THE INFLUENCE OF VARIATIONS IN THE MANUFACTURING PROCESS ON THE RATE OF ACID PRODUCTION DURING THE MAKING OF CHEDDAR CHEESE

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THE MAKING OF CHEDDAR CHEESE

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INTRODUCTION

The time required for manufacturing cheddar cheese is relatively long compared to the time required for processing other dairy products. The manufacturing process usually followed for making cheddar cheese from pasteurized milk requires about seven hours from the time the starter is added until the cheese is dressed. Added to this is the time required for receiving the milk, pasteurization, and cleaning up the equipment. The working day is, therefore, a long one for the cheese plant employees. A shorter process is sought which will be consistent with a high quality ripened cheese, and a desirable composition.

Since the time required for acid production takes up a large proportion of the total manufacturing time, most attempts at shortening the process have dealt with increasing the rate of acid production, although the elimination of the cheddaring process, as in the "stirred-curd" method, has also been used. Data concerning the quality and the composition of ripened cheese made by variations from the usual cheese making procedure are lacking. This paper is presented to show the influence of some variations in the manufacturing process on the rate of acid production during the making of cheddar cheese, and on the quality and composition of the finished cheese.

STATEMENT OF PROBLEM

The work herein reported involved showing the influence of variations in the manufacturing process on the rate of acid production during the making of cheddar cheese, and on the quality and composition of the finished cheese by (a) varying the amount of starter used, (b) using starter containing different amounts of solids-not-fat, (c) using various setting temperatures, and (d) using the "stirred-curd" method of making cheddar cheese.

REVIEW OF LITERATURE

Wilson, Hall and Rogers (13) presented a time schedule for making good quality cheddar cheese from pasteurized milk. They recommended close adherence to this schedule from day to day to obtain best results. The experimental data presented show that having the acidity at milling between a pH of 5.6 and 5.3 (approximately .35 to .50% titratable acidity) results in a much larger proportion of high quality cheese than when the acidity is higher or lower at this stage of the process. They state that a better quality cheese is obtained if the time required from setting to milling is 4½ hours, than if the rate of acid production is more accelerated. No data supporting this statement were presented. They recommend that a "not too large proportion" of starter be used.

Wilster (15) suggests using from 1/2 to 3/4 per cent starter if the time schedule referred to above is used, and if a good quality of milk is used for making the cheese. He states that a starter with an acidity of 0.75 to 0.80 per cent is best, and lists (Wilster, 14) the use of overripe starter as one cause of high acid cheese.

In developing an outline for the commercial manufacture of pasteurized milk cheese, Price (8) recommends the use of one to three per cent of starter when added at the same time the rennet is added.

As a means of saving time Watrous and Dahle (12) experimented with the use of lactic acid as a supplement to the usual starters. Their comparisons involved three methods of making cheese. Method A was used as a control batch, using from 3/4 to 1 1/2 per cent of starter, and developing 0.02 per cent acidity before setting. In Method B the same amount of starter was used and in addition enough lactic acid was added to increase the acidity 0.02 per cent. The rennet was added immediately. In Method C enough lactic acid, in the form of starter, was added to increase the acidity of the milk 0.02 per cent, or to the setting point, and setting immediately. With starter having 0.80 per cent acidity, this required about 3.25 per cent of starter.

The usual cheese making procedure was followed in all methods, except in Methods B and C the rennet was added as soon as the lactic acid, or starter, was added. An average of three trials showed that the cheese produced from Method B decreased the total making time, compared to the control batch, 46 minutes, but the flavor score was about 0.5 of a point less. The score was determined at monthly intervals for one year. The total making time for the cheese made by Method C was 82.8 minutes less than the time required for the control batch, and the flavor score was equal to, or superior to that made by the regular method at each scoring interval.

Damrow (2) describes a method of making a granulated type of American cheese. The usual cheese making process is followed through the cooking period. After the whey is drained, the curd is forked by a mechanical stirrer for a few minutes to prevent matting, then salted and hooped in the usual manner. An average of four trials carried on under commercial conditions showed the following:

Acidity at salting	0.35 per cent
Moisture after 48 hrs.	35.1 per cent
Time from adding starter to hooping	4 hrs. 54 minutes

No data on flavor score or body and texture were presented as evidence of the quality of cheese that can be made by this method. The total time of manufacture represents a saving of about one hour and 20 minutes as compared to the time schedule usually followed.

Sammis (9), and Van Slyke and Price (11) describe modifications of making a granular, or stirred-curd cheese. They state that it is difficult to make a cheese of perfect texture by this method, and both agree that it is more difficult to control undesirable fermentations in the curd, as compared with the usual method.

Foust (4) describes a streamlined method of making cheddar cheese which varies from the usual method cheifly in that the curd is drained into a centrifuge as soon as the whey is ready to drain. This machine throws off the whey, and causes the curd to matt into a closer body than is produced by the usual process. He states that the flavor of the cheese was slightly better at the end of six months, but actual data supporting these contentions were not presented. Foust stated that an acidity of 0.25 per cent could be developed in the milk before setting, thus allowing the curd to be milled about 20 minutes after the ten-minute centrifuging period. This represents a saving in both time and labor, but the author admits that a cheese plant layout for this method would be "slightly expensive".

In an attempt to show the cause of "slowness" in cheese-making Babel (1) studied the influence of cooking temperature on acid production by cheese cultures. Three different methods of demonstrating this effect were used in these experiments. In one series of trials seven different cultures were incubated for seven hours at 86°, 98°, 101° and 104° F. A 1.0 per cent inoculation was used in preparing the cultures. The titratable acidity was determined at the end of two, four, five, six and seven hours. Three of the cultures produced acid more rapidly at 86° F., while the other four were most active at 98° F. All of the cultures produced acid more slowly at the two higher temperatures.

In the second series of these trials one set of the seven cultures was held continuously at 86° F. for seven hours, and another set was held at 86° F. for two hours, then two hours at 104° F., and the final three hours at 86° F. The exposure at 104° F. for two hours decreased the rate of acid production of all but one of the seven cultures. All of the cultures continued to produce acid throughout the incubation period when exposed to 104° F., although, more slowly than at the lower temperatures.

The third method of studying the effect of cooking temperature on acid production by cultures involved the actual making of cheese, using cooking temperatures of 100°, 102° and 104° F. Five of the seven cultures produced acid most rapidly at 100° F., one showed equal activity at 100° and 102° F., and the other one was slightly more active at 102° F. All of the cultures were least active at 104° F.

Fisk (3) studied the effect of setting temperature on the moisture content and quality of cheese. The trials consisted of setting each of two vats of milk at different temperatures. Of the ten trials made, no two sets of temperatures were the same. The low setting temperatures varied from 78° to 86° F. The high temperature of each comparison ranged from 88° to 95° F. The cheese was made by the usual method, except for the variation in setting temperature.

