A STUDY OF FACTORS AFFECTING THE SHELF LIFE OF COTTAGE CHEESE

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INTRODUCTION

Under the present day conditions of processing and handling of cottage cheese there is ever present the problem of spoilage. About 30 years ago the processing of cottage cheese underwent a radical change, brought about by consumer demands for a bland product. Before the more recent practices cottage cheese curd was subjected to incomplete cooking, which resulted in a large amount of lactose being incorporated in the curd. The lactose made possible a later fermentation and an increase in acidity. This acidity protected the cottage cheese against spoilage due to certain micro-organisms. Since at the present time most cottage cheese curd is subjected to more complete cooking more of the lactose is lost in the whey. This results in a product which is lower in acidity and has less protection from the acid.

This present study was conducted to (1) determine the influence of antibiotics and antimycotics on the keeping quality of cottage cheese, (2) determine the influence of hydrogen ion concentration in (a) the creaming mixtures, (b) the time of cutting the curd, (c) the wash waters, on the keeping quality of cottage cheese, (3) the influence of modification of the creaming mixtures on the keeping quality, and (4) the influence of adding culture and salt to cottage cheese to improve the keeping quality.

REVIEW OF LITERATURE

Deane, et al (3) examined 79 samples of cottage cheese, representing 25 plants, by organoleptic, chemical, bacteriological and keeping quality tests. Samples submitted by the manufacturers were found to be of higher quality when received, than samples purchased in retail stores. The keeping quality of both groups, as measured by holding 2 days at 21° C. (69.8°F.) or 5 days at 6-7°C. (42.8-44.6°F.) were equally poor. The butterfat, moisture and total chlorides varied from 2.2 to 2.8%, 71.8 to 81.8% and 0.32 to 1.7% respectively, with corresponding averages of 5.2, 77.8 and 1.2%. The pH values ranged from 4.4 to 5.2 with 59 samples having a pH of 4.8 or above and 21 samples with pH 5.0 or above. A slime curd defect was found in both stored and fresh samples of cheese having a pH below 4.7 when received. Poor flavor characteristics of fresh cheese and cheese stored at 21°C. (69.8°F.) for 2 days were associated most closely with mold counts in excess of 100/gram. Proteolytic and lipolytic counts in excess of 100/gram on the cheese received were associated most closely with poor keeping quality after 5 days at 6-7°C. (42.8-44.6°F.).

Elliker (7) and Parker, et al (19) reported that three (3) species of bacteria, Pseudomonas fragi, Pseudomonas viscosa, and Alcaligenes metalcaligenes are responsible for much of the slimy, gelatinous curd defects of cottage cheese. These workers also reported that these bacteria are readily isolated from equipment, plant dust, creaming mixtures, and water supplies.

Elliker (7) reported that pH was very important in determining the keeping quality of cottage cheese. His tests showed that in curd inoculated and incubated at 59°F. for 72 hours, there was no visible spoilage at pH of 4.8. Pseudomonas viscosa produced slime at pH 5.0 and all bacteria did at pH 5.2.

Collins (1) reported that prolonged incubation permitted cultures of Pseudomonas fragi, Pseudomonas visocsa and Alcaligenes metalcaligenes to cause surface spoilage of cottage cheese at initial pH values as low as 4.6 and at temperatures as low as 3.5°C(38.3°F.). The defects developed slowly at low pH values and very slowly at 3.5°C. (38.3°F.). Low initial pH values did not retard Pseudomonas viscosa as much as they retarded Pseudomonas fragi and Alcaligenes metalcaligenes; low temperatures did not retard Pseudomonas fragi as much as they retarded the other two species.

Harmon and Smith (12) reported that microbiological analysis of 48 retail market and 35 plant samples of cottage cheese indicated that many types of organisms capable of causing spoilage proliferate in cottage cheese at 42°F. The average microbiological populations in cottage cheese samples purchased from retail markets were much higher than in samples secured directly from commercial plants, and held 4 days at 42°F. Most types of spoilage occurred throughout the pH range of cottage cheese, but pH below 5.0 prolonged the shelf life and reduced the rate of proliferation of coliform, lipolytic and proteolytic organisms. Terminal average yeast and mold populations increased as the pH of the cottage cheese decreased. Greater proteolysis, as measured by free tryptophan, occurred in high pH samples. Fairly good correlation existed between the type of organisms attaining dominance and the nature of

organoleptic deterioration. Fairly good correlation existed between average initial coliform and lipolytic populations and keeping quality, but there was much variation among the individual samples. There was little correlation between shelf life and organoleptic quality of the fresh cheese.

Harmon and Smith (11) reported on 17 vats of cottage cheese that were manufactured in 12 commercial plants. Microbiological analyses were performed on samples of all raw materials and on the cheese at various stages of manufacture. When held at 50° F., representative samples from 10 of the vats possessed shelf life ranging from 50 to 10 days, and the shelf life of samples from 7 vats ranged from 13 to 16 days. In the fresh cheese logarithmic averages of the counts of coliforms, lipolytic and proteolytic bacteria were 50, 1,298 and 1,967 per cent greater in the groups of samples with the short shelf life than in the group with the shelf life of 13 to 16 days. The initial organoleptic quality scores were only slightly higher in the group with the longer shelf life. The pH of the cheese and temperature at which the product is washed and handled are important factors in keeping quality. The shelf life of samples at 40° F. averaged 51 per cent longer than corresponding samples held at 50° F. Improperly pasteurized milk and cream, coagulator, starter, air and contaminated equipment were found to be sources of spoilage organisms. Samples of several of the above caused spoilage when inoculated into sterile cheese and incubated at 21° C. (69.8° F.) for 4 days.

Harmon, et al (10) reported that storage of cottage cheese at a uniform temperature of 42° F. results in a much longer shelf life than the fluctuating and much higher average temperature to which the product

is usually subjected to in retail markets and home storage. The shelf life ranged from 5 to 19 days on the samples obtained on the market and from 6 to 23 days on the samples obtained from the plants. The averages were 11.9 to 15.1 days respectively. The shelf life of samples stored at 50°F. ranged from 5 to 16 days and averaged 10.9 days and that of duplicate samples stored at 42°F. ranged from 6 to 23 days and averaged 16.5 days. Samples in which the pH increased possessed an average shelf life of 13.5 days and samples in which the pH decreased had a shelf life of 16 days. There was a definite relationship between the pH and the type of off-flavors and spoilage. Unclean flavors seldom appeared in low pH samples while musty flavors were more frequent in the low range. Putrid and bitter flavors occurred throughout the pH range, but were more common above pH 5.0. Fruity flavors occurred over the entire pH range while an acid or sour flavor was evident in samples having a pH range of 4.52 to 4.92. Surface slime or discoloration occurred throughout the pH range but was common above pH 5.0.

Rhodes and Harmon (20) reported that there is some relationship between free tyrosine content and occurrence of bitter, rancid or decomposed flavor, with off-flavors appearing when free tyrosine reached 125 to 150 ppm.

Davis and Babel (4) reported that the rate of slime formation on cottage cheese inoculated with bacteria capable of producing the defect was related to the temperature of holding. Some of the cultures failed to produce slime at 4.4 or 10°C. (40.1 or 50°F.) in 14 days, whereas, others produced it in 7 to 11 days at 4.4°C. (40.1°F.) and 5 to 7 days at 10°C. (50°F.). All of the cultures produced slime on cottage cheese held at 21°C. (69.8°F.) in 1 to 4 days. Cottage cheese

having a pH of 4.7 readily developed slime when the temperature was favorable. As slime formed on a cottage cheese sample, the pH of the slime area increased. Formation of the slime was rapid after its initial appearance. Cottage cheese curd washed with suspensions containing 2,000,000 to 120,000,000 bacteria per milliliter retained from 0.0093 to 0.40% of the organisms. Ropy cultures were retained more readily than non-ropy cultures. The temperature of incubation had a greater effect on the rate of slime formation than did the number of bacteria in the wash water.

Collins (2) reported that either 3 or 5 ppm of residual chlorine destroyed cultures of Pseudomonas fragi, Pseudomonas viscosa, Alcaligenes metalcaligenes, Escherichia coli and Aerobacter aerogenes very rapidly at pH 6.0. The bactericidal efficiency of chlorine was somewhat less at pH 8.0, and greatly reduced at pH 10.0. Pseudomonas fragi was the most resistant species studied. The effectiveness of chlorine was decreased by low temperatures. For equal destruction of Pseudomonas fragi at 4.4 and 21°C. (40.1 and 69.8°F.) approximately twice as much time was required at 4.4°C. (40.1°F.).

The influence of antibiotics and antimycotics on microorganisms in dairy products has been studied by various investigators.

Greene and Bell (8) reported that chlortetracycline and oxytetracycline added to raw milk in the order of 10 ppm effectively inhibited both acid production and bacterial growth for 20 hours at 37°C. (98.6°F.). Godkin and Cathcart (9) found that, with autoclaved custard fillings 0.6 to 1.0 ppm of chlortetracycline and oxytetracycline were effective against Micrococcus pyogenes during a 24 hour incubation period at 37°C. (98.6°F.). Pencillin showed slight effectiveness at 1.2 ppm. Bacitracin (40-60 ppm) and chloramphenicol (4-5 ppm) were valueless. Sublitin

demonstrated inhibitory action at 10 ppm and bactericidal action at 20 ppm. With non-autoclaved fillings 1.0 ppm of chlortetracycline and oxytetracycline were effective against Micrococcus pyogenes.

Hashida (13) reported that antibiotics added to cow's milk within 4 hours of milking gave the following preservations at 30°C. (86°F.): streptomycin and penicillin (200 ppm) 1 day; chloramphenicol (100 ppm) 2 days; patulin (200 ppm) 3 days; and chlortetracycline and oxytetracycline (100 ppm) 4 days.

Hashida and Asai (14) reported on mixtures of antibiotics added to raw cow's milk and the time of preservation; they are as follows: patulin (100 ppm) plus chlortetracycline (100 ppm) 10 days; penicillin (100 ppm) plus chlortetracycline (100 ppm) 8 days; and penicillin plus chloramphenicol, patulin plus chlortetracycline and chloramphenicol and chlortetracycline or patulin and chlortetracycline had a slight effect.

Inomoto and Hashida (15) reported that acid production and coagulation in milk were checked by chloramphenicol, chlortetracycline and oxytetracycline. The above antibiotics and also patulin were effective against putrefying microorganisms isolated from milk and dairy products for short preservations.

Shiveler and Weiser (21) reported that penicillin (3 ppm), dihydrostreptomycin (10 ppm) and chlortetracycline (100 ppm) effectively inhibited bacterial multiplication for 24 hours in raw milk and for 48 hours in pasteurized milk. At the levels used, chlortetracycline was the most effective.

Emard and Vaughn (6) reported that sorbic acid had been tested as a growth inhibitor on 229 different cultures of bacteria, mold, yeasts and actinomycetes. Under the conditions of the in vitro tests, it was found that sorbic acid at concentrations of about 0.1 per cent of less

selectively inhibited the growth of a large number of the cultures. Best inhibition was found to occur when the pH of the medium was adjusted to between 5 and 6.

