1 of 3

May 1972

To the Graduate Council:

I am submitting herewith a thesis written by Donald Wayne Mackens entitled "A Study of the Use of 88.7° C. Cream Dressing on the Quality of Cottage Cheese." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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A STUDY OF THE USE OF 88.7° C. CREAM DRESSING ON THE QUALITY OF COTTAGE CHEESE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Donald Wayne Mackens

June 1972

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ABSTRACT

Ten lots of cottage cheese were manufactured by the short-set method at the University of Tennessee Dairy Products Plant. Each lot was divided into three treatments which were designated as Treatments I, II, and III. Treatment I consisted of curd cooked to 60° C., dressed with cream of 87.7° C., and stored at 5° C. Treatment II consisted of curd cooked to 60° C., dressed with cream of 5° C., and stored at 5° C. Treatment III consisted of curd cooked to 53.3° C., dressed with cream of 5° C., and stored at 5° C. Each treatment was examined at intervals of 0, 7, 14, 21, and 28 days for microbiological and organoleptic quality. The objective of this study was to determine the benefits of treating freshly manufactured cottage cheese curd with a cream dressing at a temperature of 87.7° C.

The results of this study indicated Treatment I, curd cooked to 60° C. and treated with cream dressing of 87.7° C., offered an acceptable product which resisted spoilage by psychrophilic and coliform organisms. Yeast and mold growth was significantly ($P < 0.05$) retarded in Treatment I when compared to counts in Treatment II and Treatment III; however, high populations of yeast and mold organisms were present after 14 days of storage. These high numbers of yeast and mold organisms in Treatment I were probably the cause of low flavor scores.

An analysis of variance of flavor scores revealed a significant difference ($P < 0.05$) among treatments but no significant ($P > 0.05$) flavor-age interaction was found; however, Treatment I had the highest mean flavor score at the end of the 28 day storage period.

Body and texture evaluations revealed a preference for Treatment II primarily because of the firmer curd. Treatment I was found to have a softer curd but was preferred significantly ($P < 0.05$) over Treatment III, the control.

Problems with yeast and mold contamination and the softer curd of Treatment I suggested the need for further study of this method of manufacture.

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CHAPTER I

INTRODUCTION

Cottage cheese was processed or handled by 61.7 percent of the dairies in the United States in 1971. Creamed cottage cheese represented more than 99 percent of the total cottage cheese market. According to recent statistics (4), cottage cheese with a 29 percent increase, was second only to 1 and 2 percent milk in sales gain over 1970 figures. The production of cottage cheese has increased significantly over the past decade. In 1960, 799 million pounds were produced in the United States as compared to 978 million pounds in 1970 (41). This represented a 23 percent increase in 10 years. In Tennessee, cottage cheese production gained 17 percent from 1969 to 1970. In 1969, production was placed at 9,831,000 pounds and by 1970 had risen to 11,523,000 pounds (59).

The growing production and consumption of cottage cheese can be maintained only by measures involving strict controls on sanitation and subsequent keeping quality or shelf-life. Presently, most cottage cheese has a shelf-life of 10 to 20 days from the time of manufacture to the time of removal from the retail market.

The shelf-life of cottage cheese has long been a concern of the dairy industry (55). "The manufacturing technology by which cottage cheese is made has made it one of the most perishable of all dairy products" (43). Cottage cheese is an ideal media for the growth and reproduction of certain microorganisms which may be present from long

exposures to air, water, workers, and improperly sanitized equipment. Cannon (11) found inoculation rates of one per gram of certain micro-organisms could reduce shelf-life from 21.5 to 15.1 days.

The objective of this study was to determine the benefits, if any, from treating freshly manufactured cottage cheese curd with a cream dressing at a temperature of 87.7° C. Since published data using this method was not available, no comparison of results obtained in this study was possible.

CHAPTER II

REVIEW OF LITERATURE

I. SOURCES OF CONTAMINATION

Three major sources of contamination exist for cottage cheese. These are contamination from air, water, and workers.

Air has been cited as an important source of microbial contamination in cottage cheese (11, 19, 30, 34, 54). Cannon (10) found microbial counts in cheese-room air in the range of 16 to 86 per cubic foot. These counts were correlated negatively ($r = -0.642$) with the shelf-life of cottage cheese (11 to 33 days). The coefficient of determination indicated, however, that air contamination contributed approximately 40 percent to the variation in shelf-life. Heldman et al. (34) stated, "in products with high heat treatments and low microorganism populations, contamination from airborne microorganisms can greatly reduce shelf-life". These workers found under normal operating conditions within a cheese plant a mean of 22 colonies per five cubic feet of air.

The second major source of contamination is water. The large volumes of water used for washing curd constitute one of the most serious contamination hazards in cottage cheese production. Harmon (28) found the bacteriological condition of water supplies extremely important in dairy plant operations. Contaminated water was particularly detrimental because of the washing procedures of cottage cheese. Harmon (28) reported water supplies were often free of coliform

organisms while high in lipolytic, proteolytic, and psychrophilic organisms. This research indicated that water considered safe for public consumption was often unfit for use in washing cottage cheese curd. Olson et al. (45) defined psychrophilic organisms as those species capable of relatively rapid growth at low temperatures, usually within the range of 1.7° C. to 7.2° C. Harmon and Smith (30) found psychrophilic bacteria could easily be isolated from plant water supplies and Angevine (2) reported water to be the cause of poor keeping quality, especially for the psychrophilic type of spoilage.

Some bacteria common to water used in washing curd may cause spoilage at extremely low temperatures. Collins (16) reported one species of Pseudomonas caused spoilage of cottage cheese with prolonged incubation at temperatures of 3.5° C. and pH values as low as 4.6.

Workers in the cheese plant represent the third major source of contamination. Workers may be termed as moving sites of contamination. Sunga et al. (55) isolated bacteria from the arms and hands of four dairy plant workers. They identified 256 organisms of which 55.4 percent were cocci, 41.4 percent rods, and 3.2 percent yeast. Sarcina flava, Peptococcus prevotii, Sarcina aurantiaca, Sarcina lanseii, Staphylococcus epidermidis and Sarcina lutea were the most common cocci. Alcaligenes marshallii, Alcaligenes bookeri, Pseudomonas, and Corynebacterium were the most prevalent rods. Heldman et al. (34) reported a dairy plant worker contributed from 3 to 110 organisms per five cubic feet of air. A medium-sized man isolated in a five cubic foot area and relatively inactive was found to shed 110 organisms when his uniform was subjected to four hours of normal wear.

There are other sources of contamination of cottage cheese which may be grouped under a single heading of carelessness. These may range from improperly cleaned and sanitized equipment to faulty pasteurization of skim and cream.

II. SPOILAGE IN COTTAGE CHEESE

Past evidence indicates spoilage in cottage cheese results from microorganisms and enzymes liberated from them (31). Harmon and Smith (31) and Martin et al. (39) found the presence of certain microorganisms was very important in determining the shelf-life of cottage cheese. Deane and Nelson (20) found poor flavor characteristics of fresh cheese stored two days at 21° C. were associated most closely with mold counts in excess of 100 per gram. Microbial counts of proteolytic and lipolytic organisms in excess of 100 per gram were associated with poor keeping quality after five days at 7°C. Angevine (2) found spoilage in cottage cheese usually the result of psychrophilic organisms.