An average of the ten trials showed that the higher setting temperatures produced a cured cheese with 36.74 per cent moisture as compared to 35.72 per cent for the low setting temperatures. The higher temperatures resulted in 0.07 per cent less fat lost in the whey. However, the lower setting temperatures produced cheese with an average score of 93.70 after four months' curing, as compared to 91.85 for the cheese made by a higher setting temperature.

Sammis (10) found that the loss of fat is low when a setting temperature of 86° F. is used, and that there is no advantage in using a higher setting temperature when the purpose is to bring about more rapid separation of whey from the curd. In these experiments four vats of mixed milk were set at 86°, 92°, 98° and 104° F. The first three vats were heated to 104° F. 35 minutes after cutting. The higher the setting temperature, the more rapid was the whey separation during the first 30 minutes, but one hour after cutting there was no distinguishable difference. The moisture determinations in these trials were made during the cheese making process, and therefore, are not comparable to the results obtained by Fisk (3).

The relation of acid production during the cheese making process to the development of a bitter flavor in the cured cheese was studied by Phillips (6) and Price (7). The latter investigator states that bitterness in cheddar cheese is associated with an excessive acid development. He recommends slowing down the rate of acid production during the curd making process as a means of reducing the incidence of bitterness in cheese.

Phillips demonstrated that cheese with a pH of below 4.95 when 4 days old subsequently developed a bitter flavor. A few of those with a pH of 4.95 to 5.00 developed this defect, while none of the samples having a pH above 5.00 were criticized for bitterness. He emphasizes that different lactic cultures vary in their rate of acid production.

Horrall and Elliker (5) have shown that cultures carried in reconstituted skim milk are more uniform in their activity from day to day than those carried in selected herd milk. The reconstituted skim milk was prepared from high grade, spray process, non-fat dry milk solids, containing 10 per cent of the milk solids.

METHODS

Mixed herd milk from the Oklahoma A. & M. College dairy was used for these experiments. Most of the trials were made with pasteurized milk, although a limited amount of data are available on cheese made from raw milk. The pasteurization was accomplished by heating a 143° F. for 30 minutes in a 50-gallon coil vat. Prior to pasteurization the milk was standardized to a fat-casein ratio of 1.0:0.7, using good quality skim milk for this purpose. The casein content of the milk was calculated by the following formula:

(% fat in unstandardized milk - 3) x .4 + 2.1 = % casein

A. The manufacturing process

The time schedule suggested by Wilson et al (13) was followed in making the control vats. It consists briefly of the following:

(a) Adding one per cent starter one hour before setting.

(b) Setting at a temperature of about 88° F. (Three ounces of rennet extract per 1000 pounds of milk is used as the coagulant).

(c) Cutting the curd thirty minutes after setting.

(d) Stirring the curd slowly for about 15 minutes, then turning the steam on, and allowing 30 minutes for the temperature to reach 100° F.

(e) Cooking at 100° F. for one hour, after which the whey is drained.

(f) Packing and cheddaring.

(g) Milling the curd when the titratable whey acidity reaches about 0.50 per cent.

(h) Salting, hooping and pressing in the usual manner. (The salt is added at the rate of 2 1/2 pounds per 1000 pounds of standardized milk used).

In these experiments 125 pounds of standardized milk were used for each vat so that a longhorn cheese of about 12 1/2 pounds would be obtained. The vats used were of stainless steel construction, water-jacketed, with a capacity of 25 gallons and could be heated by either steam, or hot water. Cheese color was added at the rate of one-third ounce per 1000 pounds of milk. One-fourth inch knives were used for cutting the curd and during cooking the curd and whey were stirred with a stainless steel paddle. The finished cheese was paraffined and stored at 50° F.

These experiments were performed from June, 1948, to September, 1948.

B. Propagation of starters

An active starter was selected from the collection carried by the Oklahoma A. & M. College dairy department. A good quality skim milk was used for carrying both the mother culture and the bulk starter. The skim milk was heated to 210° F. for about 20 minutes, then cooled to 72° F., and inoculated with from 1/2 to 1.0 per cent of the culture. The starters were incubated at 72° F. for about 16 hours. Fresh starters were always used in these experiments. The titratable acidity of the control starters ranged from 0.80 to 0.95 per cent at the end of the incubation period.

C. Grading the cheese

After the cheese had been stored for three months, the scores of flavor, and body and texture were determined organoleptically. Notations were also made concerning the specific defects of each cheese. The sample for scoring was obtained by cutting about 1 3/4 inches off the end of the cheese so that the condition of body and texture could be easily observed.

D. Chemical analysis of cheese

1. Sampling

The samples for chemical analysis were taken from the same part of the cheese that was used for scoring. When the determinations of composition were not made immediately after scoring the cheese, the samples were re-paraffined and stored in a cooler for not more than one week.

A wedge shaped sample, weighing about 100 grams, was taken, discarding about one-fourth inch of the surface layers. All of the chemical analyses were made in duplicate at the end of three months' storage.

2. Moisture

In preparing the cheese for moisture determinations the sample described above was ground to fine shreds and weighed immediately. A modification of the procedure for moisture determinations outlined by Wilster (16) was followed. The method consists of weighing accurately from three to five grams of cheese in a flat bottom aluminum dish which had been previously dried in an oven at about 100° C. and allowed to cool to room temperature in a desiccator. The sample is dried in an oven at 105° C. for 24 hours without vacuum, then cooled in a desiccator and re-weighed to determine the loss in weight.

3. Salt content

Determinations of the salt content of the cheese were made by chopping the cheese into fine particles and weighing immediately into a tared flask. The method of analysis as described by Wilster (16) briefly is as follows:

(a) A sample of approximately three grams is accurately weighed into a 250 ml. flask.

(b) To this is added 10 ml. of .1711 N. silver nitrate, 15 ml. of nitric acid and 50 ml. of distilled water.

(c) The contents are then heated over a flame. During heating 15 ml. of a saturated solution of potassium permanganate are added in three portions. Boiling is continued until all cheese particles are digested.

(d) The liquid is decanted into a beaker, washed once with 100 ml. of distilled water, and titrated with .1711 N. KCNS, using ferric ammonium sulphate as an indicator. Since this is a back titration, the ml. of KCNS required in titrating the sample are subtracted from 10 ml. to give the amount of silver nitrate used. Each ml. of silver nitrate is equivalent to 0.01 gram of salt. The per cent salt in the cheese is then calculated by the following formula:

$$\% \text{ salt} = \frac{\text{ml. } AgNO_3 \times 0.01 \times 100}{\text{WEIGHT of sample in grams}}.$$

4. Fat content of the cheese

The samples of cheese for fat determinations were cut into strips so that they could be readily put into a Babcock test bottle. The method of making the test, as outlined by Wilster (16), briefly consists of weighing a nine-gram sample into a 50% Babcock test bottle, adding 12 ml. of water and heating to about 170° F. for 15 minutes. About 15 ml. of sulphuric acid are then added and mixed thoroughly with the contents in the bottle. After centrifuging, the bottles are tempered in a water bath at 130° to 140° F. for five minutes. Glymol is then added to the surface of each fat column, and the percentage of fat is read directly.

