THE CAUSES AND PREVENTION OF MOTTLES IN BUTTER.

F. H. HALL, L. L. VAN SLYKE AND E. B. HART.

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* Connected with Fertilizer Control.
† Resigned Jan. 9, 1905.
‡ In Second Judicial Department.
In the days when making butter at home was the rule, mottled butter very frequently appeared on the tables of both those who made and those who bought this dairy product. Even the best housewives and dairy maids were occasionally disappointed to find, on cutting the handsomely molded prints, streaks and spots of whitish hue marring the beauty of the clear, bright yellow that usually rendered so attractive the product of their churns. Commercial dairies and creameries, also, have often had to accept a cut in the price of their butter when the buyer found these clouded, white streaks and splashes on the plug removed by his trier. Such butter was undoubtedly good and wholesome; but, so much does appearance count in the sale of dairy products, it graded as second class. This would have been disappointing enough, even if the cause and remedy for the trouble had been known; but no logical explanation of mottling was offered for years; and the phenomenon appeared and disappeared most strangely when all conditions were seemingly unchanged. At length it was observed that salt seemed to influence the degree of mottling; and finally, by a process of elimination, without direct proof, it came to be generally accepted by dairy authori-

*This is a brief review of Bulletin No. 263 of this Station, on the Proteids of Butter in their Relation to Mottled Butter, by L. L. Van Slyke and E. B. Hart. Any one specially interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete bulletin. The names of those who so request will be placed on the Station mailing list to receive future bulletins, popular or complete as desired. Bulletins are issued at irregular intervals, as investigations are completed, not monthly.
ties that unequal distribution of the salt, producing strong brine in some portions of the butter, weak brine in others, influenced the color of the butter-fat unequally and so produced the mottles. Acting upon this belief, modern buttermakers have adopted the method of churning to fine granules so that the salt might readily reach all parts of the butter and of distributing the salt as uniformly and as thoroughly as possible. At the same time the fineness of the granules promoted thorough washing and easy removal of the buttermilk. This, as we shall see later, was a very important factor. The steps of this process, though taken somewhat ignorantly, almost wholly conquered the trouble, so that today in up-to-date dairies, creameries and butter factories, mottling is comparatively infrequent.

But though successful in controlling the mottling, the process outlined above is not based upon the correct explanation of the origin of the trouble. In the first place, salt does not affect the color of butter-fat, and unequal distribution of salt will not cause mottles unless a certain other factor be present.

Also, butter in which the salt is very uniformly distributed may be badly mottled if the other necessary condition exists.

In proof of these propositions, attention is called to some recent experiments made at this Station.

Fresh, colored, unsalted butter was melted and filtered to separate the butter-fat from the other constituents of butter; and the melted, purified fat, after hardening, was cut into cubes. These cubes were immersed in 30 per cent. brine so that part of each cube was in the brine, part in the air. The brine did not produce the slightest increase in depth of color, nor was any change in color whatever to be discovered. In another experiment butter-fat was stirred with salt and a variegated color was produced, due to the undissolved grains of salt, but no mottling. The same effect could be produced by mixing any other white substance, like sugar, with the butter-fat. Still another test showed that unequal distribution of the salt could not, alone, produce mottling; for well-washed, fine butter-granules were placed in a layer in a butter-mold, a layer of salt sprinkled on, another layer of butter-granules placed on the salt, then salt
again on the butter and so on until the mold was filled. The resulting print, under this extreme treatment, showed no mottles.

Analyses were made of plugs taken from opposite ends of prints of butter that had been made under conditions producing marked mottling. Yet these analyses showed the salt to be very uniformly distributed, the variation being from 5.13 per ct. to 5.19 per ct., only, in one case, and from 4.66 to 4.73 in another. In unmottled butter, plugs similarly taken from opposite ends of pound prints showed wide variations: From 3.65 per ct. to 2.61 per ct. in one print; from 4.6 to 5.3 in another, and from 1.86 to 2.59 in a third print.

Uneven distribution of the salt, then, can not be the cause of the trouble; yet salt must bear a relation to mottling; for unsalted butter, whether made experimentally at the Station or commercially in dairies and creameries, never shows mottles.

It is also found that in mottled butter the whitish areas, "mottles," contain less salt than the darker portions. This is often quite evident to the taste and is plainly shown by chemical analysis. Two samples of mottled butter showed 0.91 per ct. and 0.70 per ct. of salt, respectively, in the lighter portions, and 5.45 per ct. and 6.74 per ct. in the darker portions.

A test print of butter, made under conditions that favor mottling, but not salted, was cut into chunks and these partially submerged in strong salt solution. In a few hours the surface of the submerged areas showed very marked mottling; but this did not extend into the mass of the butter, nor was there any appearance of mottling on the portions of the butter not covered by the brine.

Thus, the salt appears to act upon something else in the butter, and by its action upon this substance produces mottles.

Salt acts on casein compound. What is this hitherto unconsidered factor? It is the casein compound left in the butter through imperfect removal of the buttermilk.

In studies made at this Station during the past few years, the first satisfactory explanation of the forms and changes of casein in cheese-making has been worked out. Certain features in con-
nection with the compounds studied directed attention to these compounds as a possible cause of the mottling of butter; and investigation established the connection clearly.

Chemical analyses showed that in cream as ordinarily ripened, that is, when the lactic acid exceeds one-half of one per cent., the casein is all in the form of casein lactate. This compound is the substance most familiar to us in the form of curdled sour milk. The form of casein first produced from milk casein in the process of souring, base-free casein, (or simply casein) is soluble in a weak solution of salt; but casein lactate is insoluble in such a solution. The salt acts upon casein lactate physically, however, when in a strong solution; and in a few hours hardens and localizes it, so that in the case of buttermilk the white, more or less firm proteid separates from the liquid, leaving two quite distinct portions. This is clearly shown in the illustration opposite.