Species of the genera Pseudomonas, Flavobacterium, Proteus, Alcaligenes, Achromobacter, and some coliforms were commonly encountered. Some workers have found a relatively small number of these organisms was actually necessary to cause spoilage. Zimmerman and Kester (60) found by adding 10 organisms per gram of cottage cheese they could produce a gelatinous curd defect in five to seven days at 10° C.

The gelatinous curd defect was first described by Elliker in 1949 (23). This defect has been characterized by the formation of a thick, gelatinous, slimy film around individual curd particles. Color variations have included white, yellor brown, or translucent. Presently,

the occurrence of a visual gelatinous curd has been fairly rare. The other characteristics such as the fruity smell or putrid and rancid taste are still encountered. Parker et al. (48) identified Alcaligenes metalcaligenes, Pseudomonas fragi, and Pseudomonas viscosa as the chief causative organisms of gelatinous curd spoilage. These organisms were isolated from cottage cheese wash water and improperly cleaned equipment. Davis and Babel (19) identified five organisms associated with the gelatinous curd defect as Proteus, Pseudomonas, Aerobacter, Alcaligenes, and Achromobacter. Bonner et al. (8) inoculated sterile cottage cheese with several organisms. Alcaligenes butyri, Alcaligenes eurydice, Alcaligenes metalcaligenes, Escherichia coli, Escherichia freundii,Pseudomonas desmolyticum, Pseudomonas fluorescens, Pseudomonas fragi, and Pseudomonas tralucida produced slime. Geotrichum candidum, Mucor plumbeus, and Penicillium frequentans produced a moldy surface. The yeast, Torulopis candida, also produced a slime on the cheese surface. Other organisms contributing to spoilage were Micrococcus candidas, Micrococcus conglomeratus, and Micrococcus flavus.

II. METHODS TO INCREASE SHELF-LIFE

No substitute exists for proper care of the manufacture, packaging, and retailing of cottage cheese. Many variables are present in the production of cottage cheese which affect shelf-life. Some of these have been identified as temperature of storage, air and water contamination, periods of inadequate refrigeration, improper pasteurization, and unclean equipment. Separately and collectively these variables have

contributed to shortened shelf-life. The shelf-life of cottage cheese may be extended significantly by attacking each of these. On the other hand, by ignoring only one of these variables, one might destroy the benefits achieved by controlling the others. The cottage cheese industry has been the recipient of much research over the past two decades. Much of this research has dealt with problems commonly encountered in cottage cheese production. Several improved techniques for producing a product of excellent quality have been suggested. Many of these suggestions have been closely studied by industry and several have been accepted for commercial production.

In any program of quality cottage cheese production attention should be focused on the necessity of using high quality milk, cream, starter, and coagulator. Once these criteria have been met, attention may be given to the methods of manufacture.

A well accepted practice in cottage cheese manufacturing has been the pasteurization of milk for cheese at the lowest possible temperature to preserve the curd forming properties as well as the firmness of the finished curd. The State of Tennessee regulations have set the minimum pasteurization temperature at 62.7° C. for 30 minutes or 71.6° C. for at least 15 seconds (56). Angevine (3) recommended three standards. These were 30 minutes at 62.2° C. for vat pasteurization, 15 to 18 seconds at 72° C. for High Temperature Short Time pasteurization, and 85° C. for 2.5 seconds for vacreator pasteurization. Hedrick and Kondrup (33) placed the maximum heat treatment for skimmilk for cheese at 85.5° C. to 104.4° C. for 3 seconds or 73.8° C. for 20 seconds. These workers found an increase in yield was possible by using

the higher temperatures. The higher yield was the result of heat denaturization and precipitation of the serum proteins which were usually lost in the whey. The flavor of the cheese was found to be equal to the control (72.2° C. for 23 seconds) and keeping quality at 14 days was better than or equal to the control. When temperatures of 110° C. were used, the resultant curd was weak and whey expulsion was slowed considerably. Kristoffersen and Chakraborty (37) recommended temperatures of 62.7° C. and 65° C. for 30 minutes in the pasteurization of skimmilk used in cottage cheese manufacturing. These temperatures coupled with cooking the curd at 62.7° C. and 76.1° C. respectively, resulted in a 61 percent improvement in keeping quality. Initial flavor scores were inversely related to the temperature of the heat treatments, ranging from 39.4 for the control to 37.8 for the high heat treatment. Flavor differences were attributed to a cooked flavor. The high heat treatment did not affect the acceptability of the cheese body and texture. Emmons and Swanson (25) found heat treatments of 79.4° C. for 30 minutes produced an acceptable product with high yield but additional amounts of rennet were suggested as necessary in maintaining firm curd characteristics.

Davis and Babel (19) reported the organisms which produced slime were destroyed by a temperature of 62.8° C. for 2.5 minutes. Bonner and Harmon (6) found a temperature of 61.7° C. for 30 minutes successfully destroyed those organisms commonly associated with spoilage in cottage cheese. Nielsen (43) suggested temperatures of 62.7° C. for 30 minutes, 71.6° C. for 15 seconds, and 82.2° C. to 85° C. for 30 minutes when pasteurizing cream for cottage cheese dressing.

The temperature of cooking has been found to be very important in cottage cheese manufacturing. Chaudhary et al. (13) found selected species of Pseudomonas did not multiply during cottage cheese setting and could not be isolated from the cheese when cooked at a temperature of 54.5° C. Collins (15) reported cooking procedures without a maximum temperature of at least 54.4° C. and a holding time of at least 18 minutes were unsatisfactory unless the rate of heating was very slow. However, Angevine (3) reported that a temperature of 48.8° C. for 20 minutes was the most suitable temperature for cooking curd.

Since cottage cheese has been found to be a very perishable product, the temperatures of storage have played an important role in shelf-life. According to a study by Angevine (2), temperature was particularly important during the processing, packaging, storing, and delivery of the cottage cheese. He suggested that curd should be cooled to 4.4° C. in the last wash water and storage should be accomplished at temperatures below 4.4° C. Further, the cream dressing should be 4.4° C. or below and not allowed to increase more than 2° C. during the creaming operation. Kristoffersen and Chakraborty (37) found an increase of 47 percent in shelf-life by cooling the curd in a 1:1 ratio of whey and water. Nielsen (43) reported one of the most effective means of increasing shelf-life was to carefully control temperatures during draining, creaming, packaging, and storing of the cottage cheese. Collins (16) found temperatures of 3.5° C. the best for storage when coupled with a pH in the range of 4.6 to 5.0. When cheese was subjected to these conditions, spoilage was retarded but

not prevented. Elliker (22) reported temperatures of 5° C. were the most beneficial in maintaining cottage cheese. This temperature coupled with a pH of 5.0 was found to provide adequate conditions for the good keeping quality. Additional adjustments in pH of 0.1 to 0.2 units were critical in delaying growth of spoilage organisms. Harmon et al. (32) found cheese stored at 5.5° C. had an average shelf-life of 16.47 days while that stored at 10° C. had an average of only 10.88 days, a 51.3 percent increase in shelf-life. Overcast and Skean (46) recommended a temperature of 4.4° C. on the basis of their study on the importance of storage temperatures. These workers found relationship between organism populations and storage temperature.

Sherbon and Thomas (52) studied the control of temperatures after the cheese left the manufacturer and was placed with the retailer. They found temperatures could be controlled to some extent by adjusting packaging materials, shapes, and sizes and found foil surfaces to be the most beneficial in reflecting heat.