Melnick, et al (17 & 18) and Smith and Rollin (22) reported that sorbic acid effectively inhibits mold growth on cheese when used in low concentrations. Melnick and Luckmann (16) reported that sorbic acid incorporated into the lining of cheese wrappers migrates from the wrapper into the cheese. Smith and Rollin (23) stated that approximately 0.05 per cent of the sorbic acid, based on the weight of cheese, is often sufficient to give protection against mold, although concentrations up to 0.1 percent may be used.

Deuel, et al (5) presented some toxicological data which indicate that sorbic acid is harmless to rats and to dogs when incorporated in the diet to the extent of 5 per cent (moisture-free basis), and that it may be used with confidence in foods in concentrations required for effective mold control.

EXPERIMENTAL METHODS

A. Hydrogen Ion Concentration Determinations

Two methods for the hydrogen ion concentration determinations were employed during the course of this study: The glass electrode system used in conjunction with a Beckman pH meter and the quinhydrone electrode system used in conjunction with a MacBeth pH meter.

The cottage cheese curd was prepared for analysis by mixing it into a paste. This was found to be equal in accuracy to blending the curd particles with a Waring Blendor and more accurate than determinations on the curd particles.

I. Glass Electrode System

The curd particles were mixed into a paste using a heavy glass stirring rod, and the determinations were made by inserting the electrode into the cheese.

II. Quinhydrone Electrode System

The curd particles were mixed into a creamy paste using a heavy glass stirring rod. When determinations were made on uncreamed cottage cheese curd it was necessary to add distilled water to obtain the creamy consistency. About 0.1 gm of quinhydrone was mixed into the paste and distilled water, in an equal volume to the volume of cottage cheese curd employed, was added. Then the determinations were made by inserting the electrodes into the cheese.

B. Organoleptic Determinations

The samples were scored by an experienced dairy products judge, who has had several years experience judging cottage cheese. The samples were removed from the incubation cabinets, scored and replaced as rapidly as possible to avoid a warm up.

EXPERIMENTAL RESULTS AND DISCUSSION

A. Influence of aureomycin and of sorbic acid on shelf-life

In order to establish the approximate levels of tolerance of cottage cheese spoilage organisms for various concentrations of sorbic acid and/or aureomycin, preliminary tests were conducted *in vitro*. One drop each of fresh cultures of *Pseudomonas fragi*, *Pseudomonas viscosa* and *Alcaligenes metalcaligenes* was inoculated individually into 10 ml quantities of litmus milk to which was added various amounts of aureomycin and/or sorbic acid to give the concentrations of from 0 to 16 ppm and from 0 to 8,000 ppm (0.8%) respectively, incubated at 71°F. and observed daily for evidence of changes. Additional trials were conducted in which the milk was inoculated with yeasts and with molds and in which sorbic acid in concentrations of from 0 to 8,000 ppm were added to the milk. The mold spores were suspended in sterile, buffered, distilled water and the yeasts were cultured in litmus milk and 1 drop of inoculum was used for each test. The molds used were: *Penicillium roqueforti* and mold #1 (*Aspergillus* type). The yeasts used were: *Candida pseudotropicalis* and *Torulopsis sphaerica*. From these tests it was decided that aureomycin in the concentrations of from 0 to 6 ppm and that sorbic acid in concentrations of from 0 to 600 ppm (0.06%) would be used to determine their influences on the shelf life of cottage cheese.

Series I

In Series I the trials were run using cottage cheese manufactured in the Oklahoma State University dairy plant. Two levels of pH and two temperatures of storage were employed to determine the influence of these factors on the rate of deterioration. A 3000 gm portion of fresh, unsalted dry cottage cheese curd was obtained and ground, using a food grinder with sieve opening of 1/16 inch. Sterile equipment was used to avoid contamination. The sample was then weighed out in enamel cups in equal portions of 1500 gm each. To one sample portion was added sufficient cold tap water to barely cover the curd. To the other sample portion was added a mixture of cold tap water and NaOH (N/1) solution to alter the pH value. It had been found in a preliminary experiment that it would require 60 ml of the NaOH solution to raise the pH approximately 0.5 units on the 1500 gm sample. The samples were packed lightly to eliminate air pockets, packed in ice, covered, and stored overnight at 45°F. After storage the samples were allowed to drain to remove the excess water. A creaming mixture was prepared by mixing equal portions of whipping cream (32% fat) and homogenized milk (3.5%fat). A 500 ml portion of the creaming mixture was inoculated with 1 ml each of fresh cultures of Pseudomonas fragi, Pseudomonas viscosa, and Alcaligenes metalcaligenes. A 320 ml portof the creaming mixture was inoculated with 1 ml of spore suspensions of Pencillium roqueforti, and Mold #1 (Aspergillus type) and with 1 ml of Candida pseudotropicalis.

Then 26 ml portions of these creaming mixtures were poured into sterile half-pint glass milk bottles, and various amounts of sorbic acid and/or aureomycin were added to give the following concentrations: (1) aureomycin: 2, 4, and 6 ppm; and (2) sorbic acid: 200, 400, and 600 ppm;

and (3) combinations of aureomycin and of sorbic acid in these same concentrations. The creaming mixtures (26 ml each) were added to 74 gm of the drained cottage cheese curd contained in 4 oz. glass jars, stored for 1 hour at 45°F. and the excess cream poured off. The creamed cheese was then dispensed in equal portions into two petri plates and incubated at 50° and 70°F. for trials 1 and 2 and at 45° and 55°F. for trial 3. The pH determinations were made using the quinhydrone electrode. The samples were examined organoleptically daily for evidence of deterioration. The results are shown in Table I.

In the cottage cheese with a pH of 4.8, inoculated with bacteria and stored at 50°F., the aureomycin added alone or in combination with sorbic acid improved the keeping quality, as the appearance of the defects was delayed 2 days with 2 ppm and 3 days with 4 or 6 ppm. When sorbic acid was added alone there was no improvement in the keeping quality. In the cottage cheese inoculated with yeasts and molds the addition of sorbic acid improved the keeping quality, as the shelf life was increased 2 days with all 3 concentrations. In the cheese with a pH of 5.3, inoculated with bacteria, 2 ppm of aureomycin had no effect, while 4 and 6 ppm delayed the appearance of defects only 1 day. Sorbic acid added alone or in combination with aureomycin improved the keeping quality at the higher levels, while a concentration of 200 ppm had no effect. In the cheese inoculated with yeasts and molds the addition of sorbic acid improved the keeping quality. Concentrations of 200 and 400 ppm delayed the appearance of defects 2 days, while 600 ppm delayed it 3 days.

In the cottage cheese with a pH of 4.8 inoculated with bacteria and stored at 70°F., the addition of aureomycin and sorbic acid alone or in combination only slightly improved the keeping quality.

TABLE I

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

Trial I

MATERIAL ADDED		INOCULATED WITH		KEEPING QUALITY AT 50°F.				KEEPING QUALITY AT 70°F.			
				pH 4.8		pH 5.3		pH 4.8		pH 5.3	
Aureomycin ppm	Sorbic Acid ppm	Bacteria	Yeast and Molds	Days*	Defects	Days*	Defects	Days*	Defects	Days*	Defects
-	-	+	-	4	fruity, putrid	3	putrid, slimy	2	rancid, slimy	2	fruity, slimy
-	-	-	+	4	yeasty, moldy	3	musty, slimy	2	musty, slimy	2	musty, slimy
2	-	+	-	6	putrid	3	slimy	2	putrid	2	fruity, slimy
4	-	+	-	7	rancid	4	slimy	3	rancid	2	putrid, slimy
6	-	+	-	7	rancid	4	putrid, slimy	3	rancid	2	putrid, slimy
-	200	+	-	4	fruity, slimy	3	putrid, slimy	2	rancid	3	musty, moldy
-	400	+	-	4	fruity	5	fruity, slimy	3	musty, slimy	3	musty, moldy
-	600	+	-	4	fruity	5	fruity, slimy	3	rancid	3	slimy
-	200	-	+	6	rancid, musty	5	fruity, bitter	2	musty, moldy	2	musty, moldy
-	400	-	+	6	fruity	5	fruity	2	fruity, moldy	2	musty, moldy
-	600	-	+	6	fruity	6	fruity	3	musty, moldy	2	musty, moldy
2	200	+	-	6	putrid, rancid	3	slimy	2	rancid	2	unclean, slimy
4	400	+	-	7	rancid	5	fruity	3	putrid, slimy	2	putrid, slimy
6	600	+	-	7		5	putrid, flimy	3	rancid, slimy	2	fruity, slimy

* = days required for definite appearance of defect(s)

TABLE I (con't)

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

Trial II

MATERIAL ADDED		INOCULATED WITH		KEEPING QUALITY AT 50°F.				KEEPING QUALITY AT 70°F.			
				pH 4.8		pH 5.2		pH 4.8		pH 5.2	
Aureomycin ppm	Sorbic Acid ppm	Bacteria	Yeast and Molds	Days*	Defects	Days*	Defects	Days*	Defects	Days*	Defects
-	-	+	-	9	fruity	4	putrid, slimy	4	fruity, slimy	5	musty
-	-	-	+	4	yeasty	4	yeasty	2	yeasty	2	fermented
2	-	+	-	12	fruity, musty	6	fruity, slimy	4	musty, moldy	3	putird, slimy
4	-	+	-	12	fruity	6	putrid, slimy	4	musty, moldy	3	putrid, slimy
6	-	+	-	12	musty	6	putrid, slimy	4	putrid, moldy	3	putrid, slimy
-	200	+	-	6	putrid, slimy	6	fruity, slimy	6	putrid	6	putrid, moldy
-	400	+	-	12	putrid, slimy	6	putrid, slimy	3	malty, unclean	2	putrid
-	600	+	-	12	putrid, slimy	6	putrid, slimy	3	malty	3	putrid, moldy
-	200	-	+	6	yeasty	6	yeasty	2	yeasty	2	yeasty
-	400	-	+	6	yeasty	6	fruity	2	yeasty	2	yeasty
-	600	-	+	6	yeasty	6	fruity	3	yeasty	3	yeasty
2	200	+	-	12	fruity, slimy	6	putrid, slimy	6	musty, moldy	6	putrid
4	400	+	-	15	putrid	6	putrid, slimy	6	fruity, moldy	3	putrid, slimy
6	600	+	-	15	rancid	6	putrid, slimy	6	musty, moldy	4	putrid, slimy

* = days required for definite appearance of defect(s)

TABLE I (con't)

