THE INFLUENCE OF ACIDITY CONTROL DURING THE MANUFACTURING PROCESS ON THE MARKET QUALITY OF COTTAGE CHEESE

by

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THE INFLUENCE OF ACIDITY CONTROL DURING THE MANUFACTURING PROCESS ON THE MARKET QUALITY OF COTTAGE CHEESE

INTRODUCTION

In 1954, 535.0 million pounds of creamed cottage cheese were manufactured in the United States with 22 per cent of this total being manufactured in Oregon, California, and Washington. These data emphasize the importance of cottage cheese to the dairy industry in the United States and to the Pacific Coast in particular. Individually, Oregon ranks sixteenth among the states in total creamed cottage cheese production (17, p.10).

The annual per capita consumption of cottage cheese in the United States has increased from 0.9 pounds in 1935 to 3.1 pounds in 1954 (8, p.146). This increase in consumption can be contributed in part to improvements in the flavor, body and texture, and keeping quality, which have favored the production of a uniform product.

Acidity control during the manufacturing process is one of the most important factors to be considered in the manufacture of quality cottage cheese.

Research workers have conducted many experiments on this subject, but the data, in some instances, are contradictory. This study was undertaken in an attempt to clarify and magnify some of the more important aspects of acidity control as affecting the market quality of cottage cheese.

Many phases of the manufacturing process may have an effect on the acidity of the finished cheese. In this study emphasis is placed on the feasibility of using pH control as method of determining the proper cutting acidity for cottage cheese; the effect of alkaline waters on the pH of the final cheese; and the effect of acidification of the wash water as a method of controlling the final pH of the cottage cheese curd.

REVIEW OF LITERATURE

1. The use of non-fat dry milk solids in cottage cheese.

Several investigators have shown that increasing the total solids content of the skim milk from which cottage cheese is to be made increases the yield of curd per pound of solids and increases the quality, workability, and appearance of the cottage cheese in process.

Baker (3, p.74) states: "Unsatisfactory results were obtained in the spring of 1950 with milk which had a low total solids content. Even though sufficient acid development took place, the milk did not form a firm enough curd so that it could be cut and cooked in a normal manner." He suggests that the addition of two per cent non-fat dry milk solids is usually sufficient to yield a cheese of satisfactory quality.

Tuckey (14, p.48) reports rennin curd is weaker and more fragile when it is produced from skim milk having only 8.5 to 8.6 per cent solids not-fat than from skim milk containing 9.3 to 9.6 per cent solids not-fat. He concludes the results of using high solids milk for cottage cheese when rennin is used as a coagulating agent are: (a) a firmer curd at cutting, (b) faster shrinkage of curd during cooking, (c) less shattering of curd during cooking, and (d) greater yield of cheese.

Angevine (2, p.34) states: "Desirable cottage cheese characteristics are obtained when solids are above 9 per cent solids not-fat, and most desirable at 9.4-9.5 per cent solids not-fat. The yield per pound of solids is better when skim milk is 9 per cent or more in solids content."

Mykleby and Zakariasen (12, p.64) made the following observations on adjusting the solids content of the skim milk with non-fat dry milk solids:

1. Fortification of fluid skim milk with low heat non-fat solids resulted in average yields of 2.29 to 2.38 pounds of cottage cheese curd per pound of non-fat milk solids used. This compared to average yields of 1.42 to 1.45 pounds of cottage cheese curd per pound of non-fat solids when only fluid skim milk was used. The yield per pound of non-fat dry milk solids started to decrease at the 10.42 per cent solids level.
2. Slightly faster acid development occurred in most vats that were fortified with non-fat dry milk solids, thereby shortening the manufacturing process.

3. The size of the curd particles in the finished product was slightly larger with each increasing degree of fortification.
4. An overall improvement in curd quality was generally apparent as a result of fortification.

2. Proper acidity for cutting cottage cheese curd.

Tuckey (14, p.52) states: "The isoelectric point of casein is pH 4.6. On either side of this pH value, the casein tends to go into solution. So far as cottage cheese is concerned, casein exhibits most desirable physical characteristics between pH 4.6 and 4.5 when rennin is used. At pH values greater than 4.6, casein exhibits marked cohesive properties. At pH values less than 4.6, the curd tends to go into solution. The cheese becomes soft and mushy; it loses its cohesive properties and shatters." He also states: "At the same pH value, the titratable acidity of the whey from high solids milk will be greater than that from low solids milk. Hence, the correct acidity for cutting cottage cheese curd depends on the composition of the milk from which the cheese is made." He concludes the only exact method of determining when the isoelectric point of casein is reached is to measure the pH of the curd.

Angevine (2, pp.34-36) reports the proper cutting acidity will vary from a titratable whey acidity of .475 per cent for 8 per cent solids not-fat skim milk to .515 per cent for skim milk of 9 per cent solids not-fat; and .60 per cent for fortified or reconstituted skim milk of 12.8 per cent solids not-fat. He states: "The titration test is more accurate in the hands of the average cheese operator for determining proper cutting point of curd when making titration from clear whey expelled at time of making test, than can be obtained by pH values in the hands of a trained technician." He concludes that the pH value for cutting the cottage cheese curd is not as accurate as titratable acidity when the total solids not-fat of the skim milk is known.

Cordes (4, p.44), in his review, states that it is best to judge the proper time for cutting the curd by use of titratable acidity. Recommended per cent acidity with regard to per cent solids is listed as follows:

Per cent solids	Per cent acidity
9	0.51
10	0.53
11	0.55
12	0.57
13	0.59

"The proper point to cut the curd is at a pH of 4.6 to 4.7 at which acidity the casein shows its minimum solubility. Some plants make use of pH determination but practical experience has not yet demonstrated that it should be relied on exclusively for the cutting of the curd. It is believed that until more work is done to definitely evaluate pH as a standard for cutting, it is best to rely on titratable acidities and establish a cutting standard based on the solids content of the skim milk that is used."

Mykleby and Zakariasen (12, p.58) report the following data on the relationship between solids content and the titratable acidity of the clear whey at pH 4.7.

Per cent solids	Titratable acidity at pH 4.7
8.0	.44-.46
8.5	.47-.49
9.0	.50-.52
9.5	.53-.55
10.0	.55-.57
10.5	.57-.59
11.0	.59-.61
11.5	.61-.63
12.0	.63-.65

Irvine (10, p.6) states: "The curd is ready for cutting as soon as the whey acidity attains a level of 0.51-0.53 per cent." No reference was made to the solids content of the skim milk.

Baker (3, p.74) states that proper control of pH during the cheese making process is very critical in the production of top quality cottage cheese. "The most critical stage in the manufacturing process is during the stage of cutting and cooking the curd. The pH range of 4.75 to 4.65 for cutting the curd is the most desirable." If the curd is cut at a pH higher than 4.75 the resultant curd will be tough. If the pH is below 4.65 when the curd is cut, the curd tends to break up into fine particles and is soft and mushy.

Davis (5, p.15) states that a definite pH for cutting the coagulum can not be set but a range of from 4.5 to 5.5 can be used with a reasonable degree of assurance.