The treatment of creaming mixtures with cultures or acid has offered some means of controlling spoilage by microorganisms. Views have differed widely on the usefulness of either method. In 1954, Marquardt (38) reported on the use of two percent starter added to the cream before pasteurization and found no acid flavors present in the finished cheese as a result of the added culture but did find a reduction in spoilage by slime forming bacteria. Nielsen (43) suggested that cream be acidified by the use of added culture or acid. Angevine (2) recommended the use of 1 to 5 percent of a good lactic culture in the chilled dressing before adding it to the curd. The results indicated

the culture was beneficial in regard to flavor and helped retard the growth of psychrophilic organisms. However, the lack of adequate storage temperatures was found to cause an increase in organism numbers and resulting acid flavors. Harmon et al. (29) found reduction in pH from 6.5 to 5.5 of the creaming mixture with citric, lactic, or phosphoric acid usually resulted in shelf-life extension, but the addition of 1 percent starter in the creaming mixture resulted in inconsistency variations in shelf-life. The variations were the result of high acid development and subsequent whey formation. They concluded the addition of starter was advisable only when the manufacturer was assured his cheese would be held at 4.4° C. or below until consumed. Kristoffersen and Chakraborty (37) found pH reduction of cream dressing to 6.0 by the addition of lactic or phosphoric acid resulted in a 40 to 68 percent increase in shelf-life. Initial flavor quality was not reduced by the acidification of the cream but when the pH was reduced by culturing the dressing, an actual decrease in keeping quality was found. Mather and Babel (40) found a mixture of 1.5 parts of cream (20 percent fat) and 1.0 part of an acdified culture of Leuconostoc citrovorum prevented slime formation in cheese inoculated with Pseudomonas fragi or Pseudomonas putrefaciens. Coliform organisms were inhibited also, but Geotrichum candidum and Candida pseudotropualis were not. Elliker et al. (24) inoculated cream (12 percent fat) with a good quality culture. After incubation for 6 hours at 21° C., the cream was mixed with 3 percent salt and stored at 7° C. Cheese treated in this manner had a shelf-life exceeding 21 days but was accompanied by a variety of flavors which were readily detectable. The increased shelf-

life was attributed to the competitiveness of the flavor organisms over those spoilage organisms which may have been present in the cheese.

Educational institutions, commercial laboratories, and cheese plants have searched constantly for new and better methods for increasing shelf-life of cottage cheese. These developments have included a greater demand for high quality raw materials, better educated plant personnel, more modern and advanced equipment, and higher standards in quality control. One of the most promising developments of recent times has been in the area of food additives. This prominence was due in part to the ability of these additives to inhibit the growth of certain spoilage organisms. Several additives have been tried with some measure of success. Some of these are sulfur dioxide, hydrogen peroxide, chlorine, carbon dioxide, benzoic acid, dehydroacetic acid, acetic acid, propionic acid, sodium chloride, and sorbic acid.

Additives may be used as coatings for contact surfaces or added directly to the food product. Brunner and Mahlman (10) found elimination of surface growth of yeast and mold was partially accomplished by dipping cheese cartons in a 1 percent solution of dehydroacetic acid and its sodium salt. Stull (54) found levels of 0.05 percent nordehydroguaiaretic acid plus 0.05 percent sorbic acid could reduce psychrophilic spoilage of cottage cheese as well as retard autocatalytic oxidation. Mather and Babel (40) found the use of acetic or propionic acid added to cottage cheese useful in retarding slime formation but was not as effective as culturing the cream with Leuconostoc citrovorum.

Bonner and Harmon (6) reported sodium chloride at levels of 7 to 10 percent was effective in retarding the growth of most spoilage organisms but was of little benefit for practical usage. Aureomycin has been found to be generally effective in controlling bacterial spoilage at levels of 6 parts per million (ppm) as reported by Olson and Ball (44).

A considerable amount of research has been done with sorbic acid and its salts. The antimycotic activity of the fatty acid was first demonstrated by Clark (14) in 1899. Gooding (27) discovered that certain of the α, β-unsaturated fatty acids like sorbic acid, were good fungistatic agents for foods or food wrappers.

The ability of mammals, particularly man, to metabolize sorbic acid was the subject of much research by Deuel et al. (21). Their work indicated sorbic acid was readily metabolizable in exactly the same way as was the natural fatty acid, caproic acid.

The effectiveness of sorbic acid in concentrations of 0.10 percent was reported by Phillips and Mundt (50). They demonstrated that levels of 0.10 percent would completely inhibit yeast and molds and concluded sorbic acid and its salts had a broad-spectrum activity against yeast and mold, but was less active against bacteria. Smith et al. (53) found selected species of Saccharomyces were inhibited by the presence of 0.025 percent potassium sorbate. In addition they found pH was very important in the role of inhibition by sorbic acid. A more extensive study concerned with pH was that of Bell et al. (5). Of the organisms they studied, all grew in media containing 0.10 percent sorbic acid at pH 7.0 but as the pH was reduced, the viability of the organisms

was decreased. Bonner and Harmon (7) isolated 20 organisms associated with spoilage in cottage cheese. The organisms were grown at various levels of pH and sorbic acid. The results indicated that Pseudomonas fragi and two species of Achromobacter decreased in activity as pH decreased and sorbic acid content increased.

As early as 1957, Olson and Ball (44) made recommendations on the use of sorbic acid in cottage cheese. They suggested the use of 0.04 percent sorbic acid at the normal pH levels of cottage cheese would generally provide protection from spoilage by yeast and mold; however, there was no significant inhibition of bacterial species at this concentration. Harmon et al. (29) found sorbic acid used at a rate of 0.05 percent by weight ususally resulted in an extension of shelf-life. Kristoffersen and Chakraborty (37) found significant extension of shelf-life by the use of 0.065 percent sorbic acid or potassium sorbate. Either compound increased shelf-life by as much as 50 percent. Angevine (2) reported 0.03 to 0.05 percent sorbic acid in cheese dressing would retard spoilage by yeast and mold. Stull (54) and Geminder (26) found levels of 0.05 percent sorbic acid inhibited the growth of psychrophilic organisms and subsequent spoilage. Geminder (26) found sorbic acid or potassium sorbate at this level extended shelf-life 30 to 35 days. Levels of 0.075 percent were found to be the most beneficial. Perry and Lawrence (49) were successful in using sorbic acid at concentrations of 0.05 and 0.07 percent. Samples containing sorbic acid at either concentration had no off-flavors at 25 days while the control had off-flavors at 15 days. Bradley et al. (9) inoculated freshly manufactured cheese with several potential spoilage organisms. Potassium sorbate at levels

of 0.05, 0.075, and 0.10 percent by weight was found to be both bacteriostatic and mycostatic. This conclusion was based on evidence showing an initial reduction in organism populations and extended lag periods in the early phase of the growth curve. Off-flavors were frequently present when concentrations of 0.10 percent were used but were not evident at concentrations of 0.075 percent. Collins and Moustafa (17) did sensory and shelf-life studies of cottage cheese treated with potassium sorbate. Sensory evaluations failed to detect potassium sorbate by flavor or odor at concentrations of 0.10 percent by weight. Levels of 0.05 to 0.07 percent improved shelf-life from 27 to 47 days.