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

Trial III

MATERIAL ADDED		INOCULATED WITH		KEEPING QUALITY							
				45°F.				55°F.			
				pH 4.8		pH 5.4		pH 4.8		pH 5.4	
Aureomycin ppm	Sorbic Acid ppm	Bacteira	Yeast and Molds	Days*	Defects	Days*	Defects	Days*	Defects	Days*	Defects
-	-	+	-	5	fruity, slimy	5	putrid, slimy	5	rancid, slimy	5	unclean, slimy
-	-	-	+	5	fruity, slimy	5	unclean, slimy	5	fruity, slimy	5	musty, slimy
2	-	+	-	7	fruity, slimy	6	putrid, slimy	5	fruity, slimy	5	fruity, slimy
4	-	+	-	8	putrid	6	putrid, slimy	6	putrid, slimy	5	fruity, slimy
6	-	+	-	8	fruity, rancid	6	putrid, slimy	6	putrid, slimy	5	putrid, slimy
-	200	+	-	6	putrid, slimy	5	fruity, slimy	5	fruity, slimy	5	rancid, slimy
-	400	+	-	6	putrid, slimy	6	putrid, slimy	5	fruity, slimy	5	fruity, slimy
-	600	+	-	6	putrid, slimy	6	putrid, slimy	5	fruity, slimy	5	fruity, slimy
-	200	-	+	6	fruity, slimy	5	putrid, slimy	5	fruity, slimy	5	fruity, slimy
-	400	-	+	6	fruity, slimy	5	fruity, slimy	5	fruity, slimy	5	fruity, slimy
-	600	-	+	6	fruity, slimy	5	fruity, slimy	5	fruity, slimy	5	fruity, slimy
2	200	+	-	7	fruity, slimy	6	putrid, slimy	5	putrid, slimy	5	putrid, slimy
4	400	+	-	8	fruity	6	putrid, slimy	5	putrid, slimy	5	fruity, slimy
6	600	+	-	8	rancid	6	putrid, slimy	6	sour, slimy	5	putrid, slimy

* ≅ days required for definite appearance of defect(s)

Concentrations of 4 or 6 ppm aureomycin and 400 or 600 ppm of sorbic acid, alone or in combination delayed the appearance of defects only 1 day. In the cheese inoculated with yeasts and molds sorbic acid in a concentration of 600 ppm delayed the appearance of defects 1 day, but with 200 or 400 ppm there was no effect on the keeping quality. In the cheese with a pH of 5.3 inoculated with bacteria, the addition of aureomycin alone or in combination with sorbic acid appeared to have no influence on the keeping quality, while the addition of sorbic acid alone effected a very slight improvement in that the defects were delayed 1 day at all 3 concentrations. In the cheese inoculated with yeasts and molds the addition of sorbic acid had no influence on the keeping quality.

Trial II was a repeat of Trial I, using cheese from a different lot from the Oklahoma State University dairy plant.

In the cottage cheese with a pH of 4.8, inoculated with bacteria and stored at 50°F., aureomycin improved the keeping quality, as the appearance of defects was delayed 3 days with all 3 concentrations. When sorbic acid was added there was an improvement in keeping quality of the cheese with 400 or 600 ppm added as the appearance of the defects was delayed 3 days. With 200 ppm, the defects were promoted rather than delayed. When a combination of aureomycin and sorbic acid was added there was an improvement in keeping quality, as the appearance of the defects was delayed 6 days with the higher concentrations, and 3 days with the lower concentration. In the cheese inoculated with yeasts and molds the addition of sorbic acid slightly improved the keeping quality. The shelf life was increased 2 days with all 3 concentrations.

In the cottage cheese with a pH of 5.2, inoculated with bacteria and stored at 50°F., aureomycin and sorbic acid added alone or in combination

slightly improved the keeping quality, as the appearance of defects was delayed 2 days with all 3 concentrations. In the cheese inoculated with yeasts and molds the addition of sorbic acid only slightly improved the keeping quality. The shelf life was increased 2 days with all 3 concentration.

In the cottage cheese with a pH of 4.8, inoculated with bacteria, and stored at 70°F., aureomycin had no effect on improving the keeping quality. When sorbic acid was added there appeared to be a detrimental effect on the keeping quality, except with 200 ppm which delayed the defects 2 days. Combinations of aureomycin and of sorbic acid only slightly improved the keeping quality, as the appearance of the defects was delayed 2 days with all 3 concentrations. In the cheese inoculated with yeasts and molds the addition of sorbic acid has only a slight effect on improving the keeping quality, as the appearance of defects was delayed 1 day with 600 ppm, but with 200 or 400 ppm added there was no effect on the keeping quality. In the cottage cheese with a pH of 5.2, inoculated with bacteria the addition of aureomycin with all 3 concentrations promoted rather than delayed the appearance of the defects. When sorbic acid was added, a concentration of 200 ppm delayed the appearance of the defects, while with 400 or 600 ppm the defects were promoted rather than delayed. When combinations of aureomycin and sorbic acid were added, the lower concentrations delayed the appearance of defects 1 day, while the defects were promoted rather than delayed with the two higher concentrations. In the cheese inoculated with yeasts and molds the addition of sorbic acid with all 3 concentrations promoted rather than delayed the appearance of defects.

Trial III was a repeat of Trials I and II, using cheese from a different lot from the Oklahoma State University dairy plant, except

that storage temperatures of 45° and 55°F. were employed rather than 50° and 70°F.

In the cottage cheese with a pH of 4.8, inoculated with bacteria and stored at 45°F., aureomycin added alone or in combination with sorbic acid improved the keeping quality, as the appearance of defects was delayed 2 days with 2 ppm and 3 days with 4 or 6 ppm. Sorbic acid only slightly improved the keeping quality, as the appearance of defects was delayed 1 day with all 3 concentrations. In the cottage cheese inoculated with yeasts and molds the addition of sorbic acid only slightly improved the keeping quality. The shelf life was increased 1 day with all 3 concentrations. In the cheese with a pH of 5.4, inoculated with bacteria, aureomycin and sorbic acid added alone or in combination only slightly improved the keeping quality, as the appearance of the defects was delayed 1 day with all concentrations. In the cottage cheese inoculated with yeasts and molds the addition of sorbic acid had no effect on improving the keeping quality.

In the cottage cheese inoculated with bacteria, with a pH of 4.8 and stored at 55°F., the addition of aureomycin only slightly improved the keeping quality, as the appearance of defects was delayed 1 day with 4 or 6 ppm, but with 2 ppm there was no effect. Sorbic acid had no effect on improving the keeping quality. When combinations of the compounds were added, a concentration of 6 ppm of aureomycin and of 600 ppm of sorbic acid only slightly improved the keeping quality, as the appearance of defects was delayed 1 day, but at the two lower concentrations there was no effect. In the cottage cheese stored at 55°F. the addition of the antibiotic or antimyotic, in concentrations employed, there appeared to be no effect on improving the keeping quality of either bacterial or yeasts and molds inoculated cottage cheese.

The temperature of storage and the pH of cottage cheese appeared to have a marked influence on the types of defects that developed during storage. At the lower pH level (4.8) and lower storage temperatures (45° to 50°F.) the most common defects that developed were the flavor defects characterized as fruity and putrid, with a slimy defect appearing intermittently, while at higher storage temperatures (55° to 71°F) the most common defects were fruity, putrid and rancid, with a slimy defect appearing at a higher rate than at a pH of 4.8.

At the higher pH levels (5.2 to 5.4) and at storage temperatures of 45° to 70°F. the most common defects were fruity, putrid, rancid and moldy with a slimy defect appearing at a much higher rate than at a pH of 4.8.

From the results presented above it may be concluded that aureomycin in concentrations of from 4 to 6 ppm was generally effective in delaying the appearance of bacterial defects in cottage cheese in which the pH was relatively low (4.8) and at storage temperatures of 45° to 55°F. At higher pH levels, (approximately 5.3) and at higher storage temperatures (70°F) the aureomycin had only a slight effect in delaying the appearance of bacterial defects.

Sorbic acid in concentrations of from 200 to 600 ppm was generally effective in delaying the appearance of defects due to bacteria and to yeasts and molds in cottage cheese in which the pH was relatively low (4.8) and storage temperatures of 45° to 55°F. However, the sorbic acid was not generally as effective in controlling bacterial defects as was the aureomycin. At higher pH levels, (approximately 5.3) and at higher storage temperatures (70°F.) the

sorbic acid had only a slight effect, if any, on delaying the defects due to either bacteria or yeasts and molds.

Combinations of aureomycin and sorbic acid, in the concentrations employed, had the same general effect in controlling the bacterial defects as did aureomycin, indicating that the improvement in the keeping quality was largely due to the aureomycin.

Different temperatures of storage were employed in this experiment in an attempt to establish whether a storage temperature of 70°F. could be used to predict the development of defects which would likely occur in cottage cheese held at temperatures normally employed in the usual merchandising channels (45° to 55°F.) The results indicated that the use of a storage temperature of 70°F. was unreliable in predicting the keeping quality of cottage cheese.

Series II

In Series II the influence of adding aureomycin and/or sorbic acid on the keeping quality of cottage cheese was determined on 26 commercial samples, representing 20 dairy plants in Oklahoma. The samples used were obtained from cottage cheese submitted to the Oklahoma State University dairy department for a cottage cheese scoring clinic. Samples from each lot were removed for analysis, using sterile equipment.

From each lot a sample of sufficient size was obtained and submitted to various treatments. The following treatments were used:

1. No treatment (controls)
2. 10 ppm aureomycin added
3. 500 ppm sorbic acid added
4. 10 ppm aureomycin plus 500 ppm sorbic acid added

From each lot and each treatment 50 gm portions were dispensed into each of 2 sterile petri plates; one was stored at 45°F. and the other at 55°F., and observed organoleptically daily for a 12 day test period for evidence of deterioration.

With the aureomycin and sorbic acid solutions, a few drops of methylene blue were added to impart a distinct blue color. After adding these compounds, the cottage cheese was stirred until a uniform blue color was effected, which was an indication of uniform distribution of the compounds used.

The hydrogen ion concentrations were determined using the quinhydrone electrode in conjunction with the MacBeth pH meter. The results are shown in Table II.

There were considerable variations in the keeping quality of the control samples. At 45°F. the shelf life ranged from 3 to 12 days, with 13 or 50% of the samples keeping for 12 days or longer. The defects appeared more rapidly at 55°F., as the shelf life ranged from 1 to 7 days, with 4 or 19% of the samples keeping for 7 days. It must be kept in mind that there were probably considerable differences in the ages of these samples when they were submitted. The most common defects at 45°F. were fruity, putrid and slimy, while at 55°F., they were fruity, slimy and sour.

At 45°F. the addition of 10 ppm of aureomycin apparently did not improve the keeping quality, because in 7 of the samples there was an improvement, while in 7 other samples it appeared to be detrimental, and in the remaining 12 samples there was no effect on improving the keeping quality. The added aureomycin appeared to favor the development of a fruity defect, because in 6 samples this defect developed in the cheese with the aureomycin added, whereas, it was not apparent in the control samples.

