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A Study of Hot Brine Treatment in Making Cheese from Antibiotic Milk

Robert E. Howe
Utah State University

A STUDY OF HOT BRINE TREATMENT IN MAKING CHEESE FROM ANTIBIOTIC MILK

by

Robert E. Howe

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Importance of project

The cheddar cheese industry is continually confronted with the problem of manufacturing cheese from milk in which the acid development is slow or non-existent. In recent years, many antibiotics have been used as a treatment for mastitis. Penicillin, streptomycin, and aureomycin are some of the more prominent antibiotics used for this purpose.

The milk from cows which have been treated for mastitis with antibiotics does not react like normal milk in cheddar cheese manufacture. Antibiotics of a high enough concentration in cheese milk cause adverse effects in acid production during the manufacture which causes a poor quality finished cheese. Successful elimination of low-score cheese made from antibiotic milk by the use of an emergency procedure would be advantageous to the cheddar cheese industry.

Purpose of investigation

Preliminary investigation in the Utah State University Creamery indicated that a hot brine treatment of the milled curd may produce an acceptable cheddar cheese body and texture without normal acid development.

This problem was to develop an emergency procedure for manufacturing cheese having quality comparable to that of natural cheddar cheese by using a hot brine treatment on the milled curd.

Scope of problem

The effects of hot brine treatment upon cheddar cheese were studied by varying the brine concentration, the temperature, and the length of time the brine was held on the curd. The results of this study provided the information necessary for the practical emergency manufacturing procedure. The emergency procedure was used to manufacture cheese from "slow" or "dead" milk caused by the antibiotic "tetracycline." Control cheese was made by the "Clock Method" (12) from normal milk and antibiotic milk and used as a basis for comparisons. Any pronounced differences in the manufacture and quality of the cheese as a result of the antibiotic and the emergency method were recorded. Efforts were made to determine the effect of the hot brine treatment on the quality of the resulting cheese.

REVIEW OF LITERATURE

Source of antibiotics in milk

During the past six years, much concern has been placed on the use of antibiotics as a treatment for mastitis and the possible difficulties resulting from the milk of the treated cow. Complaints are continually registered by cheese plant operators concerning the lack of acid production during the manufacturing process.

Myron Hales (1), Vice President of Chr. Hansen's Laboratory, Inc., concludes on the basis of his work with cheese makers in all parts of the country, that there is no actual analytical proof of antibiotic trouble. In many cases, phage has been proved present in the milk and the cause of slow or actual starter failure. There have been times when inhibitory substances must have been present, but detailed analyses were not made to determine the specific agent present. A bacterial-free filtrate showed there was an inhibitory substance present and this may have been one or more of the normal antibiotics used today.

Doan (5) reported such antibiotics as penicillin, aureomycin, and streptomycin used for the treatment of mastitis in producing dairy cows have been found in the milk of the treated cows for several milkings following treatment.

Bradfield et al. (4) report the treatment of commercial herds indicated that when mixed milk was used from such herds, little or no trouble was experienced unless three per cent or more of the quarters in the milking herd had been treated.

Katznelson and Hood (7) recommended that careful consideration be given to the acceptance of milk from aureomycin-treated cows for five to six days following treatment.

Banghart (3) concludes that the solution to the problem of antibiotics in milk lies in a good producer, distributor relationship. The producer should label all milk coming from cows treated with the antibiotic for a period of seven days after the last treatment. The distributor can use the milk containing the antibiotic in channels that do not require the growth of bacteria for acid development.

A recent antibiotic used in the treatment of mastitis is tetracycline (hydrochloride). This antibiotic is reported by a veterinary science dictionary (10) to be active against both gram positive and gram negative bacteria, clostridia, and rickettsia. It has proved to be of value in the treatment of infections due to virus-like organisms or other aureomycin and chlortetracycline--sensitive organisms. It is effective against the control of polyotic-sensitive organisms associated with virus disease.

Reports are not available at this time regarding the specific effect that it may produce upon acid production in milk. It is believed that tetracycline may produce essentially the same results as aureomycin with reference to acid production in milk.

Relation of antibiotics and cheese manufacture

The manufacture of good quality cheddar cheese is very much dependent upon the production of lactic acid. The results of many workers (3), (4), (5), (8), (7), have shown the effect of various amounts of specific antibiotics and the resulting inhibition of acid production.

Nelson and Parmelee (8) report increasing difficulties in manufacturing

processes arising out of the presence of antibiotics in milk. Penicillin, streptomycin, and aureomycin, which are used most extensively in the treatment of mastitis, all have a definite inhibitory effect on lactic streptococcus.

Bradfield et al. (4) found varying amounts of aureomycin in milk from treated cows for as long as 72 hours after treatment. Inhibition of starter activity was definitely evident for three days after treatment. They further found that cheddar cheese making operations are definitely disrupted by the presence of appreciable amounts of aureomycin in the milk. Acid development is retarded, and during curing, flavor develops slowly and may be bitter. The body is weak and pasty.

