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CLARIFICATION OF MILK FOR
AMERICAN CHEDDAR CHEESE

By

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A Thesis submitted to the Graduate Faculty
for the Degree of

DOCTOR OF PHILOSOPHY

Major subject - Dairy Bacteriology

Approved

Signature was redacted for privacy.

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Dean of Graduate College

Iowa State College

1928

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TABLE OF CONTENTS

Table of Contents (continued)

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AMERICAN CHEDDAR CHEESE

INTRODUCTION

The present yearly production of cheddar cheese in the world is approximately 660,000,000 pounds. On the basis of ten and a half pounds of milk for a pound of cheese, the amount of milk used is, therefore, 6,633,000,000 pounds. The yearly production of cheddar cheese in the United States is about 300,000,000 pounds, which is 45 percent of the world's production, and 3,150,000,000 pounds of milk are required for this amount. Assuming the average wholesale price of cheese as 22 cents a pound, the yearly value of the cheddar cheese made in this country is $66,000,000.

The activity of certain microorganisms is essential for the ripening of cheddar cheese, and accordingly conditions of manufacturing and curing favorable for their introduction and growth must be provided. These organisms should be present in the milk at the beginning of the manufacturing process, since in their absence at this stage certain undesirable types of bacteria, which may already be present, will probably develop and cause objectionable conditions. Abnormal odors and flavors are among the common defects in cheese due to microörganisms, while a pasty body and a mealy texture may also be caused by them.

Starters containing bacteria desirable for the ripening of cheese of the cheddar type have been used for many years in an attempt to control the fermentations occurring. Oftentimes, however, a starter may not have the desirable effect because of the activity of undesirable organisms that are already present in the milk and which find the conditions provided favorable for their growth.

Pasteurization of milk is being used successfully in some foreign countries in the control of the fermentations brought about by bacteria in cheese. At present, pasteurization is being introduced in the United States, but raw milk is used for most of the cheese that is made.

The blending and processing of cheese has been used with success in this country during recent years in the production of a more uniform and more easily marketable cheese.

STATEMENT OF THE PROBLEM

The magnitude of the industry warrants the introduction of improved methods of manufacture, and it was for the purpose of determining the effect of clarification on the quality of cheddar cheese that the work reported herein was undertaken.

The studies were divided into two parts. The first deals with the effect of clarification on the numbers and types of bacteria present in milk and was carried out with the idea of determining whether or not the effect of clarification on the bacteria in milk is such as to suggest an influence on the quality of cheese obtained from the milk. The second involves the making and study of cheese from unclarified and clarified milk from the same lot.

The work has been conducted for several years. Part of the cheese was made in Utah and part of it in Iowa. It has, therefore, been possible to study the effect of clarification under different conditions.

PART I

The Effect of Clarification on the Bacteria in Milk

Since the numbers and types of bacteria present in milk may show considerable variation, an extended study of the effect of clarification on the flora of milk was undertaken. The investigation involved determinations of the effect of clarification on the numbers and types of bacteria in milk using a normal and a tenth-normal rate of inflow; these were intended to show whether or not the clarifier had a selective action on the organisms. A study of the types of bacteria in clarifier slime and in the sediment obtained from milk which had been centrifuged in tubes was also included. Because of their use in cheese factories in determining the quality of milk, the methylene blue reduction test and the fermentation test were compared with the plate count from the standpoint of showing the changes caused by clarification. A study was made of the size and specific gravity of the organisms which seemed to be eliminated by the clarifier and an attempt made to classify them.

Historical

Attempts to remove the foreign material which gains entrance to the milk during its production and handling are made by means of various mechanical devices. The producer usually employs the more simple of these such as wire screens or cotton cloths, while in the milk plants the more efficient forms such as filters and centrifugal clarifiers are used. Cream separators with the outlets so arranged that the cream and skim milk were mixed were first used for cleaning milk, while later specially constructed machines, such as clarifiers, were developed. The slime which is removed from milk by means of centrifugal force has been investigated a great deal with the object of determining the effect of the centrifugal force in a separator or clarifier on the numbers and types of bacteria present in the milk.

Doane (8), in discussing the economical methods for improving the keeping qualities of milk, states that it is doubtful who first used the separator for purifying milk, but that it is natural it should be used for this purpose since anyone who has washed a separator has noticed the layer of matter that gathers on the inside of the steel bowl. He concluded from some of his investigations, "that there is no doubt but that the separator removes the greater part of the dirt from milk. On the other hand clarifying is valueless as a precaution against disease, and evidently has a tendency to cause the milk to sour more readily than when not so treated." He points out that milk which has been purified by the centrifugal methods was frequently called "clarified."

Grotenfelt (16) in studying the effect of centrifugal force on the numbers of bacteria in milk, found that in seven lots of milk centrifuging always resulted in decreases in the bacterial count. The counts on the unseparated milk ranged from 1,030 to 18,180, those on the skim milk from 220 to 11,025, and of the cream from 200 to 13,200 per cc. while those of the separator slime ranged from 150,000 to 4,241,000 per cc.

Hinkelmann (21) reported that from milk which had been inoculated with bouillon cultures of various organisms he was able to remove with a DeLaval clarifier from 57 to 96 percent, with an average of 78 percent. He believed that small or gram-positive organisms were of a greater density than the ordinary milk bacteria.

Dunbar and Kister (10), in working with a Heine cleaning centrifuge of the hollow bowl type in which there was a filter cloth, found that the running of milk through the machine caused no particular changes in the milk, as shown by the specific gravity and solids not fat content of the milk before and after it had been cleaned. They found many bacteria in the slime, but their conclusions indicate that the chief function of the machines lies in the removal of dirt particles and foreign matter.

Fleischmann (15) quotes Hueppe who asserts that "most of the organisms, and among these the most dangerous ones, remain behind in the separator residue," but Fleischmann doubts that centrifuging has this effect.

Among the first to study the effect of centrifugualization of milk upon the number of bacteria present were Eckles and Barnes (11). In each of seven experiments they found that in running milk through a separator, the milk contained from 15 to 51 percent fewer organisms after centrifuging than before. They also found that when separating milk an average of "29 percent of the total number of organisms went into the skim milk, 24 percent into the cream, and about 47 percent into the slime."

Bahlman (3) in eight tests found that the unclarified milk averaged 1,312,000, and the clarified milk 1,670,000 bacteria per cc. The increases in the counts due to clarification ranged from nine to 60 percent and averaged 27 percent. He states that the increases were due to the breaking apart of bacterial clumps by the mechanical action of the clarifier.

McClintock (30) studied the effect of clarification on the number of bacteria in milk in 59 trials in city plants using three different types of clarifiers. The unclarified milk contained from 54,000 to 2,650,000 bacteria per cc. and the clarified milk from 36,000 to 12,000,000. Sometimes clarification caused an increase and sometimes a decrease in the count, but increases occurred in only three trials. McClintock (31) also clarified sterile milk which had been inoculated with lactic acid bacteria or with pathogenic organisms. Clarification resulted in a decrease of from 15.3 to 16.1 percent in the number of acid formers and of from 95.8 to 99 percent in the pathogenic organisms.

Hammer (17) in working with a DeLaval clarifier found that the plate counts of the clarified milk were commonly, although not constantly, higher than those of the unclarified milk. Since the clarifier slime which he examined contained large numbers of bacteria, and contamination of the milk was excluded, he accounts for the increase in the counts as a result of clarification by the breaking up of clumps of organisms due to centrifuging. This investigator is of the opinion that "whether there will be an increase of a decrease in the apparent number of organisms during clarification probably depends on the types of organisms and on the presence of clumps." Working with a Sharples clarifier, Hammer (18) later obtained results which were in the main comparable to the earlier data.

McInerney (32) studied the effect of clarification on high and low count milk. In 28 lots of low count milk, the unclarified milk contained an average of 8,410, and the clarified milk 15,739 bacteria per cc. the increases in the counts due to clarification varied from 1.76 to 415.1 percent and averaged 87.15 percent. In 17 lots of high count milk the unclarified milk contained an average of 9,778,191, and the clarified milk 21,000,694 bacteria per cc. while the increases due to clarification ranged from 5.82 to 1574.7, and averaged 114.77 percent.

When studying the production of sanitary milk, Sherman (38) in 15 tests found that unclarified milk contained an average of 3,640 and clarified milk an average of 7,020 bacteria per cc.; in four tests the methylene blue test showed a quicker reduction with the clarified milk. In continuing his work he (39) later found that in 24 tests the average bacterial count of unclarified milk was 4,720 and of clarified milk 7,120 per cc. In eight tests the unclarified milk reduced methylene blue, on an average, in 15.5 hours, while the clarified milk reduced it in 17.9 hours.

Marshall and Hood (27) found that "in market milk, the number of organisms is usually increased after clarification, as revealed by the plating method.

This is doubtless due to disruption of colonies." They also observed, that the clarifier was able to eliminate bacteria in "no small degree, but no differentiation between pathogens and non-pathogens can be made."

In a later article Marshall and Hood (28) report that the clarifier had effected eliminations of from 24 to 99 percent of bacteria from milk, the large organisms and colonies of organisms being removed most readily. Pure cultures of bacteria were used in this work.

Dahlberg and Marquardt (6) in their report on the effect of clarification on the bacterial content of milk summarize as follows: "With one exception the official plate count was decreased in milk with a count below 100,000 per cc. but there was a tendency to increase the count of milk with more than 100,000 as a result of clarification. A decrease in the size of bacterial clumps in clarified milk of low count was shown by direct microscopic examination."

Traum and Hart (41) found that milk which had been naturally infected with tubercle bacilli, after having been clarified in a large milk plant, caused tuberculosis in guinea pigs which were inoculated with it.

Marpman (26) reports the tubercle organisms to be of about the same specific gravity as normal milk, varying from 1.018 to 1.046.

Moore (35) artificially infected milk with tubercle bacilli from glycerol bouillon and blood serum cultures at the rate of seven cc. to 4000 cc. of milk, and found that after running this through a hand separator the skim milk and cream both caused tuberculosis when inoculated into guinea pigs. He repeated the experiment with other pathogenic organisms and found the bacteria in the skim milk.

Methods

The milk used for the bacteriological work was that received by the Dairy Department of the Iowa State College. No attempt was made to select any of the milk, but in all cases that which was studied represented the general milk supply. Care was always taken to steam all parts of the equipment with which the milk was to come in contact. The milk was well agitated in a 100-gallon coil vat before clarification and was then pumped through a short line of sanitary pipe to the clarifier. A DeLaval No. 105 clarifier was used throughout the experiments. The clarified milk samples were taken after at least ten gallons of milk had run through the clarifier with the idea of reducing possible contamination from the pump, pipe, or clarifier, and also to be sure that the clarifier was working normally. The samples of milk were transferred to sterile tubes by means of sterile pipettes. Whenever the samples were to be held for sometime, they were placed in ice water as soon as collected to prevent multiplication of the bacteria. Various clarification temperatures were used during the earlier parts of the investigational work in order to determine at what temperature the clarifier caused the least change in the physical condition of the milk. It was found that when clarifying at temperatures from 15.5° to 37.8°C. (60° to 100°F.) considerable foam, rich in fat, was formed, while at temperatures from 10° to 15.5°C. (50° to 60°F.) the physical state of the milk was not materially influenced. It was, therefore, decided to clarify the milk at the temperatures at which it was received, which were generally about 12.8°C. (55°F.). Ordinarily, the clarifier was operated at a normal capacity, but in a number of trials the rate of inflow was reduced to about one-tenth normal.

In the preparation of the clarifier slime for plating, a representative sample was taken from the clarifier bowl by means of a sterile spatula and placed in a sterile mortar. The slime was thoroughly triturated with sterile water until it formed a homogeneous viscous material. A small amount of this was then transferred to a water blank and plates poured after the proper dilutions had been made.

Beef infusion agar, containing 1.5 per cent shred agar and 0.5 per cent peptone, adjusted to a reaction of plus 1.0 Fuller's scale, was used for all the counts. This medium was chosen because it was desired to use one which would be most favorable for the growth of the bacteria in the milk. Duplicate plates were prepared which were incubated at 37° C. (98.6° F.) for two days.

In the study of the types of bacteria present in unclarified and clarified milk and in the slime 50 contiguous colonies from representative areas on the plates were picked into sterile litmus milk. These cultures were kept at room temperature for ten days, and then classified into the following groups: acid coagulators, acid non-coagulators, inert, alkali producers, and neutral, alkali, and acid peptonizers.

The method used for the methylene blue reduction test was that recommended in the Standard Methods of Milk Analysis (4th edition) published by the American Public Health Association. The samples used for the methylene blue test were also used for the fermentation test; the tubes were kept for six days at room temperature for observations on the character of the fermentations occurring.

Results Obtained

1. Influence of clarification on the number of bacteria in milk.

In the study of the influence of clarification on the number of bacteria in milk 43 comparisons of unclarified and clarified milk were made using the plate method. Table 1 gives the bacterial counts obtained and the percentage change in numbers due to clarification. The counts on the unclarified milk ranged from 15,300 to 1,240,000 per cc. Clarification caused an increase in the bacterial count in 20 trials and a decrease in 23. The increases in the counts varied from 3.1 to 145.7 per cent and averaged 54.6 per cent, while the decreases varied from 0.4 to 59.1 per cent and averaged 24.9 per cent. Considering the 43 comparisons, there was an average increase of 12.1 per cent as a result of clarification.

The increases due to clarification as determined by the plate count are only apparent, since there was no appreciable contamination, and are accounted for by the breaking up of bacterial clumps and chains by the clarifier.

An analysis of the data given in the table shows that 23 of the 43 counts on unclarified milk were higher than 100,000 per cc., and 20 were lower. With the

TABLE 1

Influence of Clarification on the Number of Bacteria in Milk.

Date			Bacteria per cc.		Percentage	
			Unclarified	Clarified	Increase	Decrease
1926	Nov.	8	19,000	27,000	42.1	
		12	27,500	45,000	63.6	
		15	137,000	136,500		.4
		19	21,500	45,000	109.3	
		22	32,500	22,150		31.8
		29	29,000	54,000	86.2	
	Dec.	11	79,500	82,000	3.1	
		13	88,000	102,000	15.9	
		15	138,500	159,000	14.8	
		14	558,000	532,000		4.6
		18	15,300	27,800	81.6	
		20	66,500	105,000	57.9	
1927	Jan.	5	199,000	116,000		41.7
		7	297,000	250,000		15.8
		8	53,000	45,000		15.1
		10	134,500	130,500		3.0
		12	45,500	43,000		5.5
		14	21,000	39,500	88.1	
		15	322,000	139,200		56.7
		17	185,000	176,500		4.6
		19	50,500	43,000		14.8
		22	17,200	15,800		8.1
		24	44,000	18,000		59.1
		26	199,000	97,500		51.0
		29	146,000	215,000	47.2	
	Feb.	7	53,500	50,000		6.5
		11	147,000	128,000		12.9
		14	800,000	400,000		50.0
		15	1,240,000	970,000		21.8

	14	21,000	39,500	88.1	
	15	322,000	139,200		56.7
	17	185,000	176,500		4.6
	19	50,500	43,000		14.8
	22	17,200	15,800		8.1
	24	44,000	18,000		59.1
	26	199,000	97,500		51.0
	29	146,000	215,000	47.2	
Feb.	7	53,500	50,000		6.5
	11	147,000	128,000		12.9
	14	800,000	400,000		50.0
	15	1,240,000	970,000		21.8
	18	78,000	86,000	10.2	
	19	252,000	266,000	5.6	
	22	225,000	339,000	50.7	
	23	390,000	460,000	17.9	
	25	320,000	780,000	143.7	
	26	400,000	290,000		27.5
	28	103,000	149,000	44.7	
Mar.	2	48,000	63,000	31.3	
	4	75,000	111,000	48.0	
	5	380,000	360,000		5.3
	7	42,000	97,000	130.9	
	11	540,000	305,000		43.5
	12	530,000	330,000		37.7
	14	805,000	370,000		54.0

23 counts above 100,000 per cc., clarification caused a decrease in 16, or 70 per cent, and an increase in seven, or 30 per cent, while with the 20 samples of milk showing counts lower than 100,000 per cc. clarification caused a decrease in seven, or 35 per cent, and an increase in 13, or 65 per cent. This shows that with the milk studied, clarification was more likely to cause a decrease in the count when the milk contained over 100,000 bacteria per cc. than when it contained a smaller number. Other investigators report similar results, although the available data show considerable variations.

2. Influence of clarification with normal and with reduced rate of inflow on the number of bacteria in milk.

A comparison was made of the influence of clarification on the number of bacteria in milk using a normal and a tenth-normal rate of inflow. The plate counts obtained and the percentage change in numbers with 19 lots of milk are shown in Table 2. .

The counts on the unclarified milk ranged from 27,000 to 5,310,000 per cc. When the rate of inflow was normal, clarification caused an increase in the count in six trials and a decrease in 13, while when the rate

TABLE 2

Influence of Clarification with
with Reduced Rates of Inflow on
of Bacteria in Milk.

Date		Unclarified (Bacteria per cc.)	Normal Inflow	
			Bacteria per cc.	Perc Decr
1927	Mar. 26	1,730,000	1,620,000	
	Apr. 5	2,100,000	1,930,000	
	Apr. 6	1,520,000	1,090,000	
	Apr. 7	59,000	57,000	
	Apr. 8	64,000	52,000	
	Apr. 9	46,500	41,500	
	Apr. 11	170,000	180,000	-
	Apr. 12	230,500	343,000	-
	Apr. 13	1,850,000	1,070,000	
	Apr. 14	27,000	44,500	-
	Apr. 15	90,000	79,000	
	Apr. 16	1,220,000	1,600,000	-
	Apr. 28	770,000	960,000	-
	Apr. 29	3,710,000	2,920,000	
	May 2	5,310,000	2,110,000	
	May 3	2,230,000	2,010,000	
	May 4	1,220,000	855,000	
	May 5	83,500	113,000	-
	May 7	600,000	485,000	

TABLE 2

rification with Normal and
es of Inflow on the Number
ilk.

Normal Inflow		Reduced Inflow	
per cc.	Percentage Decrease	Bacteria per cc.	Percentage Decrease
,000	6.3	1,060,000	38.7
,000	8.1	580,000	72.4
,000	28.3	360,000	76.3
,000	3.4	20,500	65.2
,000	18.7	16,000	75.0
,500	10.8	16,500	64.5
,000	- 5.9	82,000	51.7
,000	-48.8	128,000	44.4
,000	42.1	417,000	77.4
,500	-64.8	17,000	37.0
,000	12.2	47,000	47.3
,000	-31.1	710,000	41.8
,000	-24.7	570,000	25.9
,000	21.2	1,670,000	55.0
,000	60.2	2,040,000	61.5
,000	9.9	435,000	80.5
,000	29.9	595,000	51.1
,000	-35.3	52,000	37.7
,000	19.1	320,000	46.7

of inflow was reduced, clarification always caused a decrease. With the normal rate of inflow there was a minimum increase in the counts of 5.9 per cent, a maximum of 64.8, and an average of 35.1, while the minimum decrease was 3.4 per cent, the maximum 60.2, and the average 20.8; considering the 19 comparisons there was an average decrease of 3.1 per cent. When the rate of inflow was reduced there was a minimum decrease of 25.9 per cent, a maximum of 80.5, and an average of 55.3. These data show that by decreasing the rate of inflow it was possible to remove, on an average, more than half of the bacteria present in milk.

Thirteen of the 19 samples of milk contained more than 100,000 bacteria per cc. while six had less. With the 13 counts above 100,000 per cc. clarification with the normal rate of inflow caused a decrease in nine, or 70 per cent, and an increase in four, or 30 per cent, while with the six counts below 100,000 per cc. there was a decrease in four or 67 per cent, and an increase in two, or 33 per cent. The milk used for these trials contained on an average more bacteria than did the milk used for the trials reported in Table 1. However, the results obtained in both series of determinations with the milk containing more than 100,000 bacteria per cc. check very closely.

3. The effect of clarification on the types of bacteria present in milk.

The results of a study of the types of bacteria present in 21 lots of milk before and after clarification are reported on a percentage basis in Table 3. The data show that the acid forming groups predominated in both the unclarified and clarified milk, while the neutral and acid peptonizers were the least numerous. Sometimes the acid coagulators were present in larger numbers than the acid non-coagulators, and sometimes the reverse was true. Separation of the acid formers into two groups on the basis of whether or not coagulation occurs is of questionable importance since with certain of the S. lactis organisms (19) the rate of coagulation of litmus milk is a character which may undergo definite fluctuations. In a few comparisons the alkali formers were present in large numbers in the unclarified milk, but they were also present in considerable numbers in the milk after clarification. Whenever a certain group of organisms was present in the unclarified milk it was nearly always also present in the clarified milk, although there was usually a change in

TABLE 3

Types of Bacteria Present in Unclarified and Clarified Milk.