With the addition of 500 ppm of sorbic acid there appeared to be little influence on the keeping quality of the cottage cheese stored

TABLE II

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

Series II--Commercial Samples Stored at 45°F

SAMPLE		CONTROL		10 ppm AUREOMYCIN		500 ppm SORBIC ACID		10 ppm AUREOMYCIN AND 500 ppm SORBIC ACID	
No.	pH	Days*	Defects	Days*	Defects	Days*	Defects	Days*	Defects
1	5.05	12	vinegar	19	vinegar	12		12	
2A	4.95	12		12		12		12	
2B	5.05	12		12		12		12	
3	5.30	5	fruity, slimy	3	fruity	5	fruity, slimy	5	fruity, slimy
4	5.15	9	putrid	12		12		12	
5	4.95	12		12	fruity	12	fruity	12	fruity
6	5.15	5	malty	12	malty	12		12	
7	5.15	5	fruity	5	fruity	9	fruity, putrid	9	fruity
8	5.15	3	malty	3	malty	12		12	
9	4.95	12		9	fruity	12		12	
10	5.15	5	putrid	9	fruity, putrid	9	fruity	9	putrid
11	5.15	9	fruity	12		9	unclean	9	unclean
12	5.05	12		12		9	unclean	9	unclean
13A	5.05	12		9	fruity	9	unclean	12	
13B	4.95	12		9	fruity	12		12	
14A	5.05	12		12		9	metallic, unclean	12	
14B	4.95	12		12		12		12	
15	5.05	12		12		12		12	
16	5.25	3	fruity, slimy	5	putrid, slimy	5	fruity, putrid	5	fruity
17A	5.15	12		7	fruity	9	unclean	9	unclean
17B	5.15	5	putrid, slimy	5	putrid, slimy	5	fruity	5	fruity, slimy
18A	5.25	5	fruity, putrid	5	fruity, putrid	5	fruity, slimy	5	fruity
18B	5.30	5	fruity, slimy	9	fruity, slimy	7	fruity	9	putrid, slimy
19A	5.15	5	fruity	9	fruity	9	yeasty	12	
19B	5.15	12		12		9	fruity	9	fruity
20	5.15	7	unclean	5	unclean	9	metallic, unclean	9	unclean

* = days required for definite appearance of defect(s)

TABLE II (con't)

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

Series II—Commercial Samples Stored at 55°F.

SAMPLE		CONTROL		10 ppm AUREOMYCIN		500 ppm SORBIC ACID		10 ppm AUREOMYCIN AND 500 ppm SORBIC ACID	
No.	pH	Days*	Defects	Days*	Defects	Days*	Defects	Days*	Defects
1	4.05	4	fruity	4	fruity	4	unclean	5	fruity
2A	4.95	4	fruity	4	fruity	4	musty	4	musty
2B	5.05	4	fruity	4	fruity, moldy	4	putrid, slimy	7	fruity
3	5.30	1	fruity, slimy	3	musty, slimy	3	fruity, slimy	3	fruity
4	5.15	5	fruity	5	fermented	5	unclean	7	fruity
5	4.95	7	fruity	4	fruity, moldy	4	fruity	4	musty, fruity
6	5.15	3	malty	3	malty	4	musty, moldy	5	fruity
7	5.15	4	fruity, slimy	3	fruity	4	fruity, slimy	4	fruity, slimy
8	5.15	4	unclean	5	unclean, slimy	4	fruity	7	unclean
9	4.95	5	fruity, moldy	4	fruity, moldy	4	fruity	4	fruity
10	5.15	3	fruity, slimy	4	fruity, slimy	3	fruity	4	putrid
11	5.15	5	fruity, slimy	4	fruity, slimy	4	fruity, slimy	4	fruity
12	5.05	5	musty, moldy	3	unclean	4	musty, moldy	4	malty, moldy
13A	5.05	7	fruity	4	fruity	4	unclean	4	fruity
13B	4.95	5	unclean	4	fruity	4	fruity	4	fruity
14A	5.05	4	sour	4	sour	4	sour	4	sour
14B	4.95	7	unclean	5	unclean	5	metallic	5	metallic
15	5.05	7	fruity	5	fruity	5	fruity	5	fruity
16	5.25	3	fruity, slimy	3	fruity	3	fruity	3	fruity
17A	5.15	5	putrid, slimy	4	putrid	4	fruity	4	putrid
17B	5.15	3	fruity, slimy	3	fruity	3	fruity	3	fruity
18A	5.25	3	fruity, slimy	3	fruity	3	fruity, slimy	3	fruity, slimy
18B	5.30	4	fruity, slimy	4	fruity, slimy	4	fruity, slimy	4	fruity, slimy
19A	5.15	3	malty	4	yeasty	4	malty	7	yeasty
19B	5.15	4	sour	4	fruity	4	fruity	4	fruity
20	5.15	3	sour	3	sour, unclean	3	sour, unclean	3	sour, unclean

* = days required for definite appearance of defect(s)

at 45°F., because it improved the keeping quality of only 9 samples, whereas, it appeared to be detrimental to the keeping quality in 5 samples and in the remaining 12 samples it appeared to have no effect on the keeping quality. The addition of sorbic acid appeared to favor a defect characterized as unclean for this defect was rather common when the sorbic acid was added, whereas, it was not apparent in the control samples.

The combination of 10 ppm of aureomycin and 500 ppm of sorbic acid appeared to be more effective in improving the keeping quality than either of the 2 compounds used alone, although the improvement was not striking. In 9 of the samples there was improvement in the keeping quality due to the action of the combination of the 2 compounds, while in 3 samples they appeared to promote the defects, and in the remaining 14 samples the combination of these 2 compounds appeared to have no effect.

At 55°F. the addition of 10 ppm of aureomycin had a detrimental effect on the keeping quality, because in only 4 samples did it appear to improve the keeping quality, while in 10 samples it appeared to be detrimental, and there was no effect on the keeping quality of the remaining 12 samples. The added aureomycin appeared to favor the development of a fruity defect, as it did at 45°F., although here the defect did appear in the control samples, but not as rapidly as it did when the aureomycin was added.

The addition of 500 ppm of sorbic acid appeared to have a detrimental effect on the keeping quality because in only 3 samples did it appear to improve the keeping quality, while in 9 samples it appeared to be detrimental to the keeping quality, and in the remaining 14 samples

it had no effect. It appeared that at this temperature an unclean flavor was less common than at 45°F.

The combination of 10 ppm of aureomycin and 500 ppm of sorbic acid was more effective in improving the keeping quality than either of the 2 compounds used alone, although the improvement was not striking. In 8 of the samples there appeared to be an improvement in the keeping quality, while in 9 samples the combination of these 2 compounds appeared to be detrimental, and in the remaining 9 samples there was no effect on the keeping quality.

From the results presented above with the cottage cheese stored at 45°F., the added aureomycin in the concentrations employed had no effect on the keeping quality while sorbic acid had only a slight effect. A combination of aureomycin and sorbic acid added to the cheese appeared to be more effective in improving the keeping quality than either of the 2 compounds employed alone, although the improvement was not striking. At 55°F. the added aureomycin and sorbic acid used individually appeared to be detrimental to the shelf life, but a combination of the compounds effected a slight improvement on the keeping quality. It appeared that the improvement effected was largely due to the action of the added sorbic acid.

It could be concluded that if the pH of the cottage cheese is maintained below 5.05, and a good sanitation program is carried on while working with the cheese, the addition of aureomycin and of sorbic acid, individually or in combination would result in only a slight improvement, if any, in the keeping quality.

The 26 commerical samples were grouped according to various pH levels and the average shelf life was calculated. These data are

shown in Table III. The temperature of storage and the pH of the creamed cottage cheese have a marked influence on the shelf life, because as the storage temperature and pH increase the shelf life is shortened.

It may be noted that the average shelf life, regardless of pH values or treatment of the samples, was considerably longer for the cheese stored at 45°F. as compared to the cheese stored at 55°F. These differences were especially great at the lower pH levels.

The striking influence of pH on the keeping quality of cottage cheese is illustrated by the data on the samples stored at 45°F. It may be noted that in the cheese with pH values of 5.14 or lower all of the control samples kept for 12 days or longer and the treated samples kept for 10.5 days or longer, whereas, with those samples with pH values of 5.15 or higher the shelf life was considerably shorter. In the cheese samples stored at 55°F. the pH levels appeared to have only a relatively slight influence on the keeping quality, although in general, the cheese with pH's in the lower ranges kept better than those at the higher levels.

TABLE III

INFLUENCE OF AUREOMYCIN AND SORBIC ACID ON KEEPING QUALITY OF COMMERCIAL COTTAGE CHEESE

pH range	No. of Samples	AVERAGE SHELF-LIFE (26 SAMPLES) IN DAYS							
		45°F.				55°F.			
		C.*	A.*	SA.*	COM.*	C.*	A.*	SA.*	COM*
4.95-5.04	5	12.0	10.8	12.0	12.0	3.8	4.2	4.2	4.2
5.05-5.14	6	12.0	11.0	10.5	11.5	5.2	3.0	3.2	4.8
5.15-5.24	11	7.0	8.3	9.5	9.7	3.8	3.8	3.8	4.7
5.25-	4	4.5	5.0	6.0	4.4	2.8	3.3	3.3	3.3

C.*----Control
A.*----Aureomycin
SA.*----Sorbic Acid
COM.*----Combination

B. Influence of pH on Shelf life

In order to determine the influence of pH on the shelf life of cottage cheese variations were made in (1) titratable acidities of the whey at the time of cutting curd, (2) pH of the creaming mixture, and (3) pH of the wash water.

(1). Variations in acidity of whey at time of cutting curd. Four small lots were made as follows: a 60 pound lot of fresh skim milk was weighed out into a steamed 10 gallon milk can and pasteurized at 143°F. for 30 minutes by partially immersing the can in an insulated water bath normally used for pasteurizing milk for bulk cultures. After pasteurizing, the milk was cooled to 90°F. Five per cent of a fresh, active lactic culture was added and 15 pound quantities of the inoculated milk were weighed out into sterile, square, stainless steel containers, ($8\frac{1}{2}$ in. by $8\frac{1}{2}$ in. by $8\frac{1}{2}$ in.). The short time procedure for cottage cheese was followed with the coagulator being added 1 hour after setting.

The titratable acidities were run every half-hour to maintain a constant check on the development of acid. The curd was cut at whey acidities of 0.49, 0.52, 0.55 and 0.57% respectively, using a 3/8 inch knife. The curd was then cooked by elevating the temperature from 90°F. to 120°F in 1 hour, held at this temperature for 15 minutes and the whey then drained off. The cottage cheese curd was washed with cold tap water, with a holding period of 15 minutes. The cheese was washed a second time with water at 45°F. which had been inoculated with 10 ml each of fresh cultures of Pseudomonas fragi, Pseudomonas viscosa and Alcaligenes metalcaligenes. After draining, 200 gm from

each lot were weighed out, creamed with 70 gm of dressing, dispensed in approximately 50 gm portions into each of 3 sterile petri plates, and incubated at 45°, 55° and 71°F. The pH of the fresh uncreamed and creamed cottage cheese was determined using both the glass, and quinhydrone electrodes. Each sample was examined organoleptically daily for evidence of deterioration. The results are shown in Table IV.

The results indicate, in general, that as the titratable acidity of the whey at the time of cutting increased, the shelf life of the creamed cottage cheese was lengthened. At a storage temperature of 45°F. the defects appeared in the cheese in 5 days when the cheese was cut at a relatively low whey acidity (0.49%), while they appeared in 9 days when cut at a relatively high acidity (0.57%), although there was a discrepancy between the shelf life of the cheese cut at an acidity of 0.52% and that cut at 0.55%. The cheese cut at an acidity of 0.52% showed a 2 day longer shelf life than that cut at 0.55%.

At a storage temperature of 55°F. the defects appeared in 4 days in the cheese cut at a whey acidity of 0.49%, while they appeared in 8 days in the cheese cut at an acidity of 0.57%.