J. C. Marquardt (1) of the New York State Department of Agriculture, in a recent report on antibiotics and cheese making, lists antibiotics as one of the contributing factors to low-quality cheese.

Katznelson and Hood (7), in experiments with six antibiotics, found penicillin the most active antibiotic giving complete inhibition of growth. The results of this experiment are shown in Table 1.

Banghart (3) concluded that aureomycin, when present in milk and used for the manufacture of cheddar cheese, may be responsible for complete inhibition of acid production when the concentration exceeds .35 p.p.m. When the concentration was between .12 p.p.m. and .35 p.p.m., acid production continued at a reduced rate and the resulting cheese was of a low quality. The treatment commonly used is 200 mg. of aureomycin hydrochloride in ointment injected into each infected quarter of the cow. If this amount is present in 1700 pounds of milk, the concentration would be .25 p.p.m. This concentration is enough to cause some difficulties in acid production during the manufacturing process.

The results obtained by Banghart (3) measuring the titratable acidity developed during the cheddar cheese manufacturing process using milk containing aureomycin show that there was little difference in titratable acidity due to aureomycin until the time of dipping. At dipping, the titratable acidity was slightly lower in the vats containing aureomycin indicating that acid development had stopped. These results are shown in Table 2.

Hot brine treatment

During the last two years, the use of hot brine in cheddar-like cheese manufacturing has come into prominence. Several procedures involving the use of hot brine are now used in effort to reduce the length of manufacturing time.

One of the new methods was developed by Walter et al. (11) of the Bureau of Dairy Industries, United States Department of Agriculture. This method was developed specifically to shorten the time required to manufacture cheddar cheese.

Briefly, this new method is as follows: Two starters are used. One is the conventional cheddar cheese lactic starter; the other is a heat and salt tolerant, lactic acid-forming streptococcus.

The milk is ripened and set at 88°F., and is cut and heated at a 100°F. temperature as in the conventional method. The mixture of curd and whey is pumped into a revolving, perforated drum where approximately one-half of the whey is removed. The curd and remaining whey fall into a cooking kettle in which it is heated to 115°- 120°F. in ten minutes. Salt is added at the rate of four per cent of the weight of the contents of the kettle. This whey brine-curd mixture is held at 115°- 120°F. for

Table 1. Influence of six antibiotics on acid production in milk using a mixed strain starter culture

Antibiotic	Reciprocal of dilution	
	Complete inhibition	No inhibition
Penicillin	3,300,000	166,000,000
Streptomycin	500,000	20,000,000
Aureomycin	1,000,000	20,000,000
Chloromycetin	100,000	5,000,000
Subtilin	1,000,000	100,000,000
Bacitracin	100,000	20,000,000

Table 2. Titratable acidity developed during the cheddar cheese manufacturing process using milk containing aureomycin

Time	Control[a]	Aureomycin parts per million				
		5.6	2.8	1.4	0.7	0.35
Starter	.16	.16	.18	.16	.16	.17
Cutting	.10	.09	.09	.10	.10	.10
Dipping	.14	.09	.09	.10	.10	.10
Cheddaring[b]	.64	.10	.09	.10	.10	.13
Milling	.72	.10	.09	.10	.10	.14

[a]Average of five vats

[b]Average of determinations taken at 15-minute intervals

eight to 10 minutes, then pumped to the hoops at 115°F. The cheese is pressed as in the conventional method.

The resulting body, texture, and flavor of the cheese made by this method are equal to those of high-quality cheese made by conventional methods. The four per cent brine solution at 115°-120°F. for 10 minutes is sufficient to insure 1.4-1.7 per cent salt in the finished product.

The results of utilizing a hot salt brine in cheese manufacture are more complete in the work done by Irvine and Price. (6)

Normal operations of setting, cutting, and cooking resemble those of cheddar cheese manufacturing. From dipping, the procedure is different. The whey is drained when the acid of the curd reaches pH 5.7-6.1. After removing most or all of the whey, enough brine is added to cover the curd; usually a volume equal to one-quarter the weight of the milk is adequate for this purpose. A three per cent brine solution at 98°F. is used. This brine has several functions: it dilutes the whey, elutes some of the lactose and soluble milk salts, incorporates a portion of the salt required in ripening, and provides uniform temperature control of the curd without interfering with the development of acid.

The temperature of this curd-brine mixture is kept at 90°-98°F. for approximately two hours or until the acidity of the curd increased from pH 6.1 to 5.5. When the curd has reached a pH of 5.5, dry salt is added to the solution to give a concentration of five per cent in the brine. The mixture is rapidly heated to 110°-130°F. depending upon the moisture content and the body characteristics desired in the finished cheese. Immediately after this heating, the brine is removed from the curd and the curd placed in the hoops and pressed.