Date			Percentage						
			Acid		Inert	Alkali	Peptonizers		
			Coagulators	Non-coagulators			Neutral	Acid	Alkali
1926	Nov. 8	Uncl.	49.1	16.3	16.3	14.3	2.0	2.0	0
		Cl.	83.4	9.3	5.4	1.9	0	0	0
	12	Uncl.	10.9	60.9	15.2	2.2	4.3	6.5	0
		Cl.	10.6	61.7	19.1	4.3	0	4.3	0
	15	Uncl.	29.6	37.0	12.9	13.0	0	5.6	1.9
		Cl.	40.4	42.4	1.9	11.5	0	1.9	1.9
	19	Uncl.	43.7	23.0	16.6	14.6	0	0	2.1
		Cl.	20.0	44.0	28.0	8.0	0	0	0
	22	Uncl.	10.0	52.0	10.0	24.0	0	0	4.0
		Cl.	10.0	50.0	18.0	20.0	0	0	2.0
	Dec. 6	Uncl.	53.8	23.1	0	15.4	0	7.7	0
		Cl.	39.6	30.1	7.7	11.3	1.9	9.4	0
	Nov.29	Uncl.	30.0	18.0	10.0	40.0	0	2.0	0
		Cl.	24.0	22.0	10.0	38.0	0	6.0	0
	Dec.11	Uncl.	42.0	14.0	14.0	22.0	0	8.0	0
		Cl.	44.0	38.0	0	14.0	0	4.0	0
	13	Uncl.	14.5	12.3	10.2	59.0	2.0	2.0	0
		Cl.	12.0	22.0	4.0	60.0	0	0	2.0
	3	Uncl.	86.0	10.0	0	4.0	0	0	0
		Cl.	85.7	8.2	2.1	2.0	0	2.0	0
	4	Uncl.	86.0	10.0	0	4.0	0	0	0
		Cl.	96.0	0	0	4.0	0	0	0
	18	Uncl.	10.2	40.8	22.5	26.5	0	0	0
		Cl.	10.0	40.0	20.0	30.0	0	0	0
	20	Uncl.	22.0	24.0	8.0	40.0	0	6.0	0
		Cl.	52.0	22.0	4.0	18.0	0	4.0	0
1927	Jan. 5	Uncl.	24.0	16.0	8.0	32.0	0	20.0	0
		Cl.	20.0	34.0	2.0	36.0	0	8.0	0
	7	Uncl.	7.8	7.8	2.0	39.2	0	43.2	0

		Cl.	96.0	0	0	4.0	0	0	0
	18	Uncl.	10.2	40.8	22.5	26.5	0	0	0
		Cl.	10.0	40.0	20.0	30.0	0	0	0
	20	Uncl.	22.0	24.0	8.0	40.0	0	6.0	0
		Cl.	52.0	22.0	4.0	18.0	0	4.0	0
1927	Jan. 5	Uncl.	24.0	16.0	8.0	32.0	0	20.0	0
		Cl.	20.0	34.0	2.0	36.0	0	8.0	0
	7	Uncl.	7.8	7.8	2.0	39.2	0	43.2	0
		Cl.	10.0	22.0	0	38.0	0	30.0	0
	8	Uncl.	13.7	31.4	19.6	5.9	0	29.4	0
		Cl.	14.0	40.0	18.0	6.0	2.0	20.0	0
	10	Uncl.	4.0	22.0	6.0	50.0	0	18.0	0
		Cl.	0	28.0	4.0	50.0	2.0	16.0	0
	12	Uncl.	16.0	20.0	2.0	24.0	2.0	36.0	0
		Cl.	18.0	20.0	4.0	40.0	4.0	14.0	0
	14	Uncl.	8.0	36.0	12.0	32.0	2.0	10.0	0
		Cl.	16.0	40.0	12.0	24.0	0	8.0	0
	17	Uncl.	24.0	24.0	16.0	18.0	0	18.0	0
		Cl.	30.0	22.0	10.0	28.0	0	10.0	0
	Feb.14	Uncl.	36.0	36.0	4.0	16.0	0	8.0	0
		Cl.	56.0	20.0	10.0	10.0	4.0	0	0

the percentage. The results show that clarification caused increases and decreases in the percentages of the various groups, but did not cause a consistent elimination of any single group.

An analysis of the changes in the percentage of the various groups caused by clarification and a summary of these changes are given in Table 4. The figures show that clarification had an irregular effect on the bacterial flora. Sometimes it caused an increase and sometimes a decrease in each of the groups of organisms present in the milk. The increases in the acid coagulators as a result of clarification varied from 0.3 to 34.3 per cent and the decreases from 0.2 to 23.7 per cent, with an average increase when all comparisons are considered of 3.4 per cent. The acid non-coagulators showed increases varying from 0.8 to 24.0 per cent, decreases from 0.8 to 16.0 per cent, and an average increase in all comparisons of 3.9 per cent. The alkali formers were increased from 0.1 to 16.0 per cent and decreased from 1.2 to 22.0 per cent with an average decrease for all comparisons of 1.8 per cent. The other groups show similar increases and decreases as a result of clarification. The summary shows that clarification caused increases in the groups approx-

Differences in the

Date			Changes in the Percenta					
			Acid Coag.		Acid Non-coag.		Inert	
			Incr.	Decr.	Incr.	Decr.	Incr.	Decr.
1926	Nov.	8	34.3			7.0		10.9
	"	12		0.3	0.8		3.9	
	"	15	10.8		5.4			11.0
	"	19		23.7	21.0		11.4	
	"	22	0	0		2.0	8.0	
	Dec.	6		14.2	7.0		7.7	
	Nov.	29		6.0	4.0		0	0
	Dec.	11	2.0		24.0			14.0
	"	13		2.5	9.7			6.2
	"	3		0.3		1.8	2.1	
	"	4	10.0			10.0		
	"	18		0.2		0.8		2.5
	"	20	30.0			2.0		4.0
1927	Jan.	5		4.0	18.0			6.0
	"	7	2.2		14.2			2.0
	"	8	0.3		8.6			1.6
	"	10		4.0	6.0			2.0
	"	12	2.0		0	0	2.0	
	"	14	8.0		4.0		0	0
	"	17	6.0			2.0		6.0
	"	14	20.0			16.0	6.0	
Average Change			3.4		3.9			1.2

σ = 12.8	σ = 9.6	σ = 7.05	σ = 8.4
p.e. = 8.34	p.e. = 6.25	p.e. = 4.72	p.e. = 5.63
p.e.$_m$= 1.82	p.e.$_m$= 1.36	p.e.$_m$= 1.03	p.e.$_m$= 1.23

TABLE 4

in the Types of Bacteria Present in Unclarified and Clarified Milk.

Percentage of the Various Groups due to Clarification

	Alkali		Neut. Pept.		Acid Pept.		Alk. Pept.	
ecr.	Incr.	Decr.	Incr.	Decr.	Incr.	Decr.	Incr.	De
0.9		12.4		2.0		2.0		
	2.1			4.3		2.2		
1.0	1.5					3.7	0	
		6.6						2
		4.0						2
		4.1	1.9		1.7			
0		2.0			4.0			
4.0		8.0				4.0		
6.2	1.0			2.0		2.0	2.0	
		2.0			2.0			
	0	0						
2.5	3.5							
4.0		22.0				2.0		
6.0	4.0					12.0		
2.0		1.2				13.2		
1.6	0.1		2.0			9.4		
2.0	0	0	2.0			2.0		
	16.0		2.0			22.0		
0		8.0		2.0		2.0		
6.0	10.0					8.0		
		6.0	4.0			8.0		
1.2		1.8	0.2			5.0		0
4	σ = 2.62		σ = 11.2		σ = 1.98			
63	p.e. = 1.7		p.e. = 7.50		p.e. = 1.27			
23	$p.e._m$ = 0.565		$p.e._m$ = 1.82		$p.e._m$ = 0.645			

ept.
Decr.

0
2.1
2.0

0.5

Summary of the Changes in the Different Groups due to Clarification

	Increase		Decrease		No Change	
	Times	(%)	Times	(%)	Times	(%)
Acid Coag.	11	52.4	9	42.8	1	4.8
Acid Non-coag.	12	57.1	8	38.1	1	4.8
Inert	7	35.0	11	55.0	2	10.0
Alkali	8	38.1	11	52.4	2	9.5
Neut. Pept.	5	55.6	4	44.4	0	0
Acid "	3	17.6	14	82.4	0	0
Alk. "	1	25.0	2	50.0	1	25.0

imately as often as decreases, with the exception of the acid peptonizers which were decreased in 82.4 per cent of the comparisons in which they were present in the original milk, but since these organisms were present in the milk in comparatively small numbers the significance of this is not great. On the average the acid coagulators were increased, and the alkali formers decreased by clarification. This is of particular interest because of later studies on the types of bacteria present in clarifier slime.

At the foot of each column is shown the standard deviation (σ), the probable error (p.e.) of the individual determinations, and the probable error of the mean ($p.e._m$) of all determinations. The probable error of the mean in most cases is in the same order of magnitude as the average changes. Very few of the average changes exceed two or three times the probable error of the mean and cannot therefore have much significance.

When one considers that milk consists of various complex substances and that the bacteria present may show daily variations both in numbers and in types, it would be expected that the effect of clarification would be variable. The changes caused by clarification were not significant enough to warrant any conclusions regarding a selective action by the clarifier on the types of organisms which were present in the milk studied.

4. The types of bacteria present in unclarified milk and in the slime obtained from it.

Although the results obtained in Section 3 did not indicate any selective action by the clarifier on the bacteria present in milk, it was decided to study this further under conditions favorable for determining such an effect. A study of the types of bacteria present in unclarified milk and in the slime obtained from it was therefore made, because if the clarifier has any selective influence on the bacteria in the milk this should be quite evident from the types of bacteria present in the slime. The results of 33 comparisons are reported on a percentage basis in Table 5. The data show that the types of bacteria present in the milk, in general, were the same as those present in the slime. The types of bacteria present in the milk were similar to those present in the unclarified milk studied in Section 3. The acid coagulators usually predominated, but sometimes the acid non-coagulators were the most numerous; the neutral and alkali peptonizers were the least prominent. In the slime the acid formers usually predominated, although occasion-

TABL

The Types of Bacter
Milk and in the Sli

Date				Percentage						
				Acid			Al-	Peptonizers		
				Coag-ulators	Non-Coag-ulators	Inert	kali	Neutral	Acid	Alkal
1926	Dec.	11	U.*	42.0	14.0	14.0	22.0	0	8.0	0
			Sl.**	41.4	12.0	0	46.6	0	0	0
		18	U.	10.2	40.8	22.5	26.5	0	0	0
			Sl.	3.9	11.7	21.6	62.8	0	0	0
1927	Jan.	5	U.	24.0	16.0	8.0	32.0	0	20.0	0
			Sl.	22.7	0	0	75.0	0	0	2.3
		7	U.	7.8	7.8	2.0	39.2	0	43.2	0
			Sl.	20.0	14.0	0	64.0	0	2.0	0
		8	U.	13.7	31.4	19.6	5.9	0	29.4	0
			Sl.	3.9	23.5	31.4	19.6	0	21.6	0
		12	U.	16.0	20.0	2.0	24.0	2.0	36.0	0
			Sl.	4.0	14.0	0	68.0	2.0	12.0	0
		14	U.	8.0	36.0	12.0	32.0	2.0	10.0	0
			Sl.	28.0	16.0	10.0	32.0	0	14.0	0
		15	U.	68.6	15.7	3.9	5.9	0	5.9	0
			Sl.	20.0	2.0	0	74.0	0	4.0	0
		17	U.	24.0	24.0	16.0	18.0	0	18.0	0
			Sl.	58.3	0.0	2.0	35.4	0	4.3	0
		19	U.	4.0	6.0	22.0	30.0	2.0	36.0	0
			Sl.	8.0	2.0	2.0	82.0	0	6.0	0
		22	U.	34.0	26.0	4.0	26.0	0	10.0	0
			Sl.	12.0	58.0	2.0	22.0	0	6.0	0
		24	U.	14.0	14.0	4.0	54.0	0	14.0	0
			Sl.	46.0	14.0	0	40.0	0	0	0
		26	U.	42.0	2.0	0	54.0	0	2.0	0
			Sl.	26.0	72.0	0	0	0	0	2.0
		29	U.	52.0	20.0	5.0	13.0	0	10.0	0
			Sl.	57.4	0	0	12.8	0	29.8	0
	Feb.	7	U.	53.0	13.7	11.8	17.6	0	3.9	0
			Sl.	26.0	6.0	2.0	64.0	0	2.0	0
		11	U.	90.0	2.0	0	8.0	0	0	0
			Sl.	76.0	8.0	2.0	14.0	0	0	0

TABLE 5

cteria Present in Unclarified
Slime Obtained from It.

					Percentage						
s	Date				Acid			Al-	Peptonizers		
lkali					Coag-ulators	Non-Coag-ulators	Inert	kali	Neu-tral	Acid	Alkali
0	1926	Feb.	12	U.	98.0	2.0	0	0	0	0	0
0				Sl.	98.0	0	0	2.0	0	0	0
0			14	U.	36.0	36.0	4.0	16.0	0	8.0	0
0				Sl.	26.0	26.0	2.0	44.0	0	2.0	0
0			15	U.	82.0	16.0	0	2.0	0	0	0
2.3				Sl.	42.0	12.0	6.0	26.0	0	14.0	0
0			18	U.	82.0	2.0	0	12.0	0	4.0	0
0				Sl.	40.0	2.0	4.0	54.0	0	0	0
0			19	U.	74.0	12.0	0	8.0	0	6.0	0
0				Sl.	90.0	4.0	0	4.0	0	2.0	0
0			22	U.	10.0	56.0	0	24.0	0	10.0	0
0				Sl.	10.0	60.0	0	26.0	0	4.0	0
0			23	U.	90.0	0	6.0	2.0	0	2.0	0
0				Sl.	84.0	0	2.0	10.0	0	4.0	0
0			25	U.	88.0	0	2.0	10.0	0	0	0
0				Sl.	88.0	0	0	12.0	0	0	0
0			26	U.	100.0	0	0	0	0	0	0
0				Sl.	64.0	12.0	10.0	8.0	0	6.0	0
0			28	U.	72.0	16.0	8.0	4.0	0	0	0
0				Sl.	30.0	16.0	16.0	24.0	0	14.0	0
0		Mar.	2	U.	12.0	82.0	6.0	0	0	0	0
0				Sl.	34.0	20.0	10.0	30.0	0	6.0	0
0			4	U.	50.0	40.0	0	4.0	0	6.0	0
0				Sl.	38.0	24.0	6.0	24.0	0	8.0	0
0			5	U.	90.0	10.0	0	0	0	0	0
2.0				Sl.	74.0	10.0	2.0	10.0	2.0	2.0	0
0			7	U.	32.0	52.0	4.0	2.0	0	8.0	2.0
0				Sl.	26.0	68.0	2.0	2.0	0	2.0	0
0			11	U.	46.0	20.0	2.0	20.0	8.0	4.0	0
0				Sl.	32.0	20.0	4.0	38.0	2.0	4.0	0
0			12	U.	22.0	8.0	4.0	34.0	4.0	28.0	0
0				Sl.	2.0	4.0	0	80.0	4.0	10.0	0
			14	U.	66.0	10.0	4.0	10.0	10.0	0	0
				Sl.	34.0	52.0	8.0	4.0	2.0	0	0

* Unclarified

** Slime

ally the alkali formers were the most prominent while the neutral and alkali peptonizers were present in the smallest percentages. Wide variations were noted in the percentages of acid coagulators and alkali formers present, but no regular elimination of either of these two groups from the milk seems to have taken place.

A comparison of the differences in the types of bacteria present in the milk and in the slime is shown in Table 6 together with a summary of these differences. The only groups which showed a fairly consistent change as a result of clarification were the acid coagulators and the alkali formers. The average changes were an 8.7 per cent decrease in the acid formers and a 16.8 per cent increase in the alkali formers in the slime as compared with those present in the milk. Whether these changes were actually brought about by the clarifier is difficult to say. As has already been pointed out, the data presented in Table 4 indicated that clarification slightly increased the percentage of acid coagulators in the milk and decreased the percentage of alkali formers. This would suggest that there should be a corresponding decrease and increase in the same groups in the slime and the figures shown in Table 6 indicate that such a change did take place. The summary of the changes show that an in-

Changes in the Types of Organisms in the Slime as

Date			Acid Coagulators		Acid Non-coagulators		Inert	
			Increase	Decrease	Increase	Decrease	Increase	Decreas
1926	Dec.	11		0.6		2.0		14.0
		18		6.3		29.1		0.9
1927	Jan.	5		1.3		16.0		8.0
		7	12.2		6.2			2.0
		8		9.8		7.9	11.8	
		12		12.0		6.0		2.0
		14	20.0			20.0		2.0
		15		48.6		13.7		3.9
		17	34.3			24.0		14.0
		19	4.0			4.0		20.0
		22		22.0	32.0			2.0
		24	32.0		0	0		4.0
		26		16.0	70.0			
		29	5.4			20.0		5.0
	Feb.	7		27.0		7.7		9.8
		11		14.0	6.0		2.0	
		12	0	0		2.0		
		14		10.0		10.0		2.0
		15		40.0		4.0	6.0	
		18		42.0	0	0	4.0	
		19	16.0			8.0		
		22	0	0	4.0			
		23		6.0				4.0
		25	0	0				2.0
		26		36.0	12.0		10.0	
		28		42.0	0	0	8.0	
	Mar.	2	22.0			62.0	4.0	
		4		12.0		16.0	6.0	
		5		16.0	0	0	2.0	
		7		6.0	16.0			2.0
		11		14.0	0	0	2.0	
		12		20.0		4.0		4.0
		14		32.0	42.0		4.0	
Avg. Change				8.7		2.2		1.4

$\sigma = 26.9$
p.e. = 17.8
$p.e._m = 3.16$

$\sigma = 22.6$
p.e. = 15.0
$p.e._m = 2.69$

$\sigma = 7.55$
p.e. = 4.95
$p.e._m = 0.947$

$\sigma = 7.1$
p.e. = 4.8
$p.e._m = 0.8$

TABLE 6

Differences in the Types of Bacteria Present in Unclarified Milk and in the Slime Obtained From It.

Compared with the Types Present in Unclarified Milk							
Alkali		Neut. Pept.		Acid Pept.		Alk. Pept.	
Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
24.6					8.0		
36.3							
43.0					20.0	2.3	
24.8					41.2		
13.7					7.8		
44.0		0	0		24.0		
0	0		2.0	4.0			
68.1					1.9		
17.4					13.7		
52.0			2.0		30.0		
	4.0				4.0		
	14.0				14.0		
	54.0				2.0	2.0	
	0.2			19.8			
46.4					1.9		
6.0							
2.0							
28.0					6.0		
24.0				14.0			
42.0					4.0		
	4.0				4.0		
2.0					6.0		
8.0				2.0			
2.0							
8.0				6.0			
20.0				14.0			
30.0				6.0			
20.0				2.0			
10.0		2.0		2.0			
0	0				6.0		2.0
18.0			6.0	0	0		
46.0		0	0		18.0		
	6.0		8.0				
16.8			2.3		5.1	0.7	

$\sigma = 5.65$
$p.e. = 3.78$
$p.e._m = 1.44$

$\sigma = 18.21$
$p.e. = 12.2$
$p.e._m = 2.56$

$\sigma = 1.96$
$p.e. = 1.31$
$p.e._m = 0.76$

ent in
d From It.

Alk. Pept.	
Increase	Decrease
2.3	
2.0	
	2.0
0.7	

.96
.31
.76

Summary of the Changes in the Various Gr

	Increase		Decrease	
	Times	(%)	Times	(%
Acid Coagulators	8	24.2	22	66.
Acid Non-coag.	8	25.8	18	58.
Inert	11	37.9	18	62.
Alkali	25	75.7	6	18.
Neut. Pept.	1	14.3	4	57.
Acid Pept.	9	32.1	18	64.
Alkali Pept.	2	66.7	1	33.

Summary of the Changes in the Various Groups

	Increase		Decrease		No Change	
	Times	(%)	Times	(%)	Times	(%)
Acid Coagulators	8	24.2	22	66.7	3	9.1
Acid Non-coag.	8	25.8	18	58.1	5	16.1
Inert	11	37.9	18	62.1	0	0
Alkali	25	75.7	6	18.2	2	6.1
Neut. Pept.	1	14.3	4	57.1	2	28.6
Acid Pept.	9	32.1	18	64.3	1	3.6
Alkali Pept.	2	66.7	1	33.3	0	0

crease and a decrease occurred in the various groups of organisms, the most consistent decrease occurring in the acid forming and the most consistent increase in the alkali forming groups.

The average change of the acid coagulators is about three times and that of the alkali formers about twenty times as great as the probable error of the mean, while the average changes of the other groups are in the same order of magnitude as the probable error of the mean. This would indicate that the change in the alkali-forming group had considerable significance and the change in the acid coagulating group some significance. From the theory of probability the chances are very slight that the changes in these two groups were due to experimental error.

Microscopic examinations of the slime showed the presence of many gram-positive clumps and chains of bacteria of varying size as well as numerous gram-positive and gram-negative organisms, isolated and in pairs. Large, gram-negative rods were very abundant; they were usually present in pairs, and corresponded in morphology and staining reaction to those of the alkali formers which had been isolated from plates.

The changes in the percentage of acid and alkali formers may have been due to a selective action of the clarifier. They may also have been due to a breaking-up of bacterial clumps and chains by the clarifier, while the increase in the percentage of alkali formers may be accounted for by assuming that these organisms were associated with the cells and dirt particles in the milk, and since these were, for the most part, removed in the slime, the organisms would be removed with them. This latter explanation is not very logical, however, because if the alkali formers were held by the cells and dirt they should practically all have been removed, while the data show that on an average the slime contained only 16.8 per cent more of these organisms than the unclarified milk.

The results obtained in this study seem to justify the conclusion, that if the clarifier had a selective action on the bacteria present in the milk used, the alkali formers were the ones responding to this influence.

5. The effect of clarification with normal and reduced rate of inflow on the types of bacteria present in milk.

In order to study the effect of prolonged exposure of milk to centrifugal force in a clarifier on the types of bacteria present, a series of 18 comparisons was made in which a normal and a one-tenth normal rate of inflow were used. The primary object was to see if it was possible, by means of a greater clarifying efficiency, to cause a significant change in the flora of the milk. The data obtained are presented on a percentage basis in Table 7. The acid formers predominated in both the unclarified milk and in the milk clarified with either method of clarification while the neutral and alkali peptonizers were the least numerous.

The results obtained agree with those obtained in Section 3. The types of bacteria present in the clarified milk were very similar to those in the unclarified milk. Although there were slight variations in the types present, no great elimination of any of the groups took place.

An analysis and summary of the changes which occurred in the types of organisms with the two methods of clarification are shown in Tables 8 and 9. It would seem, that clarification with either method caused little change in the types of bacteria in the milk. The variations are not consistent or large enough to permit of the drawing of any conclusions other than that the clarifier apparently had little or no selective action on the types of bacteria present in the milk under either method of clarification.