At a storage temperature of 71°F. the defects appeared in 3 days in the cheese cut at a whey acidity of 0.49%, while they appeared in 5 days in the cheese cut at an acidity of 0.57%.

It was noted that the temperature of storage had an influence on the keeping quality, for as the temperature of storage increased the shelf life was shortened considerably. It was also noted that the whey acidity at cutting had a greater influence on the keeping quality at a storage temperature of 45°F. than it did at 71°F. At a storage temperature of 45°F. the shelf life of the cheese was lengthened 4

TABLE IV

INFLUENCE OF ACIDITY AT TIME OF CUTTING ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

LOT NO	ACIDITY OF WHEY AT CUTTING	GLASS ELECTRODE		QUINHYDRONE ELECTRODE		SHELF LIFE AT 45°F.		SHELF LIFE AT 55°F.		SHELF LIFE AT 71°F.	
		CREAMED CURD	CREAMED CURD	UNCREAMED CURD	CREAMED CURD	Days*	Defects	Days*	Defects	Days*	Defects
1	0.49	4.95	5.30	4.90	5.25	5	fruity	4	fruity	3	fruity
2	0.52	4.80	5.20	4.75	5.15	7	fruity	5	fruity	4	fruity
3	0.55	4.80	5.20	4.75	5.15	5	fruity	5	fruity	4	fruity
4	0.57	4.70	5.10	4.65	5.05	9	fruity	8	fruity	5	yeasty

* = days required for definite appearance of defect(s)

days when the cheese was cut at a whey acidity of 0.57% over the cheese cut at an acidity of 0.49%, while this difference was only 2 days when the cheese was stored at 71°F.

Both the quinhydrone and the glass electrodes were used in making the pH measurements. The results showed that the glass electrode generally gave readings 0.05 units higher than the quinhydrone electrode. This small difference indicates that either electrode could be used successfully with cottage cheese.

2. Variations in pH of creaming mixtures

Since the results of the previous trial indicated that the acidity at the time of cutting had a marked influence on the finished cheese, it appeared that the pH of the creaming mixture would have a marked influence on the keeping quality of the creamed cottage cheese. Accordingly, trials were conducted in which the cheese was creamed with creaming mixtures at various pH levels. In general the procedure was as follows: freshly pasteurized cream was obtained and a portion removed and iced immediately, the remaining cream was then inoculated with 5% of an active lactic culture and incubated at 90°F. Determinations of pH were made at intervals and samples were removed when certain pH levels were attained, and iced immediately. Cottage cheese curd was creamed with the various creaming mixtures, dispensed into each of 3 sterile petri plates, and incubated at 45°, 55° and 71°F. Each sample was examined organoleptically daily for evidence of deterioration for a 14 day period. The hydrogen ion concentrations were determined with the glass electrode.

In trial I the cheese curd was obtained from the Oklahoma State University dairy plant, and the creaming mixture was prepared by mixing together equal portions of whipping cream (32% fat) and milk (3.5% fat) obtained from the same source. In this trial a portion of the creaming mixture was inoculated with 0.5 ml each of fresh cultures of *Pseudomonas fragi*, *Pseudomonas viscosa* and *Alcaligenes metalcaligenes*.

In trials II through V the cheese curd was obtained from the Payne County Cooperative Dairy Plant. The creaming mixture was prepared from coffee cream and milk from the same source, and mixed together to give a 12% fat mixture. For these trials (II thru V)

sufficient creaming mixture was prepared for use in all trials so that the differences among the different lots would be the cheese curd used. The creaming mixture was not inoculated with spoilage organisms. The creaming mixture was kept iced during the several days it was stored to eliminate deterioration and changes in pH due to bacterial growth.

The results are shown in Table V.

In trial I, the cheese creamed with the untreated cream with a pH of 5.3 spoiled rather rapidly as only 3 days were required for defects to develop at either 45°, 55°, or 71°F., while that with lactic culture added and ripened to different pH levels was held 12 to 14 days or more at 45°F., and 8 to 10 days at 55°F. before distinct spoilage occurred. At 71°F., all the cheese had distinct defects in 3 days, regardless of pH. It should be noted that there were no great differences in length of shelf life with the cheese creamed with lactic culture added to the creaming mixture, despite the fact that the pH levels ranged from 5.25 to 5.10. Presumably, the improvement in keeping quality was largely due to the restraining effect of the lactic culture on the spoilage organisms.

In trial I, the cheese creamed with the creaming mixture which was inoculated with spoilage organisms spoiled more rapidly than those discussed above. The cheese creamed with a creaming mixture without lactic culture added developed a distinct defect in 3 days at 45°F. storage, in 4 days at 55°F., and in 2 days at 71°F. With lactic culture added the shelf life was 8 to 10 days at 45°F. and 4 to 9 days at 55°F. All the samples stored at 71°F. spoiled in 2 days, regardless of pH level. In general, as the pH levels of the creaming mixture used became lower, the shelf life increased, and the influence of pH

TABLE V

INFLUENCE OF pH OF CREAMING MIXTURES ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

TRIAL I

pH of CREAM MIXT.	pH of CREAMED CHEESE	KEEPING QUALITY AT 45°F. Days*	Defects	55°F. Days*	Defects	71°F. Days*	Defects
			INOCULATED				
6.7	5.30	3	fruity	4	fruity	2	fruity
6.2	5.25	8	fruity	4	fruity	2	fruity
5.6	5.20	10	fruity, rancid	5	fruity	2	fruity
5.1	5.15	10	fruity	9	putrid	2	fruity
4.6	5.10	10	rancid	9	putrid	2	fruity
			NOT INOCULATED				
6.7	5.30	3	fruity	3	musty	3	putrid
6.2	5.25	12	musty	8	musty	3	fruity, putrid
5.6	5.20	14	musty	8	fruity	3	musty
5.1	5.15	14	musty	10	putrid	3	musty
4.6	5.10	14	musty	10	putrid	3	musty

*=Days required for definite appearance of defect(s)

TABLE V (con't)

INFLUENCE OF pH OF CREAMING MIXTURES ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

pH of CREAM. MIXT.	pH of CREAMED CHEESE	KEEPING QUALITY AT 45°F. Days*	45°F. Defects	55°F. Days*	55°F. Defects	71°F. Days*	71°F. Defects
			TRIAL II				
6.7	5.30	4	fruity	3	fruity	3	putrid
6.05	5.25	10	fruity, putrid	8	putrid	4	musty
5.5	5.20	12	musty	8	putrid	3	musty
4.95	5.15	12	musty	9	fruity	4	musty
4.5	5.10	14	musty	8	putrid	3	musty
			TRIAL III				
6.7	5.30	4	fruity	3	fruity	3	fruity, putrid
6.05	5.25	10	musty	8	musty	4	fruity
5.5	5.20	10	musty	10	musty	6	putrid
4.95	5.15	12	unclean	10	rancid	6	putrid, musty
4.5	5.10	13	fermented	10	unclean, musty	6	musty
			TRIAL IV				
6.7	5.30	4	fruity	4	fruity, putrid	2	fruity
6.05	5.25	6	fruity	7	fruity	3	fruity
5.5	5.20	11	musty	8	putrid, musty	6	putrid
4.95	5.15	11	musty	9	fruity	6	putrid
4.5	5.10	12	unclean	9	putrid, musty	6	putrid
			TRIAL V				
6.7	5.30	2	fruity	1	fruity	1	fruity
6.05	5.25	9	unclean, musty	6	musty	4	musty
5.5	5.20	10	musty	8	musty	4	musty
4.95	5.15	10	musty	9	musty	4	putrid, musty
4.5	5.10	11	fruity	9	musty	4	putrid
			AVERAGES OF TRIALS II TO V INCLUSIVE**				
6.7	5.30	3.50	fruity	2.75	fruity	2.25	fruity, putrid
6.05	5.25	8.75	fruity, musty	7.25	putrid, musty	3.75	fruity, musty
5.5	5.20	10.75	musty	8.50	putrid, musty	4.75	putrid, musty
4.95	5.20	11.25	musty	9.25	fruity	5.00	putrid, musty
4.5	5.10	12.50	fruity, musty	9.00	putrid, musty	4.75	putrid, musty

* = Days required for appearance of definite defect(s)

** = The defects listed in the averages are the dominant defects

was more evident at 45°F. than at 55°F. It is probable that the increase in length of shelf life was due in part to the dominating effect of the lactic culture on the flora of the cheese. However, since the lactic organisms do not grow at 45°F. the increase in shelf life must have been largely due to the lowering of the pH.

In trial II to V inclusive, the cheese creamed with the untreated cream with a pH of 5.3 spoiled rather rapidly as only an average of 3.50, 2.75, and 2.25 days were required for defects to develop at 45°, 55°, and 71°F., respectively, while that creamed with cream with lactic culture added and ripened to different pH levels kept for considerably longer periods. In general, as the pH levels of the creaming mixtures used became lower, the shelf life increased, and the influence of pH was more evident at 45°F than at 55° or 71°F. The average maximum shelf life of the cheese stored at 45°F. was 12.5 days in the cheese with a pH of 5.10, while at 55°F. it was 9.25 days with a pH of 5.15 and at 71°F. it was 5 days with a pH of 5.15. Since the lactic organisms do not grow at 45°F. the increase in shelf life at this storage temperature must have been largely due to the lowering of the pH, while at the higher storage temperatures the increase in shelf life was probably due in part to the restraining effect of the lactic culture on the spoilage organisms in the cheese.

Table V shows that the addition of the lactic culture to to the creaming mixture and ripened to the different pH levels influenced the type of defects that were dominant. In the cheese creamed with the untreated cream the dominant defects were fruitiness, while that creamed with the cultured cream the dominant defects were unclean, musty and putrid. It should be pointed out that the musty and putrid defects

appeared to be largely due to mold growth since molds grow well at the pH levels found in the cheese in these trials.

The general results that were obtained by adding culture to the creaming mixture indicate that such a practice results in a considerable improvement on the shelf life, especially at the lower storage temperatures.

3. Variations in pH of wash water

Since the results of the previous trials indicated that the acidity at the time of cutting, and the pH of the creaming mixtures had a marked influence on the finished cheese, it appeared that the pH of the wash waters would logically have an influence on the keeping quality of the finished product. Accordingly, trials were conducted in which the cheese was washed with water at various pH levels. In general, the procedure was as follows: cold tap water was placed in sterile flasks, to which was added 5 ppm of chlorine. A portion was cooled immediately, and to other portions were added enough citric acid or NaOH to lower or to raise the pH to predetermined levels. The lots of treated wash water were cooled immediately in covered flasks and stored overnight at 45°F. Cottage cheese curd was divided into several portions and each was washed twice with water at a certain pH level with the water remaining on the cheese for 15 minutes. After draining, the cheese was creamed, dispensed into each of 3 sterile petri plates and incubated at 45°, 55°, and 71°F. A sample from each freshly washed cheese sample was removed before creaming and the pH and titratable acidities were determined. The acidities were determined in the following manner: The samples to be titrated were first blended to a semi-solid (pouring) consistency using a Waring Blendor. A 9 gm sample was weighed out in duplicate on a Torsion butter balance, 8 to 10 drops of 1.0% phenolphthalein solution added and the samples titrated with 0.1 NaOH to the first definite pink color which remained for 10 to 15 seconds. The results were expressed in terms of per cent by weight of lactic acid. The hydrogen ion

concentrations were made using the quinhydrone electrode. Each sample was examined organoleptically daily for evidence of deterioration.

