Methods Used to Increase Blue Mold Growth in Cheese[1]

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THE work of Thom and Currie (5) and several other investigators has shown the significance of oxygen for the growth of *Penicillium roqueforti*. Some of the possible methods of increasing the supply of oxygen to favor the growth of *P. roqueforti* in Wensleydale cheese are herein considered.

LITERATURE

The supply of oxygen has been shown to be low in Roquefort cheese (5). Undoubtedly this condition is produced largely by the high content of CO_2, which is formed during the ripening of the cheese (6) through the action of the *Streptococcus lactis* group (2) (6) and *P. roqueforti* (5) (1).

Although it is recognized that *P. roqueforti* will grow in an atmosphere of 5 percent oxygen (5), a large number of what are supposed to be blue-veined cheeses remain white because the oxygen supply is considerably below the above percentage (5). In addition, several authorities (3) (4) report the practice of skewering and scraping cheese to produce aerobic conditions which encourage the growth of *P. roqueforti*.

EXPERIMENT 1

DRAWING AIR INTO THE CHEESE

Wensleydale cheeses of from 5 to 10 months of age were fitted with glass catheter tubes made from one-half inch test tubes. The cheeses were bored in the center with a cheese trier and a corked catheter tube forced into the hole. The corks were removed and suction applied to two cheeses at a time from a suction water pump for 24 hours.

[1] The experiments herein reported were conducted at the University of British Columbia and directed chiefly by Dr. B. W. Hammer. The data were analyzed and prepared for publication at the University of Idaho.

The cheeses were examined about six weeks after the application of the suction. Out of the 14 cheeses treated, only 3 developed satisfactory mold. The remainder developed mold only in and near the hole produced by the trier. Air leaks down the sides of the tubes accounted for this growth. In general, drawing air into the cheese by suction does not point to a satisfactory way of increasing the growth of *P. roqueforti* in cheese.

EXPERIMENT 2

INJECTING OXYGEN INTO THE CHEESE

Cheeses similar to those in experiment 1 were fitted with catheter tubes by the method just described; and, in addition, hot wax was poured around the outside of the tube to seal the junction between cheese and tube. The oxygen was injected by connecting the catheter tube with an oxygen cylinder and allowing a slow flow of oxygen into each cheese for five minutes. Twelve five-minute injections were given each cheese over a period of 27 days.

Out of the 12 cheeses treated, only 4 developed satisfactory mold. In the other cheeses mold growth was uneven and occurred chiefly around the center hole. In general the method cannot be considered satisfactory because of uneven mold development.

EXPERIMENTS 3A AND 3B

Henry's law states: "The quantity of a gas (either weight or volume) at N.T.P. dissolved by a given volume of a given liquid at a given temperature is directly proportional to the pressure under which the absorption takes place." This principle was applied to remove CO_2 from cheese.

EXPERIMENT 3A

ALTERNATING REDUCED AND ATMOSPHERIC PRESSURE ON CHEESE IN AN IRON CYLINDER

Seven cheeses, six to eight weeks old, were placed in a specially constructed 10-inch steam pipe cylinder and subjected alternately to reduced and atmospheric pressure. Twenty-four applications of reduced pressure for seven hours each were given over a period of 28 days. The average reduced pressure was 144 mm., or 616 mm. vacuum.

Although it was proved that CO_2 was removed from the cheese to the extent of about 0.1 percent, little gain in the growth of mold in the cheese was noted. Three out of the seven cheeses treated showed slight mold growth, while the seven control cheeses showed no mold. The process of aeration did not materially reduce the weight of the treated cheese beyond that of the control.

Cultures of *P. roqueforti* grown on potato agar developed normally when subjected to the treatment.

EXPERIMENT 3B

A second experiment was conducted to determine the value of less frequent suction periods over an extended period, the permeability of the rind to gases and the significance of skewering the cheese.

Wensleydale cheeses, two to three months old, were selected and divided into four groups of seven cheeses each:

Group A, control.

Group B, subjected to reduced pressure twice a week for six weeks.

Group C, the bandages removed and cheese subjected to reduced pressure twice a week for six weeks.

Group D, the bandages removed and cheese skewered from one end (28 holes 1/16 of an inch) and then subjected to reduced pressure twice a week for six weeks.

The scores for mold growth for each cheese made directly after the experiment and 10 weeks later are given in table 1, in which two significant points are brought out:

1. The alternation of reduced and atmospheric pressure hastened the mold growth but did not permanently improve it.
2. Skewering produced a definite increase in mold growth for the cheese in Group D at both scorings.

EXPERIMENTS 4A AND 4B

SUBJECTING THE CHEESE TO VARIOUS PRESSURES

The door of the iron cylinder was strengthened with six extra bolts so that the cheese could be subjected to high pressure. In spite of these precautions high pressures could not be maintained but dropped about 50 percent in 24 hours.