5. Fat content of the whey

The whey from the vats was drained into ten-gallon cans so that samples could be taken for determining the fat losses. All of the whey which drained until the cheese was milled was included. The Babcock butyl alcohol method was used in determining the fat content of the whey. This method consists of placing two ml. of normal butyl alcohol in a skim milk test bottle, adding nine ml. of whey, and from seven to nine ml. of sulphuric acid. The contents are then mixed and centrifuged in the usual manner. The reading is doubled to obtain the percentage of fat.

6. Titratable acidity

The titratable acidity was determined by titrating with

EXPERIMENTAL

A. The influence of the amount of starter used on the rate of acid production during the manufacture of cheddar cheese

The influence of the amount of starter used on the rate of acid production during the manufacture of cheddar cheese was studied by dividing approximately 375 pounds of milk into three portions of 125 pounds each, placing each portion in individual vats, and adding a different amount of starter to each vat. The following amounts of starter were added to the designated vat in each trial: vat A, 0.5%; vat B, 1.0%; and vat C, 2.0%. The usual procedure was followed in making the cheese, and an attempt was made to mill each vat at an acidity of 0.50 per cent. Six trials were made by varying the amount of starter, two of which were with raw milk and the other four with pasteurized milk. When raw milk was used the cheese was milled 4 1/2 hours after setting, regardless of the whey acidity. The influence of the amount of starter used to inovulate the milk on the rate of acid production, the time required from setting to milling, and on the quality and the composition of the finished cheese is shown in Tables 1 and 2. The trials are identified by serial numbers in the tables.

1. Raw milk cheese

The data obtained in the trials in which raw milk was used in making the cheese are shown in Table 1. In trial 171-4 the rate of acid production markedly increased as the amount of starter used was increased. The score of the cheese was not significantly affected by the amount of starter used,

Table 1

Influence of the amount of starter used on the rate of acid production during the making of cheddar cheese

Cheese made from raw milk

Serial number of trials	Vat number	Amount of starter added (per cent)	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)
	A	0.5	.170	.110	.125	.29	270
171-4	B	1.0	.170	.110	.130	.40	270
	C	2.0	.175	.120	.175	.54	270
	A	0.5	.180	.110	.120	.17	270
190-7	B	1.0	.190	.120	.135	.31	270
	C	2.0	.195	.135	.190	.45	270
	A	0.5	.175	.110	.123	.233	270
Average	B	1.0	.180	.115	.133	.352	270
	C	2.0	.185	.128	.183	.494	270

Table 1 (continued)

Serial number of trial	Vat no.	Amount of starter added (per cent)	Composition when three months old (per cent) Moisture	Salt	Fat	Score after three months storage Flavor	Criticism	Body & texture	Criticism
171-4	A	0.5	35.99	1.56	32.65	37.5	Sl. fermented	27.5	Open-gas holes
	B	1.0	35.63	1.50	32.00	38.0	Sl. acidy	28.0	Open-gassy
	C	2.0	35.35	1.46	32.50	38.0	Sl. acidy	28.5	Sl. open-not gassy
190-7	A	0.5	37.68	1.51	33.50	37.5	Sl. acidy-sl. fermented	28.0	Sl. open-sl. pasty
	B	1.0	35.49	1.52	34.62	36.5	Fermented	29.0	Sl. open
	C	2.0	35.28	1.50	35.00	36.0	Unclean-bitter	29.0	Good knit-mealy
Average	A	0.5	36.84	1.53	33.07	37.5		27.8	
	B	1.0	35.56	1.51	33.31	37.3		28.5	
	C	2.0	35.32	1.49	33.75	37.0		28.8	

although the development of an acidy flavor appeared to increase as the amount of starter was increased, while gassiness was more apparent in the cheese made by using smaller amounts of starter. The moisture content of the cheese decreased slightly as the amount of starter used was increased.

In trial 190-7 the rate of acid production increased markedly as the amount of starter used was increased. The flavor score of the cheese decreased slightly as the amount of starter used was increased, but the body and texture score tended to be slightly higher. The moisture content of the cheese decreased as the amount of starter used was increased.

Averages of the data obtained from the two trials made by using raw milk show that the acidity at milling (4 1/2 hours from setting) was considerably higher when larger amounts of starter were used than when smaller amounts were used. The total score of the cheese was not significantly affected by the amount of starter used, but the flavor score decreased slightly, and the score of body and texture increased slightly as the amount of starter was increased. The moisture content of the cheese decreased as the amount of starter was increased.

It should be noted that in the vats in which 0.5% and 1.0% starters were used, the acidity at milling was lower than is desired at this stage of the process.

2. Pasteurized milk cheese

The data showing the influence of the amount of starter used on the rate of acid production, and on the quality and composition of the finished cheese when pasteurized milk was used, are presented in Table 2. The data show that, in trial 225-14, the rate of acid development increased as the amount of starter used was increased, and that the use of 0.5% starter required 50 minutes more time from setting to milling than was required by the use of 1.0% starter, and the use of 1.0% starter required 10 minutes more time than was required by the use of 2.0% starter, however, it should be noted that the milling acidity of the cheese made by using 2.0% starter was 0.68%. The score of all three cheeses in this trial was high, although it decreased as the amount of starter used was increased. Acidy flavor and corky body were common criticisms of the cheese in this trial, and these defects appeared to increase as the amount of starter used was increased.

In trial 229-16 the use of 0.5% starter required 30 minutes more time from setting to milling than was required by the use of 1.0% starter, and the use of 1.0% starter required 35 minutes more time than was required by the use of 2.0% starter. The total score of the cheese decreased slightly as the amount of starter used was increased. All of the cheeses in this trial had an acidy flavor. The cheese made by using 1.0% and 2.0% starter was also criticized for being slightly bitter. The degree of these defects appeared to increase as the amount of starter used was increased.

In trial 232-18 the rate of acid development increased between each successive stage of the manufacturing process as the amount of starter used was increased. The use of 0.5% starter required 50 minutes more time from setting to milling

Table 2

Influence of the amount of starter used on the rate of acid production during the making of cheddar cheese

Cheese made from pasteurized milk

Serial number of trial	Vat number	Amount of starter added (per cent)	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)	Per cent of fat in whey
225-14	A	0.5	.155	.095	.125	.50	275	.300
	B	1.0	.165	.100	.125	.50	225	.285
	C	2.0	.165	.115	.170	.68	215	.265
229-16	A	0.5	.165	.100	.115	.50	255	.230
	B	1.0	.170	.100	.125	.50	225	.240
	C	2.0	.175	.115	.150	.51	190	.240
232-18	A	0.5	.155	.105	.120	.50	270	.345
	B	1.0	.170	.110	.140	.50	220	.360
	C	2.0	.185	.125	.180	.57	185	.350
240-22	A	0.5	.165	.095	.110	.47	280	.320
	B	1.0	.165	.100	.130	.49	250	.320
	C	2.0	.175	.110	.145	.50	200	.310
Average	A	0.5	.160	.100	.118	.504	270	.299
	B	1.0	.170	.102	.130	.502	230	.301
	C	2.0	.175	.116	.161	.567	198	.291