Lyophilization of cottage cheese was suggested by Jokay and Meyer (36). The final product had a moisture content of 2 percent and a reconstitution time of 10 minutes. Samples packaged in the presence of air had a shelf-life of 10, 30, and 48 weeks at temperatures of 37.8° C., 21.1° C., and 4.4° C., respectively. When packaged in nitrogen atmosphere, samples had slightly longer shelf-life. Tsantilis and Kosikowski (57) packaged cottage cheese under vacuum, nitrogen, and carbon dioxide. Cheese packaged under normal atmospheric conditions deteriorated quickly with high yeast and mold populations. Cottage cheese held under carbon dioxide retained a fresh flavor after extended storage. The control samples stored at 4.4° C. for five weeks reached a count of 27 million per gram of yeast and mold organisms while cheese packaged with carbon dioxide had yeast and mold counts of less than 10,000 per gram. Similar results were obtained when packaged with nitrogen or vacuum.

Nielsen (43) has pointed out the importance of sanitizing all equipment coming in direct contact with the cheese such as cheese vats, paddles, pipes, and other essential items. Recommendations on concentrations of sanitizers has been the subject of much research. Mueller (42) reported detergent-sanitizers at 25 ppm of available iodine compared favorably with 100 ppm of available chlorine in destroying Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa in the presence of hard water (500 ppm $CaCO_3$) and in 1 percent whole milk. Several workers (3, 12, 22) have recommended the use of 200 ppm of chlorine when sanitizing contact surfaces. Johns (35) found concentrations of 7.5 ppm idophor G, a straight germicide, to be very effective at temperatures of 20° C. to 49° C., but not as effective as chlorine at 5° C. In the presence of 0.50 percent skimmilk idophor showed favorable results while chlorine was ineffective.

The importance of water as a source of spoilage organisms has been mentioned previously in this review. Several workers (18, 19, 29, 37) have made studies of this problem and have recommended the use of certain additives or methods which destroy or inhibit spoilage organisms in cottage cheese wash water. Nielsen (43) and Seiberling and Harper (51) recommended High Temperature Short Time treatment of water supplies when contamination appeared to be extremely serious. Harmon et al. (29) recommended 7.5 ppm of hypochlorite, iodophor, or quaternary ammonia compound be added to the second wash water. Frequent increases in shelf-life were attained by the use of these compounds at this concentration. Marquart (38) demonstrated the effectiveness of 7.5 ppm of iodine in the final wash water to inhibit or destroy organisms

common to plant water supplies. Kristoffersen and Chakraborty (37) found the use of 20 ppm aureomycin in the last two wash waters improved keeping quality 67 percent but myprozin was ineffective.

Davis and Babel (19) reported 100 ppm of chlorine added to wash water immediately before the water was used to wash the curd was unsuccessful in controlling selected species of the genera Achromobacter, Aerobacter, Alcaligenes, Proteus, and Pseudomonas. However, Tuckey (58) found similar results but recommended the addition of 5 ppm of chlorine and holding a minimum of 5 minutes prior to washing the curd to control the water organisms.

The effectiveness of additives in wash waters has been found to be increased when pH is reduced to 6.0. Nielsen (43) recommended reducing pH to 6.0 or below before the addition of 7.5 to 10 ppm of chlorine. Citric or phosphoric acid was used to accomplish the pH reduction. Elliker (22) found the reduction of pH to a range of 5.0 to 7.0 and the addition of 5 to 10 ppm of chlorine for 60 seconds prior to washing the curd was effective in retarding spoilage organisms. Angevine (2) summarized the ideal conditions for wash waters which included the use of filtered water, acidified to pH 5.5 to 6.0 with phosphoric or citric acid, treated with 5 to 8 ppm chlorine, and held for at least 1 minute before use.

This literature review has provided basic information on the problems associated with cottage cheese production. With these thoughts in mind, this research was conducted to determine if yet another method could be used without destroying the basic framework of the cottage cheese manufacturing procedure, mainly the use of 87.7° C. cream dressing.

CHAPTER III

EXPERIMENTAL PROCEDURES

I. PREPARATION OF THE CURD

Whole milk was separated to prepare the milk for cheese and the cream for the dressing for 10 lots of cottage cheese. The skimmed milk was pasteurized at 62.7° C. for 30 minutes, cooled, and pumped to the cheese vat. The temperature of the milk was adjusted to 32.2° C. and 10 pounds of non-fat dry milk powder was added to 180 gallons of milk. The cream was standardized to 12.5 percent butterfat, pasteurized at 71° C. for 30 minutes, homogenized at 3,000 pounds of pressure, cooled, and stored at 5° C. until needed.

A fresh lactic culture was used to inoculate the milk of each lot of cheese. Approximately 5 percent starter was used and ranged from 0.91 to 0.96 percent titratable acidity. Culture C-14 was used for Lot 1, H-56 for Lots 2, 3, 4, and 5, H-70 for Lots 6, 7, 9, and 10, and H-253 for Lot 8. After an increase in acidity of 0.02 to 0.03 cent, usually requiring 30 to 60 minutes, the coagulator was added. For this, Hansen's Cottage Cheese Coagulator was used at the rate of 2 ml per 180 gallons of milk. The rennet was diluted in 1 quart of water, mixed thoroughly, and carefully stirred into the cheese milk. After 4.5 to 5 hours and an acidity of 0.54 to 0.56 percent, the curd was cut with 3/8 inch knives and allowed to stand undisturbed for 15 minutes. The detailed cooking procedure used in all lots was as follows:

1. The vat jacket was filled with water and with steam the jacket temperature was brought to 43.3° C. and held for 30 minutes. Little or no stirring of the curd was done during this period. Whey temperature was 37.7° C. by the end of this period.
2. The jacket temperature was gradually raised over the next 30 to 35 minutes at which time the whey temperature was 53.3° C. Total time from beginning of cook to this point was approximately 60 minutes. Some 20 to 30 pounds of curd were removed from the vat and placed in a 50 gallon vat with 25 gallons of whey. This curd remained in the vat for 15 minutes and then was drained and washed in the usual manner. This cheese served as the control and was designated as Treatment III.
3. The remaining curd was cooked to 60° C. by raising the jacket temperature to 65° C. to 71° C. Total time to this point was approximately 90 minutes. The curd was held 15 minutes in the whey and then the whey was drained.

On completion of the cooking and draining operations, the curd was washed with two wash waters. The first and second wash waters were 21° C. and 5° C., respectively. To both waters were added 10 to 15 ppm of chlorine and enough citric acid to lower the pH to 6.0. After washing, the curd was drained for 70 to 80 minutes, weighed, and creamed.

II. PREPARATION OF TREATMENTS

Three treatments were used in this study. Treatment I consisted of curd cooked to 60° C., dressed with cream of 87.7° C., and stored at 5° C. Treatment II consisted of curd cooked to 60° C., dressed with cream of 5° C., and stored at 5° C. Treatment III consisted of curd cooked to 53.3° C., dressed with cream of 5° C., and stored at 5° C.

The creaming mixture for all treatments consisted of salt and fresh cream. Salt was used at a level of one percent by weight of the finished product. The cream was used either at 5° C. or 87.7° C. depending upon the treatment. For Treatment I the cream was removed from the cooler and placed in a water bath 45 minutes in advance of use and heated to 87.7° C. A volume of curd was weighed and mixed with the salted cream at a ratio of 0.47 pounds of cream to 1 pound of curd. Ten 12 ounce samples were taken and stored at 5° C. for later analysis.

For Treatments II and III curd was weighed and combined with the salted cream at a ratio of 0.43 pounds of cream to 1 pound of curd. Ten 12 ounce samples were taken from each treatment and stored at 5° C. for later analysis.

III. ORGANOLEPTIC EVALUATION

Cheese of all treatments was evaluated at intervals of 0, 7, 14, 21, and 28 days. Twenty-five panelists were selected from the staff and students of the Department of Dairying. Samples were scored on a scale of one to nine with extreme values of like extremely and dislike extremely.