EXPERIMENT 4A

SUBJECTING THE CHEESE TO FLUCTUATING BUT CONTINUOUS PRESSURE

Eight Wensleydale cheeses, from five to seven months old, were put in the iron cylinder and subjected for 21 days to a pressure which varied from 45 to 80 pounds per square inch.

These cheeses were examined directly after the process. Three cheeses only showed a slight improvement in mold growth over that of the control.

Cultures of *P. roqueforti* grown on potato agar showed a very abnormal and stunted growth when subjected to these pressures with the cheese. After removal from the pressure chamber, however, they assumed a more normal appearance in a few days.

EXPERIMENT 4B

ALTERNATE HIGH AND ATMOSPHERIC PRESSURE

Because of the abnormal growth of the cultures it was decided to subject the cheese to two-day periods of high pressure at intervals of

TABLE 1. *Score for mold growth of Wensleydale cheese subjected to semi-weekly applications of reduced pressure over a period of six weeks*

Group	1928 Date of first treatment	Jan. 7, 1929 Directly after completion of treatment. Mold growth score, maximum 25 pts.[1]	March 16, 1929 10 weeks after completion of the treatment. Mold growth score, maximum 25 pts.[1]
A	Aug. 21	0	23
Control	Aug. 23	0	15
(not treated to	Aug. 30	0	10
reduced pressure)	Sept. 6	0	0
	Sept. 12	0	15
	Sept. 14	0	18
	Sept. 19	0	21
Average		0	14.6
B	Aug. 21	23	23
Bandage on	Aug. 23	0	10
	Aug. 30	15	15
	Sept. 6	0	0
	Sept. 12	23	22.5
	Sept. 14	0	0
	Sept. 19	18	22
Average		11.3	13.2
C	Aug. 21	20	—
Bandage	Aug. 23	15	21
removed	Aug. 30	0	18
	Sept. 6	0	0
	Sept. 12	0	15
	Sept. 14	15	22
	Sept. 19	0	10
Average		7.1	14.3
D	Aug. 21	20	21
Bandage removed	Aug. 23	18	18
and cheese skew-	Aug. 30	15	18
ered	Sept. 6	0	10
	Sept. 12	21	20
	Sept. 14	18	22
	Sept. 19	15	23
Average		15.3	18.9

[1] For simplicity of recording, each cheese was scored on a basis of 25 points for mold growth by the following system, which has been used throughout these and other experiments: Scores from 0 to 15 points represent from no growth to slight growth; scores from 15 to 25 points represent from fair to excellent.

four days. Two pressure levels were used: One with a maximum of 50 pounds usually dropping to 20 pounds, and another of 100 pounds usually dropping to about 50 pounds. Cheeses from one to three months old were used in the experiment and examined at an age when they should have been mature—namely, seven months old.

At 50 pounds maximum pressure two out of six cheeses developed satisfactory mold growth and three others slight mold growth, while only one of the controls developed satisfactory mold and the remaining five no mold growth.

At 100 pounds maximum pressure four out of seven cheeses developed satisfactory mold and two others displayed some mold growth. None of the control cheeses developed mold.

Cultures of *P. roqueforti* grown on potato agar and subjected to either of the above conditions grew normally.

DISCUSSION

Sucking air and injecting oxygen into Wensleydale cheese must be considered an unsatisfactory means of attempting to increase mold growth. Neither method gave a substantial increase of mold growth in the cheese; moreover, the plug hole would materially reduce the sale value of the cheese.

Alternating reduced and atmospheric pressure hastened mold growth. This method in combination with skewering the cheese also increased the mold growth in the cheese. It is recognized, however, that skewering alone, without further treatment, would probably have increased the mold growth in the cheese.

Thus far the subjecting of cheese to intermittent, high pressure has displayed desired results and warrants further study. The most suitable age of the cheese to apply the pressure, the degree of pressure to apply and the time intervals should be determined before practical application can be attempted.

SUMMARY

1. Wensleydale cheeses which were bored in the center and equipped with a suction tube to admit air did not develop satisfactory mold growth.

2. Similar cheeses bored in the center and fitted with a tube for the injection of oxygen resulted in only a few of these cheeses developing satisfactory mold. In general the mold growth was uneven and chiefly around the center hole.

3. Subjecting Wensleydale cheeses to alternating reduced and atmospheric pressure in an iron cylinder hastened the growth of mold but did not permanently improve it. Skewering the cheeses in addition to this treatment produced a definite increase in mold growth.

4. Subjecting Wensleydale cheeses to high pressures in an iron cylinder during ripening to increase the dissolved oxygen was investigated. Both continuous and intermittent pressures were used. Although both methods showed some improvement, the intermittent method of applying the pressure gave the best results.

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