Table 2 (continued)

Serial number of trial	Vat no.	Amount of starter used (per cent)	Composition when three months old (per cent) Moisture	Salt	Fat	Score after three months storage Flavor	Criticism	Body & texture	Criticism
225-14	A	0.5	33.69	1.52	34.0	40.0	Flat-clean	29.0	Sl. open
	B	1.0	34.09	1.52	33.8	39.0	Sl. acidy	29.0	Sl. firm
	C	2.0	33.30	1.65	34.0	38.0	Acidy	28.0	Sl. corky-sl. mealy
229-16	A	0.5	33.69	1.44	34.0	38.0	Sl. acidy-lacks flavor	28.0	Sl. corky
	B	1.0	32.86	1.47	34.0	37.5	Sl. acidy-sl. bitter	28.5	V. sl. corky
	C	2.0	32.91	1.40	34.0	37.0	Acidy-sl. bitter	27.5	Sl. crumbly
232-18	A	0.5	33.71	1.41	34.0	39.0	Sl. acidy	29.0	V. Sl. crumbly
	B	1.0	33.18	1.47	33.3	38.0	Sl. acidy	29.0	Sl. open
	C	2.0	33.08	1.36	33.3	36.5	Acidy	27.0	Crumbly
240-22	A	0.5	33.05	1.52	34.5	37.5	Sl. acidy	28.5	Sl. crumbly
	B	1.0	33.05	1.55	34.3	37.5	Sl. acidy	28.0	Sl. crumbly
	C	2.0	33.87	1.59	34.0	36.5	Acidy	27.5	Weak-flaky
Average	A	0.5	33.53	1.47	34.12	38.60		28.6	
	B	1.0	33.29	1.50	33.85	38.00		28.6	
	C	2.0	33.29	1.49	33.83	36.88		27.5	

than was required by the use of 1.0% starter, and the use of 1.0% starter required 35 minutes more time than was required by the use of 2.0% starter. The total score of the cheese decreased as the amount of starter used was increased. The degree of acidy flavor appeared to increase as the amount of starter used was increased. The moisture content of the cheese decreased slightly as the amount of starter was increased.

In trial 240-22 the rate of acid development increased as the amount of starter used was increased. The use of 0.5% starter required 30 minutes more time from setting to milling than was required by the use of 1.0% starter, and the use of 1.0% starter required 50 minutes more time than was required by the use of 2.0% starter. The total score of the cheese decreased slightly as the amount of starter used was increased. All of the cheese in this trial had an acidy flavor, and the degree of this flavor appeared to increase as the amount of starter was increased.

Averages of the data obtained in four trials, in which pasteurized milk was used to determine the influence of the amount of starter used on the rate of acid production, and on the quality and composition of the finished cheese, are shown in Table 2. The results show that the rate of acid development increased as the amount of starter was increased. The use of 0.5% starter required an average of 40 minutes more time from setting to milling than was required by the use of 1.0% starter, and the use of 1.0% starter required an average of 32 minutes more time than was required by the use of 2.0%

starter. Averages of the data show that the flavor score of the cheese decreased considerably as the amount of starter was increased from 0.5% to 2.0%. Most of the cheeses in these trials had some degree of an acidy flavor, and the degree of this defect appeared to increase as the amount of starter was increased. The body and texture score of the cheese made by using 0.5% and 1.0% starter was the same, but was 1.1 points lower when 2.0% starter was used. The body and texture appeared to be more mealy, corky and crumbly as the amount of starter used in the cheese milk was increased. These defects of body and texture may be expected when the moisture content of the cheese is as low as that found in these trials. It should be noted that the moisture content of the cheese in all of these trials was about 4.0% lower than is desired when the cheese is produced under commercial conditions. This is probably due to the use of small vats, and rapid drainage of the whey during the cheddaring, matting and salting processes.

The amount of starter used appeared to have no significant influence on the amount of salt and fat in the cheese, or the amount of fat lost in the whey.

B. The influence of the solids-not-fat content of the starter used on the rate of acid production during the making of cheddar cheese

Unpublished data at the Oklahoma A. & M. College Experiment Station show that increasing the solids-not-fat content of the milk used for preparing starters markedly increases the activity of the starters. The influence of increasing the solids-not-fat content of the starter used on the rate of acid production during the making of cheddar cheese was studied by dividing approximately 375 pounds of milk into three portions of 125 pounds each, placing each portion in individual vats, and adding starter with a different solids-not-fat content to each vat. The solids-not-fat content of the starter added to the designated vat in each trial was as follows: vat A, 9.0%; vat B, 12.0%; and vat C, 15.0%. Normal skim milk was used for propagating the starter added to vat A. The starters containing 12.0% and 15.0% solids-not-fat were prepared by thoroughly mixing appropriate amounts of a good quality of non-fat, spray dried, milk solids with normal skim milk before pasteurization. The usual procedure was followed in making the cheese, and an attempt was made to mill each vat at an acidity of 0.50 per cent. Five trials were made by varying the solids-not-fat content of the starter, one of which was with raw milk and the other four with pasteurized milk. The data showing the influence of the solids-not-fat content of the starter on the rate of acid production, and on the quality and composition of the finished cheese are presented in Tables 3 and 4.

Table 3

The influence of the solids-not-fat content of the starter used on the rate of acid production during the making of cheddar cheese

Cheese made from raw milk

Serial number of trial	Vat no.	Per cent solids in starter	Acidity of starter when added (per cent)	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)
	A	9	0.66	.180	.115	.135	.48	280
199-9	B	12	0.84	.180	.120	.140	.47	268
	C	15	1.10	.190	.125	.145	.47	230

Table 3 (continued)

Serial number of trial	Vat no.	Per cent solids in starter	Composition when three months old (per cent): Moisture	Salt	Fat	Score after three months storage: Flavor	Criticism	Body & texture	Criticism
	A	9	36.05	1.19	32.3	36.5	V. sl. bitter	29.0	Sl. weak
199-9	B	12	36.11	1.14	32.5	36.5	V. sl. bitter	29.5	No criticism
	C	15	35.45	1.14	33.0	36.0	Sl. bitter	29.0	Sl. crumbly

Table 4

The influence of the solids-not-fat content of the starter used on the rate of acid production during the making of cheddar cheese

Cheese made from pasteurized milk

Serial number of trial	Vat no.	Per cent solids in starter	Acidity of starter when added (per cent)	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)	Per cent fat in whey
	A	9	0.93	.190	.105	.130	.50	245	.310
217-11	B	12	1.15	.190	.110	.135	.50	248	.335
	C	15	1.29	.190	.115	.140	.50	200	.340
	A	9	0.94	.140	.100	.120	.52	225	.305
224-13	B	12	1.18	.145	.110	.145	.51	215	.295
	C	15	1.28	.150	.100	.150	.49	195	.275
	A	9	0.94	.145	.100	.130	.48	230	.360
238-21	B	12	1.09	.150	.095	.140	.48	210	.330
	C	15	1.19	.155	.100	.145	.49	210	.300
	A	9	0.88	.150	.100	.130	.51	215	.315
243-24	B	12	1.08	.150	.100	.145	.51	200	.310
	C	15	1.21	.160	.105	.160	.48	195	.290
	A	9	0.925	.156	.101	.131	.509	228.8	.323
Average	B	12	1.125	.157	.104	.142	.504	218.3	.318
	C	15	1.243	.169	.105	.144	.494	200.0	.301