In trial I the cheese curd was obtained from the Oklahoma State University dairy plant, and washed with water that was treated with citric acid to produce changes in the pH. The creaming mixtures were not inoculated with the spoilage organisms. Trial II was a repeat of trial I, using a different lot of cheese from the Oklahoma State University dairy plant, and both citric acid and NaOH were used to produce pH values lower and higher, respectively, than the pH of the tap water.

The results of these trials are shown in Table VI.

The results of these trials indicate that the pH of the wash water has no influence on the pH of the cheese curd, or finished cheese, for regardless of the pH of the wash water the pH of the cheese was the same. It is noted that there were some variations in the acidity values, as they ranged from 11.7 to 12.5 in trial I and from 12.1 to 13.1 in trial II. It was also noted that as the temperature of storage increased the shelf life was shortened considerably. At 45°F. the shelf life ranged from 13 to 15 days, with an average of 14.0 days; at 55°F. it ranged from 7 to 11 days, with an average of 9.14 days; and at 71°F. it ranged from 6 to 9 days, with an average of 8.14 days. These results indicate that storage temperature has a much greater influence on the shelf life of cottage cheese than does the pH of the wash water.

In these trials the most dominant defects were musty and putrid, with rancidity appearing in trial I only. It should be pointed out that the musty and putrid defects appeared to be largely due to mold growth, since molds grow well at the pH level found in the cheese in these trials.

TABLE VI

INFLUENCE OF pH OF WASH WATER ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

WATER	pH of CURD	CREAMED CHEESE	ACIDITY VALUES**	KEEPING QUALITY AT 45°F. Days*	45°F. Defects	55°F. Days*	55°F. Defects	71°F. Days*	71°F. Defects
				TRIAL I					
5.55	5.0	5.25	12.5	14	putrid	8	putrid, musty	9	musty
6.30	5.0	5.25	11.8	15	putrid, musty	7	putrid, rancid	9	musty
7.95	5.0	5.25	11.7	13	putrid, musty	8	putrid, rancid	6	musty
				TRIAL II					
5.4	5.0	5.25	12.1	14	musty	11	musty	9	musty
6.7	5.0	5.25	12.8	14		10	musty	9	musty
7.9	5.0	5.25	12.6	14		10	sour	8	musty
9.1	5.0	5.25	13.1	14		10	musty	7	musty

* = Days required for definite appearance of defect(s)

** = Ml of N/10 NaOH required to neutralize a 9 gm sample

The general results indicate that if the cheese is handled under sanitary conditions and stored at a relatively low temperature (45°F.) the pH of the wash water will not be a major factor in the keeping quality.

C. Influence of Modification of the Creaming Mixture

Since the results of the previous trails indicated that the titratable acidity of the whey at the time of cutting the curd, and that lactic culture added to the creaming mixtures had marked influences on the keeping quality of the creamed cottage cheese, it was decided to determine if the keeping quality of the creamed cottage cheese could be improved by modifying the pH of the creaming mixtures by adding citric acid and by adding various amounts of lactic cultures.

1. Adding Citric Acid

Two trials were conducted to determine the influence of adding citric acid to the creaming mixtures on the keeping quality of cottage cheese. The procedure was as follows: the creaming mixture was prepared by mixing together equal portions of whipping cream (32% fat) and milk (3.5% fat) and inoculating with 1 ml each of fresh cultures of Pseudomonas fragi, Pseudomonas viscosa and Alcaligenes metalcaligenes. The creaming mixture was divided into 5 portions. One portion was iced immediately, and to the other 4 portions citric acid was added to lower the pH to predetermined values. These samples were iced immediately. Sufficient creaming mixtures were prepared for both trials and were kept iced until used to prevent microbial deterioration.

Cottage cheese curd, that had been stored in brine, was obtained from the Oklahoma State University dairy plant and portions were creamed with the various creaming mixtures. Each sample was then dispensed into 3 sterile petri plates and incubated at 45°, 55°, and 71°F. respectively. Each sample was examined daily for evidence

of deterioration. The hydrogen ion concentrations were determined using the glass electrode. The results are shown in Table VII.

The results, in general, indicate that as the pH of the creaming mixtures were lowered, and consequently the pH of the creamed cottage cheese also lowered, the shelf life was lengthened considerably. At a storage temperature of 45°F., the cheese creamed with untreated cream with a pH of 5.30, spoiled rather rapidly as only 3 days were required for defects to develop, while with the cheese creamed with cream treated with citric acid, with a pH of 5.15 or lower, 10 days were required for defects to appear; at a storage temperature of 55°F. the cheese creamed with untreated cream spoiled rather rapidly as only 1 day was required for defects to develop, while the cheese creamed with cream treated with citric acid, with a pH of 5.10 required 8 days for defects to develop; at a storage temperature of 71°F. the cheese creamed with untreated cream spoiled rapidly as only 1 day was required for defects to develop, while the cheese creamed with cream treated with citric acid, with a pH of 5.15 or lower 3 days were required for defects to develop. In general, as the pH level of the creaming mixtures used became lower the shelf life increased, and the influence of the pH was more evident at 45° and 55°F. than it was at 71°F.

In these trials a fruity defect was the dominant defect as it appeared in nearly all the samples.

The results indicate that a pH of 5.15 or lower is desirable in the finished cheese for maximum keeping quality.

TABLE VII

INFLUENCE OF ADDING CITRIC ACID ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

pH of CREAM MIXT.	pH of CREAMED CHEESE	45°F. Days*	45°F. Defects	55°F. Days*	55°F. Defects	71°F. Days*	71°F. Defects
				TRIAL I			
6.7	5.30	3	fruity	1	fruity	1	fruity
6.1	5.25	4	fruity	2	fruity	1	fruity
5.6	5.20	9	fruity	3	fruity	3	fruity, yeasty
5.1	5.15	10	fruity	6	fruity	3	yeasty
4.7	5.10	10	fruity	8	fruity	3	yeasty
				TRIAL II			
6.7	5.30	3	fruity	1	fruity	1	fruity
6.1	5.25	5	fruity	3	fruity	1	fruity
5.6	5.25	8	fruity	4	fruity	2	fruity, putrid
5.1	5.15	10	fruity	7	fruity, rancid	3	fruity
4.7	5.10	10	fruity	8	fruity	3	fruity

* = Days required for definite appearance of defect(s)

2. Adding Lactic Cultures

Two trials were conducted in which cheese was creased with creaming mixtures which had from 0 to 40% of culture added.

The procedure used for trial I was as follows: uncreamed, and unsalted cheese curd was obtained from the Payne County Cooperative Dairy Plant, and divided into 2 equal portions. One portion of the cheese curd was then creamed with cream that was not inoculated, and the other portion was creamed with cream that had been inoculated with 1 ml each of fresh cultures of Pseudomonas fragi, Pseudomonas viscosa and Alcaligenes metalcaligenes. Table cream testing 18% fat was used and by adding various amounts of culture (buttermilk), 5 ph levels were established. Skim milk was added also in various amounts to standardize the creaming mixture to a fat content of 12%. The cheese was then dispensed into 3 sterile petri plates and incubated at 45°, 50°, and 55°F., respectively. Each sample was examined daily for evidence of deterioration. The hydrogen ion concentrations were determined using the glass electrode.

Trial II was a repeat of trial I, using a different lot of cheese from the Payne County Cooperative Dairy Plant, but only one sample was used. It was inoculated with spoiled, creamed cottage cheese that was fruity and yeasty and had surface slime. The results are shown in Table VIII.

In trial I, the cheese creamed with the untreated cream, not inoculated, and with a pH of 5.25 spoiled rather rapidly as only 4 days at 45°F., 3 days at 50°F., and 2 days at 55°F. were required for defects to develop. It appeared that 10% added culture only

TABLE VIII

INFLUENCE OF ADDING CULTURE ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

% CULTURE	pH of Creamed Cheese	KEEPING QUALITY AT 45°F. Days*	Defects	50°F. Days*	Defects	55°F. Days*	Defects
			TRIAL I				
			NOT INOCULATED				
0	5.25	4	fruity, putrid	3	fruity, slimy	2	fruity, slimy
10	5.20	4	fruity	4	fruity	4	fruity, bitter
20	5.15	10	fruity	8	yeasty, bitter	6	yeasty, bitter
30	5.10	10	fruity	10	yeasty, cheesy	10	yeasty
40	5.00	10	bitter, sour	10	putrid	10	putrid, cheesy
			INOCULATED WITH SPOILAGE ORGANISMS				
0	5.25	3	fruity, putrid	3	fruity, slimy	3	fruity, putrid
10	5.20	4	fruity	3	fruity, unclean	3	fruity, bitter
20	5.15	4	putrid	3	fruity, bitter	5	putrid
30	5.10	5	musty, bitter	4	rancid	3	rancid
40	5.00	5	musty	4	fruity, bitter	3	rancid
			TRIAL II				
			INOCULATED WITH SPOILED CHEESE				
0	5.25	2	fruity	2	fruity	2	fruity, putrid
10	5.20	3	fruity, rancid	3	fruity, yeasty	2	fruity, yeasty
20	5.15	6	fruity	5	fruity, bitter	5	fruity, bitter
30	5.10	6	fruity	4	fruity	6	putrid, bitter
40	5.00	6	fruity	5	fruity, bitter	6	putrid, rancid

*=Days required for definite appearance of defect(s)

slightly improved the shelf life, for at 45°F. there was no effect as the defects developed in 4 days which was the same as with the untreated sample, at 50°F. there was a slight effect as the defects developed in 4 days which was 1 day longer than the untreated samples, and at 55°F. there was a slight effect as the defects appeared in 4 days which was 2 days longer than the untreated sample. With 20 to 40% added culture (pH 5.15 to 5.00) it was noted that at all 3 storage temperatures there was a marked improvement in the shelf life. However with 20% added culture the improvement was not as marked at storage temperatures of 50° and 55°F. as it was at 45°F. It was also noted that with 30 and 40% added culture there was no difference in the shelf life of the cheese regardless of storage temperature.

In trial I, the cheese creamed with the creaming mixture which was inoculated with the spoilage organisms spoiled more rapidly than those discussed above. It appeared that with this highly contaminated cheese, lowering the pH by adding culture effected only a slight improvement in the keeping quality. Lowering the pH from 5.25 to 5.00 by adding culture lengthened the shelf life only 2 days at a storage temperature of 45°F. and only 1 day at 50°F.; at a storage temperature of 55°F. there was no apparent improvement in the shelf life.

In trial II, the cheese creamed with the untreated cream, with a pH of 5.25 spoiled rather rapidly as only 2 days were required for defects to appear at 45°, 50°, and 55°F. There appeared to be little, if any, influence on the shelf life when 10% culture was added to the creaming mixture, pH 5.20, while with the cheese creamed with 20 to 40% culture added to the cream there was a considerable influence on the shelf life at all 3 storage temperatures. The shelf

life was lengthened 4 days when stored at 45° and 55°F. and 3 days when stored at 50°F. It should be noted that there was little difference in the keeping quality of the cheese with a pH of 5.15 and that with a pH of 5.00.