The acid of the curd at dipping approximates that of normal cheddar

cheese. If the acidity of the curd at dipping is too high, then a sour cheese results. A desirable cheese was not produced when the pH of the curd was less than pH 5.58 at dipping. The data indicated that the best cheese was made when the whey was replaced by a brine solution.

Figure 1 indicates that a high-acid curd causes high moisture in the finished cheese. This phenomenon is contrary to the results in normal cheddar cheese manufacture. Figure 1 also indicates that between a pH range of 5.40-5.72 of the milled curd, the least moisture in the finished cheese was accounted for when the final brine temperature was 115°F.

When the milled curd has a pH of 5.5, the moisture in the curd was reduced by heating the brine to 118°F; the moisture increased upon heating the brine to 128°F. The minimum moisture was obtained when the curd was heated to 118°F. and the pH was 5.0-5.7. When the pH of the curd is 5.0-5.3, the trend is reversed and temperatures near 120°F. incorporate maximum moisture in the cheese.

Figure 2 shows that 85 per cent of the finished salt content of the cheese was absorbed in the first 15 minutes of soaking when the temperature was 98°F.

The cheese manufactured by the method of Irvine and Price (6), as discussed above, has some unusual characteristics which are not entirely clear at this time. It is believed that the hot brine changes the calcium papacaseinate formed by the rennin to a sodium paracaseinate at temperatures and acidity of the final brine treatment.

As the pH of the curd decreases, the effects of the formation of the sodium-protein complex becomes more apparent. As the pH of the curd nears the iso-electric point of the protein, the curd becomes very soft and

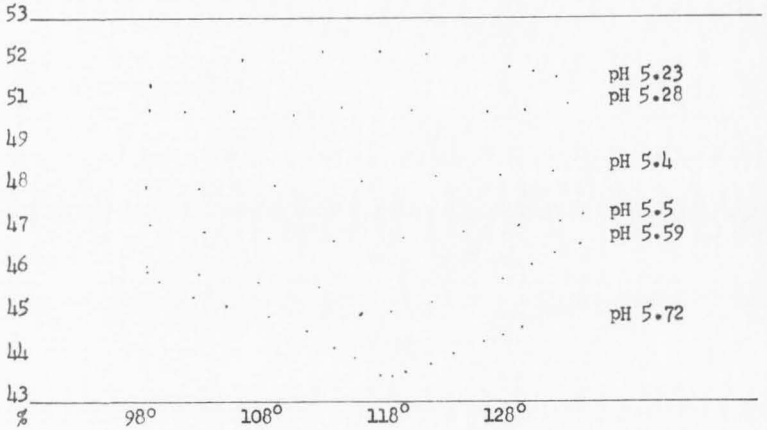

Figure 1. The effect of pH of curd and temperature of brine on the moisture of cheese

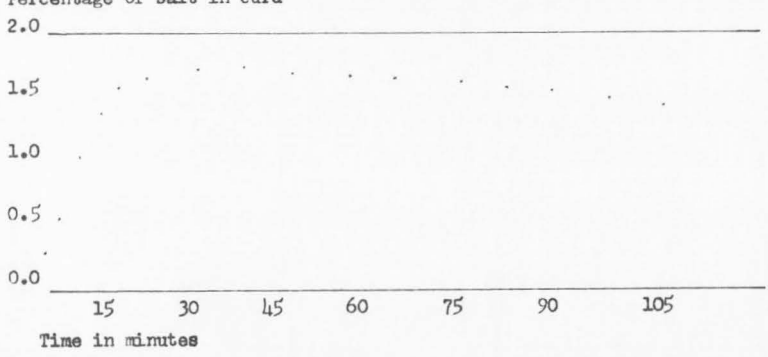

Figure 2. Rate of salt absorption by curd treated in 5 per cent brine at 98° F.

pliable. The increased moisture content and rapidity of breakdown during storage are typical characteristics of this cheese.

The abstract of a recent patent (2) reports another process for making cheese of the cheddar type utilizing salt brine.

The curd is cut, cooked, and dipped as in the conventional method. After dipping, the curd is stirred until the acid of the whey is .21-.30 tetratable acidity. Brine is added and continually stirred for not less than five minutes. Increasing the salt content of the brine increases the salt content of the cheese. Increasing the temperature and concentration of the brine tends to decrease the moisture content of the cheese.

MATERIALS AND PROCEDURE

Materials

Hansen's lactic ferment cheese culture was used as the source of starter in this experiment. The mother culture was carried in Grade A skim milk which was heated in an autoclave to a temperature of 240°F. for 10 minutes. The cultures were transferred daily using one per cent inoculum. The culture was incubated at a temperature of 70°F. for 14 to 16 hours. Bulk starter was prepared by adding one per cent mother culture to sterilized skim milk. The bulk starter was incubated by the same method used in incubating the mother culture. The bulk starter developed a titratable acidity of about .8 per cent lactic acid at the time of adding it to the cheese milk. The bulk starter had a smooth texture and fine flavor typical of good lactic starter.