Table 4 (continued)

Serial number of trial	Vat no.	Per cent solids in starter	Composition when three months old (per cent) Moisture	Salt	Fat	Score after three months storage Flavor	Criticism	Body & texture	Criticism
217-11	A	9	35.18	1.50	33.5	38.0	Sl. acidy-lacks flavor	29.0	Sl. open
	B	12	33.92	1.58	34.5	38.0	Sl. acidy-lacks flavor	29.5	No criticism
	C	15	34.11	1.48	33.5	38.0	Sl. acidy-lacks flavor	29.0	V. sl. mealy
224-13	A	9	34.55	1.57	33.3	38.0	Sl. acidy-flat	28.5	Sl. weak-sl. open
	B	12	34.51	1.54	33.5	39.0	Sl. acidy-flat	29.0	Sl. open
	C	15	33.44	1.58	34.5	38.0	Sl. acidy-flat	28.5	Sl. open
238-21	A	9	34.43	1.44	33.0	37.0	Sl. bitter-acidy	29.0	Sl. firm or corky
	B	12	33.90	1.49	33.5	37.0	Sl. bitter-acidy	29.0	Sl. firm or corky
	C	15	33.25	1.53	34.0	37.5	Acidy	29.0	Sl. firm or corky
243-24	A	9	34.38	1.51	33.0	37.0	Acidy	28.0	Sl. flaky
	B	12	33.03	1.62	33.5	37.0	Acidy	27.5	Sl. crumbly
	C	15	34.15	1.65	33.5	37.0	Acidy	27.5	Sl. crumbly
Average	A	9	34.64	1.505	33.20	37.50		28.63	
	B	12	33.84	1.556	33.75	37.75		28.75	
	C	15	33.74	1.560	33.88	37.63		28.50	

1. Raw milk cheese

The data from trial 199-9, in which raw milk was used, are presented in Table 3. It is apparent that the rate of acid production increased as the solids-not-fat content of the milk used in preparing the starters was increased, and that the time required from setting to milling was decreased 50 minutes as the amount of solids-not-fat in the starter was increased from 9.0% to 15.0%. The data indicate that the solids-not-fat content of the starter used had very little influence on the score of the cheese. All three of the cheeses made in this trial were criticized for being slightly bitter. This was probably due to the low salt content of the cheese. The results show that there was a tendency for the moisture content of the cheese to decrease as the solids-not-fat content of the starter used was increased, although the differences are insignificant.

2. Pasteurized milk cheese

The data from the trials, in which pasteurized milk was used, are shown in Table 4. In trial 217-11 it is apparent that the rate of acid development increased as the solids-not-fat content of the starter used was increased, and that the time required from setting to milling decreased 45 minutes by increasing the solids-not-fat content of the starter from 9.0% to 15.0%. The difference in the score of the cheese produced by varying the solids-not-fat content of the starter is insignificant.

In trial 224-13 it is apparent that the rate of acid production increased as the solids-not-fat content of the starters used was increased, and that the time required from setting to milling decreased 30 minutes as the solids-not-fat content of the starter was increased from 9.0% to 15.0%. A higher scoring cheese resulted by using starter containing 12.0% solids-not-fat than when starter containing either 9.0% or 15.0% was used. The moisture content of the cheese decreased slightly as the solids-not-fat content of the starters used was increased.

In trial 238-21 the time required from setting to milling was decreased 20 minutes by increasing the solids-not-fat content of the starter used from 9.0% to 12.0%, but no further saving in time was obtained by increasing the solids-not-fat content of the starter from 12.0% to 15.0%. The use of starters containing different amounts of solids-not-fat appeared to have no significant influence on the score of the cheese, but the moisture content of the cheese decreased slightly as the solids-not-fat content of the starters used was increased.

In trial 243-24 the data show that the rate of acid production increased slightly as the solids-not-fat content of the starter was increased. The use of starters containing various amounts of solids-not-fat appeared to have no significant influence on the score of the cheese.

Averages of the data from the trials in which pasteurized milk was used to determine the influence of the solids-not-fat content of the starter on the rate of acid production, and on the quality and composition of the finished cheese are shown in Table 4. It is apparent that the rate of acid production increased as the solids-not-fat content of the starter used was increased, and the time required from setting to milling decreased an average of 29 minutes as the solids-not-fat content of the starter used was increased from 9.0% to 15.0%. A slightly higher scoring cheese resulted by the use of starter containing 12.0% solids-not-fat than when starter containing either 9.0%, or 15.0% solids-not-fat was used, although the difference is of little significance. All of the cheeses in these trials had some degree of acidy flavor, but the solids-not-fat content of the starter used in setting up the cheese milk apparently had no influence on this defect. The moisture content of the cheese decreased slightly as the solids-not-fat content of the starter was increased. There was no significant difference in the salt and fat content of the cheese produced by varying the solids-not-fat content of the starter.

C. The influence of variations in the setting and in the cooking temperatures on the rate of acid production during the making of cheddar cheese

The influence of variations in the setting and in the cooking temperatures used in making cheese on the rate of acid production during the making of cheddar cheese was studied by dividing approximately 375 pounds of milk into three portions, placing each portion in individual vats, and varying the setting and cooking temperatures during the cheese making process. The setting temperature used for the designated vat in each trial was as follows: vat A, 88° F.; vat B, 95° F.; and vat C, 98° F. The usual procedure was followed for making the cheese in vat A, while the temperatures of vats B and C were held at their respective setting temperatures throughout the cooking process. An attempt was made to mill each vat at an acidity of 0.50 per cent. Six trials were made by varying the setting and cooking temperature, one of which was with raw milk and the other five with pasteurized milk. The data showing the influence of variations in the setting and in the cooking temperatures on the rate of acid production, and on the quality and composition of the finished cheese, are presented in Tables 5, 6 and 6a.