In both trials I and II, the samples with culture added and stored at 50° and 55°F. showed a curdling of the creaming mixture and free whey, which is undersirable. The general results indicate that the addition of lactic culture to the creaming mixture in sufficient quantity to give pH values of 5.15 or lower in the finished cheese is a practical method for improving the shelf life. The keeping quality would probably have been better with all the samples if salt had been added to the cheese.

Since the previous trials were conducted with Streptococcus lactis cultures which are able to grow slowly at 50°F. and higher, the improvement in keeping quality might have been due in part to the restraining effect of the growth of the Streptococcus lactis culture at the higher storage temperatures. It was thought that the use of a culture that would not grow at these temperatures would reflect the influence of the pH only on the shelf life. Also, the use of such a culture would possibly eliminate the curdling and wheying of the creaming mixtures. Accordingly, a trial was conducted in which the pH values of the creaming mixtures were adjusted to different levels by adding ripened cultures of Streptococcus lactis and of Lactobacillus bulgaricus, using the same general procedure as in the previous trials.

The cheese used was unsalted and was obtained from the Payne County Cooperative Dairy Plant. The creaming mixture was inoculated with cottage cheese spoilage organisms. The amounts of culture used ranged from 0 to 30%, in 10% increments. The results are shown in Table IX.

The results of this trial indicated that by lowering the pH of the finished cheese by adding ripened lactic cultures to the creaming mixtures, the shelf life was lengthened regardless of which culture was used. It was noted that all of the cheese samples spoiled rather rapidly as the maximum shelf life was only 5 days regardless of the pH. At a storage temperature of 45°F. it appeared that the cultures were about equal in influencing the shelf life, as the control sample spoiled in 3 days, while the cheese creamed with cream treated with either Streptococcus

TABLE IX

INFLUENCE OF ADDING *S. lactis* AND *L. bulgaricus* ON THE KEEPING QUALITY OF CREAMED COTTAGE CHEESE

% CULTURE	ACIDITY OF CREAM (%)	pH OF CREAMED CHEESE	KEEPING QUALITY AT 45°F. Days*	Defects	50°F. Days*	Defects	55°F. Days*	Defects
				S. lactis				
0	0.23	5.25	3	fruity, putrid	2	fruity, bitter	3	fruity, bitter
10	0.25	5.25	5	fruity, bitter	2	fruity, bitter	3	bitter, sour
20	0.31	5.15	5	fruity, bitter	3	rancid, bitter	3	bitter, sour
30	0.36	5.10	5	fruity, bitter	3	bitter, sour	3	bitter, sour
				L. bulgaricus				
0	0.23	5.25	3	fruity, rancid	2	fruity, bitter	3	bitter, sour
10	0.29	5.25	3	fruity, bitter	2	fruity	3	bitter, cheesy
20	0.33	5.10	5	fruity, bitter	4	bitter	3	bitter, sour
30	0.34	5.10	5	fruity, putrid	5	rancid, bitter	3	bitter, sour

*= Days required for definite appearance of defect(s)

lactis or with Lactobacillus bulgaricus with a pH of 5.15 or lower spoiled in 5 days. At a storage temperature of 50°F. it appeared that the Streptococcus lactis culture had only a slight effect on the shelf life, as the control sample spoiled in 2 days, while that with added culture, with a pH of 5.15 or lower spoiled in 3 days. It appeared that the Lactobacillus bulgaricus culture at this storage temperature was superior to Streptococcus lactis, as the cheese creamed with treated cream and with a pH of 5.10 developed defects in 4 to 5 days, an increased shelf life of 1 to 2 days. At a storage temperature of 55°F. there appeared to be no difference in the shelf life for all the samples developed defects in 3 days, regardless of pH or culture used.

It was noted that free whey was present at all 3 storage temperatures when the Streptococcus lactis culture was used to treat the cream, while this defect appeared only at 55°F. when the Lactobacillus bulgaricus culture was used.

Fruity and bitter defects were dominant regardless of the culture used. The bitter defect might have been partially eliminated if salt had been added to the cheese.

D. Influence of Adding Salt and Culture on the Shelf Life

Since salt is normally used in cottage cheese to enhance the flavor and since it is a good preservative, it was thought that the use of this compound in conjunction with culture in the creaming mixtures would effect a great improvement in the keeping quality, and would inhibit the development of the bitter flavor defect which was prominent in the unsalted cheese used in the previous trials. Accordingly, trials were conducted in which cheese was salted with various concentrations of salt and culture in an attempt to eliminate the bitter defect and to improve the shelf life.

1. Influence of Adding Salt

One trial was conducted to determine the influence of adding only salt on the keeping quality of creamed cottage cheese. The procedure was as follows: The creaming mixture was prepared by mixing together equal portions of whipping cream (32% fat) and milk (3.5% fat) and inoculated with spoilage cottage cheese. Fresh, dry, unsalted cottage cheese curd was obtained from the Payne County Cooperative Dairy Plant and creamed with the inoculated creaming mixture. The creamed cheese was then divided into 7 equal portions, to which was added from 0 to 3.0% salt. The samples were dispensed into each of 3 sterile glass jars and incubated at 45°, 50°, and 55°F. Each sample was examined organoleptically daily for evidence of deterioration. The results are shown in Table X.

The results, in general, indicate that the addition of salt had a slight influence in improving the shelf life. At a storage temperature of 45°F. the cheese with 1.0% or less of salt added

TABLE X

INFLUENCE OF ADDING SALT ON THE SHELF LIFE
OF CREAMED COTTAGE CHEESE

% SALT	KEEPING QUALITY AT 45°F. Days*	Defects	50°F. Days*	Defects	55°F. Days*	Defects
0	4	fruity, putrid	5	fruity, putrid	3	bitter
0.5	4	unclean, bitter	5	rancid, bitter	3	bitter
1.0	4	unclean, bitter	6	rancid, unclean	3	putrid, bitter
1.5	5	putrid, bitter	4	rancid, bitter	3	bitter, sour
2.0	5	bitter	6	rancid, bitter	4	putrid, bitter
2.5	6	putrid, bitter	6	rancid, bitter	4	rancid, bitter
3.0	5	unclean, bitter	4	rancid, bitter	6	rancid, bitter

* = Days required for appearance of definite defect(s)

spoiled rather rapidly as only 4 days were required for defects to develop, while with the cheese with 1.5, 2.0, and 3.0% added salt, 5 days were required for defects to develop and 6 days were required for the defects to develop in the cheese with 2.5% added salt. At a storage temperature of 50°F. the cheese with no salt and 0.5% added salt spoiled in 5 days, the cheese with 1.0, 2.0 and 2.5% added salt spoiled in 6 days, while the addition of 1.5 and of 3.0% salt appeared to be detrimental to the shelf life as only 4 days were required for the defects to develop. At a storage temperature of 55°F. the cheese with 1.5% or less of added salt spoiled in 3 days, while the cheese with 2.0, and 2.5% added salt spoiled in 4 days and that with 3.0% added salt in 6 days.

In general, as the per cent salt used increased, the shelf life increased slightly. This indicates that salt is unable to completely inhibit growth of the spoilage organisms. From the results it is evident that the salt did not stop the development of the bitter defect. The other prominent defects that developed were putrid and rancid.

2. Influence of Adding Salt and Culture

Five trials were conducted to determine the influence of adding salt and culture on the keeping quality of creamed cottage cheese. In the first trial, 0 and 10% culture (% by weight of creaming mixture) and 0, 1, 2 and 3% of salt (% by weight of finished cheese) in combinations with the culture were used. In the other 4 trials 0, 1.0, 1.5 and 2.0% salt concentrations and 0, 5 and 10% culture added to the creaming mixtures were used in various combinations. The procedure for the first trial was as follows: cream (18% fat) was inoculated with spoiled cheese, Pseudomonas fragi, Pseudomonas viscosa and Alcaligenes metalcaligenes, divided into 4 equal portions and 0, 1, 2, and 3% salt, respectively, were added.

Cottage cheese curd was obtained from the Payne County Cooperative Dairy Plant, and divided into 8-210 gm portions and each was creamed with one of the creaming mixtures. Each lot of creamed cheese was then dispensed in 3 sterile glass jars, with covers, and incubated at 45°, 50°, and 55°F., respectively. The samples were examined organoleptically daily for evidence of deterioration. The results are shown in Table XI.

The results obtained in the first trial indicated, in general, that the addition of salt and culture had a marked influence on the shelf life of the creamed cottage cheese. However, at a storage temperature of 45°F. it appeared that the improvement in the shelf life was largely due to the action of the salt, while at 50° and 55°F. it appeared that the improvement was due to the combined action of the salt and the culture.

TABLE XI

INFLUENCE OF ADDING SALT AND CULTURE ON THE SHELF LIFE OF CREAMED COTTAGE CHEESE

% CULTURE	% SALT	KEEPING QUALITY AT 45°F. Days*	Defects	50°F. Days*	Defects	55°F. Days*	Defects
				TRIAL I			
0	0	4	unclean, bitter	3	malty, bitter	3	bitter, cheesy
10	0	4	fruity, bitter	3	bitter, sour	4	bitter, sour
0	1	6	fruity, bitter	3	fruity, bitter	2	fruity, bitter
10	1	6	bitter, sour	3	bitter, sour	6	fruity, bitter
0	2	6	fruity, bitter	3	fruity, bitter	6	fruity, bitter
10	2	6	fruity	6	fruity, bitter	8	malty, bitter
0	3	9	fruity, cheesy	8	rancid, cheesy	8	malty, cheesy
10	3	9	fruity	8	fruity	8	malty, cheesy

*= Days required for appearance of definite defect(s)

At a storage temperature of 45°F. the cheese creamed with the untreated cream and that treated with culture only spoiled in 4 days. The cheese with 1 and 2% salt alone or in combination with 10% culture added to the creaming mixture spoiled in 6 days, while the cheese with 3% salt alone or in combination with the culture spoiled in 9 days.

The keeping quality of the cheese stored at 50°F. was poorer than of that stored at 45°F. The only improvement was in that with 3% salt and in that with a combination of culture and 2 or 3% salt.

At a storage temperature of 55°F. the addition of 10% culture to the creaming mixture effected a slight improvement on the shelf life, while the addition of 1% salt appeared to be detrimental. The cheese with a combination of 10% culture added to the creaming mixture and 1% salt and that with 2% salt alone kept for 6 days. The additional samples with 10% culture added to the creaming mixtures with 2 or 3% salt and with 3% salt alone kept for 8 days. The longer shelf life of the samples stored at 55°F. compared to those stored at 50°F. may be accounted for by the more rapid growth of the lactic culture at the higher temperature. It was observed that coagulation of the creaming mixtures occurred in the samples with culture added to the cream.

Fruity and bitter defects were dominant at a storage temperature of 45°F. At 50°F. fruity and bitter defects were also dominant but other defects (malty, sour, rancid, and cheesy) were also evident. At a storage temperature of 55°F. bitterness was the most common defect with fruitiness, maltiness and cheesiness also prominent.