Phillips (15, p.7) states the proper titratable acidity of the whey at the time of cutting is 0.55 per cent. "The pH values at this titratable acidity varied from 4.29 to 4.37." These data by Phillips represent pioneer work in the use of pH values for acidity control in the manufacture of cottage cheese.

Wilkowske (18, pp.22-29) showed a high degree of correlation between pH and titratable acidity of clear whey in the manufacture of cultured milk products.

Manus (11, p.62) states that a pH of 4.65 will uniformly indicate the proper time for cutting the curd.

3. The desired acidity of the completed cottage cheese.

Elliker (8, pp.72-74) found that the spoilage bacteria *Pseudomonas viscosa*, *Pseudomonas fragi*, and

Alcaligenes metalcaligenes produce spoilage defects in cottage cheese at a pH value of 5.2; no visible spoilage was produced at pH 4.8; Pseudomonas viscosa produced a slimy film at pH 5.0. Incubation time was 59°F. for 72 hours. "These studies emphasized a significant fact that has been borne out frequently in commercial operations--that an adjustment in final pH of 0.1 to 0.2 units may be critical in delaying growth of spoilage organisms." He states that the final pH level of creamed cottage cheese should be in the vicinity of 5.0. "Rapid bacterial growth occurs at higher levels, and when pH drops appreciably below 5.0 in the finished product a pronounced acid flavor results." The average increase in pH of cottage cheese curd due to creaming is about 0.2 to 0.4 pH units. Three methods that can be used for controlling the pH of the final product are the addition of butter culture to the creaming mixture, direct acidification of cream by an acid such as citric, and acidification of the wash water. Alkaline water may be acidified to the desired level by addition of citric or phosphoric acid. "This procedure should be carried out carefully because it may change the physical properties of the curd. It does lower the pH of the dry curd slightly and thus of the finished product as well."

Davis and Babel (6, p.183) state: "Cottage cheese having a pH of 4.7 readily developed slime when the temperature was favorable."

Tuckey (15, p.23) states: "Some water is alkaline in reaction due to the addition of alkaline compounds for treatment purposes. In such cases, the sodium caseinate that is formed will cause the curd to soften. Under extreme conditions the water may cause the curd to become translucent like tapioca. Acidifying the wash water with citric acid will prevent this defect from occuring."

Tuckey (14, p.52) reports high alkaline water due to the addition of soda ash should be acidified with citric acid until a pH of 6.0 to 5.5 is reached.

Deane, Nelson, and Baughman (7, p.65) in a market research study, state that a slimy curd defect was found in both unstored and stored cottage cheese that had a pH below 4.90 when received.

Tuckey (16, p.92) states: "If pH of wash water is 7.0-7.6 or higher, wash water should be acidified with acid (C.P. HCl) for second and third washings to prevent development of a soft slimy film on surface of the curd."

Wilster (19, p.8), in a market survey, reported the pH values of 29 commercial samples of cottage cheese ranged from 5.21 to 5.80. Seven samples ranged from

5.2 to 5.39; 16 samples ranged from 5.4 to 5.59; 6 ranged from 5.6 to 5.80.

Harmon, Trout, and Bonner (9, p.166), in a market survey, state that surface slime was the most common defect noticed and occurred throughout the pH range of 4.5 to 5.28. Unclean flavors were more frequent at the upper pH range while musty, yeasty and sour flavors were more numerous at low pH values. "Putrid and bitter flavors developed over the entire pH range but were more frequent above pH of 5.0."

Manus (11, p.80) states: "Successive washings with a basic reacting water will raise the pH of the curd well above pH 5.0 and allow the spoilage organisms to ruin a fine product. Also basic reacting water has a tendency to make the curd slick due to the casein dissolving power of alkaline salts in the water. Heavy chlorination of the rinse water also raises the pH value of the water which in turn has a tendency to dissolve the casein on the surface of the curd cubes as well as making conditions ideal for any surviving spoilage type bacteria."

EXPERIMENTAL PROCEDURES

1. Titratable acidity-pH relationship.

The milk used to determine the relationship between titratable acidity and pH of whey during the manufacturing process of cottage cheese was of three solid concentrations. In all cases, fresh fluid skim milk was used and the total solids content was adjusted to 9.0, 10.0, and 11.0 per cent total solids by the addition of non-fat dry milk solids. A Mojonnier tester was used for determining the total solids of the skim milk in adjusting the milk accurately to the correct solids concentration. Holstein milk was used exclusively in preparing the 9.0 per cent skim milk.

After the solids content was adjusted to the desired level, the milk was pasteurized at 145°F. for 30 minutes. Following pasteurization, the milk was adjusted to 90°F. and five per cent, by weight, active cottage cheese culture was added. The milk was divided equally into two four-liter beakers. Sufficient rennet extract was added to one beaker to encourage early coagulation. Both beakers were held in a constant temperature water bath set at 90°F. The samples were tested intermittently for pH values and titratable acidity. The values were taken of the whey from the beaker in which a rennet extract had been added. Samples were taken until neither pH nor titratable acidity showed any increase.

A Leeds and Northrup line pH meter was used for the pH determinations. A weighed five gram sample was titrated against 0.10 normal sodium hydroxide to determine the per cent of acid, as lactic acid, that had developed. The whey samples were obtained by gravitational filtration of the coagulum through a number 10 filter disk.

2. Proper acidity for cutting cottage cheese curd.

The milk used to determine the proper cutting acidity for the cottage cheese curd was of three solids concentrations: 9.0, 10.0, and 11.0 per cent total solids. The milk was reconstituted non-fat dry milk solids adjusted to the desired concentration by the use of the Mojonnier tester. The adjusted milk was pasteurized at 145°F. for 30 minutes.

The pasteurized skim milk was adjusted to 90°F. and five per cent, by weight, active cottage cheese starter was added to the milk. After one hour of incubation, a commercial rennet extract cottage cheese coagulator was added and the sample was divided equally into four one-liter beakers. The beakers were covered with aluminum foil and incubated in a controlled temperature water bath at 90°F.

The curd in each beaker was cut at different pH values. The wire knives used to cut the curd are illustrated and explained in Plate I.

After cutting the curd, the cheese was cooked, washed and drained using normal cottage cheese making procedures.