1. Raw milk cheese

In trial 212-10, in which raw milk was used, only two setting temperatures were used, 88° F. and 98° F. The data obtained from this trial are shown in Table 5. The rate of acid production was considerably greater when the usual procedure (setting at 88° F. and cooking to 98° F.) was followed

Table 5

The influence of the setting and cooking temperature on the rate of acid production during the making of cheddar cheese

Cheese made from raw milk

Serial number of trial	Vat no.	Setting and cooking temperature °F.	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)
212-10	A	88	.175	.120	.140	.47	265
	C	98	.175	.120	.140	.49	340

Table 5 (continued)

Serial number of trial	Vat no.	Setting and cooking temperature °F.	Composition when three months old (per cent): Moisture	Salt	Fat	Score after three months storage: Flavor	Criticism	Body & texture	Criticism
212-10	A	88	36.24	1.48	33.0	37.0	V. sl. bitter	29.0	Sl. open
	C	98	37.23	1.44	32.5	36.0	Sl. bitter-sl. acid	28.0	Weak-sl. open

than when a setting temperature of 98° F. was used from setting to draining. Setting at 98° F. required 75 minutes more time than was required by setting the vat at 88° F. The score of the cheese made by the usual procedure was considerably higher than when a setting temperature of 98° F. was used. The moisture content of the cheese made from milk set at 98° F. was higher than that in the cheese made from milk set at 88° F.

2. Pasteurized milk cheese

The data obtained from the trials, in which pasteurized milk was used in determining the influence of setting and cooking temperatures on the rate of acid production, and on the quality and composition of the finished cheese, are presented in Table 6. In trial 218-12 the rate of acid production was about equal when setting temperatures of 88° F. and 95° F. were used, but the data show that setting at a temperature of 98° F. required about 40 minutes more time from setting to milling than was required by setting at the lower temperatures. There was no significant difference between the scores of the cheese made by setting at 88° and 98° F., but a considerably lower score resulted when the cheese milk was set and cooked at 95° F., than as compared to setting at either 88° or 98° F. Setting at 88° F. resulted in cheese with the lowest moisture content of the three setting temperatures used, and setting at 95° F. resulted in cheese with the highest moisture content.

In trial 230-19 the rate of acid production decreased as the setting temperature was increased from 88° F. to 98° F.,

Table 6

The influence of the setting and cooking temperature on the rate of acid production during the manufacture of cheddar cheese

Cheese made with pasteurized milk

Serial number of trial	Vat no.	Setting and cooking temperature °F.	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)	Per cent of fat in whey
218-12	A	88	.170	.115	.135	.53	225	.340
	B	95	.170	.110	.125	.53	220	.320
	C	98	.165	.110	.125	.53	265	.300
230-17	A	88	.160	.100	.125	.53	230	.320
	B	95	.160	.100	.125	.54	230	.260
	C	98	.160	.100	.120	.48	310	.300
236-19	A	88	.165	.105	.130	.49	260	.380
	B	95	.165	.105	.130	.49	255	.375
	C	98	.165	.100	.120	.50	305	.400
241-23	A	88	.145	.090	.090	.24	405	.315
	B	95	.140	.090	.090	.18	420	.310
	C	98	.140	.090	.090	.12	435	.290
245-25	A	88	.160	.105	.145	.48	210	.320
	B	95	.165	.110	.135	.53	225	.365
	C	98	.165	.110	.130	.50	245	.310

Table 6 (continued)

Serial number of trial	Vat no.	Setting and cooking temperature °F.	Composition when three months old (per cent) Moisture	Salt	Fat	Score after three months storage Flavor	Criticism	Body & texture	Criticism
218-12	A	88	33.31	1.39	34.50	37.5	Sl. acidy	29.0	Sl. open
	B	95	35.36	1.35	33.38	36.0	Acidy-bitter	28.0	Mealy
	C	98	34.96	1.34	34.00	37.0	Sl. acidy	28.5	Sl. mealy
230-17	A	88	35.25	1.41	33.25	38.0	Sl. acidy-bitter	28.5	Sl. crumbly
	B	95	36.02	1.30	33.25	36.5	Sl. acidy-bitter	27.5	Crumbly
	C	98	35.16	1.26	33.50	39.0	V. sl. acidy	29.0	V. sl. crumbly
236-19	A	88	33.55	1.38	34.00	37.0	Sl. bitter-sl. acidy	29.0	Sl. open
	B	95	34.36	1.34	33.50	38.0	Sl. acidy	29.0	Sl. open
	C	98	34.77	1.35	33.50	38.0	Sl. acidy	29.5	No criticism
241-23	A	88	36.22	1.52	32.25	37.0	Sl. acidy	27.5	Weak-pasty
	B	95	37.51	1.55	32.00	37.0	Sl. acidy	27.5	Weak-pasty
	C	98	39.85	1.47	31.50	36.0	Acidy-sl. bitter	26.5	Open-v. weak-sl. gassy
245-25	A	88	35.22	1.64	33.00	37.0	Acidy	28.0	Sl. crumbly
	B	95	37.57	1.56	32.50	37.0	Acidy	27.0	Crumbly
	C	98	37.20	1.47	32.75	37.0	Acidy	28.0	Sl. crumbly

and the time required from setting to milling was 260 minutes when the cheese milk was set at 88° F., 255 minutes when set at 95° F. and 305 minutes when set at 98° F. The moisture content of the cheese appeared to increase slightly as the setting temperature was increased, being 33.55 when the cheese milk was set at 88° F., 34.36 when set at 95° F., and 34.77 when set at 98° F. The flavor score on the cheese set at 88° F. was 37.0, and that on the cheese set at 95° F. and at 98° F. was 38.0. All three of the cheeses had a slightly acidy flavor and the cheese set at 88° F. was also slightly bitter. The body and texture score of the cheese set at 88° F. and at 95° F. was 29.0, both being criticized for being slightly open, while the score of that set at 98° F. was 29.5, with no criticism being noted.

In trial 241-23, the rate of acid production decreased as the setting temperature was increased, and the time required from setting to milling was 405 minutes when the cheese milk was set at 88° F., 420 minutes when set at 95° F. and 435 minutes when set at 98° F. Due to a faulty temperature regulating mechanism, the temperature of the incubator, in which the culture used in this trial was incubated, was 110° F. at the end of the 16-hour incubation period. It was not known how long this temperature had been reached before removing the culture from the incubator. This factor apparently caused the starter to be very inactive, as indicated by the milling acidities, and the times required from setting to milling. The moisture content of the cheese set at 88°F. was 36.22, that of the cheese set at 95° F. was 37.51 and that of the cheese set at 98° F. was 39.85. The flavor score, and body and texture score of the cheese set at 88° F. and at 95° F. was equal, being 37.0 and 27.5, respectively, while the flavor score of the cheese set at 98° F. was 36.0, and the body and texture score was 26.5. All three of the cheeses had some degree of acidy flavor, with the cheese set at 98° F. also having a slightly bitter flavor. All three of the cheeses also had a weak body.

In trial 245-25 the rate of acid production decreased as the setting temperature was increased, and the time required from setting to milling was 210 minutes when the cheese milk was set at 88° F., 225 minutes when set at 95° F. and 245 minutes when set at 98° F. The moisture content of the cheese was lower when the cheese milk was set at 88° F. than when set at either 95° F., or 98° F., being 35.22%, 37.57% and 37.20%, respectively. All three of the cheeses in this trial had a flavor score of 37.0, with each cheese having a distinct acidy flavor. The body and texture score on the cheese set at 88° F. and at 98° F. was 28.0, while that on the cheese set at 95° F. was 27.0; all of these cheeses had some degree of crumbliness, with the cheese set at 95° F. having the most distinct defect.