The treatments were also scored by three experienced judges using the score card approved by the American Dairy Science Association. Copies of the score sheets are in the Appendix.

IV. MICROBIOLOGICAL EVALUATION

Initial examinations were made of starter, skimmilk, and cream for coliform and standard plate counts. Cottage cheese of each treatment was examined for coliform, total, yeast and mold, and psychrophilic counts. Since five samples were taken of each treatment to examine for microbiological quality, an unopened sample was used for each plating at 0, 7, 14, 21, and 28 days.

Samples were prepared by weighing 10 grams of cottage cheese into a homogenizing flask and mixing with 10 ml of sterile 2 percent sodium citrate. Samples were homogenized for 1 minute on a Virtis homogenizer. All parts coming in contact with cheese samples were sanitized by boiling for at least 1 minute prior to use.

Plating procedures for yeast and mold were those of Overcast and Weakley (47). Methods for recording plate counts were those as outlined in Standard Methods for the Examination of Dairy Products (1).

CHAPTER IV

RESULTS AND DISCUSSION

Ten lots of cottage cheese were manufactured by the short-set method at the University of Tennessee Creamery. Each lot was divided into three treatments which were examined for microbiological and organoleptic quality.

I. MICROBIOLOGICAL EVALUATION

Data from Table I indicated low and median coliform counts for Treatments I, II, and III were generally less than one per gram, but by comparing the high counts of the three treatments, an increase in coliform populations was particularly apparent at 21 and 28 days. While Treatment I had a high coliform count of 140 per gram at 28 days, Treatment II had a high of 552,000 per gram, and Treatment III, a high coliform count of 44,000 per gram at 28 days. The coliform counts per gram in samples plated after 21 and 28 days of storage are presented in Table II. The results indicated a pronounced increase in coliform numbers for Treatments II and III after extended storage, while Treatment I had counts of less than one per gram in nine of the 10 lots of cheese. This was particularly important since most state regulations set the maximum number of coliforms at 10 per ml. Treatment I was well within this limit at 28 days in nine of the 10 lots, while Treatments II and III exceeded the limit in five of the 10 lots.

To determine if treatments were different an analysis of variance for the logarithm of the coliform counts for the three treatments

TABLE I

LOW, MEDIAN, AND HIGH COLIFORM NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 0, 7, 14, 21, AND 28 DAYS IN TEN LOTS

Treatment	Age	Low	Median	High
I	0	<1	<1	4
	7	<1	<1	1
	14	<1	<1	12
	21	<1	<1	16
	28	<1	<1	140
II	0	<1	<1	5
	7	<1	<1	170
	14	<1	12	300
	21	<1	<1	150,000
	28	<1	<1	552,000
III	0	<1	<1	6
	7	<1	<1	4
	14	<1	<1	4,200
	21	<1	40	4,200
	28	<1	<1	44,000

TABLE II

COLIFORM NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 21 AND 28 DAYS OF AGE IN TEN LOTS

Lot	Treatment I		Treatment II		Treatment III	
	21 days	28 days	21 days	28 days	21 days	28 days
1	<1	<1	620	54,000	165	<1
2	<1	140	210	10,100	380	44,300
3	<1	<1	4,270	552,000	14	30
4	<1	<1	<1	<1	3,200	27,000
5	<1	<1	200	1,600	40	<1
6	<1	<1	<1	<1	4,200	12,000
7	<1	<1	150,000	13,000	670	150
8	16	<1	<1	<1	<1	<1
9	<1	<1	<1	<1	<1	<1
10	<1	<1	<1	<1	<1	<1

was conducted. The results found in Table III indicated treatments were different ($P < 0.05$). To determine which treatments were different a Duncan's multiple range analysis was conducted on the mean logarithmic coliform counts. The results found in Table IV revealed Treatment I was different ($P < 0.05$) from both Treatment II and Treatment III.

Low, median, and high total bacterial counts for three treatments at plating intervals of 0, 7, 14, 21, and 28 days are presented in Table V. Counts revealed low initial populations at zero days for all treatments which indicated a minimum amount of contamination. However, as storage time increased, a significant increase in population numbers was evident in Treatments II and III. This increase was particularly evident when the high counts of the three treatments were compared in Table V. The total bacterial counts at 21 days and 28 days for the three treatments are presented in Table VI. These data indicated Treatment I had terminal counts of 63,000 per gram or less in eight of the 10 lots, while Treatments II and III both had terminal counts of greater than 63,000 per gram in five of the 10 lots.

The results of an analysis of variance for the logarithm of the total counts for three treatments are found in Table VII. Results indicated treatments were significantly different ($P < 0.05$). The Duncan's multiple range analysis (Table IV) was also performed on the mean logarithmic total counts for three treatments revealing Treatment I to be different ($P < 0.05$) from Treatment II and Treatment III.

TABLE III

ANALYSIS OF VARIANCE FOR THE LOGARITHMS OF THE COLIFORM NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS IN TEN LOTS

Source of Error	D.F.	S.S.	M.S.	F Value
Corrected Total	149	258.219	1.733	
Lot	9	35.829	3.981	5.622*
Treatment	2	32.597	16.298	23.017*
Age	4	36.686	9.171	12.952*
Lot x Treatment	18	50.276	2.793	3.944*
Lot x Age	36	35.130	.975	1.378^{ns}
Treatment x Age	8	16.716	2.089	2.951*
Residual Error	72	50.985	.708	

ns = No significant difference.

* = Significance at .05 level.

TABLE IV

DUNCAN'S MULTIPLE RANGE ANALYSIS FOR THE LOGARITHMS OF THE NUMBER OF COLIFORM, TOTAL BACTERIA, YEAST AND MOLD, AND PSYCHROPHILIC BACTERIA FOR THREE TREATMENTS IN TEN LOTS OF COTTAGE CHEESE

	Treatment I	Treatment II	Treatment III
Coliform	$.1127^{a}$*	1.2049^{b}	$.9472^{b}$
Total Bacteria	3.8488^{a}	4.5212^{b}	4.5250^{b}
Yeast and Mold	2.4391^{a}	3.0151^{b}	2.7931^{a}
Psychrophilic Bacteria	3.5966^{a}	4.7134^{b}	4.5948^{b}

*Mean logarithms for an organism with different superscripts are significantly different ($P<0.05$), mean logarithms with same superscripts are not significantly different ($P>0.05$).

TABLE V

LOW, MEDIAN, AND HIGH TOTAL BACTERIAL NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 0, 7, 14, 21, AND 28 DAYS IN TEN LOTS

Treatment	Age	Low	Median	High
I	0	<3,000	<3,000	<3,000
	7	<3,000	<3,000	8,000
	14	<3,000	<3,000	19,000
	21	<3,000	6,000	460,000
	28	<3,000	40,000	7,600,000
II	0	<3,000	<3,000	4,000
	7	<3,000	<3,000	420,000
	14	<3,000	14,000	1,500,000
	21	<3,000	98,000	28,000,000
	28	<3,000	560,000	69,000,000
III	0	<3,000	<3,000	4,000
	7	<3,000	<3,000	110,000
	14	<3,000	4,000	2,800,000
	21	<3,000	450,000	28,000,000
	28	<3,000	120,000	83,000,000

TABLE VI

TOTAL BACTERIAL NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 21 AND 28 DAYS OF AGE IN TEN LOTS

Lot	Treatment I		Treatment II		Treatment III	
	21 days	28 days	21 days	28 days	21 days	28 days
	x 10^{-5}					
1	.30	2.7	62.	.56	26.	.37
2	<.03*	.40	28.	87.	46.	73.
3	<.03	<.03	.90	14.	4.5	1.2
4	4.6	76.	280.	690.	280.	830.
5	.09	.55	.98	15.	.20	.49
6	.27	.44	4.9	.12	34.	.6
7	.06	.30	34.	.57	65.	8.6
8	.16	.63	.42	1.7	.17	1.3
9	<.03	<.03	<.03	<.03	<.03	<.03
10	<.03	<.03	<.03	<.03	<.03	.14

*Less than 3,000 per gram.