Types of Bacteria Present in Unclarified Milk and in Milk Clarified with a Normal and with a Reduced Rate of Inflow.

Date		Percentage						
		Acid				Peptonizers		
		Coagulators	Non-Coagulators	Inert	Alkali	Neutral	Acid	Alkali
1927 Mar. 26	U.	74.0	14.0	4.0	0	0	8.0	0
	Cl.	78.0	16.0	2.0	0	0	4.0	0
	Cl. red.*	84.0	12.0	2.0	0	0	2.0	0
Apr. 5	U.	78.0	6.0	0	6.0	0	10.0	0
	Cl.	74.0	16.0	2.0	2.0	0	6.0	0
	Cl. red.	86.0	4.0	0	2.0	0	8.0	0
Apr. 6	U.	56.0	28.0	2.0	6.0	0	8.0	0
	Cl.	64.0	12.0	0	6.0	0	18.0	0
	Cl. red.	74.0	14.0	0	0	2.0	10.0	0
Apr. 7	U.	23.6	41.8	3.7	5.5	1.8	23.6	0
	Cl.	22.0	26.0	6.0	30.0	0	16.0	0
	Cl. red.	24.0	40.0	2.0	12.0	2.0	20.0	0
Apr. 8	U.	12.0	30.0	2.0	18.0	0	38.0	0
	Cl.	16.0	48.0	0	14.0	2.0	20.0	0
	Cl. red.	0	63.6	0	0	0	36.4	0
Apr. 9	U.	18.0	42.0	10.0	8.0	2.0	20.0	0
	Cl.	18.0	44.0	0	16.0	0	22.0	0
	Cl. red.	8.3	27.8	5.5	19.6	0	38.8	0
Apr. 11	U.	48.0	20.0	0	12.0	0	20.0	0
	Cl.	59.5	21.4	0	2.3	0	16.8	0
	Cl. red.	52.0	12.0	0	18.0	0	18.0	0
Apr. 12	U.	69.3	16.3	2.1	10.2	0	0	2.1
	Cl.	86.0	8.0	0	6.0	0	0	0
	Cl. red.	64.0	20.0	6.0	10.0	0	0	0
Apr. 14	U.	7.7	36.6	5.8	40.3	0	9.6	0
	Cl.	6.0	38.0	2.0	52.0	0	2.0	0
	Cl. red.	3.2	45.1	6.5	32.3	0	12.9	0
Apr. 15	U.	8.0	44.0	0	34.0	2.0	12.0	0
	Cl.	10.0	26.0	12.0	30.0	4.0	18.0	0
	Cl. red.	20.8	22.9	0	39.6	6.3	8.3	2.1

	Cl.	59.5	21.4	0	2.3	0	16.8	0
	Cl. red.	52.0	12.0	0	18.0	0	18.0	0
Apr. 12	U.	69.3	16.3	2.1	10.2	0	0	2.1
	Cl.	86.0	8.0	0	6.0	0	0	0
	Cl. red.	64.0	20.0	6.0	10.0	0	0	0
Apr. 14	U.	7.7	36.6	5.8	40.3	0	9.6	0
	Cl.	6.0	38.0	2.0	52.0	0	2.0	0
	Cl. red.	3.2	45.1	6.5	32.3	0	12.9	0
Apr. 15	U.	8.0	44.0	0	34.0	2.0	12.0	0
	Cl.	10.0	26.0	12.0	30.0	4.0	18.0	0
	Cl. red.	20.8	22.9	0	39.6	6.3	8.3	2.1
Apr. 16	U.	84.0	8.0	2.0	6.0	0	0	0
	Cl.	80.0	16.0	0	4.0	0	0	0
	Cl. red.	74.0	18.0	0	6.0	0	2.0	0
Apr. 28	U.	32.7	40.8	0	26.5	0	0	0
	Cl.	14.0	58.0	2.0	20.0	0	6.0	0
	Cl. red.	8.0	84.0	0	8.0	0	0	0
Apr. 29	U.	10.0	64.0	0	20.0	0	6.0	0
	Cl.	26.0	24.0	0	40.0	0	10.0	0
	Cl. red.	4.0	80.0	0	12.0	0	4.0	0
May 2	U.	14.6	66.6	0	16.7	0	2.1	0
	Cl.	44.3	13.4	1.9	23.1	0	17.3	0
	Cl. red.	24.0	24.0	0	36.0	0	16.0	0
May 3	U.	58.0	16.0	0	18.0	0	8.0	0
	Cl.	36.0	54.0	0	6.0	0	4.0	0
	Cl. red.	58.0	12.0	0	18.0	0	12.0	0
May 4	U.	10.0	74.0	0	16.0	0	0	0
	Cl.	26.0	64.0	0	10.0	0	0	0
	Cl. red.	14.0	80.0	2.0	4.0	0	0	0
May 5	U.	2.2	13.0	19.6	39.1	0	26.1	0
	Cl.	10.0	24.0	4.0	38.0	0	24.0	0
	Cl. red.	8.0	10.0	6.0	60.0	0	16.0	0
May 7	U.	10.0	52.0	2.0	32.0	0	4.0	0
	Cl.	14.0	30.0	2.0	46.0	0	8.0	0
	Cl. red.	9.1	45.5	4.5	40.9	0	0	0

* Reduced rate of inflow.

Changes in the Percentage Types of the V

Date	Acid Coag.		Acid Non-coag.		Inert	
	Increase	Decrease	Increase	Decrease	Increase	Decre
1927 Mar. 26	4.0		4.0			2.0
Apr. 5		4.0	10.0		2.0	
6	8.0			16.0		2.0
7		1.6		15.8	2.3	
8	4.0		18.0			2.0
9	0	0	2.0			10.0
11	11.5		1.4			
12	16.7			8.3		2.1
14		1.7	1.4			3.8
15	2.0			18.0	12.0	
16		4.0	8.0			2.0
28		18.7	17.2		2.0	
29	16.0			40.0		
May 2	29.7			53.2	1.9	
3		22.0	38.0			
4	16.0			10.0		
5	7.8		11.0			15.6
7	4.0			22.0	0	0
Avg. Change	3.7			4.0		1.4

σ = 11.7
p.e. = 7.85
p.e$_m$ = 1.675

σ = 22.4
p.e. = 14.6
p.e$_m$ = 3.46

σ = 6.6
p.e. = 4.3
p.e$_m$ = 1.1

TABLE 8

Differences in the Types of Bacteria Present in Unclarified Milk and in Clarified Milk with Normal Rate of Inflow.

Groups after Clarification							
Alkali		Pept. Neut.		Pept. Acid		Pept. Alkali	
rease	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
					4.0		
	4.0				4.0		
0	0			10.0			
.5			1.8		7.6		
	4.0	2.0			18.0		
.0			2.0	2.0			
	9.7				3.2		
	4.2						2.1
.7					7.6		
	4.0	2.0		6.0			
	2.0						
	6.5			6.0			
.0				4.0			
.4				15.2			
	12.0				4.0		
	6.0						
	1.1				2.1		
.0				4.0			
.8		0.05			0.2		2.1

σ = 10.2
p.e. = 6.83
p.e.$_m$ = 1.65

σ = 1.94
p.e. = 1.27
p.e.$_m$ = 0.572

σ = 7.92
p.e. = 5.31
p.e.$_m$ = 1.37

σ = 0
p.e. = 0
p.e.$_m$ = 0

nclarified
flow.

	Pept. Alkali	
e	Increase	Decrease
		2.1
		2.1

$\sigma = 0$
p.e. = 0
$p.e._m = 0$

Summary of the Changes in the Different G

	Increase		Decreas
	Times	(%)	Times
Acid Coag.	11	61.1	6
Acid Non-coag.	10	55.6	8
Inert	5	35.7	8
Alkali	6	35.3	10
Neut. Pept.	2	50.0	2
Acid Pept.	7	46.7	8
Alk. Pept.	0	0	1

ummary of the Changes in the Different Groups Due to Clarification

	Increase		Decrease		No Change	
	Times	(%)	Times	(%)	Times	(%)
Coag.	11	61.1	6	33.3	1	5.6
Non-coag.	10	55.6	8	44.4	0	0
	5	35.7	8	57.1	1	7.2
l	6	35.3	10	58.8	1	5.9
Pept.	2	50.0	2	50.0	0	0
Pept.	7	46.7	8	53.3	0	0
Pept.	0	0	1	100.0	0	0

Changes in the Percentage Types of the Vari

Date			Acid Coag.		Acid Non-coag.		Inert		
			In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	Increa
1927	Mar.	26	10.0			2.0		2.0	
	Apr.	5	8.0			2.0			
		6	18.0			14.0		2.0	
		7	0.4			1.8		1.7	6.5
		8		12.0	33.6			2.0	
		9		9.7		14.2		4.5	11.6
		11	4.0			8.0			6.0
		12		5.3	3.7		3.9		
		14		4.5	8.5		0.7		
		15	12.8			21.1			5.6
		16		10.0	10.0			2.0	0
		28		24.7	43.2				
		29		6.0	16.0				
	May	2	9.4			42.6			19.3
		3	0	0		4.0			0
		4	4.0		6.0		2.0		
		5	5.8			3.0		13.6	20.9
		7		0.9		6.5	2.5		8.9
Avg. Change				0.04	0.1			1.7	0.2

$\sigma = 10.11$
p.e. = 6.77
$p.e._m = 1.59$

$\sigma = 18.64$
p.e. = 12.1
$p.e._m = 2.86$

$\sigma = 5.59$
p.e. = 3.63
$p.e._m = 1.09$

TABLE 9

Differences in the Types of Bacteria Present i
Milk and in Clarified Milk with Reduced Rate o

the Various Groups after Clarification

	Alkali		Pept. Neut.		Pept. Acid		Pept
e	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increa
						6.0	
		4.0				2.0	
		6.0	2.0		2.0		
	6.5		0.2			3.6	
		18.0				1.6	
	11.6			2.0	18.8		
	6.0					2.0	
		0.2					
		8.0			3.3		
	5.6		4.3			3.7	
	0	0			2.0		2.1
		18.5					
		8.0				2.0	
	19.3				13.9		
	0	0			4.0		
		12.0					
	20.9					10.1	
	8.9					4.0	
	0.2		1.1		0.6		0

5.59
3.63
1.09

$\sigma = 11.2$
p.e. = 7.3
$p.e_m = 1.76$

$\sigma = 2.31$
p.e. = 1.51
$p.e_m = 0.749$

$\sigma = 7.17$
p.e. = 4.80
$p.e_m = 1.24$

9

acteria Present in Unclarified
th Reduced Rate of Inflow.

Acid	Pept. Alkali	
Decrease	Increase	Decrease
6.0		
2.0		
3.6		
1.6		
2.0		
		2.1
3.7		
	2.1	
2.0		
10.1		
4.0		
	0	0

Summary of the Changes in th		
	Increase	
	Times	(%)
Acid Coag.	9	50.
Acid Non-coag.	7	38.
Inert	4	36.
Alkali	7	41.
Neut. Pept.	3	75.
Acid Pept.	6	40.
Alk. Pept.	1	50.

σ = 7.17
p.e. = 4.80
p.e._m = 1.24

mary of the Changes in the Different Groups Due to Clarification

	Increase		Decrease		No Change	
	Times	(%)	Times	(%)	Times	(%)
g.	9	50.0	8	44.4	1	5.6
-coag.	7	38.9	11	61.1	0	0
	4	36.4	7	63.6	0	0
	7	41.2	8	47.0	2	11.8
pt.	3	75.0	1	25.0	0	0
t.	6	40.0	9	60.0	0	0
t.	1	50.0	1	50.0	0	0

Contrary to expectations, the data indicate that when the milk was retained in the clarifier for an unusually long period of time, clarification caused less change in the percentages of the various types of bacteria present in the milk than with a normal rate of inflow.

The summary of the changes which took place show that clarification caused irregular increases and decreases in the prominent groups under both the normal and the prolonged exposure.

The average changes in the various groups are all of about the same magnitude as the probable error of the mean of all determinations. This would indicate that the changes were of doubtful significance.

6. The effect of filtration and separation of milk on the numbers and types of bacteria present.

The effect of passing milk through a filter or separator on the numbers and types of bacteria present was studied in a few comparisons because of the relationship of these processes to clarification. The results obtained are presented in Table 10.

In the four runs, filtration caused an increase in the bacterial counts three times and a decrease once. The increases varied from 12.2 to 38.9 per cent, with an

TAB

Effect of Filtration an
and Types of Bacteria P

Date			Number Bacteria per cc.
1926	Nov. 27	Not filtered	20,500
	Dec. 1	" "	47,000
	8	" "	27,000
	15	" "	58,000
	Jan. 28	Not separated	365,000
	31	" "	1,250,000

Date			Percentage						
			Acid		Inert	Alkali	Peptonizers		
			Coag.	Non-coag.			Neutral	Acid	Alkali
926	Nov. 27	Not filtered	22.0	42.0	8.0	26.0	0	2.0	0
		Filtered	26.0	46.0	4.0	22.0	0	2.0	0
	Dec. 1	Not filtered	30.0	24.0	2.0	40.0	2.0	2.0	0
		Filtered	39.5	22.9	8.4	25.0	0	4.2	0
	Dec. 8	Not filtered	78.8	13.5	1.9	3.9	0	1.9	0
		Filtered	94.0	2.0	2.0	2.0	0	0	0
	Dec. 15	Not filtered	15.7	29.4	0	55.0	0	0	0
		Filtered	22.0	26.0	2.0	50.0	0	0	0
									Average
27	Jan. 28	Not separated	30.0	40.0	14.0	0	10.0	6.0	0
		Separated	43.0	20.0	10.0	0	20.0	7.0	0
	Jan. 31	Not separated	25.4	5.6	9.0	0	0	60.0	0
		Separated	52.0	14.0	12.0	0	0	20.0	2.0
									Average

E 10

l Separation on the Numbers
resent in Milk.

	Number Bacteria per cc.	Percentage	
		Increase	Decrease
Filtered	23,000	12.2	
"	56,000	19.1	
"	37,500	38.9	
"	53,000		8.6
Separated	445,000	21.9	
"	970,000		22.4

Changes in the Percentage Types of the Various Groups

	Acid				Inert		Alkali		Peptonizers					
	Coag.		Non-coag.						Neutral		Acid		Alkali	
	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease
	4.0		4.0			4.0		4.0			0	0		
	9.5			1.1	6.4			15.0		2.0	2.2			
	15.4			11.5	0.1			1.9				1.9		
	6.3			3.4	2.0			5.0						
e	8.8			3.0	1.1			6.7		2.0	0.1			
	13.0			20.0		4.0			10.0		1.0			
	26.6		8.4		3.0							40.0	2.0	
	19.8			5.8		0.5			10.0			19.5	2.0	

average of 23.4 while the one decrease was 8.6 per cent. The results of the four runs show an average increase of 15.4 per cent in the counts.

In the two comparisons separation caused an increase of 21.9 per cent in the one instance and a decrease of 22.4 per cent in the other, with an average percentage decrease of 0.5.

The analysis of the data obtained from the study of the types of bacteria present shows that filtration caused a fairly significant increase in the acid coagulators and a corresponding decrease in the alkali formers, whereas the other groups were not materially changed. The effect of passing the milk through a separator caused noticeable changes in the acid and peptonizing groups but since only two comparisons were made, the significance of these is limited.

In summarizing the data, it seems apparent that when milk was pumped through a filter only slight changes in the numbers and types of the bacteria took place. The changes were probably chiefly caused by the mechanical effect of the pump and by the milk going through the fine meshes in the cloth, both of which would have a tendency to break up bacterial clumps and chains. Separation likewise caused some changes, but no great elimination of any types took place.

For the reason that the clarifier is much more efficient in removing heavy particles from milk, further studies with the separator were not made.

7. The effect of clarification with normal and reduced rate of inflow on the bacteria in milk, as determined by the plate count, the methylene blue test and the fermentation test.

A series of determinations of the effect of clarification on the bacteria in milk with a normal and with a reduced rate of inflow was made, using the plate count, the methylene blue test, and the fermentation test. The data obtained in nine comparisons are shown in Table 11.

The bacterial counts were quite high, on an average. Clarification always resulted in a decrease in the counts. There was an average decrease of 24.2 per cent when a normal rate of inflow was used, and an average decrease of 57.2 per cent when a one-tenth normal rate of inflow was used. The reduction time of the unclarified milk ranged from 60 to 240 minutes and averaged 163 minutes, that of the normally clarified milk ranged from 90 to 255 minutes and averaged 184 minutes, while that of milk clarified with a reduced rate of inflow ranged from 120 to 285 minutes and averaged 210 minutes. With the normal

TABLE 11

The Effect of Clarification with Normal and Reduced Rate of Inflow on the Bacteria in Milk, as Determined by the Plate Count, the Methylene Blue Test, and the Fermentation Test.

Plate Count

Date	Unclarified (Bacteria per cc.)	Clarified			
		Normal Inflow (Bacteria per cc.)	Percentage Decrease	Reduced Inflow (Bacteria per cc.)	Percentage Decrease
1927 May 25	700,000	470,000	32.9	140,000	80.0
" 26	1,035,000	745,000	28.0	560,000	45.9
June 20	3,310,000	1,980,000	40.2	550,000	83.4
" 21	7,530,000	6,600,000	12.3	700,000	12.3
" 22	2,780,000	1,890,000	32.0	1,090,000	60.8
July 6	615,000	475,000	22.8	350,000	43.1
" 7	2,820,000	2,580,000	8.5	1,060,000	62.4
" 8	750,000	580,000	22.6	330,000	56.0
" 9	920,000	750,000	18.5	270,000	70.7
			Avg. 24.2		Avg. 57.2

Methylene Blue Test

Date	Unclarified (Minutes to reduce)	Clarified			
		Normal Inflow (Minutes to reduce)	Increase in Reduction Time due to Clarification (min.)	Reduced Inflow (Minutes to reduce)	Increase in Reduction Time due to Clarification (min.)

Date	Unclarified (Minutes to reduce)	Clarified			
		Normal Inflow (Minutes to reduce)	Increase in Reduction Time due to Clarification (min.)	Reduced Inflow (Minutes to reduce)	Increase in Reduction Time due to Clarification (min.)
1927 May 25	135	180	45	210	75
" 26	235	255	20	285	50
June 20	90	105	15	135	45
" 21	60	90	30	120	60
" 22	165	210	45	240	75
July 6	240	240	0	270	30
" 7	120	140	20	180	60
" 8	210	210	0	210	0
" 9	210	225	15	240	30
			Avg. 21		Avg. 47

Fermentation Test

Date	Unclarified	Clarified (Character of Curd)	
		Normal Inflow	Reduced Inflow
1927 May 25	Sl. liq. near surface of curd	Solid curd	Sl. liq. near surface of curd
" 26	Solid curd	Solid curd	Solid curd
June 20	Sl. gassy	Sl. gassy	Sl. gassy
" 21	Solid curd	Solid curd	Solid curd
" 22	Gassy	Gassy	Gassy
July 6	Badly gassy	Badly gassy	Badly gassy
" 7	Gassy	Sl. gassy	Gassy
" 8	Gassy	Gassy	Gassy
" 9	Sl. gassy	Sl. gassy	Sl. gassy

rate of inflow, clarification caused an increase in the reduction time in seven trials and no change in two and with the reduced rate of inflow it caused an increase in eight trials and no change in one. The greatest increase in the time with the normal inflow was 45 minutes and with the reduced inflow 75 minutes. The average increases when all comparisons are considered were 21 minutes with normal clarification and 47 minutes with clarification involving a reduced rate of inflow.

The data would indicate that clarification with both rates of inflow resulted in most cases in a quite noticeable increase in the reduction time. There seems to be no definite correlation, however, between the counts of the unclarified or clarified milk and the reduction time when the counts for the different runs are considered. Since clarification always resulted in a decrease in the counts in this particular series, these data are therefore not applicable to runs where clarification results in an increase.

The results obtained by the methylene blue test agreed, in general, with those obtained by the plate method. It would seem, however, that the plate method was the more refined in showing the differences in the numbers of bacteria of milk caused by clarification.

The reason why the methylene blue test does not show relatively small differences in the numbers of bacteria in milk may be accounted for by the differences in the ability of various types of bacteria to decolorize methylene blue and to the variations in their development.

The observations of the fermentation test would indicate that clarification had no influence on the type of fermentation taking place whether a normal or a reduced rate of inflow was used. The character of the curd which formed from the clarified milk was, in all cases, similar to that which formed from the unclarified milk.

8. Comparison of the effect of centrifugal force on the numbers and types of organisms present in uncentrifuged milk, and in the sediment obtained in centrifuge tubes.

In order to obtain some additional data on the effect of centrifugal force on milk tests were made in which 15 cc. samples of uncentrifuged milk were placed in conical tubes and centrifuged at room temperature for varying periods of time; the speed was 1900 revolutions per minute and the circle through which the outer edge of the tubes passed was 15 inches. The sediment was then diluted to 15 cc. with sterile water and the numbers and types of organisms determined.

The data presented in Table 12 show that in a series of four comparisons, after five minutes centrifuging a minimum of 5.8, a maximum of 20.2, and an average of 12.6 per cent of the total numbers of bacteria present in the milk were in the sediment, while after the milk had been exposed to the centrifugal force for 20 minutes a minimum of 9.5, a maximum of 29.9, and an average of 16.7 per cent were in the slime.

The results of a study of the types of bacteria present in uncentrifuged milk and in the sediment obtained from it after centrifuging samples of milk of the same lot for five, 20 and 30 minutes, respectively, in four comparisons, and for five and 20 minutes in four other comparisons are shown in Table 13. The acid formers were usually the most numerous types in both the milk and in the sediment, but sometimes the alkali formers or acid peptonizers were the most prominent. Centrifuging caused some slight variations in the types, but whenever a certain type was present in the milk it was usually also found in the sediment. Even prolonged exposure of the milk to centrifugal force did not consistently cause a complete elimination of any of the types present in the milk.

TABLE 12.

