
The Effect of Certain *Penicillia* on the Volatile Acidity and the Flavor of Iowa Blue Cheese (Roquefort Type)¹

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IOWA blue cheese, a Roquefort type made from cows' milk, has been manufactured successfully for several years at the Department of Dairy Industry, Iowa State College. Several hundred thousand pounds of milk have been made into cheese and sold through various marketing channels.

In order to learn more concerning the numerous factors involved in the ripening of blue cheese, microbiological and chemical studies, of which this report is a part, are in progress at the Iowa Agricultural Experiment Station.

The amounts and types of volatile acids produced in Roquefort type cheeses appear to be of primary importance from the standpoint of the cheese flavor. Currie (1) has shown that the characteristic peppery flavor of Roquefort cheese is due, in large part, to the accumulation of certain products in the cheese during ripening—namely, caproic, caprylic and capric acids with their easily hydrolyzable salts. Presumably, these products result largely from the hydrolysis of some of the cheese fat by enzymes of the *penicillia*.

It is logical to assume that individual strains of *penicillia* would show variations with respect to their action on the cheese fat, in which case certain strains might be more suitable than others in assisting the normal ripening of the cheese. The work herein reported compares the effects of each of eight strains of *penicillia* on the volatile acidity and the flavor of blue cheese made with the various strains.

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GENERAL PROCEDURE

Of the eight strains of penicillia used in the comparisons, three were obtained from experiment station collections, while the remaining strains were isolated from various samples of blue-veined cheeses. The sources and the identities of the strains employed are presented in the following table.

Strain No.	Source	Identified as
1	Butterfly brand cheese	<i>P. roqueforti</i>
2	Neptune brand cheese	<i>P. oxalycum</i>
3	European brand cheese	<i>P. chrysogenum</i>
4	N. S. Golding, 16	<i>P. roqueforti</i>
5	N. S. Golding, 33	<i>P. roqueforti</i>
6	Grove City cheese	<i>P. roqueforti</i>
7	C. Thom	<i>P. roqueforti</i>
8	Zenith brand cheese	<i>P. roqueforti</i>

Several hundred grams of mold-spore powder were prepared from each strain of mold by the method suggested by Hussong and Hammer (3). The powder was placed in sterile containers and stored at a low temperature until the cheese was manufactured.

In the experiments four lots of blue cheese were made; each lot contained eight cheese weighing about five pounds each. The method of manufacture employed was that developed by Goss, Nielsen and Mortensen (2). At the customary period in the manufacturing procedure, the curd of each cheese in a lot was inoculated with one of the mold strains; usually 0.2 grams of mold powder were dusted onto the curd necessary for one cheese. Care was taken to control the moisture and salt contents of the cheese in a lot so as to insure uniformity of composition. Analyses of lots of cheese at several periods during the ripening showed that the variations in the moisture content of individual cheese did not exceed 2.0 percent, while the salt content did not vary more than 1.8 percent.

EXAMINATION AND CHEMICAL ANALYSES

Each lot of cheese was examined organoleptically, and the volatile acidities were studied at a period during the ripening; lot 1 was examined after 17 weeks, lot 2 after 23 weeks, lot 3 after 30 weeks and lot 4 after 37 weeks. The cheese were scored for flavor by several competent judges and comparisons of the mold growth and color of the cheese were also made.

The volatile acidities of the cheese were studied by distilling the cheese with steam after the addition of water and sulphuric acid. Usually 200 grams of finely divided cheese, 400 ml. of water and 25 ml. of sulphuric acid (25 percent by volume) were distilled with steam from a balloon

flask until one liter of distillate was obtained. One hundred ml. of the distillate were titrated with N/10 NaOH and the volatile acidity calculated as the ml. of N/10 NaOH required for the neutralization of the first liter of distillate obtained when a 200-gram portion of cheese was distilled with steam.

The method employed to determine, in a general way, the types of volatile acids present in the distillates was the estimation of the percent Ba in the Ba salt. The procedure used in determining the percent of Ba was to add a little less than the calculated amount of $\text{Ba}(\text{OH})_2$ to the remaining 900 ml. of distillate (the 100 ml. portion, used previously for determining the total volatile acidity and to which indicator had been added, was discarded). The aqueous solution of the Ba salt was concentrated on a water bath to about 50 ml. and filtered. After evaporation to dryness on the water bath the salt was recrystallized, dried at 100°C . and the percent Ba determined as follows: Approximately $\frac{1}{2}$ gram was weighed out, dissolved in from 75 to 100 ml. of hot water, heated to boiling and a slight excess of N/1 H_2SO_4 slowly added. After digesting from 8 to 10 hours on a hot plate the BaSO_4 was filtered off, ignited and weighed. From the weight of BaSO_4 and the weight of the original salt the percent Ba in the latter was calculated.