TABLE VII

ANALYSIS OF VARIANCE FOR THE LOGARITHMS OF THE TOTAL BACTERIAL NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS IN TEN LOTS

Source of Error	D.F.	S.S.	M.S.	F Value
Corrected Total	149	210.259	1.411	
Lot	9	49.308	5.478	22.454*
Treatment	2	15.156	7.578	31.061*
Age	4	66.897	16.724	68.550*
Lot x Treatment	18	11.388	.632	2.593*
Lot x Age	36	41.163	1.143	4.686*
Treatment x Age	8	8.779	1.097	4.498*
Residual Error	72	17.568	.244	

ns = No significant difference

* = Significant at .05 level.

The low, median, and high yeast and mold counts for three treatments at 0, 7, 14, 21, and 28 days are found in Table VIII. Considerable growth was evident at seven days for all treatments and continued to increase markedly throughout the experimental period. Surface growth was not apparent in any sample during the storage period; however, high population numbers were found to exist for all treatments after seven days of age. Table IX presents yeast and mold counts for three treatments after 21 and 28 days of storage. Results indicated Treatment I had yeast and mold counts at 28 days of less than 10,000 per gram in five of the 10 lots. Treatment II had yeast and mold counts of at least 10,000 per gram in eight of the 10 lots and Treatment III reached a count of at least 10,000 per gram in all 10 lots.

Table X presents the results of an analysis of variance of the mean logarithmic counts of yeast and mold in three treatments. Treatments were found to be different ($P < 0.05$) and the Duncan's multiple range analysis (Table IV) on the mean logarithm yeast and mold counts indicated all treatments were different ($P < 0.05$) from each other.

The experimenter would be careful to note that conditions under which the cheese was manufactured were less than desirable. Even though great care was taken to avoid contamination from air, some contamination did occur. This problem was made manifest in the cheese by the presence of high yeast and mold populations.

Since psychrophilic organisms represent a major hazard to cheese quality, the benefits of eliminating these organisms are unmistakable. Data from Table XI indicated psychrophilic counts were less than 3,000

TABLE VIII

LOW, MEDIAN, AND HIGH YEAST AND MOLD NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 0, 7, 14, 21, AND 28 DAYS IN TEN LOTS

Treatment	Age	Low	Median	High
I	0	<1	<1	4
	7	<1	5	400
	14	400	2,000	4,600
	21	2,000	11,000	17,000
	28	6,000	9,000	26,000
II	0	<1	3	10
	7	<1	23	30,000
	14	100	5,000	221,000
	21	9,000	14,000	213,000
	28	3,000	18,000	200,000
III	0	<1	2	10
	7	<1	60	18,000
	14	100	2,300	34,000
	21	3,000	21,000	39,000
	28	10,000	16,000	54,000

TABLE IX

YEAST AND MOLD NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 21 AND 28 DAYS OF AGE IN TEN LOTS

Lot	Treatment I		Treatment II		Treatment III	
	21 days	28 days	21 days	28 days	21 days	28 days
1	20,000	9,000	24,000	16,000	39,000	54,000
2	11,000	25,000	213,000	200,000	28,000	10,000
3	6,000	8,000	9,000	10,000	28,000	31,000
4	2,000	8,000	14,000	9,000	16,000	14,000
5	14,000	9,000	25,000	18,000	26,000	16,000
6	11,000	14,000	13,000	40,000	18,000	17,000
7	17,000	18,000	123,000	73,000	5,000	12,000
8	14,000	26,000	13,000	29,000	21,000	21,000
9	8,000	12,000	22,000	25,000	22,000	25,000
10	4,000	6,000	9,000	3,000	3,000	13,000

TABLE X

ANALYSIS OF VARIANCE FOR THE LOGARITHMS OF THE YEAST AND MOLD NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS IN TEN LOTS

Source of Error	D.F.	S.S.	M.S.	F Value
Corrected Total	149	440.722	2.957	
Lot	9	19.335	2.148	10.350*
Treatment	2	8.439	4.219	20.328*
Age	4	363.462	90.865	437.730*
Lot x Treatment	18	10.965	.609	2.934*
Lot x Age	36	20.197	.561	2.702*
Treatment x Age	8	3.375	.422	2.032^{ns}
Residual Error	72	14.948	.207	

ns = No significant difference.

* = Significant at .05 level.

TABLE XI

LOW, MEDIAN, AND HIGH PSYCHROPHILIC NUMBERS PER GRAMS OF CHEESE FOR THREE TREATMENTS AT 0, 7, 14, 21, and 28 DAYS IN TEN LOTS

Treatment	Age	Low	Median	High
I	0	<3,000	<3,000	<3,000
	7	<3,000	<3,000	4,000
	14	<3,000	<3,000	6,000
	21	<3,000	<3,000	26,000
	28	<3,000	<3,000	46,000
II	0	<3,000	<3,000	<3,000
	7	<3,000	<3,000	290,000
	14	<3,000	66,000	1,900,000
	21	<3,000	270,000	22,000,000
	28	12,000	300,000	320,000,000
III	0	<3,000	<3,000	<3,000
	7	<3,000	<3,000	270,000
	14	<3,000	<3,000	2,100,000
	21	<3,000	2,200,000	49,000,000
	28	10,000	54,000	96,000,000

per gram at zero days for all treatments. With increasing age there was a corresponding increase in organism numbers particularly for Treatments II and III. Table XII presents the psychrophilic counts per gram for three treatments at 21 and 28 days of age. While Treatment I had psychrophilic counts of less than 3,000 per gram at 28 days in six of the 10 lots, Treatment II had psychrophilic counts exceeding 3,000 per gram in all lots with six lots attaining counts of at least 100,000 per gram. Treatment III also had psychrophilic counts of greater than 3,000 per gram in all lots with five lots attaining counts of at least 100,000 per gram.

Table XIII presents the results of an analysis of variance of the mean logarithmic number of psychrophiles for three treatments. These data indicated treatments were different ($P < 0.05$). Table IV, page 28, presents the results of treating the mean logarithmic number of psychrophiles by the Duncan's multiple range analysis. Treatment I was found to be different ($P < 0.05$) from both Treatment II and III.

The plating of treatments for psychrophilic organisms and the analysis of these counts revealed that while Treatments II and III had extremely high populations of psychrophilic organisms, Treatment I was significantly lower ($P < 0.05$) with six lots maintaining counts of less than 3,000 per gram after 28 days of storage.

II. TASTE PANEL EVALUATION

A panel of 25 members consisting of faculty, staff, and students of the University of Tennessee Department of Dairying evaluated cheese samples for flavor, body, and texture using a hedonic rating scale.