The milk used in this experiment was from the Utah State University herds at Logan, Utah. The milk was standardized to 3.5 per cent fat and pasteurized at 143°F. for 30 minutes. The milk was then cooled to 45°F. and held overnight. The following morning, 400 pounds of milk were pumped to each vat used in the trial.

The antibiotic used in this experiment was tetracycline hydrochloride. The tetracycline was handled in the crystaline form and weighed out prior to its use. The tetracycline hydrochloride was supplied by the Veterinary Science Department at Utah State University.

Hansen's cheese rennet was used in the manufacture of all cheese at the rate of three ounces per 1,000 pounds of milk.

Determination of hot brine procedure

Normal milk was used in the manufacturing process to develop a suitable hot brine procedure. Brine concentration, brine temperature, and the length of time the brine was held on the milled curd were studied in developing the brining procedure.

Strict uniformity was maintained in all vatsof cheese by use of the time schedule outlined in Figure 3.

The amount of water required to make up the brine was equal to one-fifth the weight of the original milk. This amount was satisfactory as it allowed complete coverage of the milled curd.

Preliminary investigation indicated a maximum of 35 minutes between dipping and milling was necessary for the curd to become matted enough to mill.

In Trial I, the cheese was manufactured in three vats changing only one variable in the brine treatment. This trial was made to determine the length of time the brine was to be held on the curd. The first vat was treated with brine for five minutes, the second vat treated for 10 minutes, and the third vat for 15 minutes. Trials II and III were prompted by the results of Trial I which indicated the time the curd was held in the brine was best at 15 minutes. Brine concentration and temperature had to be further studied.

Table 3 shows the treatment of six vats of cheese in Trials II and III. This comparison studied effects of brine at 115°F. and 120°F. Brine concentration of five per cent, six per cent, and seven per cent were studied in each brine temperature comparison.

Another trial was made to better determine the best emergency procedure. In this trial, three vats were used. The cheese was manufactured

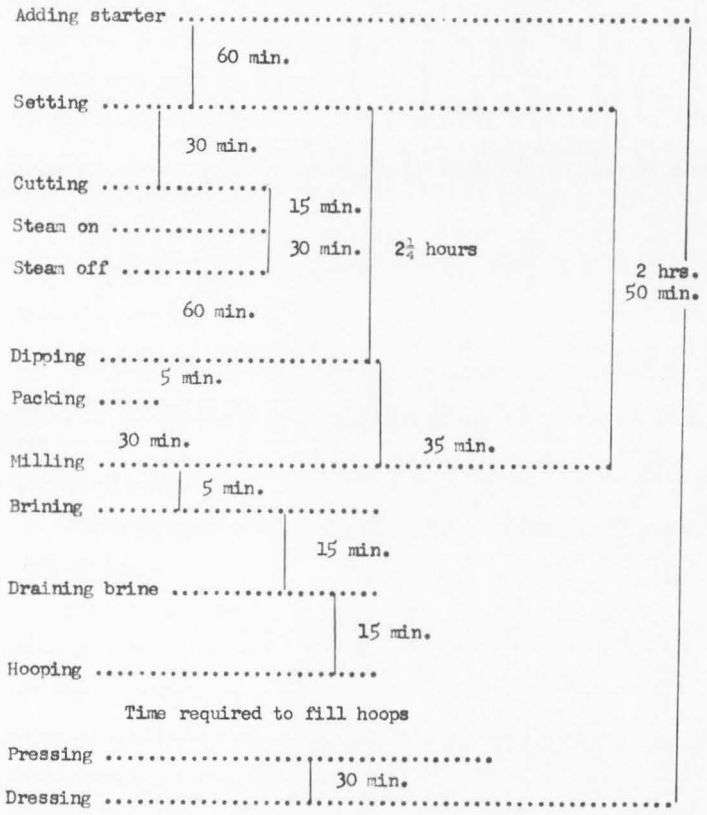

Figure 3. Time interval between steps in the manufacture of cheddar cheese using the hot brine treatment

as outlined in Figure 3. Each of the three vats were milled 35 minutes after dipping. The curd from the first vat was salted and hooped as in normal cheese making. The curd from the second vat was soaked in 120° water for 15 minutes and salted. The curd from the third vat was brine-treated with seven per cent salt at 120°F. for 15 minutes and hooped as in the normal procedure.

Method of manufacturing cheese from antibiotic milk

Four trials were made to study the cheese made from antibiotic milk. Table 4 shows five different treatments the curd received during this final study.

Tetracycline hydrochloride was added at the rate of .50 p.p.m. just prior to adding the starter. The control cheese made from normal milk was manufactured by the conventional Wilson Clock Method (12) as outlined in Figure 4.