Comparison of the Number of Bacteria Present in Uncentrifuged Milk and in Sediment Obtained from it by Centrifuging in Tubes.

Date			Time of Centrifuging Minutes.	Bacteria per cc.	Percentage Bacteria Removed from Milk
1927	Apr. 29	Uncentrifuged milk		3,710,000	
		Sediment	5	750,000	20.2
		Sediment	20	1,110,000	29.9
	May 3	Uncentrifuged milk		2,230,000	
		Sediment	5	130,000	5.8
		Sediment	20	315,000	14.1
	May 5	Uncentrifuged milk		83,000	
		Sediment	5	15,500	18.7
		Sediment	20	11,000	13.2
	May 7	Uncentrifuged milk		600,000	
		Sediment	5	34,500	5.8
		Sediment	20	57,000	9.5
		Average of percentage removed	5 min.		12.6
			20 min.		16.7

TABLE 1

The Types of Bacteria Present in
from it by Centrifuging in Tubes

Date			Time of centrifuging Min.	
1927	Jan. 8	Uncentrifuged milk		
		Sediment	5	
		Sediment	20	
		Sediment	30	
	Jan. 8	Uncentrifuged milk		
		Sediment	5	
		Sediment	20	
		Sediment	30	
	Jan. 15	Uncentrifuged milk		6
		Sediment	5	4
		Sediment	20	8
		Sediment	30	6
	Jan. 21	Uncentrifuged milk		
		Sediment	5	
		Sediment	20	
		Sediment	30	1
	Apr. 29	Uncentrifuged milk		1
		Sediment	5	1
		Sediment	20	
	May 3	Uncentrifuged milk		5
		Sediment	5	6
		Sediment	20	5
	May 5	Uncentrifuged milk		
		Sediment	5	1
		Sediment	20	
	May 7	Uncentrifuged milk		1
		Sediment	5	
		Sediment	20	1

TABLE 13

esent in Raw Milk and In Sediment Obtained
in Tubes.

of ri- ng n.	Percentage						
	Acid				Peptonizers		
	Coag.	Non-coag.	Inert	Alkali	Neutral	Acid	Alkali
	13.7	31.4	19.6	5.9	0	29.4	0
5	8.0	16.0	2.0	36.0	0	38.0	0
0	6.0	8.0	8.0	8.0	2.0	68.0	0
0	6.0	14.0	2.0	12.0	0	66.0	0
	20.0	34.0	12.0	14.0	0	20.0	0
5	44.0	20.0	10.0	8.0	6.0	10.0	2.0
0	36.0	32.0	10.0	6.0	2.0	14.0	0
0	36.0	22.0	10.0	8.0	24.0	0	0
	68.6	15.7	3.9	5.9	0	5.9	0
5	44.0	16.0	6.0	14.0	0	20.0	0
0	80.0	0	8.0	10.0	0	2.0	0
0	62.0	6.0	0	24.0	0	8.0	0
	2.0	60.0	10.0	4.0	0	24.0	0
5	0	58.0	4.0	0	0	38.0	0
0	0	69.4	2.0	0	0	28.6	0
0	17.1	55.7	1.9	3.8	0	21.5	0
	10.0	64.0	0	20.0	0	6.0	0
5	14.0	48.0	0	34.0	0	4.0	0
0	0	46.0	0	50.0	0	4.0	0
	58.0	16.0	0	18.0	0	8.0	0
5	64.0	12.0	2.0	6.0	0	16.0	0
0	54.0	14.0	4.0	12.0	0	16.0	0
	2.2	13.0	19.6	39.1	0	26.1	0
5	12.5	30.0	2.5	52.5	0	0	2.5
0	0	19.3	15.4	57.7	0	3.8	3.8
	10.0	52.0	2.0	32.0	0	4.0	0
5	2.0	16.0	14.0	62.0	0	6.0	0
0	10.0	18.0	12.0	48.0	0	12.0	0

It would seem that the exposure of milk to centrifugal force in tubes, even for a considerable time, did not materially affect the flora of the milk.

Although centrifuging of the naturally infected milk did not cause much change in the types of organisms present, it was decided to study the effect of centrifugal force on samples of low count milk heavily inoculated with large alkali forming bacteria or with yeasts obtained from agar slope cultures. Raw milk was used in preference to sterile milk because in the latter some of the constituents are changed physically and chemically by the heating process. The data obtained are reported in Table 14. In all cases, both with the alkali formers and with the yeasts, centrifuging for one-half hour caused a decrease in the numbers present. The number of organisms present in the milk and cream layer after these had been mixed, when added to the numbers in the sediment, should equal the total number of organisms present in the milk before centrifuging. This, as a rule, did not occur, due probably to a clumping of the organisms in the sediment, since microscopic examination of the sediment showed the presence of large numbers of clumps of the inoculated organisms.

TABLE 14

The effect of centrifuging milk containing yeasts and alkali forming bacteria on the number of organisms present.

Date		Yeasts per cc. in Milk Before Centrifuging	Yeasts per cc. in Milk After Centrifuging	Yeasts per cc. in Sediment. Diluted to 15 cc. with Water.
1927 Mar. 7	Raw Whole Milk	1,645,000	390,000	775,000
9	" " "	1,470,000	1,950	820,000
12	" " "	1,200,000	14,000	448,000

		Raw Milk and Added Large Alkali Forming Bacteria. Bac- Bacteria per cc.	Bacteria per cc. in Milk after Centrifuging	Bacteria per cc. in Sediment Diluted to 15 cc. with Water.
1927 Mar. 12	Raw Whole Milk	740,000	640,000	230,000
Apr. 4	Raw Skim Milk	46,200,000	6,680,000	3,900,000
4	" " "	58,000,000	15,000,000	3,050,000
4	" " "	58,300,000	20,240,000	4,240,000
Apr. 5	" " "	46,000,000	30,000,000	17,300,000
5	" " "	60,000,000	37,600,000	
5	" " "	72,000,000	18,000,000	11,200,000
Apr. 14	Raw Whole Milk	670,000	261,000	112,000
14	Raw Skim Milk	600,000	140,000	121,000
15	Raw Whole Milk (Inoculated about 4 hours)	6,800,000	3,280,000	365,000

9. The specific gravity of yeasts and alkali forming bacteria.

An attempt was made to determine the specific gravity of some of the alkali producing organisms isolated because of their relative abundance in the slime. The specific gravity of a still larger organism, Torula cremoris was also determined.

The alkali formers were grown in Petri dishes on beef infusion agar, while beef extract agar containing lactose was used for the yeast. Usually the growth obtained from eight or ten dishes was employed in each determination. As soon as a good growth had occurred this was carefully scraped off with a sharp steel blade and transferred quickly to a tared, dry, 25 cc. pycnometer. Whenever the growth was sufficient, duplicate determinations were made. The specific gravity was determined by comparing the weight of a certain volume of the organisms with the weight of an equal volume of distilled water at the same temperature. In making the determinations four different weighings were made, as follows: the dry pycnometer, the pycnometer plus the bacterial growth, the pycnometer filled with distilled water, and the pycnometer filled with the bacterial growth and distilled water. The specific gravity of the bacterial growth was obtained by dividing the weight of this as determined by subtraction by the weight of the volume of water which it displaced; the latter represented the difference between the weight of the water containing organisms and the weight of distilled water necessary to fill a pycnometer. In two determinations plain bouillon was used as a medium for the alkali formers. Five hundred cc. lots of this were inoculated, and when a good growth had occurred they were centrifuged in 50 cc. tubes; the sediment obtained was then placed in pycnometers and the specific gravity determined.

The results of the specific gravity determinations are shown in Table 15. With Torula cremoris the values ranged from 1.037 to 1.102, with an average of 1.079. With the alkali formers, when agar was the medium, the values ranged from 1.029 to 1.123, with an average of 1.0497, while when bouillon was used the specific gravities were 1.025 and 1.032 with an average of 1.0285.

The duplicate determinations sometimes showed some variation. The smallest difference between checks was 0.003, the largest 0.019, and the average of the seven runs where checks were made was 0.009. The growth obtained from ten plates usually weighed about one gram, but even

TABLE 15

Determination of the specific gravity of Torula cremoris and alkali forming bacteria.

	Length of Incubation (days)	Temperature of Incubation (deg. C.)	Det. A.	Det. B.	Average
	Growth on Agar				
Torula cremoris	3	37	1.037		1.037
" "	5	37	1.102		1.102
" "	2	37	1.097		1.097
" "	2	37	1.079		1.079
Average of 4 determinations					1.079
Alkali Bacteria No. 2	2	37	1.123		1.123
" " " 2	2	37	1.045		1.045
" " " 2	2	37	1.036		1.036
" " " 1	3	37	1.049	1.042	1.0455
" " " 12	2	37	1.058	1.055	1.0565
" " 31 cultures	7	21	1.042		1.042
" " No.27	2	37	1.053		1.053
" " " 27	1	37	1.045	1.029	1.037
" " " 20	2	37	1.054	1.049	1.0515
" " " 8	4	21	1.053	1.034	1.0435
" " " 29	4	21	1.043	1.036	1.0395
" " " 8	7	21	1.036		1.036
" " " 8	7	21	1.041	1.034	1.0375
Average of 13 determinations					1.0497
	Growth in Bouillon				
Alkali Bacteria No.27	2 weeks	21	1.025		1.025
" " " 28	"	21	1.032		1.032
Average of 2 determinations					1.0285

with heavy growth the amount obtained was too small for very accurate determinations.

The results cannot, of course, be directly applied to milk because of the variations in the composition and size of bacteria grown in different kinds of media. If the specific gravities of the alkali formers, as they occur in milk, are similar to those obtained when they are grown on agar and in bouillon, it would seem that it would be difficult, considering the short exposure to the centrifugal force, for the clarifier to remove a large percentage of them.

10. Comparison of morphological, cultural and biochemical characteristics of alkali forming bacteria.

The relative abundance of the alkali forming bacteria in the clarifier slime suggested the isolation and study of organisms of this type. The arbitrary grouping of these organisms on the basis of their ability to produce alkali in milk does not indicate that they possess other characteristics in common, and for this reason a more detailed study of these bacteria would be expected to lead to a division of them into groups or types. From several hundred litmus milk cultures of alkali forming bacteria obtained in the investigation of the types of bacteria present in milk and in clarifier slime, 31 were selected. After having been purified by plating and picking colonies the organisms were studied on the basis of morphology, staining reaction, motility, growth in or on various media, gelatin liquefaction, reaction changes in media, and the production of indol and nitrite.

The microscopic examination of the 31 cultures showed that when the organisms were grown in litmus milk at either room temperature or 37° C. (98.6° F.) they were medium to large, plump, rod shaped, non-spore forming, gram negative organisms, having rounded ends and arranged in pairs, while when they were grown on infusion agar at both the above temperatures the cells were much smaller and almost spherical. Motility was regularly noted. Growth always occurred near the surface when milk or bouillon were used as a medium and only on the surface with agar stabs. At room temperature and at 37° C. (98.6° F.) the growth on 24-hour agar slopes was moderate, white, filiform, glistening, and slightly raised, while after two weeks the growth was abundant, grey-white, filiform, and in most cases raised. A yellowish-brown growth occurred on potato slants. None of the organisms liquefied gelatin. When grown in plain bouillon or bouillon containing glycerol, dextrose, galactose, levulose, lactose, sucrose, maltose, mannitol, or raffinose, (reaction plus 0.05 Fuller's scale) an alkaline reaction was always produced after one week, as shown by the change in color which appeared on the addition of a few drops of brom-thymol blue indicator to each tube. Indol was not produced in any of the cultures. Two cultures showed nitrite production.

It would seem from the study of these cultures of alkali formers, that, in general, their main characteristics were very similar; they were probably varieties of one species of organisms. A separation of them into groups was therefore not made.

PART II

The Influence of Clarification on the Quality of Cheese

The study of the effect of clarification on the quality of cheese involved the use of 23,000 pounds of milk representing both unclarified and clarified milk from 67 different lots. Additional trials were carried out in which cheese made from unclarified milk was compared with that obtained from clarified milk to which clarifier slime or pure cultures of alkali forming bacteria had been added. A total of 145 batches of cheese were made, of which 48 were made in Utah and 97 in Iowa.

In a few comparisons the bacterial flora of the ripened cheese was studied for the purpose of determining if it had been modified by clarification.

Historical

Up to the present time clarification of milk for cheddar cheese has not been generally employed by cheese factories in the United States. The process is being used, however, to some extent in the manufacture of Swiss cheese.

Matheson (29) found that centrifuging the milk resulted in an increase in the higher grades of Swiss cheese. The cheese made from centrifuged milk did not have a flavor different than that made from untreated milk but in most cases the body was firmer, and there were larger and fewer eyes. He states, that this improvement seems to be due to the removal of dirt and cellular elements from the milk.

Hardell (20) reports that in Ohio every factory using pure cultures was clarifying milk for Swiss cheese during the winter of 1926-27. He states that clarification of milk has been an important factor in the improvement of Ohio Swiss cheese. It has resulted in a decrease in the number of eyes, and at the same time it has increased the size of the eyes. The body and texture of the cheese likewise seemed to have been improved. This investigator thinks that the results obtained by the factories substantiate the work of the Bureau of Dairying, U. S. Department of Agriculture, which consistently demonstrated the value of clarifying milk for Swiss cheese manufacture.

As early as 1891, Babcock (2) started experiments to study the influence of cleaning milk with a centrifugal cream separator on the quality of cheese. He reasoned that, because of the offensive character of the material which accumulated on the inside of the separator bowl, the removal of this from the milk would result in an improvement in the flavor and keeping quality of any milk. Nearly 100 cheese were made by students attending the Wisconsin Dairy School from milk cleaned by a separator, the skim milk and cream being mixed as it came from the machine, and "without exception the flavor and keeping quality of the cheese has been improved". It was also noticed that cleaning the milk in this way either overcame gassy or "pinholey" curds, or greatly minimized the defect. Babcock thought that cleaning milk with a separator would greatly improve the quality of cheese made from tainted milk. He was uncertain whether the improvement was caused by the aeration to which the milk was subjected when it was passing through the separator, or whether it was due to the removal of the slime. In studying this problem he found that untreated milk caused gassy cheese, while milk which had been cleaned by running it through a separator, and milk which had been cleaned but to which separator slime had been added, did not result in gassy cheese. This work was done during the winter season, and when it was repeated during the following summer it was found that "there were just as many pinholes in the curds from the cleaned milk as from that not treated". Babcock summarizes by stating that "although cleaning milk with a separator has not accomplished all that we hoped in the treatment of milk for cheese, we feel that it has been of great benefit, as it has, in nearly every case, improved the quality of the cheese, and the improvement has been more marked with tainted milk than with those in good condition. Especially has it been of benefit for long keeping cheese as such have retained their flavor much better when made from separator cleaned milk".

Fisk and Price (14) report the results of comparisons of cheddar cheese made from unclarified and clarified milk. The work was carried out during 1919 and 1920 under various conditions in different localities. A total of 82 cheese was made. There was a difference in the average score in favor of the clarified milk cheese of 1.282 for flavor, 0.673 for body and texture, and 1.865 in the total score. "The clarified milk cheese had a firmer, more springy feeling, and showed less of a tendency to puff up than the cheese made from unclarified milk". There appeared to be an improvement in the cheese made when either good or poor quality milk was used, and both with and without starter. The authors state that "the clarifier will sometimes overcome the gas in the milk and curd; at other times it will not overcome this gas, but will change it".

In studies on the effect of clarification on the quality of cheese obtained where low and where high quality milk was used, Combs, Martin, and Hugglar (5) found that the average total score of cheese made from poor quality milk handled under ordinary conditions was 0.79 points lower for the clarified milk cheese than for the unclarified, whereas when poor quality milk was handled under very sanitary conditions, the average total score of the clarified milk cheese was 1.59 points higher than that for the unclarified. When high grade milk handled under ordinary conditions was used for cheese, there was a difference of 2.53 points in the average total score in favor of the clarified milk cheese, and when very sanitary conditions were used a difference in favor of the clarified milk cheese of 2.83 points in the average total score. When cheese was made under practical conditions, the average score for flavor was 1.0 points higher for the clarified milk cheese than for the unclarified, and the average score for body and texture 1.16 points higher for the clarified milk cheese than for the unclarified. When the cheese was made under extreme sanitary conditions the average score for flavor was 0.58 points higher for the clarified milk cheese than for the unclarified, and the average score for body and texture 1.66 higher for the clarified milk cheese than the unclarified. The authors conclude that although there was a difference of 1.03 in the average total score in the 41 comparisons in favor of clarification, the clarified milk cheese, under present market conditions, would not sell for a higher price; it would therefore be doubtful whether the process of clarification would be justified in the average cheese factory.

The results obtained by the majority of the many research workers who have studied cheese ripening since Duclaux (9) in 1878 first began this type of investigation, seem to point to four outstanding facts: (1) Acid is necessary for the breaking down of the insoluble calcium paracaseinate to mono-calcium paracaseinate, which in turn changes to other forms, (2) bacteria are essential in the production of flavor and aroma and in the development of the desirable body and texture of cheese, (3) an enzyme present in rennet effects an increase in the soluble nitrogen compounds in cheese during ripening, thus aiding in producing a more plastic body, and (4) galactase breaks down the calcium paracaseinate to more soluble products. A large amount of research work has been done in various parts of the world on the subject of cheddar cheese ripening, and many theories have been put forth regarding the changes which take place during the curing process.

Evans, Hastings, and Hart (13) in 1914 reported the results of a study of the bacteria concerned in the production of the characteristic flavor of cheese of the cheddar type. They summarize their findings by stating that there are four groups of bacteria present in cheddar cheese in such numbers as to indicate that they must function in the ripening process. They are: (1) Bacterium lactis acidi, (2) the B. casei, (3) Streptococcus, and (4) Micrococcus. On the basis of the fermentation powers, each of the four groups may be divided into a number of varieties. The flora of raw milk cheese is varied and includes all the varieties into which the four groups may be divided.

The literature on the subject of cheese ripening consists of several hundred references. Hucker (23) has recently (1922) made a review of the bacteriological aspects of cheese ripening and summarizes this by the following statement: "As it stands today the investigations have clearly demonstrated that the breaking down of the insoluble casein compounds is due to enzymes, either natural or bacterial; while characteristic flavors are produced by the action of certain groups of bacteria (Bact. casei or coccus group), which depend upon the products of B. lactis acidi present in large numbers during the manufacture and early ripening stages".

Later investigational work by Hucker (24) has been done on the types of bacteria present in American cheddar cheese. He studied 265 cultures of bacteria obtained from 37 samples of various grades of commercial cheese. He divides these cultures into seven groups as follows: (1) Spore formers, (2) gram-negative rods,

(3) lactobacilli, (4) Streptococcus lactis, (5) cocci, (6) streptococci other than S. lactis, and (7) yeasts. He concludes from his study that in the higher grades of cheese, the S. lactis and lactobacilli were the predominating types, while in the lower grades the spore-forming and gram-negative rods were most abundant. There seemed to be little variation in the frequency of the cocci, and streptococci (other than S. lactis) in the different qualities of cheese.

In a study of the relation of the number of bacteria in milk to the quality of cheddar cheese, Hucker (22) found that the total number of bacteria present in milk used in the making of sixty lots of cheese had no influence upon the quality. The milk which was used varied in bacterial content from 220,000 to 41,400,000 per cc. when it was received at the cheese factory. Under the conditions of the experiment, the milk that contained from 12 to 42 million bacteria per cc. produced a cheese of a more constant quality than did the milk containing a smaller number of bacteria. He concludes that the specific types of bacteria present in the milk are far more important than the total number.

Judging from the above brief discussion of the bacteriology of cheddar cheese it would seem that in order to be effective in the production of a higher quality of cheese clarification must modify the flora of the milk in such a way that the groups of organisms which are responsible for the production of the desirable qualities in cheese predominate during the ripening period.

Methods

The milk used in the manufacture of the experimental cheese represents the general milk supply of the Dairy Departments of the Utah and Iowa Agricultural Colleges. In general, the milk was of a good quality, but off-flavored milk, and milk having a high bacterial content was occasionally used. Since the cheese was made over a period of several years in the two states, it has been possible to use milk varying as widely in quality as that employed in the various factories.

Approximately twenty gallons of milk were used for each vat, and two cheese were obtained from this amount. Immediately before using, all equipment employed was carefully steamed or rinsed with boiling water. Ten-gallon cans were used for transporting the milk from the milk vat and clarifier to the cheese vats.

In obtaining the clarified milk for the cheese, at least ten gallons of milk were run through the clarifier before the milk for the experimental work was caught.

It was the purpose throughout the trials to employ the usual commercial method of manufacture with very little variation. In brief, the method generally used was as follows: One to two per cent of starter was added to the milk as soon as it had been placed in the vats. The milk in each vat was then heated simultaneously to 30° C. (86° F.) and one ounce of color and four ounces of rennet added. Cutting was done with one-quarter inch wire knives. A cooking temperature of 27.8° to 38.9° C. (100° to 102° F.) was used and the acidity at the time of draining was 0.14 to 0.16 per cent. The matting process required two or three hours, and the acidity of the whey at the time of salting was usually about 0.8 per cent or higher. Salt was added at the rate of 2.5 per cent to the curd. The curd was placed in the hoops and pressed at a temperature of 26.7° to 29.4° C. (80° to 85° F.). Usually pressing occupied 18 to 20 hours. An average curing room temperature of 12.8° to 15.5° C. (55° to 60° F.) was maintained. The cheese were scored when they had been cured about one month and again after about three months. It was the aim to make a firm-bodied cheese having a moisture content of about 36 per cent.

When scoring, the cheese were numbered, so as to give no information to the judges on the kind of milk used for each cheese. For the purpose of making careful comparisons, the make of each day was judged separately.

