THE CAUSE AND CONTROL OF "BUTTONS" IN SWEETENED CONDENSED MILK

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The so-called "buttons" which are occasionally found in condensed milk are reddish-brown masses of curd, usually regular in their outline and resembling, as their name indicates, a button in general appearance. The consistency is cheesy and is sufficiently firm to allow them to be removed from the surface of the milk on which they float and to be washed free of the thick milk. They may be as small as $\frac{1}{4}$ inch in diameter, but the typical button has a diameter of about $\frac{1}{2}$ inch and may be as large as $\frac{3}{4}$ inch. This description does not apply to the reddish lumps which are sometimes observed in cans sealed with solder. These are caused by drops of flux which are sometimes forced through so that a small amount of the material gets into the milk, producing a discoloration and a lump of curd. These can be usually distinguished from the real buttons by their irregular shape and softer consistency.

The general appearance of well developed buttons is shown in plate 1e. They are known to occur only in sweetened milk, and are found in both skim and whole milk, and in stored bulk goods as well as in the canned product. We have no data on the extent of the trouble or the amount of damage it causes, but it is evidently something which may occur in the product of any factory at any season of the year.

The milk itself is not seriously injured either in flavor or in food value, but the appearance of the can when opened is objectionable and would cause its rejection as spoiled by most consumers.

[1] The authors are indebted to Mr. F. R. Evans and Mr. E. F. Deysher for assistance in preparing milk used in inoculation experiments.

THE CAUSE OF BUTTONS

Buttons are usually supposed to be caused by molds; in fact, it is not unusual in the industry to refer to them as "mold buttons." So far as we know, however, there is no record prior to the experiments here described of any actual proof of connection between mold growth and the buttons.

Sometimes a slight fuzzy appearance may be observed on the surface of a button, and microscopic examination not infrequently reveals mold-like hyphæ on the surface or in the interior of the button. On the other hand inoculations from the buttons to media suitable for the propagation of molds usually fails to produce any growth. This is probably due to the age of the material usually available for this purpose. The knowledge that canned milk contains buttons ordinarily comes only when the defective milk is returned by the dealer.

An outbreak of the trouble in a factory under our control gave us an opportunity to secure an abundant supply. By opening cans of various ages we were able to secure buttons in different stages of development, from simple mold colonies to typical buttons from which all evidence of the mold had disappeared. From the early stages of these buttons we obtained mold cultures which in controlled inoculation experiments produced typical buttons.

In these experiments considerable difficulty was experienced in controlling the conditions so that all of the uninoculated checks were free from mold colonies, and many of the earlier sets were invalidated for this reason. Even in milk condensed and cooled in flasks with all the usual precautions against infection many of the check cans would show mold colonies and thus render any conclusions of doubtful validity. This difficulty was finally overcome by transferring the condensed milk to small Erlenmyer flasks which had previously been cotton-plugged and dry-sterilized. The milk in these containers was carefully heated in a water-bath to a temperature of 60°C. (140°F.) and held for thirty minutes. In this way the mold spores were destroyed without seriously affecting the physical condition of the milk. After inoculation from agar cultures the cotton plugs were replaced with sterile

rubber stoppers which were sealed in with a rubber cement used successfully in high-vacuum work. It is very essential that the supply of air be limited to that contained in the small space between the milk and the top of the container.

A typical example of an experiment of this kind is given in table 1. In this case six uninoculated flasks were held as checks and six were inoculated with a culture obtained from a typical button which had been identified by Miss Church of the Bureau

TABLE 1

Results of examination of condensed milk in sealed flasks inoculated with Aspergillus repens

DAYS	RESULTS
	Inoculated flasks
5	Three flasks have small mold colonies
8	Four flasks have well developed sporulating colonies
10	Fifth flask has 2 small colonies
12	Opened one flask and made agar culture
25	Colonies beginning to show reddish yellow color
31	All colonies have distinct reddish color
74	Five of six flasks have reddish colonies from which nearly all hyphae have disappeared. Characteristic buttons, but not so thick nor so sharply defined as typical buttons found in old cans
	Check flasks
74	Clean white surface. No mold colonies or buttons

of Chemistry as Aspergillus repens. These flasks were all held in a dark locker at room temperature.