Figure 3 outlines the method of manufacture when the brine treatment was used.

The rate of acid development was noted in all vats during the process. This acid development was measured by determination of the titratable acidity express as per cent lactic acid, and the pH determined by the Beckman pH meter. The titratable acidity was measured throughout the making process. The pH of the whey was measured at cutting, dipping, and milling.

Twenty-two pounds of curd were placed in a 20-pound square hoop and placed in the press for 30 minutes. The cheese was removed from the press and cut into four 5-pound loaves. The loaves were dressed and replaced in the press for 12-14 hours. The loaves were dried for 48 hours and waxed. All cheese was aged at 47°F.

Table 3. Treatment of six vats of cheese using the hot brine treatment

Trial number	Time curd was held in brine	Brine concentration	Brine temperature
II-A	15 min.	7 per cent NaCl	115° F.
II-B	15 min.	6 per cent NaCl	115° F.
II-C	15 min.	5 per cent NaCl	115° F.
III-A	15 min.	7 per cent NaCl	120° F.
III-B	15 min.	6 per cent NaCl	120° F.
III-C	15 min.	5 per cent NaCl	120° F.

Table 4. Treatment of milled curd to determine the effect on cheese made from normal and antibiotic milk

Treatment number	Treatment of milk	Treatment of the milled curd
1.	Normal	Normal salting procedure
2.	0.50 ppm tetracycline	Milled 35 min. after dipping and hot brine treated
3.[a]	0.50 ppm tetracycline	Milled 35 min. after dipping and normal dry salting
4.[a]	0.50 ppm tetracycline	Milled 2½ hours after dipping and hot brine treated
5.	0.50 ppm tetracycline	Milled 2¼ hours after dipping and normal dry salting

[a]Used in two trials

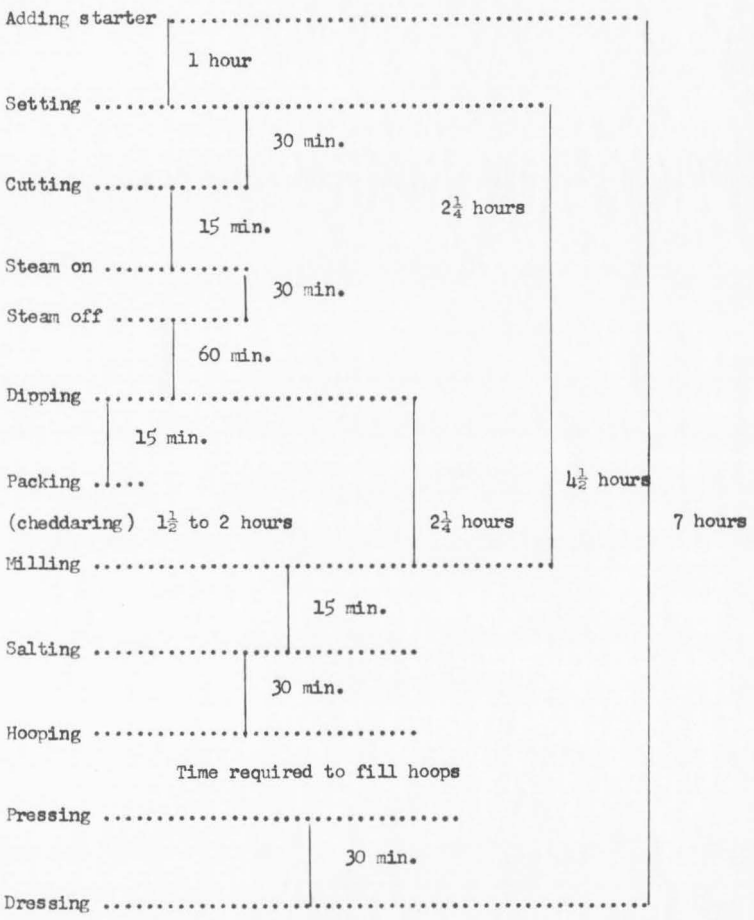

Figure 4. Time intervals between steps in the manufacture of cheddar cheese

Method of analysis

Samples were taken from the loaves by extracting three evenly spaced plugs from each end of the 5-pound loaf. Each trier reached to the center of the loaf. The sample was placed in an air-tight bottle. Prior to the analysis, the samples were cut very finely and mixed thoroughly.

The pH of the cheese was taken on a 10 and 90-day analysis. The pH was determined by the Beckman pH meter. Samples were ground to a paste and placed in contact with the electrode of the meter.

The moisture content was determined at 10 and 90-day periods. An approximate 2-gram sample was placed in 2-inch diameter cups. The cups were weighed and placed in a Mojonnier oven at 100°C. for one hour. At the end of one hour, a 23-pound vacuum was drawn for four hours. The cups were placed in the dessicator for 10 minutes and weighed. Each sample was run in duplicate.