Averages of the data obtained in the trials, in which pasteurized milk was used in determining the influence of variations in the setting and in the cooking temperatures on the rate of acid production, and on the quality and composition of the finished cheese, are shown in Table 6a. The rate of acid production was about equal when the cheese milk was set at 88° F. and at 95° F., requiring 266 and 270 minutes, respectively, from setting to milling, but when the cheese milk was set at 98° F. the rate of acid production was slower and required an average of 312 minutes from setting to milling. The average moisture content of the cheese set at 88° F. was 34.71%, that of the cheese set at 95° F. was 36.16% and that of the cheese set at 98° F. was 36.39%. The salt content of the cheese appeared to decrease slightly as the setting temperature was increased. The average flavor score on the cheese set at 88° F. was 37.30, that on the cheese set at 95° F. was 36.90 and that on the cheese set at 98° F. was 37.60. The average body and texture score on the set at 88° F. was 28.4, that on the cheese set at 95° F. was 27.8 and that on the cheese set at 98° F. was 28.3.

Table 6a

The influence of the setting and cooking temperature on the rate of acid production during the making of cheddar cheese (average of the trials in Tables 5 and 6)

	Vat no.	Setting and cooking temperature °F.	Per cent acidity at: Setting	Cutting	Dipping	Milling	Time from setting to milling (minutes)	Per cent of fat in whey
Average of five trials with pasteurized milk	A	88	.1600	.1010	.1250	.457	266.0	.335
	B	95	.1600	.1010	.1210	.457	270.0	.326
	C	98	.1590	.1020	.1170	.428	312.0	.320
Ave. of four trials with past. milk (excluding trial 241-23)	A	88	.1638	.1063	.1338	.512	231.2	.340
	B	95	.1650	.1063	.1288	.525	232.5	.330
	C	98	.1638	.1050	.1238	.506	281.2	.328

Table 6a (continued)

	Vat no.	Setting and cooking temperature °F.	Composition when three months old (per cent): Moisture	Salt	Fat	Score at three months: Flavor	Body & texture
Average of five trials with pasteurized milk	A	88	34.71	1.46	33.35	37.30	28.40
	B	95	36.16	1.42	32.93	36.90	27.80
	C	98	36.39	1.37	33.15	37.60	28.30
Ave. of four trials with past. milk (excluding trial 241-23)	A	88	34.33	1.45	33.69	37.38	28.63
	B	95	35.83	1.38	33.16	36.88	27.88
	C	98	35.52	1.35	33.44	37.75	28.75

D. The influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method

The influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method was studied by placing 250 pounds of milk in a 60-gallon vat, and dipping portions of the curd at different intervals during the cooking process. About 1/4 of the curd was dipped at each interval. A portion was dipped after cooking for each of the following lengths of time: 60 minutes, 90 minutes, 120 minutes and 150 minutes. The usual procedure for making cheddar cheese was followed until the curd was dipped, after which each portion of the curd was stirred in a vat to prevent matting, and then salted, hooped and pressed in the usual manner. Since only enough cheese was made from the amount of milk used to fill two longhorn hoops, the curd that was dipped after cooking for 60 and 90 minutes was placed in one hoop, and the curd dipped at 120 and 150 minutes was placed in the other hoop.

The usual procedure for making cheddar cheese requires from 45 minutes to 135 minutes more total making time than was required by the "stirred-curd" method used in these trials. Five trials were made by varying the cooking time, three of which were with raw milk and the other two with pasteurized milk. The data showing the influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the stirred-curd method are presented in Tables 7 and 8.

1. Raw milk cheese

The results obtained from the trials in which raw milk was used are shown in Table 7. In trial 164-3, the flavor score on the cheese increased slightly as the cooking time was increased from 60 minutes to 120 minutes but decreased slightly as the cooking time was increased from 120 to 150 minutes. All four of the cheeses had a slight acidy flavor, and the cheese cooked for 90 minutes was also slightly bitter. The body and texture score on the cheese cooked for 60 minutes was the lowest, while that on the cheese cooked for 90 minutes was the highest of the four cheeses made. The cheese cooked for 60 and 120 minutes had a slight crumbly body, that cooked for 90 minutes was slightly open in body, and that cooked for 150 minutes was acid-cut. The moisture content of the cheese showed a tendency to decrease as the cooking temperature was increased.

In trial 177-5 the cooking time appeared to have no influence on the flavor score of the cheese. All four of the cheeses had some degree of a bitter flavor, with the cheese cooked for 90 minutes having only a slight defect. The bitterness may be explained by the low salt content of these cheeses. The body and texture score was not significantly influenced by the cooking time, although the cheese cooked for 90 minutes had the highest score, and that cooked for 120 minutes had the lowest body and texture score. The moisture content of the cheese cooked for 60 and 90 minutes was about the same, and that of the cheese cooked for 120 minutes and for 150 minutes

Table 7

The influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method
(Raw milk was used in these experiments)

Serial number of trial	Cooking time (min.)	Per cent acidity at: Cutting	Per cent acidity at: Dipping	Composition at three months (per cent): Moisture	Salt	Fat	Score after three months storage: Flavor	Criticism	Body & texture	Criticism
164-3	60	.12	.15	37.65	0.99	32.5	37.0	Sl. acidy	28.0	Sl. crumbly
	90	.12	.16	35.42	1.23	34.0	37.5	Sl. acidy-sl. bitter	29.0	Sl. open
	120	.12	.18	33.21	1.53	34.0	38.5	Sl. acidy	28.5	Sl. crumbly
	150	.12	.32	34.13	1.61	34.0	38.0	Sl. acidy	28.5	Acid cut
177-5	60	.115	.140	37.68	1.21	33.8	36.0	Bitter	28.0	Pasty
	90	.115	.170	37.59	1.08	33.8	36.5	Sl. bitter	28.5	Sl. open
	120	.115	.200	35.58	1.22	35.5	36.0	Bitter	27.5	Sl. crumbly
	150	.115	.220	35.50	1.45	35.0	36.0	Bitter	28.0	Sl. crumbly
183-6	60	.110	.130	36.88	1.61	33.0	37.0	Sl. fermented	28.0	Sl. gassy
	90	.110	.130	38.22	1.72	33.0	36.5	Acidy	28.5	Sl. gassy
	120	.110	.155	37.49	1.88	33.3	37.0	Sl. fermented	28.0	Sl. gassy
	150	.110	.225	35.73	1.55	34.8	37.5	Sl. fermented	29.0	Sl. crumbly
Ave. of trials with raw milk	60	.115	.140	37.40	1.27	33.1	36.66		28.00	
	90	.115	.153	37.07	1.34	33.6	36.83		28.67	
	120	.115	.178	35.43	1.54	34.3	37.17		28.00	
	150	.115	.255	35.12	1.53	34.6	37.17		28.50	

was also about the same, but about 2.0% lower than when the two shorter cooking times were used.