Representative lots of cheese were examined for numbers and types of bacteria present. In obtaining the sample, the surface of the cheese was cut with a sterile knife, and a sterile trier was then used for securing a plug of cheese. Thin slices were cut from this and weighed on paper. About one gram of cheese was used for an analysis and this was thoroughly ground in a sterile mortar with sterile sea sand. The grinding process occupied at least twenty minutes; when completed, the material was transferred to a water blank and plated on beef infusion agar. The plates were incubated at room temperature for five to six days with the exception of those from the one month old cheese which were incubated at 37° C. (98.6° F.) for 16 hours and then at room temperature for four days.

Results Obtained

A. Scores on Cheese from Unclarified and Clarified Milk.

Five different series of cheese were made. Series one to four inclusive comprise cheese made under normal conditions, while milk containing added slime or alkali forming bacteria was used for the cheese made in series five.

Series 1. This series involved the manufacture of 48 batches of cheese from 24 different lots of milk during the period from April 7, 1923 to March 7, 1925 at the Utah Agricultural College. The cheese in 20 of the 24 comparisons were scored at the end of about one month and in 22 comparisons at the end of about three months. The scoring was supervised by Mr. H. R. Lochry of the Western Office of the U. S. Bureau of Dairying (Salt Lake City), and the results are presented in Table 16.

The data show that when the cheese were one month old clarification caused an increase in the scores for flavor and aroma in ten comparisons, a decrease in eight and no change in two. When the scores were higher with clarification the average increase was 1.15, and when they were lower the average decrease was 1.00. Considering the 20 comparisons, there was an average increase in the scores for flavor and aroma of 0.17. The scores for the three months old cheese show that clarification caused an increase in the scores for flavor and aroma in 14 comparisons, a decrease in five, and no change

No.	Flavor and Aroma					
	Unclarified		Clarified		Unclarified	
	1 Month		1 Month		3 Months	
	Score	Comment	Score	Comment	Score	Comment
97	36.0	High acid	38.0	Good	38.5	Foreign
104	38.0	" "	39.0	"	39.0	High acid
111	37.0	" "	38.0	High acid	35.0	Bitter
118	36.5	Moldy	37.0	Musty	37.0	Unclean
164	37.5	Starter	37.5	Starter		
165	39.0	Good	38.0	Good	35.5	Onion
167	39.0	"	39.0	"		
170					33.0	Strong on
171					38.0	Sweet
172					37.0	Acid
317	39.5	Good	39.0	Sl. unclean	37.0	"
335	37.5	Flat	39.0	Good	37.5	Sl. uncle
361	38.5		39.5		37.5	
362	40.0		39.0		36.5	Unclean
363	38.0		37.0	Flat	37.0	"
364	34.0	V.unclean	36.5	Unclean	34.0	V. unclea
365	38.5		38.0		37.0	Sl. uncle
114	36.5	High acid	37.0	Undeveloped	34.5	Sour bitt
235	34.5	Sl. bitter	32.5	Very bitter	35.5	Bitter
501	36.0	Flat	35.5	Sl. bitter	34.0	Fruity
901	35.5	Sl. unclean	36.0	Feed	35.0	Sl. bitte
203	33.5	Bitter	32.0	Foreign	36.0	Acid
703					35.0	"
902	37.5	High acid	38.5		34.5	Sl. fruit
Avg.	37.125		37.300		36.090	

TABLE 16

Scores and Criticisms of Cheese Made in Series

			Body			
ed	Clarified		Unclarified		Clarif	
s	3 Months		1 Month		1 Mon	
omment	Score	Comment	Score	Comment	Score	Com
eign	39.0	Fruity	29.5	Open	29.5	Open
h acid	40.0		29.5	"	29.5	"
ter	34.0	Putrid	30.0		29.5	Sl. c
lean	38.0	Sl. musty	29.0	Open	29.0	Open
			29.0	Crumbly	29.5	"
ion	38.0	High acid	29.5	Sl. mealy	29.0	Open
			29.5	Sl. open	29.5	Sl. c
rong onion	40.0	Good				
eet	38.5	Acid				
id	39.0	Good				
	39.5	"	29.5	Sl. open	29.5	Sl.
. unclean	38.0		29.0	Corky	29.0	Stic
	37.5		29.0	Corky	29.5	Cork
clean	33.0	High acid fruity	29.0	Mealy	29.0	"
"	36.5	Flat undeveloped	29.0	Corky	28.5	Very
unclean	36.5	Unclean	29.0	Corky	28.5	V. c
. unclean	35.5	"	29.0	"	29.0	Cork
ur bitter	37.0	Coarse	29.0	Mealy open	29.5	Cork
tter	32.5	Bitter	29.5	Mealy	29.0	Gas
uity	34.5	Bitter	29.5	Sl. pasty	29.5	Past
. bitter	35.5	Flat	29.5	Corky	29.5	Cork
id	36.0	Acid	29.5	Pasty	29.5	Past
	35.0	"				
. fruity	36.5	Salty	29.5	Open	29.0	Open
	36.818		29.300		29.225	

n Series 1.

	Body and	Texture			
	Clarified	Unclarified		Clarified	
	1 Month	3 Months		3 Months	
e	Comment	Score	Comment	Score	Comment
			Sl. open		
	Open	29.5	Sl. pasty	29.5	Sl. open
	"	29.5	Open	29.5	Sl. open
	Sl. open	29.5	Sl.open mealy	28.5	Crumbly
	Open	29.0	Open	29.0	Open
	"				
	Open sl. mealy	29.5	Mealy open	29.0	Swiss holes
	Sl. open				
		29.0	Open	29.0	Open
		29.0	"	29.5	Sl. open
		29.0	Yeast holes	29.5	Open
	Sl. open	29.5	Open	29.5	"
	Sticky	29.0	"	29.5	"
	Corky	30.0		30.0	
	"	29.0	Mealy corky	29.0	Mealy
	Very corky	28.0	Very corky	27.5	Very corky
	V. corky	29.0	Sl. open	29.0	Sl. open
	Corky	29.5	Open	29.5	Mealy
	Corky open	29.0	Pasty	29.5	"
	Gas holes	29.0	Mealy pasty	29.0	Open
	Pasty	29.0	Mealy weak	29.0	Open pasty
	Corky	29.5	Sl. pasty	29.5	Sl. gassy soft
	Pasty	29.5	Open	29.5	Open
		25.0	Mealy dry body	25.0	Mealy dry body
	Open sl. pasty	29.0	Pasty mealy	29.0	Pasty sl. mealy
225		29.000		29.023	

* Includes color and finish

\+ = Increase in score

\- = Decrease in score

	Total Scores*				Changes in Scores due			
	For Flavor and Aroma, Body and Texture				Flavor and Aroma		Body and Textu	
nt	Un-clarified 1 Month	Clarified 1 Month	Un-clarified 3 Months	Clarified 3 Months	1 Month	3 Months	1 Month	3
	90.5	92.5	93.0	93.5	+ 2.0	+ 0.5	0	
	92.5	93.5	93.5	94.5	+ 1.0	+ 1.0	0	
	92.0	92.5	89.5	87.5	+ 1.0	- 1.0	- 0.5	-
	90.5	91.0	91.0	92.0	+ 0.5	+ 1.0	0	
	91.5	92.0			0		+ 0.5	
es	93.5	92.0	90.0	92.0	- 1.0	+ 2.5	- 0.5	-
	93.5	93.5			0		0	
			87.0	94.0		+ 7.0		
			92.0	93.0		+ 0.5		+
			91.0	93.5		+ 2.0		+
	94.0	93.5	91.5	94.0	- 0.5	+ 2.5	0	
	91.5	93.0	91.5	92.5	+ 1.5	+ 0.5	0	+
	92.5	94.0	92.5	92.5	+ 1.0	0	+ 0.5	
	94.0	93.0	90.5	87.5	- 1.0	- 3.5	0	+
y	92.0	90.5	90.0	89.0	- 1.0	- 0.5	- 0.5	-
	88.0	90.0	88.0	90.5	+ 2.5	+ 2.5	- 0.5	
	92.5	92.0	91.5	90.0	- 0.5	- 1.5	0	
	90.5	91.5	88.5	91.5	+ 0.5	+ 2.5	+ 0.5	+
	89.0	86.5	89.5	86.5	- 2.0	- 3.0	- 0.5	
y	90.5	90.0	88.0	88.5	- 0.5	+ 0.5	0	
soft	90.0	90.5	89.5	90.0	+ 0.5	+ 0.5	0	
.	88.0	86.5	90.5	90.5	- 1.5	0	0	
body			85.0	85.0		0		
mealy	92.0	92.5	88.5	90.5	+ 1.0	+ 2.0	- 0.5	
	91.435	91.525	90.09	90.84	+ 0.175	+ 0.727	- 0.075	+

es*	Changes in Scores due to Clarification					
oma,	Flavor and Aroma		Body and Texture		Total Score	
Clarified 3 Months	1 Month	3 Months	1 Month	3 Months	1 Month	3 Months
93.5	+ 2.0	+ 0.5	0	0	+ 2.0	+ 0.5
94.5	+ 1.0	+ 1.0	0	0	+ 1.0	+ 1.0
87.5	+ 1.0	- 1.0	- 0.5	- 1.0	+ 0.5	- 2.0
92.0	+ 0.5	+ 1.0	0	0	+ 0.5	+ 1.0
	0		+ 0.5		+ 0.5	
92.0	- 1.0	+ 2.5	- 0.5	- 0.5	- 1.5	+ 2.0
	0		0		0	
94.0		+ 7.0		0		+ 7.0
93.0		+ 0.5		+ 0.5		+ 1.0
93.5		+ 2.0		+ 0.5		+ 2.5
94.0	- 0.5	+ 2.5	0	0	- 0.5	+ 2.5
92.5	+ 1.5	+ 0.5	0	+ 0.5	+ 1.5	+ 1.0
92.5	+ 1.0	0	+ 0.5	0	+ 1.5	0
87.5	- 1.0	- 3.5	0	+ 0.5	- 1.0	- 3.0
89.0	- 1.0	- 0.5	- 0.5	- 0.5	- 1.5	- 1.0
90.5	+ 2.5	+ 2.5	- 0.5	0	+ 2.0	+ 2.5
90.0	- 0.5	- 1.5	0	0	- 0.5	- 1.5
91.5	+ 0.5	+ 2.5	+ 0.5	+ 0.5	+ 1.0	+ 3.0
86.5	- 2.0	- 3.0	- 0.5	0	- 2.5	- 3.0
88.5	- 0.5	+ 0.5	0	0	- 0.5	+ 0.5
90.0	+ 0.5	+ 0.5	0	0	+ 0.5	+ 0.5
90.5	- 1.5	0	0	0	- 1.5	0
85.0		0		0		0
90.5	+ 1.0	+ 2.0	- 0.5	0	+ 0.5	+ 2.0
90.84	+ 0.175	+ 0.727	- 0.075	+ 0.023	+ 0.1	+ 0.75

in three. When the scores were higher with clarification the average increase was 1.82 and when they were lower the average decrease was 1.88. Considering the 22 comparisons, there was an average increase of 0.73 in the scores for flavor and aroma.

The scores obtained for body and texture show that in the one month old cheese clarification resulted in an increase in the scores in three comparisons, a decrease in six and no change in 11. When the scores were higher with clarification there was an average increase of 0.50, and when they were lower there was an average decrease of 0.50. Considering the 20 comparisons there was an average decrease in the scores for body and texture of 0.07. The scores for body and texture of the three months old cheese were higher with clarification in five comparisons, lower in three and alike in 14. When the scores were raised by clarification the average increase was 0.50, and when they were lowered the average decrease was 0.67. Considering the 22 comparisons, clarification caused an average increase of 0.02 in scores for body and texture.

Clarification resulted in an increase of 0.10 in the total scores with the one month old cheese and of 0.75 with the three months old cheese. At times clarification caused an increase and at times a decrease in the scores of the cheese, while in a number of comparisons the quality of the cheese was not influenced. In general, when there was a variation in the scores of the unclarified and clarified milk cheese, it was not very large; in a few instances there was a marked difference in the score for flavor and aroma, but the differences were not always in favor of the clarified milk cheese. The judges' comments show variations, as did the scores. Sometimes the criticisms were alike for both types of cheese, sometimes the comments were in favor of the unclarified milk cheese, while at other times they were in favor of the clarified milk cheese. Clarification, apparently did not eliminate consistently any of the defects in the cheese.

From this particular study it would seem that since there were no regular increases or decreases in the scores of the cheese, and since the averages of the total s cores were so nearly alike, clarification did not influence the quality of the cheese to any marked extent.

Series 2. Ten comparisons of cheese, representing unclarified and clarified milk, were made during November and December, 1926, at the Iowa State College. The scoring was supervised by Professor E. F. Goss. The scores and criticisms of the cheese when about one month and when about three months old are shown in Table 17.

In the one month old cheese the scores for flavor and aroma of the clarified milk cheese were higher than those of the unclarified milk cheese in seven comparisons, and lower in three. When the scores were higher with clarification the average increase was 0.78, and when they were lower the average decrease was 0.67. When the scores in all the comparisons are considered there was an average increase in the scores for flavor and aroma of 0.35. In the three months old cheese the scores for flavor and aroma of the cheese made from clarified milk were higher than those of the cheese made from unclarified milk in four comparisons, and lower in five, while in one instance there was no change. When the scores were higher with clarification the average increase was 1.10, and when they were lower the average decrease was 0.80. Considering all the comparisons, there was an average increase in the scores for flavor and aroma of 0.05.

The data obtained for body and texture show that in the one month old cheese there was an increase in the scores with clarification in seven comparisons, a decrease in two, and in one instance no difference. When the scores of the clarified milk cheese were higher the average increase was 0.70, and when they were lower, the average de-

No.	Flavor and Aroma							
	Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months		Clarified 3 Months	
	Score	Comment	Score	Comment	Score	Comment	Score	Comme
1	40.0	Acid	39.5	Acid	37.5	Bitter	37.0	Bitte
2	40.0	Acid	40.5	Acid	39.0	Sl. Unclean	40.0	
3	36.5	Acid Bitter	38.5	Immature	35.0	Fruity	37.0	Sl. Fruit
4	38.5	Acid	39.0		38.0	Acid Sl. Bitter	39.0	
5	36.5	Sour	37.0	Bitter	38.0	Sour	38.5	Sl.Ac " Bit
6	39.0		38.0	Bitter	39.0		38.0	Sl.Ac
7	38.0	Bitter	38.5	Sl. Bitter	37.5	Bitter	37.0	
8	37.0	Sour	37.5	Sl. Sour	38.0	Sl. Sharp	37.0	Sour
9	35.0	Fruity	36.0	Fermented	38.0	Sharp	38.0	Sharp
10	39.0	Acid	38.5	Acid Bitter	39.0	Sl. Sharp	38.0	Fermen
Avg.	37.95		38.30		37.90		37.95	

* Includes color and finish

\+ Increase in score

\- Decrease in score

TABLE 17

Scores and Criticisms of Cheese Made in Series 2.

		Body and Texture						
Clarified 3 Months		Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months		
Score	Comment	Score	Comment	Score	Comment	Score	Comment	S
37.0	Bitter	27.5	Open Corky	27.0	Open Corky	27.0	Weak	2
40.0		27.0	Open Corky	27.5	Open Corky	28.0	Sl. Crumbly	2
37.0	Sl. Fruity	27.5	Weak	28.0	Open	26.0	Weak	2
39.0		26.5	Open Weak	27.5	Open	27.5	Pasty	2
38.5	Sl.Acid " Bitter	27.5	Open	28.0	Sl. Open	27.0	Mealy	2
38.0	Sl.Acid	27.5	Mealy	27.5	Mealy	28.0		2
37.0		27.0	Mealy Open	28.0	Sl. Mealy	27.5	Sl.Pasty	2
37.0	Sour	26.5	Mealy Weak	27.0	Mealy	28.0		2
38.0	Sharp	25.0	Swiss Holes Open	26.0	Swiss Holes Open	26.0	Pasty Lumpy	2
38.0	Fermented	27.0	Sl. Mealy	26.5	Mealy	28.0	Sl. Pasty	2
37.95		26.90		27.30		27.30		2

finish

Series 2.

arified Months	Clarified 3 Months		Total Scores*			
			For Flavor and Aroma, Body and Texture			
Comment	Score	Comment	Unclarified 1 Month	Clarified 1 Month	Unclarified 3 Months	Clarifi 3 Mont
Weak	26.5	Weak Sl.Pasty	92.5	91.5	89.5	88.
Sl. Crumbly	28.5		92.0	93.0	92.0	93.
Weak	27.5	Sl.Weak	89.0	91.5	86.0	89.
Pasty	28.5		90.0	91.5	90.5	92.
Mealy	28.0	Sl.Mealy	89.0	90.0	90.0	91.
	27.5	Mealy	91.5	90.5	92.0	90.
Sl.Pasty	25.5	Sl.Pasty	90.0	91.5	90.0	89.
	28.0	Mealy	88.5	89.5	91.0	90.
Pasty Lumpy	27.5	Pasty	85.0	87.0	89.0	90.
Sl. Pasty	27.5	Sl.Pasty	91.0	90.0	92.0	90.
0	27.70		89.85	90.60	90.20	90.

		Changes in Scores Due to Clarification					
nd Texture		Flavor and Aroma		Body and Texture		Total Score	
ied s	Clarified 3 Months	1 Month	3 Months	1 Month	3 Months	1 Month	3 Mon
	88.5	- 0.5	- 0.5	- 0.5	- 0.5	- 1.0	- 1.
	93.5	+ 0.5	+ 1.0	+ 0.5	+ 0.5	+ 1.0	+ 1.
	89.5	+ 2.0	+ 2.0	+ 0.5	+ 1.5	+ 2.5	+ 3.
	92.5	+ 0.5	+ 1.0	+ 1.0	+ 1.0	+ 1.5	+ 2.
	91.5	+ 0.5	+ 0.5	+ 0.5	+ 1.0	+ 1.0	+ 1.
	90.5	- 1.0	- 1.0	0	- 0.5	- 1.0	- 1.
	89.5	+ 0.5	- 0.5	+ 1.0	0	+ 1.5	- 0.
	90.0	+ 0.5	- 1.0	+ 0.5	0	+ 1.0	- 1.
	90.5	+ 1.0	0	+ 1.0	+ 1.5	+ 2.0	+ 1.
	90.5	- 0.5	- 1.0	- 0.5	- 0.5	- 1.0	- 1.
	90.65	+ 0.35	+ 0.05	+ 0.4	+ 0.4	+ 0.75	+ 0.

crease was 0.50. Considering all the comparisons there was an average increase in the scores for body and texture of 0.40. The results for the three months old cheese show that clarification caused an increase in the scores for body and texture in five comparisons, a decrease in three, and no change in two. When there was an improvement with clarification the average increase in the scores was 1.10, and when it resulted in a lowering of the quality there was an average decrease of 0.50. Considering all the comparisons there was an average increase in the scores of 0.40.

The averages of the total scores show that clarification resulted in an increase in the scores of the one month old cheese of 0.75 and an increase in the scores of the three months old cheese of 0.45.

The results obtained in this series of comparisons agree quite closely with those obtained in Series 1. The individual scores obtained for the cheese made with and without clarification are not very different. Sometimes there was a slight improvement in the quality of the cheese as a result of clarification, while at other times there seems to have been a decrease. The criticisms offered by the judges for the cheese made with and without clarification were not very different. In many cases it was very difficult for them to see any difference in the quality of the cheese in a given comparison. Sometimes the criticisms for both types of cheese were the same, while at other times they were more severe or less severe with clarification. There was only one instance where clarification caused a difference between the total scores of more than 2.00. The judges' criticisms for this lot of cheese (No. 3) indicate that the unclarified milk cheese contained a little more acid and that it had developed a more pronounced fruity flavor and showed a weaker body than did the clarified milk cheese. This may have been caused by several factors, such as the presence of a little more moisture or more undesirable bacteria in the unclarified milk cheese than in the clarified milk cheese.

In summarizing the results obtained in this particular study, it may be concluded that clarification caused increases and decreases in the scores of the cheese, and although the average total scores show an improvement in the quality of the cheese, the differences are so small that they do not signify any marked effect.

Series 3. Seventeen comparisons of cheese manufactured from unclarified and clarified milk were made during the period from March 18 to June 11, 1927, at the Iowa State College. The scoring of the cheese was supervised by Professors E. F. Goss and N. S. Golding. All the cheese were scored at the end of about one month after manufacture, while the cheese in 14 of the 17 comparisons were also scored when about three months old. The scores and criticisms of the cheese are shown in Table 18.

In the one month old cheese the scores for flavor and aroma of the clarified milk cheese were higher than those of the unclarified milk cheese in seven comparisons, lower in six, and unchanged in four. When the scores were higher with clarification the average increase was 0.71, and when they were lower the average decrease was 1.08. Considering the scores in all the comparisons, there was an average decrease in the scores for flavor and aroma of 0.09. In the three months old cheese the scores for flavor and aroma of the cheese made from clarified milk were higher than those of the cheese made from unclarified milk in four comparisons, lower in three, and unchanged in seven. When the scores were higher with clarification the average increase was 0.63, and when they were lower the average decrease was 0.50. Considering all the comparisons, there was an average increase in the scores for flavor and aroma of 0.07.

The scores for body and texture show that in the one month old cheese there was an increase in the scores with clarification in nine comparisons, a decrease in five, and no change in three. When the scores were higher with clarification the average increase was 0.83, and when they were lower, the average decrease was 1.70. Considering all the comparisons there was an average decrease in the scores for body and texture of 0.06. In the three months old cheese, clarification caused an increase in the scores for body and texture in three comparisons, a decrease in four, and no change in seven. When the scores were higher with clarification, the average increase was 0.50, and when they were lower there was an average decrease of 0.62. Considering all the comparisons, there was an average decrease in the scores for body and texture of 0.07.

The averages of the total scores show that clarification resulted in a decrease in the scores of the one month old cheese of 0.15 and in no change in the scores of the three months old cheese.