The per cent fat in each sample was determined by the modified Babcock method as recommended by Wilster. (13)

The sodium chloride content was determined by the silver chloride titration methods as outlined by Wilster. (13)

At the 10 and 90-day periodic analysis, the cheese was scored by competent judges. The standards on the score card of the American Dairy Science Association outlined by Nelson and Trout (9) were followed by the judges. The judging was done by two expert dairy products judges from the staff of the Dairy Department at Utah State University.

RESULTS AND DISCUSSION

Development of the hot brine procedure

The results of the first experiments show that 15 minutes was the minimum length of time the brine could be held on the milled curd and allow enough salt to be retained in the finished cheese. The comparison of time intervals the brine was on the milled curd is shown in Table 5.

The minimum moisture content was found in cheese when the curd was treated with the brine for 15 minutes. When the brine was held on the curd for five and 10 minutes, the highest moisture cheese resulted. These moisture comparisons are shown in Table 6.

The results of the above experiment indicated that 15 minutes was the most favorable length of time for the brine to be held on the milled curd.

Previous experiments and cited literature indicated the best brine concentration should be from five to seven per cent and the most favorable brine temperature between 115°F. and 120°F.

Comparisons between five, six, and seven per cent brine were made to determine the most satisfactory concentration. Five per cent brine heated to 115°F. and 120°F. respectively, produced a cheese which was low in salt. This cheese was also criticized for having excessive fermented flavor. The six per cent brine on the milled curd also produced a low salt content cheese. The flavor was not criticized. The seven per cent brine treatment produced a cheese with a normal salt content of 1.43 to 1.87 per cent. The flavor was not criticized.

Table 5. Salt content of 10-day old cheese resulting from different lengths of time the hot brine was held on the curd

Brine temperature	Brine concentration	Per cent salt in cheese	Minutes brine was on curd
120° F.	5 per cent	0.83	5
120° F.	5 per cent	0.87	10
120° F.	5 per cent	1.10	15

Table 6. Moisture content of 10-day old cheese resulting from different lengths of time the hot brine was held on the curd

Brine temperature	Brine concentration	Per cent moisture of cheese	Minutes was on the curd
120° F.	5 per cent	44.10	5
120° F.	5 per cent	43.01	10
120° F.	5 per cent	42.75	15

Increasing the brine concentration from five to seven per cent tended to increase the moisture content of the cheese when the temperature of the brine was 120°F. These comparisons are noted in Table 8.

The flavor scores of the cheese resulting from the different brine treatments were the same at the 10-day analysis. At 90 days, the cheese made by treating the curd with 120°F. brine had developed fermented and yeasty flavors. The cheese resulting from the 115°F. brine treatment was not criticized for poor flavor. These results are indicated in Table 7.

The average body score of the cheese resulting from the 115°F. brine treatment was 27.7. The cheese resulting from the 120°F. brine treatment averaged 26.6 body score. Each cheese made by the hot brine treatments was criticized for having fermented, weak, and open bodies. These results are shown in Table 7.

The above results at the 10-day analysis indicated the best procedure to follow was to mill the curd at 35 minutes after dipping and treat with seven per cent brine at 115°F. for 15 minutes.

An additional experiment was set up to determine if the selected emergency treatment would actually be better than a hot water wash and soaking with dry salting of the milled curd. The milled curd was treated three different ways 35 minutes after dipping.

The first lot was salted as in normal cheese making. The resulting cheese was high in salt, moisture, and butterfat. The flavor was flat and the body was open and corky.

The second lot was treated with 120°F. water on the milled curd for 15 minutes. It was then salted in the normal manner. The resulting

Table 7. Average body and texture, and flavor score of cheese resulting from 5, 6, and 7 per cent brine held on the milled curd at 115° F. and 120° F. for 15 minutes

Temperature of brine	5% brine		6% brine		7% brine	
	Flavor	Body	Flavor	Body	Flavor	Body
115° F.	39.5	27.7	40.0	28.0	40.0	27.5
120° F.	39.2	26.5	39.0	26.7	38.7	26.5

90-day analysis

Table 8. Moisture and salt content resulting from 5, 6, and 7 per cent brine held on the milled curd at 115° F. and 120° F. for 15 minutes

Temperature of brine	5% brine		6% brine		7% brine	
	Per cent salt	moisture	Per cent salt	moisture	Per cent salt	moisture
115° F.	1.0	42.61	1.37	43.05	1.43	44.58
120° F.	1.17	44.74	1.37	45.21	1.87	44.20

cheese from the second lot was low in butterfat and moisture. The salt content was high, the flavor was flat, and the body was considerably corky.

The third lot was treated with the hot brine as recommended above. This cheese had 1.4 per cent salt, 30.5 per cent butterfat, and 41.38 per cent moisture. The flavor and the body of the cheese were not criticized.