The culture obtained on the twelfth day was found to be identical with the inoculated organisms.

From this and many other observations of a similar nature we may conclude that the button is due to the growth of a mold colony on the surface of the milk. It is apparent that the life of the mold is short and that the button is in the nature of a by-product of the growth itself. The button is made by a hardening of the casein, probable through enzym action, and continues to

develop after the mold colony has ceased to grow. We have often observed that when there is a leak in the can, even the most minute pin hole, the growth of the mold continues until the surface of the milk is covered with a felt-like growth. Under these conditions there can be no true buttons formed. In perfect cans, observations which will be reported elsewhere lead us to believe that the oxygen is almost if not quite used up in about two weeks. Since the molds are strict aerobes, growth must cease before this time. The mold hyphæ slowly disintegrate until in the old and typical button all evidence of the mold colony has disappeared.

The development from a mold colony just beginning to form spores to a button giving no indication of mold growth is shown in plate 1. The time required for the developemnt of the various stages shown in these photographs probably varies with the temperature, amount of air available, and possibly other factors. The mold colony usually appears in five to ten days. Growth probably ceases in two to three weeks on account of the exhaustion of the air. In one month the reddish-brown discoloration is quite evident and at the end of two months the button has usually assumed definite form. The disintegration of the mold hyphæ is a slow process and may not be complete before 5 or 6 months. The photographs shown in plate 1e were taken when the milk was 9 months old.

Molds of various species obtained from different sources, particularly empty condensed-milk cans, have been used in inoculation experiments, and while most of these have grown fairly well on the condensed milk and some have produced discolored spots, Aspergillus repens is the only one known to produce typical buttons. It is not impossible that other molds may produce buttons under favorable conditions, but the frequency with which we have isolated Aspergillus repens from buttons and our failure to produce buttons with others lead us to believe that this mold is the usual if not the only cause.

THE CONTROL OF BUTTONS

Exclusion of contamination. The molds and their spores are killed at a comparatively low temperature. According to Thom and Ayers[2] the spores of nearly all species of molds are killed by thirty minutes exposure to moist heat at 140°F., while the same exposure to 145°F. killed the spores of all but three of the large number of species tried. Aspergillus repens was one of these three, but the statement is made that the three molds surviving are found only occasionally in milk. They would probably be killed by the temperature of the vacuum pan, and most certainly by the forewarming. The contamination, then, comes between the pan and the can sealer.

Mold spores are very light and float in the open air even more readily than bacteria, but the moist air and clean walls and floors of the better plants are probably quite free from molds. The cans, however, are exposed to dust at various stages of their manufacture and shipment, and are almost always used without any attempt at sterilization. It might be expected that practically every can would be contaminated with button-forming molds, but the freedom of the greater part of condensed milk from buttons indicates that the can is not a serious source of contamination. Although we have examined a large number of cans, we have not isolated Aspergillus repens in a single instance.

The factory in which these experiments were made is so arranged that it was difficult to protect the condensed milk from mold infection. The pan was located in an open space extending from the second floor into an attic used for storage purposes. Notwithstanding these unfavorable conditions, by exercising unusual precautions we were able to protect the milk from contamination during the cooling and filling, and produce milk entirely free from buttons. It is probable that in properly constructued plants preventive measures of this kind will be sufficient to insure a high degree of freedom from buttons.

[2] Effect of pasteurization on mold spores. Jour. Agric. Res., vi, 153-166. 1916.

Low temperatures. It is always possible by low-temperature storage to inhibit changes brought about by microorganisms. Many molds grow slowly at reduced temperatures even in refrigerators held near the freezing point, provided moisture and other conditions are favorable. However, the mold which we have found producing buttons grows very poorly at temperatures of 20°C. (68°F.) or lower. We have never observed buttons on milk held at 20°C. or below. It is hardly practicable under commercial conditions to store the finished product for any length of time in cold storage, and this method can not be considered as a solution of the problem.