The only pronounced differences in the scores of unclarified milk cheese and the clarified milk cheese were in Nos. 319 and 322. The manufacturing reports show that there had been little acid development, especially in the clarified milk batches, during the process of

No.	Flavor and Aroma							
	Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months		Clarifi 3 Mon	
	Score	Comment	Score	Comment	Score	Comment	Score	Com
318	40.5	Sour	40.0	Sour	39.0	Sharp	39.5	Sha
319	41.0		39.0	Flat	40.0		39.5	
320	41.0		39.0	Sour fermented	40.0		40.0	
322	39.0		38.0	Acid bitter	39.5		39.0	Lac fla
323	37.0	Fermented burnt	37.0	Fermented burnt	40.0		40.0	
512	41.0		40.5		40.5		40.0	
513	40.0		40.5		39.0		39.0	
514	40.0		39.5	Immature	38.5		39.0	
516	40.0		40.0		40.0		40.0	
521	39.0	Flat	40.0		40.0		40.0	
523	37.5	Fruity	38.0	Fruity	37.5	Fruity	37.5	Fr
528	40.0		40.0		38.5		38.5	
606	39.5		40.0		40.5	Sl. bitter	41.0	Sl bi
607	39.0	Sl. off flavor	40.0					
608	37.0	Unclean	37.0	Unclean				
609	37.5	Fruity	38.5	Flat	37.0	Fruity	38.0	Sl bi
611	38.5		39.0					
Avg.	39.265		39.176		39.285		39.357	

* Includes color and finish. + Increase in

TABLE 18

Scores and Criticisms of Cheese Made in Series 3

		Body and Texture					
Clarified 3 Months		Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months	
Score	Comment	Score	Comment	Score	Comment	Score	Comment
39.5	Sharp	28.0	Sl. mealy	28.0	Sl. mealy	27.0	Sl. mealy
39.5		29.0		26.0	Crumbly corky	28.0	
40.0		28.0		27.0	Sl. corky	28.5	
39.0	Lacking flavor	27.0		24.0	Crumbly corky	27.5	Sl. mealy
40.0		26.0	Sl. crumbly	27.0	Sl. crumbly	27.5	Sl. mealy
40.0		26.5	Weak	28.0		28.0	Weak
39.0		28.0		28.0		29.0	
39.0		27.5	Sl. open	27.0	Sl. lumpy	29.0	
40.0		27.5	Sl. open	28.0		28.0	Open
40.0		26.5	Pasty sl. open	27.5	Sl. open	28.5	
37.5	Fruity	26.0	Open weak	27.0	Sl. open weak	28.0	
38.5		27.5		28.0		29.0	
41.0	Sl. bitter	27.0	Sl. open weak -	27.5	Sl. open	25.5	Sticky
		27.0	Weak	28.0			
		27.0	Open Swiss holes	27.0	Open Swiss hole		
38.0	Sl. bitter	28.0	Sl. open	27.0	Open corky	26.0	Swiss holes sticky
		27.0	Open	27.5	Sl. open		
39.357		27.264		27.206		27.821	

Increase in score. - Decrease in score.

in Series 3

ure				Total Scores*			
nclarified 3 Months		Clarified 3 Months		For Flavor and Aroma, Body and Textu			
re	Comment	Score	Comment	Unclarified 1 Month	Clarified 1 Month	Unclarified 3 Months	Clar 3 M
0	Sl. mealy	27.0	Sl. mealy	93.5	93.0	91.0	91
0		27.5	Sl. mealy	95.0	90.0	93.0	92
5		28.0		94.0	91.0	93.5	93
5	Sl. mealy	26.5	Sl. crumbly	91.0	87.0	92.0	90
5	Sl. mealy	28.0		88.0	89.0	92.5	93
0	Weak	28.0	Weak	92.5	93.5	93.5	93
0		29.0		93.0	93.5	93.0	93
0		29.0		92.5	91.5	92.5	93
0	Open	28.0	Open	92.5	93.0	93.0	93
5		29.0		90.5	92.5	93.5	94
0		27.5	Pasty	88.5	90.0	90.5	90
0		29.0		92.5	93.0	92.5	92
5	Sticky	26.0	Sticky	91.5	92.5	91.0	92
				91.0	93.0		
				89.0	89.0		
0	Swiss holes sticky	26.0	Swiss holes sticky	90.5	90.5	88.0	89
				90.5	91.5		
.821		27.750		91.529	91.382	92.106	92

Total Scores*			Changes in Scores Due tc			
and Aroma, Body and Texture			Flavor and Aroma		Body and Texture	
larified 1 Month	Unclarified 3 Months	Clarified 3 Months	1 Month	3 Months	1 Month	3 Mor
93.0	91.0	91.5	- 0.5	+ 0.5	0.0	0.0
90.0	93.0	92.0	- 2.0	- 0.5	- 3.0	- 0.5
91.0	93.5	93.0	- 2.0	0.0	- 1.0	- 0.5
87.0	92.0	90.5	- 1.0	- 0.5	- 3.0	- 1.0
89.0	92.5	93.0	0.0	0.0	+ 1.0	+ 0.5
93.5	93.5	93.0	- 0.5	- 0.5	+ 1.5	0.0
93.5	93.0	93.0	+ 0.5	0.0	0.0	0.0
91.5	92.5	93.0	- 0.5	+ 0.5	- 0.5	0.0
93.0	93.0	93.0	0.0	0.0	+ 0.5	0.0
92.5	93.5	94.0	+ 1.0	0.0	+ 1.0	+ 0.
90.0	90.5	90.0	+ 0.5	0.0	+ 1.0	- 0.
93.0	92.5	92.5	0.0	0.0	+ 0.5	0.
92.5	91.0	92.0	+ 0.5	+ 0.5	+ 0.5	+ 0.
93.0			+ 1.0		+ 1.0	
89.0			0.0		0.0	
90.5	88.0	89.0	+ 1.0	+ 1.0	- 1.0	0.
91.5			+ 0.5		+ 0.5	
91.382	92.106	92.106	- 0.089	+ 0.072	- 0.059	- 0.

Changes in Scores Due to Clarification					
Flavor and Aroma		Body and Texture		Total Score	
Month	3 Months	1 Month	3 Months	1 Month	3 Months
0.5	+ 0.5	0.0	0.0	- 0.5	+ 0.5
2.0	- 0.5	- 3.0	- 0.5	- 5.0	- 1.0
2.0	0.0	- 1.0	- 0.5	- 3.0	- 0.5
1.0	- 0.5	- 3.0	- 1.0	- 4.0	- 1.5
0.0	0.0	+ 1.0	+ 0.5	+ 1.0	+ 0.5
0.5	- 0.5	+ 1.5	0.0	+ 1.0	- 0.5
0.5	0.0	0.0	0.0	+ 0.5	0.0
0.5	+ 0.5	- 0.5	0.0	- 1.0	+ 0.5
0.0	0.0	+ 0.5	0.0	+ 0.5	0.0
1.0	0.0	+ 1.0	+ 0.5	+ 2.0	+ 0.5
0.5	0.0	+ 1.0	- 0.5	+ 1.5	- 0.5
0.0	0.0	+ 0.5	0.0	+ 0.5	0.0
0.5	+ 0.5	+ 0.5	+ 0.5	+ 1.0	+ 1.0
1.0		+ 1.0		+ 2.0	
0.0		0.0		0.0	
1.0	+ 1.0	- 1.0	0.0	0.0	+ 1.0
0.5		+ 0.5		+ 1.0	
0.089	+ 0.072	- 0.059	- 0.071	- 0.147	0.000

manufacture. This condition may have been a factor in the production of the crumbly and corky condition.

The results obtained in this series show that clarification caused minor changes in the scores of the cheese, but the differences between the average scores of all the cheese are too small to be of any significance.

Series 4. Sixteen comparisons of cheese manufactured from unclarified and clarified milk were made during the period from June 13 to July 5, 1927. The cheese were made at the Iowa State College and the scoring was supervised by Professors N. S. Golding and E. F. Goss. All the cheese were scored at the end of about one month after manufacture, while the cheese in 15 of the 16 comparisons were also scored when about three months old. The scores and criticisms of the cheese are shown in Table 19.

In the one month old cheese the scores for flavor and aroma of the clarified milk cheese were higher than those of the unclarified milk cheese in six comparisons, lower in five, and unchanged in five. When the scores were higher with clarification the average increase was 0.75, and when they were lower the average decrease was 1.10. Considering all the comparisons there was an average decrease in the scores for flavor and aroma of 0.06. In the three months old cheese the scores for flavor and aroma of the

No.	Flavor and Aroma							
	Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months		Clarified 3 Months	
	Score	Comment	Score	Comment	Score	Comment	Score	Comm
613	38.5		38.5		39.0	Fruity	41.0	
614	38.5		38.5		41.0		41.5	
615	38.0	Sl. bitter	38.5		39.0	Sl. bitter	40.0	Sl. bitte
616	37.5	Unclean	37.5	Unclean	40.5	Sl. bitter	40.0	Sl. fruit
617	37.5	Unclean	37.5	Unclean	41.5		41.5	
620	38.0	Unclean	37.5	Unclean	39.5	Sl. unclean	39.0	Sl. uncle
621	38.0	Sl. unclean	36.0	Gassy bitter	38.0	Fermented	38.5	Ferme
622	34.5	Sour gassy	33.0	Putrid	37.5	Unclean bitter	36.0	Uncle bitte
623	40.0		39.0		41.0		41.0	
624	37.0	Fruity	37.0	Fruity	39.5	Sl. fermented	40.0	Clean
627	36.5	Fruity	38.0		37.5	Fruity	39.5	Sl. fruit
628	33.5	Very unclean	34.0	Very unclean	35.5	Fruity unclean	37.5	Sl. fruit
629	34.0	Putrid	35.0	Unclean	37.5	Unclean	38.0	Sl. bitte
630	34.5	Fruity unclean	35.0	Unclean	39.0	Unclean	39.0	Sl. ferme
701	33.5	Putrid	34.0	Putrid	36.0	Fruity	36.5	Fruit
705	37.0	Sl. bitter	36.5	Sour				
Avg.	36.656		36.594		38.800		39.267	

* Includes color and finish. + = Increase in s

TABLE 19

Scores and Criticisms of Cheese Made in Series

		Body and Texture					
Clarified 3 Months		Unclarified 1 Month		Clarified 1 Month		Unclarified 3 Months	
Score	Comment	Score	Comment	Score	Comment	Score	Comment
41.0		27.5	Open	27.5	Open	26.0	Weak
41.5		27.5	Swiss holes	27.5	Swiss holes	26.5	Open
40.0	Sl. bitter	27.0	Swiss holes	27.0	Swiss holes	27.0	Swiss holes
40.0	Sl. fruity	27.5	Swiss holes	27.5	Swiss holes	26.5	Weak
41.5		26.5	Pasty gassy	26.5	Pasty gassy	27.5	Swiss holes
39.0	Sl. unclean	26.5	Sl. corky very open	27.0	Very open	28.0	Swiss holes
38.5	Fermented	27.0		26.0	Gas holes mealy	27.0	Pasty
36.0	Unclean bitter	24.0	Corky very open	23.0	Very corky very open	24.5	Gassy
41.0		28.0		27.5		27.0	Weak
40.0	Clean	27.0	Swiss holes rubbery	27.0	Pasty open	26.0	Many holes
39.5	Sl. fruity	27.0	Swiss holes rubbery	27.5	Open	25.5	Weak
37.5	Sl. fruity	26.5	Open	26.5	Open	25.5	Weak
38.0	Sl. bitter	26.5	Open	26.5	Open	25.5	Gassy
39.0	Sl. fermented	26.5	Very open	26.5	Corky open	26.0	Gassy
36.5	Fruity	25.5	Pasty open	25.5	Pasty open	25.0	Gassy pasty
		27.0	Pasty	27.0	Pasty		
39.267		26.719		26.625		26.233	

ncrease in score. - = Decrease in score.

le in Series 4.

ture				Total Scores*			
larified 3 Months		Clarified 3 Months		For Flavor and Aroma, Body and Textu			
e	Comment	Score	Comment	Unclarified 1 Month	Clarified 1 Month	Unclarified 3 Months	Clar 3
.0	Weak	28.0		91.0	91.0	90.0	9
.5	Open	27.0		91.0	91.0	92.5	9
.0	Swiss holes	27.0	Swiss holes	90.0	90.5	91.0	9
.5	Weak	26.0	Weak	90.0	90.0	92.0	9
.5	Swiss holes	27.5	Swiss holes	89.0	89.0	94.0	9
.0	Swiss holes	28.0	Swiss holes	89.5	89.5	92.5	9
.0	Pasty	27.0	Pasty	90.0	87.0	90.0	9
.5	Gassy	24.0	Gassy	83.5	81.0	87.0	8
.0	Weak	27.0	Weak	93.0	91.5	93.0	9
.0	Many holes	26.0	Many holes	89.0	89.0	90.5	9
.5	Weak	27.5	Weak	88.5	90.5	88.0	9
.5	Weak	26.5	Open	85.0	85.5	86.0	8
.5	Gassy	26.0	Open	85.5	86.5	88.0	8
.0	Gassy	26.5	Gassy	86.0	86.5	90.0	9
.0	Gassy pasty	25.5	Gassy pasty	84.0	84.5	86.0	8
				89.0	88.5		
.233		26.633		88.375	88.219	90.033	9

res*		Changes in Scores Due to Clari				
Body and Texture		Flavor and Aroma		Body and Texture		
nclarified 3 Months	Clarified 3 Months	1 Month	3 Months	1 Month	3 Months	1 M
90.0	94.0	0.0	+ 2.0	0.0	+ 2.0	
92.5	93.5	0.0	+ 0.5	0.0	+ 0.5	
91.0	92.0	+ 0.5	+ 1.0	0.0	0.0	+
92.0	91.0	0.0	- 0.5	0.0	- 0.5	
94.0	94.0	0.0	0.0	0.0	0.0	
92.5	92.0	- 0.5	- 0.5	+ 0.5	0.0	
90.0	90.5	- 2.0	+ 0.5	- 1.0	0.0	-
87.0	85.0	- 1.5	- 1.5	- 1.0	- 0.5	-
93.0	93.0	- 1.0	0.0	- 0.5	0.0	-
90.5	91.0	0.0	+ 0.5	0.0	0.0	
88.0	92.0	+ 1.5	+ 2.0	+ 0.5	+ 2.0	+
86.0	89.0	+ 0.5	+ 2.0	0.0	+ 1.0	+
88.0	89.0	+ 1.0	+ 0.5	0.0	+ 0.5	+
90.0	90.5	+ 0.5	0.0	0.0	+ 0.5	+
86.0	87.0	+ 0.5	+ 0.5	0.0	+ 0.5	+
		- 0.5		0.0		-
90.033	90.900	- 0.062	+ 0.467	- 0.094	+ 0.400	-

Changes in Scores Due to Clarification				
d	Body and Texture		Total Score	
3 Months	1 Month	3 Months	1 Month	3 Months
+ 2.0	0.0	+ 2.0	0.0	+ 4.0
+ 0.5	0.0	+ 0.5	0.0	+ 1.0
+ 1.0	0.0	0.0	+ 0.5	+ 1.0
- 0.5	0.0	- 0.5	0.0	- 1.0
0.0	0.0	0.0	0.0	0.0
- 0.5	+ 0.5	0.0	0.0	- 0.5
+ 0.5	- 1.0	0.0	- 3.0	+ 0.5
- 1.5	- 1.0	- 0.5	- 2.5	- 2.0
0.0	- 0.5	0.0	- 1.5	0.0
+ 0.5	0.0	0.0	0.0	+ 0.5
+ 2.0	+ 0.5	+ 2.0	+ 2.0	+ 4.0
+ 2.0	0.0	+ 1.0	+ 0.5	+ 3.0
+ 0.5	0.0	+ 0.5	+ 1.0	+ 1.0
0.0	0.0	+ 0.5	+ 0.5	+ 0.5
+ 0.5	0.0	+ 0.5	+ 0.5	+ 1.0
	0.0		- 0.5	
+ 0.467	- 0.094	+ 0.400	- 0.156	+ 0.867

clarified milk cheese were higher than those of the unclarified milk cheese in nine comparisons, lower in three, and unchanged in three. When the scores were higher with clarification, the average increase was 1.06, and when they were lower, the average decrease was 0.83. When all the comparisons are considered, there was an average increase in the scores for flavor and aroma of 0.47.

In the one month old cheese, the scores for body and texture of the clarified milk cheese were higher than those of the unclarified milk cheese in two comparisons, lower in three, and unchanged in 11. When the scores were higher with clarification the average increase was 0.50, and when they were lower the average decrease was 0.83. Considering all the comparisons there was an average decrease in the scores for body and texture of 0.09. In the three months old cheese the scores for body and texture of the clarified milk cheese were higher than those of the unclarified milk cheese in seven comparisons, lower in two, and unchanged in six. When the scores were higher with clarification the average increase was 1.00, and when they were lower, the average decrease was 0.5. Considering all the comparisons, there was an average increase in the scores for body and texture of 0.40.

The averages of the total scores show that clarification resulted in a decrease in the scores of the one month old cheese of 0.16, and an increase in the scores of the three months old cheese of 0.87.

The cheese in this series were made from milk which caused gas holes in the curd. Although a vigorous starter was used, pinholes were nearly always noticeable in the curd during matting. The number and size of holes in the curd from the unclarified milk were practically identical with those in the curd from the clarified milk. The results show that clarification caused increases and decreases in the scores similar to those in the scores of the cheese in the previous three series. The greatest variation in the scores for flavor and aroma and for body and texture was 2.00, while in the total scores clarification caused an improvement of 4.00 in two comparisons, and of 3.00 in one comparison. Clarification seems to have effected a more noticeable improvement in the quality of the three months old cheese in this series than in the previous three series. All the milk used for the cheese in this series was studied on the basis of the changes shown by the methylene blue test and was also examined by the plate method for the numbers of bacteria present. An attempt to correlate the scores of the cheese with the numbers of bacteria present in the unclarified and clarified milk will be made in a later discussion.

The results of this series of comparisons show that clarification caused increases and decreases in the scores for flavor and aroma and body and texture. No significantly large increases or decreases occurred, but the greatest constant improvement seems to have been in the three months old cheese. The average increase of all the scores of the three months old cheese is not large enough, however, to signify that any marked improvement took place.

Summary of the scores of cheese in series 1 to 4. The summary of the results obtained in the 67 comparisons of cheese made from unclarified and clarified milk, presented in Table 20, shows that clarification caused increases and decreases in the total scores of the cheese, while in a number of comparisons there was no change. An increase occurred more frequently than a decrease.

In the one month old cheese clarification resulted in an increase in the average score for flavor and aroma of all the cheese of 0.07, while in the three months old cheese it resulted in an increase of 0.41.

In the one month old cheese clarification caused no change in the average score for body and texture of all the cheese while in the three months old cheese it resulted in an increase of 0.15.

When the total scores of the cheese in all the

	Flavor and Aroma		
	Unclarified 1 Month	Clarified 1 Month	Unclari 3 Mont
	Avg. Score	Avg. Score	Avg. S
Series 1	37.125	37.300	36.09
" 2	37.950	38.300	37.90
" 3	39.265	39.176	39.28
" 4	36.656	36.594	38.80
Total Scores, Series 1	742.5	746.0	794.0
Number of Comparisons	20	20	22
Total Scores, Series 2	379.5	383.0	379.0
Number of Comparisons	10	10	10
Total Scores, Series 3	667.5	666.0	550.0
Number of Comparisons	17	17	14
Total Scores, Series 4	586.5	585.5	582.0
Number of Comparisons	16	16	15
Avg. of all Comparisons	37.71	37.78	37.78

\+ = Increase in scor

\- = Decrease in scor

TABLE 20

Summary of Scores of Cheese Series 1 to 4

a		Body and Texture			
arified onths	Clarified 3 Months	Unclarified 1 Month	Clarified 1 Month	Unclarified 3 Months	Clari 3 Mo
. Score	Avg. Score	Avg. Score	Avg. Score	Avg. Score	Avg.
.090	36.818	29.300	29.225	29.000	29.
.900	37.950	26.900	27.300	27.300	27.
.285	39.357	27.264	27.206	27.821	27.
.800	39.267	26.719	26.625	26.233	26.
.0	810.0	586.0	584.5	638.0	638.
	22	20	20	22	22
.0	379.5	269.0	273.0	273.0	277.
	10	10	10	10	10
.0	551.0	463.5	462.5	389.5	388.
	14	17	17	14	14
.0	589.0	427.5	426.0	393.5	399.
	15	16	16	15	15
.78	38.19	27.72	27.72	27.77	27.

core.

core.

	Average Total Scores				
ified	For Flavor and Aroma, Body and Texture, Color and Finish				F
onths	Unclarified	Clarified	Unclarified	Clarified	
Score	1 Month	1 Month	3 Months	3 Months	1
.023	91.425	91.525	90.09	90.84	+
.700	89.850	90.600	90.200	90.650	+
.750	91.529	91.382	92.106	92.106	-
.633	88.375	88.219	90.033	90.900	-
.5	1828.5	1830.5	1982.0	1998.5	
	20	20	22	22	
.0	898.5	906.0	902.0	906.5	
	10	10	10	10	
.5	1556.0	1553.5	1289.5	1289.5	
	17	17	14	14	
.5	1414.0	1411.5	1350.0	1363.5	
	16	16	15	15	
.92	90.43	90.50	90.55	90.11	+

	Changes in Average Scores due to Clarificati					
re,	Flavor and Aroma		Body and Texture		Total Scor	
Clarified						
3 Months	1 Month	3 Months	1 Month	3 Months	1 Month	3
90.84	+ 0.175	+ 0.727	- 0.075	+ 0.023	+ 0.100	+
90.650	+ 0.350	+ 0.050	+ 0.400	+ 0.400	+ 0.750	+
92.106	- 0.089	+ 0.072	- 0.059	- 0.071	- 0.147	
90.900	- 0.062	+ 0.467	- 0.094	+ 0.400	- 0.156	+
1998.5						
22						
906.5						
10						
1289.5						
14						
1363.5						
15						
90.11	+ 0.07	+ 0.41	0.00	+ 0.15	+ 0.07	

verage Scores due to Clarification				Time in Total Scores due to Clarification					
Body and Texture		Total Score		1 Month			3 Months		
1 Month	3 Months	1 Month	3 Months	Increase	Decrease	No Change	Increase	Decrease	No Change
- 0.075	+ 0.023	+ 0.100	+ 0.75	11	8	1	14	5	3
+ 0.400	+ 0.400	+ 0.750	+ 0.45	7	3	0	5	5	0
- 0.059	- 0.071	- 0.147	0.000	10	5	2	6	5	3
- 0.094	+ 0.400	- 0.156	+ 0.867	6	4	6	10	3	2
0.00	+ 0.15	+ 0.07	+ 0.56						

comparisons are considered clarification caused an increase in the average score of the one month old cheese of 0.07 and in the three months old cheese of 0.56.