TABLE XII

PSYCHROPHILIC NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS AT 21 AND 28 DAYS OF AGE IN TEN LOTS

Lot	Treatment I		Treatment II		Treatment III	
	21 days	28 days	21 days	28 days	21 days	28 days
	x 10^5					
1	<.03*	.34	71.	9.6	22.	2.4
2	<.03	.27	220.	3,200.	37.	53.
3	<.03	<.03	4.1	9.8	110.	1.2
4	<.03	<.03	220.	640.	490.	960.
5	<.03	<.03	1.8	.62	.03	.54
6	.13	<.03	2.7	3.1	24.	56.
7	<.03	.17	4.0	.26	60.	.30
8	.26	.46	1.1	3.0	.36	.49
9	<.03	<.03	<.03	.12	<.03	.10
10	<.03	<.03	<.03	.17	<.03	.24

*Less than 3,000 per gram.

TABLE XIII

ANALYSIS OF VARIANCE FOR THE LOGARITHMS OF THE PSYCHROPHILIC NUMBERS PER GRAM OF CHEESE FOR THREE TREATMENTS IN TEN LOTS

Source of Error	D.F.	S.S.	M.S.	F Value
Corrected Total	149	222.518	1.493	
Lot	9	37.773	4.197	12.664*
Treatment	2	37.625	18.812	56.770*
Age	4	54.357	13.589	41.009*
Lot x Treatment	18	22.635	1.257	3.794*
Lot x Age	36	27.954	.776	2.343*
Treatment x Age	8	18.314	2.289	6.908*
Residual Error	72	23.860	.331	

ns = No significant difference.

* = Significance at .05 level.

The total panel least square flavor means for three treatments are found in Table XIV. Treatment I had an initial flavor mean of 6.8 while Treatment II was 6.9. Treatment III, the control, was low with a flavor mean of 6.5. While Treatment II scored higher at zero days, this was not the case at 7, 14, 21, and 28 days. At 14 days of age Treatment I had the high flavor mean score of 5.3 with Treatment II scoring 5.0 and Treatment III scoring 4.4. The higher score at zero days for Treatment II may have been the result of a cooked flavor being present in Treatment I due to the hot cream treatment. However, Treatment III, the control, was also scored lower. If the differences in scores were due to a cooked flavor this was not the case after zero days since the mean flavor scores for Treatments I and II were the same, 6.6, at seven days, and at 14 days Treatment I scored higher with a flavor mean of 5.3. Treatment III was consistently scored lower throughout the test period.

Table XV presents the results of at least square analysis of variance of flavor scores as given by the total panel. The results indicated treatments were different ($P < 0.05$). As would be expected, panelist, lots, and treatment ages were also different ($P < 0.05$). The reasons being that individual panelist scored samples with varying degrees of independence and while all lots were made by the same person, he naturally could not repeat exact conditions in all lots. Treatment age difference was most probably due to flavor deterioration with storage. More important, these data from Table XV indicated treatments were not significantly different ($P > 0.05$) when subjected to treatment-age interaction. This suggests that treatment flavor scores declined with age, but at the same rate.

TABLE XIV

TOTAL PANEL LEAST SQUARE FLAVOR MEANS FOR THREE TREATMENTS IN TEN LOTS OF CHEESE

Age/Days	Treatment I	Treatment II	Treatment III
0	6.8	6.9	6.5
7	6.6	6.6	6.1
14	5.3	5.2	4.4
21	4.5	4.3	4.0
28	4.5	4.1	3.5
	$\bar{x}$ 5.5	$\bar{x}$ 5.4	$\bar{x}$ 4.9

TABLE XV

LEAST SQUARES ANALYSIS OF VARIANCE OF THE TOTAL PANEL FLAVOR SCORES FOR THREE TREATMENTS IN TEN LOTS OF CHEESE

Source of Error	D.F.	S.S.	M.S.	F Value
Total	2,679	12,163.780		
Treatment	2	198.029	99.014	35.908*
Panel	24	828.752	34.531	12,523*
Age	4	3,315.039	828.759	300.548*
Lot	9	247.850	27.538	9.987*
Treatment x Age	8	31.266	3.908	1.417^{ns}
Remainder	2,632	7,257.733	2.757	

ns = No significant difference.

* = Significant at .05 level.

The mean flavor scores of three experienced judges for three treatments in 10 lots of cheese evaluated at 0, 7, 14, 21, and 28 days are presented in Table XVI. The results indicated all treatments maintained a score of 38.0 through seven days of storage. At 14 days a noticeable decline in flavor scores was apparent. Treatment I declined to 36.9, Treatment II declined from 38.9 to 36.1, and Treatment III, the control, revealed the greatest decline in mean flavor score by dropping from 38.3 to 34.1. Since a product flavor score of 36.0 or below is generally considered unacceptable for the retail market, Treatment III would be removed between seven and 14 days while Treatment I and II could remain in the market some 14 to 21 days. Although low mean flavor scores were eventually attained by all treatments, the reason for the decline was important. Since microbiological growth (with the exception of yeast and mold) was effectively retarded in Treatment I, the cause of flavor decline may be attributed to the high populations of yeast and mold organisms. In no case did Treatment I reach a yeast and mold count in excess of 26,000 per gram; however, on several occasions after 14 days of storage a musty odor was evident and so noted by the experienced judges.

By comparing the data in Tables XIV and XVI the decline in flavor scores between seven and 14 days was noted by both total panel and experienced judges. This agreement by the lay panel and the experienced judges indicated a definite decline in flavor. The examination of yeast and mold counts in Table VIII suggests a definite increase in population numbers between seven and 14 days of storage. As was previously noted, this was the period in which cheese flavor

TABLE XVI

MEAN FLAVOR SCORES[a] FOR THREE TREATMENTS BY EXPERIENCED JUDGES IN TEN LOTS OF CHEESE

Age/Days	Treatment I	Treatment II	Treatment III
0	39.1	39.1	39.0
7	38.9	38.9	38.3
14	36.9	36.1	34.1
21	35.7	35.1	32.9
28	35.3	34.3	32.2
	$\bar{x}$ 37.2	$\bar{x}$ 36.7	$\bar{x}$ 35.3

[a]Scored on the basis of the American Dairy Science Association Score Card with 40 being maximum score for flavor.

scores began a rapid decline. Treatment II and III had in addition to high yeast and mold counts, high psychrophilic and high total bacteria counts which separately or collectively might have contributed to low mean flavor scores.

The results of body and texture evaluation for three treatments are presented in Table XVII. These data indicated a panel perference for Treatment II followed by Treatment I and Treatment III, respectively. Keeping in mind that Treatment II was cheese cooked to 60° C. and treated with 5° C. dressing, the reason for this preference is apparent. This being, while Treatment I and III were found to have acceptable body and texture by the experienced judges, the total panel preferred the firmer curd of Treatment II over that of Treatment I or Treatment III.

Body and texture scores for all treatments declined with age. While some actual deterioration of body and texture may have occurred over the storage period of 28 days, a portion of the decline may be attributed to a corresponding decline in flavor which affected panelists' rating scores.

The results of a least square analysis of variance for body and texture scores of three treatments are presented in Table XVIII. The results indicated a significant difference ($P < 0.05$) among treatments as well as among panelists, ages, and lots. Differences would be expected in such variables as panelists, ages, and lots as was explained in regard to flavor scores. Body and texture-age interaction was found to be the same as that of flavor-age interaction. That was that as body and texture scores declined, they declined at the same rate with no apparent advantage for either of the three treatments.