The results of this comparison at the 10-day analysis indicated that the hot brine treatment would be the best to use as an emergency treatment for curd which was non-acid forming. The results of the comparison of the three treatments are shown in Table 9 and Table 10.

Table 9. Comparison of body and flavor scores of cheese made by normal salting, brine treatment, and hot water treatment of curd milled 35 minutes after dipping

	Flavor		Body	
	10 days	60 days	10 days	60 days
Normal salting	39 flat	40	28.5 corky	29.5
120° F. water	40	40	27.5 corky	29.0 corky
115° F. brine	40	40	30.0	29.0 open

Table 10. Comparison of salt and moisture content of cheese made by normal salting, brine treatment, and hot water treatment of curd milled 35 minutes after dipping

	Moisture		Salt	
	10 days	60 days	10 days	60 days
Normal salting	39.3	39.19	2.0	2.0
120° F. water	35.5	35.18	1.9	2.0
115° F. brine	41.38	40.24	1.4	1.6

Emergency treatment of cheese curd made from antibiotic milk

The failure of acid to develop in cheese making may be readily noted 35 minutes after dipping. The emergency process may begin at this point.

The acid development during the manufacturing period was determined by the titratable acidity of the milk at the time the starter was added and rennet was added. Acidity was determined by pH and titratable acidity of the whey at cutting, dipping, and milling. The effects of the addition of .50 ppm tetracycline to the cheese milk are best shown in Table 11. The results show that there is very little difference in titratable acidity until the time of dipping the whey. At dipping, the antibiotic-treated milk was just slightly lower in titratable acidity indicating the effect of the antibiotic. The control cheese showed normal acid development during the process. The average milling acidity of curd from non-antibiotic milk was .46 per cent lactic acid.

During the process, the curd from the antibiotic milk did not show the same characteristics as the curd from the normal milk. It did not mat well nor did it expel moisture as fast; it did not develop any elasticity. The development of good matting and pliable characteristics are partially dependent upon acid production which changes the chemical character of the curd protein.

The use of the hot brine on the milled curd in an effort to better the body of the antibiotic cheese failed to produce a body as good as was produced by normal cheese making methods. Table 12 shows the average results of four trials, using normal cheese, antibiotic cheddar cheese, and antibiotic brine-treated cheese for comparison. This table clearly shows that cheese from dead milk does not produce a good body and texture. The emergency brine treatment on the antibiotic curd

produced a body and texture one point lower in score than the same cheese manufactured by the normal cheddaring method. The normal cheese scored one point higher in body and texture than did the antibiotic cheddar cheese. The common criticism of the cheese body made from antibiotic milk was open and corky. The cheese made from antibiotic milk and treated with the emergency brine was criticized for open, weak, and fermented bodies.

Two trials in manufacturing cheese from antibiotic milk indicated that cheddaring for two hours and 15 minutes did not produce any better bodied cheese than the cheese which was cheddared only 30 minutes.

The flavor score of 90-day old cheese made from antibiotic milk was 1.2 points lower in score than the cheese made from normal milk. The use of the emergency brine treatment on the same antibiotic curd failed to improve the flavor score. Fermented flavor was found in 75 per cent of the antibiotic brine-treated cheese. The same criticism was found in 25 per cent of the antibiotic cheddar cheese. Table 11 gives the 90-day flavor score of the normal cheddar cheese, the antibiotic cheddar cheese, and the antibiotic emergency brine-treated cheese.

The average moisture content of the normal cheddar cheese was 37.06 per cent. The antibiotic cheddar cheese was 40.74 per cent moisture. The emergency brine treatment of the antibiotic curd followed the same pattern as it did upon normal curd in previous trials producing 42.63 per cent moisture cheese.

The salt content of all the cheese ranged from 1.62 to 1.76 per cent sodium chloride indicating that about the same amount of salt is taken up by the curd whether it was from antibiotic milk emergency brine treated, antibiotic milk cheddared, or normal milk.

Table 11. Titratable acidity developed during the manufacturing of cheese made from normal milk and antibiotic milk

	Treatment of milk and curd		
	Control	.50 ppm tetracycline brine treatment	.50 ppm tetracycline normal cheddering
Starter	.179	.179	.179
Rennet	.19	.186	.186
Cutting	.121	.119	.119
Dipping	.14	.126	.127
Milling[a]	.465	--	.155
Milling[b]	--	.139	--

[a]Milled 2 hours and 15 minutes after dipping

[b]Milled 35 minutes after dipping

Table 12. Body and texture scores and criticisms of four lots of 90-day cheese made from normal milk and antibiotic milk

Normal cheese		Antibiotic and cheddar		Antibiotic and brine	
Score	Criticism	Score	Criticism	Score	Criticism
28.0	Open, corky	27.5	Open, corky	26.5	Open, weak, fermented
29.5	Open	29.0	Open	28.5	Open, fermented
29.5	Open	27.5	Open, fermented	27.0	Open, weak
29.5	Open	28.5	Open, corky	27.0	Open, fermented
29.1		28.1		27.25	Average

There was no detectable butterfat losses during the manufacturing process of the antibiotic cheese. The high moisture cheese made from the antibiotic milk resulted in lower butterfat than in normal cheese.