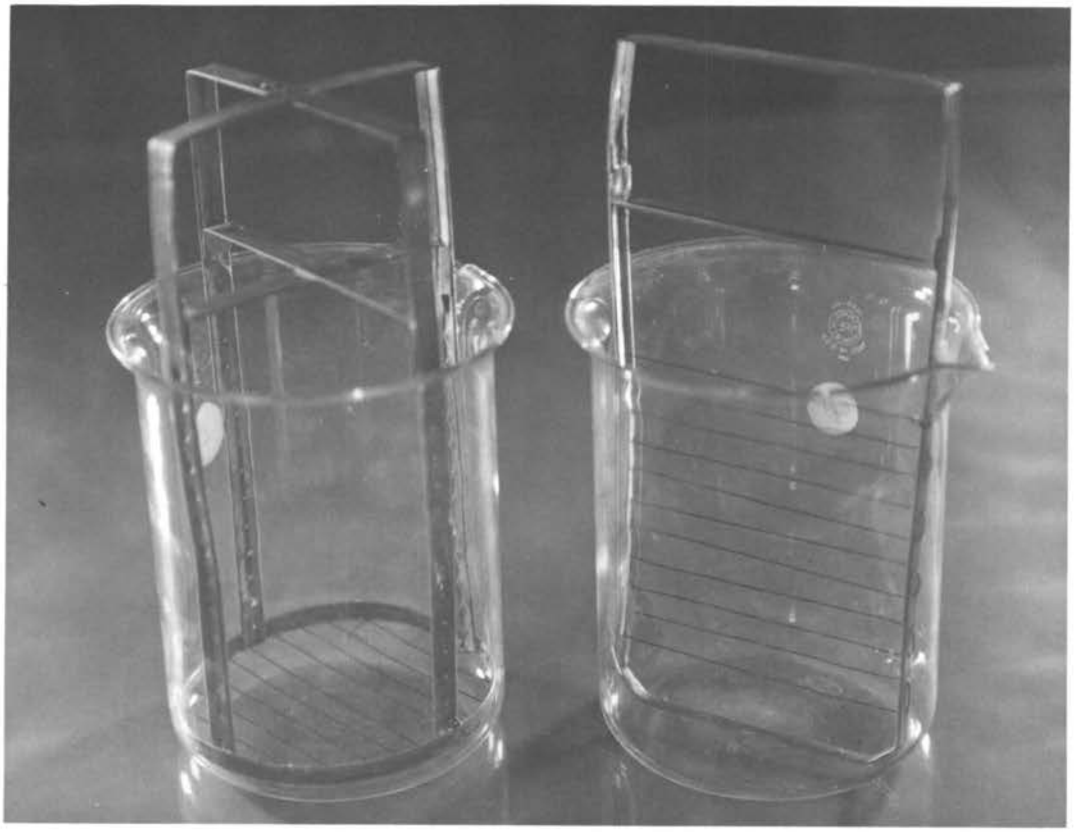
3. Effect of wash water alkalinity on the final pH of the cottage cheese curd.

To insure uniformity, the curd was taken, prior to washing, from large vats of cheese manufactured in the Oregon State College dairy products laboratory.

To obtain information on water conditions throughout the state and to obtain a typical range of water conditions for washing the curd, water samples were taken from all parts of the state. The total alkalinity of the samples ranged from 22 to 245 ppm expressed as calcium carbonate. The titration used for determining the alkalinity of the water samples is published in the Standard Methods for the Examination of Water, Sewage, and Industrial Wastes (1, pp.36-37).

The pH values of the water samples were determined by using a line Fisher titrimeter.

PLATE I



A B

The above two cheese knives were designed and used for cutting cottage cheese curd manufactured in one liter beakers. In operation, knife A was pushed down through the curd, given a one-quarter turn to the right and pulled back through the curd. Knife B was then inserted and given a quick one-half turn and removed. As the wires are three-eights of an inch apart, this operation cuts the curd into three-eight inch cubes.

As supplementary data, the total hardness of the samples was determined by use of the Schwarzenbach titration published in the Standard Methods for the Examination of Water, Sewage, and Industrial Wastes (1, p.112).

The cheese curd was given three washes with the water samples in one liter beakers. Each wash remained on the curd samples for approximately five minutes before being drained. The temperature of the first and second wash water was 60°F. and the temperature of the third wash water was 40°F.

After washing, the beakers were left in a tilted position to allow the curd to drain for 30 minutes.

The dry curd samples were prepared for pH determinations by mixing the curd in a Waring Blender with sufficient distilled water to produce a smooth consistent mass. The pH determinations were made with a glass electrode Leeds and Northrup line pH meter.

4. Effect of acidified wash water on the final pH of the cottage cheese curd.

The cottage cheese curd was taken, prior to washing, from large vats of cottage cheese manufactured in the Oregon State College dairy products laboratory.

Four cheese samples were taken in one liter beakers from each vat and washed three times. The temperature of the first two washes was 60°F. and the temperature of the third wash was 40°F. Each sample was washed in a different manner as follows:

A. All three washes with the selected water sample.

B. All three washes with distilled water.

C. First wash with sample as used in A. Second two washes with sample as used in A acidified to an approximate pH 5.0 with concentrated hydrochloric acid.

D. First two washes with sample as used in A. Third wash with sample as used in A acidified to an approximate pH 5.0 with concentrated hydrochloric acid.

After washing the curd, the beakers were placed in a tilted position and the curd allowed to drain for 30 minutes.

After draining, the cheese samples were mixed with sufficient distilled water in a Waring Blender to produce a smooth mass. This was done to facilitate accurate pH readings of the curd. pH determinations were made with a glass electrode Leeds and Northrup line pH meter.

Since many commercial plants do not employ the use of a pH meter, a method of titration seemed desirable as a method for adjusting the pH of alkaline waters to an approximate pH 5.0. Two indicators which showed color changes at a pH of 5.0 were used. Chlor phenol red, which changes from red to yellow at a pH of 5.0, and p-nitrophenol, which changes from yellow to colorless at a pH of 5.0, were the two indicators selected.

The chlor phenol red indicator was prepared as follows:

1. 0.10 grams chlor phenol red was pulverized with a mortar and pestle.
2. The chlor phenol red was poured through a funnel into a 250 cc. volumetric flask and rinsed with 23.6 cc. of 0.01 normal sodium hydroxide.
3. The volumetric flask was filled to volume with distilled water.

The p-nitrophenol indicator was prepared by dissolving 0.10 grams of p-nitrophenol in 250 cc. distilled water.

The volume of the water sample used and the strength of the hydrochloric acid for optimum efficiency in the titration were determined by the trial and error method.

The chlor phenol red indicator was selected and used in the titration for its more distinct color change at the end point.

The following steps were followed in running the titration:

1. 20 milliliters of the water sample were pipetted accurately into a 150 milliliter flask.
2. Using a 5 milliliter burette graduated in hundredths, 0.10 normal hydrochloric acid was added one drop at a time until the distinct color change occurred.
3. The reading from the burette in milliliters of 0.10 normal hydrochloric acid was applied to the conversion tables in the appendix to get the milliliters of concentrated hydrochloric acid to add to each gallon of water to adjust the water to an approximate pH 5.0.

All titrations were checked with a glass electrode Leeds and Northrup line pH meter.

RESULTS AND DISCUSSION

1. pH-titratable acidity relationship.

A definite relationship was found between the pH of the whey and the titratable acidity of the whey during the manufacturing process of cottage cheese when skim milk of 9.0, 10.0, and 11.0 total solids was used. The data are illustrated in graphic form in Figures I, II, III, and IV. The points plotted for drawing the curves represent three trial runs for the 9.0 and 10.0 per cent total solids skim milk and two trial runs for the 11.0 per cent total solids skim milk. The curves were drawn with the aid of a French curve. The specific location of the points are shown in tabular form in Table I in the appendix.

As supplementary data only, readings were also taken of the skim milk which seemed to have the same high degree of correlation as the readings on the whey. These data are also shown in graphic form in Figures I, II, III, and IV.