TABLE XVII

TOTAL PANEL LEAST SQUARE BODY AND TEXTURE MEANS FOR THREE TREATMENTS IN TEN LOTS OF CHEESE

Age/Days	Treatment I	Treatment II	Treatment III
0	6.1	6.6	5.8
7	6.1	6.5	5.5
14	5.4	5.7	5.0
21	5.2	5.3	4.5
28	5.3	5.5	4.6
	$\bar{x}$ 5.6	$\bar{x}$ 5.9	$\bar{x}$ 5.1

TABLE XVIII

LEAST SQUARES ANALYSIS OF VARIANCE OF THE TOTAL PANEL BODY AND TEXTURE SCORES FOR THREE TREATMENTS IN TEN LOTS OF CHEESE

Source of Error	D.F.	S.S.	M.S.	F Value
Total	2,679	9,083.275		
Treatment	2	324.454	162.227	67.109*
Panel	24	803.166	33.465	13.844*
Age	4	665.135	166.283	68.787*
Lot	9	533.662	59.295	24.529*
Treatment x Age	8	12.956	1.619	.670^{ns}
Remainder	2,632	6,362.513	2.417	

ns = No significant difference

* = Significance at .05 level.

CHAPTER V

SUMMARY AND CONCLUSIONS

Ten lots of cottage cheese were manufactured by the short-set method at the University of Tennessee Dairy Products Plant. Each lot was divided into three treatments which were designated as Treatments I, II, and III. Each treatment was examined for microbiological and organoleptic quality. The objective of this study was to determine the benefits of treating freshly manufactured cottage cheese curd with a cream dressing at a temperature of 87.7° C.

The results of this study indicated Treatment I, curd cooked to 60° C. and treated with cream dressing of 87.7° C., offered an acceptable product which resisted spoilage by psychrophilic and coliform organisms. Yeast and mold growth was significantly ($P < 0.05$) retarded in Treatment I when compared to counts in Treatment II and Treatment III; however, high populations of yeast and mold organisms were present after 14 days of storage. These high populations of yeast and mold organisms in Treatment I were probably the cause of low flavor scores.

An analysis of variance of flavor scores revealed a significant ($P < 0.05$) among treatments but no significant ($P > 0.05$) flavor-age interaction was found; however, Treatment I had the highest mean flavor score at the end of the 28 day storage period.

Body and texture evaluations revealed a preference for Treatment II primarily because of the firmer curd. Treatment I was found to have a softer curd but was preferred significantly ($P < 0.05$) over Treatment III, the control.

Problems with yeast and mold contamination and the softer curd of Treatment I suggested the need for further study on this method of manufacture.

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REFERENCES

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APPENDIX

TYPICAL HEDONIC SCALE SCORE SHEET

Name _____

Lot No. _____ Date _____

SAMPLE A		SAMPLE B		SAMPLE C	
FLAVOR	BODY & TEXTURE	FLAVOR	BODY & TEXTURE	FLAVOR	BODY & TEXTURE
__ Like extremely	__ Like extremely	__ Like extremely	__ Like extremely	__ Like extremely	__ Like extremely
__ Like very much	__ Like very much	__ Like very much	__ Like very much	__ Like very much	__ Like very much
__ Like moderately	__ Like moderately	__ Like moderately	__ Like moderately	__ Like moderately	__ Like moderately
__ Like slightly	__ Like slightly	__ Like slightly	__ Like slightly	__ Like slightly	__ Like slightly
__ Neither like nor dislike	__ Neither like nor dislike	__ Neither like nor dislike	__ Neither like nor dislike	__ Neither like nor dislike	__ Neither like nor dislike
__ Dislike slightly	__ Dislike slightly	__ Dislike slightly	__ Dislike slightly	__ Dislike slightly	__ Dislike slightly
__ Dislike moderately	__ Dislike moderately	__ Dislike moderately	__ Dislike moderately	__ Dislike moderately	__ Dislike moderately
__ Dislike very much	__ Dislike very much	__ Dislike very much	__ Dislike very much	__ Dislike very much	__ Dislike very much
__ Dislike extremely	__ Dislike extremely	__ Dislike extremely	__ Dislike extremely	__ Dislike extremely	__ Dislike extremely

COTTAGE CHEESE MANUFACTURING RECORD

Plant _____ Date _____ Set by _____

Lot No. _____ Kind Curd _____ Method _____ CheeseMaker _____

	Lbs.	Temp.	Acid	
Past. Fresh Skim				
Low Heat Powder __%				
Mineral Solution				
Starter __% Age __ Days				Kind____ Activity__
Total with Starter				

Time	Hours From Setting	Processing	Acid	Temperature	
				Skim or Whey	Jacket
		Acidity of Skim			
		Acidity after adding starter (setting)			
		Acidity Check			
		Added Coagulator--Amount ___c.c. Acidity Check-- Extra added started gal. ( ) lbs. ( )			
		Check whey			
		Cutting curd-- Coagulation V. Weak ( ) Ideal ( ) Too firm ( )			
		Start of cooking			
		1st period of cooking			
		2nd period of cooking			
		3rd period of cooking			
		Finish of cooking (drain jacket)			
		Drain whey Water temp.			
		1st Wash			
		2nd Wash			

TYPICAL COTTAGE CHEESE SCORE SHEET

PERFECT SCORE Criticisms	Sample No. 1	2	3	4	5	6	7	8	9	10	TOTAL GRADES
FLAVOR 40 Contestant Score											
Grade / Score											
Criticism											
Acid											
Bitter											
Coarse											
Feed											
Flat											
Foreign											
Fruity/Fermented											
High Salt											
Lacks Freshness											
Malty											
Metallic											
Musty											
Oxidized											
Rancid											
Unclean											
Yeasty											
BODY & TEXTURE 30 Contestant Score											
Grade / Score											
Criticism											
Firm/Rubbery											
Gelatinous											
Mealy/Grainy											
Pasty											
Weak/Soft											
APPEARANCE & COLOR 20 Contestant Score											
Grade / Score											
Criticism											
Free Whey											
Lacks Cream											
Lacks Uniformity											
Matted											
Free Cream											
Shattered Curd											
Slimy											
Surface Discolored											
Translucent											
Unnatural Color											

PERFECT SCORE Criticisms	Sample No. 1	2	3	4	5	6	7	8	9	10	TOTAL GRADES
PACKAGE 5 Allowed Perfect in Contest	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
TOTAL 95 Total Score of Each Sample											
TOTAL GRADE PER SAMPLE											

FLAVOR: No criticism, 40; Normal range, 31-40

BODY & TEXTURE: No criticism, 30; Normal range, 25-30

APPEARANCE & COLOR: No criticism, 20; Normal range, 15-20

FINAL GRADE

RANK

VITA

Donald Wayne Mackens was born in Montgomery County, Tennessee on September 6, 1946. He attended local elementary schools for eight years and graduated from Clarksville High School in 1964. In the fall of 1964, he enrolled in Austin Peay State University.

He received the Bachelor of Science degree with a double major in Agriculture and Biology in June, 1970. Following graduation he was granted an assistantship to do graduate work in the Dairy Department at the University of Tennessee. While attending the University he worked as the assistant to the University Milk Plant Manager.

He is a member of Who's Who in Colleges and Universities, Beta Beta Beta Biological Honor Society, Delta Tau Alpha and Gamma Sigma Delta Agriculture Honor Societies.

He is the son of Mr. and Mrs. R. B. Mackens of Clarksville, Tennessee. He is married to Sandra Kay Mackens and they have two children, Donna Michelle and Melissa Gay Mackens.