Exclusion of oxygen. Buttons may be entirely and certainly prevented by taking advantage of the fact that molds grow only where a liberal supply of oxygen is available. This has been demonstrated by holding condensed milk in glass flasks sealed while under a vacuum and also in cans sealed while held in an evacuated bell jar. In this latter experiment baby-sized cans were filled with condensed skim milk containing 26 per cent milk solids from which the air had been partially removed by allowing the milk to flow slowly into a large flask held under a vacuum of about 27 inches. After filling, the milk was inoculated from agar cultures of Aspergillus repens and the cap soldered on, the vent being left open.

The cans were placed, one at a time, under a bell jar connected with a manometer and a vacuum pump provided with stop cocks which made it possible to maintain the vacuum at any desired point. When the vacuum had been maintained at the predetermined point for about a minute the vent was sealed by means of an electric soldering iron so arranged that it could be operated without breaking the vacuum. These cans were held at room temperature, and two cans from each lot were examined at the end of two months. The results of this examination are given in table 2.

A better idea of the general appearance of this milk is given in plate 2. The discoloration shown in the upper part of the can sealed under a 20-inch vacuum was probably caused by the flux used in soldering the cap. While this photograph shows that

the growth of mold was entirely prevented by a vacuum of 20 inches it fails to bring out the remarkable difference in color produced probably by some chemical change to which oxygen is essential. The cans sealed under atmospheric pressure had a comparatively thin layer of a dirty yellowish appearance. On the other hand the cans sealed under a vacuum of 25 and 26¾ inches preserved the original appearance of the freshly condensed milk. Between these extremes were gradations in color in direct relation to the extent of the exhaustion of the air.

The perfection of a machine which would seal cans under vacuum on a commercial scale would make it possible, excluding

TABLE 2

The condition of condensed milk sealed under vacuum

PRESSURE WHEN SEALED	CONDITION OF SURFACE	COLOR OF SURFACE OF MILK*
inches		
Atmospheric	Small half-developed buttons	Pale orange yellow
10	Very small buttons; one can has well developed button on margin	Warm buff
15	3 or 4 small, half-developed buttons; one has slight discoloration and undeveloped mold colony	Maize yellow
20	Small discoloration on margin of one can	Naples yellow
25	No mold or discoloration	Cream color
26¾	No mold or discoloration	Cream color

* According to Ridgeway's standard colors.

leaking cans, to entirely eliminate buttons or other defects due to the growth of molds. It is possible also that changes produced by oxidation would be materially reduced.

SUMMARY

"Buttons" are hard, reddish-brown lumps of curd occurring on sweetened condensed milk.

They are caused by the growth of Aspergillus repens and possibly other molds. The development of the mold colony is restricted by the exhaustion of the oxygen in the can and the button

itself is probably due to enzym action continued after the death of the mold.

Molds are destroyed in the process of condensing milk, and the contamination causing buttons occurs after the milk leaves the pan. Careful attention to sanitation of the plant, expecially protection against dust, should be effective in excluding the greater part of the contamination.

Buttons do not develop in milk held at 20°C. (68°F.), but cold storage is probably not practicable under commercial conditions.

Molds do not grow in an atmosphere deficient in oxygen, and sealing the cans under a vacuum of 20 inches or more is an effective means of controlling buttons.

PLATE 1

FIG. 1a. SHOWING TWO MOLD COLONIES JUST BEGINNING TO SPORULATE

FIG. 1b. THE MILK IS SLIGHTLY DISCOLORED UNDER THE MOLD COLONY

FIG. 1c. THE COLOR IS DEEPER BUT THE MOLD IS STILL VERY EVIDENT

FIG. 1d. THE DISCOLORATION IS MORE MARKED, THE BUTTON IS THICKER SO THAT IT IS SLIGHTLY ELEVATED ABOVE THE SURFACE OF THE MILK, AND THE MOLD IS DISAPPEARING