Table 13. Flavor score and criticism of four trials of 90-day cheese made from normal milk and antibiotic milk

Normal cheddar cheese		Antibiotic cheddar cheese		Antibiotic and brine	
Score	Criticism	Score	Criticism	Score	Criticism
39.0	Acid	39.0	Acid	37.5	Fermented
40.0		40.0		40.0	
40.0		36.0	Unclean	38.0	Fermented
38.0	Fermented	36.5	Fermented	36.5	Fermented
39.2		37.9		38.0	Average

Relationship of hot brine procedure and high moisture cheese

High moisture cheese resulted in each experiment using hot brine on the milled curd. The moisture varied from 41.38 to 45.21 per cent, depending upon the brine variation used on the milled curd. The average moisture content of 15 lots of normal cheddar cheese made as a control for each lot was 38.58 per cent. The average moisture content in 15 lots using the hot brine treatment was 42.58 per cent.

Greater moisture losses during curing occurred in the cheese made by the brine treatment. Brine-treated cheese lost 2.29 per cent points, and control cheese lost 1.49 per cent points in 180 days of curing.

Association of low salt content and bitterness in flavor

The average salt content of 15 lots of normal cheese was 1.6 per cent. The flavor criticism of bitterness was not found in this cheese up to 210 days of curing. The average salt content of cheese made from brine-treated curd was 1.08 per cent. Bitterness was found in 80 per cent of the cheese which had salt content below 1.25 per cent at the 210-day analysis.

CONCLUSION

The best hot brine combination developed was seven per cent salt brine held on the milled curd at 115°F. for 15 minutes. The hot brine combination incorporated about the same amount of salt in the cheese as the normal dry salting. A brining combination of five per cent salt, 120°F. for 10 minutes produced a cheese with low salt content. The results of five trials using five per cent brine showed that over 80 per cent of this brine-treated cheese was criticized for having a bitter flavor.

Increasing the brine concentration from five per cent to seven per cent increased the per cent of salt and moisture in the finished cheese. The increase of brining temperatures from 115°F. to 120°F. also increased the salt and moisture content of the cheese. The average moisture content of all emergency brine-treated cheese was 42.6 per cent. Weak, open, and fermented body characteristics were the common criticism when the emergency brine treatment was used on the antibiotic curd.

The addition of 0.50 ppm tetracycline hydrochloride to the milk caused almost complete cessation of acid production during the cheese manufacturing process. The effect of the antibiotic upon titratable acidity could not be detected until the dipping of the whey. The negative acid production is very evident 35 minutes after dipping. The curd from antibiotic milk fails to mat, develop elasticity, and expel moisture. The resulting cheese has characteristic openness and corkiness in the body, as well as some adverse flavor. The absence of acid

due to the antibiotic fails to expel moisture resulting in a higher moisture cheese.

The use of the emergency hot brine treatment on the milled curd made from antibiotic milk produced a cheese which was one point lower in body and texture score than the cheddar cheese from the same antibiotic milk. The emergency process cheese was criticized for an open, weak, and fermented body. The moisture was high which is typical in cheese made by this emergency procedure.

It is recommended that more study be made to reduce the moisture content by treating the milled curd with hot water for 15 minutes prior to forming the brine with the addition of seven per cent salt.

SUMMARY

The best hot brine combination developed for use as an emergency procedure in manufacturing cheese from antibiotic milk was seven per cent brine, at 115°F., held on the curd which was milled 35 minutes after dipping for 15 minutes. By increasing the salt content of the brine, the salt content and the moisture content of the cheese was increased. Increasing the temperature of the brine also increased the salt and moisture content of the cheese.

High moisture cheese with a weak, open, and fermented body was characteristic of the cheese made from normal milk and antibiotic milk utilizing the emergency brine treatment. Low brine concentrations and a short hold of the brine on the curd result in low salt cheese. Eighty per cent of the low salt cheese due to the emergency process was criticized for bitterness.

The addition of 0.50 ppm tetracycline to the milk caused almost complete cessation of acid production in the cheese manufacturing process. The cheddar cheese made from antibiotic milk was characterized by high moisture, open and corky body, and a flat flavor. Cheese made from normal milk scored one point higher in body score than the cheese made from the antibiotic milk, and 1.3 points higher in flavor score.

The use of the emergency brine procedure in manufacturing cheese from "dead" milk produced a cheese one point lower in body and texture than the cheddared cheese from antibiotic milk.

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