At pH 4.7, which was found to be the proper cutting acidity in this study, there was an increase of 0.04 per cent in the apparent acidity for each one per cent increase

FIGURE I

RELATIONSHIP BETWEEN TITRATABLE ACIDITY AND pH OF SKIM MILK AND IT'S COTTAGE CHEESE WHEY

The skim milk was adjusted to 9 percent solids by addition of dry non-fat milk solids

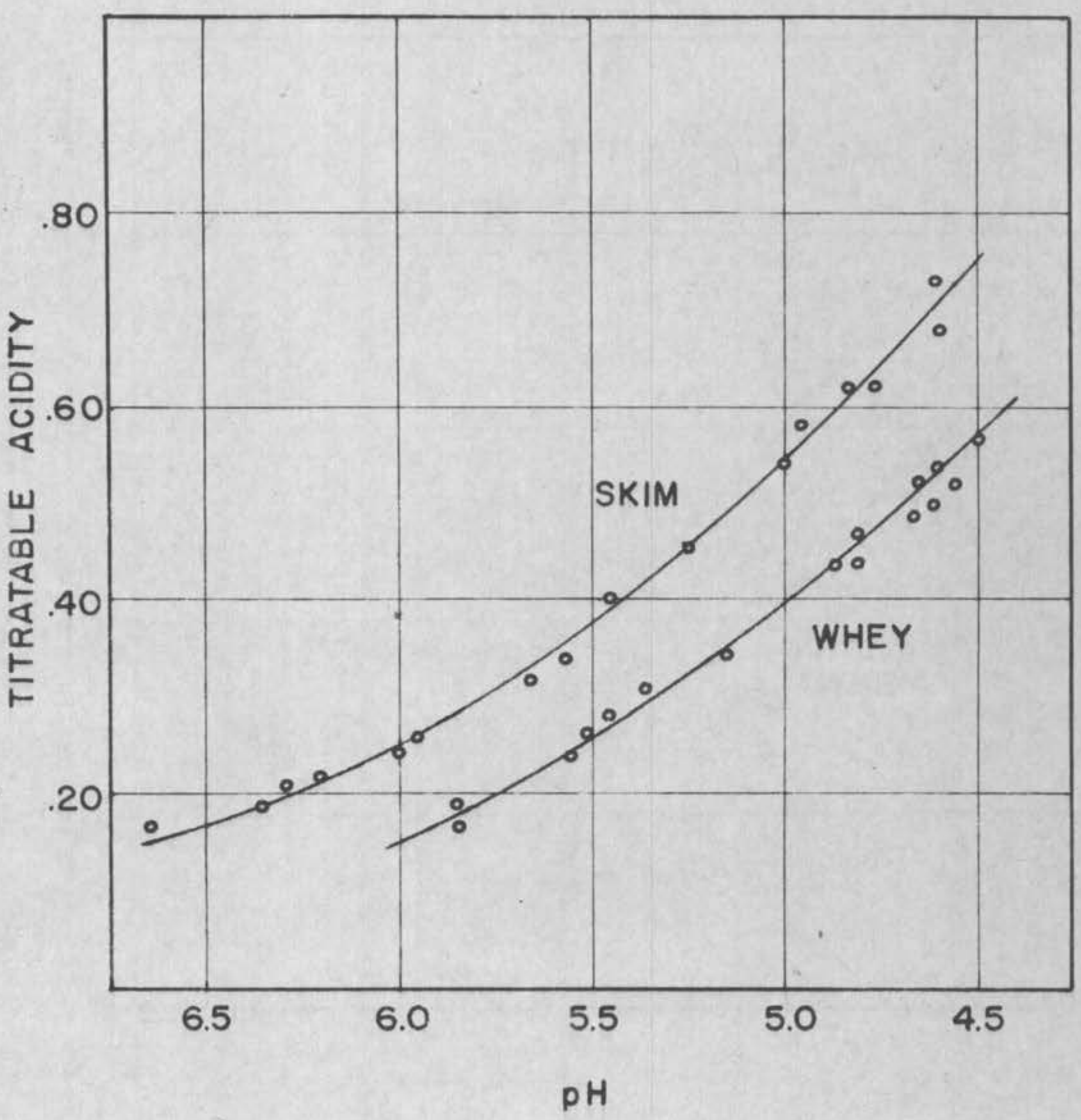


FIGURE II

RELATIONSHIP BETWEEN TITRATABLE ACIDITY
AND pH OF SKIM MILK AND IT'S COTTAGE CHEESE WHEY
The skim milk was adjusted to 10 percent solids
by addition of dry non-fat milk solids