FIG. 1e. TYPICAL BUTTONS OF DIFFERENT SIZES FROM WHICH ALL SIGNS OF MOLD HAVE DISAPPEARED

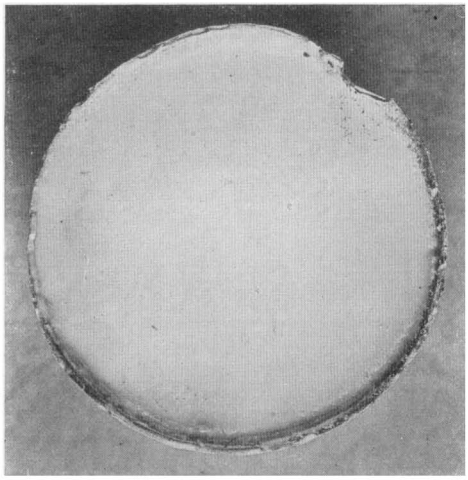


FIG. 1a

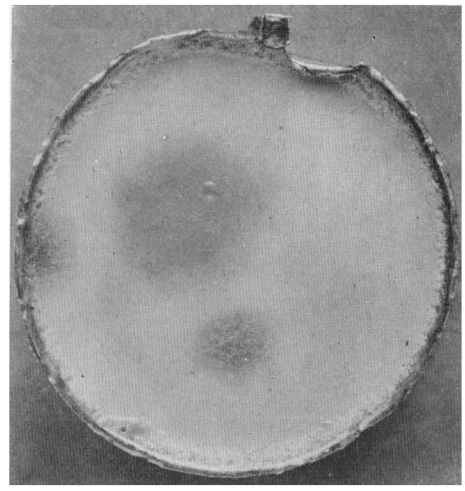


FIG. 1b

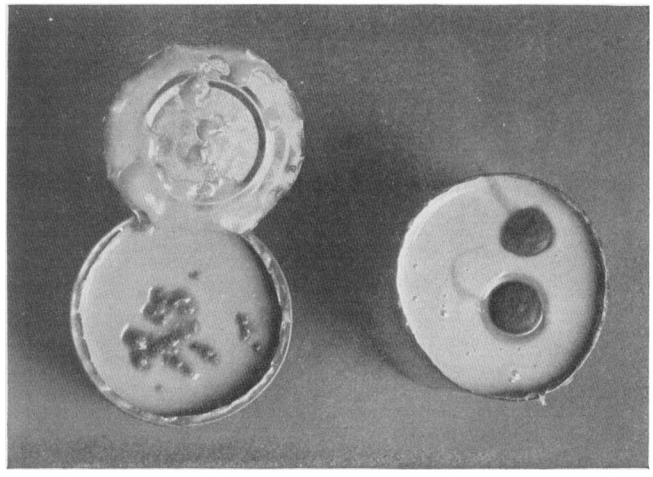


FIG. 1e

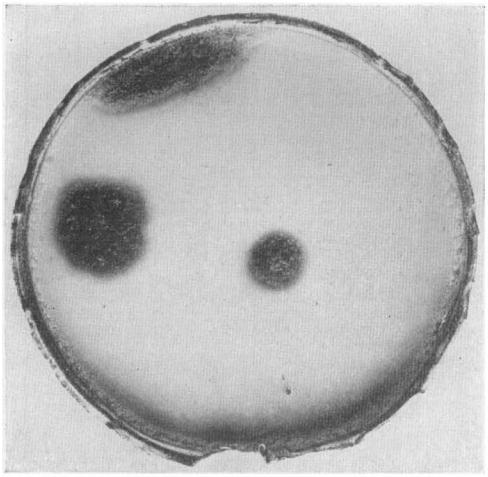


FIG. 1d

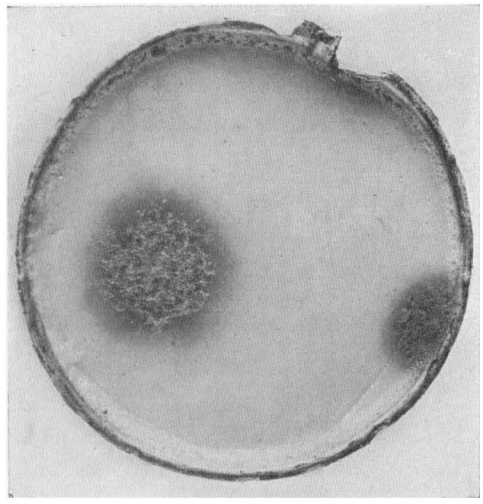