Series 5.

A. If the clarifier is to improve the quality of milk bacteriologically, it must remove undesirable bacteria from the milk and deposit them in the slime. In order to determine the effect of the addition of the slime obtained from 40 gallons of milk to 20 gallons of clarified milk on the quality of cheese obtained, in comparison with the quality of cheese obtained from unclarified milk of the same lot, six trials were made. The results obtained are shown in Table 21.

In the one month old cheese the addition of the slime caused an increase in the scores for flavor and aroma in one and a decrease in five of the six comparisons. The increase in the score when it was higher with the added slime was 0.50, and when there was a decrease, the average reduction was 0.80; when all the comparisons are considered there was an average reduction of 0.58. In the three months old cheese the addition of slime caused a decrease in the scores for flavor and aroma in four comparisons, while in two they were unchanged. The average decrease when the scores were lowered was 1.25, and when all the comparisons

No.	Added Material	Flavor and Ar			
		1 Month			
		Unclarified		Clarified and Added Material	
		Score	Comment	Score	Comment
420	Slime	41.0		40.0	Sl.sour
422	Slime	39.0		38.0	Acid bitter
423	Slime	37.0	Fermented burnt	37.5	Fermented burnt
629	Slime	34.0	Putrid	33.0	Putrid
630	Slime	34.5	Unclean fruity	34.0	Unclean fruity
701	Slime	33.5	Putrid	33.0	Putrid
	Average of 6 Comparisons	36.500		35.917	
622	Alkali former	34.5	Sour	34.5	Sour
623	Alkali former	40.0		37.0	Unclean
624	Alkali former	37.0	Fruity	36.5	Fruity
627	Alkali former	36.5	Fruity	36.0	Fruity unclean
628	Alkali former	33.5	Very unclean	33.0	Very unclean
	Average of 5 Comparisons	36.30		35.40	

* Includes color and finish

+ = Increase in score

- = Decrease in score

TABLE 21

Scores and Criticisms of Cheese in Seri

ror and Aroma							
	3 Months				1 Month		
l and erial	Unclarified		Clarified and Added Material		Unclarified		Clar Adde
mment	Score	Comment	Score	Comment	Score	Comment	Score
sour	40.0		39.5		28.0		27.0
d ter	39.5		38.0	Sl. fruity	27.0		25.0
mented nt	40.0		38.0	Bitter	26.0	Sl. crumbly	27.5
rid	37.5	Unclean	37.5	Unclean	26.5	Open	26.0
lean ity	39.0	Unclean	38.0	Sl. fermented	26.5	Very open	25.5
rid	36.0	Fruity	36.0	Fruity	25.5	Pasty open	25.5
	38.667		37.833		26.583		26.0
r	37.5	Unclean	37.0	Unclean	24.0	Corky open	24.0
lean	41.0		40.0		28.0		26.5
ity	39.5	Sl. fermented	37.5	Bitter fermented	27.0	Swiss holes rubbery	27.0
ity lean	37.5	Fruity	38.5	Sl.- bitter	27.0	Swiss holes rubbery	27.0
y lean	35.5	Fruity	35.5	Fruity	26.5	Open	26.5
	38.20		37.70		26.50		26.2

se in Series 5.

	Body and Texture						
1 Month			3 Months				
	Clarified and Added Material		Unclarified		Clarified and Added Material		Unclari
ent	Score	Comment	Score	Comment	Score	Comment	1 Mor
	27.0	Sl. corky	28.5		27.5	Sl.mealy	94.0
	25.0	Crumbly corky	27.5	Sl. mealy	27.0	Sl. mealy	91.0
ly	27.5	Sl. crumbly	27.5	Sl. mealy	27.0	Mealy	88.0
	26.0	Open pasty	25.5	Gassy	25.0	Gassy	85.5
	25.5	Sl. corky open	26.0	Gassy	26.0	Gassy	86.0
	25.5	Pasty open	25.0	Gassy pasty	25.0	Gassy pasty	84.0
	26.083		26.667		26.250		88.0
	24.0	Corky open	24.5	Gassy	24.0	Gassy	83.5
	26.5	Pasty	27.0	Sl. weak	27.0	Sl. weak	93.0
holes ry	27.0	Open pasty	26.0	Swiss holes	26.0	Swiss holes	89.0
holes ry	27.0	Swiss holes rubbery	25.5	Weak	25.5	Gassy lumpy	88.5
	26.5	Open	25.5	Weak	26.5	Open	85.0
	26.20		25.70		25.80		87.8

	Total Scores *				
	For Flavor and Aroma, Body and Texture				
fied and Material	Unclarified	Clarified and Added Material	Un-clarified	Clarified and Added Material	Fla
Comment	1 Month	1 Month	3 Months	3 Months	1 M
Sl.mealy	94.0	92.0	93.5	92.0	- 1.
Sl. mealy	91.0	88.0	92.0	90.0	- 1.
Mealy	88.0	90.0	92.5	90.0	+ 0.
Gassy	85.5	84.0	88.0	87.5	- 1.
Gassy	86.0	84.5	90.0	89.0	- 0.
Gassy pasty	84.0	83.5	86.0	86.0	- 0
0	88.083	87.000	90.333	89.083	- 0
Gassy	83.5	83.5	87.0	86.0	C
Sl. weak	93.0	88.5	93.0	92.0	- 3
Swiss holes	89.0	88.5	90.5	88.5	- 0
Gassy lumpy	88.5	88.0	88.0	89.0	- 0
Open	85.0	84.5	86.0	87.0	- 0
0	87.80	86.60	88.90	88.50	- 0

Texture larified and dded Material	Differences in Scores of Clarified Milk Cheese as Compared with Unclarified Milk Cheese					
	Flavor and Aroma		Body and Texture		Total Score	
3 Months	1 Month	3 Months	1 Month	3 Months	1 Month	3 Months
92.0	- 1.0	- 0.5	- 1.0	- 1.0	- 2.0	- 1.5
90.0	- 1.0	- 1.5	- 2.0	- 0.5	- 3.0	- 2.0
90.0	+ 0.5	- 2.0	+ 1.5	- 0.5	+ 2.0	- 2.5
87.5	- 1.0	0.0	- 0.5	- 0.5	- 1.5	- 0.5
89.0	- 0.5	- 1.0	- 1.0	0.0	- 1.5	1.0
86.0	- 0.5	0.0	0.0	0.0	- 0.5	0.0
89.083	- 0.58	- 0.83	- 0.50	- 0.42	- 1.08	- 1.25
86.0	0.0	- 0.5	0.0	- 0.5	- 0.0	- 1.0
92.0	- 3.0	- 1.0	- 1.5	0.0	- 4.5	- 1.0
88.5	- 0.5	- 2.0	0.0	0.0	- 0.5	- 2.0
89.0	- 0.5	+ 1.0	0.0	0.0	- 0.5	+ 1.0
87.0	- 0.5	0.0	0.0	+ 1.0	- 0.5	+ 1.0
88.50	- 0.9	- 0.5	- 0.3	+ 0.1	- 1.2	- 0.4

are considered there was an average reduction of 0.83.

In the one month old cheese the addition of slime caused an increase in the score for body and texture in one comparison, a decrease in four, while in one there was no change. In the comparison where there was an increase, it was 1.50 and when there was a decrease the average was 1.12, while when all the comparisons are considered, there was an average decrease of 0.50. In the three months old cheese the addition of slime caused a decrease in the scores for body and texture in four comparisons, while in two there was no change. The average decrease when there was a reduction in the scores was 0.62, while when all the comparisons are considered there was an average decrease of 0.42.

The total scores show that the addition of slime caused in the one month old cheese an average decrease of 1.08, and in the three months old cheese an average decrease of 1.25.

The results show that the addition of slime to clarified milk caused, in nearly all comparisons, a decrease in the scores for both flavor and aroma, and for body and texture in the one month old and three months old cheese when these are compared with the scores obtained from cheese made from unclarified milk of the same lot.

B. The results obtained in the study of the types of bacteria present in unclarified milk and in the clarifier slime obtained from it, which are shown in Part 1, indicate that the alkali forming bacteria are the ones which are measurable removed by the clarifier in the slime.

A study was made of the effect of the addition of one per cent of a pure milk culture of an alkali former to five batches of clarified milk on the quality of cheese obtained, in comparison with cheese obtained from unclarified milk of the same lot. The data obtained are presented in Table 21.

In the one month old cheese the addition of the alkali former caused a decrease in the scores for flavor and aroma in four comparisons while in one there was no change. When there was a decrease the average reduction was 1.12, while when all the comparisons are considered there was an average decrease of 0.90. In the three months old cheese the added organisms caused an increase in the score in one comparison, a decrease in three, while in one there was no change. In the comparison when there was an increase in the score this was 1.00, and when there was a decrease, the average reduction was 1.17. Considering all the comparisons, there was an average reduction in the scores of 0.50.

In the one month old cheese the added bacteria caused a decrease in the score for body and texture in one comparison, while in four there was no change. The decrease in the score in the one comparison was 1.50, while when all the comparisons are considered there was an average decrease of 0.30. In the three months old cheese the alkali former caused an increase in the score for body and texture in one comparison, a decrease in one, while in three there was no change. The increase was 1.00, and the decrease 0.50. When all the comparisons are considered there was an average increase of 0.10.

The total scores show that in the one month old cheese, the added organisms caused an average decrease in all the scores of 1.20, and in the three months old cheese an average decrease of 0.40.

In summarizing these results it would seem that the addition of one per cent of a milk culture of alkali forming bacteria to clarified milk caused, in general, a small decrease in the scores of the cheese when these are compared with the scores obtained for cheese made from unclarified milk of the same lot.

B. Bacteriological Studies

1. Influence of clarification of milk on the numbers and types of bacteria present in cheese.

Five different lots of cheese were examined for the numbers and types of bacteria present and the findings compared with the results obtained from the scorings.

In one comparison cheese were made from unclarified and clarified milk of the same lot, in another from unclarified milk, clarified milk, and clarified milk containing no starter, while in three unclarified milk, clarified milk, and clarified milk containing added slime were used. Table 22 gives the numbers of bacteria and the percentages of the various types present in the cheese when it was about one month and also when about three months old.

In the one month old cheese clarification caused an increase in the number of bacteria present in one comparison and a decrease in four, while in the three month old cheese clarification caused an increase in the number of bacteria present in four comparisons and a decrease in one.

In the one month old cheese the number of bacteria per gram in the cheese made from unclarified milk ranged from 1,678,000 to 20,742,000, and in the cheese made from

TABLE 22

Influence of Clarification on the Numbers and

No.		One Month		
		Bacteria per Gram	Increase Over Unclarified in Percentage	Increase to Clari
318	U.*	1,678,000		
318	Cl.**	4,326,500	157.8	- 0
319	U.	3,492,600		
319	Cl.	1,781,000	- 49.0	- 5
319	Cl. (No starter)	36,658,000	949.6	
320	U.	17,319,000		
320	Cl.	7,207,000	- 58.4	- 3
320	Cl. and Slime	16,380,000	- 5.4	
322	U.	6,920,000		
322	Cl.	5,701,000	- 17.7	- 4
322	Cl. and Slime	6,250,000	9.7	
323	U.	20,742,000		
323	Cl.	2,335,000	- 88.7	+ 1
323	Cl. and Slime	2,742,000	- 86.8	

No.							P
		Acid				Inert	
		Coagulators		Non-coagulators			
		1 Mo.	3 Mos.	1 Mo.	3 Mos.	1 Mo.	3
318	U.*	18.0	60.0	70.0	40.0	10.0	
318	Cl.**	8.0	66.0	84.0	32.0	8.0	2
319	U.	10.0	70.0	70.0	30.0	20.0	
319	Cl.	22.0	78.0	72.0	22.0	4.0	
319	Cl. (No starter)	12.0	58.0	26.0	40.0	2.0	
320	U.	8.0	84.0	84.0	16.0	4.0	
320	Cl.	6.0	90.0	90.0	10.0	4.0	
320	Cl. and Slime	16.0	92.0	62.0	8.0	12.0	
322	U.	14.0	56.0	86.0	44.0		
322	Cl.	36.8	90.0	59.2	8.0		
322	Cl. and Slime	16.0	68.0	84.0	32.0		
323	U.	82.0	90.0	18.0	6.0		4
323	Cl.	70.0	78.0	28.0	22.0		
323	Cl. and Slime	42.0	82.0	56.0	16.0	2.0	2

* Unclarified

** Clarified

BLE 22.

rs and Types of Bacteria Present in Cheese.

	Three Months		
crease in Score Due Clarification	Bacteria per Gram	Increase Over Unclarified in Percentage	Increase in Score Due to Clarification
	1,100,000		
- 0.5	2,951,000	168.3	+ 0.5
	3,268,000		
- 5.0	6,720,000	105.6	- 1.0
	10,748,000	228.9	
	8,450,000		
- 3.0	10,840,000	28.3	- 0.5
	6,806,000	- 19.5	
	4,182,000		
- 4.0	20,770,000	396.6	- 1.5
	7,039,000	68.3	
	12,150,000		
+ 1.0	8,366,000	- 31.1	+ 0.5
	7,096,000	- 41.6	

Percentage									
				Peptonizers					
nert		Alkali Formers		Neutral		Acid		Alkali	
.	3 Mos.	1 Mo.	3 Mos.	1 Mo.	3 Mos.	1 Mo.	3 Mos.	1 Mo.	3 Mos.
						2.0			
	2.0								
						2.0			
						60.0			2.0
						4.0			
						10.0			
						4.0	2.0		
	4.0								
						2.0			
	2.0								

clarified milk containing slime they ranged from 2,742,000 to 16,380,000. The one cheese made from clarified milk without starter contained 36,658,000.

In the three months old cheese the number of bacteria per gram of the cheese made from unclarified milk ranged from 1,100,000 to 12,150,000, in the cheese made from clarified milk from 2,951,000 to 20,770,000, and in the cheese made from clarified milk containing slime from 6,806,000 to 7,096,000. These great differences in the numbers of organisms present in the cheese made from treated and untreated milk may not be as significant as they would seem. The difficulty with which bacterial groups and chains present in the cheese are broken up and distributed during the grinding of the sample may result in large errors. Ordinarily the number of bacteria present in cheese is quite high. In this study the numbers present were relatively small; probably many of the organisms had died before the cheese was examined. The period of examination would suggest this.

In the one month old cheese the numbers of bacteria in the clarified milk cheese exceeded those present in the unclarified milk cheese from -88.7 to 157.8 per cent. Adding slime to clarified milk caused increases from -86.8 to -5.4 per cent, as compared with the bacteria present in the cheese from unclarified milk, while in the cheese made from milk containing no starter there was an increase of 949.6 per cent.

In the three months old cheese the numbers of bacteria in the clarified milk cheese exceeded those present in the unclarified milk cheese from -31.1 to 395.6 per cent, adding slime to clarified milk caused increases from -41.6 to 68.3 per cent, as compared with the bacteria present in the cheese from unclarified milk, while in the cheese made from milk containing no starter there was an increase of 228.9 per cent.

In the one month old cheese clarification caused an increase in the total score in one comparison and a decrease in four. In the comparison when there was an increase in the numbers of bacteria there was a decrease in the score. In the comparison where there was the greatest decrease in numbers of bacteria there was an increase in the score. An increase or decrease in the numbers of bacteria did not cause a similar increase or decrease in the total score.

In the three months old cheese clarification caused an increase in the total scores in two comparisons and a decrease in three. An increase or decrease in the numbers of bacteria present did not regularly cause a corresponding increase or decrease in the scores of the cheese.

The results of a study of the effect of clarification of milk and the addition of slime to clarified milk on the types of bacteria present in the cheese show that in both the one month and three months old cheese, with the exception of that made from clarified milk containing no starter, the acid forming groups constituted the majority of the organisms present; these groups were always present in the cheese made from unclarified milk, clarified milk, and clarified milk containing added slime; sometimes there was an increase and sometimes a decrease in these groups as a result of treating the milk. The alkali formers and neutral peptonizers were entirely absent. In some of the comparisons the one month old and the three months old cheese contained small numbers of inert and acid peptonizers. The one month old cheese made from clarified milk containing no starter contained a large percentage of acid peptonizers, while the three months old cheese showed a flora which was similar to that of the cheese made from the unclarified and clarified milk of the same lot.

In summarizing these results, it would appear that clarification of milk and the addition of slime to clarified milk had no specific influence on the numbers and types of bacteria present in the cheese, and that an increase or decrease in the numbers of bacteria present in the cheese obtained from the treated milk as compared with the numbers present in the cheese from the untreated milk of the same lot did not result in a corresponding constant increase or decrease in the total scores of the cheese.

2. Relation between the numbers of bacteria present in unclarified and clarified milk and the quality of cheese obtained. In order to determine the relation between the numbers of bacteria present in the unclarified and clarified milk used and the quality of the cheese made, 28 comparisons were made. The cheese were made during the period May to July 1927, inclusive, and the scores obtained are shown in Tables 18 and 19.

Table 23 shows the plate counts of the milk used, the percentage change in numbers due to clarification, and the increase in the total scores of the cheese caused by clarification. The counts of the unclarified milk ranged from 20,900 to 15,010,000 per cc. Clarification caused an increase in the bacterial count in three trials and a decrease in 25. The increases in the counts varied from 5.0 to 23.8 per cent and averaged 11.8 per cent, while the decreases varied from 5.3 to 53.1 per cent and averaged 26.1 per cent. Considering the 28 comparisons,

TABLE 23

Relation Between the Numbers of Bacteria Present in Unclarified and Clarified Milk and the Quality of Cheese Obtained.

Number	Unclarified	Clarified	Percentage		Increase in Total Score due to Clarification	
			Increase	Decrease	1 Month	3 Months
512	20,900	19,800		5.3	1.0	- 0.5
513	530,000	485,000		8.5	0.5	0.0
514	350,000	250,000		28.6	- 1.0	0.5
516	710,000	530,000		25.4	0.5	0.0
521	11,470,000	9,480,000		17.4	2.0	0.5
523	11,400,000	9,160,000		19.7	1.5	- 0.5
528	1,160,000	880,000		24.1	0.5	0.0
606	200,000	210,000	5.0		1.0	1.0
607	63,000	78,000	23.8		2.0	-
608	1,080,000	590,000		45.4	0.0	-
609	1,220,000	745,000		38.9	0.0	1.0
611	1,810,000	1,360,000		24.3	1.0	-
613	490,000	360,000		26.5	0.0	4.0
614	260,000	190,000		26.9	0.0	1.0
615	137,000	119,000		13.1	0.5	1.0
616	114,000	107,000		6.1	0.0	- 1.0
617	3,290,000	2,630,000		20.1	0.0	0.0
620	2,480,000	2,340,000		5.6	0.0	- 0.5
621	15,010,000	7,620,000		49.2	- 3.0	0.5
622	560,000	400,000		28.6	- 2.5	- 2.0
623	8,180,000	5,340,000		34.7	- 1.5	0.0
624	4,200,000	2,000,000		52.4	0.0	0.5
627	1,490,000	820,000		45.0	2.0	4.0
628	2,210,000	1,635,000		26.0	0.5	3.0
629	1,960,000	2,090,000	6.6		1.0	1.0
630	1,170,000	980,000		16.2	0.5	0.5
701	875,000	410,000		53.1	0.5	1.0
705	11,800,000	10,600,000		10.2	- 0.5	-

there was an average decrease of 22.0 per cent as a result of clarification. The results are comparable with those obtained in Part I, where clarification caused increases and decreases in the counts, a decrease being caused more often when the number of bacteria per cc. exceeded 100,000.

With the smallest increase in bacterial count, as a result of clarification, there was an increase in the total score of the one month old cheese of 1.0, and an increase in the total score of the three months old cheese of 1.0. With the largest increase in the count, there was an increase in the total score of the one month old cheese of 2.0. The three months old cheese in this comparison was not scored.

With the smallest decrease in the bacterial count, as a result of clarification, there was an increase in the total score of the one month old cheese of 1.0, and a decrease in the total score of the three months old cheese of 0.5. With the largest decrease in the count, there was an increase in the total score of the one month old cheese of 0.5 and an increase in the total score of the three months old cheese of 1.0.

When all the comparisons are considered, there was an average increase in the total score of the one month old cheese of 0.23 and an increase in the total score of the three months old cheese of 0.60.

Comparisons Nos. 613, 627 and 628 show the largest increase in the total score of the cheese and clarification caused a decrease in numbers of bacteria in the milk used of 26.5, 45.0, and 26.0 per cent, respectively. Comparisons Nos. 621 and 622 show the largest decreases in the total score of the cheese and in these clarification caused a decrease in the numbers of bacteria in the milk used of 49.2 and 28.6 per cent, respectively.

These results show that increases or decreases in the numbers of bacteria present in the milk as a result of clarification did not have definite effects on the score of the cheese.

3. Influence of clarification on the results obtained by the methylene blue test and the fermentation test. All the milk used for the cheese made during the period, May to July 1927, inclusive, was studied from the standpoint of the influence of clarification on the results obtained by the methylene blue reduction test and the fermentation test. Table 2 4 shows the data obtained in the 28 comparisons.

The time required to decolorize the methylene blue with the unclarified milk varied from 20 to 385 minutes and with the clarified milk from 35 to 385 minutes.