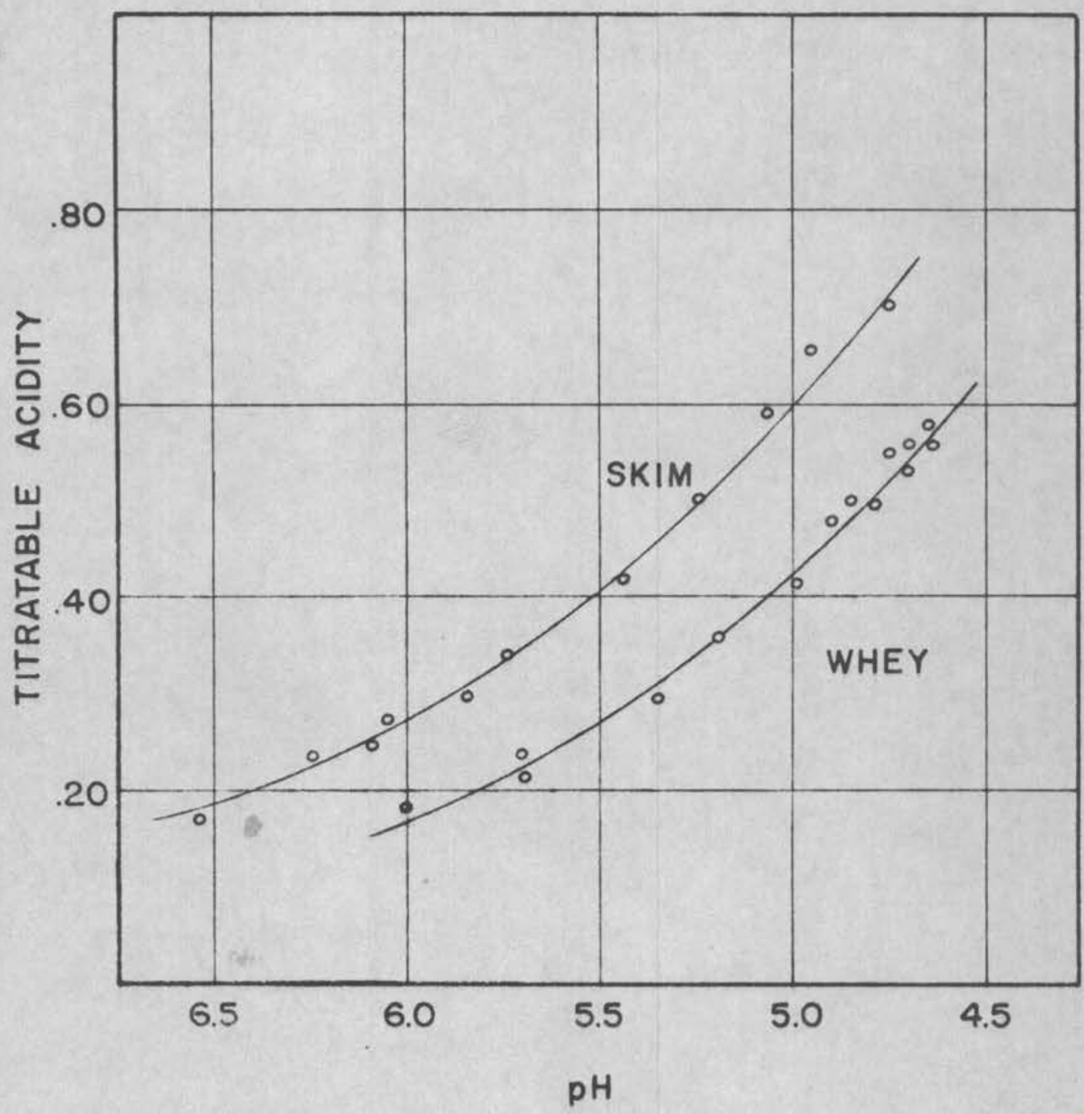


FIGURE III

RELATIONSHIP BETWEEN TITRATABLE ACIDITY AND pH OF SKIM MILK AND IT'S COTTAGE CHEESE WHEY

The skim milk was adjusted to 11 percent solids by addition of dry non-fat milk solids

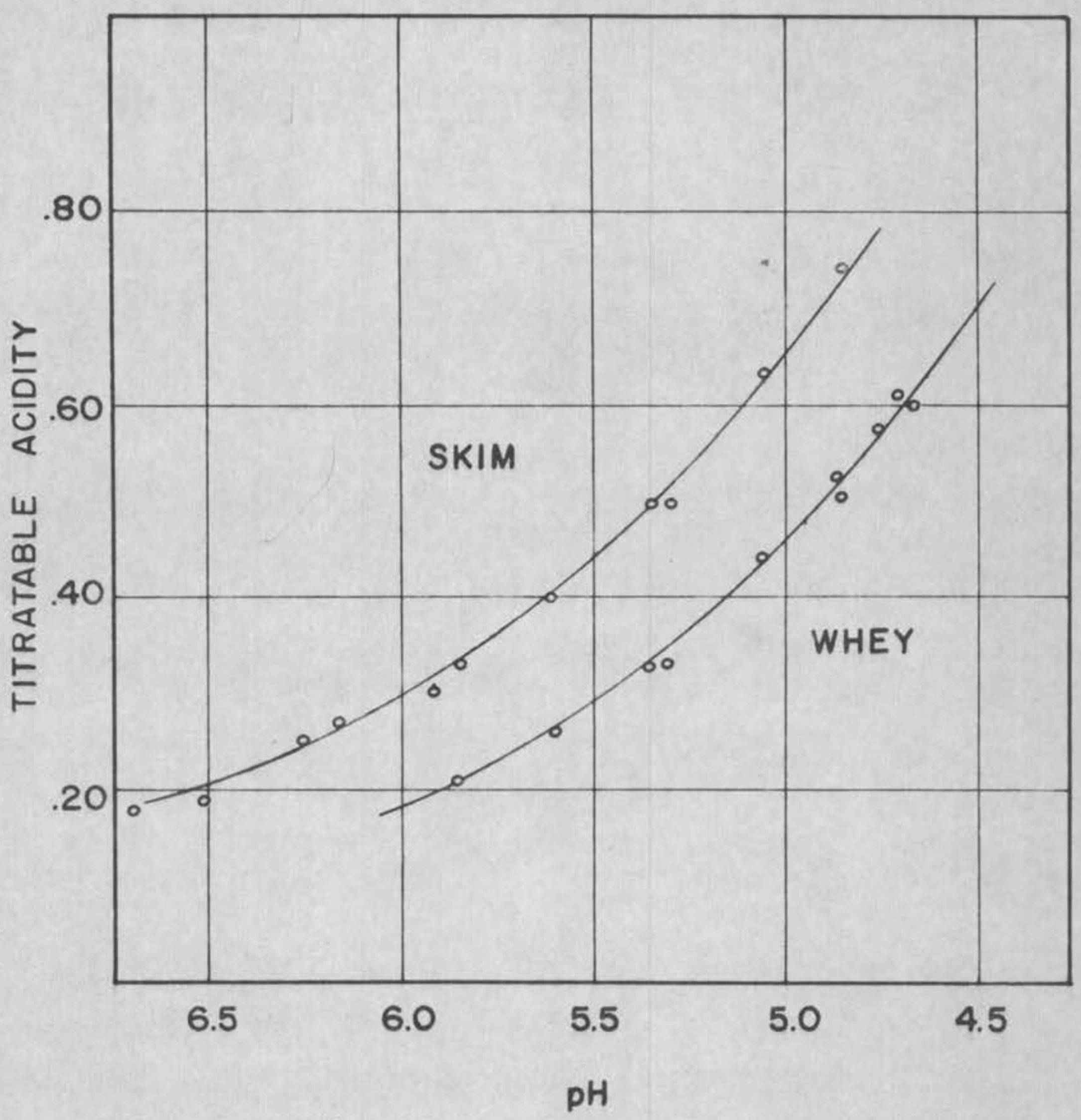
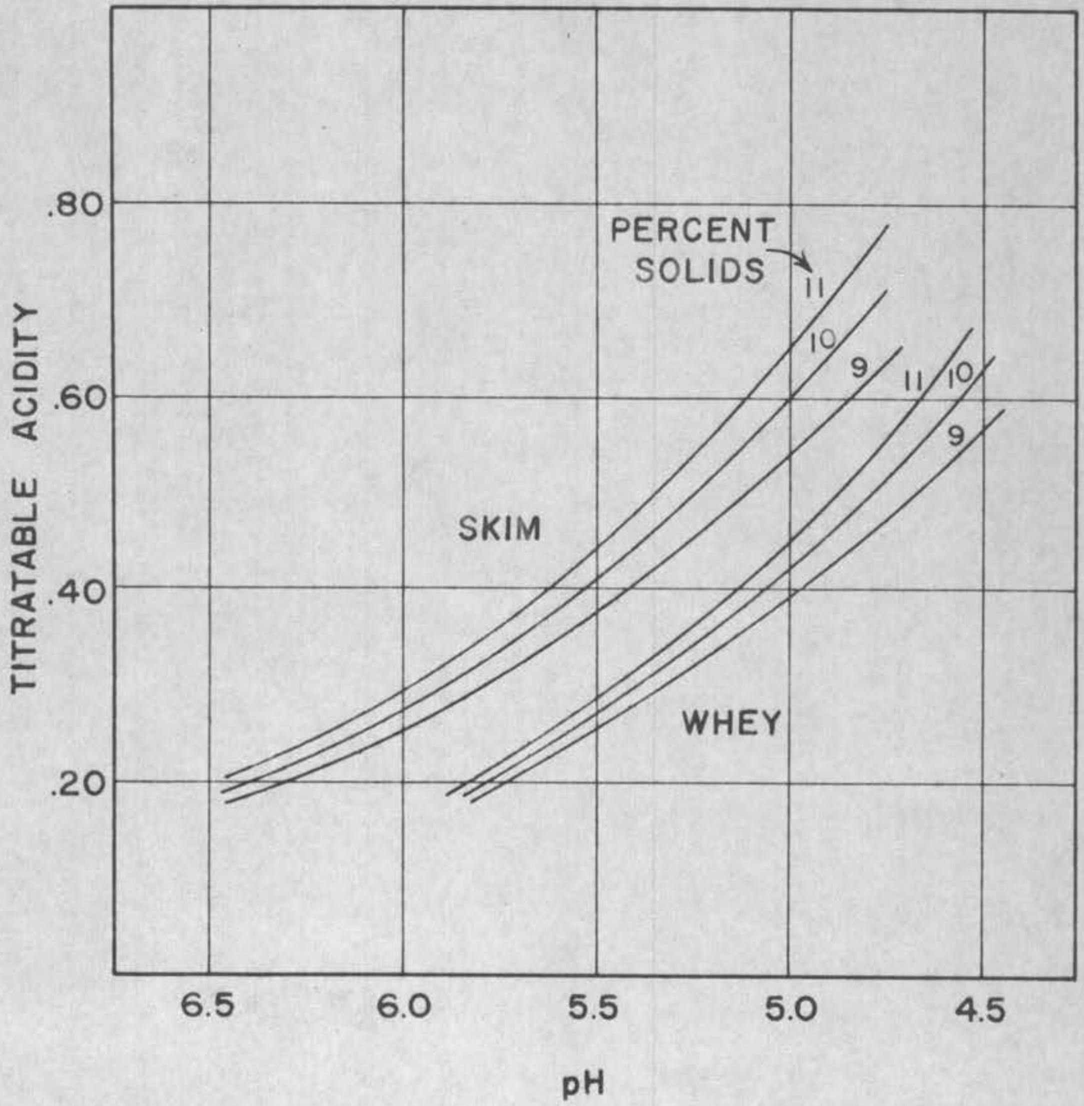