Now, in making butter, unless the greatest care is used, more or less buttermilk will be left in the butter, and the buttermilk contains casein lactate. When the salt is added to such butter it forms, with the small amount of water, a strong brine that acts upon the casein lactate just as it does when the latter is free in the buttermilk to which salt is added. It collects it in the small interstices left between the lumps of butter, hardens it and localizes it. When the butter is worked the white casein lactate is spread and drawn into the streaks, clouds and spots we know as mottles. The mottling does not show itself immediately, since it takes some time for the salt to produce its greatest effect on the proteid.

If the buttermilk be thoroughly removed from the butter-fat, there will be no mottling, no matter how irregularly the salt be distributed; for there will then be nothing present for the salt to act upon in any way that will effect color. This has been well proved in actual making of butter at the Station, as in some of the experiments already mentioned, and in others in which particular care was taken to have the butter freed from buttermilk. There were no mottles in well-washed butter.

On the other hand, mottling will not take place unless salt is added; for the casein lactate does not harden and become localized unless salt is present. It remains in suspension in the but-
termilk contained in the butter, in minute aggregations that affect the eye only by a slight lightening of the color of the butter as a whole.

The casein lactate does not "take" the salt as does butter-fat; so that the light areas contain less salt than the other portions of the butter.

The secret, then, in controlling mottles, is to get **How control** rid of the buttermilk. This is usually well done **mottling**. in modern, up-to-date buttermaking; as the churning to fine granules and the thorough washing recommended by all dairy authorities are the best possible means of freeing the butter from an excess of buttermilk. A certain amount of buttermilk is, of necessity, enclosed within the butter granules, but if these are small the amount of proteid (casein lactate) so held is not sufficient to cause mottling, while the small size of the granules promotes thorough washing and the removal of the buttermilk adhering to the outside of the granules, which is the true source of the mottles.

If the granules are pea-size or larger, or if they are soft through churning at too high a temperature or through washing with water above 50° F. and so tend to unite into lumps, thorough washing is exceedingly difficult if not impossible; and the casein lactate in the buttermilk held mechanically upon and between the large granules and lumps is usually sufficient to cause mottles after the salt is added.

Careful tests were made, in this investigation, to **Incidental factors**. ascertain what effect other factors might have upon mottling; and it was found that none had any influence except as it hindered or favored perfect removal of the buttermilk.

Very rich cream (40 per ct. of fat) and ordinary cream (20 per ct.) both gave unmottled butter when churned to granules the size of rice grains; but when overchurned or "gathered" in the buttermilk so that larger chunks were formed, both gave mottled butter. In the case of the rich cream when overchurned—and overchurning is more apt to occur with rich than with poor cream—the butter was pasty and the mottles occurred in large patches, the whole mass of butter being rather light-
colored from the presence of an excess of buttermilk. Aside from this liability to overchurning in the case of rich cream, the percentage of fat in the cream has no effect on mottling.

Neither does the degree of acidity influence the trouble. Butter made from sweet cream or from cream varying in acidity from 0.22 to 0.78 per ct. was free from mottles when churned to small granules and thoroughly washed with cold water. When over-churned or washed with lukewarm water so that lumps were formed, similar creams, whether low or high in acidity, gave mottled butter.

Similarly, churning at low temperatures tends to prevent mottling, as it makes it easier to keep the butter in small particles and so promotes thorough washing. Churning at higher temperatures favors the production of larger masses of butter and makes it less easy to remove the buttermilk.

As already clearly indicated, the size of the granules of butter is exceedingly important; for, in the tests, when butter was churned to rice-grain size it was easy to free it from the buttermilk by two washings with water below 50° F., preferably at 40° F.; but when the granules were as large as peas traces of mottles showed unless the washing was done with very cold water and very thoroughly. When the granules were of hickory-nut size or larger it was almost impossible to secure unmottled butter, however carefully other conditions were controlled. The illustration on the title page shows butter properly and improperly made, so far as ease in freeing from buttermilk is concerned.

The temperature of the wash water is important though it may vary somewhat according to the natural hardness of the butter due to feed or breed. In our tests, unless it was below 50° F. it did not harden the surfaces of the granules and these tended to unite, forming masses that held the buttermilk in such a way that it was almost impossible to wash it out. This, invariably, means mottling.

When the butter is properly churned and washed free from buttermilk, no amount of working will produce mottles; but if the conditions have favored the production of mottles, working will not free the butter from them. It may, if carried far enough to injure or destroy the grain of the butter, break or draw the
mottles to pieces so that they become smaller and show less plainly; but careful examination will reveal the casein lactate scattered in minute portions all through the butter, so that the whole mass appears lighter in color.

Since the presence of mottles in butter is primarily due to an excess of buttermilk in the mass directions of butter granules, the most effective method of preventing mottled butter is to free the butter granules as completely as practicable from the buttermilk adhering to the small granules. In order to accomplish this, the churning should be stopped when the granules are about the size of rice grains, preferably at a temperature of 50° to 55° F. After the buttermilk has been drawn from the granules, they are treated with an amount of water at 35° to 45° F., about equal to the buttermilk drawn off, the churn being rotated a few times to insure complete contact, after which the water is drawn off and the granules are similarly treated a second time. The granules are then allowed to drain; the final drainage water from the granules should be clear. After this the salting and working are carried out in the usual way.

In working with large quantities of butter, it is obvious that somewhat more care will need to be used to make the washing effective than in the case of smaller amounts.