanitation must be practiced only after pasteurization. It must be carried out before, during, and after pasteurization.

The principal sources of contamination, as far as equipment is concerned, are *pipes, pumps,* and *churn.*

Pipes and pumps, unless they are taken down, cleaned, sterilized, and dried daily, become a tremendously important source of contamination. They should be easily dismantled, easily cleaned, and kept dry when not in use. Molds grow only where there is moisture. There is no reason why pipes and pumps should continue to be sources of mold.

The churn is perhaps the worst of all creamery equipment from the standpoint of mold contamination. It is the most difficult to clean and the easiest to neglect. Churns and workers often offer hiding

places for molds in the crevices, in the drum or workers, shelves (under side particularly), sight-glasses, bolt heads, stuffing boxes, doors, and gates. Constant attention must be given, not occasionally but every day.

The importance of daily sterilization of the churn is shown by Figures 9 and 10. The creamery where these tests were made has two churns. At the time of the visit, one churn was being used daily, the other had stood idle for several weeks.

Figure 10 illustrates what happened when it was necessary to use the idle churn because the other broke down. Note the excessive contamination which resulted. A sample of this butter was retained and after a few weeks the surface was found to be badly molded.

After this churning the churn was rinsed, scalded with boiling water, and cooled before adding the cream for the next churning, made on the same day. Plates 4, 5, and 6 were prepared from the cream in the churn, the butter, and the buttermilk, respectively, of this second churning. Some molds were still being added but not a fraction of those added to the first churning. The third churning in the same churn gave even better results, as indicated by 7, 8, and 9. This illustrates the necessity for sterilizing the churn daily and also the fact that continued use tends to keep the churn cleaner.

Packing tools, print boxes, and wooden trays are often carelessly washed and become contaminated after being allowed to stand in a dusty room. As the wood is often water- and grease-soaked, molds find a happy feeding ground and may then be introduced into the butter.

Wooden boxes and tubs are almost always subjected to mold contamination. If they are green or left in a damp place molds may develop in the pores of the wood.

Parchment paper and cloth circles are often left on open shelves in a damp or dusty storeroom, where they pick up mold spores.

Creamery equipment must be cleaned and sterilized daily and every effort made to keep it in good condition. "Sanitation" is the watchword.

Miscellaneous sources.—Water is often infected with molds. This is particularly true when water is stored in inaccessible open wooden tanks. Starter may be a source of contamination. If salt is left in a damp place or exposed to dust, it may contribute molds to the butter.

Wherever ventilation is bad in a creamery, refrigerator, or elsewhere, the condensation of vapor on the walls, ceiling, pipes, shafting, etc., may encourage the growth of mold on these surfaces with the result that drippings or dust from them may contaminate equipment or the product.

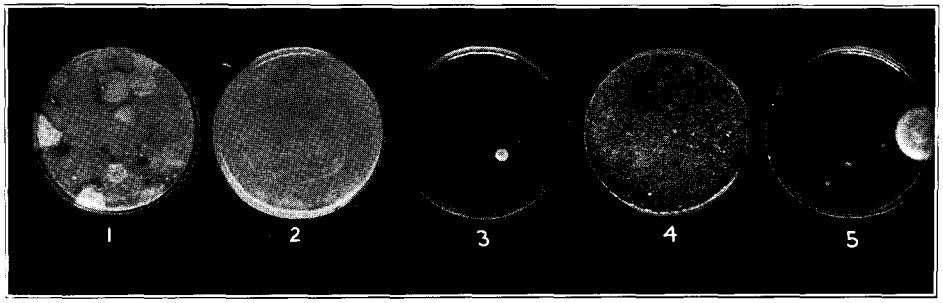


Fig. 9. Results of Contamination from Churn in Daily Use

1. Raw cream, shows many molds
2. Same cream after pasteruization, all molds destroyed
3. Rinse water from pipes and pumps, only one mold
4. Rinsings from idle churn, covered with mold
5. Rinsings from churn used daily, only five molds

The mold-laden dust of the creamery air is a source which must be considered. It may not be very important in a single instance but through an accumulation of dust in storerooms where parchment and tubs are stored, or in attics and similar places where there are open water tanks, and in the creamery where equipment may stand for some time unused, the effect may be very significant.

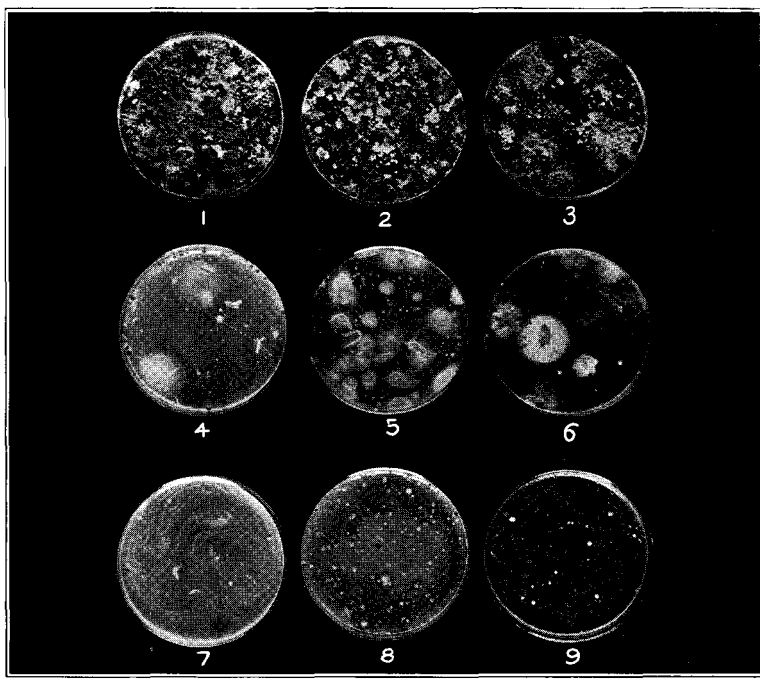


Fig. 10. Results of Contamination from Idle Churn

First churning
1. Cream shown in 2, Fig. 9
2. Buttermilk
3. Finished butter

Second churning
4. Cream shown in 2, Fig. 9
5. Buttermilk
6. Finished butter

Third churning
7. Cream
8. Buttermilk
9. Finished butter

Occasionally, where ice is used in bunkers for cooling rooms, the butter may be contaminated when it is left exposed in open receptacles. Ice is usually heavily contaminated with mold because of the way in which it is stored and handled.

It is also possible that a slight amount of contamination may be introduced from the hands or clothes of the operator.

It is clear that there are many sources of mold in the creamery and elsewhere and sources other than those mentioned may be found. However, the principle sources of mold in the creamery are *raw cream,*

pipes, pumps, churn, and *defective equipment.* Other sources, at times, may be more important, particularly parchment paper, water, and packing devices. None of these can be neglected. Even a source which may be of minor importance under ordinary conditions may develop into a major factor because of faulty practice.

Thoro pasteurization and sanitation will eliminate practically all of the sources. When all the sources are eliminated there is no longer a mold problem.