FIGURE IV

RELATIONSHIP BETWEEN TITRATABLE ACIDITY AND pH OF SKIM MILK AND IT'S COTTAGE CHEESE WHEY

A summation of figures 1, 2, and 3



in milk solids. Wilkowske (17, p.25) stated that at pH 4.6 there was an increase in the apparent acidity of the whey of 0.06 per cent for each one per cent increase in milk solids.

This relationship between the pH and the titratable acidity indicates that either pH measurements or titratable acidity per cents can be used in determining the proper cutting point of the coagulum.

It was observed that the pH reading remained the same whether it was taken of the whey or of the coagulum. Therefore in using pH as a method of determining the cutting point for the coagulum, a filtered whey sample was found to be unnecessary. Identical readings were obtained by immersing the electrodes of the pH meter in the coagulum and by immersing the electrodes in a filtered whey sample.

2. <u>Proper acidity for cutting cottage cheese curd.</u>

Nine separate trials were used in this section of the study. Each trial was split into four samples to facilitate varying the cutting pH under identical conditions. Two trials were made on each solids concentration to determine the optimum pH for cutting the curd. After obtaining almost identical results regardless of the solids concentration, four additional trials were made using 10.0 per cent solids milk.

The most desirable appearance of the curd, after cutting, during cooking and of the final dry curd, was obtained when the cutting pH ranged from 4.70 to 4.65. The curd cut in this range showed a good clean cut, handled well during cooking with very little or no shattering of the curd and the final curd showed uniform curd particles.

Cottage cheese curd cut at pH values above 4.70 showed excessive shattering and the time required to cook the curd to firmness was found to be much shorter than normal, although no time data were kept. After the cooking process was completed, the curd was found to be tough and showed uneven curd particles. One 9.0 per cent solids sample, cut at pH 4.90, had the characteristics of cooked curd after only 30 minutes at 98°F. and after washing, the curd was tough.

Curd cut at pH values below 4.65 showed excessive shattering and had a mushy consistency. The cheese cut in this pH range required temperatures as high as 160°F. to cook to the desired firmness. In most cases the cheese curd never reached the desired firmness and had to be discarded. The final curd showed uneven curd particles.

Although pH determinations were used as a basis for determining when the desired cutting point was reached, the titratable acidity was also checked with each pH reading. The values substantiated the results presented in Figures I, II, III, and IV.

Most commercial dairy plants manufacturing cottage cheese do not have pH meters or the trained personnel to operate them. The titratable acidity is used to determine the proper cutting acidity of the cheese. A chart has been prepared to show the desired titratable acidities of various solids milk corresponding to the pH range 4.70 to 4.65 which these experiments indicated to be the optimum cutting pH for cottage cheese making. Figure V was made by plotting the titratable acidity per cents corresponding to pH 4.70 to 4.65 against the three solids concentrations used in this study. The three points plotted showed a straight line relationship which facilitated ease in interpolation for titratable acidity per cents for solids concentrations other than 9.0, 10.0, and 11.0 per cent total solids.

Table III represents the titratable acidity per cents corresponding to the optimum cutting pH range 4.70 to

4.65 for various solids milk. This table was prepared from Figure V.

TABLE III

Per cent solids	Titratable acidity at pH 4.70-4.65
8.0	0.47
8.5	0.49
9.0	0.51
9.5	0.53
10.0	0.55
10.5	0.57
11.0	0.59
11.5	0.61
12.0	0.63

3. <u>Effect of wash water alkalinity on the final pH of cottage cheese curd.</u>

The nine water samples used in this study were collected throughout the state. They represent a wide range in alkalinity. Table IV summarizes the analysis made on water samples for pH, total hardness, and titratable alkalinity.

The results from six vats of cheese are shown in Table V. These data show that the alkalinity of the wash water does have a decided effect on the final pH of the dry cottage cheese curd.