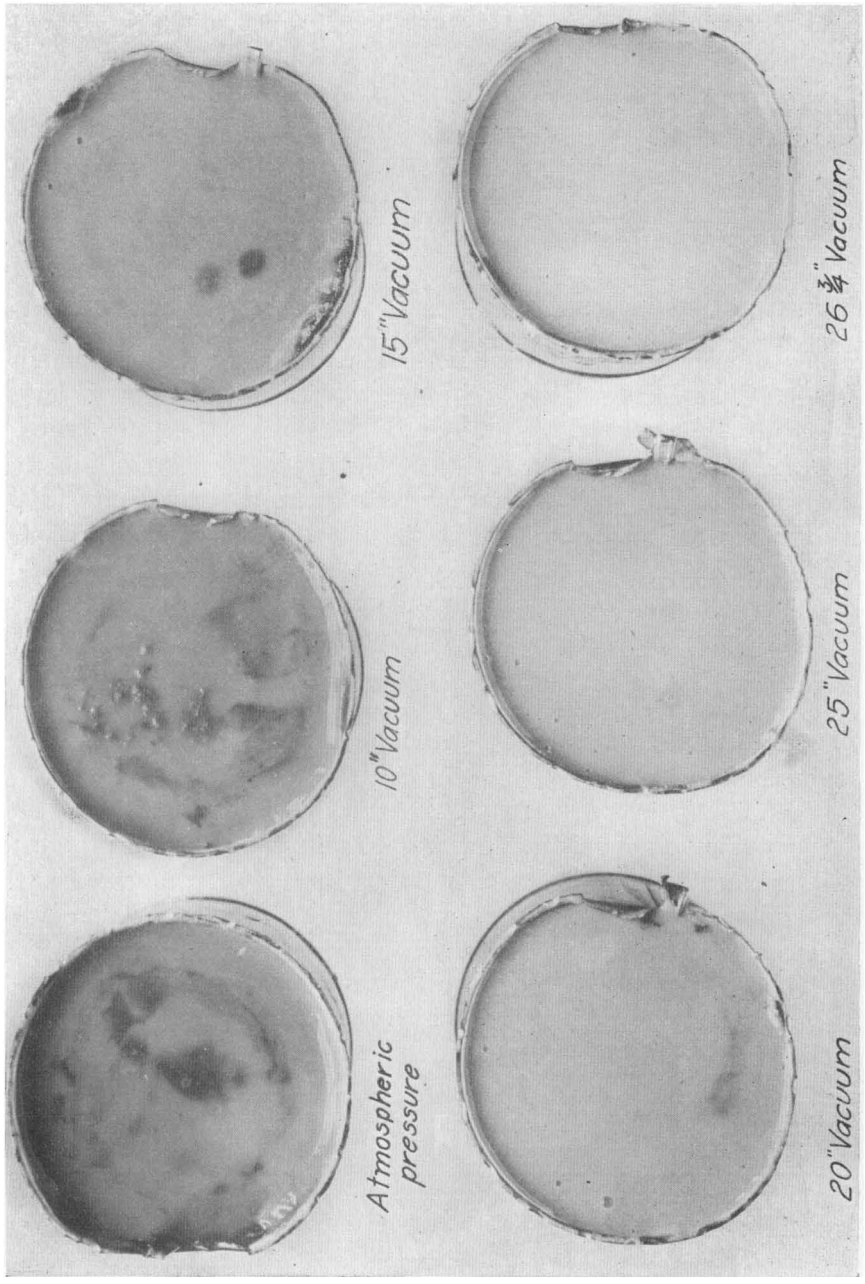


FIG. 1c

PLATE 2

EFFECT OF AIR ON THE DEVELOPMENT OF BUTTONS AND ON THE COLOR OF THE MILK.

THE DARK SPOT ON THE CAN SEALED UNDER A 20 INCH VACUUM WAS PROBABLY CAUSED BY FLUX USED IN SEALING THE CAN.


Atmospheric pressure
10" Vacuum
15" Vacuum
20" Vacuum
25" Vacuum
26¾" Vacuum