It should be noted that the samples with 3% salt added did not develop the bitter defect at any of the storage temperatures.

It was also observed that 3% salt was much too high for the average palate.

The general results indicated that the addition of salt and/or culture improved the keeping quality of cottage cheese, especially, when the storage temperatures are higher than 50°F. It should be remembered that the cheese used in this experiment was highly contaminated with spoilage organisms and that with moderate contamination the influence of salt and of culture would have probably been more evident.

Since the observations in trial I indicated that salt and culture had a favorable influence on the keeping quality of creamed cottage cheese and that a salt content of 3% was too high for the average person's taste, 4 additional trials were conducted using different amounts of culture and of salt. The same general procedure was used, except that 0, 5 and 10% culture were added to the creaming mixtures and 0, 1.0, 1.5 and 2.0% salt were used in the cheese. A storage temperature of 50°F. was used. Cheese from the Oklahoma State University dairy plant was used in trial II and from the Payne County Cooperative Dairy Plant in the remaining 3 trials. Both inoculated and inoculated creaming mixtures were used. The results are shown in Table XII.

The cottage cheese in trials II-V inclusive that was creamed with the untreated, uninoculated creaming mixtures spoiled in an average of 5 days, that with salt added to the cheese in concentrations of 1.0, 1.5 and 2.0% spoiled in 7.0, 8.5, and 10.75 days, respectively, while that creamed with cream to which culture was added in concentrations of 5 and 10% spoiled in 4.75 and 8.25, respectively. The cottage cheese creamed with cream to which 5% culture was added in combination with 1.0, 1.5 and 2.0% salt spoiled in 11.0, 11.75 and

TABLE XII

INFLUENCE OF ADDING SALT AND CULTURE ON THE SHELF LIFE OF CREAMED COTTAGE CHEESE

Creaming Mixture Not Inoculated

% Salt	% Culture	KEEPING QUALITY AT 50°F. Trial II Days*	Defects	Trial III Days*	Defects	Trial IV Days*	Defects	Trial V Days*	Defects	Average
0.0	0	5	fruity, bitter	5	fruity, bitter	5	fruity, bitter	5	fruity, bitter	5
1.0	0	8	bitter, slimy	7	bitter, slimy	7	fruity, bitter	6	fruity, putrid	7.0
1.5	0	8	bitter, slimy	7	bitter, slimy	9	fruity, bitter	10	musty, bitter	8.5
2.0	0	9	musty, moldy	13	bitter, unclean	9	fruity, yeasty	12	musty, moldy	10.75
0.0	5	4	bitter, unclean	4	bitter, unclean	6	putrid, bitter	5	fruity, bitter	4.75
1.0	5	9	bitter, slimy	13	sour, unclean	11	bitter, musty	11	bitter, musty	11.00
1.5	5	10	musty, moldy	13	musty, moldy	12	bitter, unclean	12	musty, moldy	11.75
2.0	5	10	musty, moldy	13	musty, moldy	13	musty, moldy	12	musty, moldy	12.00
0.0	10	6	rancid, bitter	8	bitter, moldy	9	putrid, bitter	10	musty, bitter	8.25
1.0	10	10	bitter, unclean	13	bitter, moldy	9	putrid, bitter	10	musty, bitter	10.5
1.5	10	14	musty, moldy	13	unclean, moldy	13	musty, moldy	13	musty, moldy	13.25
2.0	10	14	musty, moldy	14	unclean, moldy	14	musty, moldy	14	musty, moldy	14.00

* = Days for Definite Appearance of Defect(s)

TABLE XII (CONT)

INFLUENCE OF ADDING SALT AND CULTURE ON THE SHELF LIFE OF CREAMED COTTAGE CHEESE

Inoculated Creaming Mixture

% Salt	% Culture	KEEPING QUALITY AT 50°F. Trial II Days*	Trial II Defects	Days*	Trial III Defects	Days*	Trial IV Defects	Days*	Trial V Defects	Average
0.0	0	4	fruity, bitter	4	fruity, bitter	4	fruity, bitter	3	putrid, bitter	3.95
1.0	0	6	fruity, bitter	4	fruity, bitter	6	putrid, bitter	4	putrid, bitter	5.0
1.5	0	6	fruity, bitter	4	fruity, bitter	6	rancid, bitter	5	rancid, bitter	8.25
2.0	0	7	fruity, bitter	6	fruity, bitter	9	fruity, bitter	9	fruity, bitter	7.75
0.0	5	5	fruity, bitter	5	fruity, bitter	5	fruity, bitter	4	fruity, bitter	4.75
1.0	5	5	fruity, bitter	5	fruity, bitter	5	fruity, bitter	6	fruity, bitter	5.25
1.5	5	7	fruity, bitter	6	fruity, bitter	9	fruity, sour	7	fruity, bitter	7.25
2.0	5	8	fruity, bitter	7	fruity, bitter	9	fruity, cheesy	8	fruity, bitter	8.00
0.0	10	4	bitter, cheesy	4	fruity, bitter	6	rancid, bitter	3	fruity, bitter	4.25
1.0	10	5	bitter, sour	5	fruity, bitter	8	fruity, sour	5	fruity, bitter	5.75
1.5	10	8	fruity, bitter	5	fruity, bitter	10	fruity, cheesy	6	fruity, bitter	7.25
2.0	10	9	fruity, bitter	8	fruity, bitter	11	unclean, bitter	8	fruity, bitter	9.0

*= Days for Definite Appearance of Defects(s)

12.0 days, respectively while that creamed with 10% culture and salt spoiled in 10.5, 13.25 and 14.0 days, respectively.

Bitter, musty, moldy and unclean were the most prominent defects observed in these trials when the creaming mixtures were not inoculated. It should be noted that in the samples with 2.0% added salt alone and with 1.5% or higher added salt used in combination with 5 or 10% culture, the bitter defect did not develop. It was also noted that with 1.5% or higher added salt used in combination with 5 or 10% culture, in general, the spoilage appeared to be due to mold growth rather than bacterial growth.

The cheese creamed with the creaming mixture that was inoculated with the spoiled cheese and the spoilage organisms deteriorated more rapidly than those discussed above. It appeared that with this highly contaminated cheese the addition of salt only to the cheese, in the concentrations used, lengthened the shelf life considerably, while that creamed with culture added to the creaming mixture lengthened the shelf life only slightly. When the salt and 5% culture were used in combination they effected a marked improvement on the shelf life, the best improvement being attained with 1.5% added salt, while that with 10% added culture the shelf life, in general, was about equal to that with 5% added culture.

It was noted that, with these inoculated creaming mixtures, the 2 compounds added alone or in combination failed to inhibit the bitter flavor defect.

The general results of these trials (II to V inclusive) indicated that the addition of salt and/or culture improves the keeping quality of cottage cheese when stored at 50°F. It was noted that when

the cheese was not inoculated the spoilage appeared to be due largely to mold growth, and that the influence of salt and of culture was more evident in the cheese with low or moderate contamination than in that with high contamination.

SUMMARY AND CONCLUSIONS

A study was conducted to determine the influence of various factors on the keeping quality of creamed cottage cheese. The cheese was subjected to various treatments and samples stored at temperatures of from 45° to 70° F., and observed for rate and extent of deterioration.

The influence of aureomycin and/or sorbic acid on the keeping quality of cottage cheese was determined by adding various concentrations of these compounds to the dressing used to cream the cheese. The results, in general, indicated that these compounds improved the shelf life considerably when the pH of the finished cheese was relatively low, but they were ineffective when the pH was high. Sorbic acid was generally less effective in controlling bacterial defects than was aureomycin. Concentrations of 4 to 6 ppm of aureomycin were generally effective against bacterial development, while 400 to 600 ppm of sorbic acid were needed to control defects due to yeasts and molds.

A storage temperature of 70° F. was found to be unreliable for predicting the keeping quality of the cheese held under the conditions found in the normal merchandising channels.

Aureomycin and/or sorbic acid, in concentrations of 10 ppm and 500 ppm, respectively, were used on 26 commercial samples. The results indicated that these compounds improved the keeping quality of some of the lots, but that they cannot be relied upon to insure long shelf life.

The samples with pH values of 5.14 or lower had good keeping quality, whereas, those with higher values generally deteriorated rapidly.

The influence of the acidity of the whey at the time of cutting was determined by making four small lots of cheese from the same lot of milk and cutting at different whey acidities and determining the keeping quality. The results indicated that as the whey acidity at the time of cutting the curd increased, the shelf life of the finished cheese increased. At a storage temperature of 45°F., the whey acidity at the time of cutting the curd had a greater influence on the keeping quality than it did at higher storage temperatures.

Creaming mixtures were inoculated with an active lactic culture, incubated and samples were removed at various pH levels. The cultured creaming mixtures were then used to cream cottage cheese curd and the keeping quality determined. The general results indicated that as the pH of the creaming mixture was lowered the shelf life was lengthened considerably. Since lactic cultures grow at temperatures above 50°F., the increase in shelf life at storage temperature of 50°F. or above was probably due, in part, to the restraining action of the culture, but at a storage temperature of 45°F. the increase in shelf life must have been largely due to the lowering of the pH.

Cottage cheese curd was washed with cold tap water which was treated with citric acid or NaOH to attain predetermined pH levels. The cheese was then creamed and the keeping quality determined. The results, in general, indicated that the pH of the wash water had little or no influence on the pH of the finished cheese. However, there were slight variations in the titratable acidities of the finished cheese. It was concluded that if cheese is produced under good sanitation practices

and stored at low temperatures, the pH of the wash water will not be a major factor in determining the keeping quality.

Citric acid was added to the creaming mixtures until predetermined pH levels were attained. These creaming mixtures were then used to cream cheese curd and the keeping quality determined. The results, in general, indicated that as the pH of the creaming mixture was lowered the shelf life was lengthened considerably. A pH of 5.15 or lower was found to be desirable in the finished cheese for maximum keeping quality.

Cottage cheese curd was creamed with from 0 to 40% lactic culture added to the creaming mixtures. The results indicated that as the per cent added culture increased the shelf life was lengthened considerably. There was little difference in the keeping quality of the cheese with a pH of 5.15 and that with a pH of 5.00. At storage temperatures of 50°F. or higher a curdling and wheying off of the creaming mixture was noted.

In an attempt to eliminate the curdling and wheying off of the creaming mixture, a trial was conducted to compare the effects of adding Streptococcus lactis and of Lactobacillus bulgaricus cultures to the creaming mixtures. The results, in general, indicated that the 2 cultures were about equal in delaying the development of defects. The creaming mixture with Lactobacillus bulgaricus added did not curdle and whey off during storage as did those with Streptococcus lactis culture added.

Various concentrations of salt and lactic culture were added to the creaming mixtures in an attempt to improve the shelf life and to inhibit the bitter flavor defect that was prominent when culture only was added. The results, in general, indicated that there was an improvement in the shelf life when either salt or culture was added alone, but that the bitter flavor defect generally developed. When they were used

in combination they markedly improved the shelf life. Combinations of 1.5% or higher of salt and 5 or 10% of culture inhibited the development of the flavor defect in low or moderately contaminated cheese.

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