From the data presented in Table V, it can be seen that the pH of the dry curd washed with the soft, low alkaline waters of water samples 4 and 8 varies an average

FIGURE V

TITRATABLE ACIDITY OF COTTAGE CHEESE
WHEY AT pH 4.70–4.65
FOR VARIOUS TOTAL SOLIDS SKIM MILK

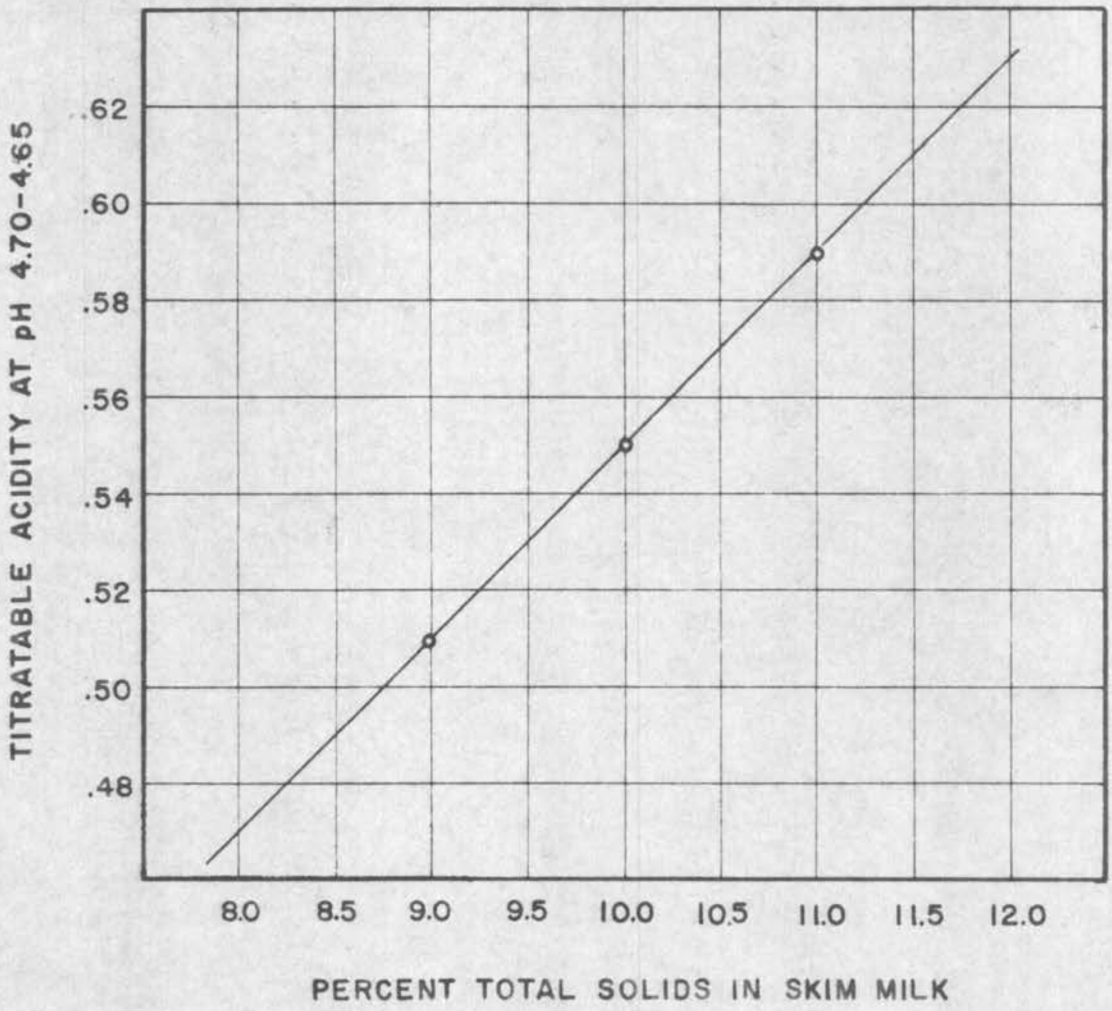


TABLE IV

ANALYSIS OF WATER SAMPLES

Sample No.	pH	Total Hardness ppm	Total Hardness Gr/Gal	Alkalinity Phenol-ppm	Alkalinity Total ppm
1	7.85	270	15.7	13	239
2	7.20	300	17.4	15	245
3	8.05	110	6.4	12	200
4	7.70	40	2.3	0	40
5	7.45	190	11.0	15	227
6	7.65	70	4.1	0	76
7	7.0	0	0	0	0
8	7.70	30		0	22
9	7.60	60		0	64
10	7.60	56		0	75

TABLE V

EFFECT OF WATER ALKALINITY OF
WASH WATER ON pH OF FINAL DRY CURD

Cottage Cheese Vat No.	Cutting pH	pH of Final Cheese Curd Wash Water Sample								
		1	2	3	4	5	6	7	8	9
1	4.70	5.20	5.30	5.00	4.85	5.20	4.95	4.75	--	--
2	4.65	4.90	4.90	4.80	4.70	4.80	4.70	4.65	4.65	--
3	4.70	4.95	4.90	4.85	4.75	4.85	4.75	4.70	4.75	--
4	4.70	4.85	4.85	4.85	4.75	4.85	4.80	4.75	4.75	--
5	4.60	4.70	4.65	4.65	4.60	--	--	4.55	4.55	--
6	4.50	--	4.65	4.60	4.50	4.65	--	4.45	4.45	4.55

of 0.2 pH units from the pH of the curd washed with hard, high alkaline waters as in water samples 1 and 2.

The pH of the final dry curd showed a higher degree of correlation with the titratable alkalinity of the wash water than it did with the pH values of the wash water. Therefore, it is concluded that the titratable alkalinity of the wash water is a more reliable indicator of the effect of the water on the final pH of the cottage cheese than is the pH of the wash water.

Elliker (7, p.74) stated that an adjustment in the final pH of 0.1 to 0.2 pH units may be critical in delaying growth of spoilage organisms in cottage cheese, and that more rapid spoilage occurs at pH 5.0 and higher. He also states that the average increase in pH of the cottage cheese curd due to creaming is about 0.2 to 0.4 pH units.

Using Elliker's work as a guide, it was concluded that high alkaline waters such as water samples 1, 2, 3, and 5 raise the pH of the dry curd to a level where it can be easily elevated above pH 5.0 when creamed. As shown in Table V, this is only true when the coagulum was cut at the optimum cutting pH of 4.70 to 4.65 or higher. Cheese cut at lower pH values of 4.6 and 4.5 as in vats 5 and 6 had sufficiently low initial pH readings to prevent the high alkaline waters from raising the pH

TABLE VI

EFFECT OF WASH WATER ACIDIFICATION
ON THE pH OF THE FINAL DRY CURD

Vat No.	Water * Hardness	Water * Alkalinity	pH of the Water: Before Acidification	pH of the Water: After Acidification	Cutting pH	pH of Dry Curd: A	pH of Dry Curd: B	pH of Dry Curd: C	pH of Dry Curd: D
1	295	245	8.20	5.05	4.75	4.95	4.80	4.85	4.85
2	110	200	8.50	4.85	4.65	4.75	4.60	4.65	4.70
3	56	75	7.60	5.00	4.55	4.60	4.45	4.45	4.50
4	190	227	7.45	5.00	4.70	4.85	4.70	4.75	4.75

* parts per million as calcium carbonate

of the dry curd to a critical level. However, cutting the coagulum at this low pH is objectionable if the desirability of the curd is to be maintained.

4. The effect of acidified wash water on the final pH of the cheese.

This portion of the study was undertaken to determine what effect acidification of the wash water would have on the pH of the final dry cheese curd as a method of controlling the final pH of the cottage cheese.

The wash water used was adjusted to a pH of 5.0 by the addition of concentrated hydrochloric acid. Table II in the appendix was used to calculate the amount of hydrochloric acid to be used in acidifying the wash water.

The results of four trials are shown in tabular form in Table VI. These data show that acidifying the wash water to an approximate pH 5.0 will lower the pH of the cheese curd from 0.1 to 0.15 pH units. This decrease in pH is critical and is an important aid in keeping the pH of the final creamed cottage cheese at a pH of 5.0 or below.