In trial 183-6 the cooking time appeared to have no significant influence on the flavor score of the cheese. The cheeses cooked for 60 minutes, 120 minutes and 150 minutes had a slight fermented flavor, while that cooked for 90 minutes was acidy. The scores of body and texture showed a tendency to increase slightly as the cooking time was increased. The cheeses cooked for 60 minutes, 90 minutes and 120 minutes had a slightly gassy body, while that cooked for 150 minutes was slightly crumbly. The moisture content of the cheese definitely decreased as the cooking time was increased from 90 to 150 minutes, but the moisture content of the cheese cooked for 60 minutes was definitely lower than that of the cheese cooked for 90 minutes.

Averages of the data from the trials in which raw milk was used to determine the influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method are shown in Table 7. The average flavor score of the cheese increased slightly as the cooking time was increased, although the differences are insignificant. The average body and texture score on the cheese cooked for 60 minutes, and for 120 minutes was 28.0, that on the cheese cooked for 90 minutes was 28.7 and that on the cheese cooked for 150 minutes was 28.5.

2. Pasteurized milk cheese

The data obtained from the trials in which pasteurized milk was used to determine the influence of the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method are shown in Table 8.

In trial 227-15 the flavor score of the cheese decreased considerably as the cooking time increased from 90 minutes to 150 minutes, however, the flavor score on the cheese cooked for 60 minutes was 2.0 points lower than that on the cheese cooked for 90 minutes. The cheeses cooked for 60 minutes, 120 minutes and 150 minutes had some degree of acidy flavor, while the cheese cooked for 120 minutes had only a slight defect. The cheeses cooked for 60 and 150 minutes also had a bitter flavor, while that cooked for 90 minutes was only criticized for lacking flavor. The cooking time appeared to have no significant influence on the body and texture score, although the cheese cooked for 120 minutes had the highest body and texture score, and that cooked for 150 minutes had the lowest score of the four cheeses in this trial. The cooking time appeared to have no significant influence on the composition of the cheese.

In trial 237-20, the flavor score of the cheese appeared to decrease as the cooking time was increased. All of the cheeses in this trial had an acidy flavor, and the degree of this defect appeared to increase as the cooking time increased. The cheeses cooked for 60 minutes and 90 minutes also had a

Table 8

The influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method (Past. milk was used in these experiments)

Serial number of trial	Cooking time (min.)	Per cent acidity at: Cutting	Per cent acidity at: Dipping	Composition at three months (per cent): Moisture	Salt	Fat	Score after three months storage: Flavor	Criticism	Body & texture	Criticism	% fat in whey
227-15	60	.10	.12	31.17	1.21	34.5	37.0	Acidy-sl. bitter	27.5	Open	.200
	90	.10	.16	32.11	2.03	36.0	39.0	Lacks flavor	27.0	Crumbly-mealy	.205
	120	.10	.20	32.34	1.68	36.0	37.5	Sl. acidy	28.0	Open	.200
	150	.10	.22	31.04	1.51	36.5	35.5	Acidy-bitter	26.0	Mottled-v. crumbly	.220
237-20	60	.09	.115	33.71	1.72	33.3	37.0	Sl. bitter-acidy	27.5	V. open	.340
	90	.09	.140	31.89	1.68	34.0	37.0	Sl. bitter-acidy	28.0	Sl. corky-open	.330
	120	.09	.170	31.86	1.61	34.3	36.0	V. acidy	26.5	Corky-crumbly	.315
	150	.09	.250	32.10	1.70	34.5	35.5	Strong acidy	24.0	Corky-v. crumbly	.335
Ave. of trials with past. milk	60	.095	.118	32.44	1.47	33.9	37.0		27.5		.270
	90	.095	.150	32.00	1.85	35.0	36.5		27.5		.268
	120	.095	.185	32.10	1.64	35.2	36.0		27.3		.258
	150	.095	.235	31.57	1.60	35.5	35.5		25.0		.278
Ave. of all trials	60	.107	.131	35.42	1.35	33.42	36.80		27.80		
	90	.107	.152	35.05	1.55	34.16	37.30		28.20		
	120	.107	.181	34.10	1.58	34.56	37.00		27.70		
	150	.107	.237	33.70	1.56	34.96	36.50		27.10		

slightly bitter flavor. The body and texture score definitely decreased as the cooking time was increased from 90 minutes to 150 minutes. The three cheeses cooked for 90, 120 and 150 minutes had some degree of a corky body and texture. The cheese cooked for 60 minutes had a very open body. The cooking time appeared to have no significant influence on the composition of the cheese.

Averages of the data from the trials in which pasteurized milk was used to determine the influence of variations in the cooking time on the quality and the composition of cheddar cheese made by the "stirred-curd" method are shown in Table 8. The data show that the flavor score, and the body and texture score decreased slightly as the cooking time was increased. Averages of the data show that the cooking time had no significant influence on the composition of the cheese. It should be noted that the moisture content of the cheese shown in these trials is far below that desired in cheddar cheese. This factor logically explains the high incidence of a crumbly body and texture.

DISCUSSION

In all of these experiments a very low moisture cheese resulted, being from 2.0 per cent to 5.0 per cent lower than is desired in cheddar cheese. This is probably due to the use of small vats in which drainage of the whey after the dipping process, is more complete than when cheese is made in commercial vats of 10,000 pounds capacity. The high incidence of cheese with a mealy, corky and crumbly texture, found in these experiments, was probably caused by the low moisture content.

It is apparent, from the data in these trials, that increasing the rate of acid production during the cheese making process with increased amounts of starter is associated with an acidy flavor in the finished cheese. It is difficult to explain the cause of this relationship. Further work in showing the influence of using a lower milling acidity on the incidence of acidy flavors in the finished cheese may explain part of this relationship.

There is no reason to believe that normal skim milk, or whole milk is the best media for propagating starters for cheese making, and the data in these experiments show that a more active starter is obtained by increasing the solids-not-fat content of the skim milk used in preparing the starters. If a high acid cheese results by use of these starters, it is only logical to reduce the amount of starter used to inoculate the cheese milk. It is practical as a means of reducing the making time, and of economizing on the amount of starter required to make cheese, to increase the solids-not-fat content of the starter. The data in these trials show that there is no significant influence of the solids-not-fat content of the starter used in setting up cheese, on the quality of the finished cheese.

Increasing the setting temperature from 88° F. to 95° F., or 98° F. is of no advantage in making cheddar cheese, as the time required for making the cheese is considerably more when a setting temperature of 98° F. is used, and the quality of the cheese is not significantly increased. The strain of bacteria in the cultures used in these experiments was apparently less active at 98° F. than at 88° F. Babel (1) presents data showing that some starter cultures used for cheese making are more active at 88° F. than at 98° F., while others are more active at 98° F. than at lower temperatures.

In these experiments the cheese made by the "stirred-curd" method was of very poor quality. The body and texture, especially, was open, mealy and very corky, with a poor knit being obtained in most of the trials. It is very difficult to control the moisture content of the cheese made by this method.

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