In ten comparisons clarification caused no change in the reduction time, while in 18 it caused an increase. The increases varied from five to 60 minutes and averaged 27 minutes. When all the comparisons are considered there was an average increase in the reduction time of 17.5 minutes.

The time required to decolorize the methylene blue with the unclarified milk containing starter ranged from five to 60 minutes and with the clarified milk containing starter from 15 to 120 minutes. Clarification caused an increase in all of the eleven comparisons. This increase varied from five to 60 minutes and averaged 16.8 minutes.

The results from the fermentation test show that the curds obtained from unclarified milk were very similar to those obtained from clarified milk. This was also true where the milk contained starter.

With the clarified milk containing added alkali forming bacteria there was little difference in the reduction time as compared with the time for the clarified milk of the same lot, while when slime was added to clarified milk there was a slight decrease in the reduction time. The curds obtained in the fermentation test from milk containing alkali formers and slime was very similar to those obtained from the unclarified and clarified milk

TABLE 24.

Influence of Clarification on Milk as shown by the Methylene Blue Test and the Fermentation Test.

	Methylene Blue Test						Fermentation Test			
No.	Minutes to Decolorize		Increase in Reduction Time Due to Clarification (minutes)	Minutes to Decolorize		Increase in Reduction Time Due to Clarification (minutes)	Un-clarified	Clarified	U.+ Starter	Cl.+ Starter
	U.*	Cl.**		U.+ Starter	Cl.+ Starter					
512	385	385	0				Smooth curd	Smooth curd		
513	300	300	0				" "	" "		
514	285	315	30				" "	" "		
516	300	345	45				" "	" "		
521	90	90	0				" "	" "		
523	20	35	15				" "	" "		
528	220	240	20				" "	" "		
606	300	300	0				" "	" "		
607	360	360	0				Sl. gassy	Sl. gassy		
608	135	135	0				Smooth curd	Smooth curd		
609	195	240	45				Sl. gassy	Sl. gassy		
611	150	210	60				" "	" "		
613	210	240	30				" "	" "		
614	300	315	15				" "	" "		
615	330	330	0				Gassy	Gassy		
616	330	330	0							
617	135	150	15							
620	50	80	30	5	15	10	Smooth curd	Smooth curd	Smooth curd	Smooth curd
621	45	60	15	10	15	5	" "	" "	" "	" "
622	270	300	30	60	120	60	Very gassy	Very gassy	Sl. gassy	Sl. gassy
623	75	105	30	25	35	10	Sl. gassy	Sl. gassy	" "	" "
624	150	165	15	30	45	15	" "	" "	" "	Smooth curd
627	180	210	30	25	30	5	" "	" "	" "	Sl. gassy
628	150	180	30	55	60	5	" "	Smooth curd	" "	" "
629	135	165	30	30	45	15	Gassy	Gassy	Gassy	Gassy

617	135	150	15							
620	50	80	30	5	15	10	Smooth curd	Smooth curd	Smooth curd	Smooth curd
621	45	60	15	10	15	5	" "	" "	" "	" "
622	270	300	30	60	120	60	Very gassy	Very gassy	Sl. gassy	Sl. gassy
623	75	105	30	25	35	10	Sl. gassy	Sl. gassy	" "	" "
624	150	165	15	30	45	15	" "	" "	" "	Smooth curd
627	180	210	30	25	30	5	" "	" "	" "	Sl. gassy
628	150	180	30	55	60	5	" "	Smooth curd	" "	" "
629	135	165	30	30	45	15	Gassy	Gassy	Gassy	Gassy
630	90	95	5	20	25	5	Sl. gassy	Sl. gassy	"	"
701	270	270	0	40	80	40	Gassy	" "	Sl. gassy	Smooth curd
705	180	180	0	60	75	15	Spongy	Spongy	Spongy	Spongy
Average			17.5			16.8				

622	Cl. +	Alk. Bact. No. 7	300	Gassy
623	" +	" " " 2	105	Sl. gassy
624	" +	" " " 1	135	" "
627	" +	" " " 28	180	" "
628	" +	" " " 29	180	Smooth curd
629	" +	Slime	120	Gassy
630	" +	"	75	Sl. gassy
701	" +	"	150	" "

* U = Unclarified

** Cl = Clarified

of the same lot.

DISCUSSION OF RESULTS

Part I

From the study of the influence of clarification on the number of bacteria in milk it would seem that the process caused variable increases and decreases in the numbers present as determined by the plate count. The increases must have been only apparent since there was no contamination from the equipment used and are accounted for by the breaking up of bacterial clumps and chains by the clarifier. The greatest reduction of bacteria generally occurred with milk containing more than 100,000 bacteria per cc. and the lowest with milk containing a smaller number. A reduced rate of inflow always resulted in a reduction in the numbers of bacteria present, the reduction being generally greatest in the milk containing the larger number of bacteria.

Considering that the viscosity of milk is quite high and that there is a tendency for the fat globule clusters to entangle bacterial cells and remove them in the cream, it would be reasonable to expect considerable variation in the effect of clarification on the numbers of bacteria present. The specific gravity of bacteria, because of their high moisture content, may be nearly like that of milk and for this reason it would be difficult for the clarifier to remove them in the slime during the short period of exposure of the milk to the centrifugal force. The data seem to indicate that with milk containing a large number of bacteria a greater percentage of these were removed in the slime than where the milk contained a small number of organisms; this may possibly have been due to the presence of a larger proportion of bacterial clumps and chains than in milk containing fewer bacteria. Likewise, by increasing the length of time the milk was exposed to the centrifugal force by decreasing the rate of inflow a greater removal of bacteria from the milk took place than where it was passing through the clarifier at the normal rate. It should be noted, however, that even when the rate of inflow was reduced to the least which was practical, which was one-tenth normal, on an a verage only a little over one-half of the total number of organisms present could be removed from the milk. Such a reduction would not have much significance from the standpoint of numbers removed, but it would have considerable importance if the undesirable organisms were removed.

Clarification caused variable and minor changes in the types of bacteria present in milk both when a normal and a reduced rate of inflow was used. The clarified milk in general always contained the same groups of bacteria as the unclarified milk, although the percentages varied to some extent. The differences were so small, however, that they do not permit of any conclusions regarding a selective action by the clarifier on the types of organisms which were present in the milk, as has been suggested by some investigators.

The summary of the changes shows that in the major groups there was approximately as often an increase as a decrease. This was true both with a normal and a reduced rate of inflow. If there had been a selective action by the clarifier certain groups should have shown either regular increases or decreases. The magnitude of the average change in each group was so small as to be within the experimental error as indicated by the probable error of the mean and cannot, therefore, be said to have any significance. In only one trial was more than one-half of the organisms in a group changed by clarification.

A study of the effect of filtration and separation of milk on the numbers and types of bacteria present showed that these processes caused both increases and decreases in the numbers of bacteria similar to those caused by the clarifier. The changes were probably caused by the breaking up of bacterial clumps and chains by mechanical action and to the elimination of some bacteria by the filter cloth and separator bowl. Since only two comparisons were made of the effect of separation on the types of bacteria present in milk, the results obtained are not extensive enough to permit conclusions.

The effect of clarification with normal and reduced rates of inflow on the bacteria in milk was determined by the plate method, the methylene blue test, and the fermentation test. Clarification with normal and reduced rates of inflow resulted in all comparisons in decreases in the counts. This agrees with the results obtained in previous trials where the milk used contained a similar number of bacteria. With the methylene blue test clarification, both with a normal and a reduced rate of inflow, caused an increase in the reduction time, the increase being more pronounced with clarification under a reduced rate of inflow. The results obtained by the methylene blue test agreed, in general, with those obtained by the plate method. The reduction time did not always seem to be in direct proportion to the number of bacteria present, as determined by the plate method. Some types of organisms do not reduce methylene blue as quickly as do others. The time of reduction of methylene blue by bacteria present in milk would naturally be increased by the removal of some of the organisms by clarification, but the rate of reduction may be changed on account of the removal of a greater proportion of certain types of bacteria than of others. The fermentation tests showed that clarification with a normal and a reduced rate of inflow had little or no influence on the occurring fermentations. The results obtained in the study of the effect of clarification on the types of bacteria present, indicate that clarification had only a minor effect on the flora so it would not be expected that the fermentation test should show much difference between the curds obtained from unclarified and clarified milk.

A comparison of the bacteria in the slime and in the milk from which it was obtained showed that the slime contained a lower percentage of acid forming organisms and a larger percentage of alkali formers than did the milk. The probable error of the mean seems to indicate that the average change in the acid coagulating group has some significance, while the average change of the alkali forming group has considerable significance. The alkali formers were regularly more numerous in the slime than in the milk.

In a few trials the slime contained, on a percentage basis, about 50 per cent more alkali formers than the milk from which it was obtained, while the average of all comparisons shows that the slime contained 16.8 per cent more alkali formers than did the milk. This suggests that the clarifier might have a selective influence on the alkali forming bacteria, probably because they were larger or of a greater specific gravity than the other organisms present.

A study of the effect of varied exposure of raw milk to centrifugal force in centrifuge tubes on the organisms present was made. The results obtained showed that even prolonged exposure of raw milk to the centrifugal force did not result in the complete elimination of any of the types of bacteria present probably because some bacteria were retained by fat globule clusters and others were of such a small size and low specific gravity as to be held in the milk serum. A maximum of 30 per cent of the bacteria present could be removed in the sediment. In some trials the sediment contained a greater percentage of alkali formers than did the raw milk, while in others the reverse was noted. Apparently the bacteria in the milk were not materially affected by the centrifugalization process.

It was possible, however, to cause a large elimination of alkali forming bacteria and yeasts from raw milk inoculated separately with pure cultures of these organisms when the samples were subjected to centrifugal force in tubes. Since microscopic examination of these organisms showed them to be relatively large, as compared with the majority of the bacteria commonly found in milk, they would naturally be removed from milk by the centrifugal force more easily than smaller cells of the same specific gravity. Direct comparison of the effect of clarification of raw milk on the bacteria present with the effect of centrifuging raw milk containing organisms added from agar slopes, cannot be expected to have much significance but this study seemed to indicate that the raw milk artificially inoculated with large cell organisms, a large percentage of these can be removed from it by subjecting it to centrifugal force.

The results of the study of the specific gravity of alkali forming bacteria and of yeasts showed that the alkali formers were of slightly higher specific gravities than that of normal milk when they were grown on agar, while when bouillon was used their specific gravities were slightly lower than that of normal milk. This should explain why it was possible to remove a large number of these bacteria in the sediment obtained by centrifuging raw milk inoculated with pure agar slope cultures of the organisms. The failure to remove a similar percentage of them from naturally infected milk by exposure to centrifugal force might be due to the bacteria being of a lower specific gravity when grown in milk than when they were grown on agar. The composition, size, and density of bacteria are known to vary according to the kind of medium in which they live. In four determinations the specific gravity of yeasts, when grown on agar, was higher than that of normal milk.

If the specific gravity of the alkali forming bacteria grown in milk is the same as when they are grown on agar it should be possible, under favorable conditions, to remove a considerable number of them by subjecting the milk to centrifugal force in a clarifier. The work with the centrifugalization of the naturally infected raw milk showed that the alkali formers were not consistently eliminated in the slime. This would indicate that the organisms were of approximately the same specific gravity as the milk, since prolonged centrifuging did not remove them.

Part II

The results obtained from the scorings of the cheese made from unclarified and clarified milk indicate that clarification caused slight changes in the scores of the cheese when it was about one month and about three months old. The results of the first four series are very similar. Sometimes there was a slight increase in the scores, sometimes there was a slight decrease, while in some comparisons clarification caused no change. The summary of all the scorings shows that in the one month old cheese clarification caused a very slight increase in the average score for flavor and aroma, while there was no improvement in body and texture. In the three months old cheese clarification caused a small increase in the average score for flavor and aroma and a slight increase in the average score for body and texture. The total scores show that clarification caused a slight increase in the average score in the one month old cheese and a small increase in the score of the three months old cheese. The increases are too small, however, to be of any great significance. If clarification had resulted in the removal of most of the objectionable organisms, the scores of the cheese from the clarified milk should show a greater difference from the scores of the unclarified milk than was obtained in this study. The lack of change in the types of bacteria present in the milk as a result of clarification harmonizes with the results of the scorings. The changes caused by clarification in the various groups of organisms were of little or no significance and the ripening changes which occurred in the cheese with and without clarification were very similar, while the differences in the cheese scores caused by clarification were too small to allow of definite conclusions.

The addition of slime to clarified milk caused small, but fairly constant, decreases in the scores for flavor and aroma, and for body and texture. The lowering in the quality of the cheese might have been caused by the addition of alkali forming bacteria in the slime. The addition of pure cultures of these organisms to clarified milk caused decreases in the scores somewhat comparable to the decreases caused by the addition of slime. It would seem from these results that the alkali forming organisms were somewhat detrimental to the quality of cheese when added to milk in large quantities. This group of bacteria apparently is only of minor importance in cheese ripening since otherwise the large numbers of the organisms added to milk should have had a pronounced influence on the changes which took place during ripening.

A study of the effect of clarification of milk and the addition of slime to clarified milk on the numbers and types of bacteria present in the cheese obtained indicated that there was no noticeable difference between the numbers and types of bacteria in the cheese made from unclarified milk and in the cheese made from the treated milk. There seemed to be no correlation between the number of bacteria present in any of the cheese and the total scores obtained. Previous results reported in Part I have shown that the only organisms in the milk studied which were materially eliminated by clarification were the alkali formers. If these organisms are detrimental to the quality of cheese it would be expected that when they were present in the milk used for cheese, they would also be present in the cheese obtained. The cheese made from unclarified milk would be expected to contain a greater number of these bacteria than the clarified milk cheese, while if clarifier slime was added to the milk they should be present in still larger numbers. With the cheese studied bacteriologically, even where slime had been added to the milk, this group of organisms was never isolated from the cheese. It would thus seem that, unless their action had been completed before the cheese was one month old, the alkali forming organisms play no part in the ripening of cheese.

In studying the relation between the numbers of bacteria present in unclarified and clarified milk and the scores of the cheese obtained, it was found that the increases and decreases in the counts resulting from clarification did not cause corresponding increases or decreases in the scores of the cheese. The reason for this is difficult to explain. Other investigators have obtained similar results, and it would seem that further investigational work is needed before a satisfactory explanation can be given.

The methylene blue test and the fermentation test were used for studying the effect of clarification on the milk used for cheese during the period May to July 1927, inclusive. Clarification as a rule caused a pronounced increase in the time required to reduce the methylene blue. This increase in the reduction time was probably caused by the removal of bacteria by the clarifier. Unclarified milk containing starter reduced the dye more quickly than did clarified milk containing starter. The fermentation test did not indicate that clarification had caused any change in the flora of the milk. These results compared with those obtained in Part I.

SUMMARY

Part I

1. Forty-three comparisons of the effect of clarification on the numbers of bacteria in milk showed that clarification caused an increase in the counts in 20 trials and a decrease in 23. The increases in the counts varied from 3.1 to 143.7 per cent and averaged 54.6 per cent, while the decreases varied from 0.4 to 59.1 per cent and averaged 24.9 per cent. Considering the 43 comparisons clarification caused an average increase of 12.1 per cent. With the milk studied, clarification more often caused a decrease in the count in the milk containing over 100,000 bacteria per cc. than when the number was smaller.

2. Nineteen comparisons of the influence of clarification on the number of bacteria in milk using a normal and a reduced rate of inflow showed that with a normal rate of inflow clarification caused an increase in the counts in six trials and a decrease in 13, while when the rate of inflow was reduced, clarification always caused a decrease. With the normal rate of inflow the increases varied from 5.9 to 64.8 per cent and averaged 35.1 per cent, while the decreases varied from 3.4 to

60.2 per cent and averaged 20.8 per cent. Considering the 19 comparisons there was an average decrease of 3.1 per cent. When the rate of inflow was reduced there was a minimum decrease of 25.9 per cent, a maximum of 80.5 and an average of 55.3 per cent.

3. Twenty-one comparisons of the influence of clarification on the types of bacteria present in milk showed that clarification had an irregular effect on the bacterial flora. Sometimes it caused an increase and sometimes a decrease in each of the groups of organisms present in the milk. The increases in the acid coagulators varied from 0.3 to 34.3 per cent and the decreases from 0.2 to 23.7 per cent, with an average increase when all the comparisons are considered of 3.4 per cent. The acid non-coagulators showed increases varying from 0.8 to 24.0 per cent, decreases from 0.8 to 16.0 per cent, and an average increase in all comparisoms of 3.9 per cent. The alkali formers were increased from 0.1 to 16.0 per cent and decreased from 1.2 to 22.0 per cent, with an average decrease for all comparisons of 1.8 per cent. The other groups showed similar increases and decreases.

4. Thirty-three comparisons of the types of

bacteria present in unclarified milk and in the slime obtained from it showed that the only groups which indicated a fairly consistent change as a result of clarification were the acid coagulators and the alkali formers. The average changes were an 8.7 per cent decrease in the percentage of acid formers and a 16.8 per cent increase in the percentage of alkali formers in the slime as compared with the milk.

5. The results of a series of 18 comparisons on the effect of clarification with a normal and a reduced rate of inflow on the types of bacteria in milk showed that clarification with both methods caused little change in the types of bacteria present. The variations were not consistent or large enough to permit of any conclusions other than that the clarifier had no very pronounced selective action on the types of bacteria present in the milk under either method of clarification.

6. In four trials, filtration caused an increase in the bacterial counts of milk three times and a decrease once. The increases varied from 12.2 to 38.9 per cent with an average of 23.4. The decrease in the single case was 8.6 per cent. Considering the four comparisons, there was an average increase of 15.4 per cent in the counts. In two trials separation caused an increase of 21.9 per

cent in one instance and a decrease of 22.4 per cent in the other, with an average percentage decrease of 0.5.

7. In nine comparisons clarification under a normal and under a reduced rate of inflow caused an increase in the time required to reduce methylene blue, when unclarified milk was used as the basis for comparison. The average increases in the reduction time when all the comparisons are considered were 21 minutes with a normal rate of inflow and 47 minutes with clarification under a reduced rate of inflow. The results agreed, in general, with those obtained by the plate method but the latter method was more refined in showing the changes in the numbers of bacteria of milk resulting from clarification. Observations of the fermentation test indicated that clarification with both rates of inflow had little effect on the fermentation occurring.

8. When raw milk was subjected to centrifugal force in centrifuge tubes for various periods of time, it was found in four comparisons that five minutes centrifuging removed an average of 12.6 per cent of the bacteria present while 20 minutes exposure to the centrifugal force removed an average of 16.7 per cent in the sediment. The centrifuging of samples of milk of the same lot for five,

ten and 30 minutes, respectively, in four comparisons, and for five and 20 minutes in four other comparisons caused only slight changes in the bacterial flora; whenever a certain type of organism was present in the milk it was also found in the sediment. Even an exposure of the milk to centrifugal force for 30 minutes did not cause a complete elimination of any of the types of bacteria present in the milk. By subjecting raw milk to centrifugal force in tubes, it was possible to remove a large percentage of alkali forming organisms or yeasts which had been inoculated into it from agar slopes.

9. The specific gravity of *Torula cremoris*, when grown on agar, was found in four determinations to vary from 1.037 to 1.102, with an average of 1.079. Various cultures of alkali forming bacteria grown on agar were found in 13 determinations to have specific gravities ranging from 1.029 to 1.123 and averaging 1.0497, while when bouillon was the medium, the specific gravities in two determinations were 1.025 and 1.032, with an average of 1.0285.

10. A morphological, cultural and biochemical study of 31 cultures of alkali forming bacteria showed that the differences exhibited were too small to permit of a division into varieties of the species to which they belong.

Part II

1. The study of the influence of clarification on the quality of cheese made from 67 different lots of milk showed that in the one month old cheese clarification resulted in an increase in the average score for flavor and aroma of all the cheese of 0.07, while in the three months old cheese it resulted in an increase of 0.41. In the one month old cheese clarification caused no change in the average score for body and texture of all the cheese, while in the three months old cheese it resulted in an increase of 0.15. When the total scores of the cheese in all the comparisons are considered, clarification caused an increase in the average score of the one month old cheese of 0.07 and in the three months old cheese of 0.56.

2. In six comparisons the addition of clarifier slime to clarified milk caused, on an average, a decrease in the quality of the cheese. In the one month old cheese it caused an average decrease in the total score of 1.08 and in the three months old cheese an average decrease of 1.25.

In five comparisons the addition of a pure culture of alkali forming bacteria to clarified milk caused an average decrease in the total scores of the one month old cheese of 1.20, and in the three months old cheese an average decrease of 0.40.

3. Clarification of milk and the addition of slime to clarified milk did not have any specific influence on the numbers and types of bacteria present in the resultant cheese. An increase or decrease in the numbers of bacteria in the cheese obtained from the treated milk as compared with the numbers present in the cheese from the untreated milk of the same lot did not result in a corresponding increase or decrease in the total scores of the cheese.

4. Clarification caused increases and decreases in the numbers of bacteria present in milk but corresponding increases or decreases in the scores of the cheese did not regularly follow these.

5. In a study of the influence of clarification on the milk used for cheese, as shown by the methylene blue test, it was observed that in 28 comparisons clarification caused no change in the reduction time in ten of these, while in 18 it caused an increase. The increases varied from five to 60 minutes and averaged 27 minutes. When the 28 comparisons are considered, there was an average increase in the reduction time of 17.5 minutes. This increase in the reduction time was also noticeable when

the milk contained starter.

6. The fermentation test showed that the curds obtained from unclarified milk were very similar to those obtained from clarified milk.

7. The addition of clarifier slime to clarified milk slightly decreased the time required to reduce methylene blue, while the addition of alkali forming bacteria to clarified milk caused little change in the reduction time as compared with the results obtained from clarified milk of the same lot.

8. The curds obtained in the fermentation test with milk containing alkali forming bacteria and slime were very similar to those obtained from the unclarified and clarified milk of the same lot.

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