Tucky (15, p.92) states: "If pH of wash water is 7.0-7.6 or higher, wash water should be acidified with acid (C.P. HCl) for second and third washings to prevent development of a soft slimy film on the surface of the curd." As shown in Table IV under columns C and D, no significant difference was noted in washing the curd two times instead of only one time. It is therefore concluded that acidification of only the final wash is necessary.

SUMMARY

A close relationship exist between pH and titratable acidity of the whey in the manufacture of cottage cheese. The titratable acidity will vary with the solids content of the skim milk while the pH will remain constant.

Either pH or titratable acidity can be used to determine the proper cutting point for cottage cheese.

pH readings taken of the coagulum and of the whey are the same.

pH 4.70-4.65 is the desirable point for cutting the coagulum.

High alkaline waters can raise the pH of the cheese above pH 5.0 which will establish conditions favorable for growth of spoilage bacteria.

The pH of the final cheese can be partially controlled by acidifying the alkaline wash waters with concentrated hydrochloric acid.

Only acidification of the third wash water is necessary.

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APPENDIX

TABLE I

SUMMATION OF DATA USED FOR
PLOTTING FIGURES I, II, AND III

9 Per Cent Solids Milk				10 Per Cent Solids Milk				11 Per Cent Solids Milk			
Whey		Skim		Whey		Skim		Whey		Skim	
pH	TA	pH	TA	pH	TA	pH	TA	pH	TA	pH	TA
5.85	0.17	6.65	0.17	6.00	0.18	6.55	0.17	5.85	0.21	6.7	0.18
5.85	0.19	6.35	0.19	5.70	0.22	6.25	0.24	5.85	0.21	6.5	0.19
5.55	0.24	6.30	0.21	5.70	0.24	6.10	0.25	5.60	0.26	6.25	0.25
5.50	0.26	6.20	0.22	5.35	0.30	6.05	0.28	5.80	0.33	6.15	0.27
5.45	0.28	6.00	0.25	5.20	0.36	5.85	0.30	5.85	0.33	5.90	0.30
5.35	0.31	5.95	0.26	5.00	0.41	5.75	0.34	5.05	0.44	5.85	0.33
5.15	0.35	5.65	0.32	4.90	0.48	5.45	0.42	5.05	0.44	5.60	0.40
4.85	0.44	5.55	0.34	4.85	0.50	5.45	0.42	4.85	0.50	5.35	0.49
4.80	0.44	5.45	0.40	4.80	0.50	5.25	0.50	4.85	0.52	5.30	0.49
4.80	0.47	5.25	0.45	4.75	0.55	5.05	0.59	4.75	0.57	5.05	0.63
4.65	0.49	5.00	0.54	4.70	0.53	4.95	0.66	4.65	0.61	5.05	0.63
4.65	0.52	4.95	0.58	4.70	0.56	4.75	0.70	4.60	0.60	4.75	0.74
4.60	0.50	4.80	0.62	4.65	0.56	--	--	--	--	--	--
4.60	0.54	4.75	0.63	4.65	0.58	--	--	--	--	--	--
4.55	0.52	4.60	0.68	--	--	--	--	--	--	--	--
4.50	0.56	4.60	0.73	--	--	--	--	--	--	--	--

TABLE II

CONVERSION TABLE FOR ACIDIFYING WASH WATER TO pH 5.0

Ml of 0.10 N HCl	Volume of Concentrated HCl to Add to Water			
	Ml/Gal	Oz/Gal	Ml/100 Gal	Oz/100 Gal
0.02	0.031	0.0011	3.1	0.11
0.04	0.063	0.0021	6.3	0.21
0.06	0.094	0.0032	9.4	0.32
0.08	0.125	0.0042	12.5	0.42
0.10	0.156	0.0053	15.6	0.53
0.12	0.188	0.0063	18.8	0.63
0.14	0.218	0.0074	21.8	0.74
0.16	0.250	0.0085	25.0	0.85
0.18	0.282	0.0095	28.2	0.95
0.20	0.313	0.0106	31.3	1.06
0.22	0.344	0.0116	34.4	1.16
0.24	0.375	0.0127	37.5	1.27
0.26	0.407	0.0138	40.7	1.38
0.28	0.438	0.0148	43.8	1.48
0.30	0.469	0.0159	46.9	1.59
0.32	0.500	0.0169	50.0	1.69
0.34	0.532	0.0180	53.2	1.80
0.36	0.563	0.0190	56.3	1.90
0.38	0.594	0.0201	59.4	2.01
0.40	0.625	0.0212	62.5	2.12
0.42	0.657	0.0222	65.7	2.22
0.44	0.688	0.0233	68.8	2.33
0.46	0.719	0.0243	71.9	2.43
0.48	0.751	0.0254	75.1	2.54
0.50	0.782	0.0264	78.2	2.64
0.52	0.813	0.0275	81.3	2.75
0.54	0.845	0.0286	84.5	2.86
0.56	0.876	0.0296	87.6	2.96
0.58	0.907	0.0307	90.7	3.07
0.60	0.938	0.0317	93.8	3.17
0.62	0.970	0.0328	97.0	3.28
0.64	1.001	0.0338	100.1	3.38
0.66	1.032	0.0349	103.2	3.49
0.68	1.063	0.0360	106.3	3.60
0.70	1.095	0.0370	109.5	3.70
0.72	1.126	0.0381	112.6	3.81
0.74	1.157	0.0391	115.7	3.91
0.76	1.189	0.0402	118.9	4.02
0.78	1.220	0.0413	122.0	4.13
0.80	1.251	0.0423	125.1	4.23
0.82	1.282	0.0434	128.2	4.34
0.84	1.314	0.0444	131.4	4.44

TABLE II (Continued)

Ml of 0.10 N HCl	Volume of Concentrated HCl to Add to Water			
	Ml/Gal	Oz/Gal	Ml/100 Gal	Oz/100 Gal
0.86	1.345	0.0455	134.5	4.55
0.88	1.376	0.0465	137.6	4.65
0.90	1.408	0.0476	140.8	4.76
0.92	1.439	0.0487	143.9	4.87
0.94	1.470	0.0497	147.0	4.97
0.96	1.501	0.0507	150.1	5.07
0.98	1.533	0.0518	153.3	5.18
1.00	1.564	0.0529	156.4	5.29
1.02	1.595	0.0539	159.5	5.39
1.04	1.627	0.0550	162.7	5.50
1.06	1.658	0.0561	165.8	5.61
1.08	1.689	0.0571	168.9	5.71
1.10	1.720	0.0582	172.0	5.82

The following steps are recommended in using this table:

1. Pipette accurately 20 ml. of the water to be acidified into a flask.
2. Add 5 drops chlor phenol red indicator as prepared on page 18.
3. Using a burette graduated in hundredths, add 0.10 N HCl one drop at a time until the end point is reached. The color change is from red to bright yellow.
4. Apply the ml. of 0.10 N HCl used to Table II, and reading across, derive the volume of concentrated HCl required to acidify the water to pH 5.0.