RESULTS OBTAINED

The results obtained on the effect of the individual strains of penicillia on the volatile acidity and the flavor of the cheese studied is shown in table 1. The total volatile acidities of all the cheese appeared to increase as the ripening progressed. There were, however, large variations in the amounts of volatile acids among the cheese in the same lot. In the relatively young cheese of lot 1 (aged 17 weeks), cheese made with strain 7 had a volatile acidity of only 15 as compared with 26 for the cheese made with strain 3. The same large variations in the amounts of volatile acids were also apparent in the well-ripened cheese. In the comparatively old cheese of lot 4 (aged 37 weeks), cheese made with strain 7 had a volatile acidity of 62 as compared with 100 for the cheese made with strain 1. These results indicate that the strain of mold employed may have considerable influence on the amounts of volatile acids produced in the cheese.

The barium values obtained on the salts prepared from the volatile acid distillates varied only slightly among the individual cheese in a lot. For example, in lot 1 the lowest value obtained was 46.87 on the cheese made with strain 2, whereas the highest value was 49.84 on the cheese made with strain 4, or a difference of only 2.97. Since the variations in the barium values of cheese in the same lot were relatively small, it appears that the strain of mold employed has little effect on the types of volatile acids produced. There were, however, relatively large differences in the barium values obtained among the four lots of cheese. Apparently the barium values decreased as the ripening periods increased. The

TABLE 1. *Effect of certain strains of penicillia on the volatile acidity and the flavor of Iowa blue cheese (Roquefort type)*

	Mold number							
	1	2	3	4	5	6	7	8
Lot 1. Cheese aged 17 weeks								
Volatile acidity ¹	20	23	26	16	25	16	15	18
% Ba in barium salt	48.48	46.87	47.63	49.84	48.06	48.89	47.83	47.93
Placing on flavor	3	5	8	4	1	6	7	2
Lot 2. Cheese aged 23 weeks								
Volatile acidity ¹	22	26	21	14	28	24	16	25
% Ba in barium salt	41.37	40.31	41.96	40.32	42.32	42.46	41.06	42.50
Placing on flavor	2	5	7	6	1	8	4	3
Lot 3. Cheese aged 30 weeks								
Volatile acidity ¹	50	24	32	38	32	28	35	33
% Ba in barium salt	42.49	39.95	41.51	41.14	42.37	40.76	41.47	41.08
Placing on flavor	2	5	3	6	1	8	7	4
Lot 4. Cheese aged 37 weeks								
Volatile acidity ¹	100	82	90	74	96	74	62	82
% Ba in barium salt	41.38	41.31	41.38	41.32	42.00	40.98	41.12	40.42
Placing on flavor	3	2	6	4	1	5	8	7

¹ No. ml. of N/10 normal NaOH required for the neutralization of the first liter of distillate obtained when a 200-gram portion of cheese was distilled with steam.

average of the barium values for the eight cheese of lot 1 (aged 17 weeks) was 48.19 as compared with 41.24 for those of lot 4 (aged 37 weeks). Presumably there was a greater percentage of volatile acids of relatively high molecular weight, such as caproic, caprylic and capric acids, in the old cheese than in the young cheese where acetic and propionic acids apparently predominated.

The strain of mold employed seemed to influence the flavor of the

cheese considerably. Certain strains regularly produced cheese having the characteristic peppery flavor of typical Roquefort in a relatively short time, while cheese made with other strains either lacked flavor and aroma or developed off flavors. Of the eight strains used, strains 5 or 1 appeared to be the most desirable from the standpoint of obtaining a desirable flavor in the cheese. The cheese made with strain 5 placed first in all four comparisons, whereas that made with strain 1 placed either second or third in all comparisons. Strain 7 appeared to be the least desirable of the eight strains employed, since the cheese made with this strain placed either seventh or eighth in three of the four comparisons. In general, the cheese containing comparatively large amounts of volatile acids regularly had considerable of the peppery flavor, whereas cheese containing relatively small amounts were commonly lacking in flavor.

CONCLUSIONS

1. Certain strains of penicillia appeared to bring about the production of considerably more volatile acids in blue cheese than other strains.
2. In general, the types of volatile acids produced in blue cheese by each of several strains of molds were about the same.
3. Apparently greater percentages of volatile acids of relatively high molecular weights were found in well-ripened blue cheese than in young cheese.
4. Certain strains of molds were regularly associated with blue cheese having a desirable flavor, while other strains were associated with cheese lacking in flavor or containing off flavors.
5. In general, cheese containing comparatively large amounts of volatile acids usually had much of the sharp, peppery flavor characteristic of Roquefort cheese, whereas cheese containing relatively small amounts were usually lacking in flavor.

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